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PFAS Contamination of U.S. Surface Waters

WATERKEEPER® ALLIANCE

ACKNOWLEDGMENTS

This report was produced by Waterkeeper® Alliance, New York, NY, in cooperation with participating Waterkeeper groups from across the United States. Data, analysis, and technical findings were supplied for the sole purpose of this report by the contracted service provider, Cyclopure Inc., Skokie, IL. The Cyclopure technical report can be accessed at waterkeeper.org/pfas. Previously published supplementary and contextual content referenced herein with permission from the Environmental Working Group (EWG). A third-party scientific review was provided by Robert W. Bowcock, Founder and Managing Director of Integrated Resource Management and Dominique Lueckenhoff, Senior Vice-President Corporate Affairs, EHS & Sustainability at HUGO NEU and a former water program official with the U.S. Environmental Protection Agency (EPA). The monitoring project that led to the creation of this report was managed by Christian Breen, Field Investigator for Waterkeeper Alliance.

ABOUT WATERKEEPER ALLIANCE

Waterkeeper Alliance is a global water movement that unites more than 300 community-based Waterkeeper Organizations and Affiliates in 46 countries. We advance a shared mission to protect everyone's right to clean water by focusing citizen action on issues that affect our waterways, from pollution to climate change. Together, the movement patrols and protects over 2.6 million square miles of rivers, lakes, and coastlines in the Americas, Europe, Australia, Asia, and Africa. Learn more at waterkeeper.org.

This report was produced as part of Waterkeeper Alliance's ACT50 initiative, which celebrates the 50th anniversary of the U.S. Clean Water Act (CWA). Foundational to the Alliance's U.S.-based advocacy work, the Act was expanded in 1972 to regulate discharges of pollutants into the waters of the United States and to maintain quality standards for U.S. surface waters. The goals of the initiative are to celebrate CWA successes, rally support to strengthen this important law, and inspire worldwide action for clean water. Learn more at waterkeeper.org/ACT50.

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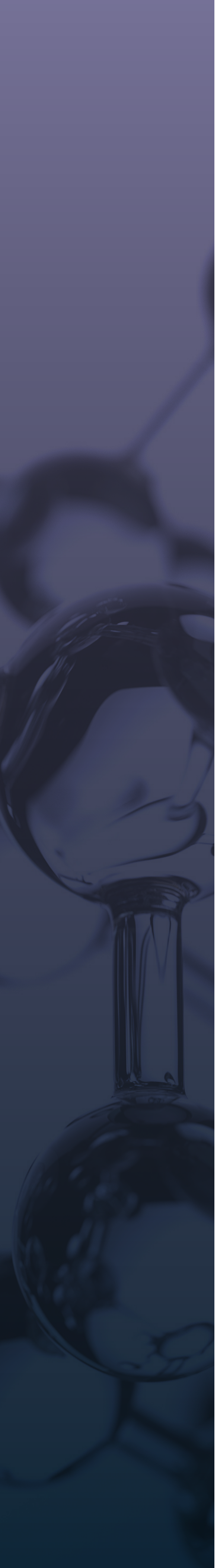

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EXECUTIVE SUMMARY

Per- and polyfluoroalkyl substances (PFAS) are a class of manufactured organic chemicals that are pervasive in the environment and are linked to harmful public health and ecosystem impacts.[1] Health risks include increased incidence of cancer, liver and kidney disease, reproductive issues, immunodeficiencies, and hormonal disruptions.

Widely used in manufacturing since at least the 1950s, and incorporated into many industrial and common consumer products such as non-stick cooking pans, food packaging, and water- and stain-resistant clothing, PFAS are often referred to as "forever chemicals." They are biopersistent, meaning they remain in organisms indefinitely without breaking down, and are bioaccumulative, meaning that over time, they build up in ever increasing amounts in people, wildlife, aquatic life, and the environment. Though experts estimate that more than 200 million Americans are exposed to PFAS through drinking water,[2] EPA has yet to finalize binding, enforceable regulatory standards that protect the public and our nation's waters, including sources of drinking water, from this serious health hazard.

As a class of chemicals, PFAS consist of approximately 9,000 different derivatives. The origins of PFAS pollution[3] are well documented by EPA and other sources.[4] PFAS contamination is found in drinking water sources (both ground and surface waters), industrial wastewater, landfill leachate, and wastewater treatment plant (WWTP) effluent. Contamination is particularly notable at airbases and airports across the country due to the historic and continued use of PFAS-laden firefighting foams.[5]

While PFAS compounds are believed to be ubiquitous in U.S. waterways, no nationwide surface water quality survey exists. As a result, the levels and effects of PFAS are unknown for many rivers, streams, lakes, and other U.S. surface waters that serve as drinking water sources, recreational waters, and fisheries. To address this troubling lack of information about the presence of, and dangers posed by, PFAS in U.S. surface waters, Waterkeeper Alliance contracted with Cyclopure, Inc., a materials science and environmental engineering firm headquartered in Illinois, to help conduct a monitoring project in which we worked with more than 100 Waterkeeper groups across the United States on an unprecedented initiative to test U.S. surface waters for PFAS contamination.

During the late spring and early summer of 2022, a nationwide effort was carried out by 113 U.S. Waterkeeper groups, whose shared mission is to patrol, monitor, and protect rivers, lakes, and coastal waters from degradation. These participating Waterkeeper groups, listed below in Appendix 1, collected water samples from two locations in their respective home waterways — generally one upstream and one downstream of potential source of PFAS contamination — between May 26 and July 28, 2022.[6] A total of 228 samples were collected in 34 states and the District of Columbia (D.C.)., where U.S. Waterkeeper groups that agreed to participate in the project are located. States in which no samples were taken are listed in Appendix 5. To the best of our knowledge, this project constitutes the most extensive coordinated PFAS monitoring study conducted in the U.S. to date.

Cyclopure provided sampling kits to all of the participating Waterkeeper groups, ran the laboratory analysis for 55 PFAS structures on each returned test kit, and generated a technical data report in September 2022, setting forth the results for each tested sample. The report is the first of its kind to provide high-quality PFAS pollution data for surface waters across the country, and confirms the prevalence of significant harmful PFAS pollution from many different compounds across diverse waterways types and geographically unique locations.

This data unequivocally demonstrates that dangerous PFAS pollution is widespread in surface waters across the country, and that existing laws and regulations have been inadequate to protect public health and the environment from this under-appreciated threat. It is apparent from the results of this project and other credible information cited herein that EPA and the states must take more urgent action to monitor waterways, adopt standards for eliminating pollution sources and cleaning up existing contamination, and enforce those standards through permitting and enforcement actions.

TABLE 1

Description of 35 PFAS Compounds Usage, Impacts, and Status

PFAS Compound	Description from EWG Human Toxome Project[7] Unless Noted
PFOA (Perfluorooctanoic acid)	• Used to make Teflon pan coatings; breakdown product of stain- and grease-proof coatings. • Likely human carcinogen and other health impacts. • Widespread presence documented in human blood serum. CDC[8] • Most use/production has been voluntarily discontinued in the U.S.. • **Does not break down or degrade in the environment - continuing human exposure.**
PFOS (Perfluorooctanesulfonate)	• Active ingredient in Scotchgard prior to 2000. • Phase out forced by EPA because concentrations in human blood close to levels that harm lab animals. • Most use/production discontinued in the U.S.. • Accumulates to a high degree in humans and wildlife and is known to damage the liver and to produce severe birth defects in lab animals. • **Does not break down in the environment - continuing human exposure.**
PFHxA (Perfluorohexanoic acid)	• Breakdown product of stain- and grease-proof coatings on food packaging and household products. • Highly persistent in people and the environment. • **No restrictions on the production/use in the U.S..**
PFPeA (Perfluoro-n-pentanoic Acid)	• Breakdown product of stain- and grease-proof coatings on food packaging, couches, carpets, including Stainmaster. • A 5-carbon version of PFOA; highly persistent. • **No restrictions on the production/use in the U.S..**
PFBS (Perfluorobutane sulfonate)	• An active ingredient in 3M's new Scotchgard. • Structurally similar to PFOS, persistent • **No restrictions on the production/use in the U.S..**
PFHpA (Perfluoroheptanoic acid)	• Breakdown product of stain- and grease-proof coatings on food packaging, couches, and carpets. • A 7-carbon version of PFOA; persistent. • **No restrictions on the production/use in the U.S..**
PFHxS (Perfluorohexanesulfonate)	• In firefighting foams and carpet treatments. • 6-carbon sister chemical of the better known 8-carbon PFOS. • Phased out of consumer products by 3M in 2000 over health concerns - no longer manufactured. • **Residual environmental contamination results in continued exposures.**

PFAS Compound	Description from EWG Human Toxome Project[7] Unless Noted
PFBA (Perfluorobutyric acid)	• Breakdown product of stain- and grease-proof coatings on food packaging, couches, and carpets, including Stainmaster. • 4-carbon version of PFOA; persistent. • **No restrictions on the production/use in the U.S..**
PFNA (Perfluorononanoic acid)	• Breakdown product of stain- and grease-proof coatings on food packaging, couches, and carpets. • 9-carbon version of PFOA; persistent; bioaccumulative. • **No restrictions on the production/use in the U.S**
FBSA (Perfluorobutane sulfonamide)	• Used by 3M to make water- and stain-resistant products. Univ. of Rhode Island[9]
PFDA (Perfluorodecanoic acid)	• Breakdown product of stain- and grease-proof coatings on food packaging, couches, and carpets. • 10-carbon version of PFOA; persistent; bioaccumulative. • **No restrictions on the production/use in the U.S.**.
6:2 FTS (6:2 Fluorotelomer Sulfonate)	• Used as an alternative to perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) for different purposes such as chrome mist suppressant (CMS) and active ingredient in firefighting foams. Science Direct[10]
PFPeS (Perfluoropentane Sulfonic Acid)	• Member of a group of perfluorinated chemicals used in many consumer products. PFPeS and other perfluorinated chemicals can cause serious health effects, including cancer, endocrine disruption, accelerated puberty, liver and immune system damage, and thyroid changes. EWG[11]
FHxSA (Perfluorohexane Sulfonamide)	• Member of a group of perfluorinated chemicals used in many consumer products. FHxSA and other perfluorinated chemicals can cause serious health effects, including cancer, endocrine disruption, accelerated puberty, liver and immune system damage, and thyroid changes. EWG[12]
PFECHS (Perfluoro-4-ethylcyclohexane Sulfonic Acid)	• "8-carbon cyclic PFAS and is considered an analog of • PFOS and is used as a replacement for PFOS in various formulations." • "The 3M corporation began phasing out production of PFECHS in 2002," but current status is unknown. Michigan PFAS Action Team[13]
PFHpS (Perfluoroheptane Sulfonic Acid)	• Member of a group of perfluorinated chemicals used in many consumer products. PFHpS and other perfluorinated chemicals can cause serious health effects, including cancer, endocrine disruption, accelerated puberty, liver and immune system damage, and thyroid changes. EWG[14]

PFAS Compound	Description from EWG Human Toxome Project[7] Unless Noted
N-EtFOSAA (N-Ethyl Perfluorooctane Sulfonamido Acetic Acid)	• Member of a group of perfluorinated chemicals used in many consumer products. N-EtFOSAA and other perfluorinated chemicals can cause serious health effects, including cancer, endocrine disruption, accelerated puberty, liver and immune system damage, and thyroid changes. EWG[15]
PFEESA (Perfluoro(2-ethoxyethane) Sulfonic acid)	• **Limited Information Available**
PFOSA (Perfluorooctanesulfonic acid)	• Intermediate breakdown product of some of the active ingredients used for decades in the original formulation of 3M's Scotchgard stain and water repellent. • Part of the 'PFOS chemistry' phased out of use by 3M in 2000 over health concerns. • Metabolized into PFOS by the body in humans.
PFUnA (Perfluoroundecanoic acid)	• Breakdown product of stain- and grease-proof coatings on food packaging, couches, and carpets. • 11-carbon version of PFOA; persistent; bioaccumulative.
8:2 FTS (8:2 Fluorotelomer Sulfonate)	• Member of a group of perfluorinated chemicals used in many consumer products. 8:2FTS and other perfluorinated chemicals can cause serious health effects, including cancer, endocrine disruption, accelerated puberty, liver and immune system damage, and thyroid changes. EWG[16]
5:3 FTCA (2h,2h,3h,3h-Perfluorooctanoic Acid)	• **Limited Information Available**
GenX or HFPO-DA (Hexafluoropropylene Oxide Dimer Acid)	• Successor to PFOA, formerly used by DuPont to make Teflon. • Used for non-stick coatings on food wrappers, outdoor clothing and many other consumer goods. EWG[17] • **No restrictions on the production/use in the U.S.**
PFPrS (Perfluoropropane Sulfonic Acid)	• **Limited Information Available**
N-MeFOSAA (N-Methyl Perfluorooctane Sulfonamido Acetic Acid)	• Member of a group of perfluorinated chemicals used in many consumer products. NMeFOSAA and other perfluorinated chemicals can cause serious health effects, including cancer, endocrine disruption, accelerated puberty, liver and immune system damage, and thyroid changes. EWG[18]
4:2 FTS (4:2 Fluorotelomer Sulfonate)	• Under Evaluation by EPA[19]
MeFBSA (N-Methylperfluorobutanesulfonamide)	• **Limited Information Available**

PFAS Compound	Description from EWG Human Toxome Project[7] Unless Noted
PFDoA (Perfluorododecanoic acid)	• Breakdown product of stain- and grease-proof coatings on food packaging, couches, and carpets, including Stainmaster. • Highly persistent and bioaccumulative. • **No restrictions on the production/use in the U.S..**
3:3 FTCA (3-Perfluoropropyl Propanoic Acid)	• **Limited Information Available**
N-AP-FHxSA (N-(3-dimethylaminopropan-1-yl) perfluoro-1-hexanesulfonamide)	• **Limited Information Available**
PFMOPrA or PFMPA (Perfluoro-3-Methoxypropanoic Acid)	• Member of a group of perfluorinated chemicals used in many consumer products. PFMOPrA and other perfluorinated chemicals can cause serious health effects, including cancer, endocrine disruption, accelerated puberty, liver and immune system damage, and thyroid changes. EWG[20]
FOSAA (Perfluorooctane Sulfonamido Acetic Acid)	• **Limited Information Available**
FOUEA (2H-perfluoro-2-decenoic acid)	• **Limited Information Available**
NMeFOSE (N-methyl perfluorooctanesulfonamidoethanol	• Under Evaluation by EPA[21]
ADONA (4,8-Dioxa-3H-Perfluorononanoate)	• Member of a group of perfluorinated chemicals used in many consumer products. ADONA and other perfluorinated chemicals can cause serious health effects, including cancer, endocrine disruption, accelerated puberty, liver and immune system damage, and thyroid changes. EWG[22]

KEY TAKEAWAYS

PHOTO: COOSA RIVERKEEPER

In this section we highlight several key findings of the study. More detailed technical findings are discussed later in this report.

- At least one PFAS compound was detected in **95 of the 114 waterways sampled (83%).**
- Nineteen of the 114 waterways sampled had no detection of PFAS compounds above the method detection limit (17%). **Many of these non-detect waterways are rural and relatively undeveloped.**
    - It is notable that the laboratory detection level for PFOA and PFOS in this study is significantly higher than EPA's recently-published interim Drinking Water Health Advisory Limits[23] for those substances (0.004 parts per trillion (ppt) and 0.02 ppt[24], respectively). It is, thus, possible that waterways with non-detect results are in fact contaminated with these PFAS compounds at levels below the detection limits but above EPA's interim Health Advisory Limits.
- 35 of the 55 individual PFAS compounds tested for in this study were detected in at least one sampled waterway (63.6%).
- PFAS compounds were found at measurable concentrations in at least one waterway in 29 states and D.C. (out of the 34 states and D.C. where monitoring was conducted).
- PFOA and PFOS, both of which are highly persistent in the environment, were the most frequently detected PFAS compounds across the 114 sampled waterways (approximately 70% of samples).
    - **PFOA was detected in 158 out of 228 sampling sites (a 69% detection frequency),** with measured concentrations ranging from <1.0 to 847 ppt. The interim EPA health advisory limit for PFOA is 0.004 ppt.
    - **PFOS was detected in 159 sampling sites (a 70% detection frequency),** with measured concentrations ranging from <1.0 to 1,364.7 ppt. The interim health advisory limit for PFOS is 0.02 ppt.
    - While these high incidences of PFOA and PFOS contamination in surface waters are extremely troubling, **it was also very concerning to find that contamination by lesser-known types of PFAS was also extremely prevalent.**
        - For example, PFHxA was found in measurable concentrations at 153 of the 228 sampling sites (67%), with a highest reported concentration of 607.1 ppt, and PFPeA was found in measurable concentrations at 126 of 228 sites (55%), with a highest reported concentration of 166.5 ppt.
        - Many other PFAS compounds were also found at a large number of sites and at extremely high concentrations. *See* Table 3.
- Potential sources of PFAS contamination identified in this study included landfill sites, airports, industrial sites, and wastewater treatment plants.
- These data plainly demonstrate that **Congress and EPA must act with urgency to control and remediate persistent PFAS contamination across the country**. Experts estimate that nearly 30,000 facilities[25] discharge PFAS to surface waters or to wastewater treatment plants (which then discharge their contaminated effluent to surface waters), but no federal limits exist for PFAS releases into surface waters under the Clean Water Act.
    - EPA has proposed[26] to designate certain PFAS as hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), *i.e.*, the federal "Superfund" site cleanup law, but this designation has yet to be finalized.
    - EPA also expects to establish drinking water standards for PFOA and PFOS, but not until 2023.
- **The current lack of oversight puts the health and safety of communities and ecosystems across the nation at risk** and results in costly cleanup and treatment activities to remove PFAS contamination after it has occurred. It also constrains the ability of governments and the public to stop ongoing pollution and clean up existing contamination.

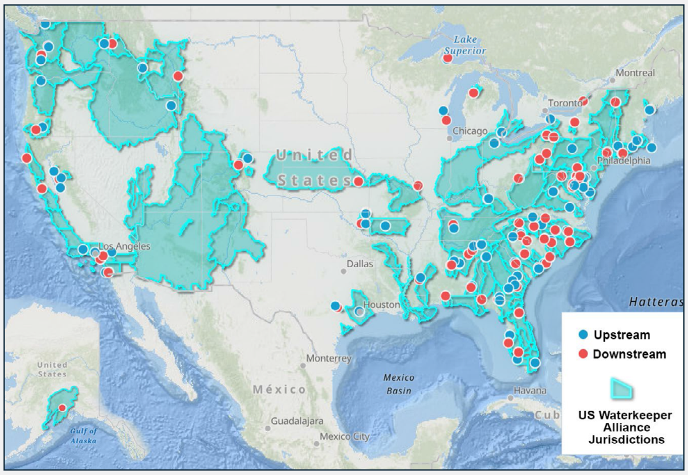

FIGURE 1

Waterkeeper Alliance National PFAS Water Sample Collection Map

METHODOLOGY

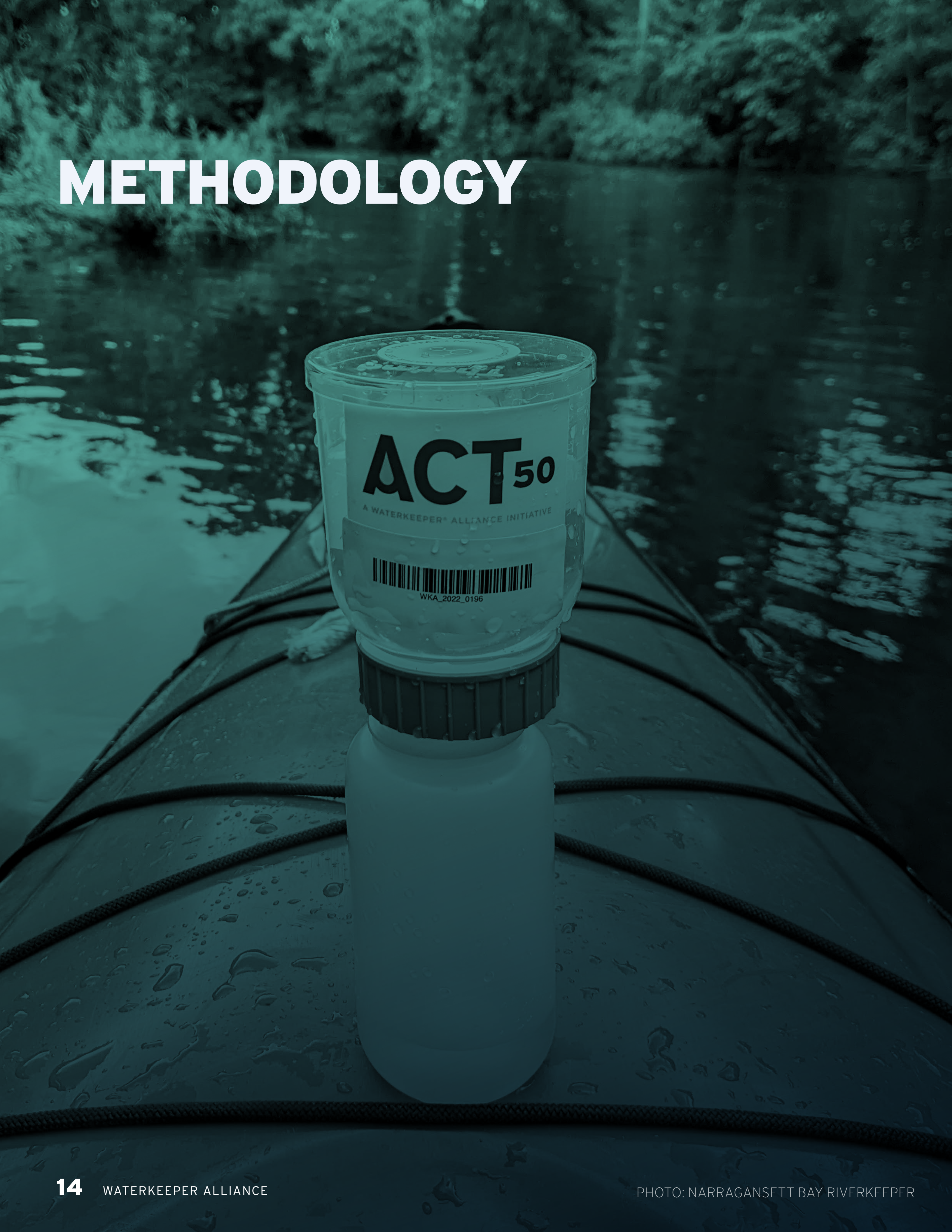

PHOTO: NARRAGANSETT BAY RIVERKEEPER

Water Sample Collection

All the sample information that is available in this report was collected by licensed Waterkeeper groups throughout the country. All Waterkeeper groups collecting sample information were given training and instruction on water sample collection procedures. Waterkeeper groups collected two samples, generally one upstream and one downstream from an identified potential source of PFAS contamination, see Appendix 4 for details on each sample collected.

- **Engaging Waterkeepers (March 7 - May 27)**: Waterkeeper Alliance performed extensive outreach to U.S. Waterkeeper groups starting in March of 2022. Waterkeeper Alliance facilitated all questions and was in contact with many participating Waterkeeper groups throughout the sample collection period of the project.
- **Training**: Waterkeeper Alliance held a webinar for participating Waterkeeper groups on May 10, 2022. During the webinar, U.S. Waterkeepers received instruction in following specific water sample collection procedures for the PFAS water test kit, as well as: (1) guidance on where/how to collect the PFAS surface water samples within their waterways, and (2) a brief overview of the analytical methodologies that were utilized in the project.
- **Test Kit Distribution (May 15 - July 26)**: Test kits were shipped directly to Waterkeeper groups and completed kits were shipped back to the laboratory after sample collection.
- **Sample Site Selection**: Two water samples were taken by each Waterkeeper group. The sample collection sites were established prior to sampling within each individual waterway. The upstream sample was selected in a location expected to have minimal PFAS contamination. The downstream location was located in an area of suspected contamination, such as below a potential PFAS pollutant source.
- **Sample Collection**: All samples were collected between May 26 and July 28 of 2022 by 113 individual Waterkeeper groups in 34 states and D.C.. Samples were taken in the upper clear layers of the surface water sources, while dipping the collection cup away from the water's edge and avoiding sediments.
- **Sample Submission**: 113 Waterkeeper groups returned samples to Cyclopure Inc. upon completion. Waterkeeper groups collected and submitted the following information for each sampling location on a provided water test kit data card: (1) the physical location of the sample collected as recorded via GPS handheld receiver, and (2) the date and time of sample collection.

For more detailed information on Cyclopure's analytical methodologies, *see* Appendices 2 and 3 below, and the technical data report at pages 4 - 5.

ANALYSIS & FINDINGS

PHOTO: THREE RIVERS WATERKEEPER

I. Overview of National and State Levels Results for All 55 PFAS Compounds

PFAS were detected in the surface waters of 29 states and D.C. (of the 34 states and D.C. sampled), and in 95 of the 114 waterways sampled by Waterkeeper groups (83%).

Of the 55 individual PFAS compounds tested for in this study, 35 PFAS compounds were detected in one or more surface waters sampled by Waterkeeper groups in multiple states across the country, *see* Table 2.

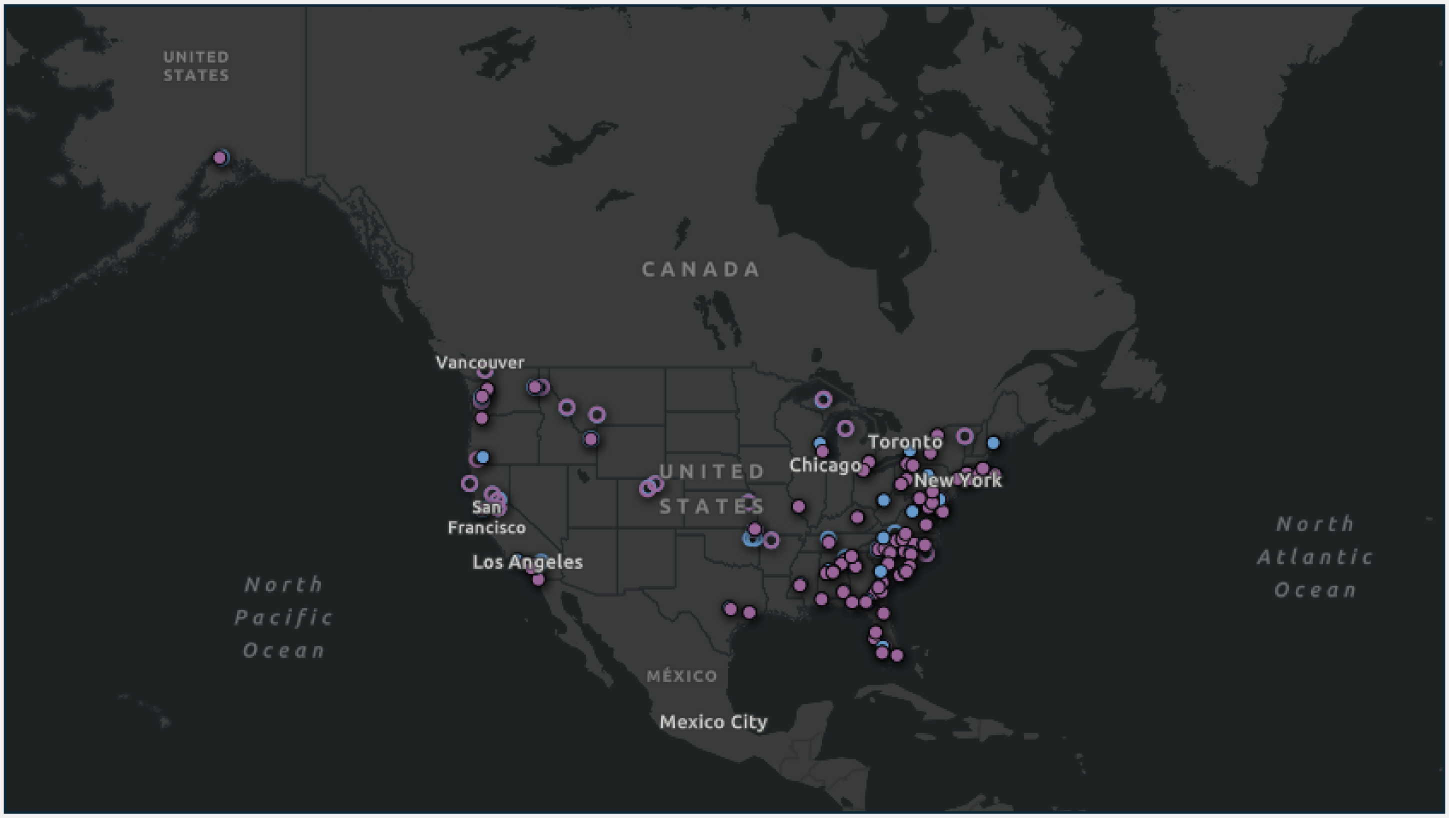

FIGURE 2

PFAS Contamination of U.S. Surface Waters

TABLE 2

Surface Waters by States and D.C. With PFAS Detections for Each of the 35 Detected PFAS Compounds

PFAS Compound	Detected In Surface Water of the Following States
PFOS (Perfluorooctanesulfonate)	Alabama, Alaska, California, Connecticut, District of Columbia, Florida, Georgia, Kentucky, Maine, Maryland, Massachusetts, Michigan, Mississippi, Missouri, New Jersey, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Virginia, Washington, West Virginia, Wisconsin
PFOA (Perfluorooctanoic acid)	Alabama, Alaska, California, Connecticut, District of Columbia, Florida, Georgia, Idaho, Maine, Maryland, Massachusetts, Michigan, Mississippi, Missouri, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Virginia, West Virginia, Wisconsin
PFHxA (Perfluorohexanoic acid)	Alabama, Alaska, California, Connecticut, District of Columbia, Florida, Georgia, Idaho, Kentucky, Maine, Maryland, Massachusetts, Michigan, Mississippi, Missouri, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Virginia, Washington, West Virginia, Wisconsin
PFPeA (Perfluoro-n-pentanoic Acid)	Alabama, Alaska, California, Connecticut, District of Columbia, Florida, Georgia, Kentucky, Maine, Maryland, Massachusetts, Michigan, Mississippi, Missouri, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Virginia, West Virginia
PFBS (Perfluorobutane sulfonate)	Alabama, California, District of Columbia, Florida, Georgia, Maryland, Massachusetts, Michigan, Mississippi, MIssouri, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Virginia, West Virgina, Wisconsin
PFHpA (Perfluoroheptanoic acid)	Alabama, California, Connecticut, District of Columbia, Florida, Georgia, Maryland, Massachusetts, Michigan, Mississippi, Missouri, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Virginia, West Virginia, Wisconsin
PFHxS (Perfluorohexanesulfonate)	Alabama, Alaska, California, Connecticut, District of Columbia, Florida, Georgia, Maryland, Massachusetts, Michigan, Mississippi, Missouri, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, West Virginia, Wisconsin
PFBA (Perfluorobutyric acid)	Alabama, California, District of Columbia, Florida, Georgia, Maryland, Michigan, Missouri, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, Texas, Wisconsin
PFNA (Perfluorononanoic acid)	Alabama, California, District of Columbia, Florida, Georgia, Maryland, Massachusetts, Michigan, Missouri, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island

PFAS Compound	Detected In Surface Water of the Following States
FBSA (Perfluorobutane sulfonamide)	Alabama, California, Florida, Georgia, Maryland, Missouri, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, West Virginia
PFDA (Perfluorodecanoic acid)	Alabama, California, Georgia, Maryland, Missouri, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas
6:2 FTS (6:2 Fluorotelomer Sulfonate)	California, Connecticut, Florida, Georgia, Maryland, Missouri, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Texas
PFPeS (Perfluoropentane Sulfonic Acid)	California, Florida, Georgia, Maryland, Missouri, New York, North Carolina, Ohio, Pennsylvania, Rhode Island
FHxSA (Perfluorohexane Sulfonamide)	California, Florida, Georgia, Maryland, Missouri, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, West Virginia
PFECHS (Perfluoro-4-ethylcyclohexane Sulfonic Acid)	Florida, Georgia, Maryland, Michigan, Missouri, North Carolina, Ohio, Pennsylvania, Rhode Island
PFHpS (Perfluoroheptane Sulfonic Acid)	Califorrnia, Georgia, Maryland, Missouri, New York, Ohio, Pennsylvania, Rhode Island
N-EtFOSAA (N-Ethyl Perfluorooctane Sulfonamido Acetic Acid)	Alabama, Florida, Georgia, Michigan, Pennsylvania, Rhode Island, Tennessee
PFEESA (Perfluoro(2-ethoxyethane) Sulfonic acid)	Maryland, Missouri, New Jersey, Ohio, Pennsylvania
PFOSA (Perfluorooctanesulfonic acid)	Alabama, Florida, Georgia, Maryland, Pennsylvania
PFUnA (Perfluoroundecanoic acid)	Maryland, New York, Rhode Island
8:2 FTS (8:2 Fluorotelomer Sulfonate)	Florida, Maryland, Missouri, New York, Pennsylvania
5:3 FTCA (2h,2h,3h,3h-Perfluorooctanoic Acid)	Florida, Maryland, Pennsylvania, Rhode Island
GenX or HFPO-DA (Hexafluoropropylene Oxide Dimer Acid)	North Carolina, Oklahoma, South Carolina

PFAS Compound	Detected In Surface Water of the Following States
PFPrS (Perfluoropropane Sulfonic Acid)	Maryland, Missouri, Pennsylvania, Rhode Island
N-MeFOSAA (N-Methyl Perfluorooctane Sulfonamido Acetic Acid)	Georgia, North Carolina, Tennessee
4:2 FTS (4:2 Fluorotelomer Sulfonate)	Maryland, Pennsylvania
MeFBSA (N-Methylperfluorobutanesulfonamide)	Georgia, Pennsylvania
PFDoA (Perfluorododecanoic acid)	Maryland
3:3 FTCA (3-Perfluoropropyl Propanoic Acid)	Pennsylvania
N-AP-FHxSA (N-(3-dimethylaminopropan-1-yl) perfluoro-1-hexanesulfonamide)	Pennsylvania
PFMOPrA or PFMPA (Perfluoro-3-Methoxypropanoic Acid)	Maryland
FOSAA (Perfluorooctane Sulfonamido Acetic Acid)	Pennsylvania
FOUEA (2H-perfluoro-2-decenoic acid)	Florida
NMeFOSE (N-methyl perfluorooctanesulfonamidoethanol)	Michigan
ADONA(4,8-Dioxa-3H-Perfluorononanoate)	Tennessee

For example, PFAS compounds were detected in surface waters at 20 sampling sites located in Maryland, 18 sites located in North Carolina, 18 sites located in Georgia, and 16 sites located in Alabama, *see* Figure 3.

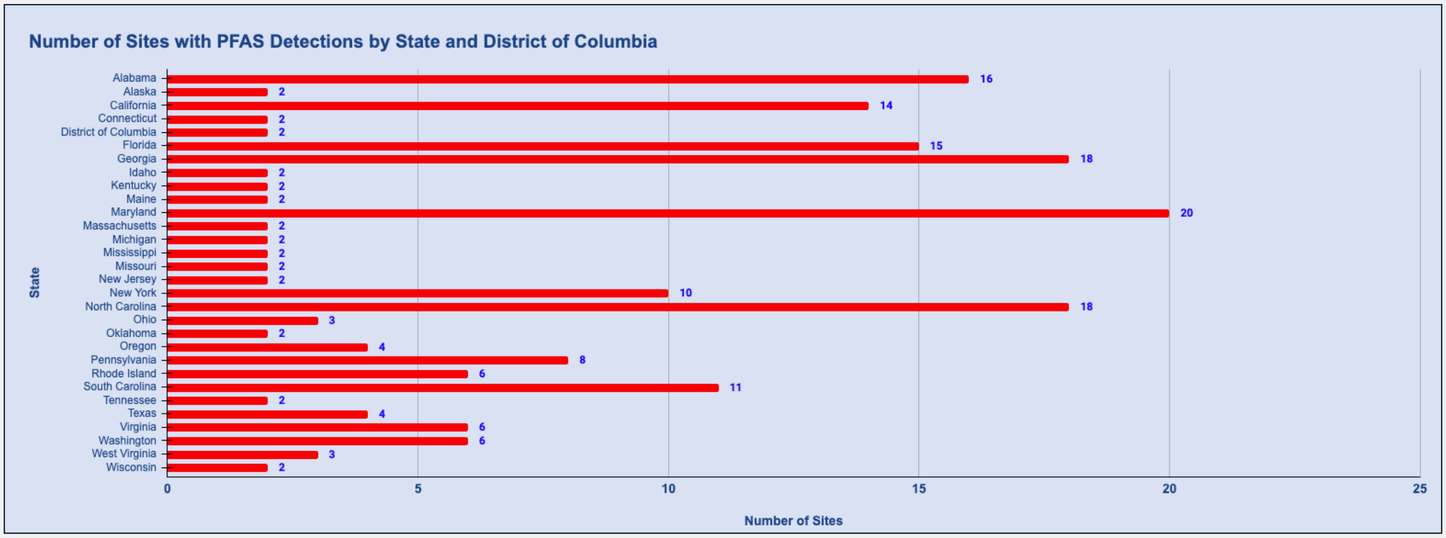

FIGURE 3

Number of Water Sample Sites With PFAS Detections by States and D.C.

PFAS compounds were detected in surface waters at very high levels. Concentrations of PFAS compounds exceeded EWG's Health Guideline of 1 ppt at every site where PFAS was detected. There are only EPA Drinking Water Health Advisory Levels for four PFAS compounds (PFOA, PFOS, GenX, and PFBS), but PFOA and PFOS exceeded those levels in every sample where those compounds were detected. There are no other federal standards in place to prevent and clean up PFAS pollution in the nation's waters. *See* Table 3.

TABLE 3

PFAS Compounds Detections and Exceedances of National Standards

PFAS Compound	# of Detections	% of Total Samples with Detections (Out of 228)	Federal Water Quality Criteria or Drinking Water Standard?	# of Samples Above EPA Health Advisory Level (HAL)	# Samples Above EWG Health Guideline (1 ppt)
PFOS (Perfluorooctanesulfonate)	159	69.7%	NO	159	159
PFOA (Perfluorooctanoic acid)	158	69.2%	NO	158	158
PFHxA (Perfluorohexanoic acid)	153	67.1%	NO	No HAL	153
PFPeA (Perfluoro-n-pentanoic Acid)	126	55.2%	NO	No HAL	126
PFBS (Perfluorobutane sulfonate)	118	51.8%	NO	1	118
PFHpA (Perfluoroheptanoic acid)	111	48.7%	NO	No HAL	111
PFHxS (Perfluorohexanesulfonate)	94	41.2%	NO	No HAL	94
PFBA (Perfluorobutyric acid)	67	29.3%	NO	No HAL	67
PFNA (Perfluorononanoic acid)	35	15.3%	NO	No HAL	35
FBSA (Perfluorobutane sulfonamide)	31	13.6%	NO	No HAL	31
PFDA (Perfluorodecanoic acid)	27	11.8%	NO	No HAL	27
6:2 FTS (6:2 Fluorotelomer Sulfonate)	21	9.2%	NO	No HAL	21
PFPeS (Perfluoropentane Sulfonic Acid)	18	7.9%	NO	No HAL	18
FHxSA (Perfluorohexane Sulfonamide)	13	5.7%	NO	No HAL	13
PFECHS (Perfluoro-4-ethylcyclohexane Sulfonic Acid)	9	3.9%	NO	No HAL	9
PFHpS (Perfluoroheptane Sulfonic Acid)	9	3.9%	NO	No HAL	9
N-EtFOSAA (N-Ethyl Perfluorooctane Sulfonamido Acetic Acid)	8	3.5%	NO	No HAL	8

PFAS Compound	# of Detections	% of Total Samples with Detections (Out of 228)	Federal Water Quality Criteria or Drinking Water Standard?	# of Samples Above EPA Health Advisory Level (HAL)	# Samples Above EWG Health Guideline (1 ppt)
PFEESA (Perfluoro(2-ethoxyethane) Sulfonic acid)	6	2.6%	NO	No HAL	6
PFOSA (Perfluorooctanesulfonic acid)	6	2.6%	NO	No HAL	6
PFUnA (Perfluoroundecanoic acid)	6	2.6%	NO	No HAL	6
8:2 FTS (8:2 Fluorotelomer Sulfonate)	5	2.2%	NO	No HAL	5
5:3 FTCA (2h,2h,3h,3h-Perfluorooctanoic Acid)	4	1.8%	NO	No HAL	4
GenX or HFPO-DA (Hexafluoropropylene Oxide Dimer Acid)	4	1.8%	NO	1	4
PFPrS (Perfluoropropane Sulfonic Acid)	4	1.8%	NO	No HAL	4
N-MeFOSAA (N-Methyl Perfluorooctane Sulfonamido Acetic Acid)	3	1.3%	NO	No HAL	3
4:2 FTS (4:2 Fluorotelomer Sulfonate)	2	0.8%	NO	No HAL	2
MeFBSA (N-Methylperfluorobutanesulfonamide)	2	0.8%	NO	No HAL	2
PFDoA (Perfluorododecanoic acid)	2	0.8%	NO	No HAL	2
3:3 FTCA (3-Perfluoropropyl Propanoic Acid)	1	0.4%	NO	No HAL	1
N-AP-FHxSA (N-(3-dimethylaminopropan-1-yl) perfluoro-1-hexanesulfonamide)	1	0.4%	NO	No HAL	1
PFMOPrA or PFMPA (Perfluoro-3-Methoxypropanoic Acid)	1	0.4%	NO	No HAL	1
FOSAA (Perfluorooctane Sulfonamido Acetic Acid)	1	0.4%	NO	No HAL	1
FOUEA (2H-perfluoro-2-decenoic acid)	1	0.4%	NO	No HAL	1
NMeFOSE (N-methyl perfluorooctanesulfonamidoethanol)	1	0.4%	NO	No HAL	1
ADONA (4,8-Dioxa-3H-Perfluorononanoate)	1	0.4%	NO	No HAL	1

Surface water PFAS concentrations were greater than EPA's Health Advisory Levels for these four PFAS compounds in one or more samples as shown below:

- **PFOS was detected above the EPA Interim Health Advisory Level of 0.02 ppt in 159 samples taken in waterways located in 28 states and D.C,** *see* Tables 2 - 3. The highest level detected was 1,364.7 ppt in a sample from Piscataway Creek, Maryland taken by Potomac Riverkeeper. *See* Table 4 below.
- **PFOA was detected above the EPA Interim Health Advisory Level of 0.004 ppt in 158 samples taken in waterways located in 26 states and D.C.,** *see* Tables 2 - 3. The highest level detected was 847 ppt in a sample from Kreutz Creek, Pennsylvania taken by the Lower Susquehanna Riverkeeper. *See* Table 4 below.
- **GenX was detected above the EPA Health Advisory Level of 10 ppt in one sample from the Cape Fear River, North Carolina** taken by Cape Fear Riverkeeper. *See* Tables 2 - 4.
- **PFBS was detected above the EPA Health Advisory Level of 2,000 ppt in one sample from Kreutz Creek, Pennsylvania** taken by the Lower Susquehanna Riverkeeper. *See* Tables 2 - 4.

Multiple PFAS compounds were detected in the majority of the water samples, adding to the total concentration of PFAS in the waterway and increasing the likelihood of harm, *see* "Appendix 4". The five most detected PFAS Compounds were frequently detected with other PFAS compounds, which frequently occurred at high concentrations as well. *See* Table 4 for the Top 5 Detected PFAS and "Appendix 4" for all PFAS detections.

TABLE 4

Maximum Individual Concentrations of the Top 5 Detected PFAS in States With At Least One Detection

Highest Detections in Each State in Red[27]

State	Waterkeeper	Waterbody	Max. PFOA in ppt	Max. PFOS in ppt	Max. PFHxA in ppt	Max. PFPeA in ppt	Max. PFBS in ppt
Alabama	Black Warrior Riverkeeper	Black Warrior River	2	3.9	1.8	2.2	1.3
	Cahaba Riverkeeper	Cahaba River	3.3	4.4	4.2	6	5.7
	Choctawhatchee Riverkeeper	Pea River	ND	1.3	ND	ND	ND
	Coosa Riverkeeper	Neely Henry Lake on the Coosa River	16.8	27.8	14	16.9	48.7
	Hurricane Creekkeeper	Hurricane Creek	1.1	1.4	1.3	ND	ND
	Little River Waterkeeper	Little River Canyon	1.1	1.4	ND	ND	2.3
		West Fork of Little River	ND	ND	ND	ND	ND
	Mobile Baykeeper	Mobile River	4.3	6.5	3.4	3.8	8.4
	Waterkeepers Alabama	Buck Creek	5.1	3.8	7.6	16.8	9.2
Alaska	Cook Inletkeeper	Ship Creek	2.4	7.1	2.4	1.5	ND
California	Inland Empire Waterkeeper	Santa Ana River	8.9	7.7	12.5	10.3	5.2
		Temescal Creek	26.3	20	21.5	11	11
	Los Angeles Waterkeeper	Los Angeles River	12.9	4.3	13.2	4.2	3.9
	Orange County Coastkeeper	San Diego Creek	61.5	34.4	57.9	28.9	21.2
	Russian Riverkeeper	Healdsburg Pit discharge to Russian River	1.5	ND	1.2	2.2	1
		Russian River	ND	ND	ND	ND	ND
	San Diego Coastkeeper	Chollas Creek	16.6	22	15.6	10.6	10.4
	Santa Barbara Channelkeeper	Ventura River	3.8	1.5	4	6.7	2.8
Connecticut	Long Island Soundkeeper	Naugatuck River	4.2	9.5	4.5	3.4	ND
District of Columbia	Anacostia Riverkeeper	Anacostia River	3.5	5.1	3.2	3.3	2.1
		Kingman Lake	4.6	7.7	4.6	3.7	3
Florida	Apalachicola Riverkeeper	Apalachicola River	6.5	4.2	2.7	2.3	1.3
	Calusa Waterkeeper	Caloosahatchee River	4.7	5.6	2.4	ND	3.2
		Shallow Groundwater	ND	ND	ND	ND	ND
	Collier County Warerkeeper	Golden Gate Main Canal	3.5	6.2	1.8	1.9	3.2
		Gordon River	4.2	8.5	2.7	2.1	3.6
	Miami Waterkeeper	Little River	10	58.5	27	31.8	6.1
		Spur Canal	5.9	21.3	7.2	6.6	4.5
	St. Johns Riverkeeper	St. Johns River	2	3.3	1.9	1.7	1.8
	Suncoast Waterkeeper	Bowlees Creek	11	29.6	17.5	19	13.8
	Tampa Bay Waterkeeper	Hillsborough River	3.7	10.1	3.2	2.8	4.1
	Waterkeepers Florida - Suwannee Riverkeeper	Withlacoochee River	1.2	3.8	1.5	1.2	1.8

State	Waterkeeper	Waterbody	Max. PFOA in ppt	Max. PFOS in ppt	Max. PFHxA in ppt	Max. PFPeA in ppt	Max. PFBS in ppt
Georgia	Altamaha Coastkeeper	Altamaha River	2.3	4.4	2.7	2.7	2.3
	Altamaha Riverkeeper	Ohoopee River	1.9	1.1	ND	ND	4.5
	Chattahoochee Riverkeeper	Chattahoochee River	2.5	2.4	2.9	1.9	1.7
	Lower Savannah River Alliance, A Waterkeeper Alliance Affiliate	Savannah River	2.7	4	1.4	ND	1.3
		Tributary to Rocky Creek	3	7.5	1.3	ND	ND
	Ogeechee Riverkeeper	Little Lotts Creek	3.7	6.7	14.5	17.3	3
	Satilla Riverkeeper	Little Hurricane Creek	1.7	1.8	1.2	1.1	ND
	Savannah Riverkeeper	Savannah River at Lock and Dam Rd	6.1	14.1	10.3	7	4.9
	Suwannee Riverkeeper	Withlacoochee River	2.2	9.1	3	2.4	3.2
	Upper Coosa Riverkeeper	Conasauga River	75.7	82	48.8	64	207.4
	Waterkeepers Florida - Suwannee Riverkeeper	Withlacoochee River	1.4	4.9	2.5	1.7	2.2
Idaho	Snake River Waterkeeper	Henry's Fork	1.3	ND	1.4	ND	ND
Kentucky	Kentucky Riverkeeper	Kentucky River	ND	1.6	1.4	1.4	ND
Maine	Casco Baykeeper	Presumpscot River	1.8	1.8	1.1	1.1	ND
Maryland	Assateague Coastkeeper	Walston Branch	3.5	ND	6	5.3	ND
	Baltimore Harbor Waterkeeper	Jones Falls	4.2	10.7	3.6	3.3	1.9
	Chester Riverkeeper	Morgan Creek	1.3	2	1.4	ND	ND
	Choptank Riverkeeper	La Trappe Creek	5.6	2.6	14.5	9	5.2
	Gunpowder Riverkeeper	Little Gunpowder Falls	2.3	3.1	2.2	2	1.7
	Miles and Wye Riverkeeper	Mill Creek	5.2	2.2	2.6	1.4	4.7
		Tributary to Mill Creek	ND	ND	ND	ND	ND
	Potomac Riverkeeper	Piscataway Creek	282.8	1364.7	194.6	86.2	48.2
	Sassafras Riverkeeper	Dyer Creek	ND	ND	ND	ND	ND
		Mill Creek	1.3	ND	1.1	ND	ND
	Severn Riverkeeper	Jabez Branch	2.8	3	2.9	2.2	1.2
	South, West & Rhode Riverkeeper	Church Creek	4.1	4.9	3.7	3.3	1.4
Massachusetts	Nantucket Waterkeeper	North Head Long Pond	6.5	5.1	3.1	1.2	1.1
		Tributary to Madaket Harbor	6.3	7.3	2.5	ND	ND
Michigan	Detroit Riverkeeper	Ecorse River	3.1	17.9	2.4	ND	1.9
		Rouge River	1	2.2	2.3	1.4	ND
Mississippi	Pearl Riverkeeper	Pearl River	2.5	3.6	2.6	2.7	1.8
Missouri	Missouri Confluence Waterkeeper	Coldwater Creek	17	125.5	24.7	18.3	11.6
New Jersey	Hackensack Riverkeeper	Hackensack River	7.9	5.2	2.8	2.7	1.6
		Lake Tappan / Hackensack River	7.8	6.7	3	2	1.9

State	Waterkeeper	Waterbody	Max. PFOA in ppt	Max. PFOS in ppt	Max. PFHxA in ppt	Max. PFPeA in ppt	Max. PFBS in ppt
New York	Buffalo Niagara Waterkeeper	Cayuga Creek	10.3	147.7	17.9	12	5.2
	Chautauqua-Conewango Consortium, a Waterkeeper Alliance Affiliate	Chadakoin River	1.7	1.8	1.2	ND	ND
	Peconic Baykeeper	Peconic River	3.9	12	2.5	2.2	ND
	Seneca Lake Guardian, a Waterkeeper Alliance Affiliate	Black Brook	12.2	2.6	7.6	3.4	1.5
	Upper St. Lawrence Riverkeeper	St. Lawrence River	1.9	2.3	1.5	1.2	ND
North Carolina	Broad Riverkeeper	Buffalo Creek	2	1.1	2.8	ND	ND
	Cape Fear Riverkeeper	Cape Fear River	7.4	17.3	6.7	6.9	5
	Green Riverkeeper	White Oak Creek	1.3	1.2	ND	1.6	ND
	Haw Riverkeeper	South Buffalo Creek	15.3	38	61.5	52.8	27.3
	Lumber Riverkeeper	Aberdeen Creek	4.6	3.4	3.8	4.3	1.3
	Neuse Riverkeeper	Neuse River	5.6	10.3	4.4	3.8	2.8
	Pamlico-Tar Riverkeeper	Tar River	2.6	4.1	1.2	ND	1.2
	Watauga Riverkeeper	South Fork New River	1.3	3.3	1	2.1	1.5
	Yadkin Riverkeeper	Muddy Creek	5.1	11.6	11.5	7	2
Ohio	Lake Erie Waterkeeper	Cairl Creek	8.4	98.3	5	4.1	3.3
		Tributary to Cairl Creek	3.8	5.6	1.5	ND	1.8
	West Virginia Headwaters Waterkeeper	Ohio River	6.8	2	1.7	1.1	1.3
Oklahoma	Tar Creekkeeper	Tar Creek	ND	1.4	ND	ND	ND
Oregon	Rogue Riverkeeper	Rogue River	ND	ND	ND	ND	ND
	Tualatin Riverkeepers	Tualatin River	2.7	6	2.2	2.3	1.9
Pennsylvania	Lower Susquehanna Riverkeeper	Kreutz Creek	847	374.3	607.1	166.5	2083.3
	Middle Susquehanna Riverkeeper	Glade Run	1.1	1.1	1.3	ND	ND
		West Branch Susquehanna River	1	ND	1	ND	ND
	Three Rivers Waterkeeper	Allegheny River	1.6	3.5	ND	ND	1.1
	Upper Allegheny River Project, a Waterkeeper Alliance Affiliate	Tunungwant Creek	1.3	1.7	ND	1.3	ND
		West Branch Tunungwant Creek	ND	ND	ND	1.1	ND
Rhode Island	Narragansett Bay Riverkeeper	Pawtuxet River	7.8	8.9	11.7	12.3	2.2
	Narragansett Baykeeper	Buckeye Brook	7.1	4	4	3.1	3.7
		Spring Green Pond	29	34.5	63.1	60.7	6.6
	South County Coastkeeper	Mastuxet Brook	2.9	1.7	1.7	1.9	2.2

State	Waterkeeper	Waterbody	Max. PFOA in ppt	Max. PFOS in ppt	Max. PFHxA in ppt	Max. PFPeA in ppt	Max. PFBS in ppt
South Carolina	Black-Sampit Riverkeeper	Boggy Swamp	2.4	3.2	1.5	1.9	1
		Sampit River	4.5	6.7	2.6	1.9	1.5
	Catawba Riverkeeper	Catawba River	4.8	3.6	12.2	15.4	1.4
	Charleston Waterkeeper	Bushy Park Reservoir	4.3	6.5	5.2	6	2.5
		Chicken Creek	4.2	5.8	4	2.2	2.4
	Congaree Riverkeeper	Saluda River	4	6.4	3.5	3.3	2
	Savannah Riverkeeper	Savannah River	2.7	1.9	1.7	ND	1.6
	Waccamaw Riverkeeper	South Prong Steritt Swamp	3.6	1.7	3.1	2.3	2.4
		Steritt Swamp	5.8	2.2	5.2	3.5	2.2
Tennessee	Tennessee Riverkeeper	Jones Creek	7.1	7.2	5.9	6.8	1.8
		Lick Creek	ND	ND	ND	ND	ND
Texas	Bayou City Waterkeeper	Whiteoak Bayou	4.7	4.6	10.2	9.5	3
	Environmental Stewardship, a Waterkeeper Alliance Affiliate	Colorado River	2.7	4.2	3.8	3.9	1.9
Virginia	Dan RiverKeeper	Dan River	1.9	2.2	1.2	ND	ND
	James Riverkeeper	Gravelly Run	2.3	1.8	2.1	1.4	1.3
	Shenandoah Riverkeeper	South Fork Shenandoah River	ND	ND	1.6	1.9	ND
Washington	Deschutes Estuary Restoration Team, a Puget Soundkeeper Affiliate	Deschutes River	ND	ND	1.2	ND	ND
	Puget Soundkeeper	Duwamish River	ND	1.8	ND	ND	ND
	Spokane Riverkeeper	Spokane River	ND	1.7	1.6	ND	ND
West Virginia	Upper Potomac Riverkeeper	Opequon Creek	2.6	14.6	4.8	3.6	3.7
	West Virginia Headwaters Waterkeeper	Ohio River	3.3	1.6	1.4	ND	1.6
Wisconsin	Milwaukee Riverkeeper	East Branch Milwaukee River	1	ND	1	ND	ND
		Milwaukee River	3	3.1	2.5	ND	1.7

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The highest total number of PFAS detections in surface water samples were found in the following states, *see* Table 5.

- Maryland had 134 PFAS detections, including 25 different PFAS compounds.
- Georgia had 127 PFAS detections, including 20 different PFAS compounds.
- Florida had 119 PFAS detections, including 19 different PFAS compounds.
- North Carolina had 111 PFAS detections, including 16 different PFAS compounds
- California had 103 PFAS detections, including 15 different PFAS compounds.
- Alabama had 96 PFAS detections, including 13 different PFAS compounds.

PFOS, PFOA, PFHxA, PFPeA, and PFBS were detected in the greatest number of surface waters that were sampled by Waterkeeper groups. In addition to the high number of PFOA and PFOS detections, **other PFAS compounds were also detected with high frequency**. For example, PFHxA was detected in 153 samples (67.1% of all samples); PFPeA was detected in 126 samples (55.2% of all samples), and PFBS was detected in 118 samples (51.8% of all samples), *see* Table 3 and Figure 4. For the percentage of samples with PFAS detections in relation to the total number of samples taken in each State and D.C., see Appendix 7.

TABLE 5

Top Six States With Highest Number of Total PFAS Detections

State	PFAS with Highest # of Detections	PFAS with Second Highest # of Detections	Total # of PFAS Detections
Maryland	PFOA (17) PFHxA (17)	PFOS (14)	134
Georgia	PFOA (18)	PFOS (17)	127
Florida	PFOS (14) PFOA (14) PFHxA (14) PFBS (14)	PFPeA (13) PFHpA (13)	119
North Carolina	PFOA (16) PFOS (16)	PFHxA (14)	111
California	PFBS (12)	PFPeA (11) PFOA (11) PFHxA (11)	103
Alabama	PFOS (15)	PFOA (13)	96

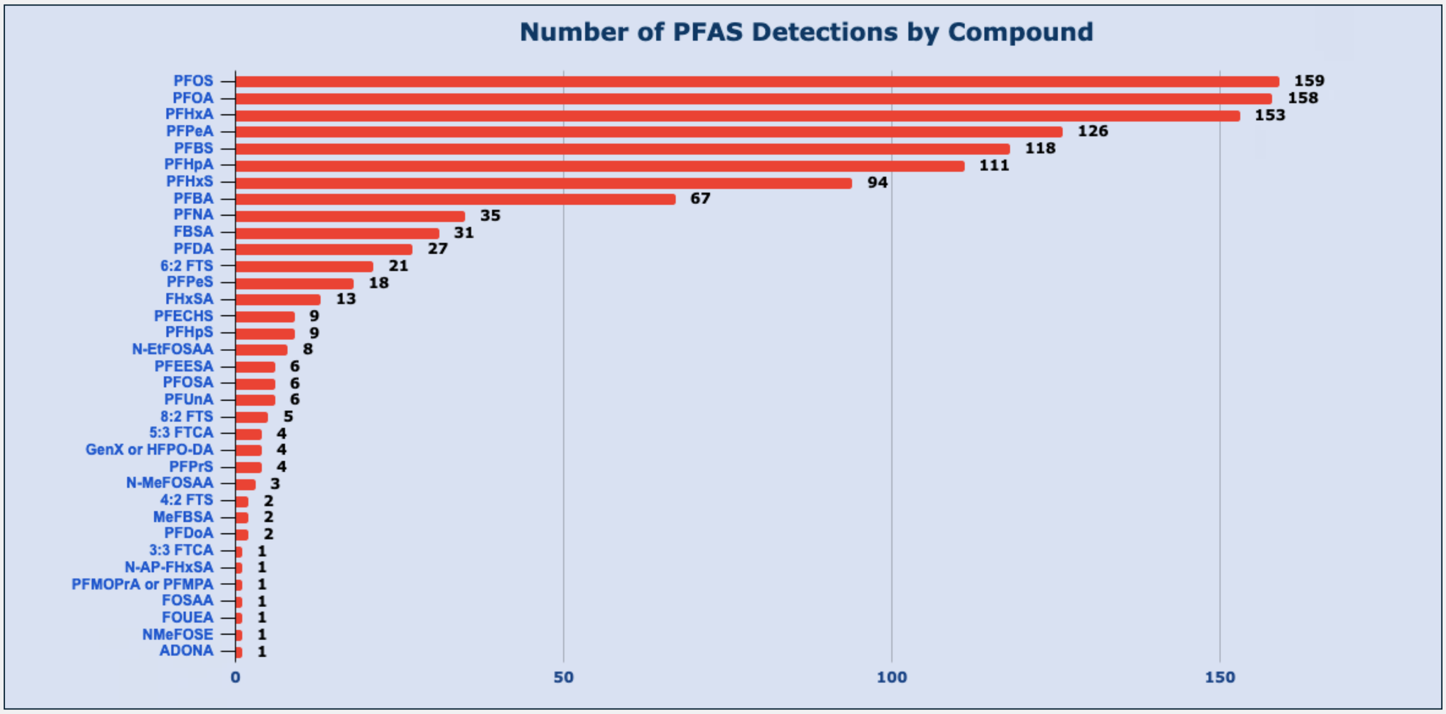


FIGURE 4

Total Number of PFAS Detections by Compound

Several states had multiple surface waters that were contaminated with these five most prevalent PFAS at significant levels, *see*, e.g., Maryland, Alabama, California, and Georgia in Figures 5-8.

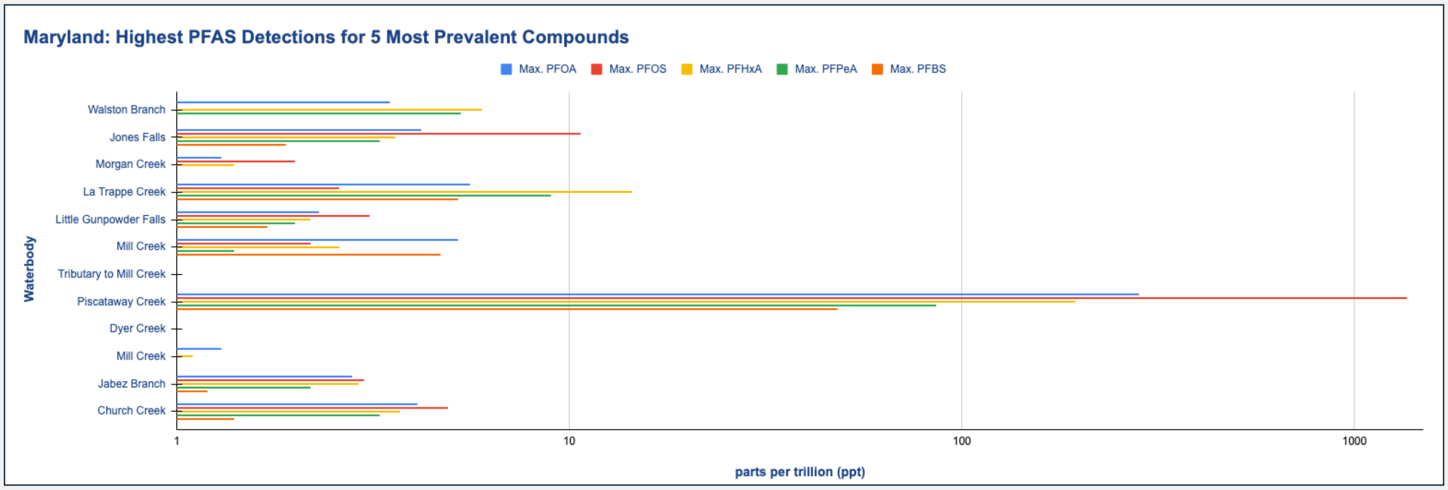


FIGURE 5

Maryland Detections for Most Prevalent PFAS Compounds

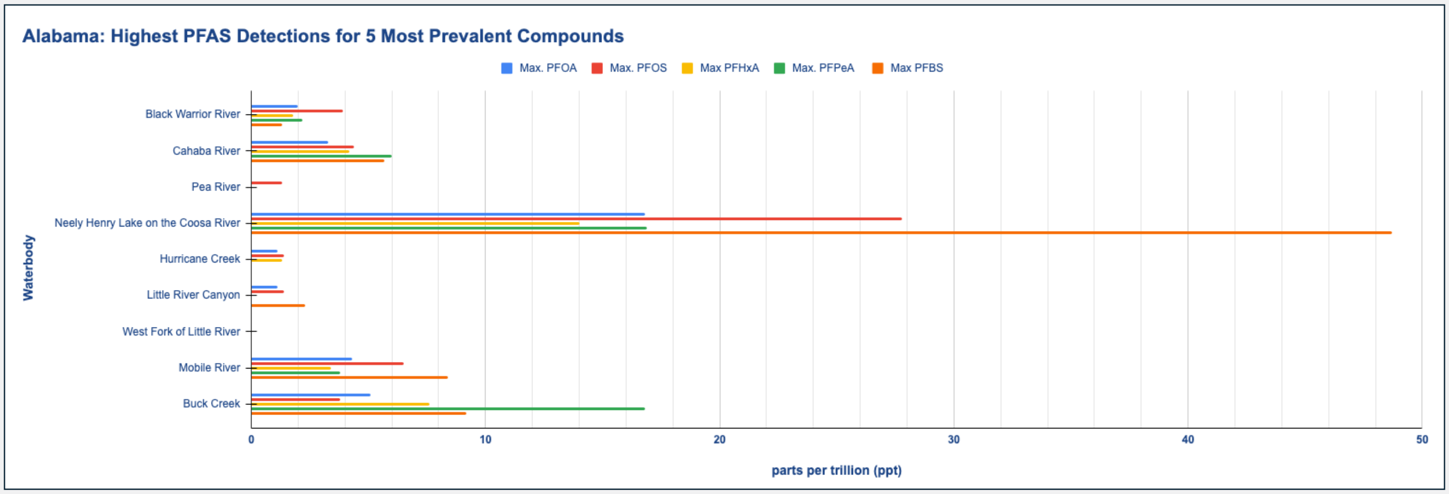


FIGURE 6

Alabama: Detections for Most Prevalent PFAS Compounds

Nineteen of the 114 waterways sampled had no detection of PFAS compounds above the method detection limit (17%). Most of these non-detect waterways are rural and relatively undeveloped. It is notable that the laboratory detection level for PFOA and PFOS in this study is significantly higher than EPA's recently-published interim Drinking Water Health Advisory Limits[28] for those substances (0.004 ppt and 0.02 ppt, respectively). **It is thus possible that waterways with non-detect results are in fact contaminated with these PFAS compounds at levels below the detection limits but above EPA's interim Health Advisory Limits.**

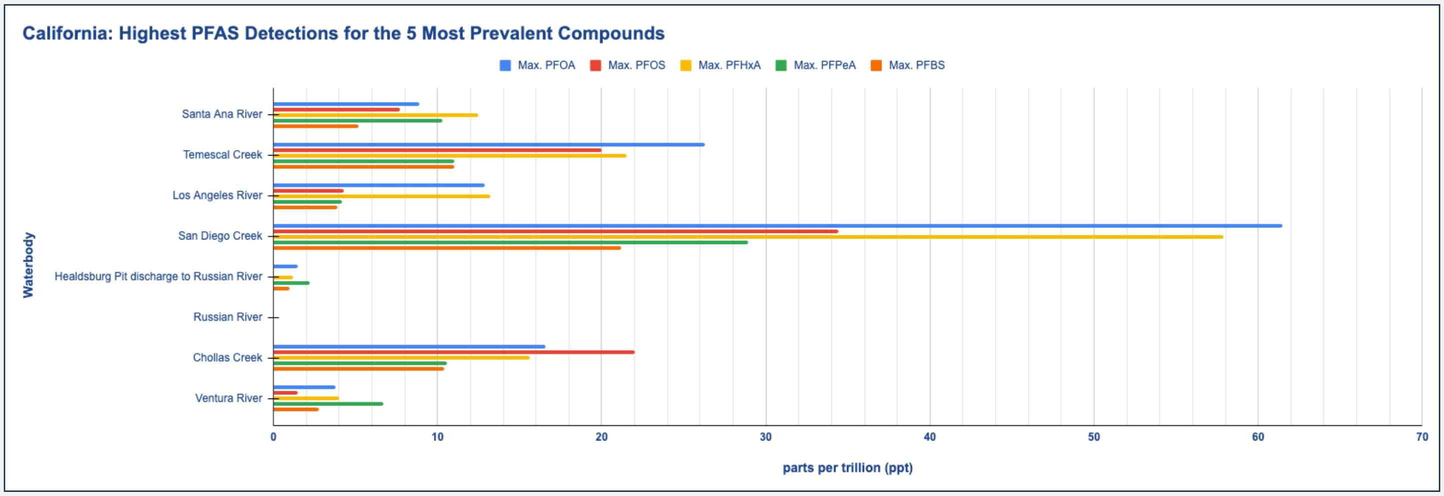


FIGURE 7

California: Detections for Most Prevalent PFAS Compounds

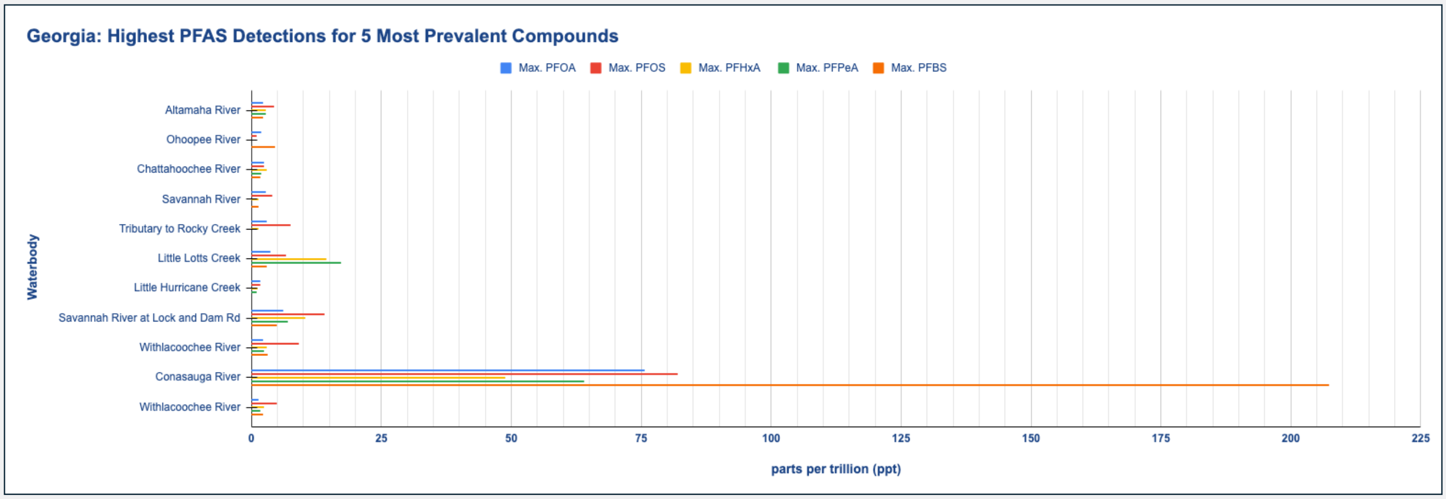


FIGURE 8

Georgia: Detections for Most Prevalent PFAS Compounds

II. Individual PFAS Detections Within Three Defined Groupings

This section is organized around Cyclopure's categorization of PFAS into three groups based on the number of analytes measured or the number of analytes with available guidance: EPA PFAS 4; States PFAS 11, and EPA 1633 (Draft) PFAS 40.

A. EPA PFAS 4 Group.[29] This group is composed of the four PFAS (PFOA, PFOS, PFBS, and GenX) that were the subject of EPA's June 15, 2022 health advisory update.[30] EPA's advisory update established the following Health Advisory Levels for each of the four PFAS compounds:

1. Interim updated Health Advisory Level for PFOA = 0.004 parts per trillion (ppt). No state has a proposed PFOA standard or advisory less than 0.004 ppt.
2. Interim updated Health Advisory for PFOS = 0.02 ppt. No state has a proposed PFOS standard or advisory less than 0.02 ppt.
3. Final Health Advisory for GenX chemicals = 10.0 ppt.
4. Final Health Advisory for PFBS = 2,000 ppt.

PFOA and PFOS, which are highly persistent in the environment, were the most frequently detected PFAS across the 114 sampled waterways (roughly 70% of 228 total samples). For example:

1. PFOA was detected in 158 out of 228 sampling sites (a 69% detection frequency), with measured concentrations ranging from <1.0 to 847 ppt. The Interim Health Advisory Limit is 0.004 ppt.
2. PFOS was detected in 159 sampling sites (a 70% detection frequency), with measured concentrations ranging from <1.0 to 1364.7 ppt. The Interim Health Advisory Limit is 0.02 ppt.
3. PFBS was detected in 118 out of 228 sampling sites (a 52% detection frequency), with measured concentrations ranging from <1.0 to 2,083.3 ppt. The Final Health Advisory Limit is 2000 ppt.
4. GenX was detected in four samples from three waterways, the Saluda River (South Carolina), Cape Fear River (North Carolina), and Tar Creek (Oklahoma). The highest concentration (25.8 ppt) was measured in the Cape Fear River downstream sample. The Final Health Advisory Limit is 10 ppt.

B. EPA State PFAS 11 Group.[31] This group is composed of the EPA PFAS 4 Group plus seven selected PFAS compounds for which the states have promulgated, proposed, or finalized standards or advisories, including specifically PFHxA, PFHxS, PFNA, PFDA, PFHpA, PFPeA, and PFBA.

For example, the Michigan Department of Environment, Great Lakes, and Energy established Maximum Contaminant Levels (MCLs) for a total of seven PFAS: PFOA, PFOS, PFHxA, PFNA, PFBS, PFHxS, and GenX (HFPO-DA). The Massachusetts Department of Environmental Protection published a cumulative MCL of 20 ppt for a group of six PFAS: PFOA, PFOS, PFHpA, PFNA, PFDA, and PFHxS. Additional information about current and proposed state limits for drinking water and surface water is available in the PFAS Water and Soil Values Table from the Interstate Technology and Regulatory Council (ITRC).[32]

EPA has also announced plans[33] for developing toxicity assessments for PFBA, PFHxA, PFHxS, PFNA, and PFDA that, once complete, can be applied to determine health advisory levels for each of these PFAS.

As shown in Table 6, all seven of the PFAS compounds selected based on state regulatory activity were detected in surface waters during this sampling project.

TABLE 6

Detections and Maximum Concentrations for Seven of the EPA State PFAS 11 Group PFAS

PFAS Compound	Number of Sites	Percent of Sites (%)	Maximum (ppt)
PFHxA	153	67	607.1
PFPeA	126	55	166.5
PFHpA	111	49	272.8
PFHxS	94	41	1,093.3
PFBA	67	29	159.4
PFNA	35	15	60.3
PFDA	27	12	45.4

PFHxA was detected at 153 out of 228 sampling sites (a 67% detection frequency), with measured concentrations ranging from <1.0 to 607.1 ppt. This is similar to the concentration level and detection rate for PFOA. PFPeA, PFHpA, and PFHxS also had high detection frequencies and had high maximum concentration levels.

Among these seven compounds, six are carboxylic acids (PFBA, PFPeA, PFHxA, PFHpA, PFNA, and PFDA) having the same head group as PFOA in chain lengths varying from 3 to 9 fluorinated carbons; and one is a sulfonic acid (PFHxS) having the same head group as PFOS with a chain length of 6 fluorinated carbons. This data indicates a need for additional regulatory activity to address these particular PFAS compounds.

C. EPA 1633 PFAS 40 Group.[35] This group is composed of all the PFAS in the EPA State PFAS 11 Group plus twenty-nine additional PFAS analytes encompassed within EPA's June 2022 Draft Method 1633. None of the PFAS compounds encompassed with the EPA 1633 PFAS 40 Group are regulated by any federal water quality limit or standard. State standards are also lacking, as demonstrated by the limited number of standards shown in the PFAS Water and Soil Values Table from the Interstate Technology and Regulatory Council (ITRC).[36]

Within this group, approximately 68% of the PFAS compounds (27 out of 40) were detected at least once across the sampled waterways, and ten of the PFAS compounds measured had greater than 10% detection frequency. FBSA, in particular, was detected at 31 sites (14% detection frequency) and the highest concentration detected was 99.8 ppt. Thirteen of the PFAS compounds within this group were not detected above the Method Detection Limit. *See* Figure 9.

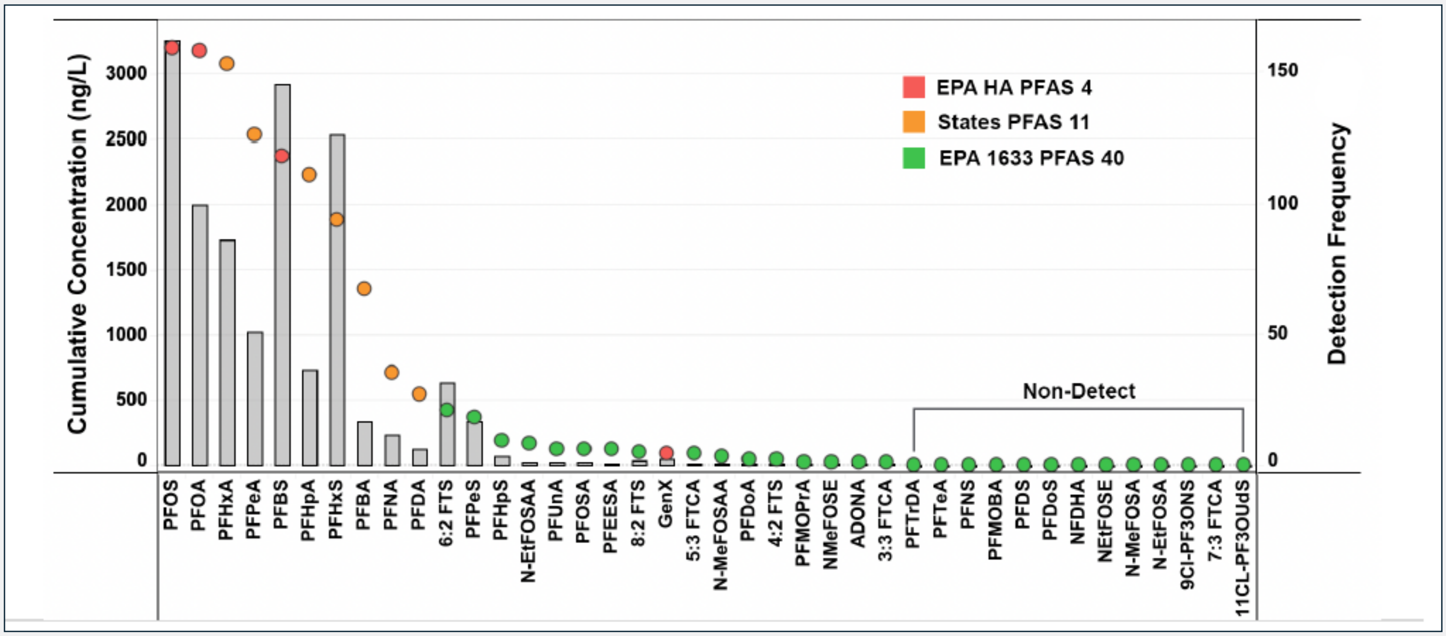


FIGURE 9

Summary of detection frequency (circles) and cumulative concentration (ng/L; bars) of PFAS measured in surface water samples for PFAS in the three groups.[34]

As illustrated in Figure 10, this sampling project detected the majority of all PFAS compounds within the three groups in surface water samples across the country, often at high concentrations. None of these PFAS are governed by federal standards or criteria adequate to protect public health or the nation's surface waters as evidenced by the number of detections and the presence of these dangerous chemicals in waters that we tested across the country.

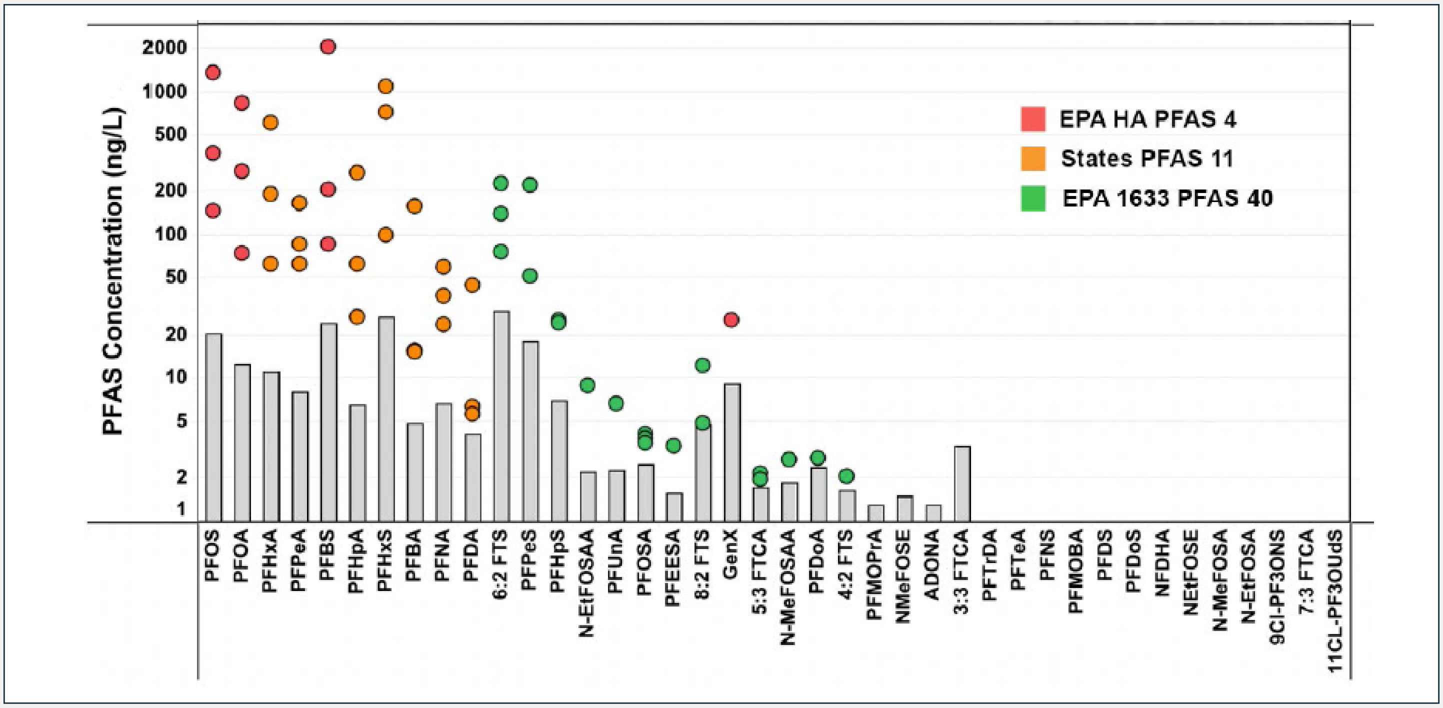


FIGURE 10

Distribution of PFAS concentrations by compound within the three groups. The gray bar represents the average concentration of each PFAS for all detections. Circles show the three highest concentrations for each PFAS.[37]

III. Geospatial Distribution of PFAS Contamination

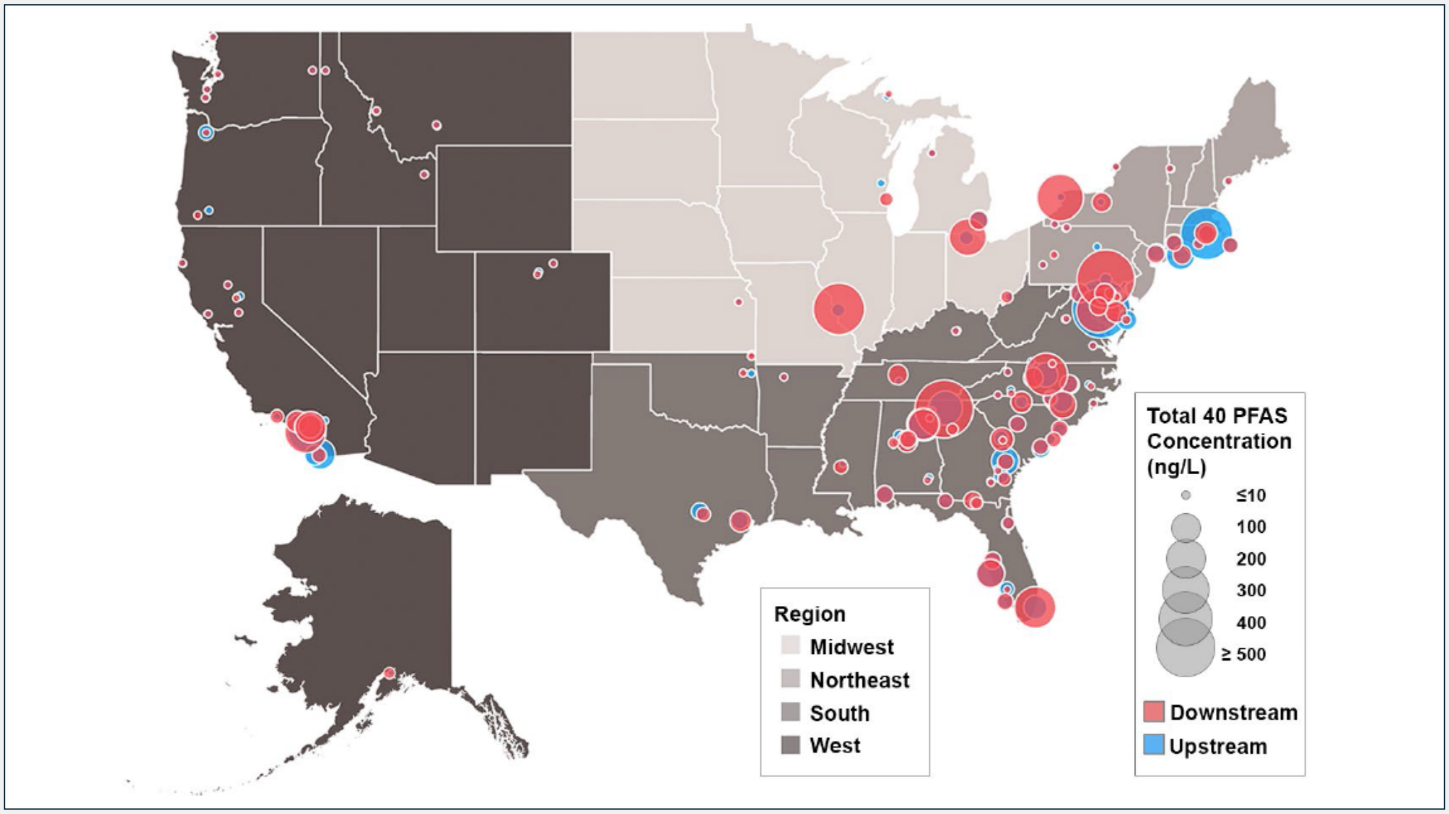


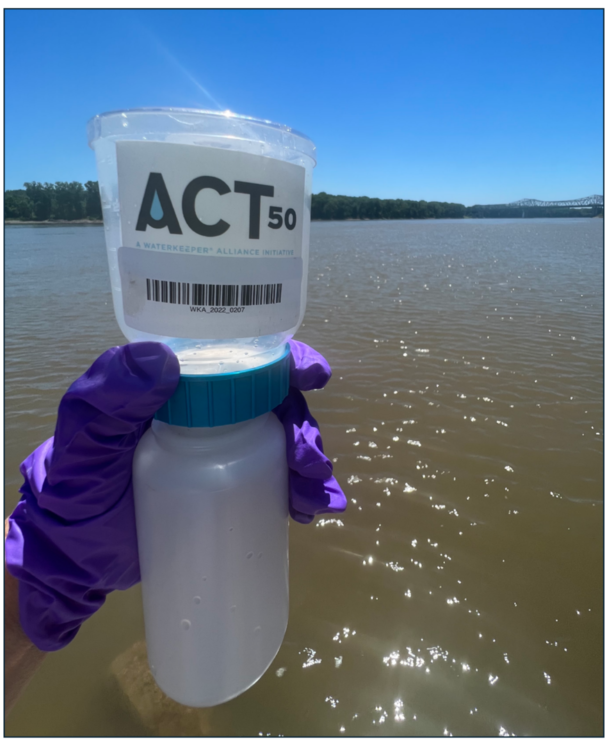
FIGURE 11

Total PFAS concentrations (EPA PFAS 40) in each watershed for Upstream site (blue circles) and for Downstream site (red circles). Circle sizes correlate to measured PFAS concentrations at a sampling location. *See* legend. The base map is colored by four U.S. regions.[38]

MIDWEST[39]

16 sampling sites from a total of 5 states

Among these states, the most elevated PFAS concentrations in this region were measured at sites in Missouri (Missouri Confluence Waterkeeper, PFOS (125.5 ppt)) and Ohio (Lake Erie Waterkeeper, PFOS (98.3 ppt)). In this region, the highest total PFAS concentration for all detections in a sample was 417.8 ppt, found in the downstream sample collected by Missouri Confluence Waterkeeper from Coldwater Creek, which flows into the Missouri River. Numerous PFAS compounds were detected in the downstream Coldwater Creek sample, *see* Table 7.



MISSOURI CONFLUENCE WATERKEEPER

TABLE 7

Missouri Confluence Waterkeeper Coldwater Creek Downstream PFAS Sample (ppt)	
PFOS	125.5
PFHxS	101.1
6:2 FTS	40.7
PFHxA	24.7
PFPeA	18.3
PFOA	17.0
FHxSA	16.6
PFHpA	13.2
PFECHS	12.7
PFBS	11.6
PFPeS	11.5
FBSA	7.1
8.2 FTS	4.9
PFBA	3.0
PFHpS	2.8
PFNA	2.7
PFDA	1.8
PFPrS	1.5
PFEESA	1.1

NORTHEAST[40]

34 sampling sites from a total of 8 states

Sites in Pennsylvania (Lower Susquehanna Riverkeeper, PFBS 2,083.3 ppt), Rhode Island (Narragansett Baykeeper, 6:2 FTS 76.4 ppt), and New York (Buffalo Niagara Waterkeeper, PFOS, 147.7 ppt) had the most elevated PFAS concentrations in this region. In this region, the highest total PFAS concentration for all detections in a sample (6,510.3 ppt) was found in the downstream sample collected by Lower Susquehanna Riverkeeper from Kreutz Creek in Pennsylvania. Numerous PFAS compounds were detected in the downstream Kreutz Creek sample, *see* Table 8.

BUFFALO NIAGARA WATERKEEPER

TABLE 8

Lower Susquehanna Riverkeeper Kreutz Creek Downstream PFAS Sample (ppt)	
PFBS	2,083.30
PFHxS	1,093.30
PFOA	847
PFHxA	607.1
PFOS	374.3
PFHpA	272.8
6:2 FTS	231.6
PFPeS	223.4
PFPeA	166.5
PFBA	159.4
FBSA	99.8
FHxSA	91.8
PFPrs	72.1
PFDA	45.4
PFNA	37.7
PFECHS	32.4
PFHpS	25.6
MeFBSA	14.7
N-EtFOSAA	9
N-AP-FHxSA	5.9
PFOSA	4.1
3:3 FTCA	3.4
8.2 FTS	2.6
4:2 FTS	2.1
5:3 FTCA	2
FOSAA	1.7
PFEESA	1.3

SOUTH[41]

126 sampling sites from a total of 14 states and D.C.

Sites in Maryland, Georgia, Florida, West Virginia, and North Carolina had the most elevated PFAS concentrations in this region. The highest total PFAS concentration for each detection in a sample (3,192.3 ppt) was found in the upstream sample collected by Potomac Riverkeeper from Piscataway Creek in Maryland. Numerous PFAS compounds were detected in the upstream Piscataway Creek sample, *see* Table 9.

UPPER POTOMAC RIVERKEEPER

TABLE 9

Potomac Riverkeeper Piscataway Creek Upstream PFAS Sample (ppt)	
PFOS	1,364.70
PFHxS	726
PFOA	282.8
PFHxA	194.6
6:2 FTS	142.7
FHxSA	99.1
PFPeA	86.2
PFHpA	63.1
PFPeS	52.8
PFBS	48.2
FBSA	28
PFHpS	24.2
PFNA	24
PFBA	15.8
8.2 FTS	12.4
PFPrS	7.7
PFECHS	7.4
PFDA	5.2
PFOSA	3.8
4:2 FTS	1.2
5:3 FTCA	1.2
PFUnA	1.2

WEST[42]

50 sampling sites from a total of 7 states

The highest PFAS concentrations in this region were detected in Southern California (e.g., Orange County, San Diego, and Los Angeles). In this region, the highest total PFAS concentration for each detection in a sample, (227.9 ppt), was found in the downstream sample collected by Orange County Coastkeeper from San Diego Creek in California. Numerous PFAS compounds were detected in the downstream San Diego Creek sample, *see* Table 10.

HUMBOLDT BAYKEEPER

TABLE 10

Orange County Coastkeeper San Diego Creek Downstream PFAS Sample (ppt)	
PFOA	61.5
PFHxS	52.4
PFOS	34.4
PFHxA	23.7
PFBS	12.7
PFPeA	12.2
PFHpA	10.2
PFPeS	5.4
FBSA	3.2
PFBA	2.9
FHxSA	2.4
PFNA	2.4
PFDA	2.2
PFHpS	1.3
6:2 FTS	1

Data from the eight regional sites with the highest total PFAS 40 Levels (Table 11) reveals some similarities in the frequency of PFAS detections, regardless of region. For example, PFOA, PFOS, and PFBS were detected and measured in the sample for each of the eight regional sites. For six of the regional sites, the highest PFAS concentration came from the EPA PFAS 4 group.

This data shows that PFAS, like PFOA, PFOS, and PFBS, are still the prevalent PFAS in waterways across the country due, in part, to high environmental persistence and their continuing presence in landfills and other areas. Other PFAS compounds are also prevalent and often found at concentrations higher than the concentrations of PFOA, PFOS, and PFBS in the same sample. This data confirms the need for further federal PFAS regulatory activity for all PFAS.

TABLE 11

Waterkeeper Groups With Highest Total EPA 1633 PFAS 40 Group Concentration Measurements in Each Region[43] [44]

Region	Waterkeeper	Regional Rank	State	Upstream / Downstream	Total 40 PFAS Concentration (ng/L or ppt)
Midwest	Missouri Confluence Waterkeeper	Top 1	Missouri	Downstream	380
Midwest	Lake Erie Waterkeeper	Top 2	Ohio	Downstream	177
Northeast	Lower Susquehanna Riverkeeper	Top 1	Pennsylvania	Downstream	6192
Northeast	Narragansett Baykeeper	Top 2	Rhode Island	Upstream	385
South	Potmac Riverkeeper	Top 1	Maryland	Upstream	3050
South	Upper Coosa Riverkeeper	Top 2	Georgia	Downstream	558
West	Orange County Coastkeeper	Top 1	California	Downstream	222
West	Orange County Coastkeeper	Top 2	California	Upstream	181

IV. SOURCE ANALYSIS AND IDENTIFICATION FOR TEN WATERWAYS

Ten case study waterways were selected for having the greatest difference between total upstream and downstream PFAS concentrations.[45] *See* Figure 12 for total EPA 1633 PFAS 40 Group PFAS concentrations for each of the 10 case study waterways. Each of these waterways was then classified based on the four primary potential contamination sources: landfills, airports, industrial sites, and wastewater treatment plants.

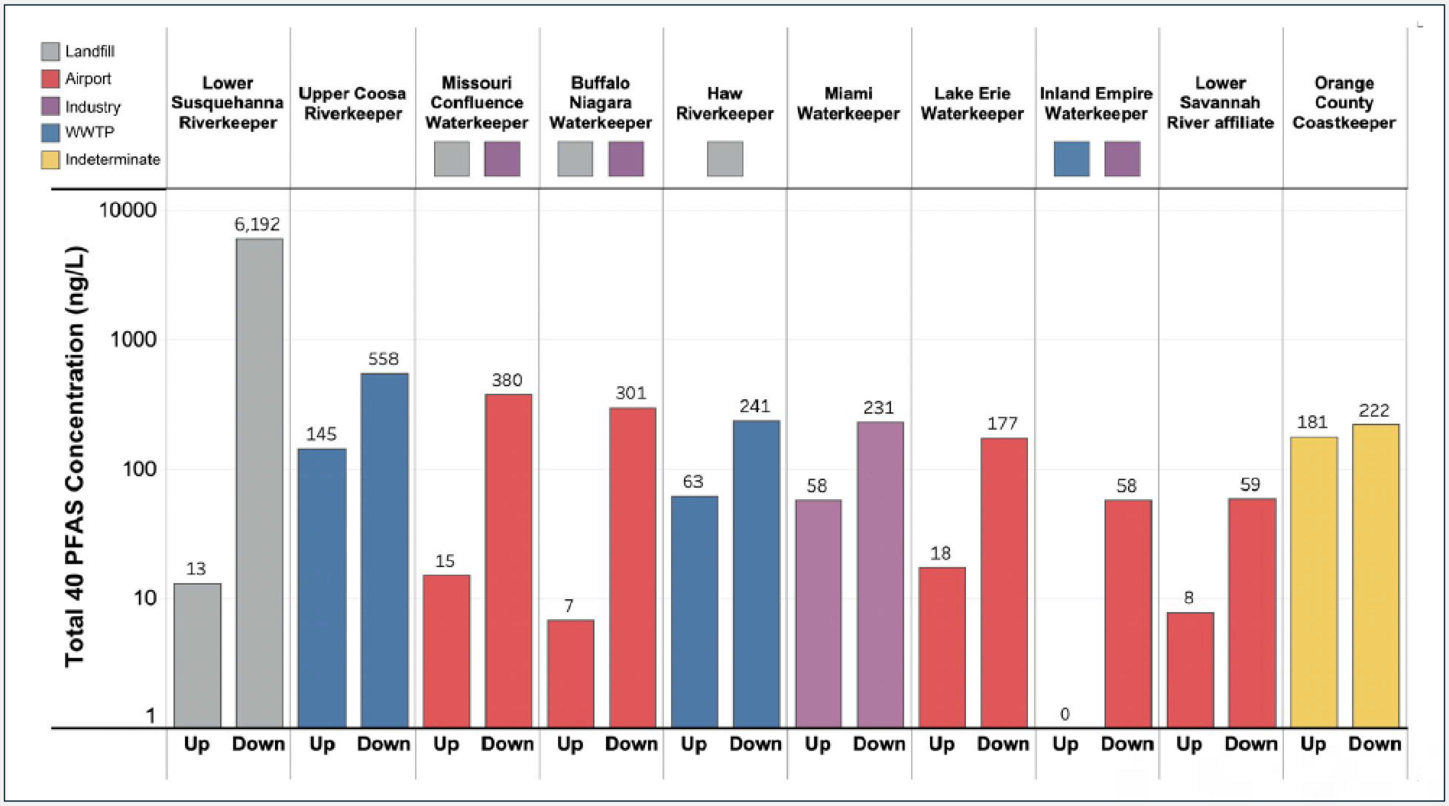


FIGURE 12

Ten Case Study Waterways. PFAS potential point contamination sources: landfill in gray, airport in red, industry in purple, WWTP in blue, and indeterminate in yellow. Bar colors indicate the primary suspect sources for each waterway. Colored boxes depicted above the bar, indicate secondary suspect sources. Up denotes upstream and down denotes downstream.[46]

Landfills[47]

PFAS are incorporated into many consumer and commercial products that are ultimately disposed of in landfills. This results in PFAS leaching into water as it flows through landfills creating leachate, which in turn seeps from landfills into ground and surface waters.

The waterway with the highest total EPA PFAS 40 concentration change between upstream and downstream was sampled by Lower Susquehanna Riverkeeper at Kreutz Creek in PA. For this location, a landfill site was identified as the major potential source for PFAS contamination.

Only one-half mile apart, the upstream and downstream samples had total EPA PFAS 40 detections of 13.4 ppt and 6,191.9 ppt, respectively. In the downstream sample, 20 PFAS were detected with dominant species concentrations of 2,083.3 ppt for PFBS, 1,093.3 ppt for PFHxS, 847.0 ppt for PFOA, 607.1 ppt for PFHxA, 374.3 ppt for PFOS, and 272.8 ppt for PFHpA.

Landfills were also identified as potential PFAS contamination sources in the sampling locations for Missouri Confluence Waterkeeper, Buffalo Niagara Waterkeeper, and Haw Riverkeeper.

Airports[48]

PFAS, such as PFOS, have historically been, and continue to be, incorporated into firefighting foams which are used for firefighting training and emergency fire suppression at commercial airports, military bases, and small airstrips. Once these compounds are sprayed on the ground they become extremely susceptible to running off with stormwater or snowmelt into surface waters or seeping into the ground to contaminate soils and groundwater aquifers.

Five case study locations were found to have at least one airport as a potential primary or secondary PFAS contamination source. The identified airports include:

- St. Louis Lambert International Airport (Missouri Confluence Waterkeeper)
- Niagara Falls International Airport (Buffalo Niagara Waterkeeper)
- Eugene F. Kranz Toledo Express Airport (Lake Erie Waterkeeper)
- SBD International Airport and Flabob Airport (Inland Empire Waterkeeper)
- Augusta Regional Airport (Savannah Riverkeeper and affiliate)

The waterways sampled by Missouri Confluence Waterkeeper (Coldwater Creek) and Buffalo Niagara Waterkeeper (Cayuga Creek) flow directly through the subject airports and show larger PFAS concentration variation between upstream and downstream sites than sampling locations associated with Lake Erie, Inland Empire, and Lower Savannah River.

Industrial Sites[49]

PFAS compounds are used to produce and/or are incorporated into myriad industrial and common consumer products, including non-stick cooking pans, food packaging, and water- and stain-resistant clothing.[50] The discharge of solid and liquid waste generated during these industrial activities is a source of PFAS contamination of soil and water systems.

Industrial sites were identified as the potential primary or secondary source of PFAS contamination for four of the 10 case study waterways: Miami Waterkeeper, Missouri Confluence Waterkeeper, Buffalo Niagara Waterkeeper, and Inland Empire Waterkeeper.

- For Miami Waterkeeper, the Eastview Commerce Center, located between upstream and downstream sampling sites, contains numerous industrial activities, including furniture manufacturing.
- For Missouri Confluence Waterkeeper, two categories of industry were identified: (i) consumer products manufacturers, such as plastic fabrication, janitorial supplies, home improvement products, and packaging materials; and (ii) aerospace industry and high precision machining.
- For Buffalo Niagara Waterkeeper, identified manufacturers included the aerospace and sensor industries.
- For Inland Empire Waterkeeper, numerous industries are located between upstream and downstream sampling sites over a distance of 50 miles, including artificial turf, plumbing supplies, battery testers, and control panels.

Wastewater Treatment Plants[51]

Industrial discharges of PFAS-laden wastewater into publicly owned treatment works is a primary source of PFAS in sewage treatment plant effluents, and studies have shown that PFAS are present at every stage of the wastewater treatment process (i.e., raw wastewater, treated wastewater, sewage sludge, and suspended solids).

Among the 10 case study waterways, three have WWTPs as the potential primary or secondary source of PFAS contamination, including:

- Upper Coosa Riverkeeper (Dalton Utilities Wastewater Treatment Facilities)
- Haw Riverkeeper (TZ Osborne WWTP)
- Inland Empire Waterkeeper (Western Riverside County Regional Wastewater Authority, Riverside WWTP, Colton WWTP, San Bernardino Water Reclamation, Redlands Wastewater Treatment)

Indeterminate PFAS Source[52]

For Orange County Coastkeeper, the upstream and downstream sites are located in a highly populated residential area. Due to divergent community activities, a potential source of PFAS contamination was not identifiable.

PHOTO: ASSATEAGUE COASTKEEPER

RECOMMENDATIONS

Even with the clear danger and prevalence of PFAS in waters across the United States, broad-based action to address contamination (e.g., prohibitions on manufacture and sale of PFAS compounds; comprehensive water testing; regulatory oversight and enforcement at the source; investment in research and technologies; and implementation of treatment applications) has been slow and inadequate to date. For example:

- **There are currently no federal limits on PFAS releases into surface waters under the Clean Water Act,** putting the health and safety of communities across the nation at risk and resulting in costly cleanup and treatment activities to remove PFAS contamination after it has occurred.

- According to a recent map published by the EWG,[53] PFAS contamination has been detected at more than 2,800 sites in 50 states. These include military sites that use firefighting foam containing PFAS and industrial sites where PFAS chemicals were manufactured or used in production. **Experts estimate that nearly 30,000 facilities[54] discharge PFAS to surface water** (or to wastewater treatment plants which then discharge their effluent to surface water).

- By the end of 2023, EPA expects to set drinking water standards for PFOA and PFOS[55] that will require drinking water utilities to undertake expensive upgrades to their systems, even as PFAS manufacturers and users continue to operate with impunity because of the lack of federal limits on sale and use of these chemicals. **The cost of mitigating this contamination should not fall solely on utilities and, by extension, everyday people who pay their rates to water utilities for clean water.**

- Under the PFAS Strategic Road Map[56] developed by EPA, it could be many years before federal limits are in place for PFAS discharges from pollution sources, and the plan only includes deadlines for proposing rules governing discharges from a few sources — chemical manufacturing, electroplating, and metal finishing.

Congress and EPA can address these challenges with the urgency they require by prioritizing:

1. Passing Clean Water Act legislation
2. Adopting regulatory standards and designations
3. Funding and implementing more strategic and coordinated water monitoring in surface waters, groundwater, and drinking water supplies
4. Developing improved analytical methods
5. Prioritizing implementation and enforcement of clean water and cleanup laws

Clean Water Standards for PFAS Act[57]

The Clean Water Standards for PFAS Act would help reduce levels of PFAS contamination from entering water sources in the first place. The bill requires EPA to set new standards under the Clean Water Act for at least nine industry categories that are known to discharge PFAS into the environment. These standards would restrict the flow of PFAS chemicals into surface waters and to public treatment works. Specifically, the Clean Water Standards for PFAS Act would:

- Require EPA to review the sources of PFAS in waterbodies and use that information to set protective limits on the amount of PFAS chemicals that can be released.
- Require EPA to establish water quality criteria for each measurable PFAS and class of PFAS within three years. Water quality criteria[58] are numerical criteria developed by EPA for determining, e.g., when water becomes unsafe to human health. EPA has previously developed water quality criteria for many pollutants,[59] but not for PFAS.
- Set enforceable deadlines for EPA to develop effluent limitations, including industrial pretreatment standards, for measurable PFAS and classes of PFAS.
    - Effluent limitation guidelines[60] are national standards for wastewater discharged to surface waters and publicly owned wastewater treatment plants. EPA issues these regulations for certain industrial categories,[61] based on the performance of treatment and control technologies. These technology-based standards are intended to represent the greatest pollution reductions that are economically achievable by industry.
    - Pretreatment standards[62] are a type of effluent limitation. Pretreatment standards are discharge limits developed by EPA that apply to certain manufacturers who send wastewater to a wastewater treatment plant.

> Pretreatment standards and requirements can be expressed as numeric limits, narrative prohibitions, and best management practices.

EPA would be required to establish effluent limitations and pretreatment standards for discharges to surface water or to publicly owned treatment works from nine different sources on the following schedule:

- Chemical manufacturing and formulating, electroplating, and metal finishing by June 30, 2024;
- Landfills, textile mills, and electronics manufacturing by June 30, 2025;
- Plastics molding, leather tanning, and paint formulating by December 31, 2026.
- The bill also imposes monitoring requirements for paper mills and airports. EPA must determine whether to establish discharge limits for those sources by December 31, 2023, and complete those limits by December 31, 2027.

Provide appropriations for EPA to complete this work.

Drinking Water Limits[63]

According to its PFAS Strategic Roadmap,[64] EPA plans to establish "a national primary drinking water regulation for PFOA and PFOS that would set enforceable limits and require monitoring of public water supplies, while evaluating additional PFAS and groups of PFAS. (*Science Advisory Board consultation ongoing*;[65] *proposed rule fall 2022, final rule fall 2023*)." EPA must follow through on these proposals, issue the notices in the fall of 2022, and act urgently to finalize this drinking water regulation.

CERCLA Hazardous Substance Designation[66]

As EPA proposed in its PFAS Strategic Roadmap[67] on August 26, 2022, the agency announced[68] that it was proposing to designate PFOA and PFOS as CERCLA hazardous substances to "increase transparency around releases of these harmful chemicals and help to hold polluters accountable for cleaning up their contamination." At the same time, EPA also announced its future plan to issue "an Advance Notice of Proposed Rulemaking...to seek public comment on designating other PFAS chemicals as CERCLA hazardous substances."[69] EPA must now follow through as expeditiously as possible on each of these proposals, and act urgently to finalize these designations including designating the entire class of PFAS given that mixtures of multiple PFAS compounds were found in the majority of surface water samples.

RCRA Hazardous Waste Designation[70]

According to the PFAS Strategic Roadmap,[71] EPA intends to initiate "two rulemakings under the Resource Conservation and Recovery Act to address PFAS" (initiated October 2021). According to EPA:

- "First, the agency will initiate the process to propose adding four PFAS chemicals as RCRA Hazardous Constituents under Appendix VIII, by evaluating the existing data for these chemicals and establishing a record to support such a proposed rule. The four PFAS chemicals EPA will evaluate are: perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorobutane sulfonic acid (PFBS), and GenX. Adding these chemicals as RCRA Hazardous Constituents would ensure they are subject to corrective action requirements and would be a necessary building block for future work to regulate PFAS as a listed hazardous waste." The agency's current regulatory agenda[72] indicates this may be proposed in August 2023.
- "The second rulemaking effort will clarify in EPA regulations that the RCRA Corrective Action Program has the authority to require investigation and cleanup for wastes that meet the statutory definition of hazardous waste, as defined under RCRA section 1004(5). This modification would clarify that emerging contaminants such as PFAS can be cleaned up through the RCRA corrective action process." The agency's current regulatory agenda[73] indicates this may be proposed in January 2023.

EPA must now follow through on these proposals, issue the notices as proposed, and act urgently to finalize the listing and clarifying rule.

Water Quality Criteria for Surface Waters[74]

According to the PFAS Strategic Roadmap,[75] EPA will publish "final recommended ambient water quality criteria for PFAS for aquatic life and human health to help Tribes and states develop standards, write permits, and assess cumulative impacts (expected winter 2022 and fall 2024)." EPA must follow through on the adoption of water quality criteria and act urgently on protective criteria as soon as possible, and no later than the fall of 2024.

Monitoring[76]

The Bipartisan Infrastructure Law provides $10 billion in funding[77] to address PFAS contamination over five years. EPA should leverage this funding and implement a coordinated water monitoring program for PFAS with federal, state, and interstate agencies. EPA should include the PFAS contaminants in its National Aquatic Resource Surveys of rivers/streams, lakes, coastal waters, and wetlands and U.S. Geological Survey should include these contaminants in their National Water Quality Assessment Program and in their special studies for states.

APPENDICES

PHOTO: GUNPOWDER RIVERKEEPER

APPENDIX 1

Participating Waterkeeper Groups

Waterkeeper Group	Name	State
Black Warrior Riverkeeper	Nelson Brooke	Alabama
Cahaba Riverkeeper	David Butler	Alabama
Choctawhatchee Riverkeeper	Michael Mullen	Alabama
Coosa Riverkeeper	Justinn Overton	Alabama
Hurricane Creekkeeper	John Wathen	Alabama
Little River Waterkeeper	Bill Shugart	Alabama
Mobile Baykeeper	Cade Kistler	Alabama
Waterkeepers Alabama	Justinn Overton	Alabama
Cook Inletkeeper	Sue Mauger	Alaska
Arkansas Ozark Waterkeeper	Teresa Turk	Arkansas
CA Urban Streams Alliance - The Stream Team, a Waterkeeper Alliance Affiliate	Timmarie Hamill	California
California Coastkeeper Alliance	Sean Bothwell	California
Humboldt Baykeeper	Jennifer Kalt	California
Inland Empire Waterkeeper	Garry Brown	California
Los Angeles Waterkeeper	Bruce Reznik	California
Orange County Coastkeeper	Garry Brown	California
Russian Riverkeeper	Don McEnhilll	California
San Diego Coastkeeper	Phillip Musegaas	California
Santa Barbara Channelkeeper	Benjamin Pitterle	California
Yuba River Waterkeeper	Aaron Zettler - Mann	California
Poudre Waterkeeper	Gary Wockner	Colorado
Upper Colorado River Watershed Group, a Waterkeeper Alliance Affiliate	Andy Miller	Colorado
Long Island Soundkeeper	William Lucey	Connecticut
Anacostia Riverkeeper	Trey Sherard	District of Columbia
Apalachicola Riverkeeper	Georgia Ackerman	Florida
Calusa Waterkeeper	John Cassani	Florida
Collier County Warerkeeper	KC Schulberg	Florida
Miami Waterkeeper	Rachel Silverstein	Florida
St. Johns Riverkeeper	Lisa Rinaman	Florida
Suncoast Waterkeeper	Abbey Tyrna	Florida
Suwannee Riverkeeper	John Quarterman	Florida

Waterkeeper Group	Name	State
Tampa Bay Waterkeeper	Justin Tramble	Florida
Waterkeepers Florida	John Quarterman	Florida
Altamaha Coastkeeper	Maggie Van Cantfort	Georgia
Altamaha Riverkeeper	Fletcher Sams	Georgia
Chattahoochee Riverkeeper	Jason Ulseth	Georgia
Lower Savannah River Alliance, a Waterkeeper Alliance Affiliate	Tonya Bonitatibus	Georgia
Ogeechee Riverkeeeper	Damon Mullis	Georgia
Satilla Riverkeeper	Chris Bertrand	Georgia
Savannah Riverkeeper	Tonya Bonitatibus	Georgia
Upper Coosa Riverkeeper	Jesse Demonbreun-Chapman	Georgia
Lake Coeur d'Alene Waterkeeper	Shelley Austin	Idaho
Snake River Waterkeeper	Ferrell Ryan	Idaho
Kansas Riverkeeper	Dawn Buehler	Kansas
Kentucky Riverkeeper	Pat A Banks	Kentucky
Casco Baykeeper	Ivy L. Frignoca	Maine
Assateague Coastkeeper	Gabrielle Ross	Maryland
Baltimore Harbor Waterkeeper	Alice Volpitta	Maryland
Chester Riverkeeper	Annie Richards	Maryland
Choptank Riverkeeper	Matt Pluta	Maryland
Gunpowder Riverkeeper	Theaux Le Gardeur	Maryland
Miles-Wye Riverkeeper	Elle Bassett	Maryland
Potomac Riverkeeper	Dean Naujoks	Maryland
Sassafras Riverkeeper	Zack Kelleher	Maryland
Severn Riverkeeper	Sara Caldes	Maryland
South, West & Rhode Riverkeeper	Evann Magee	Maryland
Nantucket Waterkeeper	RJ Turcotte	Massachusetts
Detroit Riverkeeper	Robert Burns	Michigan
Grand Traverse Baykeeper	Heather Smith	Michigan
Yellow Dog Riverkeeper	Chauncey Moran	Michigan
Pearl Riverkeeper	Abby Braman	Mississippi
Missouri Confluence Waterkeeper	Rachel Bartels	Missouri
Bitterroot River Protection Association, a Waterkeeper Alliance Affiliate	Michael Howell	Montana
Upper Missouri Waterkeeper	Guy Alsentzer	Montana
Hackensack Riverkeeper	Bill Sheehan	New Jersey
Buffalo Niagara Waterkeeper	Jill Jedlicka	New York
Chautauqua-Conewango Consortium, a Waterkeeper Alliance Affiliate	Jane Conroe	New York
Peconic Baykeeper	Peter Topping	New York
Seneca Lake Guardian, a Waterkeeper Alliance Affiliate	Joseph Campbell	New York
Upper St. Lawrence Riverkeeper	John Peach	New York
Broad Riverkeeper	David Caldwell	North Carolina
Cape Fear Riverkeeper	Kemp Burdette	North Carolina

Waterkeeper Group	Name	State
Catawba Riverkeeper	Brandon Jones	North Carolina
Green Riverkeeper	Erica Shanks	North Carolina
Haw Riverkeeper	Emily Sutton	North Carolina
Lumber Riverkeeper	Jefferson Currie II	North Carolina
Neuse Riverkeeper	Samantha Krop	North Carolina
Pamlico-Tar Riverkeeper	Jill Howell	North Carolina
Watauga Riverkeeper	Andy Hill	North Carolina
White Oak Waterkeeper	Riley Lewis	North Carolina
Yadkin Riverkeeper	Edgar Miller	North Carolina
Lake Erie Waterkeeper	Sandy Bihn	Ohio
Grand Riverkeeper	Martin Lively	Oklahoma
Spring Creek Coalition, a Waterkeeper Alliance Affiliate	Beth Rooney	Oklahoma
Tar Creekkeeper	Rebecca Jim	Oklahoma
Rogue Riverkeeper	Frances Oyung	Oregon
Tualatin Riverkeeper	Victoria Frankeny	Oregon
Lower Susquehanna Riverkeeper	Ted Evgeniadis	Pennsylvania
Middle Susquehanna Riverkeeper	John Zaktansky	Pennsylvania
Three Rivers Waterkeeper	Heather Hulton VanTassel	Pennsylvania
Upper Allegheny River Project, a Waterkeeper Alliance Affiliate	Pamela Digel	Pennsylvania
Narragansett Bay Riverkeeper	Kate McPherson	Rhode Island
Narragansett Baykeeper	Mike Jarbeau	Rhode Island
South County Coastkeeper	David Prescott	Rhode Island
Black-Sampit Riverkeeper	Erin Donmoyer	South Carolina
Charleston Waterkeeper	Andrew Wunderley	South Carolina
Congaree Riverkeeper	Bill Stangler	South Carolina
Waccamaw Riverkeeper	Cara Schildtknecht	South Carolina
Tennessee Riverkeeper	David Whiteside	Tennessee
Bayou City Waterkeeper	Kristen Schlemmer	Texas
Environmental Stewardship, a Waterkeeper Alliance Affiliate	Steve Box	Texas
Lake Champlain Lakekeeper	Julie Silverman	Vermont
Dan Riverkeeper	Steven Pullian	Virginia
James Riverkeeper	Erin Reilly	Virginia
Shenandoah Riverkeeper	Mark Frondorf	Virginia
Deschutes Estuary Restoration Team, a Puget Soundkeeper Affiliate	Paige Anderson	Washington
North Sound Baykeeper	Eleanor Hines	Washington
Puget Soundkeeper	Sean Dixon	Washington
Spokane Riverkeeper	Jerry White Jr.	Washington
Twin Harbors Waterkeeper	Lee First	Washington
Upper Potomac Riverkeeper	Brent E Walls	West Virginia
West Virginia Headwaters Waterkeeper	Angie Rosser	West Virginia
Milwaukee Riverkeeper	Cheryl Nenn	Wisconsin

APPENDIX 2

EPA Analytical Methods

EPA Method 533

EPA Method 537[78]

EPA Method 1633 (Draft)[79]

APPENDIX 3

PFAS Detected by Cyclopure Analytical Methods

PFAS Detected by Cyclopure Using EPA Methods 533, 537 and 1633 (Draft)	Compound Name	CAS#	Method 1633 (Draft)
PFBA	Perfluorobutanoic Acid	375-22-4	Y
PFPeA	Perfluoropentanoic Acid	2706-90-3	Y
PFHxA	Perfluorohexanoic Acid	307-24-4	Y
PFHpA	Perfluoroheptanoic Acid	375-85-9	Y
PFOA	Perfluorooctanoic Acid	335-67-1	Y
PFNA	Perfluorononanoic Acid	375-95-1	Y
PFDA	Perfluorodecanoic Acid	335-76-2	Y
PFUnA	Perfluoroundecanoic Acid	2058-94-8	Y
PFDoA	Perfluorododecanoic Acid	307-55-1	Y
PFTrDA	Perfluorotridecanoic Acid	72629-94-8	Y
PFTeA	Perfluorotetradecanoic Acid	0376-06-07	Y
PFPrS	Perfluoropropane Sulfonic Acid	423-41-6	
PFBS	Perfluorobutane Sulfonic Acid	375-73-5	Y
PFPeS	Perfluoropentane Sulfonic Acid	2706-91-4	Y
PFHxS	Perfluorohexane Sulfonic Acid	355-46-4	Y
PFHpS	Perfluoroheptane Sulfonic Acid	375-92-8	Y
PFOS	Perfluorooctane Sulfonic Acid	1763-23-1	Y
PFNS	Perfluorononane Sulfonic Acid	474511-07-4	Y
PFDS	Perfluorodecane Sulfonic Acid	335-77-3	Y
PFDoS	Perfluorododecane Sulfonic Acid	79780-39-5	Y
4:2 FTS	4:2 Fluorotelomer Sulfonate	414911-30-1	Y
6:2 FTS	6:2 Fluorotelomer Sulfonate	425670-75-3	Y
8:2 FTS	8:2 Fluorotelomer Sulfonate	481071-78-7	Y
10:2 FTS	10:2 Fluorotelomer Sulfonate	120226-60-0	
FBSA	Perfluorobutane Sulfonamide	30334-69-1	
MeFBSA	N-Methylperfluorobutanesulfonamide	68298-12-4	
FHxSA	Perfluorohexane Sulfonamide	41997-13-1	
PFOSA	Perfluorooctane Sulfonamide	754-91-6	Y
FDSA	Perfluorodecane Sulfonamide	N/A	
NEtFOSA	N-Ethylperfluorooctane-1-Sulfonamide	4151-50-2	Y
NMeFOSA	N-Methylperfluorooctane-1-Sulfonamide	31506-32-8	Y

PFAS Detected by Cyclopure Using EPA Methods 533, 537 and 1633 (Draft)	Compound Name	CAS#	Method 1633 (Draft)
FOSAA	Perfluorooctane Sulfonamido Acetic Acid	2806-24-8	
NEtFOSAA	N-Ethyl Perfluorooctane Sulfonamido Acetic Acid	2991-50-6	Y
NMeFOSAA	N-Methyl Perfluorooctane Sulfonamido Acetic Acid	2355-31-9	Y
NMeFOSE	N-methyl perfluorooctanesulfonamidoethanol	24448-09-07	Y
NEtFOSE	N-ethyl perfluorooctanesulfonamidoethanol	1691-99-2	Y
HFPO-DA (GenX)	Hexafluoropropylene Oxide Dimer Acid	13252-13-6	Y
ADONA	4,8-Dioxa-3H-Perfluorononanoate	919005-14-4	Y
PFMPA or PFMOPrA	Perfluoro-3-Methoxypropanoic Acid	377-73-1	Y
PFMBA	Perfluoro-4-Methoxybutanoic Acid	863090-89-5	Y
NFDHA	Perfluoro-3,6-Dioxaheptanoic Acid	151772-58-6	Y
9Cl-PF3ONS	9-Chlorohexadecafluoro-3-Oxanone-1-Sulfonic Acid	756426-58-1	Y
11CL-PF3OUdS	11-Chloroeicosafluoro-3-Oxanonane-1-Sulfonic Acid	763051-92-9	Y
PFEESA	Perfluoro(2-ethoxyethane) Sulfonic acid	113507-82-7	Y
PFECHS	Perfluoro-4-ethylcyclohexane Sulfonic Acid	646-83-3	
8Cl-PFOS	8-Chloroperfluoro-1-Octanesulfonic Acid	777011-38-8	
3:3FTCA	3-Perfluoropropyl Propanoic Acid	0356-02-05	Y
5:3FTCA	2h,2h,3h,3h-Perfluorooctanoic Acid	914637-49-3	Y
7:3FTCA	3-Perfluoroheptyl propanoic acid	812-70-4	Y
FDUEA	2H-Perfluoro-2-dodecenoic acid	70887-94-4	
FOUEA	2H-perfluoro-2-decenoic acid	70887-84-2	
6:6PFPi	Bis(perfluorohexyl)phosphinic acid	40143-77-9	
6:8PFPi	(Heptadecafluorooctyl)(tridecafluorohexyl) Phosphinic Acid	610800-34-5	
8:8PFPi	Bis(perfluorooctyl)phosphinic acid	40143-79-1	
N-AP-FHxSA	N-(3-dimethylaminopropan-1-yl) perfluoro-1-hexanesulfonamide	50598-28-2	

APPENDIX 4

All Waterkeeper Group Sample Results

Link to Spreadsheet (Waterkeeper.org)

APPENDIX 5

List of States Not Sampled for PFAS in Surface Waters

- **Arizona**
- **Delaware**
- **Hawaii**
- **Illinois**
- **Indiana**
- **Iowa**
- **Louisiana**
- **Minnesota**
- **Nebraska**
- **Nevada**
- **New Hampshire**
- **New Mexico**
- **North Dakota**
- **South Dakota**
- **Utah**
- **Wyoming**

APPENDIX 6

QA/QC Protocol

QUALITY ASSURANCE-QUALITY CONTROL (QA/QC) PROJECT PLAN FOR NATIONAL PFAS SURVEY DATA COLLECTION AND ANALYSIS

Waterkeeper Alliance Quality Assurance Statement of Collected National PFAS Survey Information

National PFAS Survey Information

Waterkeeper Alliance and licensed U.S. Waterkeeper groups will collect reliable and accurate water samples consistent with standards for quality assurance and quality control. Waterkeeper Alliance and U.S. Waterkeeper groups aim to produce quality data that is accurate, precise, complete, and representative. Quality Assurance, Quality Control, and Quality Assessment (QA/QC) measures will be implemented and are consistent with EPA analytical methods for PFAS.

Application of Protocol:

This QA/QC Plan for the national PFAS monitoring project is intended to ensure the use of procedures that are consistent and reliable in order to obtain water samples that are scientifically defensible and representative. The specific techniques described herein are intended to assure representative samples are collected without contamination, loss, or degradation.

Summary of Method Requirements:

The validity of water sampling results depends on: (1) ensuring that each sample obtained is representative of water quality conditions; (2) employing proper sampling, handling, and preservation techniques; (3) properly identifying the collected samples and location information on the provided Cyclopure Water Test Kit data card; (4) verification of each water sample location information, waterbody name, date of sample collection by Waterkeeper Alliance staff with written confirmation by participating U.S. Waterkeeper groups.

Special Qualifications:

The QA/QC plan is designed to assure that water sampling follows proper, validated methodologies. The generation of reliable data requires that all activities are conducted by knowledgeable and trained personnel. Each PFAS water sample collected in this project was conducted by a licensed Waterkeeper or designated, qualified Waterkeeper group staff member.

Universal Requirements and Precautions:

The following are the *water sample collection requirements implemented in this project*:

- All designated staff collecting water samples must wear appropriate clothing and footwear during sampling events. Additionally, non-powdered gloves are consistent with safety procedures when handling sample bottles and sampling equipment, before, during, and after sample collection. New gloves are required at each sample location. Gloves are supplied to each Waterkeeper group in each individual Cyclopure test kit.
- Determine the direction of flow and, if the directional flow is present, position the sample bottle so that it is facing in an upstream direction.
- If possible, avoid entering the waterway to collect samples. If it is necessary to enter a waterbody to obtain the sample, the sample collector should enter downstream of the sampling location and obtain the sample at least 6 feet upstream of that location.
- Avoid disturbance of any bottom sediments during sample collection, and avoid collecting floating material, insects, algae, and other debris where possible.
- As directed by laboratory methodology, obtain samples directly from the stream using laboratory-supplied sampling containers.

Parameters of Sample Site Selection:

The sample collection sites are established by the Waterkeeper group prior to sample collection within each individual Waterkeeper basin with site selection support available from Waterkeeper Alliance and Cyclopure staff. Generally, the upstream sample will be selected in a location expected to have minimal PFAS contamination and the downstream location will be in an area of suspected contamination, such as below a potential PFAS pollutant source.

Water Sample Collection

All the water sample information available in the report shall be collected by licensed Waterkeeper groups. All Waterkeeper groups collecting water sample information are provided with training and instruction on water sample collection procedures via a live presentation on May 10, 2022, or through a recording of that event. Waterkeeper groups are provided with detailed instructions covering sample collection and analysis methodologies. Waterkeeper groups are instructed to fill collection cups with 250 mL taken in the upper clear layers of surface water sources while dipping the collection cup away from the water's edge and avoiding sediments. In order to obtain a Cyclopure water test kit, a valid Waterkeeper license had to be on file with Waterkeeper Alliance at the time of shipment.

Labeling, Processing, and Handling Water Samples:

Cyclopure will ship test kits directly to Waterkeeper groups and completed kits will be shipped back to Cyclopure after sample collection. The test kit includes detailed instructions and pre-paid return shipping labels.

Cyclopure's PFAS test kit consists of a 250 ml collection cup with a DEXSORB-loaded extraction disc in a bottom filter. Using the PFAS test kit, Cyclopure can accurately measure and quantify the presence of short and long-chain PFAS with Point-of-Site extraction method. Point-of-Site sample extraction is completed by filling the test kit collection cup with 250 mL of the water sample and then allowing the water to pass through the DEXSORB-loaded extraction disc. While draining, the sampler sets the cup on top of the 250 mL HDPE drain bottle. Once all water passes through the PFAS sampler, the sampler pours the water out of the drain bottle. The PFAS collection cup containing the DEXSORB-loaded extraction disc is returned to Cyclopure's lab. No water is shipped to Cyclopure.

The physical location of the sample collected is recorded via GPS handheld receiver and recorded on the provided data information card.

Analytical Methods

Waterkeeper groups performed PFAS extractions in the field using the company's DEXSORB-loaded extraction disc. Field extraction avoids trip contamination; PFAS are absorbed and securely locked into DEXSORB's cyclodextrin cups.

When the completed PFAS test kit is received, Cyclopure analytical chemists perform standard solid-phase extraction (SPE) to recover PFAS compounds collected in the DEXSORB extraction disc. See Attachment 1. The PFAS sample is subsequently analyzed on an HPLC-MS/MS (QExactive hybrid quadrupole orbitrap, ThermoFisher). Analytical procedures use isotope dilution for PFAS measurement and quantification. The analysis of water samples has been validated to the requirements of EPA Methods 533, 537, and 1633 (draft), and follows instrument procedures for internal standardization and calibration. Cyclopure tests for 55 PFAS structures, including 21 precursors and all PFAS listed under EPA Methods 533, 537, and 1633 (draft). The limit of quantification (LOQ) for all 55 PFAS tested under Cyclopure analytical methods is 1 - 2 ppt (ng/L). Reporting limits have been validated to the accuracy criteria of EPA methods, including Minimum Reporting Limit (MRL) confirmation.

Attachment 1

APPENDIX 7

Percentage of Samples with PFAS Detections by States and D.C.

State	Total # Samples	# Samples with PFAS Detections	% of Total Samples with PFAS Detections
Alabama	16	16	100.00%
Alaska	2	2	100.00%
Arkansas	2	0	0.00%
California	22	14	63.64%
Colorado	4	0	0.00%
Connecticut	2	2	100.00%
D.C.	2	2	100.00%
Florida	15	15	100.00%
Georgia	18	18	100.00%
Idaho	4	2	50.00%
Kansas	2	0	0.00%
Kentucky	2	2	100.00%
Maine	2	2	100.00%
Maryland	20	20	100.00%
Massachusetts	2	2	100.00%
Michigan	6	2	33.33%
Mississippi	2	2	100.00%
Missouri	2	2	100.00%
Montana	4	0	0.00%
New Jersey	2	2	100.00%
New York	10	10	100.00%
North Carolina	20	18	90.00%
Ohio	3	3	100.00%
Oklahoma	6	2	33.33%
Oregon	4	4	100.00%
Pennsylvania	8	8	100.00%
Rhode Island	6	6	100.00%
South Carolina	11	11	100.00%
Tennessee	2	2	100.00%
Texas	4	4	100.00%
Vermont	2	0	0.00%
Virginia	6	6	100.00%
Washington	10	6	60.00%
West Virginia	3	3	100.00%
Wisconsin	2	2	100.00%
Grand Total	**228**	**190**	**83.33%**

THANK YOU TO THE WATERKEEPER ALLIANCE MEMBERS WHO MADE THIS POSSIBLE!

COLLAGE: CYCLOPURE, INC.

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