U.S. House Committee on Energy and Commerce
Subcommittee on Environment
"Examining the Impact of EPA's CERCLA Designation for Two PFAS Chemistries and Potential Policy Responses to Superfund Liability Concerns.
Documents for the Record
December 18, 2025

Majority

1. A letter from ACC to Chairman Palmer and Ranking Member Tonko.
2. A letter from NAPA to Chairman Guthrie and Ranking Member Pallone.
3. A letter from VEOLIA to Chairman Palmer, Chairman Guthrie, Ranking Member Tonko, and Ranking Member Pallone.

Minority

1. An article from Norh Carolina Public Radio titled "Hidden PFAS pollution uncovered in NC as EPA proposes reporting rollback"
2. A report from the Environmental Working Group titled "PFAS Contamination of Drinking Water far More Prevalent Than Previously Reported"
3. A memo from the EPA on PFAS Enforcement Discretion and Settlement Policy Under CERCLA
4. An article from the Environmental Working Group titled "Congress' scrutiny of toxic 'forever chemicals' cleanup liability puts public health at risk"
5. A letter from environmental advocacy groups to Sen. Carper, Sen. Capito, Rep. McMorris Rodgers, and Rep. Pallone
6. An article from the Environmental Working Group titled "EWG: 2.5 million pounds of PFAS pesticides spread on California farmland annually"
7. A map of PFAS contamination in the U.S. from the Environmental Working Group
8. An article from the Journal of Exposure Science & Environmental Epidemiology titled "Exploratory profiles of phenols, parabens, and per- and polyfluoroalkyl substances among NHANES study participants in association with previous cancer diagnoses"
9. A timeline from Clean Cape Fear on PFAS pollution
10. A Green Wire article titled "Blind spots': EPA's 'forever chemicals' plan sparks concern"
11. A Wired article titled "The Trump Administration's Data Center Push Could Open the Door for New Forever Chemicals"
12. A Washington Post article titled "Study shows dangers of 'forever chemicals' on babies"
13. A PNAS article titled "PFAS contaminated drinking water harms infants"

December 18, 2025

The Honorable Gary Palmer
Chairman
Subcommittee on Environment
House Committee on Energy & Commerce
United States House of Representatives
Washington, DC 20515

The Honorable Paul Tonko
Ranking Member
Subcommittee on Environment
House Committee on Energy & Commerce
United States House of Representatives
Washington, DC 20515

Dear Chairman Palmer and Ranking Member Tonko:

Thank you for convening this important hearing "Examining the Impact of EPA's CERCLA Designation for Two PFAS Chemistries and Potential Policy Responses to Superfund Liability Concerns." We appreciate your engagement on a complicated and challenging issue for communities and companies throughout the United States.

The American Chemistry Council supports strong, science-based regulations that are protective of public health and the environment, including appropriate clean-up actions and remediation at specific sites. We are also supportive of advancing research and development into technologies to safely and effectively manage PFAS wastes.

We urge Congress and the Environmental Protection Agency (EPA) to pursue science-based, risk-focused measures that provide clarity and certainty while enabling effective management of PFAS. These steps should include:

- **Establishing an updated working definition of PFAS** including an updated definition of "priority PFAS" that can be used to focus and guide PFAS policies in the U.S. EPA can more accurately define priority PFAS, including various sub-groups of PFAS with similar properties and use profiles. A more precise approach can guide regulatory policy and focus on the highest priority substances and issues.

- **Updating and finalizing EPA's PFAS Destruction and Disposal Guidance** to clearly identify acceptable practices and technologies for managing PFAS wastes. Guidance should be updated annually rather than every three years to reflect evolving science and technology and should utilize new research and analysis from the business community.

- **Ensuring adequate disposal and destruction capacity**, including permitting, and incentivizing development of additional remediation technologies.

- **Developing guidance for defining background levels** and establishing risk-based de minimis levels for various media.

- **Developing an effective Waste Management Framework** to guide future determinations and regulatory actions, ensuring consistency and predictability.

- **Exploring additional actions and measures that can help inform and expedite remediation**.

- **Restricting Long-Chain PFAS (e.g. PFOA and PFOS) from Non-Domestic Sources** to develop a comprehensive approach to managing PFAS.

- **Appointing Someone to Lead PFAS Coordination among all Federal Agencies** to advance a comprehensive approach to PFAS management across agencies and ensure coordination among federal regulations and the federal regulatory agenda.

These actions would provide greater regulatory certainty, reduce unintended consequences, and accelerate real-world cleanup without imposing disproportionate costs on communities and critical industries.

The Biden EPA's move to designate PFOA and PFOS as hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) will not result in timely and effective cleanup of contaminated sites.

Moreover, consistent with EPA's PFAS Stewardship Program, PFOA and PFOS have not been manufactured in the United States for more than a decade, so imposing CERCLA liabilities could discourage the domestic production and use of safe and essential fluorochemistries that are critical to the U.S. competitiveness and national security, including domestic priorities such as defense, energy storage, semiconductors, and medical technologies.

We appreciate the Committee's leadership and stand ready to work with you and the EPA to advance practical, science-based solutions that protect public health and the environment while supporting U.S. economic and national security priorities.

Sincerely,

Chris Jahn
President & CEO
American Chemistry Council

NAPA
NATIONAL ASPHALT PAVEMENT ASSOCIATION

December 18, 2025

The Honorable Brett Guthrie
Chairman, Energy and Commerce
2161 Rayburn House Office Building
Washington, DC 20515

The Honorable Frank Pallone Jr.
Ranking Member, Energy and Commerce
2107 Rayburn House Office Building
Washington, DC 20515

Dear Chairman Guthrie and Ranking Member Pallone,

The National Asphalt Pavement Association (NAPA) is the lone national trade association representing more than 1,000 companies involved in asphalt pavement production and paving applications across the country. Our members produce over 400 million tons of asphalt pavement each year, support nearly 350,000 jobs nationwide, and account for more than $30 billion in capital investment. Asphalt comprises roughly 94% of the highway-pavement market and 80% of the airfield-pavement market, making it the most flexible, resilient, and sustainable pavement material available. NAPA members operate approximately 3,500 asphalt mix plants in virtually every Congressional district – coast to coast and border to border – providing the essential materials needed to build and maintain nearly 4 million miles of roadway across the United States.

Pavement recycling is a cornerstone of routine pavement maintenance and a critical component of our industry's environmental stewardship. Each year, the asphalt pavement industry recycles more than 90 million tons of material, making asphalt the most recycled material in the United States. These recycling practices save State Departments of Transportation more than $5 billion annually, allowing taxpayer dollars to go further and enabling states to undertake additional infrastructure projects.

As you know, last year the Environmental Protection Agency finalized a rule designating certain PFAS chemistries as CERCLA hazardous substances. While the asphalt pavement industry does not manufacture, use, or intentionally add PFAS, we are increasingly encountering PFAS – containing pavements – particularly in locations impacted by PFAS-containing firefighting foams used on airport runways and roadway tanker fires. Unfortunately, the EPA's rule could impose significant liability on entities that store, transport, or use PFAS-containing materials, placing our members at risk during normal business operations, even when such chemistries are unknowingly present.

In response to these challenges, NAPA has partnered with the Federal Aviation Administration and the University of Florida to research solutions that encapsulate PFAS during the asphalt recycling process. This research is expected to conclude in the coming months, and preliminary findings are highly encouraging. Early results indicate that approximately 95% of PFAS chemistries are effectively encapsulated within new asphalt mixtures that incorporate PFAS-containing material, rendering the finished pavement as environmentally protective.

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While we are optimistic about these findings, it is essential that Congress pursues a reasonable and balanced approach to addressing PFAS in the environment, including within asphalt pavements. We recognize the importance of preventing further PFAS proliferation; however, Congress must also consider the unintended consequences of imposing severe CERCLA liability on passive receivers of PFAS-containing or contaminated materials.

As Congress considers the upcoming surface transportation reauthorization, it is critical that asphalt producers have the certainty and confidence needed to continue building and maintaining the nation's critical pavement infrastructure without hesitation. Maintaining – and expanding – the deployment of recycled asphalt and other pavements is critical towards maximizing precious federal resources and responsibly managing our raw materials. The work before you on PFAS and working with partners, like the asphalt industry, is a partnership we hope to continue to grow.

We look forward to working with the Committee on this important issue and view this engagement as a positive step toward providing clarity and certainty regarding liability and recycling. Thank you for your consideration. Please consider the asphalt pavement industry a resource – we stand ready to collaborate with you to protect the environment and keep America moving

Sincerely,

Nile Elam
Vice President of Government Affairs
National Asphalt Pavement Association

December 18, 2025

The Honorable Gary Palmer, Chairman
Subcommittee on Environment
House Energy and Commerce Committee
U.S. House of Representatives
2125 Longworth House Office Building
Washington, D.C. 20515

The Honorable Paul Tonko, Ranking Member
Subcommittee on Environment
House Energy and Commerce Committee
U.S. House of Representatives
2323 Longworth House Office Building
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The Honorable Brett Guthrie, Chairman
House Energy and Commerce Committee
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2125 Longworth House Office Building
Washington, D.C. 20515

The Honorable Frank Pallone, Jr., Ranking Member
House Energy and Commerce Committee
U.S. House of Representatives
2125 Longworth House Office Building
Washington, D.C. 20515

Dear Chairmen Palmer and Guthrie and Ranking Members Tonko and Pallone:

Thank you for holding the hearing today titled "*Examining the Impact of EPA's CERCLA Designation for Two PFAS Chemistries and Potential Policy Responses to Superfund Liability Concerns."* With the U.S. Environmental Protection Agency (EPA) designating certain chemicals as hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), it is important that Congress examine the potential consequences of those designations, including for companies like Veolia. To that end, please accept this statement describing some of the potential impacts to the water sector from the CERCLA designation as well as Veolia's efforts to treat, manage, and dispose of perfluoroalkyl and polyfluoroalkyl substances (PFAS).

Veolia provides drinking water and wastewater services for more than 20 million people across the United States. We are at the forefront of treating America's water supplies to mitigate the risks of PFAS, which are ubiquitous in the environment but can be treated through the use of available technologies. Veolia has already treated more than 24 billion gallons of water for PFAS at more than 30 sites across the United States, with several more projects under construction or in planning. Veolia's *BeyondPFAS*[1] suite of offerings helps industries and businesses confronting the challenge of regulated PFAS compounds in their water supplies, work processes or waste streams. It streamlines Veolia's offerings with a holistic approach from initial site assessment and sampling, to implementation of tailored treatment technologies, through proper handling and disposing of contaminants in line with current EPA-recommended methods such as incineration, deep well injection and secured, approved landfills.

Passive Receiver

[1] https://www.veolianorthamerica.com/pfas-treatment

In 2024, EPA designated two of the most common PFAS – perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) – as hazardous substances under CERCLA. This action could impose strict environmental cleanup liability on water and wastewater system owners and operators that passively receive PFOA and PFOS in water or wastewater and work to prevent those chemicals from re-entering the environment. As passive receivers, water and wastewater utilities do not manufacture or use PFAS. These chemicals enter water treatment or collection systems through no fault of the utilities but rather because other entities introduced them into the environment. Water treatment companies and municipalities that operate their own water and wastewater systems now face potential legal and financial liability from an environmental problem they are diligently trying to fix for their customers and stakeholders.

Veolia wishes to emphasize the critical importance of passive receiver protections from an affordability perspective. CERCLA was enacted so companies that release hazardous substances into the environment would pay the cost of remediating the contamination they caused – a principle known as "polluter pays." Now, however, water and wastewater operators that treat PFOA and PFOS in water supplies could find themselves inaccurately treated as polluters under CERCLA. This situation could pose an enormous cost on water and wastewater system operators, rather than on the companies that made, used, and profited from PFAS compounds, leading to rate increases for the general public – precisely the population CERCLA is supposed to protect. With affordability concerns paramount in the water sector, it is essential for the CERCLA liability scheme to be tailored to ensure that the real polluter pays while protecting passive receivers and communities from bearing the brunt of that contamination.

We urge Congress to provide statutory liability protections under CERCLA and ensure water and wastewater service providers can continue providing affordable essential services to the public. Our industry and the water customers we serve should not be forced to pay for a problem they did not cause.

For example, legislation before your committee would make clear that liability for PFAS contamination should remain with the organizations most responsible for creating it. The bipartisan *Water Systems PFAS Liability Protection Act* (H.R. 1267) would exempt water and wastewater owners and operators from liability under CERCLA when they responsibly treat water and wastewater in their normal course of business. This legislation will help the water sector protect public health and the environment from the risks associated with PFAS contamination while shielding communities and water customers from potentially significant increased costs.

Disposal of PFAS

Pursuant to Section 7361 of the National Defense Authorization Act for Fiscal Year 2020 (NDAA), Public Law 116-92 (December 19, 2019), EPA has published PFAS destruction and disposal guidance and has committed to updating it annually. In the guidance, EPA identified permitted underground injection wells, permitted hazardous waste landfills and permitted hazardous waste combustors as viable and protective methods to destroy or dispose of PFAS. Veolia has been an active stakeholder in EPA's efforts to update its PFAS disposal

and destruction guidance, and we provided the attached written comments on the 2024 updated interim guidance. We look forward to seeing clear and durable instructions from EPA consistent with Veolia's comments.

Due to the ubiquity and varying levels of PFAS in the environment, Veolia urges Congress to promote and preserve flexibility in PFAS disposal and destruction options, recognizing that there is no one-size-fits-all solution, and that science, innovation and experience will help inform which options are the most appropriate fit in a particular situation. In fact, the market capacity and technological capability for PFAS destruction has evolved significantly since NDAA 2020.

For example, in May 2025, Veolia published the waste management industry's most comprehensive testing to date on the incineration of targeted PFAS compounds.[2] The results demonstrate that high temperature incineration at Veolia's RCRA-permitted hazardous waste incinerator in Port Arthur, Texas is a reliable and proven disposal solution for high concentrations of targeted PFAS, destroying greater than 99% of targeted substances, including up to 99.9999% of PFOS and PFHxS.

The two-phased study was conducted at Veolia's hazardous waste incinerator in Port Arthur, Texas in July and October of 2024 by a third party provider. The facility was chosen based on its track record of managing PFAS-containing material, and its ability to reach a secondary combustion chamber temperature of 2,040 degrees Fahrenheit and a residence time of 2.3 seconds. This testing, conducted using the EPA's most current guidance, advances the scientific understanding of PFAS disposal and gives cities and industries more options for management of these compounds.

The testing evaluated thermal treatment of AFFF fire fighting foam, PFAS-contaminated soil and spent carbon water treatment media in alignment with EPA's most current guidance for solids, liquids and stack air emissions.[3] The testing used the Other Test Method (OTM)-45 and OTM-50 to evaluate products of incomplete combustion (PICs) in stack air emissions.

The key findings of the testing included:

- Overall result: High temperature incineration is an efficient disposal solution for high concentrations of targeted PFAS, destroying greater than 99% of targeted substances, including up to 99.9999% of PFOS and PFHxS.
- Solid residue: In 41 of 45 samples, there were no detectable quantities of the targeted PFAS in any of the ash, slag or filter cake. In four ash samples, targeted PFAS levels close to the method detection limit were identified.

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[2] PFAS Destruction Testing at Veolia's Port Arthur Incinerator, June 2025. Available at https://www.veolianorthamerica.com/pfas-testing.

[3] U.S. Environmental Protection Agency, *Interim Guidance on the Destruction and Disposal of Perfluoroalkyl and Polyfluoroalkyl Substances and Materials Containing Perfluoroalkyl and Polyfluoroalkyl Substances—Version 2 (2024), April 8, 2024*. https://www.epa.gov/system/files/documents/2024-04/2024-interim-guidance-on-pfas-destruction-and-disposal.pdf.

- Liquid residue: Very low levels of the targeted PFAS were detected in liquid residues; the targeted PFAS residuals were below the method detection minimum, as well as the Maximum Contaminant Levels (MCLs) set by the EPA for drinking water.
- Air emissions: The destruction and removal efficiency was greater than 99% for the majority of the targeted PFAS, and few to no PICs were detected during incineration, indicating highly effective destruction.

Veolia appreciates this opportunity to share its perspective and expertise with the Committee and would welcome the opportunity for further engagement as we work together in communities all across the country to solve the nation's PFAS crisis.

Sincerely,

Dave Ross
Executive Vice President, Government Affairs and Sustainability
Veolia | North America

Attachment: Veolia comments on *Interim Guidance on Destruction and Disposal of Perfluoroalkyl and Polyfluoroalkyl Substances and Materials Containing Perfluoroalkyl and Polyfluoroalkyl Substances – Version 2 (Apr. 8, 2024)*. Submitted October 15, 2024.

Hidden PFAS pollution uncovered in NC as EPA proposes reporting rollback

WUNC | By Will Atwater | North Carolina Health News

Published December 5, 2025 at 9:26 AM EST

National Institutes Of Environmental Health Sciences

Though the holiday season is here — with all the responsibilities it entails — some North Carolinians might consider adding one more thing to their to-do lists: weighing in on an EPA proposal that could reshape how the government collects information about per- and polyfluoroalkyl substances, or PFAS. The agency is taking input during the public

On Nov. 10, the EPA announced a proposal to loosen reporting requirements for businesses that make or use PFAS. Agency officials say the changes are intended to make the rules easier for companies to follow and to avoid duplicate or unnecessary paperwork, while still allowing EPA to collect key information about how PFAS are used and what risks they may pose.

Currently PFAS are regulated under the Toxic Substances Control Act, a federal law that allows the EPA to require businesses to report, test, track or even ban chemicals that may threaten human health or the environment.

In October 2023, the Biden administration's EPA finalized a one-time PFAS reporting rule under TSCA's Section 8. The rule requires companies that manufactured or imported PFAS between 2011 and 2022 to disclose how the chemicals were used and provide available environmental or health data. Industry groups have pushed back, saying the rule is too costly and difficult for small businesses to navigate.

"This Biden-era rule would have imposed crushing regulatory burdens and nearly $1 billion in implementation costs on American businesses," EPA Administrator Lee Zeldin said in announcing the proposed changes. "Today's proposal is grounded in common sense and the law, allowing us to collect the information we need to help combat PFAS contamination without placing ridiculous requirements on manufacturers, especially the small businesses that drive our country's economy."

But environmental advocates and clean water managers say the proposal would significantly weaken PFAS oversight.

"By EPA's own estimate, the proposed rule would eliminate more than 97 percent of the information that would have otherwise been generated by the [current] rule," said Stephanie Schweickert, NC Conservation Network's director of Environmental Health Campaigns.

"With PFAS and Chemours in North Carolina, we really need more information about PFAS, not less. This [proposal] is very problematic for public health in North Carolina," Schweickert said.

Harder-to-detect PFAS raise new concerns

WUNC
All Things Considered

The proposal comes when North Carolina researchers are uncovering PFAS pollution that standard monitoring can't detect — raising new questions about whether EPA already has blind spots.

Duke University

Lee Ferguson loads a water sample into one of his laboratory's powerful mass spectrometers, which are used to discover chemicals and contaminants in environmental samples.

Recent Duke University research uncovered a previously unrecognized source of contamination in the Haw River, a tributary of the Cape Fear River: tiny solid PFAS "precursor" particles in industrial wastewater from a Burlington textile manufacturer that entered the local sewer system. These nanoparticles don't show up in standard PFAS tests, which typically look for dissolved chemicals. But during wastewater treatment processes, the particles break down into better-known PFAS compounds that can contaminate rivers, drinking water sources and agricultural sludge.

At peak discharge, researchers detected precursor-particle levels exceeding 12 million parts per trillion — millions of times higher than EPA's enforceable drinking-water limits of 4-10 ppt for regulated PFAS. The findings highlight major blind spots in current monitoring and suggest that industries may be releasing far more PFAS (or PFAS precursors) than regulators currently can detect.

"We have some of the most sophisticated instruments in the world for PFAS analysis, and we couldn't detect these until we dramatically changed our approach," said lead researcher Lee Ferguson, professor of civil and environmental engineering at Duke, in a

learned about blind spots in our analyses when it comes to looking for new PFAS in the environment."

In a follow-up email, Ferguson said the findings show why PFAS disclosure rules should be strengthened, not rolled back. "Our work highlights why it is important to increase, not decrease, PFAS waste discharge reporting requirements for industries."

Downstream utilities feel the impact

A public utility that relies on the Cape Fear River, echoed Ferguson's concerns.

Will Atwater|NCHN

At the Cape Fear Public Utility Authority's Sweeney Treatment Plant, water passes through deep granular activated carbon filters to remove PFAS, then undergoes ultraviolet disinfection before entering a finished-water storage tank.

The Cape Fear Public Utility Authority, which provides drinking water to more than 200,000 customers in New Hanover County and spent $43 million installing a granular activated carbon filtration system in 2022 to remove PFAS, said weakened reporting would make their job harder.

"We are concerned that these [proposed] exemptions could create additional uncertainty for utilities, such as CFPUA, that are located downstream from known PFAS polluters," the agency said.

provide our customers," the statement continued. "Rolling back reporting requirements for PFAS manufacturers passes more of the burden of monitoring and testing source water on to utilities and our ratepayers."

Advocates say the stakes extend beyond utilities.

"The EPA is carving out loopholes under the Toxic Substances Control Act that allow industry to avoid reporting its use of PFAS — current forever chemicals that pose serious risks to people's health," a Southern Environmental Law Center spokesperson said in an emailed statement to NC Health News.

"These exemptions include PFAS produced as byproducts, the very issue at the heart of the Chemours crisis," the SELC statement said. "For decades, Chemours discharged GenX as a byproduct before intentionally manufacturing it, yet the harm caused by byproduct PFAS is no different from that caused by intentionally produced PFAS. This reality devastated 500,000 North Carolinians who drank—and continue to drink—water contaminated by Chemours' PFAS pollution, and it remains true for communities across the country today."

Health risks tied to PFAS exposure

These gaps in monitoring matter because PFAS exposure has been associated with a growing list of health concerns. Often called "forever chemicals" because they break down slowly and accumulate in the body over time, PFAS have been linked to immune system suppression, developmental and reproductive harm, thyroid disruption, elevated cholesterol and certain cancers.

Will Atwater | NCHN

Phlebotomist Patricia Branham draws blood from a GenX Exposure Study participant at the Town of Navassa's Community Center on Nov. 19, 2023.

In North Carolina, the GenX Exposure Study has documented elevated PFAS levels in blood samples from people living near the Cape Fear River, along with health markers such as increased cholesterol and changes in liver enzymes that have been associated with PFAS exposure. Researchers say the findings underscore the risks for communities living downstream of industrial PFAS sources.

"Some PFAS are formed as byproducts of chemical manufacturing. These chemicals, even though they aren't used to make new products, are released into air and water and have been found in the blood of people who rely on downstream drinking water," said N.C. State University epidemiologist Jane Hoppin, when responding to questions about the new Duke research and the EPA's proposal.

"In our research, PFMOAA was detected at the highest levels in blood samples collected more than a year before the contamination was publicly identified," she said. "Other byproducts of PFAS — Nafion byproduct 2 and PFO5DoA — were found in nearly all Wilmington residents tested in 2017 and remain in people's blood today. We need more, not less, information about chemical byproducts to ensure drinking water safety."

"The mission of the EPA, in the beginning, was to protect the public and the environment," said Robert Bullard, a professor of urban planning and environmental

environmental justice movement. “Anytime you’re relaxing rules that would not only threaten the environment but also compromise public health — that’s the wrong way to go.”

The public comment period is open through Dec. 29. To submit a comment, go to: https://www.regulations.gov/commenton/EPA-HQ-OPPT-2020-0549-0311.

Tags Environment | PFAS | Pollution | Environmental Protection Agency

Environment

Study shows dangers of ‘forever chemicals’ on babies

Mothers in New Hampshire who were downstream of sites contaminated with “forever chemicals” experienced triple the rate of infant deaths, according to a new study.

December 9, 2025

By Amudalat Ajasa

Mothers in New Hampshire who were downstream of sites contaminated with “forever chemicals” experienced triple the rate of infant deaths and had more premature births or babies with low birth weights, according to a new study released Monday.

The analysis by a team of economists, published in the journal Proceedings of the National Academy of Sciences, sampled data from more than 11,000 births between 2010 and 2019. Researchers looked at how per- and polyfluoroalkyl substances, also known as PFAS, affected fetal health after these chemicals contaminated the drinking water supply.

While some experts cautioned that the study focused on a small subset of the overall U.S. population, the findings underscore the potential risks of a class of over 10,000 compounds that have been widely used in nonstick cookware, food packaging and waterproof clothing.

These chemicals, which make products resistant against oil, water and stains, have been linked to several kinds of cancer, birth defects and damage to the liver and immune system, among other health problems. They have been detected in nearly half of the nation's drinking water and in the blood of nearly every American.

Researchers from the University of Arizona took advantage of a natural experiment in New Hampshire, identifying mothers who were unknowingly exposed to PFAS from 41 contaminated sites, and comparing those living downstream and upstream of the locations using groundwater flow data.

The study found that mothers drinking water downstream of sites contaminated with PFOA and PFOS — both of which are considered likely carcinogens — lost their child during their first year at a 191 percent higher rate than average, with a total of 35 extra deaths. They also experienced preterm births at a 20 percent higher rate, and low-weight births at a 43 percent higher rate.

“These are very rare outcomes,” said Ashley Langer, one of the study’s co-authors and an economic professor at the University of Arizona.

The mothers living downstream from the contaminated water were from higher-income households compared to those living upstream, the researchers noted, suggesting that they did not lack access to medical care or the ability to filter water. Dive deeper

“We generally think and see in the data that birth outcomes are better for higher-socioeconomic-status mothers,” said Derek Lemoine, a co-author and professor of economics at the University of Arizona, adding that the data suggests that “if there weren’t a PFAS site there, you would think that they would have better birth outcomes.”

Previous research has linked high levels of PFAS exposure duri
systems in infants, while others have found that the toxic conta
breast milk.

But this study “provides rare causal evidence,” said Kate Hoffm
environmental natural sciences at Duke University.

“The authors use a clever design that gives unusually convincing evidence of a causal effect, not just a correlation,” said Hoffman, who is also an associate professor of pediatrics.

The American Chemistry Council, an industry trade group, said in an email that the study’s limitations, which include a reliance “on modeled exposure rather than direct measurements,” mean that “any conclusions about causality remain highly uncertain.”

Still, Laurene Allen, co-founder of the Merrimack Citizens for Clean Water in New Hampshire, said women in her community, including herself, have faced health challenges they attribute to a local fabric coating operation that used PFAS. The study, she said, validates their experience.

“We do see a pattern here,” said Allen, who was the 2025 North American Goldman Environmental Prize Winner for her anti-pollution work. “What we see is the most vulnerable population in utero, infants, and after birth, are going to be the most impacted.”

Nearly half of the residents in New Hampshire rely on private wells as a primary drinking water source. Unlike water from public water utilities, private wells are not subject to federal water regulations.

This spring, the Environmental Protection Agency proposed weakening drinking water standards for the chemicals set under the Biden administration.

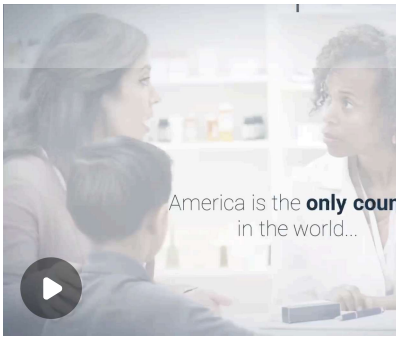
More than 172 million Americans are exposed to PFAS through drinking water, according to EPA data analyzed by the Environmental Working Group, an advocacy organization. Sydney Evans, the group’s senior science analyst, said the study underscores the need for stronger federal standards.

“This is just one more piece of evidence that the public is bearing the cost of that contamination,” Evans said.

The EPA had estimated that it would cost utilities $1.5 billion a year to comply with the Biden-era rule, which required them to test for and reduce levels of six common PFAS contaminants in drinking water.

But the authors of the new study argue that if their finding were extrapolated across the country, Americans might be bearing up to $7.8 billion in annual health and wage costs from exposure to these chemicals.

“The water utility customers are going to bear the cost of cleaning PFAS up, but they’re also bearing the real cost of the health outcomes and the infant outcomes from drinking PFAS,” Lemoine said.



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PNAS RESEARCH ARTICLE | SUSTAINABILITY SCIENCE

PFAS-contaminated drinking water harms infants

Robert Baluja[a], Bo Guo[b], Wesley Howden[c], Ashley Langer[d,e], and Derek Lemoine[d,e,1]

Affiliations are included on p. 9.

Edited by Catherine Kling, Cornell University, Ithaca, NY; received April 24, 2025; accepted October 22, 2025

There is evidence of widespread human exposure to per- and polyfluoroalkyl substances (PFAS) but limited evidence of the human health impacts of this exposure. Using data on New Hampshire births from 2010–2019, we show that mothers receiving water that had flowed beneath a PFAS-contaminated site, as opposed to comparable mothers receiving water that had flowed toward a PFAS-contaminated site, had 191% [95% CI: 83–298%] higher first-year infant mortality (611 [268–955] additional first-year deaths per 100k births); 168% [42–294%] more births before 28 wk of gestational age (466 [116–817] additional such births per 100k births); and 180% [57–302%] more births with weight below 1,000 g (607 [192–1022] additional such births per 100k births). Extrapolating to the contiguous U.S., PFAS contamination imposes annual social costs of approximately $8 billion. These health costs are substantially larger than current outside estimates of the cost of removing PFAS from the public water supply.

PFAS | water pollution | reproductive health | infant mortality | birthweight

Significance

Per- and polyfluoroalkyl substances (PFAS), so-called "forever chemicals," are pollutants of increasing concern. However, there is not yet firm evidence that the types of PFAS exposure occurring in daily life cause human health impacts. We show that New Hampshire mothers whose drinking water wells were downstream of PFAS releases had more extremely low-weight births, more extremely preterm births, and higher infant mortality than did mothers whose wells were upstream of PFAS releases. Mothers did not know the locations of their wells and so should be comparable but for their PFAS exposure. Extrapolating to the rest of the United States, PFAS impose billions of dollars of costs on U.S. residents each year by worsening infant health.

Policymakers and scientists are increasingly concerned about the potential for per- and polyfluoroalkyl substances (PFAS) to impact human health (1, 2). These extremely persistent chemicals serve a range of industrial and household purposes (3), from firefighting foams to nonstick coatings. PFAS have been found throughout the global environment (4, 5), including in drinking water systems (6–8), groundwater resources (9, 10), and human blood samples (11, 12). Regulatory bodies around the world are studying and enacting controls that include restrictions on production, imports, use, and disposal (13–15). However, a lack of epidemiological evidence for causal impacts on human health has hampered regulatory efforts to control PFAS (16). Here we provide evidence of a causal link from PFAS exposure to human health in real-world populations.

We study the impacts of PFAS on reproduction, an area of particular concern. Animal toxicology studies suggest that PFAS can lower birthweight (17), but whether the types of PFAS exposure that occur in daily life rather than in the lab affect human reproduction has not been clear, both because results are mixed and because human studies have nearly all been associational rather than causal (18). Human epidemiological studies have examined the relationship between PFAS measured in (maternal or cord) blood serum and birth outcomes. Results are mixed (19–22), with some studies finding an association with preterm births and/or low-weight births and other studies not finding an association with either or both of these outcomes. Moreover, even when an association is detected, it is possible that an additional health factor drives both PFAS measurements and birth outcomes. For example, poor maternal kidney functioning can cause both high blood PFAS levels and low birthweight (23, 24).

Here, we link exposure to PFAS through public water systems to infant mortality, preterm births, and low-weight births. When a population has PFAS in its water supply, drinking water becomes its primary source of exposure (22, 25, 26). Prior studies have measured the correlation between drinking water systems' PFAS and reproductive outcomes, again with mixed results (27, 28), and have tested how a community's installation of a water filtration system changed birth outcomes relative to other communities (29). However, these prior studies might not capture the causal effect of PFAS. First, households who choose to live in areas served by water systems with more PFAS contamination (27, 28), or in areas that have not yet cleaned up PFAS contamination (29), may be different from households who choose to live in areas with less contamination or that have cleaned up contamination (30). These differences may be due to health preferences or may be a response to PFAS contamination lowering house prices (31). Either way, households' sorting into and out of PFAS exposure might generate a spurious correlation between PFAS contamination and reproductive outcomes. Second, households may undertake preventive actions such as purchasing bottled water when public water systems either contain more PFAS or plan to install a filtration

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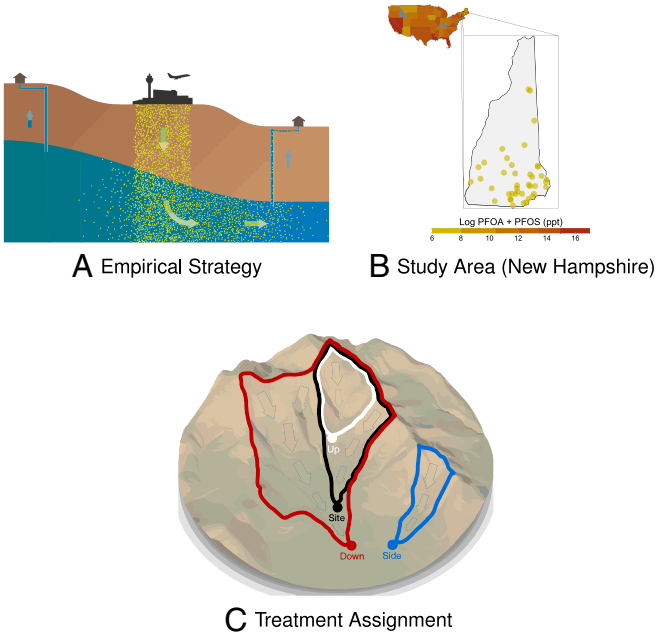

Fig. 1. (*A*) Our empirical strategy compares reproductive outcomes among households who receive water from wells that draw groundwater flowing either to or from a PFAS-contaminated site (here, an airport). (*B*) The study region comprises circles of 5 km radius centered on each PFAS-contaminated site. Circles are colored by the level of PFAS attributed to each site. The map of the United States is colored by the maximum level of confirmed PFAS contamination within each state. Both are measured in log-scale (ppt). (*C*) Groundwater flows downhill. The PFAS-contaminated site ("Site") is in the catchment area (outlined in red) of the downgradient well ("Down"). The upgradient well ("Up") is within the catchment area of the contaminated site (outlined in black). The remaining well ("Side") and the contaminated site are outside of each other's catchment areas (outlined in blue and black, respectively).

system (32). These preventive actions may obscure the true causal effect of PFAS contamination on reproductive outcomes.

We rely on variation in PFAS exposure that we argue is as good as random. In particular, we compare reproductive outcomes among mothers whose homes receive water piped from wells on groundwater flowing toward a source of PFAS contamination with reproductive outcomes among mothers whose homes receive water piped from wells on groundwater flowing from a source of PFAS contamination (Fig. 1*A*). To do so, we combine geocoded data on all births and infant deaths among New Hampshire residents from 2010–2019 with the locations of PFAS-contaminated sites and public drinking water wells (Fig. 1*B*). We compare mothers who live similar distances from contaminated sites. Because the locations of public water wells are confidential, these mothers should not know whether they receive water from a well whose groundwater flows to or from a contaminated site. As a result, we compare mothers who should not have differentially chosen where to live based on potential PFAS exposure and should not differentially take actions to mitigate PFAS exposure.

In our primary analysis, we study 41 sites with contamination of the two most prominent PFAS, perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), above 1,000 ppt (*SI Appendix*, section A). These sites are mostly contaminated by industrial sources and landfills, but some are contaminated by fire fighting related activities. We focus on groundwater supplies for several reasons. First, it is more straightforward to connect water supplies to contamination when on groundwater because the contamination is typically persistent [driven by PFAS-impacted soils (33)] where PFOA and PFOS slowly leach to the water table (34). In contrast, surface water contamination can vary with current polluting activities and migrates further over a broader region. Second, preexisting treatment plants for groundwater systems rarely remove PFAS (35). Third, groundwater is more challenging to sample and test than surface water, making it more likely that mothers do not know their exposure. Finally, short-chain species of PFAS, which may have different health implications and may require different removal techniques, are generally much less abundant than PFOA and PFOS in groundwater (36, 37).

Framework for Testing the Effects of Receiving Water Flowing From a PFAS-Contaminated Site

To implement our empirical strategy, we develop a multivariate regression framework (38, 39) that relates birth outcomes to exposure to PFOA and PFOS (*Materials and Methods*). We study whether a baby dies within their first year of life ("infant mortality"), whether a birth occurs before 37 wk ("preterm"), and whether a baby's birthweight is below 2,500 grams ("low birthweight"). We also distinguish degrees of prematurity and degrees of low birthweight. Using conventional thresholds (40, 41), we separately test for effects of PFAS on moderately preterm births (between 32 and 36 wk), very preterm births (between 28 and 31 wk), and extremely preterm births (less than 28 wk). And again using conventional thresholds (39, 42), we separately test for the effects of PFAS on moderately low-weight births (between 1,500 and 2,500 grams), very low-weight births (between 1,000 and 1,500 grams), and extremely low-weight births (less than 1,000 grams).

A location's "catchment area" is the area upslope from it, so that water flows to a location from the points in its catchment area. PFAS released in a location's catchment area plausibly end up at the location, and PFAS released elsewhere plausibly do not. We proxy for the direction of groundwater flow with high-resolution data on land surface topography. The correlation between groundwater flow and surface topography is widely accepted and used in the hydrological sciences (43–45). *SI Appendix*, section L provides direct evidence of this correlation in our study area.

We calculate whether each public well in our data is within the catchment area of a PFAS-contaminated site and whether a PFAS-contaminated site is within the catchment area of the well (*Materials and Methods*). We classify a well as "downgradient" if at least one nearby (i.e., within 5 km) contaminated site is within its catchment area. If the well is not downgradient, then we classify it as "upgradient" if it is within the catchment area of every nearby contaminated site. Otherwise we classify the well as to the "side." Within our multivariate regression framework, the coefficient on the downgradient indicator gives the effect on birth outcomes of receiving water from a well downgradient of some nearby contaminated site relative to receiving water from a well upgradient of all nearby contaminated sites.

Fig. 1*C* illustrates this assignment. The *Top* of the figure is a hilltop. Groundwater flows from this peak toward a contaminated site (black dot). The well at the red dot is downhill from the contaminated site. Its catchment area (outlined in red) includes the contaminated site. Because PFAS flow from the contaminated site to the well at the red dot, we classify that well as downgradient.

In contrast, the well at the white dot is uphill from the contaminated site. The catchment area of the contaminated site

(outlined in black) includes the well at the white dot and all of its catchment area (outlined in white). Because PFAS flow from the well at the white dot to the contaminated site, we classify that well as upgradient with respect to this contaminated site.

The well at the blue dot is in the valley on the other side of a ridge from the contaminated site. The contaminated site is outside that well's catchment area (outlined in blue), and the well is outside the contaminated site's catchment area (outlined in black). We classify the well at the blue dot as to the side with respect to the contaminated site.

We test whether mothers who receive water from wells like that at the red dot have worse birth outcomes than mothers who receive water from wells such as that at the white dot. We use demographic, environmental, medical, house, and well control variables and both county and year-by-month fixed effects to make the mothers as similar as possible (*Materials and Methods* and *SI Appendix*, section B). Our regression framework compares births in the same month, in the same county, to observably similar mothers, some of whom are provided with water from public wells upgradient of a contaminated site and some of whom are provided with water from public wells downgradient of a contaminated site.

Birth Outcomes Are Worse Among Mothers Served by Wells Whose Water Flows From a PFAS-Contaminated Site

We find that being served by a well downgradient from a PFAS-contaminated site causes worse birth outcomes. Fig. 2 reports estimates as a percentage change in the base rate of that reproductive outcome in the sample (*SI Appendix*, section G reports results as additional births per 100,000 births). The panel across the top reports results for infant mortality. In the *Lower* panels, the *Left* column contains results for preterm births and the *Right* column contains results for low-weight births. Within each column, the *Upper* panels report results for all preterm or low-weight births and the *Lower* panels report results for extremely preterm or extremely low-weight births. Significance tests are relative to a null hypothesis of a weakly negative effect of PFAS exposure.

In our baseline specification (*Top* row in each panel), we estimate that being served by a well downgradient of a PFAS-contaminated site, as opposed to being served by a well upgradient of a PFAS-contaminated site, increases the chance of a baby dying during their first year of life by 191% [95% CI: 83%–298%, $P < 0.001$] (611 [268–955] additional deaths per 100k births), increases the chance of a preterm birth by 20% [−4.0–44%, $P = 0.06$] (1,475 [−291–3,240] additional preterm births per 100k births), and increases the chance of a low-weight birth by 43% [19–68%, $P < 0.001$] (2,639 [1,164–4,114] additional low-weight births per 100k births). *SI Appendix*, section G reports results for births that are moderately and very preterm or moderately and very low-weight. We do not have hypotheses regarding how the number of births in these less severe categories of preterm and low-weight births should change, because our estimated effects net out shifts into these less severe categories from healthier categories with shifts from these less severe categories into more severe categories. However, we do have hypotheses regarding how the number of births in the most severe categories should change. Indeed, Fig. 2 shows that we estimate large and statistically significant (at the 1% level) effects on the most severe categories of preterm and low-weight births: The chance of an extremely preterm birth increases by 168% [42–294%, $P = 0.007$] (466 [116–817] additional such births per 100k births), and the chance of an extremely low-weight birth increases by 180% [57–302%, $P = 0.004$] (607 [192–1,022] additional such births per 100k births).

The remaining rows demonstrate the robustness of our primary results. The second row drops mothers from the sample if their drinking water comes from a well within 1km of a contaminated site. These mothers are more likely to be misassigned because the topography-based groundwater flow direction may be less accurate at a smaller scale of 1km (e.g., groundwater flow and PFAS may transport from lower to higher elevation due to local spatial heterogeneities). These mothers may also be more likely to be aware of the contaminated site. The third row drops

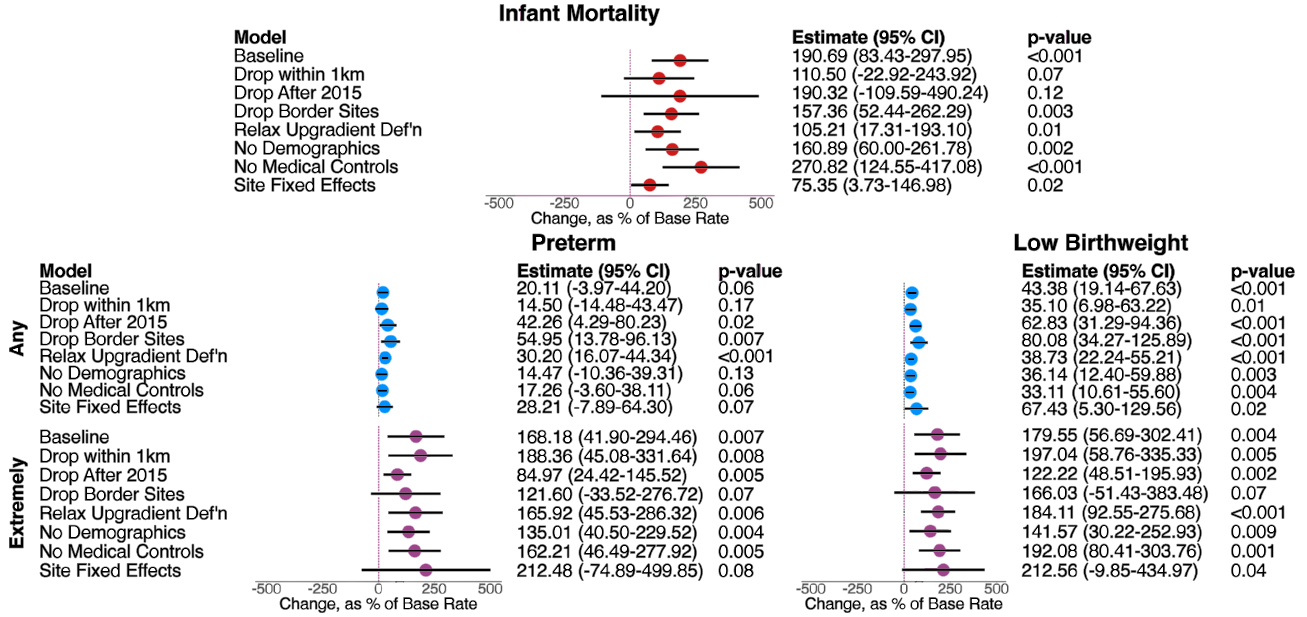

Fig. 2. Estimated effects of a mother being served by a downgradient well instead of an upgradient well, by reproductive outcome. Effects reported as percentage increases in the base rate of that reproductive outcome. Reported *P*-values are for one-sided tests of a null hypothesis of a weakly negative effect.

births after 2015 (so keeping births in 2010–2015), when the State of New Hampshire began a testing program. This testing program might have raised awareness of PFAS, which could have led households to attempt to sort on exposure or to take preventive actions regardless of exposure. The fourth row drops contaminated sites within 5 km of a state border, in case PFAS could have flowed to wells from unobserved contaminated sites beyond our study area. The fifth row applies a less stringent definition of upgradient, requiring only that a well be upgradient of *some* nearby contaminated site (rather than of *all* nearby contaminated sites) while not being downgradient of any nearby contaminated site. The control population becomes more likely to include individuals who have been treated to some degree, which would work to attenuate estimates (as we indeed see for infant mortality). The sixth and seventh rows remove all demographic and medical control variables, respectively. The final row includes contaminated site fixed effects so that, at the cost of power to detect a true effect, we compare mothers whose wells are near the same contaminated site. *SI Appendix*, section D changes the radius used to define "nearby" contaminated sites. Our results are remarkably robust to each of these alternate specifications.

Several additional results reinforce our primary analysis. *SI Appendix*, section G shows that being served by a well that is upgradient of a contaminated site (relative to a well classified as to the side) does not significantly increase the chance of infant mortality, of a preterm birth, or of a low-weight birth—and in some specifications significantly decreases the chance of those births. It also shows that being served by a well downgradient of a contaminated site increases the chance of a low-weight birth by 87% [37–137%, $P < 0.001$] even among full-term babies and, dropping the preterm and low-weight categorizations, reduces gestational length by 0.18 [0.004–0.4, $P = 0.03$] weeks and weight by 50 [12–88, $P = 0.008$] grams on average (with P-values for a null hypothesis of a weakly positive effect of PFAS exposure). It reports suggestive evidence that birth outcomes are worse for mothers who receive water from wells that are closer to contaminated sites. It shows that our results are not driven by exceptionally contaminated sites, by limiting our definition of downgradient to the well nearest a mother's residence, or by excluding surface water sources. And it shows that effects of being served by a well downgradient of a contaminated site are broadly similar for mothers who were long-term and short-term residents, with suggestive evidence of stronger effects on some outcomes for the longest-term residents.

Several additional tests suggest interpreting our results as causal. First, *SI Appendix*, section C shows that downgradient mothers tend to be of higher socioeconomic status, which one would expect to bias us against finding that PFAS exposure negatively affects infant health. *SI Appendix*, section E shows that if upgradient and downgradient mothers differed only in their observed socioeconomic and demographic characteristics (and not also in their exposure to PFAS), then we would expect infant health outcomes to be similar between the two groups—and if anything, we would expect infant mortality and birthweight to be better among downgradient mothers. Second, *SI Appendix*, section F tests whether we would estimate similarly significant effects of being downgradient if we assigned random locations around New Hampshire to be "contaminated sites." It shows that downgradient wells are not generically associated with worse birth outcomes than upgradient wells. Finally, *SI Appendix*, section M shows that we obtain qualitatively similar results for preterm births and low-weight births in an out-of-sample test that uses coarser data available for New York State.

PFAS Impose Costs Throughout the United States

We use our estimated health impacts to learn about the aggregate importance of PFAS as a public health problem in the United States. We calculate the social costs imposed by PFAS in three steps.

First, instead of estimating the effect of a mother being served by a downgradient well, we estimate a continuous measure of the effect of a mother being served by a well that we project as having greater PFAS in its groundwater. Fig. 3*A* reports the estimated effect of increasing the PFAS concentration by 100 ppt, which is approximately half of the median concentration predicted for the estimation sample's wells (*Materials and Methods*). We estimate that being served by a public well predicted to have more PFAS significantly increases the chances of infant mortality ($P = 0.012$) and also significantly increases the chance of a preterm ($P < 0.001$) or low-weight ($P < 0.001$) birth. As in Fig. 2, effects are especially large for the worst health outcomes.

Second, we impute PFAS concentrations around each contaminated site in 11 U.S. states with PFAS testing programs by combining topographical data with data on PFAS contamination (46) (*Materials and Methods*). We combine those imputed PFAS levels with data on births close to the contaminated sites and with our estimated effects of PFAS from Fig. 3*A* in order to predict the change in a year's birth outcomes around each contaminated site. The blue bars in Fig. 3*B* (*Left* axis) tally these effects across the 11 states. We estimate around 400 additional deaths, over 1,000 additional preterm births (of which around 600 are extremely preterm), and over 1,000 additional low-weight births (of which around 850 are extremely low-weight).

Finally, we combine these estimates with the social cost per reproductive outcome (*Materials and Methods*). The lifetime social costs from a preterm birth include additional medical costs for the child, additional delivery costs at birth, additional educational services, and lost labor productivity. These costs increase sharply in the degree of prematurity (40). The lifetime social costs from a low-weight birth include increased mortality in the first year, increased medical costs and disabilities, lost adult income, and increased long-term mortality risk. *SI Appendix*, section I details the calculations, which are based on several sources (39, 47, 48). We do not have social cost estimates per moderately low-weight birth. Our calculations are conservative in that we assume that the extra children born in one category would have otherwise been born in the next-most severe category. For the social cost of infant mortality, we conservatively assume that, had they survived through birth, these babies' life expectancies, quality of life, and medical outcomes would have been comparable to babies with extremely low birthweight, from ref. 49. The red hatched bars in Fig. 3*B* (*Right* axis) show that social costs in the 11 states are dominated by infant mortality and extremely low-weight births. Fig. 3*C* maps the lifetime social costs imposed by additional low-weight births on each year's birth cohort.

Fig. 3*D* aggregates social costs across the categories of preterm births and across the categories of low-weight births. It adds the social costs of infant mortality to the social costs of preterm births because the latter do not account for mortality risk. The purple bars plot the costs imposed on each year's birth cohort in the 11 states, which amount to $1.9 billion for preterm births and infant mortality and $2.7 billion for low-weight births. Likely sources of PFAS contamination are found throughout the United States (50). The hatched green bars scale our estimates to the whole U.S. by assuming that PFAS testing was comprehensive in those 11 states and that PFAS exposure in those 11 states

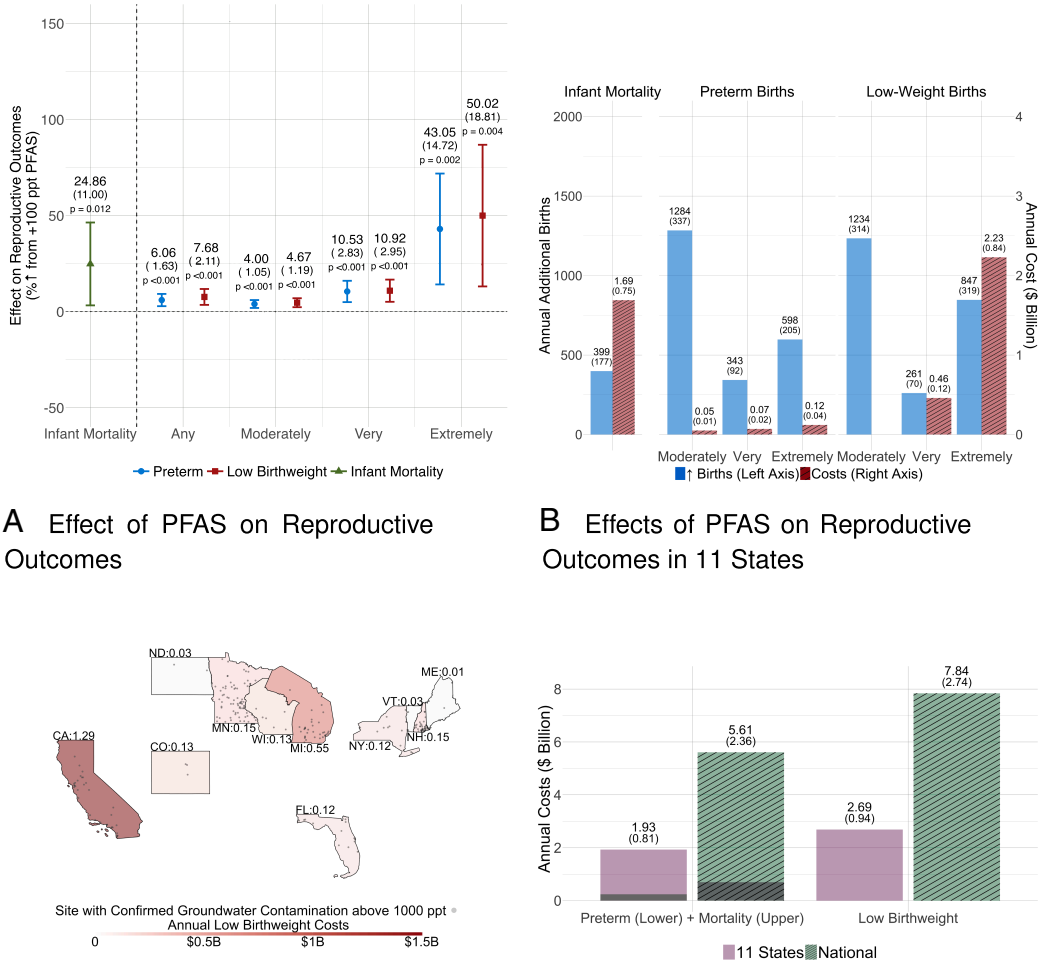

Fig. 3. (*A*) Estimated effect of a 100 ppt increase in PFAS at the median PFAS level, with 95% CIs. Labels give the point estimate, the SE (in parentheses), and the one-sided *P*-value for a null of a weakly negative effect. (*B*) Estimated change in annual rates of infant mortality, of preterm births, and of low-weight births (in blue). Social costs (hatched red bars) are lifetime social costs for an annual birth cohort. SEs in parentheses. (*C*) Map of lifetime social costs from each year's additional low-weight births, by state. (*D*) Social costs from infant mortality and preterm births (*Left*) and from low-weight births (*Right*) in the 11 states with data on contaminated sites (purple) and extrapolated to the contiguous U.S. (green, hatched).

is representative of exposure in the other states (*Materials and Methods*). We estimate costs per annual birth cohort of $5.6 billion from preterm births and infant mortality and of $7.8 billion from low-weight births. *SI Appendix*, section G shows that PFAS exposure increases infant mortality and extremely preterm births even after controlling for birthweight. The lifetime social costs across all three types of birth outcomes are therefore greater than the $7.8 billion we estimate from low-weight births alone.

Discussion

We have shown that PFAS exposure causes worse birth outcomes across the population of the U.S. state of New Hampshire. Extrapolating to the population of the United States, we estimate that PFAS generate at least $2.7 billion in annual costs in just the 11 states with a high level of testing—and at least $7.8 billion in annual costs nationwide. Either cost estimate far exceeds the estimated $1.5 billion in annual health benefits generated by the new U.S. PFAS rule (51). The national cost estimate also far exceeds even high-end estimates (of around $3.8 billion) of the cost of cleaning up PFAS to achieve this rule (52).

Our estimates are likely to be a lower bound on the true effects of PFAS on reproductive outcomes. Our assignment of mothers to treated and control groups is likely to be noisy: Both our matching of mothers to public wells and our calculated groundwater gradients are imperfect. In particular, some of the wells assigned as downgradient (or otherwise predicted to have high PFAS) may not be highly contaminated, whereas others assigned as upgradient or off to the side (or otherwise predicted to have low PFAS) may in fact be contaminated. Moreover, mothers are likely to drink water from other sources, including when out of the house, which reduces the strength of our treatment. All such complications should work to attenuate our estimates toward zero, which makes the strength and robustness of our estimated effects both more notable and more socially concerning.

Our estimated social costs are also likely to be lower bounds. In particular, our social costs per reproductive outcome assume that additional births would have otherwise come from the next-most severe category. However, some of the additional extremely preterm or extremely low-weight births are likely from babies who would have otherwise been above 31 wk or 1,500 g, respectively. Similarly, it is likely that some of the babies who died within

their first year of life would have experienced better life outcomes, measured by their quality of life and overall life expectancy, than babies born in the extremely low-weight category. By ignoring the potential movement of birth outcomes across multiple categories, we conservatively underestimate social costs.

Our estimated social costs are also a lower bound on the total social cost of PFAS because they include only the monetized portion of reproductive harms due to PFAS. Concurrent work suggests that early PFAS exposure reduces earnings and college completion (53). Some of these long-run consequences may be due to the effects on birthweight or gestational age that we estimate here, but to the extent that these consequences are additional to our estimates, their costs should be added to our social costs. In addition, PFAS are widely believed to cause a range of medical (2), ecological (3), and developmental (54) harms. Future work should seek causal estimates of these other effects from effectively random real-world exposure.

One limitation of the current study is that we do not observe the history of exposure. As a result, we do not know how the effects of PFAS vary with the duration of exposure or how rapidly cleaning up PFAS may provide benefits. We do find that outcomes are broadly similar among short- and long-term residents, which suggests that benefits from cleaning up PFAS could accrue rapidly. Future work should seek to distinguish short- and long-term impacts.

Another limitation of the current study is that our extrapolation uses only PFOA and PFOS, which are two of the more prominent species of PFAS. These two chemicals may be correlated with other pollutants, including other species of PFAS (*Materials and Methods*). Our estimated health impacts in New Hampshire then capture the broader costs of unregulated pollution associated with PFAS sources. Our estimated social costs are still well-defined even if other pollutants contribute to them: They define the benefits of installing PFAS-removal technologies such as granular activated carbon filtration as long as these technologies clean up correlated pollutants (*Materials and Methods* for why this is likely to be the case). When we extrapolate health impacts to other states, we implicitly hold correlations with other pollutants constant over space. It is not obvious if these correlations do in fact vary substantially over space or how such variation would affect our extrapolation.

Finally, we use data from New Hampshire because that is the only state for which we were able to obtain data on PFAS-contaminated sites, groundwater wells, and individual births. Supplemental analyses (in *SI Appendix*, sections D and H) show that our estimated effects appear to be similar for more- and less-contaminated sites and are approximately constant in the level of PFAS we predict for a mother's well. These results suggest that other states' PFAS-contaminated sites could have similar effects as in New Hampshire. On the other hand, New Hampshire has limited variation in mothers' demographics, which could affect how PFAS exposure translates into infant health. As more data become available, future work will have more power to assess how sensitivity to PFAS may vary with mothers' characteristics.

Materials and Methods

Data. Our analysis uses five primary sources of data, detailed in *SI Appendix*, section A. First, we use the universe of birth records for infants born to New Hampshire residents from 2010–2019, obtained from the New Hampshire Department of Health and Human Services. We match these birth records with the universe of death records for New Hampshire residents who die within their first year of life. The University of Arizona Institutional Review Board determined that our study was exempt. Second, we obtain locations served by public water systems and locations of groundwater-sourced public wells from the New Hampshire Department of Environmental Services. These data, particularly the locations of public wells, are not publicly available due to homeland security concerns. To receive access, one must apply directly to the New Hampshire Department of Environmental Services. Third, our set of contaminated sites comes from the Northeastern University PFAS Lab's set of sites with known PFOA/PFOS releases to nearby groundwater (46). Fourth, we use groundwater PFAS measurements from tests undertaken by the New Hampshire Department of Environmental Services. Fifth, we obtain a high-resolution digital elevation model of the state (55). Sixth, we obtain data on wind direction, air pollution, temperature, demographics, catchment area boundaries, and toxic contaminated sites from various sources.

Sample Construction. We use land surface topography from the high-resolution digital elevation model as the determinant of groundwater flow. The strong correlation between land surface topography and the direction of groundwater flow was first shown theoretically by ref. 43 and has since been widely validated and accepted in the field of hydrology (44, 45). We provide direct evidence of this correlation in New Hampshire at 13 sites for which detailed data on the groundwater table are available (*SI Appendix*, section L). For each PFAS-contaminated site and public well, we calculate its catchment area as the area from which water would flow to the given location, using the `Watershed` tool in Whitebox Tools.

In our base specification, we restrict attention to contaminated sites with concentrations above 1,000 ppt and define nearby contaminated sites as those within 5 km of a well (*SI Appendix*, section D assesses robustness to the 1,000 ppt and 5 km thresholds). If there exists at least one nearby contaminated site within the catchment area of a well, then we classify the well as downgradient and match it to the nearest such site. Otherwise, if a well is within the catchment areas of all nearby contaminated sites, then we classify it as upgradient and match it to the nearest such site. The wells that are classified as to the side are those that do not have any nearby contaminated site within their catchment areas but that also have some nearby contaminated site that is not clearly downstream of the well. We match these wells to the nearest contaminated site. If a well does not have any contaminated site within 5 km, then we drop the well from the sample. *SI Appendix*, section K provides more details of groundwater calculations and well classification. Our classification of wells as upgradient, downgradient, or to the side is conservative in that we place all wells that are plausibly treated by a nearby contaminated site into the downgradient group and we reserve the upgradient group only for wells that are clearly not treated by any nearby contaminated site (i.e., that are clearly a good control population). *SI Appendix*, section G shows that downgradient classification is positively correlated with the probability of PFAS at a well from ref. 56 and that upgradient classification is negatively correlated with the probability of PFAS at a well from ref. 56.

To assign mothers to public wells, we overlay a map of public water system (PWS) service areas onto the set of points representing the location of maternal residences, as found in the birth record data. We remove all individuals who reside in the service area of a system that receives its water solely from surface water sources or imports its water from nonlocal sources. We also discard all births to mothers who reside outside of the service area for any PWS. With the PWS of each mother determined, we attribute a mother's water source to the well within that PWS that is nearest to her residence. *SI Appendix*, section G assesses robustness to this assignment.

Our final sample drops individuals with missing data for any of the covariates used in our regression framework. (*SI Appendix*, section G shows that including these covariates does not appreciably alter our results. In addition, Fig. 2 includes specifications in which we drop medical and demographic controls and do not drop individuals missing the dropped covariates. These specifications again show that missing covariates do not drive our results.) Our final sample contains 11,539 births. *SI Appendix*, section C details how many births survive each of our sample restrictions and contains balance tables.

Regression Model: Effects of Being Downgradient. Our main analysis takes advantage of a spatial discontinuity: The groundwater beneath some drinking water wells contains PFAS from a contaminated site, whereas the groundwater beneath other drinking water wells does not contain PFAS from a contaminated site. Spatial boundaries have been used to identify causal effects in other contexts

(57–59). In order for this analysis to capture the causal impact of PFAS on infant health outcomes, it must be the case that mothers receiving water from wells that are near PFAS-contaminated sites but upgradient of those sites would, but for PFAS, have similar infant health outcomes as mothers receiving water from wells that are near PFAS-contaminated sites but downgradient of some contaminated site, conditional on the control variables. *SI Appendix*, section C shows that mothers receiving water from wells that are near PFAS-contaminated sites but downgradient of a contaminated site are, if anything, of higher socioeconomic status than mothers receiving water from wells that are near PFAS-contaminated sites but upgradient of those contaminated sites. *SI Appendix*, section E confirms that these differences imply that, if not for PFAS exposure, infant health outcomes would be broadly similar among these mothers and, if anything, would tend to be better among downgradient mothers.

In our main analysis, we estimate equations of the following form:

$$H_{ict} = \gamma Up\_or\_Down_{ict} + \beta Down_{ict} + \Gamma X_{ict} + \eta_c + \nu_t + \epsilon_{ict} \quad [1]$$

for birth i in county c and month t. In each equation, H_{ict} is the health outcome of interest, which can be an indicator for mortality within one year of birth, for a preterm birth, for a low-weight birth, or for a subcategory thereof. $Up\_or\_Down_{ict}$ is an indicator that is equal to 1 if the mother in birth i receives water from a well that is classified as either upgradient or downgradient of a contaminated site and is equal to 0 if the well is classified as to the side, relative to groundwater flow. $Down_{ict}$ is an indicator variable that is equal to 1 if the mother in birth i receives water from a well that is classified as downgradient and is equal to 0 if the well is not. The coefficient γ gives the effect of a well being upgradient of a nearby contaminated site relative to being to the side. The coefficient of interest is β, which gives the effect of a well being downgradient of some nearby contaminated site relative to being upgradient of all nearby contaminated sites. X_{ict} is a vector that contains an extensive set of demographic, environmental, medical, house, and well control variables, detailed in *SI Appendix*, section B. η_c and ν_t are county and year-by-month fixed effects, respectively.

In the main text, we report results in terms of the percentage change in the base rate: Letting $\hat{\beta}$ indicate the estimated coefficient and $\bar{H}$ indicate the average value of H_{ict} in the estimation sample, we report $100 \cdot \hat{\beta}/\bar{H}$. We hold $\bar{H}$ fixed across robustness checks. We estimate SEs that are robust to two-way clustering at the contaminated site level (in order to account for possible unobserved correlation among mothers near a given contaminated site) and at the year-by-month level (to account for possible unobserved correlation among mothers within a time period).

Including fixed effects at the county level absorbs the average effect of being in one county or another. Our estimates therefore only use the variation in outcomes across upgradient mothers and downgradient mothers within the same county, not across counties (60). Analogously, our year-month fixed effects mean that our estimates use the variation in outcomes across upgradient mothers and downgradient mothers who gave birth within the same month of a given year. And our vector of control variables means that our estimates implicitly compare upgradient mothers to downgradient mothers who have similar houses, wells, demographics, etc. This means that, while we use data on individual births across different counties, months, and maternal characteristics, our estimates implicitly compare upgradient mothers and downgradient mothers who gave birth within the same month and the same county and who have similar houses, wells, demographics, etc.

Other pollutants besides PFAS could differ between upgradient and downgradient mothers. Indeed, some other pollutants are known to co-occur with PFAS. To the extent that other pollutants do covary with PFAS around contaminated sites, our estimates capture the health impact of PFAS and associated pollutants. The primary water pollutants found to covary with PFAS are 1,4-dioxane and chromium-6 (61). However, both were regulated in New Hampshire prior to our study period, and are therefore likely to be removed by existing water system technologies (62, 63). Moreover, 1,4-dioxane is not known to affect reproductive or developmental outcomes (64), and water systems that violate chromium standards must warn customers only of the possibility of allergic dermatitis (65). The co-occurring pollutants that would affect our health estimates are unregulated pollutants such as microplastics, pharmaceuticals, and species of PFAS beyond PFOA and PFOS, provided that they are present in groundwater during our study period. Below we discuss the implications of these emerging pollutants for our social cost estimates.

Regression Model: Effects of Predicted PFAS. In our secondary analysis, we use a two-sample instrumental variables (IV) model (60), in which we first predict PFAS at the well level (a form of exposure estimation) and then relate predicted well-level PFAS to birth outcomes. This analysis allows us to understand how different concentrations of PFAS at contaminated sites–and wells–affect infant health, which is useful for moving to a national analysis of the potential impact of PFAS on infant health. We take this two-sample approach because we do not observe PFAS contamination at all of the wells in our sample: In a first-stage regression, we predict well-level PFAS contamination given the spatial relationship between the contaminated site and the well, soil characteristics, and local control variables, and in a second stage, we regress infant health outcomes on predicted PFAS contamination from the first stage. This IV approach can be used to handle issues of measurement error (here, missing well-level contamination data) under two assumptions. First, the instruments (downgradient indicator, distance from the contaminated site to the well, and soil characteristics) must be correlated with well-level PFAS contamination but otherwise uncorrelated with infant health outcomes conditional on the control variables. Second, the wells where we observe PFAS contamination must be similar to the wells where we do not observe PFAS contamination.

In the first stage, we use data on wells w in county c tested for PFAS at month t to estimate PFAS concentrations as a function of observable characteristics of a well w and its associated contaminated site j:

$$\begin{aligned}
&\operatorname{asinh}(PFAS_{wct}) \\
=&\lambda_1 Up_or_Down_{wjc} + \lambda_2 Down_{wjc} + \lambda_3 SP_{jc} + \lambda_4 AWC_{wc} \\
&+ \lambda_5 Clay_{wc} + \lambda_6 Sand_{wc} + \lambda_7 Silt_{wc} \\
&+ \lambda_8 \ln(dist_{wjc}) + \lambda_9 Down_{wjc} SP_{wc} + \lambda_{10} Down_{wjc} AWC_{wc} \\
&+ \lambda_{11} Down_{wjc} Clay_{wc} + \lambda_{12} Down_{wjc} Sand_{wc} \\
&+ \lambda_{13} Down_{wjc} Silt_{wc} + \lambda_{14} Down_{wjc} \ln(dist_{wjc}) \\
&+ \lambda_{15} \operatorname{asinh}(SitePFAS_{jc}) + \Gamma \tilde{X}_{wc} + \gamma t + \epsilon_{wct}. \quad [2]
\end{aligned}$$

Here, $PFAS_{wct}$ is the measured level of PFAS in well w, which we transform with the inverse hyperbolic sine (*asinh*) because our data include a large number of zeros. $Up\_or\_Down_{wc}$ and $Down_{wc}$ are assigned as in the primary specification. In addition to whether a well is downgradient of a contaminated site, we use a series of instruments for well-level PFAS contamination, including the measured soil porosity (mm/m) SP_{wc} [which affects the speed at which PFAS migrate horizontally and to the groundwater table (44)]; well w's available water capacity (mm/m) AWC_{wc}; the fractions of clay, sand, and silt particles in the soil ($Clay_{wc}$, $Sand_{wc}$, and $Silt_{wc}$, respectively), which control how water and PFAS move through the soil to reach groundwater (34, 66); and the distance from well w to contaminated site j, $dist_{wjc}$. We record $SitePFAS_{jc}$ as the PFAS attributed to a matched contaminated site by the Northeastern University PFAS Lab (46), which does not vary over time. The vector $\tilde{X}_{wc}$ of well-level control variables includes an indicator for whether a well is a residential well; Census tract-level median house sales price, median income, number of housing units, and percent of the workforce employed in manufacturing; Census block group-level temperature and particulate matter (PM2.5) pollution; the number of Toxics Release Inventory Program sites within 5km of the well; wind transport of PFAS (*SI Appendix*, section A.6); and the surface elevation of the well. We allow for a linear time trend, γt, in order to capture the migration of PFOA and PFOS through soils and into groundwater over time. *SI Appendix*, section J reports the results of estimating regression Eq. **2**. It also shows that predicted PFAS correlates with our downgradient classification.

Once we have estimated regression Eq. **2**, we use the estimated coefficients to predict $\widehat{asinh(PFAS_{ict})}$, which is a transformation of PFAS at the well used to supply water to the mother in birth i. We then estimate:

$$\begin{aligned}
H_{ict} =& \beta \operatorname{asinh}(\widehat{PFAS_{ict}}) + \lambda \operatorname{asinh}(SitePFAS_{jc}) \\
&+ \Gamma \tilde{X}_{ict} + \eta_c + \nu_t + \epsilon_{ict}. \quad [3]
\end{aligned}$$

H_{ict} and the fixed effects η_c and ν_t are as in regression Eq. **1**. $\tilde{X}_{ict}$ is the same as X_{ict} in Eq. **1** except without site-level PFAS (here pulled out separately) and without distance from the well to the contaminated site (here used an instrument). For those households with wells within 5 km of a PFAS-contaminated site, the coefficient β identifies the effect of receiving water from a well with marginally greater PFAS relative to receiving water from a well with marginally less PFAS. We bootstrap the SEs (*SI Appendix*, section J). *SI Appendix*, section G reports the estimated infant health effects of being downgradient implied by this two-sample IV model, obtained by multiplying the estimated $\hat{\beta}$ from regression Eq. **3** by the difference in predicted PFAS for downgradient and upgradient wells. It shows that these estimates are similar to the results of our primary analysis. *SI Appendix*, section H tests for nonlinear effects of PFAS exposure. It shows that the effects of PFAS are approximately constant in the domain of the data.

Calculating Effects Across the United States. In addition to the data sources used in the primary analysis, we obtain county-level data on the number of births in 2010 from the Centers for Disease Control Wonder service and population data from the 2010 Census at the block group (CBG) level. We use these data to impute CBG-level births:

$$\text{births}_g = \frac{\text{population}_g}{\text{population}_c}\text{births}_c, \qquad [4]$$

where g indexes CBGs and c is the county that contains the CBG.

To attribute exposure to PFAS at the CBG level, we calculate the catchment area for each contaminated site throughout the United States for which we have PFAS data from ref. 46 and for each CBG centroid that is within 5 km of a contaminated site. We classify each CBG as upgradient, downgradient, or to the side based on the relation of its centroid to nearby contaminated sites, following the procedure used for wells.

To attribute PFAS exposure to the residents within a given CBG, we fit the following equation to our New Hampshire data:

$$\begin{aligned}&\text{asinh}(PFAS_{wct})\\ =&\lambda_0 + \lambda_1 Up\_or\_Down_{wjc} + \lambda_2 Down_{wjc} + \lambda_3 SP_{jc} + \lambda_4 AWC_{wc}\\ &+ \lambda_5 Clay_{wc} + \lambda_6 Sand_{wc} + \lambda_7 Silt_{wc} + \lambda_8 \ln(dist_{wjc})\\ &+ \lambda_9 Down_{wjc} SP_{jc} + \lambda_{10} Down_{wjc} AWC_{wc}\\ &+ \lambda_{11} Down_{wjc} Clay_{wc} + \lambda_{12} Down_{wjc} Sand_{wc}\\ &+ \lambda_{13} Down_{wjc} Silt_{wc} + \lambda_{14} Down_{wjc} \ln(dist_{wjc})\\ &+ \lambda_{15} \text{asinh}(SitePFAS_{jc}) + \varepsilon_{wct}.\end{aligned}$$

This regression modifies regression Eq. **2** to include only explanatory variables that we observe nationwide. We use the fitted equation to predict the inverse hyperbolic sine of PFAS exposure at the CBG level from contaminated sites in the 11 U.S. states with widespread testing. Multiplying $\widehat{PFAS}_{ict}$ by the estimated $\hat{\beta}$ from regression Eq. **3** and births_g from Eq. **4** gives us the predicted change in reproductive outcomes within CBG g.

Summing across the CBGs within 5 km of a contaminated site for which we have data yields the predicted change in births in these 11 states. (Within these 11 states, more than 87% of the population lives in a CBG for which we have data from the Wonder service, so we ignore the possibility of health impacts in CBGs for which we lack data.) We extrapolate to the 48 states of the contiguous U.S. by multiplying the total effect in these 11 states by the ratio of the contiguous U.S. population to the population of these 11 states. That ratio is 2.91. This extrapolation assumes both that we have comprehensively tallied the effects of PFAS in those 11 states (which would not be true if there are untested contaminated sites) and that contamination in these 11 states is representative of contamination in the other 37 states (which would not be true if states that chose to test did so because of well-founded special concern about PFAS or if states that chose not to test did so because of well-founded special concern about high liability for PFAS).

Social Costs of Health Outcomes. From ref. 40, the social cost of each extremely preterm birth is $445,852; the social cost of each very preterm birth is $241,769; and the social cost of each moderately preterm birth is $36,728. Each of these figures incorporates differential costs borne by preterm individuals due to differentials in medical care, maternal delivery costs, early intervention services, special education services, assistive devices, and lost labor market productivity, all relative to a full-term birth. In order to make each cost relative to the next-most severe category, we difference the social cost of an extremely preterm birth from that of a very preterm birth to arrive at a social cost of $204,083 per extremely preterm birth. And we difference the social cost of a very preterm birth from that of a moderately preterm birth to arrive at a social cost of $205,041 per moderately preterm birth. The social cost of a moderately preterm birth is $36,728, as in ref. 40.

To calculate the social cost of the different severities of low-weight births, we closely follow Appendix F of ref. 39. We discuss these calculations in more depth in *SI Appendix*, section I. Most importantly, unlike the social costs used for preterm births, we directly account for differential mortality risks across the distribution of birthweight when calculating relative social costs for each severity group. When calculating the social costs of increased mortality risk, we conservatively use different values of life based on, among others, differential life expectancies for infants born in each low-weight bin (49). We obtain a social cost of $2,636,968 for each extremely low-weight birth (relative to a very low-weight birth) and of $1,767,021 for each very low-weight birth.

To calculate the social cost of infant mortality, we again use the results from ref. 49. In particular, we assume that if an infant who died within their first year of life had instead remained alive, then they would have had the quality of life of an infant who was born at an extremely low weight. This yields a social cost of $4,230,796 for each infant death.

We interpret our social cost estimates as reflecting the benefit of cleaning up PFAS. Yet, as discussed above, our health estimates could reflect contaminants that correlate with PFAS, especially unregulated contaminants. The primary technology for removing PFAS at the scale of a treatment plant is granular activated carbon filtration. This treatment captures many of the unregulated contaminants that may correlate with PFAS, including microplastics (67) and pharmaceuticals (68). The primary exceptions are short-chain PFAS, which are less effectively removed than long-chain PFAS such as PFOA and PFOS by granular activated carbon (69–72). However, short-chain PFAS have much smaller concentrations than PFOA and PFOS in groundwater systems (36, 37). Moreover, some of the PFAS-contaminated sites in our sample were closed before 2000 (46). Long-chain PFAS were the dominant forms produced prior to 2010, and it takes time for PFAS to migrate through soils to groundwater (33, 34). As a result, our estimated health impacts over 2010–2019 are likely to reflect exposure to long-chain PFAS more than short-chain PFAS, consistent with many groundwater PFAS concentration datasets that show much greater concentrations of PFOA and PFOS than short-chain PFAS (37).

Data, Materials, and Software Availability. All nonrestricted data and associated code are available on Figshare (73). Restricted data include (1) shapes of public water system service areas in New Hampshire, (2) the locations of public water wells, and (3) geocoded natality data for all births in New Hampshire. 1. Water and Sewer Line Distribution Areas (a. Department: New Hampshire Department of Environmental Services, Drinking Water and Groundwater Bureau, Email: dwgbinfo@des.nh.gov; b. Point of Contact: Kelsey Vaughn, Email: kelsey.vaughn@des.nh.gov; c. Instructions to obtain data: Email department/person of contact to apply for access). 2. Public Water Supplies (a. Department: New Hampshire Department of Environmental Services, Drinking Water and Groundwater Bureau, Email: dwgbinfo@des.nh.gov; b. Point of Contact: Pierce Rigrod, Email: pierce.laskey-rigrod@des.nh.gov; c. Instructions to obtain data: Email department/person of contact to apply for access). 3. New Hampshire Natality and Mortality Data (a. Department: New Hampshire Department of Health and Human Services, Email: HealthStatisticsMailFile@dhhs.nh.gov; b. Instructions to obtain data: https://www.dhhs.nh.gov/programs-services/population-health/health-statistics-informatics/vital-records-birth-death-data).

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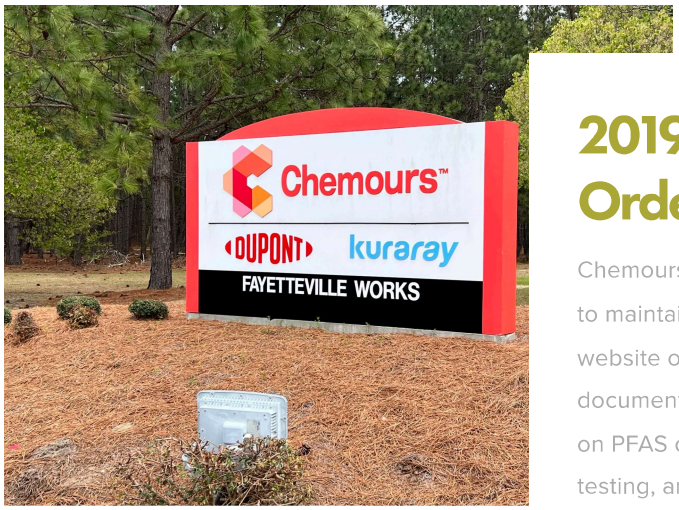
Chemours Fayetteville Works



2019 Consent Order

Chemours is legally required to maintain a compliance website of publicly accessible documents regarding progress on PFAS clean-up, toxicity testing, and other terms agreed within the consent order. Click here to learn more.

Half a Century of PFAS Pollution

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1977

"During the period 1977–1984, DuPont invested in building a monomer, polymer, and membrane fabrication plant in Fayetteville NC to meet the needs of the Chloralkali market." Excerpts from a 2004 DuPont paper.

1980

DuPont publicly discloses they began manufacturing Vinyl Ether at Fayetteville Works plant, releasing GenX as byproduct – until forced to stop in 2017.

1999

Discovery from lawsuits proved DuPont was aware of health risks from PFOA/C8 and in their own testing, found it caused testicular, pancreatic and liver cancer in lab animals.

2000

MAY: 3M announces it will voluntarily phase out PFOA production. At this time, they are

ewg

Chemical companies like 3M and DuPont knew PFAS were toxic in the 1950s and 1960s. Check out Environmental Working Group's timeline documenting these discoveries.

aeon

Environmental Sociologist, Rebecca Altman, documents the haunting connection between the atomic bomb and PFAS. Click here to learn about the birth of fluorocarbon chemistry.

2017 - 2018 Detailed Timeline

2017

FEB: $670.7 million settlement: DuPont and Chemours will pay plaintiffs to settle 3,550 lawsuits related to the release of PFOA in Ohio and

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Fayetteville Works. According to file on DEQ website, DuPont submitted permit application May 8, 2001 which indicates they started producing Teflon in Dec. 2000 (seemingly without permit). Quote from file: "... [permit application] adds wastewaters from the new Teflon® facility for fluoropolymer resin manufacturing which produces PMDF and fluoroproducts (APFO). The new facility started production in December 2000. Process wastewaters are treated in the Waste Water Treatment Plant." Not until 2004, does it show they began collecting wastewater (which contained C8) and disposing of it off-site.

2001

Class-action lawsuit against DuPont filed in West Virginia due to C8 contamination.

2004

in Ohio and WV. The companies also agreed to pay up to an additional $50 million a year for the next five years for any additional claims that might arise.

JUN 7: Wilmington residents publicly learn about GenX in their tap water when the local StarNews publishes a front page headline story called “Toxins Taint CFPUA Drinking Water.”

JUN 12: NC Dpt. Health and Human Services releases statement claiming they believe GenX "poses a low risk."

JUN 15: Closed door meeting with NC officials and Chemours; Wilmington Mayor demands Chemours stop all discharge of GenX in river immediately.

JUN 19: DEQ announces staff will sample at 13 locations for three weeks; Chemours agreed to bear all costs.

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drinking water. DuPont agreed to pay $85 million directly to the residents, mostly in cash, as well as $22.6 million in attorneys' fees. DuPont will fund a medical monitoring program for up to $235 million to test local residents. The company is also providing six water districts in the two states with water-treatment systems to reduce the level of C-8 contamination.

2005

$10.25 million civil penalties against DuPont for "multiple failures to report information to EPA about substantial risk of injury to human health or the environment that DuPont obtained about PFO from as early as 1981 and as recently as 2004."

2006

Environmental groups for the C8 Working Group to watchdog DuPont's manufacturing of PFOA at Fayetteville Works site.

2009 order issued under the Toxic Substances Control Act (TSCA) for the production of GenX, and toxicity data submitted by the company, as required under the consent order, and updating the risk assessment using the additional toxicity data specific to GenX."

JUN 21: Clean Cape Fear and Cape Fear River Watch host the first Water Wednesday, a GenX forum which drew more than 300 attendees.

JUN 27: DEQ officials' onsite inspection finds Chemours capturing wastewater into storage tanks for shipment and burning in Arkansas

JUL 5: Cape Fear Public Utility Authority's Executive Director, Jim Flechtner announces at a Clean Cape Fear Water Wednesday event that CFPUA will send mailers to all customers.

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2009

U.S. EPA issues provisional health advisory for PFOA (400 ppt) and PFOS (200 ppt).

EPA directs DuPont to substitute PFOA with GenX at Fayetteville plant 'voluntarily'.

2010

DuPont began communicating with NC DEQ about phasing out PFOA (C8) by 2015 - and replacing it with GenX. Due to laws protecting privacy for corporations, the actual date of replacement of C8 with GenX is unknown. Internal docs have been published by DEQ that shed some light on this and the CFPUA notice of intent to file civil suit provides some insight.

2012

GenX reported in river by scientists, including 2 from EPA - published findings in 2015.

2013 - 2014

JUL 7: CFPUA attorneys send letter to NCDEQ

JUL 10: Clean Cape Fear met with Downtown Business Alliance to discuss "Clean Water Promise" initiative

JUL 12: CFPUA Board Meeting: Clean Cape Fear, specifically Harper Peterson and Kemp Burdette were thanked for their role in communicating the issue with the public and inviting CFPUA to forums etc. CCF's Harper Peterson spoke during public comment. Find minutes at: http://cfpua.iqm2.com/Citizens/Default.aspx

JUL 13: NCDEQ site visit finds Chemours STILL discharging GenX. Chemours claims it is stopping processing of those operations.

https://deq.nc.gov/additional-genx-discharge-chemours-facility-identified-and-stopped

limit exists for the unregulated GenX. Chemours claims it installed technology to reduce discharge of GenX.

2014

It is assumed DuPont stops making C8 at Fayetteville works - this is not verified due to company's ability to withhold information under privacy protections.

2015

DuPont spins off “Performance Chemicals” business and forms Chemours Co.

2016

U.S. EPA issues combined lifetime health advisory limit for PFOA/PFOS at 70 ppt.

NC State Study published, confirming GenX and 6 other unknown fluorochemicals in Cape Fear River. Sun et. al paper,

2017

DHHS announces 3 PEEP drop to safe levels from 70,909 parts per trillion (ppt) to 140 ppt, based on "newly discovered" data; DEQ and DHHS joint press release HERE; DHHS Q and A on updated Risk Assessment HERE

JUL 14: TEST RESULTS: Early results from all 13 test sites can be found on the N.C. Department of Environmental Quality’s GenX website - HERE; A document showing the results in a spreadsheet is HERE

JUL 24: Governor Cooper's visit to Wilmington.

JUL 21: Gov. Cooper calls Centers for Disease Control and Prevention Director Dr. Brenda Fitzgerald to request they perform a public health assessment of the long-term health effects of GenX.

JUL 26: Clean Cape Fear hosts Just the Facts Please: An Evening With Scientists. during which it is

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Wilmington residents publicly learn about GenX in their tap water when the local StarNews publishes a front page headline story called “Toxins Taint CFPUA Drinking Water.”

Clean Cape Fear and Cape Fear River Watch host the first ever public forum on GenX, which drew more than 300 attendees.

Fayetteville Observer reports PFOA is found in wells near the Fayetteville Works plant.

2018

Cape Fear River Watch sues Chemours and NCDEQ. A settlement is reached after four months of litigation.

Emily Donovan testifies testifies before Congress, for the first time, about NC's PFAS contamination crisis.

2019

Consent order between Cape Fear River Watch, Chemours and

JUL 27: DEQ releases new data from water sampled along the Cape Fear River July 12 and 13.

JUL 28: U.S. Attorney’s Office for the Eastern District of North Carolina issues a subpoena to DEQ for six years of records and documents related to GenX and other fluorinated chemicals produced at the Chemours' Fayetteville Works facility to include permits, reports, emails, research and notes; deadline for delivery to Wilmington grand - Aug. 22, 2017

Cooper expands the charter of the state's Science Advisory Board for appointment by secretaries of DEQ and DHHS of 11 members to help environmental and health officials determine "factors for establishing acceptable levels for contaminants," among other things.

AUG 2: Test results released from sampling locations along

the Need for Corporate Accountability hearing.

2020

Clean Cape Fear partners with Center for Environmental Health and organizes a coalition of NC environmental and justice groups to petition U.S. EPA to issue human health and toxicity testing orders on 54 Chemours specific PFAS.

2022

Clean Cape Fear participated on the conference planning team for the 3rd National PFAS Conference as the lead local organizer. The three day event was hosted in Wilmington, NC in June 2022. Emily Donovan presented at the conference.

U.S. EPA announces new health advisories for 4 PFAS at 3rd National PFAS Conference hosted in Wilmington, NC. Final health advisories for GenX (10 ppt), PFBS (2,000 ppt), interim

AUG 8: Leaders with DEQ and DHHS request $2.6 million in additional funding from the legislature. More info on the request and which legislators have opposed it and/or supported it can be found HERE.

AUG 9: Test results from sampling locations along the Cape Fear River from July 24 to 27.

AUG. 10: A group of Republican state senators, including Sen. Bill Rabon (R-Brunswick) and Sen. Michael Lee (R-New Hanover), send a series of questions to Cooper in response to his request for more DEQ/DHHS funding.

AUG 14: DEQ and DHHS respond to the above series of questions.

AUG 15-19: Erin Brokovich and 'water guy' Robert Bowcock visit Wilmington. They attend a forum (no other panelists accepted), a closed-door meeting with

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U.S. EPA Administrator Michael Regan hosts a press conference in Wilmington to announce proposed first-ever drinking water standards for 6 PFAS—including GenX.

NRDC publishes a tap water study in Science of the Total Environment showing the highest levels of unmonitored PFAS were found in the Brunswick County, North Carolina samples. Clean Cape Fear participated in the study.

ABC News releases a docuseries called Trouble on Tap. The first episode focuses on PFAS in the lower Cape Fear River basin. Emily Donovan is featured in this episode.

2024

United Nations human rights experts officially call out Chemours and DuPont for business-related human rights abuses in North Carolina after Brokovich's comment to organizer (Beth Markesino of Wilmington's Stop GenX in Our Water Facebook page) that she had a family emergency.

AUG 23: Port City Daily story indicates Sen. Lee will not support funding to CFPUA, INSTEAD of DEQ/DHHS. Letter from well-funded lobby may have instigated this idea.

AUG 31: NCDEQ released report from EPA showing TWO NEW likely toxic compounds have likely been being discharged from the Fayetteville Works plant by Chemours/DuPont since 1980.

NC passes HB56, allocating funding to CFPUA and UNCW for GenX related testing.

EPA releases report indicating two more unregulated compounds - they are calling Nafion Byproduct 1 and Nafion Byproduct 2 - are at high levels in Cape Fear River

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for 6 PFAS including GenX. Emily Donovan introduced EPA Administrator, Micheal Regan, during the official press conference in Fayetteville, NC.

the company to stop the discharge

Chemours Senior VP sells 13,337 shares of Chemours stock for $646,577.76

SEP 5: DEQ sends notice of intent to suspend Chemours' discharge permit

NCDOJ, on behalf of DEQ, sends summons and letter with summons to Chemours

Chemours insider (President of Titanium Technologies) sells $641,550.00 worth of Chemours stock; he sold stock worth $462,000 in August - two trades totally $1.1 million

SEP 6: DEQ announces it will issue a notice of violation to Chemours for groundwater contamination near the plant.

SEP 8: Partial Consent Order issued in Bladen County Court between DEQ and Chemours - full order found HERE

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Commissioner Peterson threatens to sue the state of NC for its actions against Chemours

SEP 13: Fayetteville Observer reports C8 is found in wells near the Fayetteville Works plant

SEP 14: DEQ announces it will test wells near Fayetteville works; Chemours will also test wells near the facility, Star News reports

SEP 15: Clean Cape Fear and school boards announce pilot to provide clean drinking water to low-income students in New Hanover and Brunswick Counties.

Test shows that GenX is traveling by air, NC Policy Watch reports

SEP 27: DEQ orders Chemours to supply water to 8 more personal drinking wells (making total 19 to date) through Chemours' test samples and DEQ samples - analyzed by separate labs showing GenX at

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after-latest-preliminary-tests

SEP 28: The N.C. House of Representatives' Special Select Committee on North Carolina River Quality meets with DEQ and DHHS. ALL presentations available at: this site

OCT 3: New Hanover County resident Brent Nix files Class Action lawsuit on behalf of all other similarly situated

OCT 4: Seven more homes' wells tested above 140 ppt of GenX - Chemours must supply them bottled water - total is up to 26 households

Lawmakers Override Gov. Cooper Veto of HB56 - funding CFPUA and UNCW - ignoring request to fund DEQ and DHHS

OCT 5: DEQ orders expansion of private wells to be tested near Chemours facility

OCT 9: Contaminants possibly leaching out of filtration systems

to support funding DEQ and DHHS - motion was denied.

OCT 16: CFPUA sends letter of intent to file for violations of Clean Water Act (60 days notice given August 3, 2017)

OCT 19: Two Cumberland County schools tested for GenX

Clean Cape Fear member Emily Donovan attends Science Cafe

OCT 20: CFPUA releases first results of plant-wide filtration testing.

Brunswick county resident Roger Morton files Class Action lawsuit on behalf of all others similarly situated

OCT 23: Leland resident Victoria Carey files Class Action lawsuit on behalf of all others similarly situated after testing her water heater and finding high levels of GenX

Members of Clean Cape Fear attend the State's first Science

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Quality meeting in Raleigh. Presentations HERE

OCT 30: CFPUA sends public information request to DEQ

OCT 31: Brunswick County announces it has filed lawsuit against Chemours.

NOV 1: GenX Exposure Study begins for Wilmington residents only.

NOV 3: DEQ instructs Chemours to provide bottled water to 15 more residents near the plant - total is now 50

NOV 7: DEQ releases results of lakes and baseball field water - showing high levels of GenX - indicating it traveled by air.

WWAY reports that Brunswick County refused 200,000 funding to supply clean water to some public schools, funds were secured by Clean Cape Fear member Emily Donovan

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Plant's vinyl ether processing area releases 55 pounds of hexafluoropropylene oxide (HFPO) and 70 pounds of HFPO dimer acid fluoride. DEQ investigating for possible violation of air permit.

NOV 16: DEQ sends letter to Chemours notifying of intent to revoke wastewater permit and partial suspension of wastewater permit. DEQ press release

NOV 19: NC Senators Burr and Tillis announce they will not support nomination of business-friendly Michael Dourson to head the EPA's Chemical Safety Division.

NOV 21 - 25: Clean Cape Fear sends postcards to residents in Bladen and Cumberlands Counties within 3 mile radius of Fayetteville Plant with information on how to request water and air sampling.

suspension and intent to revoke wastewater permit. DEQ cannot take further action to revoke permit until Jan. 15 (per 60-days notice rule).

CCF members attend House Select Committee on NC River Quality in Raleigh.

DEC 4: Science Advisory Board meets, DEQ announces GenX found in honey.

DEC 13: Judge orders Belville to retain H2GO's assets, all parties to cease reverse osmosis construction.

30 more private wells found with GenX at levels higher than NCDHHS goal, bringing number up to 115.

DEC 14: 350 citizens show up for Bladen County GenX forum.

Trump industry-friendly EPA chemical safety nominee withdraws.

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DEC 21: Chemours announces price increase in fluorchemicals.

GenX cousin chemicals found in Jordan Lake which supplies drinking water 700,000 residents living in the Raleigh, NC area.

DEC 26: DowDuPont and Chemours ordered to clean up lead, arsenic and other pollutants in Chicago.

DEC 29: Contaminated wells found across river from plant.

2018

JAN 5: House Select Committee on River Water Quality holds meeting in Raleigh - after snowmageddan crippled travelers from the area hit. Only 10 people were there to comment. 9 of which opposed the legislation - that did nothing and provided zero funding to DEQ or DHHS

JAN 10: Clean Cape Fear went to Raleigh for the special session -

the day. See media timeline and our FB page for more on this political theater.

JAN 17: Judge orders class-actions to be filed together - lawyers (one who handled Flint cases) assigned.

JAN 20: Robeson County announces it will offer free well testing.

Clean Cape Fear co-founder Lynne Shoemaker's Wilmington Organizing for Women holds Women's March in Wilmington. Three members of Clean Cape Fear speak

JAN 23: Four NC Senators send letter to EPA asking for an audit of NCDEQs compliance with federal law and asking EPA to clarify NC state law for senators.

JAN 29: DEQ receives letter from Chemours about a 1-gallon leak of dimer acid

JAN 30: Southern Environmental Law Center sends letter to four

information session - Bladen Community College, providing updates from Division of Water Resources (spike at outfall most likely due to soil contamination; continuing composite sampling); Division of Waste Mgmt (continuing to study soil and rainwater around site, and beginning fish tissue sampling from Marshwood Lake; Division of Air Quality: Chemours hired firm to test 2 air stacks; DEQ asked for split sampling so samples will be sent to EPA as well).

Many residents spoke about concern for their health and that of their children and grandchildren; some who are outside the current range of testing asked for their well to be tested; Rep. Billy Richardson made plea for Precautionary Principle; residents called for voters to vote out legislators not taking action; said Chemours

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Chemours about a loading hose leak

FEB 9: DEQ approves of air-stack scrubber pilot

Senate releases their version of House bill 189

FEB 12: DEQ issues notice of violation due to groundwater contamination.

FEB 14: DEQ receives notification by email of two more chemical spills at the plant

FEB 21: 70 well owners file lawsuit, more info HERE

UNCW releases report GenX found in rain near campus, more HERE

House Select Committee on River Water Quality Meeting. Presentations HERE

FEB 24: CCF members attend rally against factory farming

FEB 25: UNCW Professor Chris Dumas sends 4000 GenX

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POWERED BY SQUARESPACE

Congress' scrutiny of toxic 'forever chemicals' cleanup liability puts public health at risk

By **Monica Amarelo** (/news-insights/our-experts/monica-amarelo) (EWG)

DECEMBER 16, 2025

As the Trump administration rolls back environmental (https://www.brookings.edu/articles/tracking-regulatory-changes-in-the-second-trump-administration/) and public health safeguards (https://www.kff.org/other-health/tracking-key-hhs-public-health-policy-actions-under-the-trump-administration/), Congress may exempt some industries from cleaning up toxic "forever chemicals," (https://www.ewg.org/areas-focus/toxic-chemicals/pfas-chemicals) or PFAS, pollution.

The House Energy and Commerce Committee's environment panel will hold a December 18 hearing (https://energycommerce.house.gov/events/environment-subcommittee-examining-the-impact-of-epa-s-cercla-designation-for-two-pfas-chemistries-and-potential-policy-responses-to-superfund-liability-concerns) to address what GOP leaders call "concerns" about liability for PFAS contamination. The panel will review the Biden Environmental Protection Agency's decision to classify PFOA (https://www.ewg.org/tapwater/contaminant.php?contamcode=E207) and PFOS (https://www.ewg.org/tapwater/contaminant.php?contamcode=E206) – two of the most hazardous PFAS (https://www.ewg.org/tapwater/reviewed-pfcs.php) – as hazardous substances (https://www.epa.gov/superfund/designation-perfluorooctanoic-acid-pfoa-and-perfluorooctanesulfonic-acid-pfos-cercla) under the Comprehensive Environmental Response, Compensation and Liability Act, or CERCLA.

A memo prepared for the hearing (https://d1dth6e84htgma.cloudfront.net/12_18_2025_ENV_PF_As_Hearing_af0a7c10e8.pdf) by Republican committee staff raises questions about the potentially negative impact of the decision on "critical uses" of PFAS and whether so-called passive industrial receivers of PFAS have suitable exemptions from liability. That's in line with calls to shield industries from PFAS liability, letting them continue to pollute without accountability.

The EPA in April 2024 finalized its designation for PFOA and PFOS (https://www.ewg.org/news-insights/news-release/2024/04/epa-hazardous-substance-designation-holds-polluters-accountable) under CERCLA, also known as the Superfund law. The rule remains one of the most consequential actions (https://www.ewg.org/news-insights/news/2024/04/what-theyre-saying-about-epas-hazardous-

substances-designation-two-pfas) taken to address **widespread PFAS contamination** (https://www.ewg.org/interactive-maps/pfas_contamination/map/) across the country.

The designation gives regulators the authority to identify PFOA and PFOS contamination, and require **reporting of chemical releases** (https://www.ewg.org/interactive-maps/2021_suspected_industrial_discharges_of_pfas/map/). It also crucially holds polluters financially responsible for cleanup, rather than leaving taxpayers to foot the bill.

In September, the Trump EPA **reaffirmed the rule** (https://www.ewg.org/news-insights/statement/2025/09/ewg-statement-epa-defends-superfund-hazardous-substance-designation), despite legal challenges from industry groups. In court filings and a public statement, the EPA defended the CERCLA designation of PFOA and PFOS as scientifically sound and legally justified. The reaffirmation cleared the way for cleanup at hundreds of contaminated sites nationwide, including **more than 600 military installations** (https://www.ewg.org/interactive-maps/2020-military-pfas-sites/map/).

Seeking harmful exemptions

Industry lobbyists have long sought exemptions from costly cleanup obligations, and some in Congress appear eager to grant them. Such exemptions would undermine CERCLA's "polluter pays" principle and open the door to more pollution and associated health harms.

The Superfund law already contains long-standing exemptions and enforcement discretion to protect non-polluters and smaller parties.

Weakening the law's reach is a slippery slope that could let the real polluting culprits off the hook. Expanding exemptions would leave communities to bear the costs of cleaning up contamination while enabling companies to keep using and releasing toxic PFAS.

PFOA and PFOS are among the most well-studied (http://www.c8sciencepanel.org/) and hazardous PFAS compounds. Once used extensively in products such as food packaging (https://www.ewg.org/research/decades-fda-knew-toxic-forever-chemicals-were-dangerous-continued-allow-their-use), nonstick cookware (https://www.ewg.org/news-insights/news/2024/02/forever-chemicals-top-3-ways-lower-your-exposure), firefighting foam (https://www.ewg.org/research/decades-department-defense-knew-firefighting-foams-forever-chemicals-were-dangerous) and stain-resistant fabrics (https://www.ewg.org/news-insights/news/2022/11/new-baby-textile-product-tests-show-concerning-levels-toxic-forever), they are found in the blood of virtually everyone (https://www.sciencedirect.com/science/article/pii/S0160412019318495?via%3Dihub), including newborn babies (https://www.ewg.org/news-and-analysis/2019/02/children-s-exposure-pfas-chemicals-begins-womb). Because they do not break down in the environment, they accumulate in water, soil and the human body.

Very low doses of PFAS in drinking water have been linked to suppression of the immune system (https://www.atsdr.cdc.gov/pfas/health-effects/index.html), including reduced vaccine efficacy (https://www.ewg.org/news-and-analysis/2019/06/pfas-chemicals-harm-immune-system-decrease-response-vaccines-new-ewg), and an increased risk of certain cancers (https://www.ewg.org/news-insights/news-release/study-pfas-act-similar-known-cancer-causing-chemicals). PFAS exposure is linked with increased cholesterol, reproductive and developmental problems (https://www.ewg.org/news-and-analysis/2019/09/pfas-and-developmental-and-reproductive-toxicity-ewg-fact-sheet) and other health harms (https://www.atsdr.cdc.gov/pfas/health-effects/index.html).

For decades, chemical giants like DuPont and 3M knew these chemicals were toxic (https://www.ewg.org/research/decades-polluters-knew-pfas-chemicals-were-dangerous-hid-risks-public) and concealed the risks from regulators and communities. Designating PFOA and PFOS as hazardous substances is not just scientifically necessary, it is morally urgent.

Consequential conversation

The stakes are especially high as the Trump EPA pursues a broader deregulatory agenda. Against that backdrop, Thursday's hearing represents a key test of whether Congress will defend communities exposed to PFAS or bend to industry pressure.

CERCLA is explicitly designed to prioritize cleanup of contaminated sites that pose the greatest risks to human health and the environment, particularly in vulnerable and overburdened communities.

For families living near contaminated water supplies, the outcome of the upcoming debate is not abstract. It will determine who pays for cleanup, how fast it happens and whether decades of chemical contamination are finally addressed.

For communities polluted by PFAS, the hearing may be one of the most consequential conversations Congress holds this year.

WHAT: House Energy and Commerce Committee Environment Subcommittee hearing to discuss the current statutory and regulatory landscape for PFAS

DATE: Thursday, December 18, 2025

TIME: 10 a.m. ET

LOCATION: 2123 Rayburn House Office Building

AREAS OF FOCUS: **Toxic Chemicals** (/areas-focus/toxic-chemicals)
PFAS Chemicals (/areas-focus/toxic-chemicals/pfas-chemicals)

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DECEMBER 16, 2025

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MAAHA: EWG's 'Make America Actually Healthy Again' agenda for EPA Administrator Zeldin (/news-insights/news/2025/12/maaha-ewgs-make-america-actually-healthy-again-agenda-epa-administrator)

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DECEMBER 11, 2025

Tiny bits of plastic are found nearly everywhere, from the summit of Mount Everest to the ocean floor. Are some of them coming from your washer and dryer?

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(/news-insights/news/2025/12/ditching-older-furniture-can-cut-your-exposure-some-harmful-flame)

WOMEN'S HEALTH (/AREAS-FOCUS/FAMILY-HEALTH/WOMENS-HEALTH) | CHILDREN'S HEALTH (/AREAS-FOCUS/FAMILY-HEALTH/CHILDRENS-HEALTH) | FLAME RETARDANTS (/AREAS-FOCUS/TOXIC-CHEMICALS/FLAME-RETARDANTS) | CALIFORNIA (/AREAS-FOCUS/REGIONAL-ISSUES/CALIFORNIA)

Ditching older furniture can cut your exposure to some harmful flame retardants (/news-insights/news/2025/12/ditching-older-furniture-can-cut-your-exposure-some-harmful-flame)

DECEMBER 9, 2025

Foam-containing furniture sitting in your home for years can be a hidden source of harmful flame retardant exposure. Removing these old sofas and chairs can lower the amount of one type of flame...

ALL NEWS (/NEWS-INSIGHTS/NEWS)

June 20, 2023

The Honorable Thomas Carper
Chairman
Senate Committee on Environment & Public Works
410 Dirksen Senate Office Building
Washington, DC 20510

The Honorable Shelley Moore Capito
Ranking Member
Senate Committee on Environment & Public Works
456 Dirksen Senate Office Building
Washington, DC 20510

The Honorable Cathy McMorris Rodgers
Chair
House Committee on Energy & Commerce
2125 Rayburn House Office Building
Washington, DC 20515

The Honorable Frank Pallone, Jr.
Ranking Member
House Committee on Energy & Commerce
2322 Rayburn House Office Building
Washington, DC 20515

Dear Chairman Carper, Ranking Member Capito, Chair Rodgers, Ranking Member Pallone:

We strongly urge you to reject proposals to weaken the Superfund law's protections by exempting certain responsible parties from liability. Such legislation represents another injustice for communities already harmed by PFAS.

Communities of color and low-income communities historically have received disproportionate chemical exposures and other environmental harms, and often do not receive vigorous protection under federal and state environmental laws.

For these reasons we strongly oppose industry-supported liability loopholes designed to exempt certain industries from their responsibility to clean up "forever chemicals" known as PFAS (per- and polyfluoroalkyl substances) under the Superfund law, formally CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act).

EPA's proposal to designate two widespread "forever chemicals" as hazardous substances has given hope to communities impacted by PFAS contamination. EPA's designation, while long overdue, would provide an avenue for holding polluters responsible for recklessly fouling the environment with PFAS chemicals.

The principle of "polluter pays" is particularly important for low-income communities and communities of color who, as a consequence of historical environmental injustice, are facing not only health threats, but insurmountable costs for remediation or water treatment.

Efforts to undermine long-standing precedents for liability under Superfund are misguided, unjustified, and self-serving. Industry associations, often purporting to represent water utility ratepayers or impacted communities, assert that liability under the law will harm innocent parties. This argument ignores 40 years of history under CERCLA. The law works as intended. Proposals to exempt certain industries would disrupt long-standing precedent under CERCLA in resolving complex, fact-based, site-specific questions of liability.

There's no "fix" for a problem that doesn't exist.

It's no surprise that certain industries are lobbying Congress to weaken the nation's preeminent "polluter pays" law. Congress should stand with those who have been harmed by polluters and resist any categorical exemptions from Superfund liability.

Sincerely,

Active San Gabriel Valley
Alamosa Riverkeeper
Alaska Community Action on Toxics
Alliance of Nurses for Healthy Environments
Anacostia Riverkeeper
Atchafalaya Basinkeeper
Ban Single Use Plastic
Buxmont Water
Cahaba Riverkeeper
Cape Fear River Watch
Center for Environmental Health
Choctawhatchee Riverkeeper
Clean Cape Fear
Clean Water Action Minnesota
Clean Water Task Force at Windsor Climate Action
Coastal Carolina Riverwatch
Congaree Riverkeeper
Coosa River Basin Initiative
Delaware Riverkeeper Network
Democracy Green
Endangered Species Coalition
Environmental Justice Task Force
Environmental Stewardship
Fight for Zero
Grand Riverkeeper
Great Lakes PFAS Action Network
Green Science Policy Institute
GreenLatinos
Greenpeace USA
Gunpowder RIVERKEEPER
Hackensack Riverkeeper
Haw River Assembly
Hurricane Creekkeeper
Kissimmee Waterkeeper
Long Island Soundkeeper
Los Angeles Waterkeeper
Lower Susquehanna Riverkeeper Association
Matanzas Riverkeeper
Milwaukee Riverkeeper

Missouri Confluence Waterkeeper
Nantucket PFAS Action Group
National Stewardship Action Council
Need Our Water (NOW)
Newburgh Clean Water Project
Norwalk River Watershed Association
Nuclear Information and Resource Service
NY/NJ Baykeeper
Ogeechee Riverkeeper
Oscoda Citizens for Clean Water
PfoaProject NY
Potomac Riverkeeper Network
Puget Soundkeeper
RE Sources
Rio Grande Waterkeeper
Rogue Riverkeeper
San Antonio Bay Estuarine Waterkeeper
San Diego Coastkeeper
SEE (Social Eco Education)
Seneca Lake Guardian
Songbird Farm
South Carolina Indian Affairs Commission
Spokane Riverkeeper
Suncoast Waterkeeper
Tampa Bay Waterkeeper
Tar Creekkeeper
Tennessee Riverkeeper
Testing for Pease
The National PFAS Contamination Coalition
Three Rivers Waterkeeper
Toxic Free North Carolina
Tualatin Riverkeepers
Upper Allegheny Waterkeeper
Waccamaw Indian People
Waterkeeper Alliance
Westfield Residents Advocating For Themselves (WRAFT)
Windsor Climate Action
Women for a Healthy Environment
Women’s Indigenous Alliance of SC
Wurtsmith Community Member
Yellow Dog Watershed Preserve

EWG: 2.5 million pounds of PFAS pesticides spread on California farmland annually

By **Jared Hayes** (/news-insights/our-experts/jared-hayes) (EWG), **Al Rabine** (/who-we-are/our-team/al-rabine) (EWG)

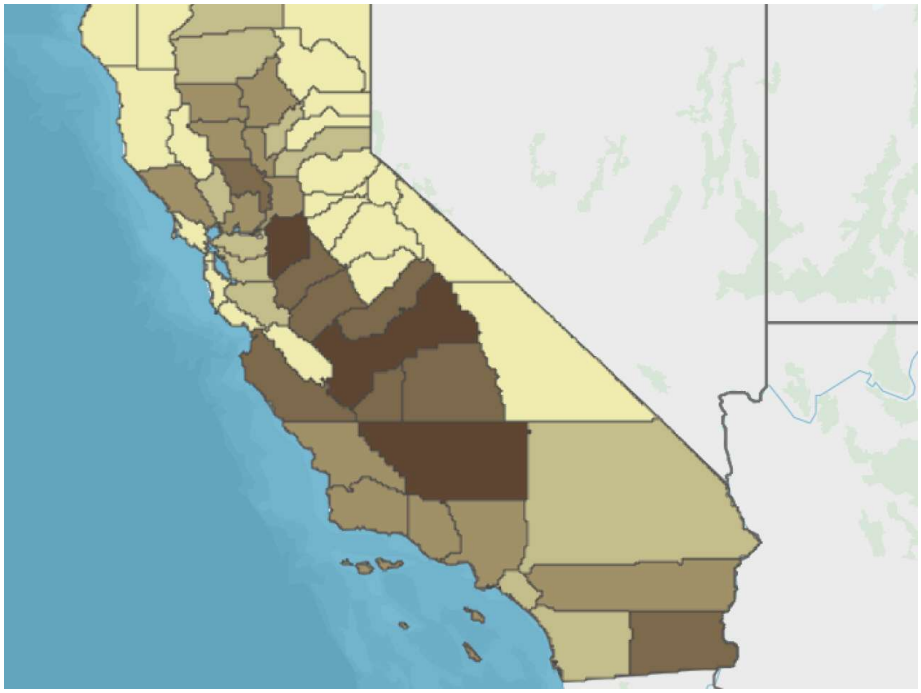
NOVEMBER 18, 2025

(https://www.ewg.org/areas-focus/toxic-chemicals/pfas-chemicals), known as PFAS, a new Environmental Working Group analysis and map shows. This widespread use could be contaminating produce, soil and drinking water, and exposing millions to potential health harms.

This new analysis by the Environmental Working Group shows these PFAS pesticides – herbicides, insecticides and fungicides – are widely used across the state's most productive farmland, potentially exposing millions of Californians to hazardous chemicals that never break down in the environment.

EWG analyzed the use of 66 active PFAS pesticide ingredients identified in a **peer-reviewed paper** (https://pmc.ncbi.nlm.nih.gov/articles/PMC11268133/) by EWG scientists and scientists from Center for Biological Diversity and Public Employees for Environmental Responsibility, published in July 2024. The EPA has since approved one additional PFAS pesticide and **proposed approving** (https://biologicaldiversity.org/w/news/press-releases/epa-plans-to-approve-fifth-forever-chemical-pesticide-since-trump-took-office-2025-11-04/), four others for active use in the U.S.

Based on this review, EWG created a new interactive map revealing that 52 federally approved PFAS pesticides were used in 58 counties across the state from 2018 to 2023. The map also highlights the types of crops soaked with those pesticides in those counties.



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INTERACTIVE MAP

Map showing PFAS pesticides use in California from 2018-2023

(https://experience.arcgis.com/experience/03a7e2a0ba6d41ada00031071827866f/page/Page#data

_s=id%3A25d9a188d3d247a792eefc3a0e345055-19911f27eda-layer-7%3A15)

CLICK HERE

(HTTPS://EXPERIENCE.ARCGIS.COM/EXPERIENCE/03A7E2A0BA6D41ADA0

0031071827866F/PAGE/PAGE#DATA_S=ID%3A25D9A188D3D247A792EEFC

3A0E345055-19911F27EDA-LAYER-7%3A15)

Source: ***State of California Pesticide Use Reporting*** (https://calpip.cdpr.ca.gov/main.cfm).

Between 2018 and 2023, nearly 15 million pounds of PFAS pesticides were applied to California farmland, according to data from California's **Department of Pesticide Regulation** (https://calpip.cdpr.ca.gov/county.cfm). This figure reflects the total use over that six-year period and highlights the widespread presence of these forever chemicals in the state's agricultural system.

Counties with the largest amounts of PFAS pesticides during this period were Fresno with 2.1 million pounds, Kern with 1.6 million pounds, San Joaquin with 923,000 pounds and Imperial with 898,000 pounds. Other counties where PFAS pesticides were used include Monterey, Riverside and Sonoma.

EWG also found that PFAS pesticides are being used most heavily on some of California's most iconic and lucrative crops. The heaviest uses included almonds, pistachios, wine grapes, alfalfa and tomatoes.

The analysis further revealed that 85% of PFAS pesticides used in the state were used for crop production. The remaining 15% were used for various structural practices, such as use as an insecticide for termite control and as an herbicide for landscape maintenance. In places like Imperial County, 98% of PFAS pesticides were used for crop production. Among the most frequently applied pesticides are the herbicide oxyfluorfen, the insecticide bifenthrin, the herbicide trifluralin, the insecticide lambda-cyhalothrin and the fungicide penthiopyrad.

Two of these pesticides, bifenthrin and trifluralin, have already been banned in the European Union due to health and environmental concerns. Yet they remain in widespread use on California farmland.

Under federal law, PFAS can be approved as **active ingredients** (https://www.epa.gov/ingredients-used-pesticide-products/basic-information-about-pesticide-ingredients) in pesticide products, playing a direct role by controlling the "pest" in an herbicide, fungicide or insecticide. Active ingredients are disclosed on a pesticide's label.

In the U.S., there are at least 66 PFAS active ingredients approved for use. PFAS may also be inert, or non-active, ingredients in pesticides. But that's hard to assess given pesticide makers' lack of disclosure about such ingredients. Inert ingredients don't play a direct role in addressing pests, are added as performance enhancers, and are not individually disclosed.

When PFAS are listed as an active ingredient on a pesticide product, they often represent the greatest amount of forever chemicals in a pesticide compared to other PFAS that might be present, for example as inert ingredients.

Increasingly, active ingredient pesticides are fluorinated. The **fluorinated qualities of the chemicals make the pesticide more stable** (https://www.sciencedirect.com/science/article/abs/pii/S0269749121018972) and less likely to break down into other types of chemicals. But fluorination can turn the ingredients into PFAS, based on the **commonly accepted definition** (https://one.oecd.org/document/ENV/CBC/MONO(2021)25/En/pdf) of forever chemicals.

While the fluorinated qualities are attractive for agrichemical manufacturers, those same traits may also have unintended consequences, like increased persistence and toxicity in the environment, prolonging peoples' exposure and potential health risks.

In addition to the use of active pesticide ingredients identified as PFAS, the fluorinated plastic containers used to store pesticides **have been found**

(https://www.epa.gov/pesticides/epa-releases-data-leaching-pfas-fluorinated-packaging) to leach PFAS into products. PFAS leached into pesticides in this way are not disclosed either.

Pesticides marketed and used by consumers for home and lawn purposes are also allowed to be sold in the state, however their use was not reported and tracked as part of this study. They may still be a significant source of PFAS in the everyday environment.

Health hazards from PFAS

While the full impact of PFAS pesticides on human health are not well understood, the chemical class of PFAS do not break down in our environment and many build up in blood and organs.

Forever chemicals studied to date are associated with a range of serious health harms. Very low doses of PFAS in drinking water have been linked to **the suppression of the immune system** (https://www.atsdr.cdc.gov/pfas/health-effects/index.html) and are associated with an elevated risk of cancer, increased cholesterol, and **reproductive and developmental harms** (https://www.ewg.org/news-and-analysis/2019/09/pfas-and-developmental-and-reproductive-toxicity-ewg-fact-sheet), among **other serious health concerns** (https://www.atsdr.cdc.gov/pfas/health-effects/index.html).

The widespread use of PFAS pesticides is a significant but overlooked source of contamination and exposure, affecting millions in California alone. These forever chemicals can accumulate in soil, be absorbed by crops and migrate into nearby water sources, yet current monitoring efforts fail to track this pollution. As forever chemicals, all PFAS are environmentally persistent, meaning the strong carbon-fluorine bond does not break down.

Over time, PFAS pesticides may degrade into other forever chemicals, like the ultra-short-chain trifluoroacetic acid, or TFA, which is increasingly

people. Research suggests that pesticides are a **major source of TFA** (https://www.sciencedirect.com/science/article/pii/S0160412024006470) in the environment.

For most people, food and drinking water are the primary routes of exposure to PFAS. That makes the use of these chemicals in agriculture especially concerning.

Lack of regulation increases exposure risks

Despite the known health harms of forever chemicals, the EPA has a long history of failing to protect Americans from PFAS. The EPA has also failed to deal **with other toxic pesticides** (https://www.ewg.org/news-insights/news-release/ewg-study-epa-fails-follow-landmark-law-protect-children-pesticides-food). Waiting for the agency to act on nationwide regulations on using PFAS pesticides will take too long, leaving farmers and Californians at risk.

In light of federal inaction on PFAS pesticides, states are beginning to step up. They're protecting consumers by putting restrictions on the use of these substances.

Maine enacted the first statewide ban on PFAS pesticides in 2023, covering intentionally added PFAS, and pesticides contaminated with PFAS. That ban goes into effect in 2030.

Other countries are taking swift action to address the risks from forever chemicals in pesticides. **Denmark** (https://www.food-safety.com/articles/10543-denmark-bans-pesticides-containing-problematic-pfas-ingredients) banned six PFAS pesticide ingredients in July 2025. The country cited PFAS groundwater contamination resulting from the use of these pesticides in agriculture. Records show that four of these banned PFAS pesticides are used in California, including Fluopyram, with more 519,000

European regulators declined to renew approval (https://eur-lex.europa.eu/eli/reg_impl/2025/910/oj/eng), of the PFAS herbicide flufenacet. In March 2025, the herbicide's approval wasn't renewed over thyroid health risks and groundwater contamination from its breakdown product TFA.

But California regulators and legislators have not taken regulatory actions to address pesticides made with PFAS – despite the state being among the biggest users of them.

Tips to reduce risk

There are non-PFAS alternatives to pesticides on the market – from herbicides to insecticides to fungicides – without the long-lasting health risks of exposure to forever chemicals.

Anyone concerned about exposure to PFAS pesticides should not reduce consumption of produce in an attempt to avoid pesticide residues. The health benefits of fruit and vegetable consumption outweigh the risks of pesticide exposure.

Instead, consumers can take practical steps to reduce exposure:

- Thoroughly wash produce before eating
- Choose organic options when possible
- Use trusted resources like EWG's guide to washing produce (https://www.ewg.org/consumer-guides/ewgs-guide-washing-produce) and EWG Shopper's Guide to Pesticides in Produce™ (https://www.ewg.org/foodnews/?gad_source=1&gad_campaignid=436846738&gbraid=0AAAAD_iHo4_jWULh4uroMttFR2NMjy5l&gclid=Cj0KCQjw18bEBhCBARIsAKuAFEbWTcEPo1PGQKZGurFo1LEQz30tgsP4QAw4O8fgtzZ7lWMaB0VDGeIaAp7pEALw_wcB) to help lower dietary exposure

We're in this together

Donate today and join the fight to protect our environmental health.

DONATE(HTTPS://ACT.EWG.ORG/GA5TECMDGKGGFESIR_7VGQ2?SOURCEID=1020222)

TOPICS

Learn about these issues

(/areas-focus/regional-issues/california)

California (/areas-focus/regional-issues/california)

EWG's California team takes aim at toxic chemicals threatening the health of state residents, from lead to pesticides to cosmetics ingredients.

(/areas-focus/farming-agriculture/food-farm-workers)

Food & Farm Workers (/areas-focus/farming-agriculture/food-farm-workers)

America's food system relies on food and farm workers, who often have little to no protection against diseases like COVID-19. EWG wants to fix the system.

(/areas-focus/toxic-chemicals/pesticides)

Pesticides (/areas-focus/toxic-chemicals/pesticides)

Millions of people rely on EWG's Shopper's Guide to Pesticides in Produce to reduce their exposure to toxic synthetic pesticides used on fruits and vegetables. The alternative is buy organic.

(/areas-focus/toxic-chemicals/pfas-chemicals)

PFAS Chemicals (/areas-focus/toxic-chemicals/pfas-chemicals)

DuPont's Teflon changed our lives, but also polluted our bodies. Today, Teflon-like compounds called PFAS are found in the blood of almost all Americans. These "forever chemicals" pollute water, don't break down, and remain in the environment and people for decades.

PFAS Contamination of Drinking Water Far More Prevalent Than Previously Reported

New Detections of 'Forever Chemicals' in New York, D.C., Other Major Cities

JANUARY 2020

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CONTENTS

ABOUT EWG

The Environmental Working Group is the nation’s most effective environmental health research and advocacy organization. Our mission is to conduct original, game-changing research that inspires people, businesses and governments to take action to protect human health and the environment. With your help—and with the help of hundreds of organizations with whom we partner—we are creating a healthier and cleaner environment for the next generation and beyond.

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New laboratory tests commissioned by EWG have for the first time found the toxic fluorinated chemicals known as PFAS in the drinking water of dozens of U.S. cities, including major metropolitan areas. The results confirm that the number of Americans exposed to PFAS from contaminated tap water has been dramatically underestimated by previous studies, both from the Environmental Protection Agency and EWG's own research.

Based on our tests and new academic research that found **PFAS widespread in rainwater**, EWG scientists now believe PFAS is likely detectable in all major water supplies in the U.S., almost certainly in all that use surface water. EWG's tests also found chemicals from the PFAS family that are not commonly tested for in drinking water.

Of tap water samples from 44 places in 31 states and the District of Columbia, only one location had no detectable PFAS, and only two other locations had PFAS below the level that independent studies show pose risks to human health. Some of the highest PFAS levels detected were in samples from major metropolitan areas, including Miami, Philadelphia, New Orleans and the northern New Jersey suburbs of New York City.

In 34 places where EWG's tests found PFAS, contamination has not been publicly reported by the Environmental Protection Agency or state environmental agencies. Because PFAS are not regulated, utilities that have chosen to test independently are not required to make their results public or report them to state drinking water agencies or the EPA.

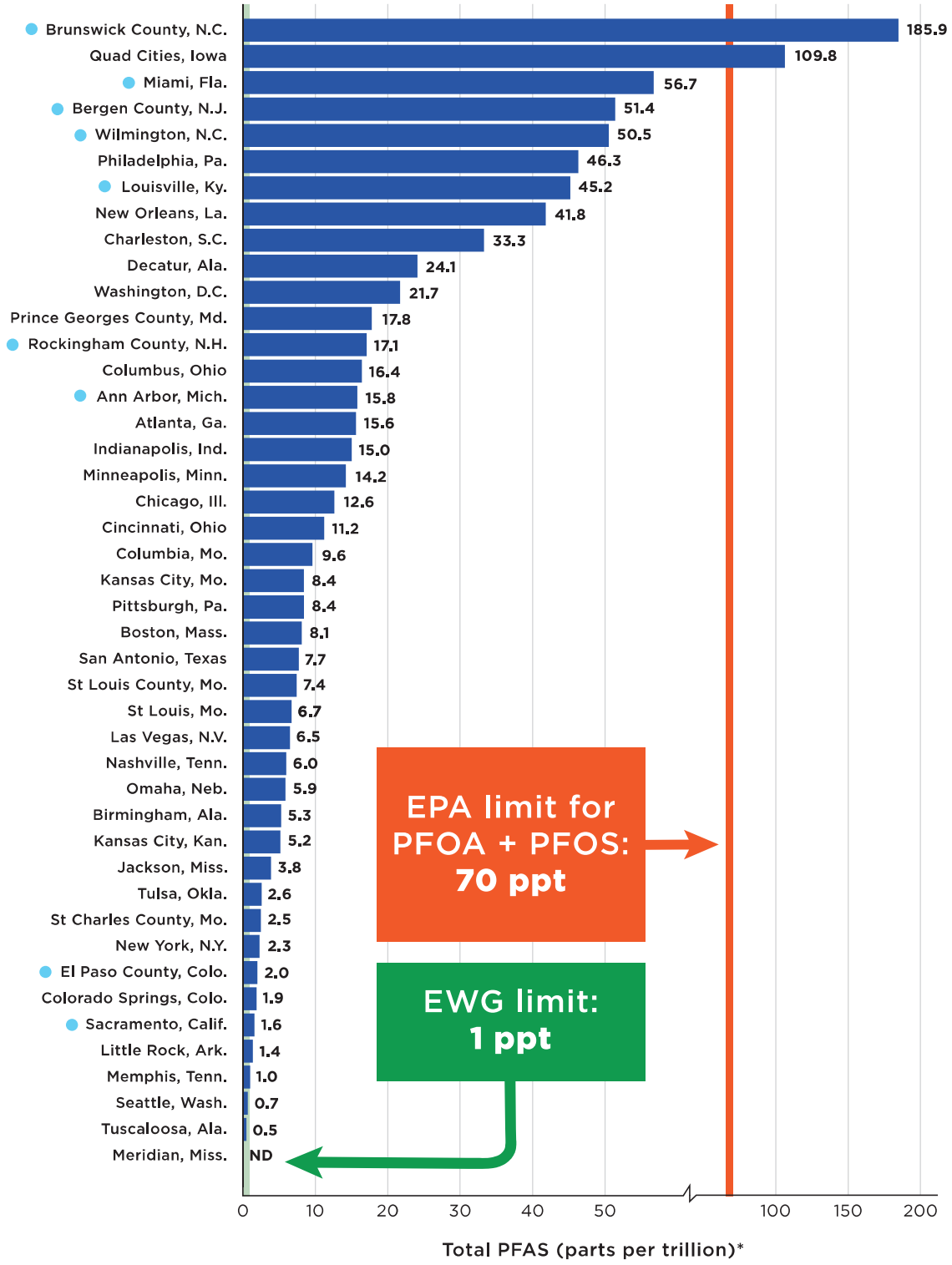
EWG's samples—collected by staff or volunteers between May and December 2019—were analyzed by an accredited independent laboratory for 30 different PFAS chemicals, a tiny fraction of the thousands of compounds in the family of per- and polyfluoroalkyl substances.

An EPA-mandated sampling program that ended in 2015 tested for only a few types of PFAS and required utilities to report only detections of a higher minimal level. The EPA also only mandated testing for systems serving more than 10,000 people, whereas EWG's project included a sample from a smaller system excluded from the EPA program. Because of those limitations, the EPA reported finding PFAS at only seven of the locations where EWG's tests found contamination.

In the 43 EWG samples where PFAS was detected, the total level varied from less than 1 part per trillion, or ppt, in Seattle and Tuscaloosa, Ala., to almost 186 ppt in Brunswick County, N.C. The only sample without detectable PFAS was from Meridian, Miss., which draws its drinking water from wells more than 700 feet deep.

The samples with detectable levels of PFAS contained, on average, six or seven different compounds. One sample had 13 different PFAS at varying concentrations. The list of the 30 PFAS compounds we tested for, and the frequency with which they were detected, is detailed in the appendix.

EWG Tests Found Toxic PFAS Chemicals in Tap Water in 31 States and D.C.



Source: EWG, from samples taken between May and December 2019.

* "Total PFAS" is the sum of detections of 30 different types of PFAS.

● PFAS previously reported by EPA or State

Samples were taken by EWG staff or local volunteers and analyzed by an independent accredited laboratory using a modified version of EPA Method 537. Details of all samples taken at each site and the precise sampling dates are in the tables in the

'FOREVER CHEMICALS'

PFAS are known as "forever chemicals" because once released into the environment they do not break down, and they build up in our blood and organs. Exposure to PFAS **increases the risk of cancer**, **harms the development of the fetus** and **reduces the effectiveness of vaccines**. Biomonitoring studies by the federal **Centers for Disease Control and Prevention** show that the blood of nearly all Americans is contaminated with PFAS.

The most notorious PFAS compounds are PFOA, formerly used by DuPont to make Teflon, and PFOS, formerly an ingredient in 3M's Scotchgard. Those compounds have been phased out under pressure from the EPA, but they persist in drinking water, people and the environment. In EWG's tests, PFOA was detected in 30 of 44 samples, and PFOS in 34 samples. The two compounds represented approximately a quarter of the total PFAS level in each sample.

EWG has **mapped** PFAS contamination of drinking water or ground water in almost 1,400 sites in 49 states. Previously, our **analysis** of unpublished EPA data estimated that water supplies for 110 million Americans may be contaminated with PFAS—an estimate that could be much too low, based on our new findings.

The EPA was first alerted to the problem of PFAS in drinking water in 2001 but in almost 20 years has failed to set an enforceable, nationwide legal limit. In 2016, the agency issued a non-enforceable lifetime health advisory for PFOA and PFOS in drinking water of 70 ppt. Independent scientific studies have recommended a safe level for PFAS in drinking water of 1 ppt, which is **endorsed by EWG.**

In the absence of a federal standard, states have started to set their own legal limits.

New Jersey was the first to set to a maximum contaminant limit for the compound PFNA, at 13 ppt, and has proposed standards of 13 ppt for PFOS and 14 ppt for PFOA. Some other states have now set or proposed limits or guidelines for PFAS in drinking water, including California, Connecticut, Massachusetts, Michigan, Minnesota, New Hampshire, New York, North Carolina and Vermont.

EWG TESTS UNCOVER CONTAMINATION MISSED BY EPA

EWG's results are in sharp contrast to **nationwide sampling by most public water systems** mandated by the EPA between 2013 and 2015. In the EPA tests, 36 of 43 water systems tested reported no detectable PFAS, including New York, Chicago, Philadelphia, Boston and Washington, D.C. The EPA's Unregulated Contaminant Monitoring program included only six PFAS compounds, and the minimum reporting limits were from 10 ppt to 90 ppt, obscuring the full scope of PFAS contamination.

Since the EPA program ended there has been no further nationwide testing of public water systems for PFAS. Some states, including New Jersey, Michigan, Pennsylvania and California, have conducted additional sampling and made the results public. And some local communities, including **Ann Arbor, Mich.**, and **Wilmington, N.C.**, regularly test for PFAS and release the results.

But other communities have been less forthcoming with PFAS test data. The **Philadelphia Water Department** states that it is "proactively testing for PFAS in source water and has not detected concentrations above EPA's advisory level." EWG's tests of Philadelphia water show total PFAS concentrations at nearly 50 ppt.

Our results are meant to highlight the ubiquity of PFAS and the vulnerability of the nation's drinking water supply to PFAS contamination. They underscore what an expert at the Water and Environmental Technology Center at Temple University, in Philadelphia, said about PFAS contamination: **"If you sample, you will find it."**

EWG's tests represent a single sample from each water system and may not represent what is coming out of a tap today. Results from a single sample form a snapshot of what was found in tap water at a specific site. They are likely representative of the water in the area where the sample was taken but are not intended to identify specific water systems. The cities and counties listed may be served by multiple public water systems, serving various proportions of the area's population.

The compounds in EWG's study are a small fraction of the entire PFAS class of thousands of different chemicals—**more than 600 are in active use**—including the new generation of so-called short-chain PFAS chemicals. Chemical companies claim that short-chain PFAS are safer than the long-chain predecessors they replaced, but the EPA allowed them on the market without adequate safety testing, and the new chemicals may pose even more serious problems.

A recent **study** by a team of scientists at Auburn University reported that short-chain PFAS are "more widely detected, more persistent and mobile in aquatic systems, and thus may pose more risks on the human and ecosystem health" than the long-chain compounds. The researchers also **noted** that existing drinking water treatment approaches for the removal of long-chain PFAS are less effective for short-chain PFAS. **Scientists at the University of Wisconsin-Madison** found PFAS, primarily the shorter-chain types, in all 37 rainwater samples they collected from around the country.

OPTIONS FOR DRINKING WATER SYSTEMS TO ADDRESS PFAS CONTAMINATION

There is no simple and inexpensive technology for removing PFAS from drinking water effectively. Selecting drinking water treatment options to remove PFAS typically requires a case-by-case evaluation to identify the best option and to design and install a treatment facility.

Current options for drinking water treatment technologies to remove PFAS include granular activated carbon, ion exchange and reverse osmosis.

Of these, granular activated carbon, or GAC, is the most common, with many water treatment facilities already using it to remove other contaminants. The design of the GAC filter and how often the carbon is exchanged can affect performance significantly.

Some of the systems we tested already use GAC filters, including those serving Ann Arbor, Mich., and the Quad Cities, in

Iowa. Reverse osmosis is the most effective PFAS removal technology, but it is also the most expensive. Ion exchange is a newer technology for PFAS removal, with a limited number of current installations.

The type of PFAS present, such as long- or short-chain, their concentrations and the potential presence of other contaminants all are factors that determine which treatment technology will be most effective or appropriate. Studies have shown that perfluorinated sulfonates, such as PFOS, are more effectively removed than perfluoroalkyl acids, such as PFOA, and that longer-chain PFAS are more effectively removed by GAC than shorter-chain.

Studies have demonstrated that reverse osmosis treatment is effective for removal of all types of long and shorter-chain PFAS we tested for, including PFOS, PFOA, PFBS, PFHxS, PFHxA and PFNA. This technology can also be combined with GAC to achieve higher removal rates or maintain the efficacy of the sensitive reverse osmosis membranes. However, water-treatment-plant-size reverse osmosis systems are expensive, require significant expenditures of energy and waste a lot of water, a problem in water-scarce areas.

Operating and maintenance costs are also important components to consider as part of the design of a long-term treatment plant, as are options for the disposal of PFAS removed from drinking water. Identifying safe ways to dispose of "forever chemicals" creates a new set of challenges. Once loaded with PFAS, GAC and ion exchange resins require disposal and could end up in incinerators or landfills and create contamination issues for local communities. PFAS-loaded wastewater produced from reverse osmosis must be treated before disposal.

IF PFAS IS DETECTED IN YOUR WATER

This project demonstrates the far-reaching PFAS contamination of U.S. drinking water, showing the urgent need for wider testing.

Judging from information from state health agencies, testing labs, and scientific researchers, the most effective choice for **in-home treatment of PFAS-tainted tap water** is a reverse osmosis system that combines an activated carbon filter with a reverse osmosis membrane.

Although some bottled water companies voluntarily meet industry standards for PFAS, there is no government requirement for PFAS testing of bottled water, no public information about potential PFAS contamination of water supplies that manufacturers use for production of bottled water, and no guarantee that the levels of PFAS in bottled waters are lower than those of tap water. For example, in 2019, the Massachusetts Department of Public Health **advised** pregnant women, nursing mothers and infants to avoid drinking certain brands of bottled water due to their high levels of PFAS contamination.

Use EWG's **tip sheet** to learn more about other products, materials, or activities that may be sources of exposure to PFAS in your home or local environment and how to avoid them. For more information about PFAS and what EWG is doing to combat this contamination crisis, visit our **"Forever Chemicals" website.**

WHAT POLICYMAKERS SHOULD DO

Federal and state policymakers should set science-based drinking water standards for PFAS in tap water, reduce ongoing PFAS discharges into water supplies, end non-essential uses of PFAS, require reporting of ongoing PFAS discharges into water supplies, ensure that PFAS wastes are properly disposed of, and expand PFAS monitoring efforts. Congress recently enacted **legislation that will expand PFAS reporting and monitoring**, but lawmakers have so far failed to set drinking water standards for most states, restrict ongoing PFAS releases into drinking water supplies, or clean up legacy PFAS contamination.

Guide to PFAS Chemicals

CHEMICAL	ABBREVIATION	DETECTION LIMIT, PARTS PER TRILLION
Perfluorooctane sulfonic acid	PFOS	0.4
Perfluorooctanoic acid	PFOA	0.3
Ammonium 2,3,3,3-tetrafluoro-2-(heptafluoropropoxy)propanoate	GenX	0.5
10:2 Fluorotelomer sulfonic acid	10:2 FTSA	1.0
4:2 Fluorotelomer sulfonic acid	4:2 FTSA	1.0
6:2 Fluorotelomer sulfonic acid	6:2 FTSA	1.0
8:2 Fluorotelomer sulfonic acid	8:2 FTSA	2.0
4,8-dioxa-3H-perfluorononanoate	ADONA	0.3
Perfluorooctane sulfonamide	FOSA	0.5
N-ethyl perfluorooctane sulfonamido acetic acid	N-EtFOSAA	1.0
N-methyl perfluorooctane sulfonamido acetic acid	N-MeFOSAA	1.0
Perfluorobutanoic acid	PFBA	2.0
Perfluorobutane sulfonic acid	PFBS	0.3
Perfluorodecanoic acid	PFDA	0.9
Perfluorododecane sulfonic acid	PFDoDA	0.3
Perfluorododecanoic acid	PFDoDS	0.5
Perfluorodecane sulfonic acid	PFDS	0.6
Perfluoroheptanoic acid	PFHpA	0.4
Perfluoroheptane sulfonic acid	PFHpS	0.4
Perfluorohexanoic acid	PFHxA	0.4
Perfluorohexadecanoic acid	PFHxDA	0.3

CHEMICAL	ABBREVIATION	DETECTION LIMIT, PARTS PER TRILLION
Perfluorohexane sulfonic acid	PFHxS	0.4
Perfluorononanoic acid	PFNA	0.4
Perfluorononane sulfonic acid	PFNS	0.6
Perfluorooctadecanoic acid	PFODA	0.5
Perfluoropentanoic acid	PFPeA	2.0
Perfluoropentane sulfonate	PFPeS	0.4
Perfluorotetradecanoic acid	PFTeDA	0.3
Perfluorotridecanoic acid	PFTrDA	0.4
Perfluoroundecanoic acid	PFUnA	0.4

Frequency of PFAS Detections by Chemical

CHEMICAL	NUMBER OF SAMPLES WHERE CHEMICAL WAS DETECTED[1]	RANGE DETECTED[2], PARTS PER TRILLION
PFOS	34	0.4–14
PFOA	30	0.4–14
GenX	6	0.5–31
6:2 FTSA	2	2.1–15
FOSA	21	0.4–1.9
PFBA	32	1.8–72
PFBS	27	0.5–5.0
PFDA	3	0.5–0.9
PFHpA	26	0.5–24
PFHxA	31	0.4–36
PFHxS	23	0.5–7.3
PFNA	10	0.5–1.9
PFPeA	31	0.5–39
PFPeS	3	0.4–1.6

CHEMICALS NOT DETECTED IN ANY SAMPLE:

4:2 FTSA	ADONA	PFDoDA	PFHpS	PFODA	PFTrDA
8:2 FTSA	NEtFOSAA	PFDoDS	PFHxDA	PFTeDA	PFUnA
10:2 FTSA	NMeFOSAA	PFDS	PFNS		

1 Number of detections out of 44 water samples

2 Range of concentrations for individual PFAS in samples where the compound was detected.

APPENDIX: FULL RESULTS

Ann Arbor, Mich.

Sample Date: 6/18/2019

Sample collected from Ann Arbor within the likely service area of the Ann Arbor community water system.

TOTAL	15.8 ppt
PFOS	0.8 ppt*
PFOA	0.4 ppt*
PFBA	5.0 ppt*
PFBS	0.9 ppt*
PFHpA	1.3 ppt
PFHxA	2.6 ppt
PFPeA	4.8 ppt*

Atlanta, Ga.

Sample Date: 12/2/2019

Sample collected from Atlanta within the likely service area of the Atlanta community water system.

TOTAL	15.6 ppt
PFOS	2.0 ppt
PFOA	2.3 ppt
PFBS	2.3 ppt
PFHpA	0.9 ppt*
PFHxA	3.2 ppt
PFHxS	1.4 ppt*
PFPeA	3.5 ppt

Arrived at the lab with slightly elevated temperature

Bergen County, N.J.

Sample Date: 8/6/2019

Sample collected from Bergenfield within the likely service area of United Water New Jersey.

TOTAL	51.4 ppt
PFOS	5.3 ppt
PFOA	14.0 ppt
FOSA	0.6 ppt*
PFBA	5.1 ppt
PFBS	3.2 ppt
PFDA	0.5 ppt*
PFHpA	4.4 ppt
PFHxA	6.0 ppt
PFHxS	2.9 ppt
PFNA	1.9 ppt
PFPeA	7.0 ppt
PFPeS	0.5 ppt*

Birmingham, Ala.

Sample Date: 11/8/2019

Sample collected from Birmingham within the likely service area of the Birmingham Water Works Board.

TOTAL	5.3 ppt
PFOS	0.7 ppt*
PFOA	0.5 ppt*
PFBA	2.5 ppt*
PFBS	0.7 ppt*
PFHxA	0.4 ppt*
PFPeA	0.5 ppt*

**Concentration detected was above the limit of detection but below the limit of quantitation.*

Boston, Mass.

Sample Date: 7/30/2019

Sample collected from Boston within the likely service area of the Boston Water and Sewer Commission.

TOTAL	8.1 ppt
PFOS	1.0 ppt*
PFOA	1.8 ppt*
FOSA	0.7 ppt*
PFBS	0.5 ppt*
PFHpA	1.0 ppt*
PFHxA	1.5 ppt*
PFPeA	1.6 ppt*

Charleston, S.C.

Sample Date: 5/13/2019

Sample collected from Charleston within the service area of the Charleston Water System.

TOTAL	33.3 ppt
PFOS	6.3 ppt
PFOA	4.7 ppt
PFBA	2.9 ppt*
PFBS	3.3 ppt
PFHpA	2.4 ppt
PFHxA	5.3 ppt
PFHxS	1.9 ppt
PFNA	0.9 ppt*
PFPeA	5.6 ppt*

Brunswick County, N.C.

Sample Date: 10/22/2019

Sample collected from Leland within the likely service area of the Brunswick County Water System.

TOTAL	185.9 ppt
PFOS	14.0 ppt
PFOA	9.3 ppt
GenX	31.0 ppt
FOSA	0.5 ppt*
PFBA	16.0 ppt
PFBS	5.0 ppt
PFDA	0.9 ppt*
PFHpA	24.0 ppt
PFHxA	36.0 ppt
PFHxS	7.3 ppt
PFNA	1.3 ppt*
PFPeA	39.0 ppt
PFPeS	1.6 ppt*

Chicago, Ill.

Sample Date: 8/20/2019

Sample collected from Chicago within the likely service area of the City of Chicago community water system.

TOTAL	12.6 ppt
PFOS	2.3 ppt
PFOA	2.0 ppt
6:2 FTSA	2.1 ppt*
PFHpA	0.9 ppt*
PFHxA	3.3 ppt
PFHxS	0.7 ppt*
PFPeA	1.3 ppt*

Arrived at the lab with slightly elevated temperature

**Concentration detected was above the limit of detection but below the limit of quantitation.*

Cincinnati, Ohio

Sample Date: 11/5/2019

Sample collected from Cincinnati within the likely service area of the Cincinnati Public Water System.

TOTAL	11.2 ppt
PFOS	0.5 ppt *
GenX	4.8 ppt
FOSA	0.5 ppt*
PFBA	3.8 ppt*
PFPeA	1.5 ppt*

Colorado Springs, Colo.

Sample Date: 11/4/2019

Sample collected from Colorado Springs within the likely service area of Colorado Springs Utilities.

TOTAL	1.9 ppt
PFBA	1.9 ppt*

Columbia, Mo.

Sample Date: 11/6/2019

Sample collected from Columbia within the likely service area of the Columbia community water system.

TOTAL	9.6 ppt
PFOS	1.4 ppt*
PFOA	0.7 ppt*
FOSA	0.4 ppt*
PFBA	3.7 ppt*
PFBS	0.5 ppt*
PFHpA	0.5 ppt*
PFHxA	0.9 ppt*
PFHxS	0.5 ppt*
PFPeA	1.1 ppt*

Columbus, Ohio

Sample Date: 11/4/2019

Sample collected from Columbus within the likely service area of the Columbus Public Water System.

TOTAL	16.4 ppt
PFOS	2.0 ppt
PFOA	2.4 ppt
FOSA	1.0 ppt*
PFBA	4.8 ppt
PFBS	1.2 ppt*
PFHpA	0.7 ppt*
PFHxA	1.5 ppt*
PFHxS	0.9 ppt*
PFPeA	2.0 ppt

**Concentration detected was above the limit of detection but below the limit of quantitation.*

Decatur, Ala.

Sample Date: 11/8/2019

Sample collected from Decatur within the likely service area of the Decatur community water system.

TOTAL	24.1 ppt
PFOS	2.1 ppt
PFOA	2.4 ppt
PFBA	6.6 ppt
PFBS	2.6 ppt
PFHpA	1.0 ppt*
PFHxA	5.9 ppt
PFHxS	0.6 ppt*
PFPeA	2.9 ppt

El Paso County, Colo.

Sample Date: 11/4/2019

Sample collected from Colorado Springs within the likely service area of the Security Water District.

TOTAL	2.0 ppt
FOSA	0.6 ppt*
PFBS	0.5 ppt*
PFHxA	0.5 ppt*
PFPeA	0.5 ppt*

Indianapolis, Ind.

Sample Date: 11/5/2019

Sample collected from Indianapolis within the likely service area of Citizens Water—Indianapolis.

TOTAL	15.0 ppt
PFOS	1.4 ppt*
PFOA	1.4 ppt*
PFBA	3.3 ppt*
PFBS	1.6 ppt*
PFHpA	0.8 ppt*
PFHxA	2.6 ppt
PFHxS	0.5 ppt*
PFPeA	3.3 ppt

Jackson, Miss.

Sample Date: 11/7/2019

Sample collected from Jackson within the likely service area of the City of Jackson community water system.

TOTAL	3.8 ppt
PFOS	0.6 ppt*
PFBA	3.2 ppt*

**Concentration detected was above the limit of detection but below the limit of quantitation.*

Kansas City, Kan.

Sample Date: 11/6/2019

Sample collected from Kansas City, Kan., within the likely service area of the Kansas City Board of Public Utilities.

TOTAL	5.2 ppt
PFOS	0.5 ppt*
FOSA	0.6 ppt*
PFBA	3.5 ppt*
PFPeA	0.6 ppt*

Kansas City, Mo.

Sample Date: 11/6/2019

Sample collected from Kansas City, Mo., within the likely service area of the Kansas City community water system.

TOTAL	8.4 ppt
PFOS	0.4 ppt*
PFOA	0.5 ppt*
FOSA	0.5 ppt*
PFBA	4.8 ppt
PFHpA	0.6 ppt*
PFHxA	0.6 ppt*
PFHxS	0.6 ppt*
PFPeA	0.5 ppt*

Las Vegas, Nev.

Sample Date: 8/10/2019

Sample collected from Las Vegas within the likely service area of the Las Vegas Valley Water District.

TOTAL	6.5 ppt
PFOS	0.5 ppt*
PFOA	0.5 ppt*
FOSA	1.6 ppt*
PFBA	1.8 ppt*
PFBS	0.5 ppt*
PFHxA	0.8 ppt*

Arrived at the lab with slightly elevated temperature

Little Rock, Ark.

Sample Date: 11/7/2019

Sample collected from North Little Rock within the likely service area of Central Arkansas Water.

TOTAL	1.4 ppt
FOSA	1.4 ppt*

**Concentration detected was above the limit of detection but below the limit of quantitation.*

Louisville, Ky.

Sample Date: 7/29/2019

Sample collected from Louisville within the likely service area of Louisville Water Company.

TOTAL	45.2 ppt
PFOS	2.6 ppt
PFOA	7.7 ppt
GenX	22.0 ppt
PFBA	3.4 ppt*
PFBS	1.5 ppt*
PFHpA	1.2 ppt*
PFHxA	2.9 ppt
PFHxS	0.8 ppt*
PFNA	0.6 ppt*
PFPeA	2.5 ppt

Memphis, Tenn.

Sample Date: 11/7/2019

Sample collected from Memphis within the likely service area of Memphis Light, Gas and Water.

TOTAL	1.0 ppt
FOSA	1.0 ppt*

Meridian, Miss.

Sample Date: 11/7/2019

Sample collected from Meridian within the likely service area of the City of Meridian community water system.

TOTAL	ND

Miami, Fla.

Sample Date: 7/19/2019

Sample collected from Miami within the likely service area of the Miami Dade Water and Sewer Authority.

TOTAL	56.7 ppt
PFOS	12.0 ppt
PFOA	4.6 ppt
GenX	0.5 ppt*
FOSA	0.9 ppt*
PFBA	12.0 ppt
PFBS	4.1 ppt
PFHpA	3.1 ppt
PFHxA	6.5 ppt
PFHxS	2.2 ppt
PFNA	0.8 ppt*
PFPeA	10.0 ppt

Minneapolis, Minn.

Sample Date: 6/4/2019

Sample collected from Minneapolis within the likely service area of the Minneapolis community water system.

TOTAL	14.2 ppt
PFOS	0.5 ppt*
PFOA	0.8 ppt*
PFBA	11.0 ppt
PFBS	0.5 ppt*
PFHpA	0.5 ppt*
PFHxA	0.9 ppt*

**Concentration detected was above the limit of detection but below the limit of quantitation.*

Nashville, Tenn.

Sample Date: 11/8/2019

Sample collected from Nashville within the likely service area of Nashville Water Department #1.

TOTAL	6.0 ppt
PFOA	0.5 ppt*
FOSA	1.9 ppt
PFBA	2.4 ppt*
PFBS	0.6 ppt*
PFPeA	0.6 ppt*

New Orleans, La.

Sample Date: 7/7/2019

Sample collected from New Orleans within the likely service area of the New Orleans Carrollton Waterworks.

TOTAL	41.8 ppt
PFOS	2.9 ppt
PFOA	1.9 ppt
GenX	7.3 ppt
6:2 FTSA	15.0 ppt
PFBA	9.6 ppt
PFBS	1.7 ppt
PFHpA	0.8 ppt*
PFHxA	1.3 ppt*
PFHxS	0.7 ppt*
PFNA	0.5 ppt*

New York, N.Y.

Sample Date: 7/10/2019

Sample collected from New York within the likely service area of the New York City System.

TOTAL	2.3 ppt
PFOS	0.6 ppt*
PFOA	0.6 ppt*
FOSA	0.7 ppt*
PFHxA	0.5 ppt*

Omaha, Neb.

Sample Date: 8/18/2019

Sample collected from Omaha within the likely service area of the Metropolitan Utilities District.

TOTAL	5.9 ppt
PFOS	0.8 ppt*
PFBA	3.4 ppt*
PFHpA	0.7ppt*
PFHxA	0.6 ppt*
PFHxS	0.5 ppt*

**Concentration detected was above the limit of detection but below the limit of quantitation.*

Philadelphia, Pa.

Sample Date: 8/27/2019

Sample collected from Philadelphia within the likely service area of the Philadelphia Water Department.

TOTAL	46.3 ppt
PFOS	5.3 ppt
PFOA	7.7 ppt
FOSA	1.3 ppt*
PFBA	5.5 ppt
PFBS	3.4 ppt
PFDA	0.8 ppt*
PFHpA	3.3 ppt
PFHxA	7.1 ppt
PFHxS	1.8 ppt
PFNA	1.8 ppt
PFPeA	8.3 ppt

Prince George's County, Md.

Sample Date: 7/22/2019

Sample collected from Prince George's County within the service area of the Washington Suburban Sanitary Commission.

TOTAL	17.8 ppt
PFOS	2.1 ppt
PFOA	2.4 ppt
PFBA	2.8 ppt*
PFBS	1.2 ppt*
PFHpA	1.4 ppt*
PFHxA	3.3 ppt
PFHxS	1.0 ppt*
PFNA	0.5 ppt*
PFPeA	3.2 ppt

Pittsburgh, Pa.

Sample Date: 11/4/2019

Sample collected from Pittsburgh within the likely service area of the Pittsburgh Water and Sewer Authority.

TOTAL	8.4 ppt
PFOS	1.3 ppt*
PFOA	1.6 ppt*
PFBA	2.3 ppt*
PFBS	0.7 ppt*
PFHpA	0.7 ppt*
PFHxA	1.0 ppt*
PFPeA	0.9 ppt*

Quad Cities, Iowa

Sample Date: 8/8/2019

Sample collected from Davenport within the likely service area of Iowa-American Water Company—Davenport.

TOTAL	109.8 ppt
PFOS	3.0 ppt
PFOA	2.6 ppt
PFBA	72.0 ppt
PFBS	3.5 ppt
PFHpA	0.9 ppt*
PFHxA	1.5 ppt*
PFHxS	0.9 ppt*
PFNA	0.5 ppt*
PFPeA	25.0 ppt

The Quad Cities refers to the region that includes Davenport and Bettendorf, Iowa, and Rock Island, Moline, and East Moline, Ill.

**Concentration detected was above the limit of detection but below the limit of quantitation.*

Rockingham County, N.H.

Sample Date: 11/21/2019

Sample collected from Rye within the likely service area of the Rye Water District.

TOTAL	17.1 ppt
PFOS	3.3 ppt
PFOA	4.3 ppt
FOSA	0.7 ppt*
PFBA	1.9 ppt*
PFBS	1.9 ppt
PFHpA	1.3 ppt*
PFHxA	1.3 ppt*
PFHxS	1.0 ppt*
PFPeA	1.4 ppt*

Sacramento, Calif.

Sample Date: 5/15/2019

Sample collected from Sacramento within the likely service area of the City of Sacramento community water system.

TOTAL	1.6 ppt
PFOS	0.7 ppt*
PFOA	0.4 ppt*
FOSA	0.6 ppt*

San Antonio, Texas

Sample Date: 8/13/2019

Sample collected from San Antonio within the likely service area of the San Antonio Water System.

TOTAL	7.7 ppt
PFOS	2.0 ppt*
PFOA	1.0 ppt*
FOSA	0.6 ppt*
PFBS	1.4 ppt*
PFHxA	0.7 ppt*
PFHxS	1.2 ppt*
PFPeA	0.9 ppt*

Collection date estimated based on sample shipping documentation.

Seattle, Wash.

Sample Date: 7/10/2019

Sample collected from Seattle within the likely service area of Seattle Public Utilities.

TOTAL	0.7 ppt
FOSA	0.7 ppt*

**Concentration detected was above the limit of detection but below the limit of quantitation.*

St. Louis, Mo.

Sample Date: 11/5/2019

Sample collected from St. Louis within the likely service area of the St. Louis City community water system.

TOTAL	6.7 ppt
PFOS	0.5 ppt*
PFBA	3.8 ppt*
PFHpA	0.6 ppt*
PFHxA	0.7 ppt*
PFHxS	0.6 ppt*
PFPeA	0.6 ppt*

St. Louis County, Mo.

Sample Date: 11/5/2019

Sample collected from St. Ann within the likely service area of the Missouri American St. Louis County and St. Charles County community water system.

TOTAL	7.4 ppt
PFOS	0.6 ppt*
PFOA	0.5 ppt*
PFBA	3.8 ppt*
PFHpA	0.6 ppt*
PFHxA	0.7 ppt*
PFHxS	0.5 ppt*
PFPeA	0.5 ppt*

St. Charles County, Mo.

Sample Date: 11/5/2019

Sample collected from St. Charles within the likely service area of the St. Charles community water system.

TOTAL	2.5 ppt
PFBA	1.9 ppt*
PFPeA	0.6 ppt*

Tulsa, Okla.

Sample Date: 11/6/2019

Sample collected from Tulsa within the likely service area of the Tulsa community water system.

TOTAL	2.6 ppt
FOSA	0.7 ppt*
PFBA	1.9 ppt*

Tuscaloosa, Ala.

Sample Date: 11/8/2019

Sample collected from Tuscaloosa within the likely service area of Tuscaloosa Water and Sewer.

TOTAL	0.5 ppt
PFBS	0.5 ppt*

**Concentration detected was above the limit of detection but below the limit of quantitation.*

Washington, D.C.

Sample Date: 7/22/2019

Sample collected from Washington within the service area of D.C. Water and Sewer Authority.

TOTAL	21.7 ppt
PFOS	3.3 ppt
PFOA	3.0 ppt
PFBA	3.4 ppt*
PFBS	1.8 ppt
PFHpA	1.6 ppt*
PFHxA	3.2 ppt
PFHxS	1.2 ppt*
PFNA	0.6 ppt*
PFPeA	3.6 ppt

Wilmington, N.C.

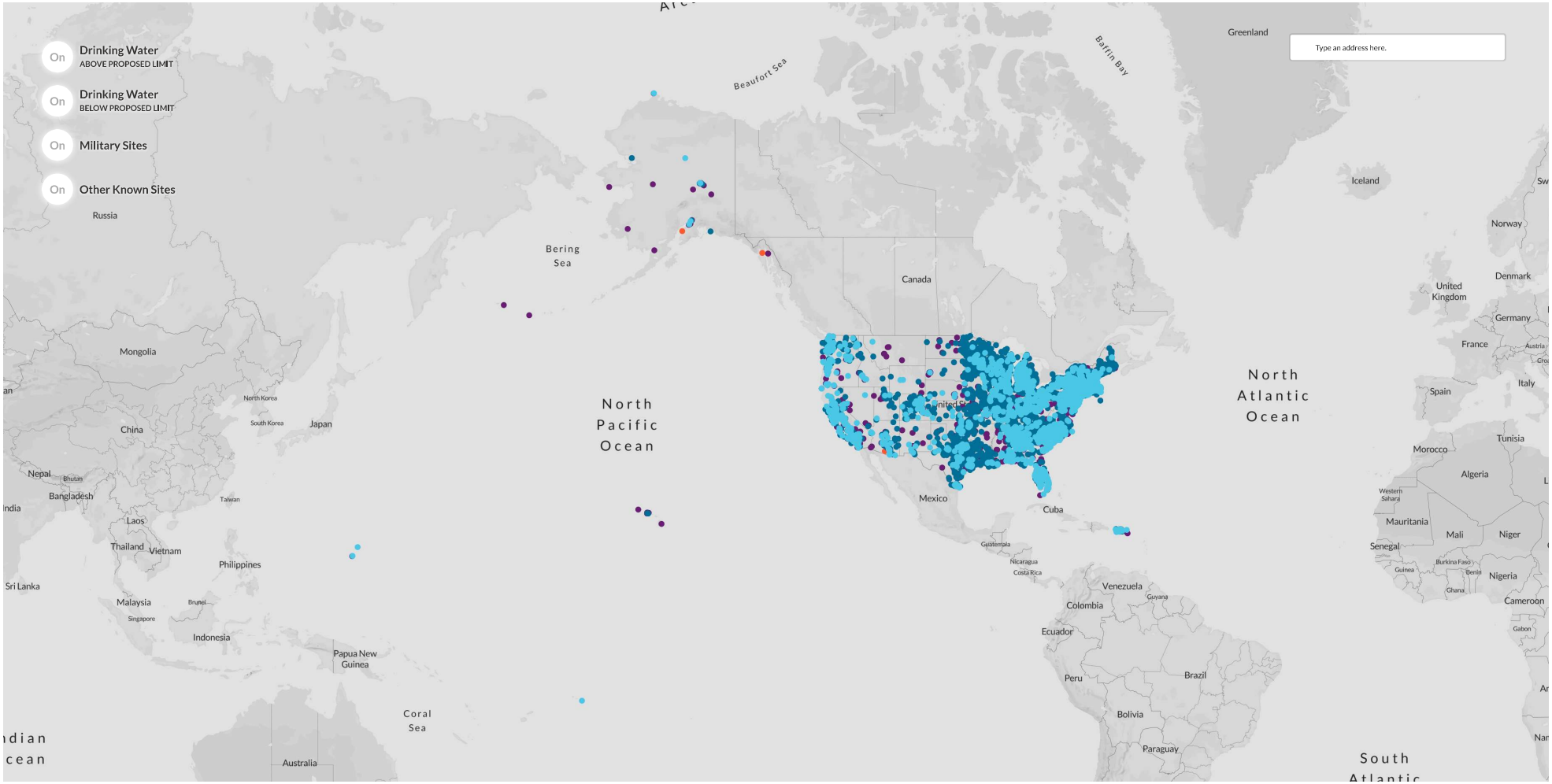
Sample Date: 6/27/2019

Sample collected from Wilmington within the likely service area of the Cape Fear Public Utility Authority—Wilmington.

TOTAL	50.5 ppt
PFOS	1.2 ppt*
PFOA	1.9 ppt
GenX	10.0 ppt
PFBA	8.3 ppt
PFBS	1.7 ppt
PFHpA	4.1 ppt
PFHxA	10.0 ppt
PFHxS	0.9 ppt*
PFPeA	12.0 ppt
PFPeS	0.4 ppt*

**Concentration detected was above the limit of detection but below the limit of quantitation.*

PFAS contamination in the U.S. (August 14, 2025)



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Exploratory profiles of phenols, parabens, and per- and polyfluoroalkyl substances among NHANES study participants in association with previous cancer diagnoses

Amber L. Cathey[1], Vy K. Nguyen[1,2], Justin A. Colacino[1], Tracey J. Woodruff[3], Peggy Reynolds[4] and Max T. Aung[5]✉

BACKGROUND: Some hormonally active cancers have low survival rates, but a large proportion of their incidence remains unexplained. Endocrine disrupting chemicals may affect hormone pathways in the pathology of these cancers.
OBJECTIVE: To evaluate cross-sectional associations between per- and polyfluoroalkyl substances (PFAS), phenols, and parabens and self-reported previous cancer diagnoses in the National Health and Nutrition Examination Survey (NHANES).
METHODS: We extracted concentrations of 7 PFAS and 12 phenols/parabens and self-reported diagnoses of melanoma and cancers of the thyroid, breast, ovary, uterus, and prostate in men and women (≥20 years). Associations between previous cancer diagnoses and an interquartile range increase in exposure biomarkers were evaluated using logistic regression models adjusted for key covariates. We conceptualized race as social construct proxy of structural social factors and examined associations in non-Hispanic Black, Mexican American, and other Hispanic participants separately compared to White participants.
RESULTS: Previous melanoma in women was associated with higher PFDE (OR:2.07, 95% CI: 1.25, 3.43), PFNA (OR:1.72, 95% CI: 1.09, 2.73), PFUA (OR:1.76, 95% CI: 1.07, 2.89), BP3 (OR: 1.81, 95% CI: 1.10, 2.96), DCP25 (OR: 2.41, 95% CI: 1.22, 4.76), and DCP24 (OR: 1.85, 95% CI: 1.05, 3.26). Previous ovarian cancer was associated with higher DCP25 (OR: 2.80, 95% CI: 1.08, 7.27), BPA (OR: 1.93, 95% CI: 1.11, 3.35) and BP3 (OR: 1.76, 95% CI: 1.00, 3.09). Previous uterine cancer was associated with increased PFNA (OR: 1.55, 95% CI: 1.03, 2.34), while higher ethyl paraben was inversely associated (OR: 0.31, 95% CI: 0.12, 0.85). Various PFAS were associated with previous ovarian and uterine cancers in White women, while MPAH or BPF was associated with previous breast cancer among non-White women.
IMPACT STATEMENT: Biomarkers across all exposure categories (phenols, parabens, and per- and poly- fluoroalkyl substances) were cross-sectionally associated with increased odds of previous melanoma diagnoses in women, and increased odds of previous ovarian cancer was associated with several phenols and parabens. Some associations differed by racial group, which is particularly impactful given the established racial disparities in distributions of exposure to these chemicals. This is the first epidemiological study to investigate exposure to phenols in relation to previous cancer diagnoses, and the first NHANES study to explore racial/ethnic disparities in associations between environmental phenol, paraben, and PFAS exposures and historical cancer diagnosis.

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INTRODUCTION

Prostate and breast cancer are the most commonly diagnosed cancers among men and women, respectively [1]. Despite their prevalence, risk factors explaining the majority of cases remain elusive [2]. Previous work has shown that genetic heritability does not fully explain the incidence and outcomes of these cancers, thus multiple environmental and social factors are likely to be involved in the initiation and progression of these diseases [3]. Prostate and breast cancer are both hormone-mediated cancers, as are other less common cancer types including ovarian cancer, endometrial cancer, testicular cancer, thyroid cancer, and melanoma. Growth and progression of these cancer types depend largely on endogenous steroid and thyroid hormones [4], therefore identifying environmental insults that impact these hormone levels may be important for discovery of new cancer prevention and mitigation methods. These efforts could include targeted environmental health interventions to reduce exposure to these chemicals in high-risk individuals or cancer patients, regulations to limit the exposure of these chemicals in the general population, and the replacement of these chemicals with safer alternatives.

Many environmental toxicants have been identified as endocrine disruptors, including phenols, parabens, and per- and polyfluoroalkyl substances (PFAS). Human exposure to phenols and parabens occurs most commonly via plastic food/beverage

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packaging and personal care products. PFAS chemicals are found in stain resistant fabrics and flame retardant furniture, are persistent in the environment, and can bioaccumulate inside the body following exposure. Previous work has shown these chemicals to have effects on circulating concentrations of estrogens [5, 6], thyroid hormones [6–8], and testosterone [6, 9] in human studies. Further, effects on hormones have been identified as a key characteristic of carcinogenesis [10]. Despite the established endocrine disrupting potential of these chemicals, few epidemiology studies have assessed their relationships with endocrine-active cancer outcomes. Several case control studies have shown positive or suggestive associations between breast cancer and bisphenol-A (BPA) [11] and PFAS chemicals [12–15], but similar studies involving other emerging phenols or other cancer types are lacking.

The National Health and Nutrition Examination Survey (NHANES) is a United States nation-wide biomonitoring effort which has demonstrated evidence of widespread human exposure to environmental toxicants including phenols, parabens, and PFAS [16]. NHANES also provides self-reported cancer diagnoses for all participating individuals aged 20 years and older, constituting an ideal dataset for conducting preliminary analyses to evaluate the relationships between environmental chemicals and cancer outcomes. Therefore, the aim of this study was to utilize NHANES data from 2005 to 2018 to conduct a cross-sectional study evaluating associations between current exposure levels to phenols, parabens, and PFAS chemicals and previous endocrine-active cancer diagnoses. The results from this study can help identify the potential role of environmental toxicants in prospective studies of cancer.

METHODS

Study population

Data from NHANES was used for the present analysis. NHANES is composed of a non-institutionalized, nationally representative, sample of children and adults and is used to assess the health and nutritional status of the United States population. A flowchart depicting how we built our analytical datasets is presented in Fig. 1. From NHANES data collected between 2005 and 2018, we extracted demographic variables, self-reported cancer diagnoses from the medical conditions questionnaire, and concurrent biomarker concentrations of phenols, parabens, and PFAS. We first restricted our dataset to all individuals 20 years and older with complete data on selected covariates (age, serum concentrations of the tobacco smoke metabolite cotinine, poverty-income ratio, race, education, body mass index, and creatinine (for phenol/paraben analysis only)) for an initial sample size of 48,712 people. Additionally, in NHANES there are non-overlapping participants with measurements for different exposure chemical panels, thus, we created two separate analytical datasets – one for phenols/parabens and one for PFAS. After removing individuals missing biomarker data, the PFAS dataset contained 16,696 people and the phenols/parabens dataset contained 10,428 people (phenols and parabens were not measured in the 2017–2018 cycle). Our study goal was to focus on sex-specific relationships between environmental PFAS, phenols and parabens exposure with previous cancer diagnosis, partly due to sexual dimorphic profiles for cancer risk. Therefore, to evaluate sex-specific cancers, both datasets were separated between males and females for final sample sizes of 8010 men and 8686 women in the PFAS analysis and 5084 men and 5344 women in the phenol/paraben analysis.

Biomarker assessment

We included NHANES measures of a total of seven PFAS chemicals and 12 phenols/parabens. Five PFAS chemicals were measured in all cycles from 2005 to 2018: perfluorohexane sulfonic acid (PFHS), 2-(N-methyl-PFOSA) acetic acid (MPAH), perfluorodecanoic acid (PFDE), perfluorononanoic acid (PFNA), and perfluoroundecanoic acid (PFUA). Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) were included from all cycles except 2013–2014. PFAS were quantified from serum samples using high performance liquid chromatography-turbo ion spray ionization-tandem mass spectrometry. Seven phenols/parabens were measured in all cycles between 2005 and 2016: bisphenol-A (BPA), benzophenone-3 (BP3), triclosan (TCS), methyl paraben (MPB), ethyl paraben (EPB), propyl paraben (PPB), and butyl paraben (BPB). Five additional phenols/parabens were measured from 2013 to 2016: bisphenol-F (BPF), bisphenol-S (BPS), triclocarban (TCC), 2,4-dichlorophenol (DCP24), and 2,5-dichlorophenol (DCP25). Phenols and parabens were quantified in urine samples using on-line solid phase extraction coupled to high performance liquid chromatography and tandem mass spectrometry.

Cancer outcome assessment

Self-reported cancer diagnoses were obtained from the medical conditions questionnaire administered to all participants 20 years and older. Participants were first asked "Have you ever been told by a doctor or other health professional that you had cancer or a malignancy of any kind?" Those who responded yes were then asked to indicate which type of cancer it was, and they were able to indicate up to three different cancer types. We extracted data for 7 cancer types: breast, ovarian, uterine, prostate, testicular, thyroid, and melanoma. We also created a variable for combined reproductive cancers which included breast, ovarian, and uterine cancers for women and prostate and testicular cancer for men.

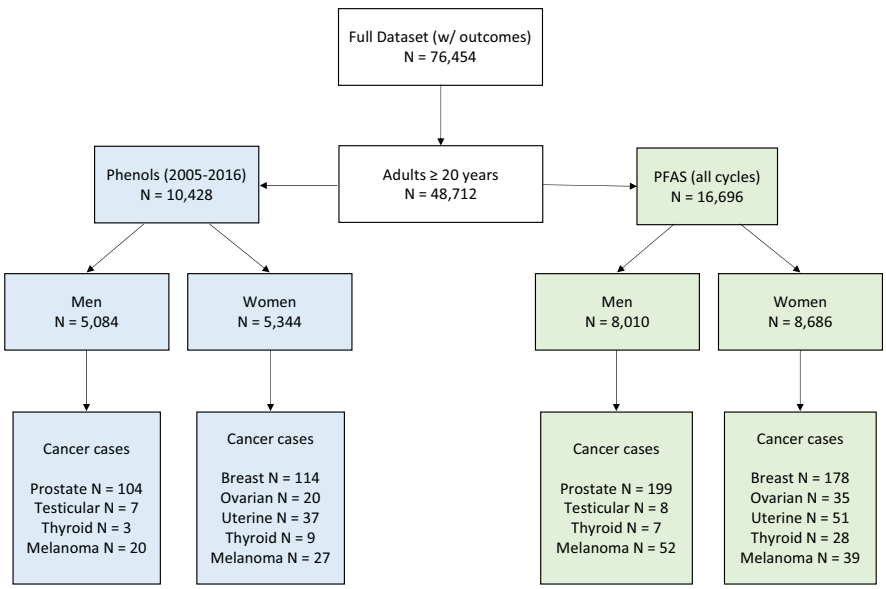

Fig. 1 Flow chart for building the final analytical datasets. Sample size are indicated in green boxes for PFAS chemicals and blue boxes for phenols/parabens.

Testicular cancer and thyroid cancer among men were excluded from regression analyses because of low case numbers ($N < 10$).

Statistical analyses

Demographic characteristics among participants 20 years and older who provided data on at least one exposure-outcome pair were tabulated for both PFAS and phenol/paraben populations. Case/control sample sizes of cancer outcomes were tabulated, and distributions of all exposure variables were evaluated. All exposure biomarkers were right-skewed and were thus natural log-transformed for all analyses. Concentrations of BPB, EPB, and triclocarban were measured below the limit of detection (LOD) in more than 50% of samples, so these were treated as categorical variables with all concentrations below the LOD as the reference group and the remaining concentrations split between those below the median and those at or above the median of detectable values. All concentrations below the LOD were imputed with the LOD divided by the square root of two. Associations between exposure biomarkers and cancer outcomes were estimated using logistic regression. Based on the literature of potential cancer risk factors [17] we considered demographic, social, and biological covariates to determine potential confounders, and we examined bivariate associations between exposures, outcome, and these potential confounders to build our adjusted models. Based on these relationships, adjusted models included age at the time of survey, natural log-transformed cotinine, poverty-income ratio, race, education, body mass index, and an indicator variable for NHANES cycle to capture changing exposure and outcome trends over time. Phenol/paraben models also were adjusted for natural log-transformed urinary creatinine to account for differences in urinary dilution. We also considered adjusting melanoma models for self-reported sunscreen use due to many brands being a source of phenol exposure [18], but there was not enough overlap in participants who provided sunscreen use data and those who reported having melanoma. All results are presented as the odds of previous cancer diagnosis with an interquartile range (IQR) increase in current exposure biomarker concentration. All analyses were conducted in R version 4.0.4.

Effect modification by race

To explore the possibility of race as a social construct proxy of structural social factors and an effect modifier on the associations between environmental exposures and cancer outcomes, we ran sensitivity analyses in which effect estimates were calculated among non-White racial groups separately (non-Hispanic Black, Mexican American, and other Hispanic) and compared to effects among White participants only. Models included interaction terms specific to each White/non-White pair such that the p-value of the interaction term (p-int) could be interpreted as the significance of the difference between those two groups ($p < 0.05$ was considered statistically significant).

Sampling weights sensitivity analyses

As a sensitivity analysis, we accounted for survey sampling weights in all adjusted models to determine consistency in findings in unweighted analyses. Application of the survey weights accounts for sampling based on demographic factors and produces estimates that are representative of the non-institutionalized general US population. Across multiple NHANES cycles, we utilized R to apply the weighting algorithm explained by Nguyen and colleagues [16], which prioritizes weights on the smallest subsample of biomarker data for integration of weights.

RESULTS

Demographic information is shown in Table 1. Both PFAS and phenol/paraben populations had similar proportions of men and women, with slightly more women. Across both sexes and datasets, the median age was about 49 years, the median poverty

Table 1. Demographic characteristics of NHANES participants, 20 years and older, who provided data on at least one PFAS or phenol/paraben chemical.

	PFAS Population		Phenol Population	
	Men ($N = 8010$)	**Women ($N = 8686$)**	**Men ($N = 5084$)**	**Women ($N = 5344$)**
Median (SD)				
Age	50 (17.9)	49 (17.8)	49 (17.8)	48 (17.9)
Poverty Income Ratio	2.19 (1.63)	1.99 (1.62)	2.2 (1.64)	1.98 (1.64)
Serum Cotinine	0.063 (140)	0.03 (108)	0.75 (138)	0.034 (118)
BMI	27.4 (5.62)	27.4 (7.34)	27.4 (5.77)	27.1 (6.89)
***N* (%)**				
Race				
Non-Hispanic White	3358 (41.9%)	3428 (39.5%)	2206 (43.4%)	2232 (41.8%)
Non-Hispanic Black	1693 (21.1%)	1867 (21.5%)	1106 (21.8%)	1179 (22.1%)
Mexican American	1212 (15.1%)	1370 (15.8%)	792 (15.6%)	844 (15.8%)
Other Hispanic	731 (9.1%)	922 (10.6%)	447 (8.8%)	548 (10.3%)
Other	1016 (12.7%)	1099 (12.7%)	533 (10.5)	541 (10.1%)
Annual Household Income				
Less than $20k	1353 (18.9%)	1751 (22.5%)	915 (20.0%)	1169 (24.2%)
[$20k–$45k)	2252 (31.5%)	2449 (31.5%)	1416 (30.9%)	1516 (31.3%)
[$45k–$75k)	1449 (20.3%)	1541 (19.8%)	947 (20.7%)	925 (19.1%)
$75 K or more	2089 (29.2%)	2027 (26.1%)	1306 (28.5%)	1228 (25.4%)
Education				
Less than 9th grade	856 (10.7%)	881 (10.2%)	583 (11.5%)	549 (10.3%)
9th–11th grade	1204 (15.1%)	1145 (13.2%)	770 (15.2%)	784 (14.7%)
Diploma or equivalent	1848 (23.1%)	1857 (21.4%)	1203 (23.7%)	1203 (22.5%)
Some college/AA	2217 (27.7%)	2810 (32.4%)	1354 (26.7%)	1626 (30.5%)
College grad or more	1874 (23.4%)	1977 (22.8%)	1170 (23.0%)	1174 (22.0%)

SD Standard deviation, *BMI* Body mass index.

Table 2. Cancer case numbers, among those who provided complete data on selected covariates and cancer outcome data, between the PFAS and phenols analytical datasets.

		PFAS Population		Phenols Population	
	***N* (%)**	**Men (*N* = 6360)**	**Women (N = 6886)**	**Men (*N* = 3606)**	**Women (N = 3807)**
All Reproductive Cancers*	Yes	207 (3.3%)	255 (3.7%)	111 (3.1%)	168 (4.4%)
	No	6153 (96.7%)	6631 (96.3%)	3495 (96.9%)	3639 (95.6%)
Prostate Cancer	Yes	199 (3.1%)		104 (2.9%)	
	No	6161 (96.9%)		3502 (97.1%)	
Testicular Cancer	Yes	8 (0.1%)		7 (0.2%)	
	No	6352 (99.9%)		3599 (99.8%)	
Breast Cancer	Yes		178 (2.6%)		114 (3.0%)
	No		6708 (97.4%)		3693 (97.0%)
Ovarian Cancer	Yes		35 (0.5%)		20 (0.5%)
	No		6851 (99.5%)		3787 (99.5%)
Uterine Cancer	Yes		51 (0.8%)		37 (1.1%)
	No		6215 (99.2%)		3432 (98.9%)
Melanoma	Yes	52 (0.8%)	39 (0.6%)	20 (0.6%)	27 (0.7%)
	No	6308 (99.2%)	6847 (99.4%)	3586 (99.4%)	3780 (99.3%)
Thyroid Cancer	Yes	7 (0.1%)	28 (0.4%)	3 (0.1%)	9 (0.2%)
	No	6353 (99.9%)	6858 (99.6%)	3603 (99.9%)	3798 (99.8%)

*All reproductive cancers include prostate and testicular cancers for men and breast, ovarian, and uterine cancers for women.

income ratio was about 2, and the median body mass index was about 27 kg/m^2. Serum cotinine concentrations were higher in men than in women. Racial distributions were consistent between sex and chemical datasets, with approximately 40% non-Hispanic White, 20% non-Hispanic Black, 15% Mexican American, 10% other Hispanic, and 15% other. The majority of participants reported having an education level of at least some college.

Distributions of biomarker concentrations are shown in Supplementary Tables 1 and 2, and counts of cancer diagnoses and controls are shown in Table 2. Prostate cancer was the most frequently reported malignancy among men (PFAS subset $N = 199$; phenol/paraben subset $N = 104$) and breast cancer was the most frequently reported among women (PFAS $N = 178$; phenol/paraben $N = 114$).

Associations between current PFAS concentrations and odds of having a previous cancer diagnosis are depicted in Fig. 2 (corresponding numeric data is shown in Supplementary Table 3; numerical data with survey weights applied are shown in Supplementary Table 5). We did not observe any associations between PFAS biomarkers and previous cancer diagnoses in men. However, we did observe positive associations between several PFAS biomarkers and odds of previous melanoma among women. IQR increases in PFDE, PFNA, and PFUA were associated with 2.07 (95% CI: 1.25, 3.43), 1.72 (95% CI: 1.09, 2.73), and 1.76 (95% CI: 1.07, 2.89) times greater odds of previous melanoma diagnosis in women. There was also a positive association between an IQR increase in PFNA and odds of previous uterine cancer (OR: 1.55, 95% CI: 1.03, 2.34) and a marginally ($0.5 \le p < 0.1$) positive association between an IQR increase in PFUA and odds of previous ovarian cancer (OR: 1.61, 95% CI: 1.00, 2.59).

Associations between current phenol/paraben concentrations and odds of having a previous cancer diagnosis are depicted in Fig. 3 (corresponding numeric data is shown in Supplementary Table 4; numerical data with survey weights applied are shown in Supplementary Table 6). There was a marginally ($0.5 \le p < 0.1$) positive association between an IQR increase in PPB and odds of previous prostate cancer diagnosis (OR: 1.35, 95% CI: 1.00, 1.83). Increased odds of previous reproductive cancer diagnosis among women was associated with IQR increases in DCP25 (OR: 1.61, 95% CI: 1.13, 2.29) and DCP24 (OR: 1.42, 95% CI: 1.06, 1.90). These findings were likely driven by positive associations with both previous breast cancer diagnosis (DCP25 OR: 1.49, 95% CI: 0.95, 2.34; DCP24 OR: 1.36, 95% CI: 0.94, 1.95) and previous ovarian cancer diagnosis (DCP25 OR: 2.80, 95% CI: 1.08, 7.27; DCP24 OR: 1.95, 95% CI: 0.94, 4.06). Increased odds of previous ovarian cancer diagnosis were also observed with an IQR increase in BPA (OR: 1.93, 95% CI: 1.11, 3.35), and marginally ($0.5 \le p < 0.1$) with an IQR increase in BP3 (OR: 1.76, 95% CI: 1.00, 3.09). Reduced odds of previous uterine cancer were associated with EPB (OR: 0.31, 95% CI: 0.12, 0.85). Finally, odds of previous melanoma diagnosis among women was associated with an IQR increase in BP3 (OR: 1.81, 95% CI: 1.10, 2.96), DCP25 (OR: 2.41, 95% CI: 1.22, 4.76), and DCP24 (OR: 1.85, 95% CI: 1.05, 3.26).

Distribution of cancer outcomes by race are reported in Supplemental Table 7, and differential associations between current exposure biomarkers and previous cancer diagnoses by racial groups are shown in Figs. 4, 5 (complete numerical data is shown in the "Supplemental_Tables 8–11" excel document). There was a greater association between previous prostate cancer diagnosis and an IQR increase in PFNA exposure (p-int=0.043) among other Hispanic men (OR: 2.24, 95% CI: 0.95, 5.29) when compared to White men (OR: 0.89, 95% CI: 0.65, 1.21). Associations between numerous PFAS chemicals and previous ovarian cancer were also modified by race. White women were more likely than Black women to have a previous ovarian cancer diagnosis with an IQR increase in PFOS (OR in White women: 4.34, 95% CI: 1.24, 15.1; OR in Black women: 0.75, 95% CI: 0.31, 1.80; p-int = 0.010) and PFDE (OR in White women: 2.56, 95% CI: 1.27, 5.16; OR in Black women: 0.87, 95% CI: 0.36, 2.09; p-int=0.051), and also more likely to have a previous diagnosis of uterine cancer with IQR increases in PFDE (OR in White women: 3.08, 95% CI: 1.53, 6.21; OR in Black women: 0.42, 95% CI: 0.14, 1.27; p-int=0.002), PFNA (OR in White women: 2.36, 95% CI: 1.28, 4.37; OR in Black women: 0.85, 95% CI: 0.36, 1.98; p-int=0.043), and PFUA (OR in White women: 3.37, 95% CI: 1.89, 6.04; OR in Black women: 0.41, 95% CI: 0.13, 1.25; p-int=0.001). White women were also more likely than Mexican American women to have a previous ovarian cancer diagnosis with an IQR increase in PFOA (p-int=0.007), PFOS (p-int=0.001),

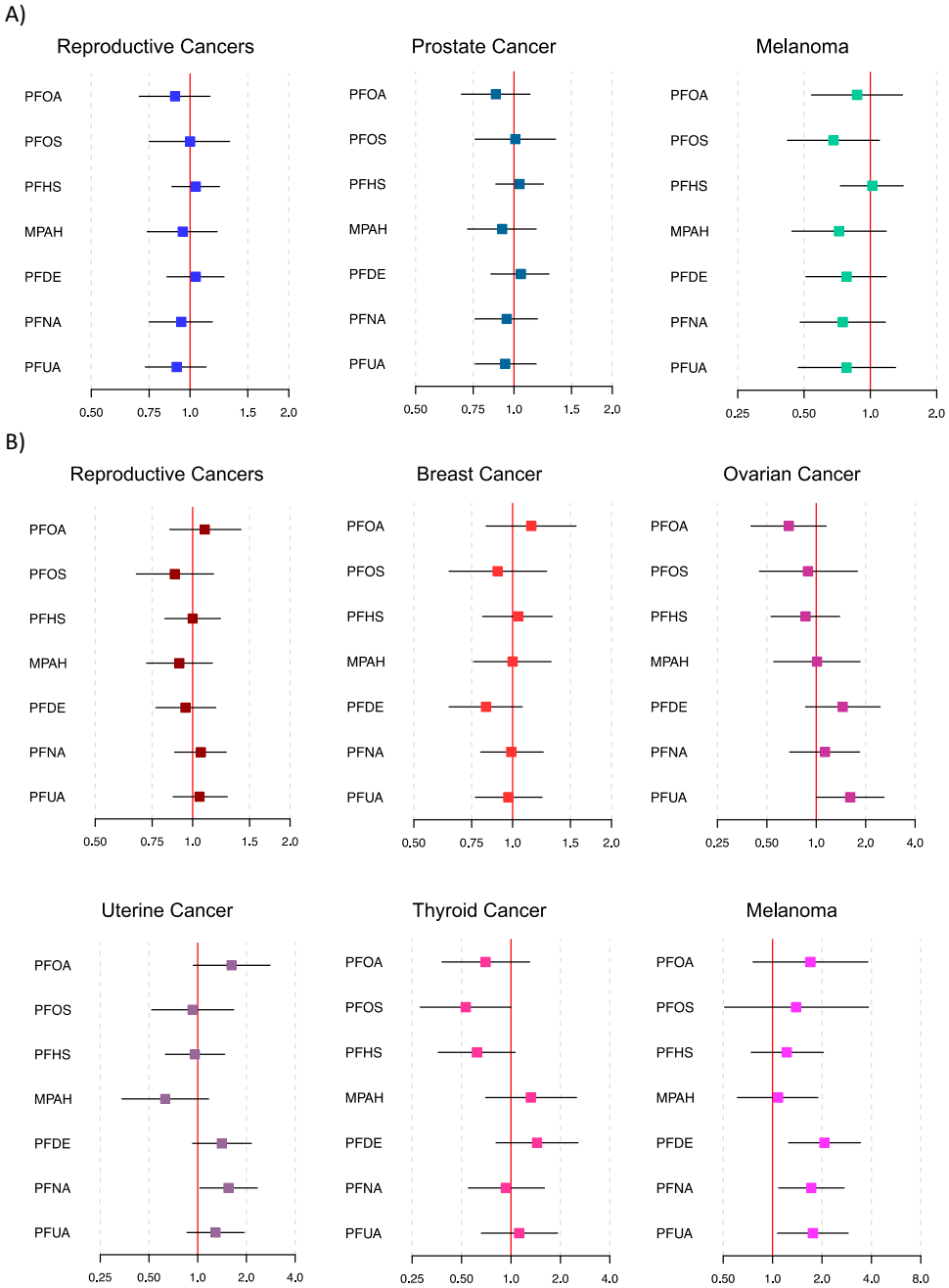

Fig. 2 Odds of each cancer type with an IQR increase in each PFAS chemical. Effect estimates and 95% confidence intervals are reported among men (Panel **A**) and women (Panel **B**). Models adjust for age at the time of survey, cotinine, poverty-income ratio, race, education, body mass index, and an indicator variable for NHANES cycle.

PFDE (p-int=0.015), and PFNA (p-int=0.001), and to have a previous uterine cancer diagnosis with an IQR increase in PFDE (p-int=0.006), but low ovarian and uterine cancer case numbers among Mexican American women may have contributed to unreliable effect estimates. Conversely, Mexican American women were more likely than White women to have a previous breast cancer diagnosis with an IQR increase in MPAH (OR in Mexican American women: 2.46, 95% CI: 1.19, 5.09; OR in White women: 1.03, 95% CI: 0.74, 1.45; p-int=0.026), and other Hispanic women were more likely to have a previous uterine cancer diagnosis than White women (OR in other Hispanic women: 3.18, 95% CI: 1.03, 9.82; OR in White women: 0.55, 95% CI: 0.21, 1.41; p-int=0.009). Most associations between previous cancer diagnosis and phenol/paraben exposures did not differ by race among men, but White men were more likely than Black men to have a previous prostate cancer diagnosis with an IQR increase in BP3 (OR in White men: 1.42, 95% CI: 1.07, 1.89; OR in Black men: 0.70, 95% CI: 0.41, 1.21; p-int=0.022) and BPF (OR in White men: 1.40, 95% CI: 0.78, 2.54; OR in Black men: 0.33, 95% CI: 0.10, 1.12; p-int=0.034). Finally, other Hispanic women were more likely than White women to have a previous breast cancer diagnosis with an IQR increase in BP3 (OR in other Hispanic women: 3.03, 95% CI: 1.22, 7.50; OR in White women: 0.94, 95% CI: 0.67, 1.31; p-int=0.017).

DISCUSSION

Here we have reported numerous associations between current concentrations of biomarkers of exposure to PFAS, phenol, and

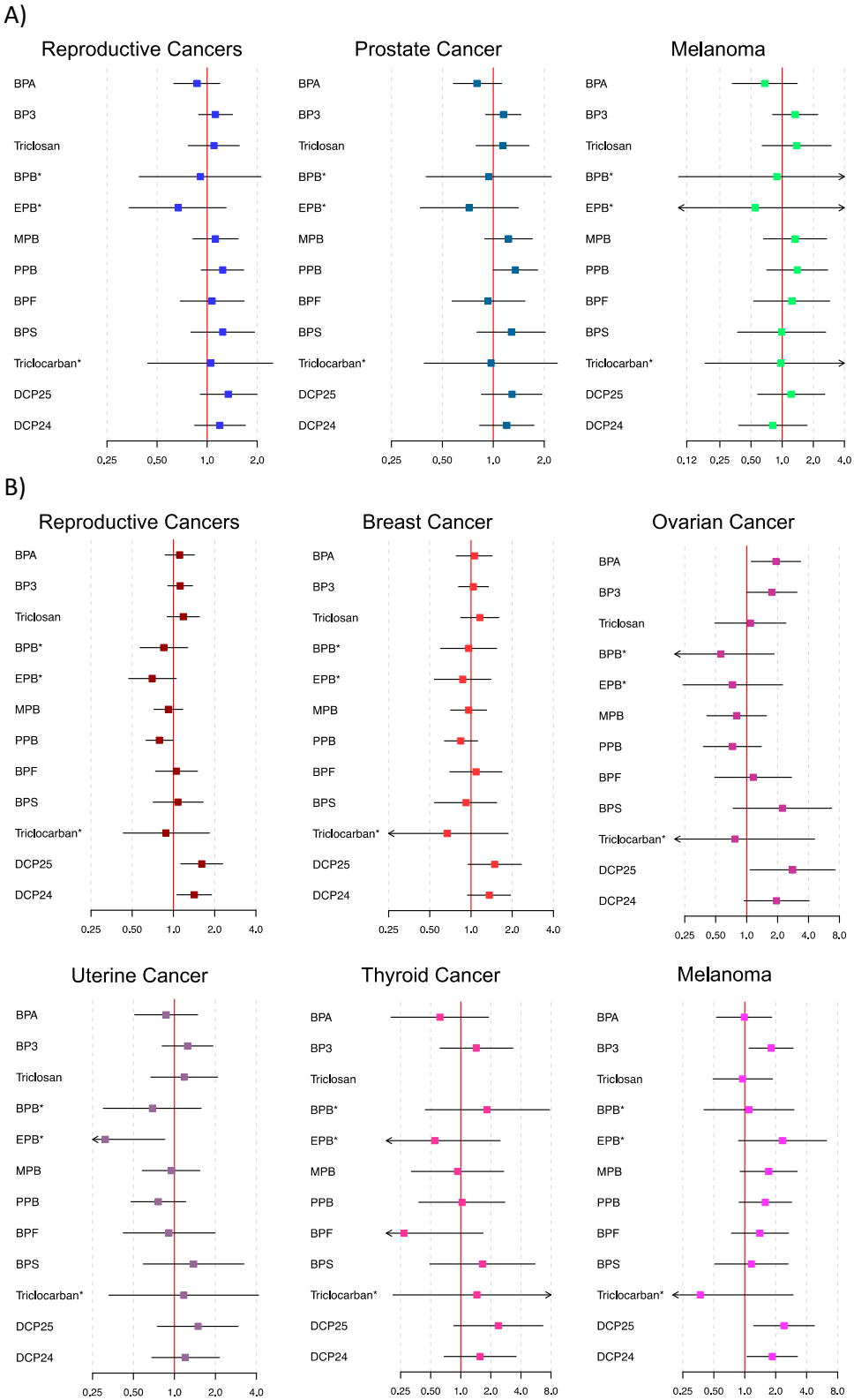

Fig. 3 Odds of each cancer type with an IQR increase in each phenol/paraben chemical. Effect estimates and 95% confidence intervals are reported among men (Panel **A**) and women (Panel **B**). Models adjust for age at the time of survey, cotinine, poverty-income ratio, race, education, body mass index, an indicator variable for NHANES cycle, and creatinine.

paraben chemicals and previous cancer diagnoses over multiple NHANES cycles. Of note, the PFAS chemicals PFDE, PFNA, and PFUA were associated with increased odds of prior melanoma diagnosis among women, but not men. Also, among women, concentrations of BPA, BP3, and two dichlorophenols were associated with greater odds of ovarian cancer. Both dichlorophenols showed positive associations with the odds of every cancer type assessed, particularly among women. Finally, greater

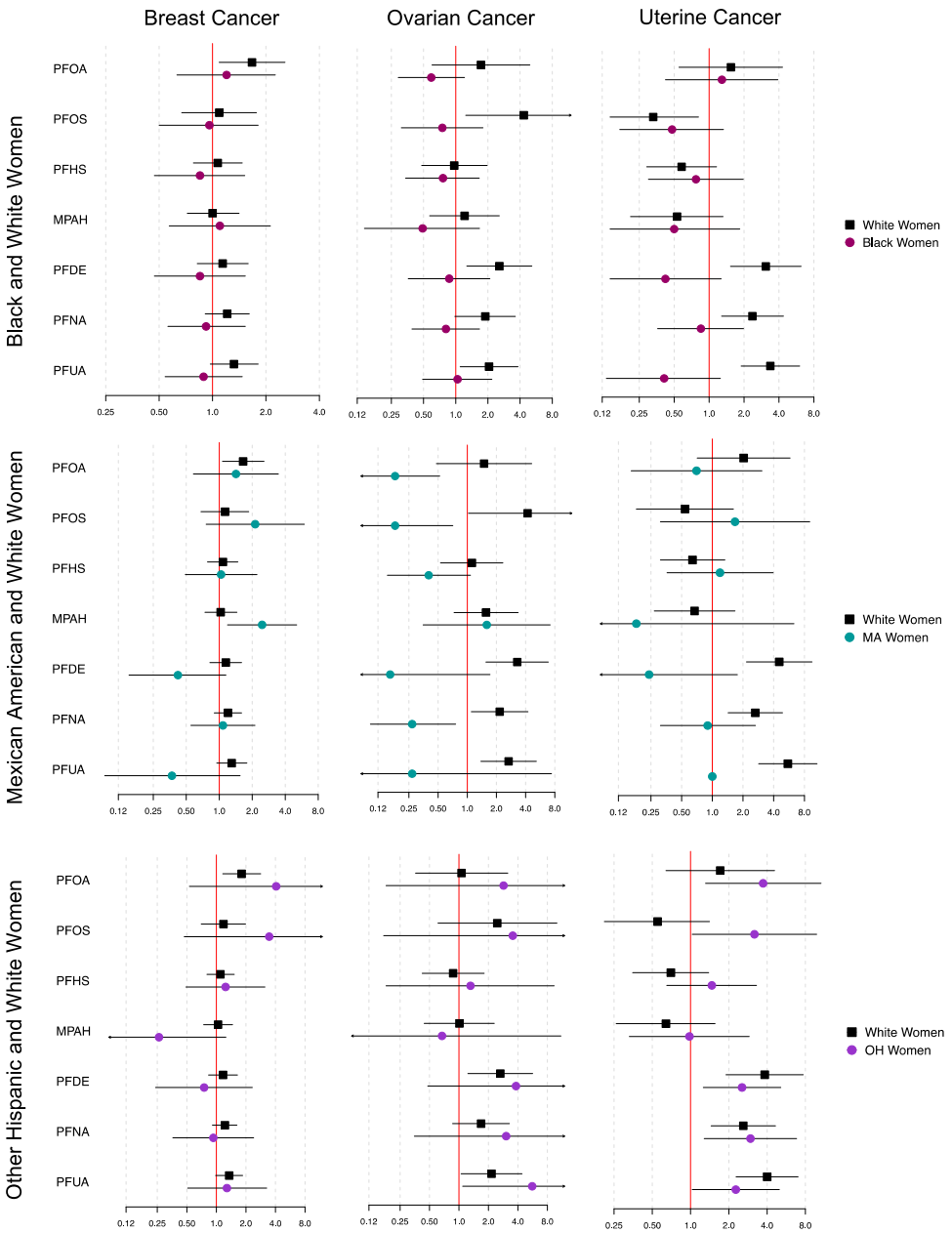

Fig. 4 Differential associations between PFAS exposures and previous cancer diagnosis by race among women. Complete corresponding numerical data can be found in the supplementary materials "Supplemental_Tables 8–11.xlsx". Forest plot reports the odds of each cancer outcome and 95% confidence interval with an IQR increase in PFAS chemical for each race. For each respective row of plots, estimates were generated utilizing subsets of data containing only white women and women of the specified race.

odds of previous cancer diagnoses among White women were observed with higher PFAS exposure, while Black and Mexican American women were more likely to have a previous cancer diagnosis with increased phenol/paraben exposure.

Numerous epidemiology studies have investigated potential associations between PFAS exposure and melanoma, but no notable effects have been found and most studies assessed only PFOA and PFOS exposures. Importantly, melanoma is the fifth most common cancer in the U.S. and recent estimates indicate increasing incidence in higher-income countries [19]. While the proportion of melanoma diagnoses is higher among White individuals, survival rates have been shown to be significantly lower among individuals who are Black, Hispanic, Asian American, Native American, and Pacific Islander [20]. Two large scale cohort studies have shown a null association between PFOA exposure and melanoma [21, 22], but both studies estimated exposure using indirect modeling rather than biomarker measurements, potentially leading to exposure misclassification and inability to account for inherent biological differences between participants such as PFAS elimination. Previous occupational exposure studies have also reported null associations between PFOA/PFOS and malignant melanoma, but these studies report low melanoma case numbers and are composed of mostly men (>80% male) [23–25]. One occupational study observed increased odds of melanoma with higher exposure to PFOS, but that cohort included only 5 cases of melanoma, reducing the reliability of their results [26]. Importantly, these occupational cohort studies utilized job-exposure matrices to ascertain PFAS exposure levels and thus their results are highly susceptible to exposure misclassification. Though the cohort study design is preferable to cross-sectional

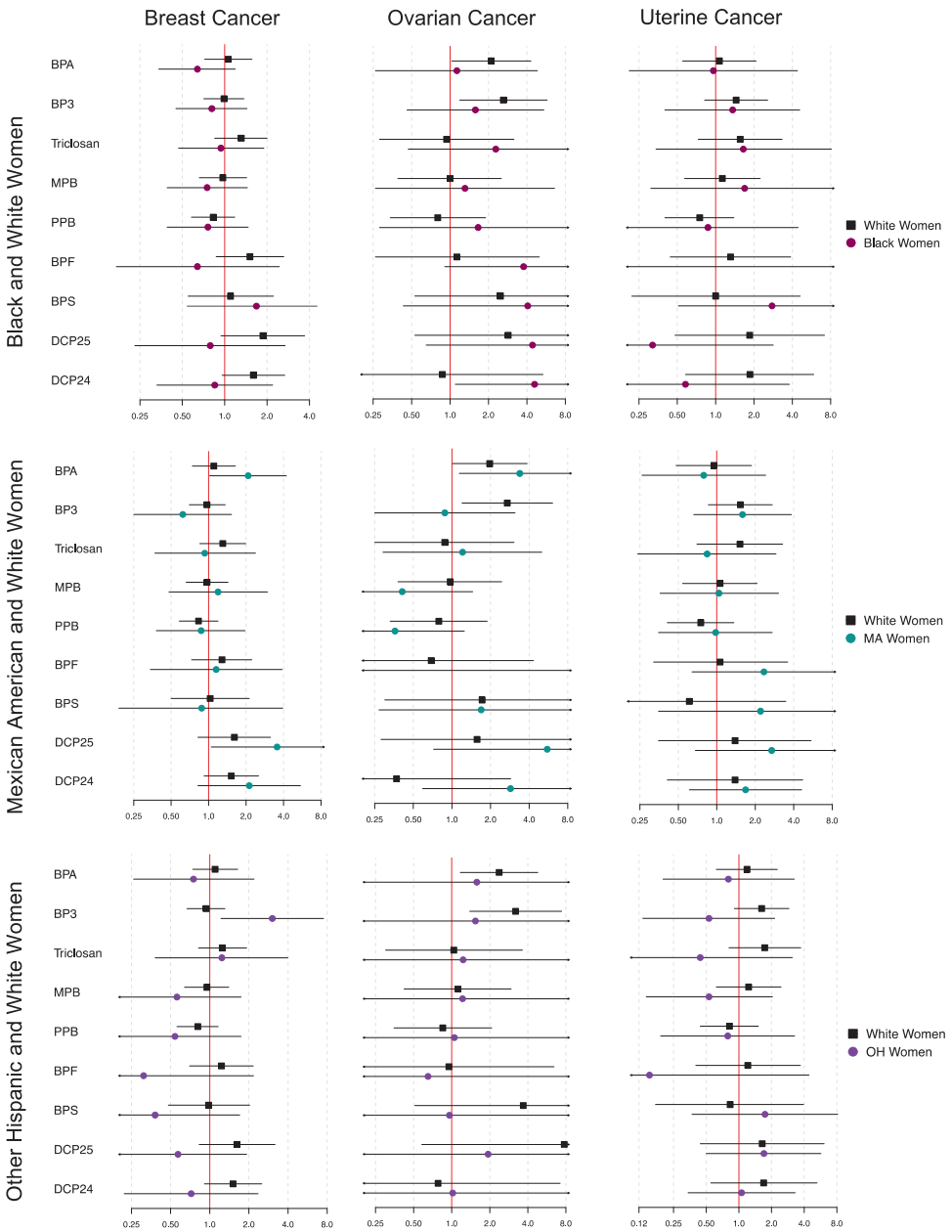

Fig. 5 Differential associations between phenol/paraben exposures and previous cancer diagnosis by race among women. Complete corresponding numerical data can be found in the supplementary materials "Supplemental_Tables 8–11.xlsx". Forest plot reports the odds of each cancer outcome and 95% confidence interval with an IQR increase in phenol/paraben for each race. For each respective row of plots, estimates were generated utilizing subsets of data containing only white women and women of the specified race.

studies, the lack of biomonitoring data on the study participants presents a significant limitation to these studies. Further investigation of prospective associations is needed, especially in women based on findings from our study that phenols (DCP25, DCP24, BP3) and PFAS (PFDE, PFNA, and PFUA) were positively associated with previous melanoma diagnosis.

Sex-specific associations between PFAS chemicals and previous melanoma diagnosis, suggest that sex-mediated mechanisms may be at play. Previous work has shown that women are more likely than men to be diagnosed with melanoma, but metastasis and mortality rates are higher among men than women [27]. Differences in melanoma outcomes based on sex may be driven by sex-specific differences in perturbations to biological processes such as cellular immortality, inflammation, oxidative stress, and hormone disruption, which are mechanisms that have been shown to be both influenced by chemical exposures and linked to cancer [10]. For example, a previous review highlighted evidence of sex differences in immune homeostasis (e.g., differences in lymphocyte activation), oxidative stress (e.g., differences in antioxidant enzyme levels), and sex hormones (e.g., differences in estrogen levels) [28]. The important role of estrogens during human pregnancy can shed light on how estrogens may also be implicated in cancer development and progression. Estrogens are critical for maintenance of pregnancy as they stimulate blood vessel formation in the uterus. Because melanoma tumor cells express estrogen receptors [29], this angiogenic property of estrogens that is so critical during pregnancy may also promote nourishment of malignant melanomas. Further, it is plausible that environmental toxicants which exhibit estrogenic activity could exacerbate this process. Toxicological evidence for estrogenicity of

PFAS is mixed: a recent in vitro study demonstrated PFAS interaction with estrogen receptor-α [30]; another recent study used in vitro and in silico methods to show that particular interactions with the estrogen receptor surface can result in PFAS exerting both estrogenic and antiestrogenic activities [31]; and other recent studies have shown no effect on estrogen levels with PFAS exposure [32, 33]. Clearly, the sexually dimorphic nature of melanoma warrants further investigation in future prospective studies, both in terms of baseline level risk between men and women and the ability of estrogenic environmental insults to further increase risk.

Based on data collected from 1999 to 2015, uterine cancer was one of few cancers increasing in incidence and mortality in the United States [34]. Uterine cancer is the fourth most commonly diagnosed cancer among U.S. women, and previous work has shown racial disparities in both incidence and histological types, with White women showing higher incidence rates than other racial/ethnic groups, and Black women showing higher mortality than other racial/ethnic groups due to diagnoses at more advanced stages of disease [35]. In our study, we observed numerous differences between racial groups, with most associations being significant and positive in White women compared to other racial groups. Notably, increased exposure to PFOA and PFOS was associated with significantly greater odds of previous uterine cancer diagnosis among Other Hispanic women relative to White women, while increased exposure to PFDE, PFNA, and PFUA were significantly associated with greater odds of previous uterine cancer diagnosis among both White and Other Hispanic women. It has been established that elevated circulating estrogens and greater rates of obesity are strongly linked to risk of uterine cancer [36]. Though the links between these factors and endocrine-disrupting chemicals including PFAS and phenols/parabens remain controversial, these may represent modifiable risk factors for targeted intervention strategies.

We observed an inverse association between PFOS exposure and odds of previous thyroid cancer diagnosis among women, while all other associations with thyroid cancer were null. To our knowledge, only one previous study has explored associations between PFAS exposure and risk of thyroid cancer. That community-based analysis found that those living in an area known to have experienced PFAS contamination of drinking water showed greater risk ratios of thyroid cancer relative to those living in unexposed control areas [37]. Additionally, one previous biomonitoring study found that increased urinary levels of the parabens MPB, EPB, and PPB were positively associated with odds of thyroid cancer [38]. Importantly, both previous studies assessed thyroid cancer outcomes among both men and women combined, while our analysis was only able to assess previous thyroid cancer diagnoses in women due to low case numbers among men. Future work should aim to better characterize endocrine disruptor associations with thyroid cancer by disentangling associations between men and women, and by using biomonitoring exposure assessment methods.

Ovarian cancer is the leading cause of death among gynecological cancers and is the seventh most commonly diagnosed cancer among women around the world [39]. Black women are disproportionately affected and have higher odds of more aggressive tumor stages [40]. Ovarian cancer, despite being less common than other cancer types among women, has a low 5-year survival rate due to the advanced stage at which it is usually diagnosed; about 75% of women are diagnosed in late-stage disease and face a 5-year survival rate of about 29% [41]. Current clinical researchers are putting considerable effort into identifying effective screening strategies but there have been no approved protocols to-date [42]. Clearly, identifying environmental exposures that puts one at greater risk of developing ovarian cancer is critical for furthering screening and prevention efforts.

Our results suggest that various environmental chemicals (PFUA, BPA, BP3, and DCP25) are associated with previous diagnosis of ovarian cancer among all women. Previous work has shown that exposure to environmental toxicants can influence cells to undergo the epithelial-mesenchymal transition (EMT), a process, defined by epithelial cells losing their cell-to-cell adhesion properties and becoming migratory, that may be crucial in the transformation of benign cells into malignant cells [43]. Upon treating ovarian cancer cells with BPA, a previous study observed that mRNA expression and protein levels of vimentin and snail, two protein families involved in the EMT, were increased. Further, protein levels of E-cadherin, a cell adhesion protein, were decreased following treatment with BPA [44]. Similarly, another study utilizing a different type of ovarian cancer cell line found that treatment of cells with BPA resulted in stimulated cell migration via upregulation of matrix metalloproteinases and N-cadherin [45]. Ovarian cancer is known to be hormonally driven; about 50% of ovarian cancer cells in humans express higher levels of estrogen receptor-α and -β relative to cells from a normal ovary or benign tumor cells [46]. Accordingly, both previous studies used treatment with estradiol as a positive control and observed that the effects of BPA treatment were similar to that of estradiol, indicating the importance of mitigating exposures to estrogenic chemicals for ovarian cancer prevention.

A previous review illustrates that BPA can regulate the expression of genes in ovarian cancer cells which act on pathways implicated in many of the key characteristics of cancer. For example, genes involved in cell proliferation can be upregulated by BPA, while other genes involved in apoptosis can be downregulated by BPA [47]. However, despite the large number of studies that have implicated BPA in the initiation and/or progression of ovarian cancer, no epidemiology studies to our knowledge have evaluated associations between BPA exposure, or any other phenols, and ovarian cancer. This highlights a significant gap in the environmental epidemiology literature and presents an opportunity to explore impactful mechanisms by which environmental estrogenic compounds may contribute to onset and progression of ovarian cancer.

It is critical for future studies to understand the effects of endocrine active compound exposures on survivors of hormonally-driven cancers. Our findings highlight that across multiple tumor types, individuals with a prior cancer diagnosis have elevated body burdens of a range of toxicants. Hormonally-driven cancers are often treated with hormone therapy to reduce or alter the circulating concentrations of hormones [48]. Exposure to endocrine active compounds could subvert the effects of these therapies and cause disease progression and recurrence [49]. For example, approximately 70% of breast cancers express the estrogen receptor [50]. These breast cancers are often treated with antiestrogen therapies. Unexpected exposure to estrogenic xenobiotic compounds could promote the growth and spread of estrogen receptor-positive tumors. This potential impact on long term cancer patient outcomes is particularly salient in light of the high rates of distant recurrences in estrogen-positive breast cancer survivors up to 20 years following the cessation of treatment [51]. Our findings build upon a growing literature showing that cancer survivors are an important population for endocrine active chemical biomonitoring and interventions.

We observed that various associations between environmental chemical exposures and previous cancer diagnoses were modified by race. Environmental exposures may differ by racial groups through various sources. For example, chemicals such as phthalates, phenols, and parabens may be found at higher concentrations in certain beauty products (e.g., hair straightening chemicals and skin-lightening creams) that are marketed to Black, Asian, and Latina women [52]. Another example is evidenced by disparities in PFAS water contamination, with a recent report from the Natural Resources Defense Council indicating that many

counties in California with higher CalEnviroScreen scores (indicating greater pollution and socioeconomic disadvantage) also had higher detected PFAS in drinking water systems [53]. A previous study in NHANES showed that significant racial disparities exist in biomonitored environmental toxicants, including several exposures included in this analysis [16]. Of note, the aforementioned study observed that non-White racial groups had much higher concentrations of chemical biomarkers including DCP25, MPB, PPB, BPS, and PFDA, while White participants had higher levels of other chemicals including BPF, BP3, PFOA, and PFOS. These exposure levels partly contextualize our findings that White men had higher odds of previous prostate cancer with elevated exposures to BP3 and BPF, and White women had higher odds of previous ovarian cancer with elevated exposures to PFOS and PFOA. Additionally, despite greater increases of uterine cancer incidence among Black women compared to White women [54], we observed that White women were more likely to have previous uterine cancer with increasing biomarker levels of PFDE, PFNA, and PFUA. Interestingly, Nguyen and colleagues showed that Black women had higher concentrations of PFNA than White women, suggesting that the positive association between PFNA and previous uterine cancer among White women compared to Black women may not be influenced by trends in incidence or exposure levels to PFNA between racial groups. Finally, we observed that Mexican-American women had higher odds of previous breast cancer with elevated exposure to MPAH, and other Hispanic women had higher odds of previous breast cancer with elevated exposure to BP3. Accordingly, a previous review article demonstrates that Hispanic women are at greater risk of breast cancer-specific mortality when compared to non-Hispanic White women [55]. There may also be underlying metabolic factors influencing the relationship between endocrine-disrupting chemicals and cancer risk. For example, a previous multi-omics investigation identified differences in genetic and epigenetic loci relevant for xenobiotic metabolism based on genetic ancestry, which may be relevant since endocrine-disrupting chemicals are metabolized by overlapping enzymes, including cytochrome p450 [56]. Future prospective studies should not only consider disparities in exposure and cancer risks, but also evaluate potential sources of environmental contamination to endocrine-disrupting chemicals to guide potential interventions.

These results highlight the need to carefully consider the use of survey regression methods based on whether the study hypothesis is aimed at obtaining results that are generalizable or specific to vulnerable populations. NHANES oversamples racial/ethnic minorities, which can be very useful when trying to evaluate rare disease states as outcomes in those populations. However, when survey regression methods are applied, the results generated are targeted at being generalizable to the entire United States population rather than being truly representative of the study population, which has the desired larger population of minority groups. Thus, if an association is observed among a minority group but null among non-Hispanic White participants, the survey regression results will be influenced towards the null to account for the oversampling of the minority group. We observed this in our analysis with PFDE exposure and odds of previous ovarian cancer. Standard regression analysis showed a non-significant positive association, but sensitivity analyses revealed that the association was observed only among non-Hispanic White participants. Accordingly, survey regression methods also resulted in a positive association. Thus, survey regression methods will generate more generalizable results, but if there are true differences in associations between racial groups, the survey regression results will be more representative of non-Hispanic White participants than of the minority groups.

This analysis was subject to various limitations. First, our outcomes were previous cancer diagnoses and therefore causality cannot be determined. While we would have liked to account for the time between cancer diagnoses and biomarker measurement, this information was not available in NHANES. Further, because our exposures were measured after the cancer diagnoses occurred, reverse causation is a possibility if behavioral changes occurred. Subsequent treatment for cancer may also influence concentrations of endocrine-disrupting chemicals through altered metabolism, which may also be an important source of exposure misclassification among those with previous cancer diagnoses. Additionally, we have assumed that exposure biomarker measurements are accurate proxies of historical exposure levels, and so there is high risk for exposure misclassification. Despite this limitation, there is still utility in assessing PFAS and phenol/paraben profiles among previous cancer patients to inform prospective hypotheses in emerging cohort studies. Additionally, our results were likely subject to bias from unmeasured confounding factors such as family history of cancer or anatomical alterations such as ovariectomy and thyroidectomy. Our regression models may not have accounted for any correlations between covariates and biomarkers, possibly resulting in inflated associations. Similarly, we did not set multiple comparison thresholds, therefore some associations may be false positives. However, future prospective studies can build on our preliminary findings to perform targeted hypothesis testing on specific environmental contaminants. Another limitation includes potential outcome misclassification since previous cancer diagnosis was assessed using self-report questionnaire data. A previous study identified the validity of self-reported cancers with data from state cancer registries and while they identified fairly good accuracy (sensitivity of ≥ 0.9) for certain cancers (e.g., breast and prostate) [57], future studies should build on our preliminary findings using gold-standard cancer diagnosis for outcome phenotyping.

This study was also strong in a number of ways. Compared to previous studies, we leveraged NHANES data to investigate multiple classes of endocrine-disrupting chemicals to inform prioritization and hypothesis-driven investigation of environmental exposures in future prospective study designs. Additionally, our approach helps build the foundation for supervised multi-pollutant chemical mixtures analyses that intend to delineate chemical class-specific effects and potential interactions between chemicals. Multi-chemical class exposure assessment is becoming more common with technological advancements in high-throughput assays, however, these can be cost-prohibitive and time-consuming in certain contexts with limited resources. We also contribute toward reporting exploratory associations with understudied cancers in the context of endocrine-disrupting chemicals. For example, this is the first epidemiological study to assess phenols exposure in the context of previous ovarian cancer diagnosis. Further, this is the first NHANES analysis to investigate racial/ethnic disparities in associations between environmental exposures and previous cancer diagnoses. We also add to the current body of literature suggesting a role for estrogens in the onset and progression of ovarian cancer and melanoma, which could help inform future mechanistic and experimental studies as well as risk assessment and prevention efforts.

In conclusion, we report various associations between exposure to environmental chemicals and previous cancer diagnoses that have not been previously explored. Several PFAS chemicals were positively associated with odds of previous melanoma diagnosis among only women, and various PFAS and phenols were positively associated with odds of previous ovarian cancer diagnosis. These findings highlight a sexually dimorphic nature of melanoma risk, as well as a potential estrogen-dependent mechanism for both cancer types. We also showed differential associations between environmental exposures and previous cancer diagnoses by racial groups, underscoring racial disparities that exist both in innate risk of cancer outcomes and in exposures to environmental toxicants. Future work in prospective cancer studies should aim to explore the roles of estrogenic chemicals

and estrogen disruption in the pathology of melanoma and ovarian cancer and consider racial disparities when evaluating cancer mechanisms and risk. Findings from this study can be used to help inform and prioritize toxicants for policies surrounding greater surveillance of chemical exposures and risk assessment in communities with existing or emerging risk of environmental contamination.

DATA AVAILABILITY

NHANES data is publicly available. The analytical dataset for this study and code can be available upon request (Amber Cathey [acathey@umich.edu], Max Aung [maxaung@usc.edu]).

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AUTHOR CONTRIBUTIONS

ALC: formal analysis, investigation, methodology, visualization, writing - original draft, writing - review and editing; VKN: methodology, writing - review and editing; JAC: supervision, writing - review and editing; TJW: supervision, writing - review and editing; PR: conceptualization, project administration, supervision, writing - review and editing; MTA: conceptualization, funding acquisition, project administration, supervision, writing - review and editing.

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COMPETING INTERESTS

The authors declare no competing interests.

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ASSISTANT ADMINISTRATOR FOR ENFORCEMENT AND COMPLIANCE ASSURANCE
WASHINGTON, D.C. 20460

April 19, 2024

MEMORANDUM

SUBJECT: PFAS Enforcement Discretion and Settlement Policy Under CERCLA

FROM: David M. Uhlmann

TO: Regional Administrators and Deputy Regional Administrators
Regional Counsels and Deputy Regional Counsels

Communities across the United States face public health and environmental challenges because of toxic PFAS contamination.[1] PFAS have been manufactured in the United States and around the world since the 1940s for use in a wide range of industrial and consumer products from fire-fighting foam to non-stick cookware and water-resistant fabrics. PFAS are referred to as "forever chemicals" because of their persistence in the environment. Exposure to PFAS has been linked to deadly cancers, impacts to the liver and heart, and immune and developmental damage to infants and children.

On August 17, 2023, EPA announced a new National Enforcement and Compliance Initiative (NECI) to address exposure to PFAS.[2] NECIs are intended to focus on the most serious and widespread environmental problems facing the United States. PFAS is no exception. Due to the toxicity and persistence of PFAS chemicals, and the breadth and scope of PFAS contamination throughout the country, addressing PFAS contamination is a significant priority for EPA.

EPA now has designated two types of PFAS, perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), as hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).[3] The rule designating PFOA and PFOS as hazardous substances will allow EPA to use the full strength of CERCLA to address PFAS contamination. At the same time, the rule does not change the statute's liability framework, which provides liability protections in certain circumstances for parties that are not primarily responsible.

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[1] PFAS, or per- and polyfluoroalkyl substances, are a large group of manufactured chemicals. For the majority of this document, EPA will use PFAS as a shorthand to refer to perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), including their salts and structural isomers, consistent with the definition in the Final Designation of PFOA and PFOS as Hazardous Substances. *See infra* note 3.

[2] *See* FY 2024 – 2027 National Enforcement and Compliance Initiatives.

[3] *See* Final Designation of PFOA and PFOS as Hazardous Substances. *See also* Proposed Designation of PFOA and PFOS as Hazardous Substances.

With this memorandum, I am providing direction to all EPA enforcement and compliance staff about how EPA will exercise its enforcement discretion under CERCLA in matters involving PFAS, just as EPA exercises enforcement discretion regarding other hazardous substances. EPA will focus on holding responsible entities who significantly contributed to the release of PFAS into the environment, including parties that manufactured PFAS or used PFAS in the manufacturing process, federal facilities, and other industrial parties.

EPA does not intend to pursue entities where equitable factors do not support seeking response actions or costs under CERCLA, including, but not limited to, community water systems and publicly owned treatment works, municipal separate storm sewer systems, publicly owned/operated municipal solid waste landfills, publicly owned airports and local fire departments, and farms where biosolids are applied to the land. For these same parties, EPA can use CERCLA statutory authorities when appropriate to enter into settlements that provide contribution protection from third party claims for matters addressed in the settlement.

I. Executive Summary

EPA is issuing this PFAS Enforcement Discretion and Settlement Policy Under CERCLA regarding enforcement considerations that will inform EPA's decisions to pursue or not pursue potentially responsible parties (PRPs) for response actions or costs under CERCLA to address the release or threatened release of PFAS. This Policy is intended to clarify when EPA intends to use its CERCLA enforcement authorities or decide not to pursue a particular party. This Policy applies only to the exercise of EPA's enforcement discretion when requiring action to address releases of PFAS under CERCLA; it does not apply to enforcement under other EPA programs or statutes, including other EPA programs that may address PFAS.

The designation of PFOA and PFOS as hazardous substances should not disrupt CERCLA's liability framework; CERCLA will continue to operate as it has for decades. In enforcement matters, the facts, circumstances, and equities of each case inform which parties the Agency pursues. CERCLA's liability limitations and protections safeguard against liability in certain circumstances for parties that are not primarily responsible. EPA's enforcement discretion policies historically have given EPA much-needed flexibility to provide additional protections when circumstances warrant.[4]

Although CERCLA's liability framework is broad, the statutory affirmative defenses and EPA's enforcement discretion provide mechanisms to narrow the scope of liability and focus on the significant contributors to contamination. Some stakeholders have expressed concern that the designation of PFOA and PFOS as hazardous substances will result in parties being pursued for PFAS liability under CERCLA, even if the equities do not support seeking CERCLA response actions or costs. EPA intends to rely upon CERCLA statutory protections and EPA's existing enforcement discretion policies to alleviate those concerns, as well as the factors set forth here.

Consistent with CERCLA's objectives, EPA will focus on holding accountable those parties that have played a significant role in releasing or exacerbating the spread of PFAS into the environment, such as those who have manufactured PFAS or used PFAS in the manufacturing process, and other industrial

[4] *See* Unique Parties and Superfund Liability.

parties. For purposes of this Policy only, these parties are referred to as major PRPs. EPA also intends to pursue federal agencies or federal facilities when they are responsible for PFAS contamination.[5]

EPA remains committed to environmental justice and identifying and protecting overburdened communities that may be disproportionally impacted by adverse health and environmental effects.[6] EPA intends to pursue major PRPs and federal agencies to conduct investigations and cleanup to protect communities from high-risk, high-concentration PFOA and PFOS exposures.

As more fully described in Section IV of this memorandum, and subject to the limitations set forth in Section V, EPA does not intend to pursue otherwise potentially responsible parties where equitable factors do not support seeking response actions or costs under CERCLA, including, but not limited to, the following entities:

(1) Community water systems[7] and publicly owned treatment works (POTWs);[8]
(2) Municipal separate storm sewer systems (MS4s);[9]
(3) Publicly owned/operated municipal solid waste landfills;
(4) Publicly owned airports and local fire departments; and
(5) Farms where biosolids are applied to the land.

EPA may extend enforcement discretion under this Policy to additional parties even if they do not fall within the categories listed above, based on the equitable factors set forth in Section IV.B.

In addition to potential EPA action, EPA understands that entities are concerned about being sued by other PRPs for PFAS cleanup costs under CERCLA. In CERCLA settlements with major PRPs, EPA will seek to require those settling parties to waive their rights to sue parties that satisfy the equitable factors. The major PRPs would then not be able to sue those non-settling parties for matters addressed under the settlement. These settlement protections are consistent with settlement protections regularly applied by EPA in other CERCLA contexts.

Further, consistent with current CERCLA enforcement practice to mitigate these litigation risk concerns, EPA can enter settlements with concerned parties under our statutory authorities when appropriate. Such settlements would help to mitigate litigation risk concerns and associated costs by providing protection from CERCLA contribution claims by other PRPs seeking a portion of PFAS response costs.[10] This exercise of enforcement discretion is discussed in Section IV.C.

To provide context for this policy, Section II provides below a short overview of CERCLA, including a description of the statutory liability framework. Section III includes a summary of the Agency's integrated approach to addressing PFAS. Section IV discusses how EPA intends to exercise its CERCLA

[5] *See* Executive Order 12580, 52 Fed. Reg. 2923 (Jan. 23, 1987).
[6] *See* Strengthening Environmental Justice Through Cleanup Enforcement Actions (July 1, 2021).
[7] A community water system is a public water system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents. *See* 40 C.F.R. § 141.2.
[8] POTW means a treatment works (as defined by CWA section 212) that is owned by a state or municipality (as defined by Clean Water Act (CWA) section 502(4)).
[9] An MS4 is a conveyance or system of conveyances that is: owned by a state, city, town, village, or other public entity that discharges to waters of the U.S.; designed or used to collect or convey stormwater (e.g., storm drains, pipes, ditches); not a combined sewer; and not part of a sewage treatment plant, or publicly owned treatment works (POTW). *See* 40 C.F.R. § 122.26(b)(8).
[10] *See* CERCLA section 113(f)(2), 42 U.S.C. § 9613(f)(2).

enforcement discretion for PFAS. Section V identifies limitations and contingencies that apply to the use of enforcement discretion in this policy.

II. Overview of CERCLA

CERCLA was enacted in 1980 in response to public concern about abandoned hazardous waste sites. CERCLA authorizes the federal government to assess sites, clean up contaminated sites, and respond to releases or threatened releases of hazardous substances, pollutants, and contaminants.

There are over 800 hazardous substances designated under CERCLA. Hazardous substance designation gives rise to a requirement to report releases at or above a certain quantity[11] and enables EPA to order actions by and recover response costs from PRPs. CERCLA's liability framework aims to ensure that, wherever possible, PRPs perform or pay for cleanups instead of relying on the Hazardous Substance Trust Fund (Superfund), consistent with EPA's "polluter pays" principle.

As described in CERCLA section 107(a), the following categories of persons may be liable for the costs or performance of a cleanup of a hazardous substance under CERCLA:

(1) Current owners and operators of a facility where hazardous substances come to be located;
(2) Owners and operators of a facility at the time that hazardous substances were disposed of at the facility;
(3) Generators and parties that arranged for the disposal or transport of the hazardous substances; and
(4) Transporters of hazardous waste that selected the site where the hazardous substances were brought.

To conserve Superfund money for cleanups at sites where there are no financially viable PRPs, EPA has adopted an "enforcement first" policy[12] to compel those responsible for contaminated sites to take the lead in cleanup (the "polluter pays" principle). In keeping with this policy, EPA routinely reaches settlements with PRPs to clean up sites. In addition, EPA can compel PRPs to clean up sites where there may be an imminent and substantial endangerment to public health or welfare or the environment from an actual or threatened release of hazardous substances. When EPA spends Superfund money to finance a response action, EPA may then seek reimbursement from PRPs. Private parties may also conduct cleanups and seek reimbursement of eligible response costs from PRPs.

CERCLA liability is not unlimited. CERCLA includes several statutory protections that may limit liability and discourage litigation (e.g., the provision for settlements with "de minimis" or minor parties, CERCLA section 122(g)). Moreover, EPA has well-established enforcement discretion policies that provide EPA flexibility to offer liability protections to parties when circumstances warrant (e.g., innocent landowners, de micromis parties, owners of residential property at or near Superfund sites,

[11] The designation of PFOA and PFOS, including their salts and structural isomers, as hazardous substances, can trigger the applicability of release reporting requirements under CERCLA sections 103 and 111(g), and accompanying regulations, and section 304 of the Emergency Planning and Community Right-to-Know Act. Facilities must report releases of hazardous substances at or above the reportable quantity (RQ) within a 24-hour period. For PFOA and PFOS, a default RQ of one pound is assigned to these substances pursuant to CERCLA section 102(b). This Policy does not apply to these requirements, and parties that may be eligible for enforcement discretion must comply with this requirement if a reportable release occurs at their facility.

[12] *See* Enforcement First for Remedial Action at Superfund Sites (Sept. 20, 2002).

and contiguous property owners).[13] Existing CERCLA limitations and enforcement policies are sufficient to mitigate concerns about liability that may arise after designation. No additional action should be necessary to ensure that those limitations and policies continue to operate as they have for decades. Nonetheless, EPA is issuing this CERCLA PFAS enforcement discretion policy consistent with existing statutory protections and policies.[14]

EPA's CERCLA enforcement discretion policies help the Agency focus on sites that pose the most risk and PRPs who have contributed significantly to contamination. EPA will continue to implement its "enforcement first" policy, which compels PRPs to conduct and pay for cleanup before resorting to the Superfund, in furtherance of CERCLA's "polluter pays" principle.

III. EPA's Approach to PFAS

On October 18, 2021, EPA released its PFAS Strategic Roadmap,[15] which highlighted the integrated approach the Agency is taking across a range of environmental media and EPA program offices to protect the public and the environment from PFAS contamination. EPA's approach to PFAS is focused on three central directives to address PFAS contamination:

(1) *research* – to invest in research, development, and innovation to increase understanding of PFAS exposures and toxicity, human health, and ecological effects and effective interventions that incorporate the best available science;
(2) *restrict* – to pursue a comprehensive approach to proactively prevent PFAS from entering air, land, and water at levels that can adversely impact human health and the environment; and
(3) *remediate* – to broaden and accelerate the cleanup of PFAS contamination to protect human health and ecological systems.[16]

Historically, PFAS have been found in, or used in making, a wide range of consumer products including carpets, clothing, fabrics for furniture, packaging for food, and cookware. PFAS also have been components of firefighting foams used to extinguish liquid fuel fires at airfields, refineries, military bases and other locations, and in several industrial processes. As a result of their widespread use, environmental releases of PFAS have occurred for decades, leaving many communities and ecosystems exposed to PFAS in soil, sediment, surface water, groundwater, and air. A growing body of scientific evidence shows that exposure at certain levels to specific PFAS is linked to adverse impacts to human health.[17] EPA uses its various enforcement authorities, including under the Safe Drinking Water Act, the Resource Conservation and Recovery Act, the Toxic Substances Control Act, the Clean Air Act, and the Clean Water Act, to identify and address PFAS releases at private and federal facilities and in communities.

[13] For example, for parties who have contributed a miniscule amount of waste to the site (De Micromis Parties), EPA policy is that they should not participate in financing the cleanup. *See* Superfund Cleanup: De Minimis/De Micromis Policies and Models.
[14] *See supra* note 4.
[15] *See* PFAS Strategic Roadmap: EPA's Commitments to Action 2021-2024.
[16] *Id.* at 5.
[17] *Id.* at 7.

In September 2022, based on significant evidence that PFOA and PFOS may present a substantial danger to human health or welfare or the environment,[18] the Agency proposed to designate PFOA and PFOS as hazardous substances under section 102(a) of CERCLA. Findings from laboratory animal toxicological studies and human epidemiology studies suggest that exposure to PFOA and/or PFOS may lead to cancer and reproductive, developmental, cardiovascular, liver, and immunological effects.[19]

On April 17, 2024, EPA signed the final rule[20] to designate PFOA and PFOS as hazardous substances under section 102(a) of CERCLA. This designation allows EPA to use its CERCLA enforcement authorities, as appropriate and where relevant statutory elements are met, which could shift the cost burden of CERCLA response costs from the Superfund to PRPs. As with any other hazardous substance, EPA will determine what, if any, response and enforcement actions may be necessary to protect human health and the environment. Further, EPA and its state, local, and Tribal partners, may carry out a response action to address PFAS contamination, wholly distinct from CERCLA enforcement-driven actions.

IV. CERCLA Enforcement Discretion and Settlement Policy

Although EPA has the authority under CERCLA to require parties to perform response actions and to seek response costs incurred by the United States, the Agency has discretion on how to exercise its authority, which the Agency has utilized since CERCLA was enacted in 1980.

Consistent with EPA's past practice, this Section describes how EPA intends to exercise its CERCLA enforcement discretion for matters involving PFAS. As noted above, EPA intends to focus its enforcement efforts on entities who significantly contributed to the release of PFAS contamination into the environment, including parties that manufactured PFAS or used PFAS in the manufacturing process, federal facilities, and other industrial parties.

Section IV.A identifies entities where equitable factors do not support seeking response actions or costs under CERCLA. Section IV.B sets forth the equitable factors that EPA will consider in deciding whether to exercise enforcement discretion under CERCLA for other PRPs. Section IV.C. sets forth EPA's approach to settling with parties described in this Section.

A. Parties Covered by the PFAS Enforcement Discretion Policy

EPA does not intend to pursue, based on equitable factors, PFAS response actions or costs under CERCLA against the following parties:

1. Community Water Systems and POTWs

Community water systems and POTWs conduct public services by providing safe drinking water and managing and processing public waste. These entities are required to treat PFAS-contaminated sources of drinking water and receive PFAS-contaminated wastewater. They do not manufacture PFAS nor use PFAS as part of an industrial process. Through their operation processes, these parties may discharge

[18] *See* Proposed Designation of PFOA and PFOS as Hazardous Substances.
[19] *See id.* or related news release to proposed designation.
[20] *See supra* note 3.

effluents;[21] dispose or manage sewage sludge, biosolids,[22] and drinking water treatment residuals; and arrange for the disposal of spent treatment media (i.e., activated carbon filters, anion exchange media, or membranes) and/or the discharge of leachate, permeate, or regeneration brines.

2. Municipal Separate Storm Sewer Systems (MS4s)

MS4s do not manufacture PFAS nor use PFAS as part of an industrial process. Owners/operators of regulated MS4s perform a public service and are required to develop, implement, and enforce a stormwater management program (SWMP) to describe how the MS4 will reduce the discharge of pollutants from its sewer system.[23] While the SWMP should detect and eliminate illicit discharges, illegal dumping and connections may result in illicit discharges of non-stormwater wastes into the MS4. MS4s implement programs to prevent or reduce pollutant runoff from municipal operations into the storm sewer system, which helps to control pollutant discharges by minimizing the potential pathways for contaminants carried in runoff.

3. Publicly Owned or Operated Municipal Solid Waste Landfills

Publicly owned or operated municipal solid waste landfills perform a public service by handling municipal solid waste. They do not manufacture PFAS nor use PFAS as part of an industrial process. In addition to receiving waste from communities and other residential entities, these landfills may accept solid waste from POTWs that may be contaminated with PFAS, particularly sewage sludge and solid residues that result from treatment processes and filtration media such as granular activated carbon filters.

4. Publicly Owned Airports and Local Fire Departments

State or municipal airports and local fire departments provide a public service by preparing for and suppressing fire emergencies and protecting public safety. They do not manufacture PFAS nor use PFAS as part of an industrial process. Many airports and fire departments, however, store and use aqueous film forming foam (AFFF),[24] fire-fighting foam that may contain PFAS. Many airports have been required by Federal Aviation Administration regulations to maintain adequate amounts of AFFF to address fire emergencies.[25] State or municipal airports and local fire departments have also used AFFF during fire emergencies and training exercises.

To the extent publicly owned airports and local fire departments are legally required to continue to use AFFF, these parties must follow all applicable regulations governing the use, storage, handling, and disposal of AFFF that contains PFAS.[26] EPA also expects these parties to exercise a high standard of care

[21] CERCLA enumerates 11 categories of federally permitted releases, including releases regulated by CWA section 402 which established a National Pollutant Discharge Elimination System permit program. In this Policy, EPA does not take a position on the applicability of a "federally permitted release" as defined in CERCLA section 101(10).

[22] Sewage sludge is a product of the wastewater treatment process. During wastewater treatment, the liquids are separated from the solids and then may be treated physically and chemically to produce a semisolid, nutrient-rich product. The terms "biosolids" and "treated sewage sludge" are often used interchangeably; however, biosolids typically means sewage sludge treated to meet the requirements in 40 C.F.R. part 503 and intended to be applied to land as a soil amendment. Disposal (incineration and landfilling) requirements in Part 503 refer to sewage sludge.

[23] *See* Stormwater Discharges from Municipal Sources-Developing an MS4 Program.

[24] A Class B fire is a fire in flammable liquids or flammable gases, petroleum greases, tars, oils, oil-based paints, solvents, lacquers, or alcohols. States, Tribes, or municipalities may have regulations for the use and handling of AFFF.

[25] 14 C.F.R. part 139.

[26] Protocols for handling, storage, and accidental release can be found in the Material Safety Data Sheet for AFFF.

to limit the release of PFAS, minimize and contain releases, and forgo, when possible, the use of AFFF in the process of cleaning equipment and training exercises.

5. Farms that Apply Biosolids to Land

POTWs also produce sewage sludge that may be treated to become biosolids. Farms then routinely apply these biosolids to the land, and by doing so, provide for a beneficial application of a product from the wastewater treatment process.[27] Under the Clean Water Act, EPA and the states have regulated standards for the application of sludge as an agricultural fertilizer that ensures strict guidelines and agronomic application rates are followed that support crop growth and protect soil and water quality.[28] EPA recognizes that such land application can result in both economic and resource management benefits, including conservation of landfill space, reduction in methane gas from landfills, reduction of releases from incinerators, and a reduced demand for synthetic fertilizers.[29] Further, these farms do not manufacture PFAS nor use PFAS as part of an industrial process.

B. Factors Considered for Enforcement Discretion for Other Parties

Consistent with EPA's practice of considering fairness and equitable factors, EPA will exercise its enforcement discretion to not pursue additional entities for PFAS response actions or costs under CERCLA, informed by the totality of the following factors:

(1) Whether the entity is a state, local, or Tribal government, or works on behalf of or conducts a service that otherwise would be performed by a state, local, or Tribal government.
(2) Whether the entity performs a public service role in:
    - Providing safe drinking water;
    - Handling of municipal solid waste;
    - Treating or managing stormwater or wastewater;
    - Disposing of, arranging for the disposal of, or reactivating pollution control residuals (e.g., municipal biosolids and activated carbon filters);
    - Ensuring beneficial application of products from the wastewater treatment process as a fertilizer substitute or soil conditioner;[30] or
    - Performing emergency fire suppression services.
(3) Whether the entity manufactured PFAS or used PFAS as part of an industrial process.
(4) Whether, and to what degree, the entity is actively involved in the use, storage, treatment, transport, or disposal of PFAS.

[27] Under CERCLA section 101(22)(D), the definition of "release" explicitly excludes "the normal application of fertilizer." EPA believes this language is best read as requiring a site-specific analysis.
[28] *See* 40 C.F.R. part 503.
[29] EPA acknowledges that biosolids used as soil amendment are subject to an evolving regulatory scheme. CWA sections 405(d) and (e) authorize EPA to promulgate regulations containing guidelines for the use and disposal of sewage sludge, including by establishing numerical limitations where feasible. Under CWA section 405(d)(2)(D), these regulations must be "adequate to protect human health and the environment from any reasonably anticipated adverse effect of each pollutant." *See also* Policy on Municipal Sludge Management, 49 Fed. Reg. 24358 (June 2, 1984).
[30] *See, e.g.*, Standards for the Use or Disposal of Sewage Sludge, 58 Fed. Reg. 9248, 9262 (Feb. 19, 1993).

In helping to ensure equitable outcomes in addressing PFAS contamination, the above factors are instructive in determining whether an entity's CERCLA responsibility should be limited.

C. Settlement Agreements and Contribution Protection

EPA has broad discretion to decide whether to respond to a release or threat of release under CERCLA. Response decisions are made on a case-by-case basis after considering the specific circumstances related to the release at issue. CERCLA section 104(a) provides that whenever there is a release or threat of release of a hazardous substance, or a release of a pollutant or contaminant which may present an imminent and substantial danger to public health or welfare, "the President is authorized to act" and take any response action the President "deems necessary to protect the public health or welfare or the environment." EPA is further directed to employ settlement procedures "[w]henever practicable and in the public interest…to expedite effective remedial actions and minimize litigation."[31]

To further the goals of this policy, EPA can provide some measure of litigation and liability protection through settlement agreements in two primary ways when circumstances warrant.[32]

First, EPA may protect certain non-settling parties when the Agency enters settlement agreements with major PRPs. For example, if EPA settles with a PFAS manufacturer, EPA may secure a waiver of rights providing that the PFAS manufacturer cannot pursue contribution against certain non-settling parties to that settlement. The waiver of rights helps provide some protection to parties that EPA does not intend to pursue from both the costs of litigation and the costs of cleanup. Without such a waiver, settling major PRPs could pursue contribution under CERCLA from those other parties for a portion of the CERCLA cleanup.

Second, EPA may enter into settlement agreements with parties where factors do not support enforcement against them for PFAS response actions under CERCLA, as discussed in Section IV.A and B of this Policy. A party that resolves its liability through a CERCLA settlement with the United States will not be liable for third-party contribution claims related to the matters addressed in the settlement.[33] Non-settling PRPs will not be able to pursue these settling parties for contribution costs under CERCLA related to the settlement, thus minimizing litigation costs and discouraging third-party litigation.

EPA intends to discuss possible settlement approaches with interested parties that are identified by this Policy. In certain situations, parties may qualify for *de minimis* or *de micromis* settlements under the terms of the Agency's 2002 enforcement discretion/settlement policy.[34] On a case-by-case basis,

[31] CERCLA section 122(a), 42 U.S.C. § 9622(a).

[32] *See*, *e.g.*, Interim Revisions to CERCLA Judicial and Administrative Settlement Models to Clarify Contribution Rights and Protection from Claims Following the *Aviall* and *Atlantic Research Corporation* Decisions (Mar. 16, 2009); Defining "Matters Addressed" in CERCLA Settlements (Mar. 14, 1997).

[33] "A person who has resolved its liability to the United States or a state in an administrative or judicially approved settlement shall not be liable for claims for contribution regarding matters addressed in the settlement. Such settlement does not discharge any of the other potentially liable persons unless its terms so provide, but it reduces the potential liability of the others by the amount of the settlement." CERCLA section 113, 42 U.S.C. § 9613.

[34] *See* Revised Settlement Policy and Contribution Waiver Language Regarding Exempt De Micromis and Non-Exempt De Micromis Parties (Nov. 6, 2002); *see also* Model De Minimis Contributor Consent Decree, Model De Minimis Contributor ASAOC, Model De Minimis Landowner Consent Decree and Model De Minimis ASAOC; Superfund Cleanup Subject Listing De Minimis/De Micromis Policies and Models.

EPA may enter into limited "ability to pay" settlements with parties to resolve CERCLA response costs, where payment could result in undue financial hardship for the PRP.[35]

Parties may also be asked to perform actions such as in-kind services, including PFAS monitoring activities and implementing institutional controls. Further, parties identified by this Policy may seek settlement with EPA in order to take actions to address contamination, which would provide protection from potential contribution claims.

V. Limitations and Contingencies and Responsibilities of Other Federal Agencies and Facilities

A. Limitations and Contingencies

Any exercise of CERCLA enforcement discretion pursuant to this Policy is contingent upon a party's full cooperation with EPA, including providing access and information when requested and not interfering with activities that EPA is taking or directing others to undertake to implement a CERCLA response action. This Policy does not exempt parties from reporting PFAS releases under CERCLA.

This Policy in no way affects EPA's ability to pursue any responsible party, including those entities set forth in Section IV, whose actions or inactions significantly contribute to, or exacerbate the spread of significant quantities of PFAS contamination, thereby requiring a CERCLA response action. Where conditions may present an imminent and substantial endangerment to public health, EPA retains its authority to take any necessary action under CERCLA section 106.

This Policy does not apply to enforcement actions taken under any EPA programs or statutes other than CERCLA. As with any other hazardous substance, this Policy also does not affect EPA's ability to determine and address what, if any, response and enforcement action may be necessary to protect human health and the environment.

Further, the Agency, working with state, local, and Tribal partners, may carry out a response action to address PFAS contamination, wholly distinct from CERCLA enforcement-driven actions. In the event the exercise of CERCLA enforcement discretion results in some or all responsible parties at a Superfund site not being pursued to fund or perform PFAS cleanup, characterization, or other response actions, EPA may use all available resources and work with state, local, and Tribal partners to address the contamination.

EPA also recognizes that the science and legal requirements associated with PFAS continue to evolve.[36] As a result, the scope of this policy may change to reflect newly emerging science or regulatory requirements, or other relevant considerations. Entities must continue to follow all applicable laws and regulations.

This Policy is intended to assist EPA personnel in its exercise of CERCLA enforcement discretion in the normal course of business. It is intended solely for the guidance of employees of the Agency. This policy is not a regulation and does not create new legal obligations or limit or expand obligations under any federal, state, Tribal, or local law. It is not intended to and does not create any substantive or

[35] *See* General Policy on Ability to Pay Determinations (Sept. 30, 1997).
[36] *See, e.g.*, Interim Guidance on the Destruction and Disposal of Perfluoroalkyl and Polyfluoroalkyl Substances and Materials Containing Perfluoroalkyl and Polyfluoroalkyl Substances (2024).

procedural rights for any persons. In addition, this guidance does not alter EPA's policy of not providing no action assurances outside the framework of a legal settlement, and EPA will evaluate each request for relief under this policy based on all available information.

B. Federal Agencies

Nothing in this policy affects the scope of CERCLA liability or responsibility of federal agencies, such as the Department of Defense (DoD) and the Department of Energy (DoE), to address PFAS contamination. DoD, DoE, and other federal agencies are responsible for cleaning up releases of hazardous substances, pollutants, and contaminants (including PFAS) from their facilities, and are delegated the President's CERCLA section 104 response authorities for releases on or from facilities under their own jurisdiction, custody, or control.[37] CERCLA section 111(e)(3) prohibits the use of Superfund money for remedial action at a federal facility on the National Priorities List.

VI. Next Steps and Contacts

EPA has established a team to support the implementation of this policy. This team will respond to issues pertaining to this policy and, where appropriate, assist EPA regional staff in formulating and expediting settlement agreements as needed. For questions, please contact Tina Skaar at skaar.christina@epa.gov.

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[37] *See* Executive Order 12580, 52 Fed. Reg. 2923 (Jan. 23, 1987).

GREENWIRE

‘Blind spots’: EPA’s ‘forever chemicals’ plan sparks concern

The Trump administration proposed a slate of exemptions to the reporting rule meant to fill data gaps regarding PFAS uses.

BY: **ELLIE BORST** | 11/12/2025 01:27 PM EST | UPDATED 11/13/2025 01:29 PM EST

A water sample is measured as part of a PFAS drinking water treatment experiment on Feb. 14, 2023, at EPA's Center for Environmental Solutions and Emergency Response in Cincinnati.| Joshua A. Bickel/AP

GREENWIRE | EPA's plan to significantly narrow what was supposed to be the largest federal data collection on "forever chemicals" is prompting criticism that the new approach would produce a far less robust dataset and trigger state action to fill in the cracks.

The agency on Monday unveiled its proposed slate of exemptions to a Biden-era PFAS reporting rule meant to fill knowledge gaps on the health risks and different uses of per- and polyfluoroalkyl substances.

Those exemptions would shrink the estimated number of respondents from 131,410, under the 2023 final rule, to 255. That's because roughly 99.8 percent of the original batch of respondents were firms that import articles containing PFAS, which would be exempt under the proposal.

"These exemptions risk creating significant blind spots in tracking PFAS sources," said Dave Kempisty, vice president of technology at Montrose Environmental Group.

EPA spokesperson Brigit Hirsch acknowledged in an email "the total number of reporters for this rule will be significantly lower," but added that the agency "expects to receive approximately 74% of the PFAS data from manufacturing firms the agency expected under the 2023 final rule." That approximation, not included in the rule proposal, is in the updated economic analysis, which was published to the rule's docket Thursday morning.

"This proposed action is expected to reduce burden on entities least likely to report information without sacrificing most of the known and reasonably ascertainable data related to historically manufactured PFAS from manufacturing firms, allowing the Agency to retain many of the benefits of the 2023 final rule," Hirsch said.

Cally Edgren, vice president of regulatory and sustainability for Assent Compliance, said excluding article importers contradicts "one of the goals of doing the data call in the first place," which is to get "a better idea of what's actually being used and where."

"My concern is, if the data call is meant to inform which ones you'll study, you're not really getting the true picture of what's being used, you might miss something, and that could have health effects in the long run," she said.

In 2019, Congress mandated EPA conduct a one-time call for data submissions dating back to 2011 relating to the uses and effects of PFAS, a family of thousands of chemicals popularly used to make a range of products water-repellant or nonstick.

The most infamous substances in the family have been tied to a variety of chronic illnesses, including endocrine disruption and cancer. But much is still unknown about exactly which PFAS are used in which products as well as whether the substances pose health risks to the public.

EPA, facing technological difficulties and an onslaught of industry resistance, has yet to fulfill its statutory data-collecting duty.

Partially to blame is the agency's outdated electronic reporting site, the Central Data Exchange, which is not equipped to handle an influx of submissions. Congress allocated $17 million earlier this year to update the platform.

Manufacturers and chemical industry groups have come out en masse to oppose the Biden-era rule, saying it is too burdensome and expensive.

The Trump administration has heeded such concerns. Its proposed rule includes industry-requested exemptions for article importers, de minimis thresholds, and chemicals used only for research and development.

Under the proposal, the estimated cost burden on companies required to submit information would be approximately $11 million per year, a significant decrease from the annual cost estimate upward of $281 million included in the 2023 final rule.

"These proposed exemptions also aim to minimize, to the extent feasible, the burden of regulatory compliance on small manufacturers," EPA Administrator Lee Zeldin wrote.

"Here, it is reasonable to defer the collection of certain information until there is a clear role that such information could play to support a program mission of the Agency," he continued.

One of the actions included in EPA's plan to address PFAS contamination is to "Identify and address available information gaps where not all PFAS can be measured and controlled," an April news release says.

The American Chemistry Council, a trade association representing many of the nation's largest chemical manufacturers, welcomed the proposed exemptions.

"These proposed amendments reflect a balanced, science-based approach to chemical data collection that supports environmental protection while reducing unnecessary regulatory burdens on American manufacturers," ACC said in a statement.

Edgren echoed the push for "smart, workable regulations" but warned of consequences down the line.

"My biggest fear is that this is just going to drive more state regulations," Edgren said.

California Gov. Gavin Newsom, a Democrat, in 2022 vetoed a PFAS reporting bill over similarities with federal data-collecting efforts at EPA.

"The states are frustrated that they feel the federal government doesn't move fast enough on chemical laws," Edgren said.

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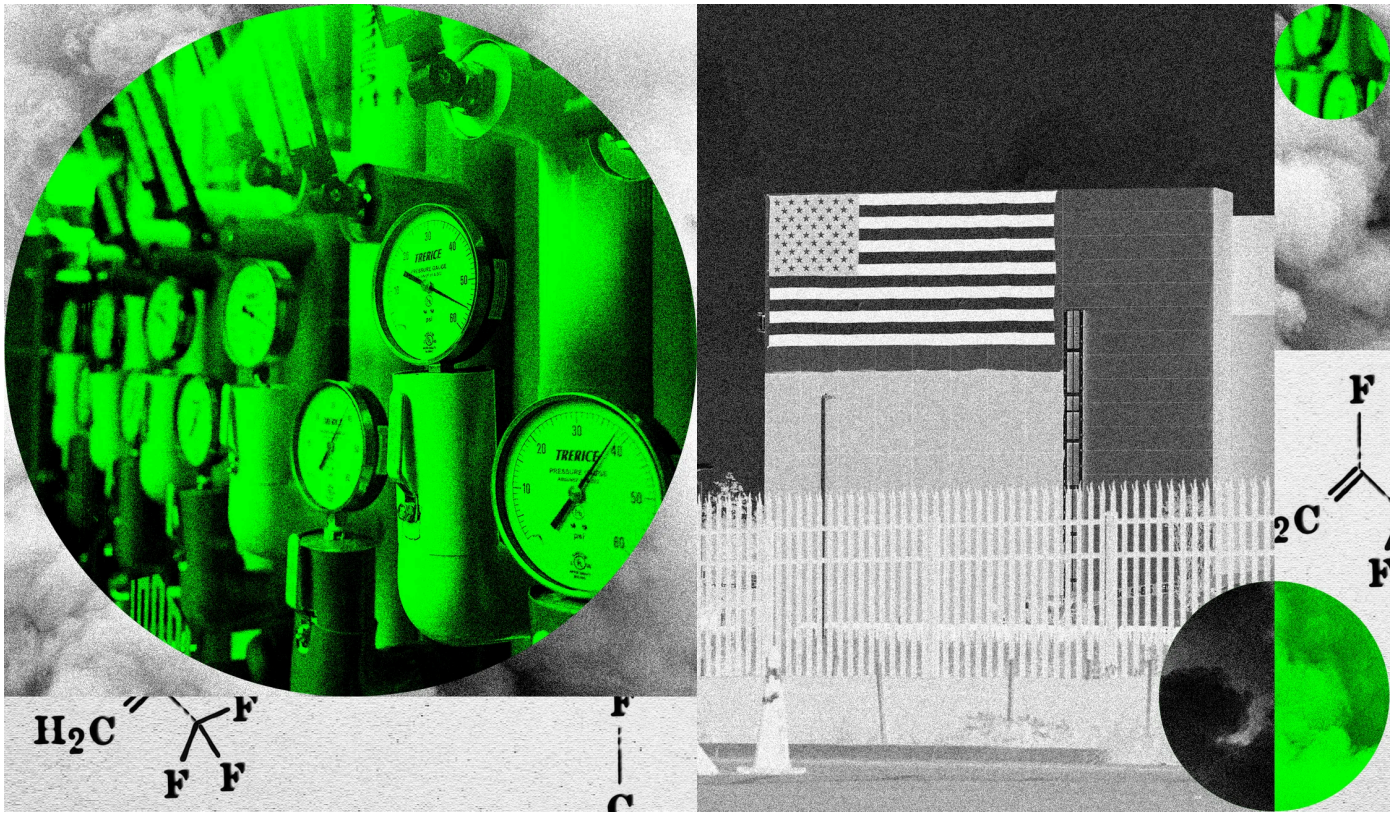
BY ADAM ATON

MOLLY TAFT ENVIRONMENT NOV 26, 2025 7:00 AM

The Trump Administration's Data Center Push Could Open the Door for New Forever Chemicals

The EPA is prioritizing review of new chemicals to be used in data centers. Experts say this could lead to the fast approval of new types of forever chemicals—with limited oversight.



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IN RECENT MONTHS, the Trump administration has opened a deregulatory floodgate in the name of building more data centers. Among other things, this has involved ordering rollbacks of clean water regulations and opening up public lands to coal mining.

Now, it's turning its eye to chemical regulation with a new policy that could, experts say, potentially fast-track the approval of new chemicals for use in the US—including new types of forever chemicals—with limited oversight.

In September, the EPA announced it would be prioritizing the regulatory review of new chemicals used in data centers or related projects. The announcement is part of a sweeping set of overhauls pushed by the Trump administration following several executive orders related to AI and a White House AI Action Plan, both rolled out in July. The Action Plan was formed after soliciting more than 10,000 public comments, which included hundreds from industry interests. These actions, the White House has said, will usher in a "golden age for American manufacturing and technological dominance."

"I think they want to impose as few restrictions as possible on chemicals," says Greg Schweer, who served as the EPA chief of the new chemicals management branch between 2008 and 2020. "In previous administrations, political people stayed out of

September's announcement was part of a larger push to expedite new chemical reviews at the EPA. The new chemical review process underwent a significant reform in 2016; in the decade since, a backlog of chemical reviews has piled up at the agency, garnering complaints from industry and bipartisan criticism from lawmakers. Clearing out that backlog has been a priority of Trump's second-term EPA. Helping to lead that charge at the agency are several former chemical industry executives, lobbyists, and lawyers.

"We inherited a massive backlog of new chemical reviews from the Biden Administration which is getting in the way of projects as it pertains to data center and artificial intelligence projects," EPA administrator Lee Zeldin said in a statement. "The Trump EPA wants to get out of the way and help speed up progress on these critical developments, as opposed to gumming up the works."

As part of September's announcement, the EPA created instructions for companies to submit documentation showing that the chemical for which they are seeking expedited review is part of a "qualifying project." Companies must prove that the substance they want reviewed more quickly will be used in data centers or "covered component projects." That includes projects that add at least 100 megawatts to the electric grid or projects that "[protect] national security," as well as any projects deemed applicable by the secretary of defense, the secretary of the interior, the secretary of commerce, or the secretary of energy.

In an email responding to questions about the new program, the EPA said that chemicals that meet the criteria would simply be fast-tracked to the front of the line.

"No part of the new chemicals review process will be skipped or bypassed for chemicals that meet the criteria for data center or covered component projects," agency press secretary Brigit Hirsch said in an email. "The new chemical review

the same thresholds for risk determinations."

But Schweer fears that the new policy could be used by chemical manufacturers to drive through new or existing chemicals with little oversight.

"There are some really big loopholes in here to get chemicals through," Schweer says. "If you've got some friend at the Department of Defense or the Department of Commerce, all you have to do is get that person to send a letter saying, 'This is a qualifying project.' There's no proof involved."

Political pressure to get a chemical approved, Schweer alleges, could also lead to sloppiness on the part of agency reviewers. "If you have to do things quickly, you look for shortcuts, and you don't always have time to look at all the data very well."

Experts tell WIRED that physical data centers themselves are unlikely to be a major source of chemical applications under this new policy. Walter Leclerc, an independent health and safety consultant to the data center industry, points out that many of the chemicals currently used in data centers are already used in a variety of other industries. Most of those chemicals, including lubricants, fire suppressants, and water treatment chemicals, are not specific to data centers—they "are no different from [what's used in] Suzie and John's industrial business." he says.

But there is one area of data center development where newer chemicals might be game changers. Keeping the equipment inside data centers cool is a huge component of their operating costs. One technique that can help cut these costs, called immersion cooling, involves dunking server racks and other machinery in a special liquid that does not conduct electricity. A subtype of immersion cooling, known as two-phase immersion cooling, takes this one step further. The liquid boils off into gas that then hits a coil, turns back into a liquid, and drips back into the tank.

electricity bills. The market for specialty cooling liquids for data centers has skyrocketed in recent years, with big names like Exxon and Shell getting into the game.

“Immersion cooling is the best,” Leclerc says. “The problem is it’s got all the environmental effects.”

Some of the substances used in two-phase immersion cooling largely contain fluorine and carbon, which help create types of per- and polyfluoroalkyl chemicals (PFAS). Colloquially called “forever chemicals” because of how long they persist in the environment, some of these chemicals have been linked to a wide variety of human health problems, from increased risk of cancer and reproductive issues to suppressed immune response. They have also been subject to increased regulation in recent years, with the EU proposing working towards what could be a particularly strict ban on PFAS. Several US states are also moving to restrict or eliminate the chemicals. (While the Trump administration has said that PFAS regulation is a priority, it has begun to roll back some Biden-era rules on some of these chemicals.)

Some bigger companies seem well aware of the risks of using forever chemicals in their cooling systems—especially following legal battles and settlements that have hurt PFAS producers like 3M, which has pledged to discontinue manufacturing and using PFAS this year. A study released in April, coauthored by Microsoft researchers, on the environmental life cycles of data center cooling techniques noted that “emerging PFAS regulations in the European Union and the United States” could “restrict” the use of two-phase immersion cooling.

While Microsoft has touted its research into two-phase cooling in the past, including a hyped-up pilot project at a data center in Washington, Microsoft spokesperson Donna Whitehead told WIRED that the company “is not currently using immersion

two-phase cooling—as "PFAS-free."

But at least one chemical giant—Chemours—has introduced new products for use in two-phase immersion in recent years. After developing a line of products that uses fluids containing fluoride, hydrogen, and carbon, which can be types of PFAS, Chemours collaborated with Samsung to test one liquid's performance earlier this year. In August the Delaware-based company said that "testing for subsequent generations will begin in the months ahead." (While the chemical compounds being used in these products have not been linked to specific health effects, some scientists are concerned about forever chemicals as a larger class.) Chemours has emphasized in its sustainability reports that these fluids could help reduce the energy needed to cool data centers by up to 90 percent.

In public comments it submitted on the Trump administration's AI Action Plan, Chemours encouraged reforms to the new chemicals program in order to allow the country to "swiftly adopt new technologies that can drive [the US's] competitiveness globally." According to a press release from 2023, the company's two-phase cooling liquids were originally targeted to be introduced to the market this year, "pending appropriate regulatory approvals."

Chemours, which spun off from multinational chemical company DuPont in 2015, has agreed to pay out hundreds of millions of dollars worth of settlements related to PFAS pollution in recent years. The company, along with DuPont and other chemical companies, still faces a number of multinational lawsuits from cities, counties, and states over pollution from PFAS production.

In response to questions on its two-phase cooling products from WIRED, including whether or not the company planned to submit chemicals for fast-tracked consideration under the administration's new data center exemption, Chemours spokesperson Cassie Olszewski said the company is "in the process of

“Our work in this area has been focused on developing more sustainable and efficient cooling solutions that would allow data centers to consume less energy, water, and footprint while effectively managing the increasing amount of heat generated by the next generation of chips with higher processing power,” Olszewski said.

These chips could also be a significant source of new chemicals. Both Schweer and Jonathan Kalmuss-Katz, a lawyer at environmental nonprofit Earthjustice, say that the semiconductor industry, which produces the chips that provide the computing power in data centers, stands to gain significantly from the expedited review process. The semiconductor manufacturing process uses forever chemicals at multiple different points of production, including in the crucial photolithography process, which uses light to transfer patterns to the surface of silicon wafers.

Schweer says that in his last few years working at the EPA, this industry submitted a large number of applications for new chemicals. Kalmuss-Katz says that semiconductor manufacturers “are a main driver of new chemicals.”

“The administration has this kind of AI-at-all-costs mindset, where you’re rushing to build more and more data centers and chip fabs without any meaningful plan for dealing with their climate impacts, their natural resource impacts, and the toxic substances that are being used and released from these new facilities,” he says.

Lobbying documents show that the semiconductor industry has been asking for changes this year to the EPA’s new-chemicals program. In March, Nancy Beck, a former policy director for an industry lobbyist group who now leads the Office of Chemical Safety and Pollution Prevention, the office that oversees new chemical reviews, met with representatives from SEMI, a global advocacy organization for the industry. The meeting was initially organized to discuss the “EPA’s approach to regulations on PFAS and other chemicals that are essential to semiconductor manufacturing,” according to emails obtained by WIRED via a Freedom of Information Act request. Emails show that Beck suggested during the meeting that the lobbying group follow up with a public comment in support of changes to the

proposed rules so that we get a diverse array of perspectives," says Hirsch, the EPA spokesperson.)

“Making the United States the global capital of artificial intelligence (Al) ... will depend on the country’s ability to significantly expand domestic production of semiconductors and reshore large portions of the semiconductor manufacturing supply chain,” the letter from SEMI to Beck reads. “This can only be realized through a regulatory approach that effectively balances risk-based controls with ensuring access to chemicals that are vital to the production of semiconductors.” (SEMI declined to comment for this article.)

Companies don’t have to develop data centers directly—or even components that go into data centers, like semiconductors—to benefit from the EPA’s new policy. Both this summer’s AI executive orders and the EPA’s new policy open the door to fast-track chemicals far beyond those used only, or even primarily, within data centers. This, experts tell WIRED, could enable a wide variety of companies to try and get approval for their new products by linking them to data center construction.

“If [a company has] planned a data center, they’re not gonna be waiting around for a new chemical to be approved by the agency,” Schweer says. “They should have everything they need ready to go. That doesn’t mean that somebody won’t use [the new policy] as an excuse to try to get some chemical through.”

Both Leclerc, the data center specialist, and Schweer support reforms to the new chemical review program and clearing the backlog of chemical reviews from the agency. But they both expressed concerns about the new data center policy.

Making it quicker and easier for chemicals to go through the EPA is “a pro-growth move,” Leclerc says. “But there’s definitely long-term safety implications.”

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Molly Taft is a senior writer for WIRED, covering climate change, energy, and the environment. Previously, they were a reporter and editor at Drilled, an investigative climate multimedia reporting project. Before that, they wrote about climate change and technology for Gizmodo, and served as a contributing editor for the New ... Read More

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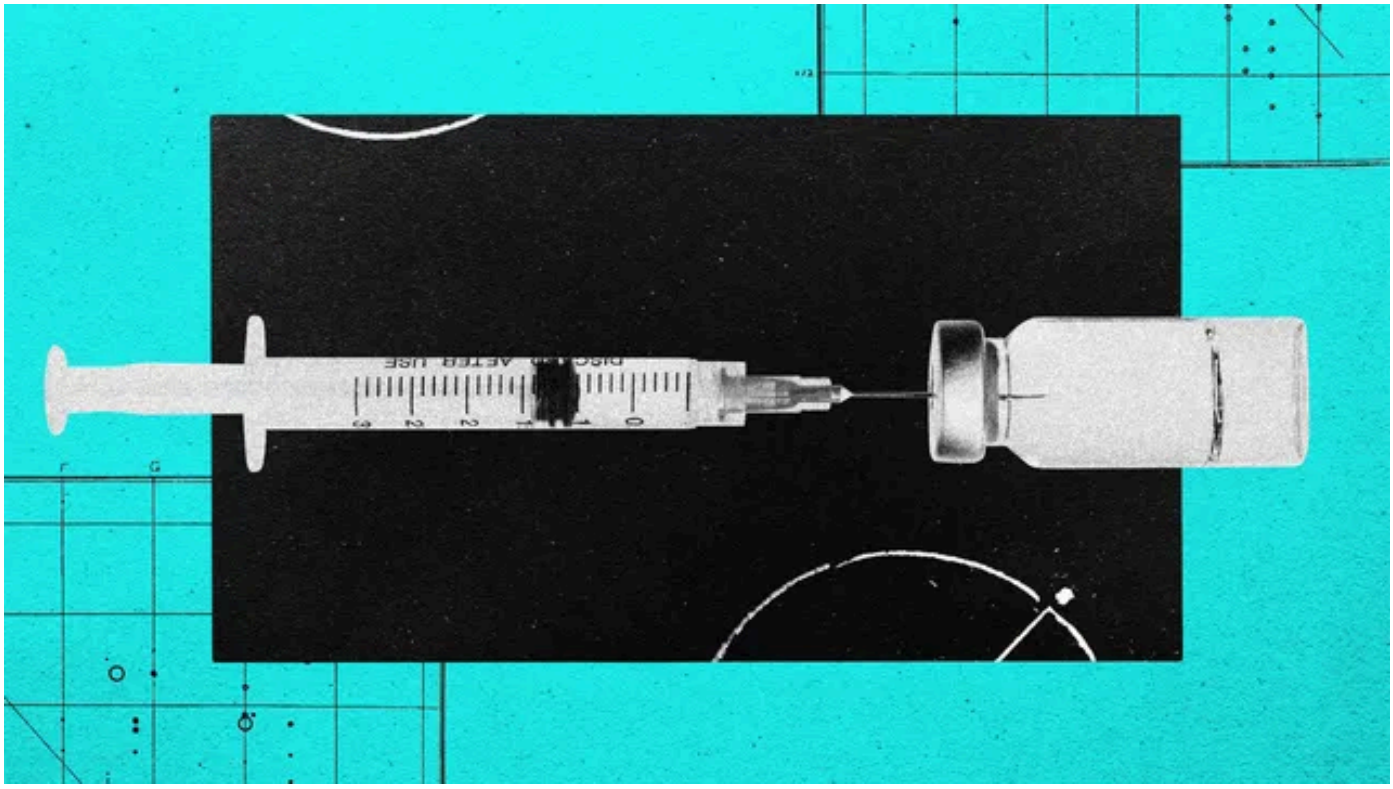

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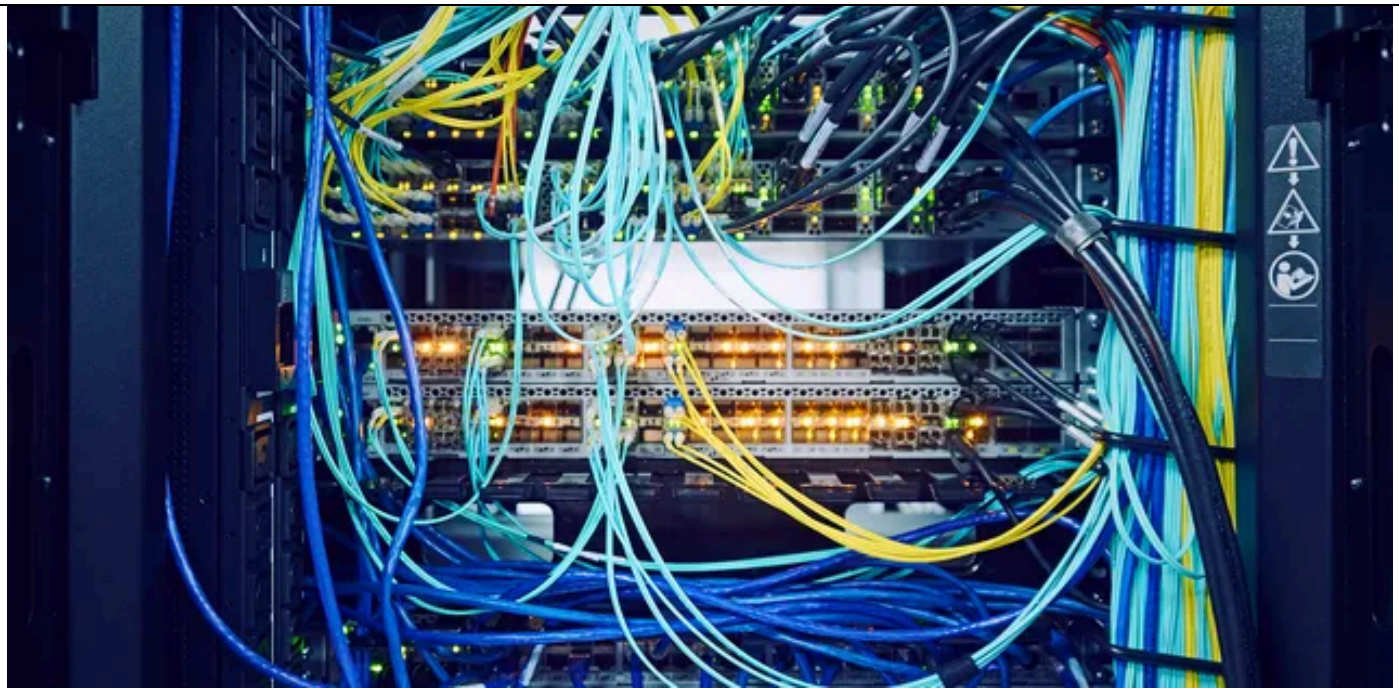

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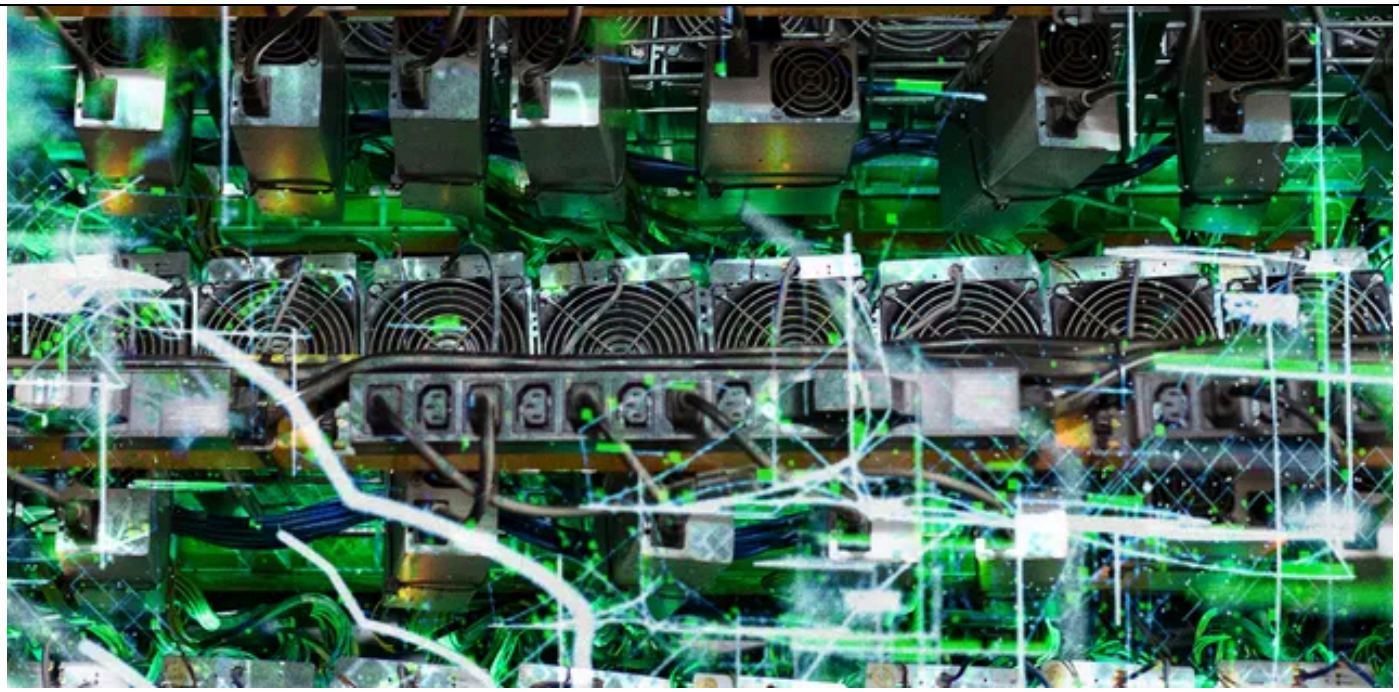

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