May 22, 2023

Dr. Michal Freedhoff, Assistant Administrator
Office of Chemical Safety and Pollution Prevention
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

Submitted via www.regulations.gov

RE*: Certain New Chemicals; Receipt and Status Information for January 2023, EPA–HQ–OPPT–2023–0061*

Dear Assistant Administrator Freedhoff,

Public Employees for Environmental Responsibility (PEER) and Center for Environmental Health (CEH) are providing comments on 18 Inhance Technologies, LLC (Inhance) Significant New Use Notifications (SNUNs) under review by the Environmental Protection Agency (EPA) pursuant to section 5(a) of the Toxic Substances Control Act (TSCA). These SNUNs were submitted pursuant to EPA's 2020 Long-Chain Perfluoroalkyl Carboxylate and Perfluoroalkyl Sulfonate Chemical Substances Significant New Use Rule (SNUR).[1]

As the SNUNs acknowledge, Inhance has been in violation of the SNUR since the fall of 2020 by manufacturing and processing nine long-chain perfluoroalkyl carboxylates (LCPFACs) during its fluorination of plastic containers. These LCPFACs are a subset of per-and polyfluoroalkyl substances (PFAS), a class of substances raising deep concern around the world because of their persistence and prevalence in people's blood serum and the environment, resulting in harmful effects on human health. TSCA prohibited Inhance from producing these PFAS without complying with the LCPFAC SNUR, but Inhance rejected EPA's repeated requests to stop production and belatedly submitted the 18 SNUNs to obtain EPA approval to continue the unsafe formation of PFAS during fluorination.

We demonstrate in these comments that the PFAS uses proposed in the SNUNs **present an unreasonable risk of injury** to human health and the environment. We therefore strongly urge

[1] 85 Fed. Reg. 45109 (July 27, 2020).

EPA to issue an order prohibiting Inhance from manufacturing and processing the nine LCPFACs for these uses under TSCA section 5(f).

The issues raised by these SNUNs have important and far-reaching implications for protection of public health and the effectiveness and credibility of EPA's actions to address the PFAS crisis. We believe it is essential for you and your staff to meet with PEER and CEH to discuss the many concerns and recommendations presented in these comments and will be contacting EPA to arrange a meeting shortly.

Attached to these comments is a report by Dr. Jimena Diaz Leiva, CEH Science Director, which reviews and analyzes the publicly available data on the presence of PFAS in fluorinated containers and their contents. Also attached is a report by Drs. Jamie DeWitt and Drake Phelps of East Carolina University which reviews the health effects literature for the nine LCPFACs, compares their adverse effect levels to the LCPFAC concentrations measured in fluorinated containers and their contents, and recommends risk assessment approaches consistent with the most recent EPA scientific determinations on these substances and other PFAS.

Thank you for the opportunity to comment.

Cordially,

Timothy Whitehouse, Executive Director
Public Employees for Environmental Responsibility

Regina Jackson, Interim CEO
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cc: Denise Keehner, Director, OPPT
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Public Employees for Environmental Responsibility (PEER) and Center for Environmental Health (CEH) comments on 18 Inhance Technologies, LLC (Inhance) Significant New Use Notifications (SNUNs), *EPA–HQ–OPPT–2023–0061*

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BACKGROUND

Inhance is a limited liability corporation formed in Delaware and headquartered in Houston, Texas. It is engaged in treating high-density polyethylene (HDPE) and other plastic containers by "fluorination," a process in which fluorine gas is applied to the container in varying concentrations under high temperatures to improve the containers' barrier properties (i.e., increase impermeability) and prevent loss of its contents. Inhance conducts fluorination across the United States and in other countries. Its U.S. facilities are in Allentown, Pennsylvania; Forest Park, Georgia; Homerville, Georgia; Centerville, Iowa; Mt. Pleasant, Iowa; West Chicago, Illinois; Columbus, Ohio; Houston, Texas; St. Louis, Missouri; Yuma, Arizona; and Troy, Alabama.[2]

Inhance describes itself as "a global leader in fluorine chemistry," and boasts that it has fluorinated over 2 billion plastic containers.[3] It claims that it "is the sole fluorination provider, worldwide, so enabled to deliver the cost benefits, high barrier performance and superior consistency of fluorination."[4]

Inhance fluorinates over 200 million containers and other items each year.[5] In the post-mold fluorination process, plastic manufacturers heat and then extrude High Density Polyethylene (HPDE) resin in the presence of oxygen and mold the resin into containers of various shapes and sizes.[6] After molding, these containers are shipped to Inhance facilities by truck, where they are fluorinated. Following treatment, they are returned to their manufacturers or sent to distributors or product suppliers who add their contents and ship the filled containers to downstream users. The HDPE containers that undergo fluorination "vary in size from around 24 ounces (for household products) to 1,000 liters (for industrial chemicals)."[7]

According to Inhance:

> . . . [t]he chemistry of fluorination of HDPE is well-known and has been well studied for decades . . . Fluorine gas reacts with the HDPE at the exposed surfaces of the HDPE container to form a thin layer of partially fluorinated polyethylene that will impart the [desired] barrier properties . . . . The depth of [the] partially fluorinated polyethylene layer varies from a few nanometers to a few microns from the surface. The actual amount of fluorination achieved, and the depth of partially fluorinated polyethylene formed, is determined by a variety of factors including fluorine concentration, pressure, temperature, and length of time of exposure.[8]

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[2] E.D. Pa., U.S. v. Inhance Technologies, Case 5:22-cv-05055-EGS, 12/19/22

[3] https://rocketreach.co/inhance-technologies-formerly-fluoro-seal-international-profile_b5ccac65f42e0ae5

[4] https://news.agropages.com/News/NewsDetail---22899.htm

[5] Fluoro-Seal International, LLC, Making the Impossible Possible – Transforming Plastics.

[6] SNUN, Attachment 010, Pollution Prevention Statement

[7] SNUN, Attachment 005, Diagram of the Fluorination of HDPE Containers and Worker Activities Associated with Production Steps

[8] SNUN, Attachment 004, Fluorination Process Information for HDPE Containers

Inhance fluorinates HDPE containers to different levels, classified as low, medium, and high. The "required level of container barrier protection drives the fluorination level, with higher amounts of fluorination used for greater degrees of barrier protection."[9] "Level of fluorination" refers to how many fluorine atoms are substituted for hydrogen atoms on the polymer molecule, and the higher the fluorination, the deeper the fluorination of the container's surface. Inhance's customers request the higher fluorination levels when they have "aggressive permeants" or need longer shelf-life.[10]

HDPE containers fluorinated by Inhance are widely used for a variety of consumer, commercial and industrial products. Examples cited by Inhance include household spray cleaners, household countertop polish, floor cleaners and polish, furniture wipes, spray pesticides and herbicides, hose-end sprayer herbicides, commercial pesticides, and industrial chemical storage.[11] Although Inhance does not focus on additional uses for its fluorinated containers in the SNUNs, other major applications of fluorinated containers include degreasers, shampoos and conditioners, medical skin adhesives, foods, fuel additives, automotive maintenance fluids, paint and coating removers, and solvents.

It is important to note that there are three types of plastic fluorination currently available on the market: post-mold fluorination, where fluorination occurs after the plastic containers are formed; in-mold fluorination, where the fluorine gas is introduced into the molten plastic before the containers are molded; and post-mold plasma fluorination, where a fluorocarbon-based plasma yields an ultrathin layer of a fluorocarbon material on the surface of the container. Inhance engages in post-mold fluorination.

[9] SNUN, Attachment 005, Diagram of the Fluorination of HDPE Containers and Worker Activities Associated with Production Steps
[10] SNUN, Attachment 004, Fluorination Process Information for HDPE Containers
[11] SNUN, Attachment 004, Fluorination Process Information for HDPE Containers

SUMMARY OF KEY CONCLUSIONS AND RECOMMENDATIONS

As our comments demonstrate, there are several compelling reasons why the formation of the nine LCPFACs during the Inhance fluorination process presents an unreasonable risk of injury to health and environment and must be prohibited under section 5(f) of TSCA.

- **The presence of PFAS in fluorinated containers and their contents is unavoidable in the post-mold process and testing consistently demonstrates significant PFAS levels in both the containers and their contents.**

    - In its SNUNs, Inhance recognizes that "an apparently unavoidable aspect of fluorination of HDPE containers" is the production of PFAS and "there is no easy solution to the problem of [PFAS] formation."
    - Multiple studies conducted by EPA and other researchers confirm that Inhance's post-mold fluorination process results in the formation of perfluoroalkyl carboxylic acids (PFCAs) in the surface layer of plastics. Nine LCPFACs subject to the EPA SNUR were consistently found in the studies, plus four short-chain perfluoroalkyl carboxylic acids (PFCAs).
    - The evidence from these studies indicates that LCPFAC and short-chain PFCAs readily leach from HDPE containers into their contents. Chemically and materially distinct solvents like methanol, acetone, and water, as well as household products and foodstuffs like insecticides, carpet cleaners, and condiments, have all been shown to contain PFCAs from fluorinated containers. Combined PFAS in container leachate have consistently been measured at significant ppb levels.

    - The concentration of PFCAs in the contents of these containers increases over time due to continual leaching from the containers. Heating of container contents, a common occurrence at different stages of the container lifecycle, such as shipping and storage, also increases PFCA levels.

- **Based on the latest EPA science, levels of PFCAs found in fluorinated containers and their contents likely cause significant adverse effects to human health**
    - EPA has been concerned about the human health and environmental impacts of PFOA and other LCPFACs since at least 2006 and believed its voluntary stewardship program had phased out the use of PFOA and its salts by 2013. The 2020 SNUR was intended to prevent manufacture of LCPFACs from resuming.
    - The risk assessments in the SNUNs are based on outdated "safe levels" that are not health-protective and do not take into account the latest EPA peer-reviewed findings on the toxicity of PFOA.
    - EPA's March 29, 2023 proposed drinking water regulations under the Safe Drinking Water Act (SDWA) set a Maximum Contaminant Level Goal (MCLG) for PFOA of zero because PFOA "is *Likely to be Carcinogenic to Humans* based on sufficient evidence of carcinogenicity in humans and animals and . . . a linear default extrapolation approach is

appropriate as there is no evidence demonstrating a threshold level of exposure below which there is no appreciable cancer risk."

- The proposal also sets a non-cancer reference dose for PFOA of 3 x 10^{-8} mg/kg/day, equivalent to 0.03 ng/kg/day, based on evidence of "effects across immune, developmental, cardiovascular, and hepatic organ systems at the same or approximately the same level of PFOA exposure."

- According to Drs. Phelps and DeWitt, an acceptable level of exposure via drinking water based on the non-cancer reference dose would be 2.4 ng per day. By contrast, the maximum amount of PFOA found in fluorinated HDPE by Peaslee and Whitehead is 7.25 ng/g. *Thus, 1 gram of fluorinated HDPE may contain more than triple the acceptable levels of PFOA being considered by EPA for drinking water.*

- EPA proposed 4.0 ppt as the MCL for PFOA on the ground that it is the concentration "close as feasible to the MCLG" of zero. By comparison, as Dr. Diaz Leiva notes in her report, PFOA was consistently found in extracts and solvents in fluorinated containers at significantly higher levels ranging from 0.13 ppb to 4.49 ppb*, between 32.5 and 1,122.5 times higher than the proposed MCL.*

- Based on developmental toxicity in rodents, EPA's drinking water proposal derived a health-based water concentration for PFNA of 0.00001 mg/L or 10 ppt. From the Whitehead and Peaslee report, PFNA was measured at concentrations up to 3.61 ng/g in fluorinated HDPE, equivalent to 3.61 ppb or 3,610 ppt. Thus, *in 1 gram of fluorinated HDPE, there is more than 360 times the acceptable level of PFNA, according to EPA's calculations for drinking water.*

- The other seven LCPFACs found in fluorinated containers have toxicity profiles similar to those of PFOA and PFNA.

- The DeWitt/Phelps report identified six LCPFACs for which available human studies reported statistically significant adverse health effects and LCPFAC in human blood (serum) associated with these effects: PFOA, PFNA, PFDA, PFUnDA, PFDoDA and PFTrDA. In each case, "adverse health outcomes were observed at serum concentrations that overlap with or are exceeded by the range of concentrations reported for . . . fluorinated HDPE by Whitehead and Peaslee."

- ***EPA's SNUN risk assessment should use health-protective methodologies based on current EPA science***

  - Because of the common health effects of PFOA and the eight other LCPFACs and the greater availability of data for PFOA, EPA's SNUN risk assessment should assume that these LCPFACs have the same toxicity profiles as PFOA. Under this approach, all the LCPFASs should be considered non-threshold carcinogens with no safe level of exposure.

- Consistent with EPA's drinking water proposal, dose-additivity is required for the nine LCPFACs found in fluorinated containers and their contents because they are similar in chemical structure, exhibit similar adverse effects in human and animal studies, and co-occur during fluorination and the use of fluorinated containers, resulting in simultaneous exposure to all nine substances by workers and consumers who come in contact with these containers.
- The four short-chain PFCAs consistently detected in fluorinated containers have caused many of the same health effects as the LCPFACs. EPA's risk assessment should also reflect the additive effects of co-occurring short-chain PFCAs because they contribute to the overall risk to container users.
- The combined PFCA levels (short- and long-chain) measured in the leachate from fluorinated containers by Whitehead and Peaslee ranged from 0.47 ppb to 94.81 ppb. If PFOA is used as a surrogate to represent all 13 PFCAs, *the total sum of all PFCA concentrations would exceed the EPA RfD for PFOA used to derive the proposed MCL by more than 15,000 – 3,000,000-fold on a ng/g basis.*

- **Millions of workers and consumers have significant dermal, inhalation and ingestion exposure to PFAS during manufacture, distribution, use and disposal of fluorinated containers**
  - Given the many points in the container life-cycle with opportunities for exposure to PFAS, there are numerous exposed worker and consumer subpopulations, including:
    - Workers directly engaged in fluorination at Inhance's 11 U.S. treatment facilities are exposed to LCPFACs during equipment cleanup and maintenance and handling of fluorinated containers;
    - Inhance workers who ship fluorinated containers to distributors or packaging sites;
    - Workers at packaging sites who fill fluorinated containers with liquid or solid products and prepare them for shipment to downstream users;
    - Workers at end-use sites who handle fluorinated containers and access their contents during commercial or industrial tasks;
    - Workers in container recycling and disposal operations;
    - Fenceline communities living near Inhance's 11 facilities exposed to airborne PFAS and PFAS in the wastewater coming out of these facilities;
    - Consumers who purchase or otherwise use fluorinated containers and their contents in residences or commercial establishments and may be exposed to PFAS when handling or discarding containers and their contents;
    - People living near farms or pesticide applicators who are spraying pesticides from fluorinated containers;
    - People living near landfills where fluorinated containers are disposed, given that the PFAS will end up in the landfill leachate; and
    - People with private wells near a landfill with fluorinated containers, a recycling facility, or people who drink water from a source where Inhance is discharging to a wastewater treatment plant (WWTP).

With over 200 million fluorinated containers and other items placed in commerce annually, workers and consumers with exposure to PFAS in these containers and their contents likely number in the tens of millions.

- Since downstream facilities and their workforces have not been informed and are likely unaware of the presence of PFAS in fluorinated containers and their contents, it is unlikely that process controls or personal protective equipment (PPE) are in use to prevent or reduce PFAS exposure.

- As Drs. Phelps and DeWitt emphasize, "[t]he ubiquity of PFAS in the environment leads to exposure via ingestion, dermal absorption, and inhalation concurrently."

  - Handling of fluorinated containers and their contents at all levels of distribution and use is a common and frequent mode of dermal contact with PFAS. Considerable data (described in these comments) show that PFOA and other LCPFACs penetrate skin and that dermal absorption is an important exposure route for PFCAs formed during fluorination. As emphasized by Drs. Phelps and DeWitt, "[t]hese data underscore that dermal absorption of PFAS – long- and short-chain – occurs and can induce adverse health outcomes."

  - Evaporation of the contents of consumer and commercial products during use can release PFAS-containing vapors or aerosol particles which are inhaled. Many of these products are exposed to elevated temperatures during processing, distribution and use, which would increase volatilization of their contents. Inhalation of PFAS is also likely when fuels, oils and other transportation products stored in fluorinated containers are combusted, releasing fumes and particles containing PFAS.

  - Based on a comprehensive literature review, EPA recently found that "[s]everal studies suggest that PFOA and its precursors in indoor air and/or house dust may be an important exposure source for some individuals," and that "PFOA is generally a dominant ionic PFAS constituent in indoor air and dust, frequently occurring above detection limits and at relatively high concentrations in all or most samples." EPA's risk assessment must thus examine the presence of PFCAs in vapors, aerosols or other dust in indoor air as a result of the extensive use of household products packaged in fluorinated containers, together with exposure from pesticide drift.

- Inhance does not provide respiratory protection to workers at its facilities because of its assumption that LCPFAC inhalation among Company workers is unlikely. However, immediately after fluorination of HDPE containers, including fuel tanks, workers are almost certainly exposed to high concentrations of volatile precursors to PFCAs. These substances will be inhaled by workers, absorbed onto their skin and clothing, and contaminate the workplace and external environment. Moreover, if workers do not shower and change before leaving their shifts, this dust can be carried into their homes.
- Exhaust from engines with fluorinated fuel tanks is a potentially significant pathway for inhalation exposure to PFCAs in light of the Inhance testing demonstrating high concentrations of all nine LCPFACs in fuel stored in these tanks and portable fuel containers. Contrary to Inhance, PFCAs in engine exhaust cannot be assumed to be

"destroyed" during combustion. There is considerable debate over the effectiveness and safety of combustion technologies in destroying PFAS. EPA's SNUN risk assessment should assume that PFAS in fuels are present in engine exhaust and inhaled by engine users and bystanders.

- Significant volumes of HDPE plastics are recycled and the recycling stream includes a large quantity of discarded fluorinated containers. Recycling facilities apply high heat to HDPE p lastic wastes so they can be melted and formed into sheets or pellets that can be remolded into containers or other articles. Thus, LCPFACs in fluorinated plastics may be present in vapors or aerosols emitted from the facility, resulting in inhalation exposure by workers and nearby communities.

- **Releases of PFAS to the environment during the fluorinated container life-cycle are another major source of exposure**

  - Environmental releases provide additional pathways of human exposure to PFAS, including:
    - Stack emissions and wastewater discharges from Inhance treatment facilities or sites where fluorinated containers are processed or used;
    - Releases from wastewater treatment operations;
    - Releases to soil and groundwater from recycling or landfilling of used containers.
  - The Inhance SNUNs generally downplay the release of PFAS to environmental media. However, air emissions and discharges to water at Inhance facilities are not adequately controlled and are a likely source of PFAS exposure. In addition, the SNUNs provide no information on pollution control equipment at downstream facilities and effective controls of PFAS releases are likely non-existent or ineffective because of lack of knowledge of the presence of PFAS by these facilities.

- **There are viable alternative barrier protection technologies that can replace post-mold fluorination**

  - The Inhance SNUNs emphasize that in-mold fluorination is a "critical technology" to reduce the permeability of plastic containers and prevent leakage of their contents. However, the benefits of fluorination are not relevant to EPA's determinations of risk for SNUNs under TSCA section 5(a)(3), because these determinations cannot consider "costs or other nonrisk factors."

In any case, as the President's National Science and Technology Council (NSTC) concluded in a March 2023 report: "Steel drums and non-PFAS coated HDPE containers are alternatives to PFAS-containing packaging. There are also alternative fluorination processes that reduce the potential for unintentional manufacture of PFAS, which the EPA and United States Department of Agriculture (USDA) have communicated to manufacturers." Another alternative is barrier technology for HDPE containers that does not involve fluorine chemistry. This technology is achieving growing acceptance in the plastics industry and was approved by EPA as a

replacement for in-mold fluorination for the Anvil 10+10® insecticide in 2021. Finally, alternative types of plastics, which have good solvent barrier properties, could be utilized.[12]

[12] https://www.tricorbraun.com/blog/understanding-types-of-plastic.html#:~:text=PETE%20%2D%20Polyethylene%20Terephthalate&text=PET%20plastic%20is%20often%20rigid,and%20a%20fair%20water%20barrier.

I. PRESENCE OF PFAS IN FLUORINATED CONTAINERS AND THEIR CONTENTS

A. The formation of PFAS during post-mold fluorination is unavoidable

In its SNUNs, Inhance recognizes that "an apparently unavoidable aspect of fluorination of HDPE containers" is the production of PFAS and "there is no easy solution to the problem of [PFAS] formation."[13] As Inhance explains, during the molding process, some of the HDPE breaks down into carboxylic acids and certain other lower-molecular weight species. The fluorination process introduces fluorine gas (F_2) to these carboxylic acids and other chemicals, which creates the thin layer of fluoropolymer, but also results in the formation of PFAS. Inhance further indicates that "[m]uch of the LCPFACs remain in the barrier layer of the HDPE containers, but some may migrate into the contents of those containers."[14]

Because F_2 is so reactive, it is not very selective in the chemical reactions it causes. During the fluorination of polyethylene, a small amount of chain scission occurs. Chain scission refers to the breaking of carbon – carbon bonds in the polymer chain.[15] A likely reaction mechanism for this is where a chain is broken to form two segments, one with a double bond and one with a free radical. In the presence of oxygen (O_2) or water (H_2O), fluorine will react with the carbon chain radicals and double bonds to form perfluorinated carboxylic acid structures.

Consistent with Inhance's analysis, since there are oxidation products on the surface of the polyethylene containers being fluorinated,[16] these will undergo fluorination and ultimately create perfluorocarboxylic acids. Examples of oxidation products that can be converted to perfluorinated carboxylic acids include alcohols, aldehydes, and carboxylic acids. In addition, the post-mold fluorination process itself is a source of oxygen, making it essentially impossible to eliminate O_2 and H_2O during fluorination of plastic containers.

The chemical reactions in the post-mold process form a large number of short-chain and long-chain perfluorinated carboxylic acids (PFCAs). In addition to PFCAs, the post-mold process is likely to result in perfluoroalkanes, another type of PFAS. Molded polyethylene has very small concentrations of short-chain alkyl groups, primarily formed during the molding process, and these will be fluorinated along with the longer polymer chains. In addition, the highly exothermic fluorination reactions are expected to cause some amounts of chain scission, which will generate perfluoroalkanes.

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[13] SNUN, Attachment 010, Pollution Prevention Statement

[14] SNUN, Attachment 010, Pollution Prevention Statement

[15] Book – Comprehensive Chemical Kinetics. Edited by C.H. Bamford, C.F.H. Tipper Volume 18, "Selected Elementary Reactions"; p. 1-486 (1976)

[16] Syed Raihan Alam; "Revising The Mechanism of Polyolefin Degradation and Stabilization: Insights from Chemiluminescence, Volatiles and Extractables"; Ph.D. Thesis from Manchester Metropolitan University , 2019; *see also* Gugumus, F.; "Physico-chemical aspects of polyethylene processing in an open mixer, Part 27: Formal kinetics of aldehyde and carboxylic acid formation in the initial stages"; Polymer Degradation and Stability 92 (1) 2007: p. 125 – 142 *and* Ceretti, D.V.A.; Edeleva, M.; Cardon, L.; D'hooge, D.R.; " Molecular Pathways for Polymer Degradation during Conventional Processing, Additive Manufacturing, and Mechanical Recycling" Molecules (2023), 28 2344. P. 1 – 30

It is critical to note, as Inhance concedes, that "The LCPFACs subject to this SNUR are not isolated but reside within the surface layer of the HDPE containers. As such, these LCPFACs are not stored or shipped separately."[17] In other words, *all* nine LCPFAC are created every time Inhance fluorinates containers. Inhance is therefore unable to eliminate the creation of PFOA, one of the most well-studied and toxic of all PFAS.

B. Multiple studies demonstrate the formation of nine LCPFACs and at least four short-chain PFCAs during post-mold fluorination

The attached report of CEH's Science Director, Dr. Jimena Diaz Leiva, reviews six studies examining the presence of perfluoroalkyl carboxylic acids (PFCAs), a subset of PFAS that includes LCPFACs and short-chain perfluoroalkyl carboxylates, in fluorinated containers and their contents. Dr. Diaz Leiva's report summarizes the findings of these studies as follows:

> The evidence from the literature presented in this declaration demonstrates that Inhance Technologies' direct, post-mold fluorination process causes PFCAs to form in the surface layer of high-density polyethylene (HDPE) containers. These PFCAs have been found to leach into a variety of solvents, including methanol, water, and even food. The ability for PFCAs to leach into the contents of fluorinated containers constitutes an important exposure pathway for workers and consumers that come into contact with or consume products held in these containers.

As Dr. Diaz Leiva indicates, across the various studies, 14 PFCAs have been found in fluorinated containers and their contents, including nine LCPFACs subject to EPA's SNUR and four short-chain PFCAs. These substances are identified in Table 1.

> **Table 1.** Perfluoroalkyl carboxylic acids (PFCAs) positively identified in extracts from post-mold fluorinated HDPE plastic containers by study. PFCAs ordered by carbon chain length.

PFAS Compound (C-chain length)	Eurofins (2023)	Whitehead and Peaslee (2023)	Vitale et al. (2022)	EPA (2022)	EPA (2021)	Rand and Mabury (2011)
TFA (C2)						X
PFPrA (C3)						X
PFBA (C4)	X	X	X	X	X	X
PFPeA (C5)	X	X	X	X	X	X
PFHxA (C6)	X	X	X	X	X	X
PFHpA (C7)	X	X	X	X	X	X
PFOA (C8)	X	X	X	X	X	X
PFNA (C9)	X	X	X	X	X	X
PFDA (C10)	X	X	X	X	X	X

[17] SNUN, Diagram of the Fluorination of HDPE Containers and Worker Activities Associated with Production Steps

PFUnDA (C11)	X	X	X	X	X	
PFDoDA (C12)		X	X			
PFTrDA (C13)		X	X			
PFTDA (C14)		X	X			
PFHxDA (C16)		X				
PFODA (C18)		X				

1. Rand and Mabury (2011)

The first published report of the presence of PFAS as byproducts of post mold fluorination was from testing conducted in 2011.[18] The authors identify the manufacturer ("Manufacturer A") as Fluoro-Seal International,[19] which was an earlier name for Inhance Technologies.[20] In this paper, they explained that Fluoro-Seal did post mold fluorination, while Manufacturer B (Air Products and Chemicals) used in-mold fluorination. The study found no detectable amounts of PFCAs from the Manufacturer B sample, but significant amounts from Manufacturer A, which is Inhance.

Dr. Diaz Leiva describes the findings of this testing as follows:

> Rand and Mabury (2011) presented the first evidence in the peer-reviewed literature of the formation of PFCAs in directly fluorinated plastic containers. Studies from the EPA (2021, 2022), Vitale et al. (2022), and Whitehead and Peaslee (2023), build off of this work and provide further evidence of the potential for PFCAs to leach from directly fluorinated plastic containers into solvents and foodstuffs held in these containers. Rand and Mabury extracted PFCAs from directly fluorinated HDPE bottles treated with differing levels of fluorination. They compared their results to unfluorinated bottles, finding that the total concentration of PFCAs from fluorinated bottles increased with level of fluorination and was significantly higher than the levels in unfluorinated bottles. The authors note that:
>
> > The amount of PFCAs formed on directly fluorinated HDPE is proportional to the amount of fluorination the HDPE receives, and presumably the amount of oxygen within the fluorination chamber… (p. 8057).
>
> In the fluorinated bottles, the authors reported total PFCA concentrations in methanol extract ranging from 8.5 ± 0.53 ng/cm^2 in the least fluorinated bottles (Level 1) up to 113 ± 2.5 ng/cm^2 in the most fluorinated bottles (Level 5). Many of the PFCAs identified in the methanol extract were LCPFCAs including PFOA, PFNA, and PFDA. These long-chain PFCAs were more common in the extracts from higher fluorination levels. After identifying

[18] Amy A. Rand and Scott A. Mabury, Perfluorinated Carboxylic Acids in Directly Fluorinated High-Density Polyethylene Material, *Environmental Science & Technology* **2011** *45* (19), 8053-8059, DOI: 10.1021/es1043968
[19] Id. at 8054.
[20] https://www.prweb.com/releases/2013/8/prweb10987068.htm

> and quantifying PFCAs in extract from fluorinated HDPE bottles, Rand and Mabury performed a one-year leaching experiment using water to show that these PFCAs migrate into solvents held in the bottles.
>
> After one year, the total concentration of PFCAs in water held in fluorinated HDPE bottles (Level 3), exceeded the total concentration of PFCAs in methanol extracts from bottles treated with all levels of fluorination.

Therefore, it is clear that the scientific community knew that fluorination of HDPE containers resulted in the formation of PFAS as early as 2011. It is difficult to imagine that Inhance's scientists were not aware of this.

2. 2021 EPA Testing

After PEER found PFAS in the pesticide Anvil 10+10®, EPA conducted their own studies, confirming this finding, but also discovering that the PFAS contamination was from the fluorinated containers. Dr. Diaz Leiva's report describes 2021 testing by EPA's Analytical Chemistry Branch as follows:

> On March 4, 2021, a decade after Rand and Mabury's (2011) seminal study, the US EPA released a memorandum describing their results from testing fluorinated HDPE containers. This testing followed reports of PFAS compounds detected in a mosquito pesticide held in a fluorinated HDPE container. The EPA tested fluorinated containers by rinsing them with methanol and then analyzing the rinsate for PFAS compounds. The agency tested both used and unused, fluorinated and non-fluorinated containers, and found that the rinsate from all fluorinated containers had detectable concentrations of PFAS, including PFOA and other PFCAs. In non-fluorinated containers, the agency found PFAS concentrations in the rinsate from the containers of 1 ppb or less. In fluorinated containers, the EPA found PFAS concentrations that ranged from 20-50 ppb in the rinsate. The agency found a greater number of PFAS compounds in the rinsate of the fluorinated containers. All of the compounds detected were PFCAs, with 5 of the 8 compounds being LCPFCAs. EPA's analysis of these results indicate that the agency believes that the fluorination process results in the formation of PFCAs. They state that:
>
> > Based on the results of the rinsate samples as described above and the preliminary results of the product samples…the EPA believes that through the fluorination process of HDPE containers, PFAS compounds may be formed and then partly leach into the products inside the containers (p. 3).

This 2021 testing was the first time that PFAS creation was directly linked to Inhance's fluorination of HDPE containers.

3. EPA August 2022 Testing

EPA reported additional test results in August 2022, which Dr. Diaz Leiva has summarized as follows:

> Through this additional testing, the Agency set out to determine whether PFAS compounds leached into different solvents held in fluorinated HDPE containers. EPA filled fluorinated and non-fluorinated containers with water and methanol and held these solvents in the containers for a 20-week period to determine whether PFAS would leach into the solvents from the container and whether longer residence times would lead to greater concentrations of PFAS. The agency analyzed an aliquot of the solvents held in these containers after 1 day, 1 week, 4 weeks, 10 weeks, and 20 weeks. The EPA detected PFAS compounds in both water and methanol at every interval but noted that the methanol contained higher concentrations of PFAS compared to water. Of the 31 PFAS compounds screened, the agency positively identified eight compounds in the leachate from fluorinated bottles. These eight compounds were all PFCAs, and five were LCPFCAs including PFOA.
>
> Importantly, the Agency noted that while the sum concentration of PFAS analyzed in the leachate from fluorinated containers varied amongst the three types of HDPE containers that they tested, in comparison to unfluorinated containers, the concentration of PFAS was elevated in all fluorinated containers. Moreover, EPA found that with increasing residence time, the sum concentration of PFAS in both solvents increased, indicating that PFAS continued to leach from the containers over time. For the containers holding water, the total PFAS concentration ranged from 0.016 ppb to 2.888 ppb whereas for the methanol the total PFAS concentration ranged from 0.977 to 14.720 ppb. The Agency's two memorandums are in agreement with the findings of Rand and Mabury (2011), showing that PFCAs leach from fluorinated containers into their contents and will continue to leach over time.

4. Vitale et al. (2022)

The authors conducted a series of leaching experiments using fluorinated and non-fluorinated HDPE bottles, reporting the following results:

> In accordance with the findings from Rand and Mabury (2011) and EPA (2022), Vitale et al. (2022) found that post-mold fluorinated HDPE bottles leached PFCAs at every interval during the 12-week study period. At each interval, PFCAs including PFOA, were detected in the methanol leachate. The most frequently detected PFCAs from the post-mold fluorinated leachate were those in the C5-C7 chain length. Consistent with the results from EPA (2022), the sum concentration of PFAS increased in the leachate with longer residence periods. After 12 weeks, the total PFAS concentration in the leachate from post-mold fluorinated bottles reached up to 9,700 ng/L or 9.7 ppb. The authors did not measure PFAS compounds above the limit of quantitation of any specific analyte in HDPE bottles treated with in-mold fluorination.

5. Whitehead and Peaslee (2023)

This study documented leaching of PFCAs from directly fluorinated HDPE containers into different solvents and foodstuffs that may be held in these types of containers. According to Dr. Diaz Leiva:

> Whitehead and Peaslee found that the sum of PFAS concentrations in fluorinated containers was greater than 200 times the concentrations in non-fluorinated containers. In fluorinated containers, the sum of PFAS concentrations was 63.75 ± 13.12 ng/g (ppb) plastic compared to 0.29 ± 0.30 ng/g (ppb) plastic in non-fluorinated containers. These data confirm that plastic containers subjected to direct, post-mold fluorination, contain high concentrations of PFAS chemicals. The authors identified 20 different PFAS chemicals including many short-chain carboxylic acids like PFBA and PFPeA, as well as 10 long-chain compounds including PFOA and PFNA. While these PFAS compounds were detected in the fluorinated plastic containers themselves, the authors also conducted numerous leaching experiments to determine whether these compounds migrated from the containers into solvents and foodstuffs.
>
> Whitehead and Peaslee (2023) present evidence of PFCA leaching from fluorinated containers into water, acetone, and methanol. After a seven-day leaching experiment, they found that each of these three solvents contained PFCAs, with the highest concentration of PFCAs found in methanol. The sum of PFAS concentrations that they measured in the solvents were comparable to the results obtained from the EPA (2022) studies. Finally, the authors conducted a leach test using common foods that might be stored in fluorinated containers such as olive oil, mayonnaise, and ketchup. The results of this experiment are perhaps most concerning for the uses of fluorinated containers that involve food contact. After seven days, PFAS were found in each of the three foodstuffs and in particular, short-chain PFCAs were found to have leached into all foods. In the olive oil, ketchup, and mayonnaise, the sum of PFAS concentrations were 2.66 ± 0.82, 5.95 ± 1.59, and 7.19 ± 3.39 ng/g (ppb), respectively. The sum of PFAS concentrations for these foodstuffs also exceeded the sum of PFAS concentrations that leached into water after seven days indicating that these foodstuffs acted as better solvents to pull out PFCAs from the fluorinated plastic containers.

6. Eurofins Replication of Peaslee and Whitehead (2023)

Most recently, fluorinated and non-fluorinated HDPE containers were sent by PEER to Eurofins Lancaster Laboratories Environment Testing, LLC - a third-party accredited analytical laboratory – to corroborate the results of Whitehead and Peaslee's (2023) study. Seven day leaching experiments were conducted with water, methanol, and acetone to determine whether PFCAs leached from fluorinated containers into the contents. As summarized by Dr. Diaz Leiva, eight different PFCAs were detected in the leachate, including five LCPFCAs. The highest concentrations of PFCAs were detected in the acetone followed by the methanol solvent. PFOA was detected in all three replicate samples of methanol and acetone at an average concentration of 4.07 ± 0.96 ppb and 4.93 ± 0.50 ppb, respectively. The results from Eurofins' testing strongly validates Whitehead and Peaslee's findings and provide further confirmation of the presence of PFCAs in fluorinated containers and their ability to leach into the contents held in these containers.

7. Unpublished Work by Whitehead (2023)

Whitehead evaluated whether in-mold fluorinated HDPE containers contained PFCAs by performing targeted analyte extracts of these containers. As summarized by Dr. Diaz Leiva, "[i]n line with the findings of Vitale et al. (2022), Whitehead found that none of the target analytes measured above their limit of quantitation in the extracts from in-mold fluorinated containers. Only one short-chain PFCA, perfluoro-heptanoic acid (PFHpA), was measured just above the limit of quantitation in this level 3 in-mold fluorinated container."

Whitehead also measured the amount of PFAS that would leach from fluorinated HDPE containers into indoor and outdoor home products. As Dr. Diaz Leiva summarized the results:

> [An] indoor carpet cleaner and indoor/outdoor insecticide were found to contain PFCAs of the same chain length and identities as observed in the extraction of containers and solvent leaching experiments described in Whitehead and Peaslee (2023). The average sum of PFAS concentration in the indoor carpet cleaner was 20.7 ± 4.9 ng/g (ppb) plastic and was 6.9 ± 2.5 ng/g (ppb) plastic in the insecticide. Between the carpet cleaner and insecticide, Whitehead detected 13 different PFCAs, including nine LCPFACs.

Taken together, these studies all confirm that Inhance's post-mold fluorination process results in the formation of PFCAs in the surface layer of plastics. Nine LCPFACs subject to the EPA SNUR were consistently found in the studies, as were four short-chain PFCAs. There is a high level of concurrence among the study results. For example, PFOA concentrations measured in extracts from fluorinated HDPE containers and in different solvents held in these containers, are all comparable across the studies where specific analyte concentrations are reported.

C. Testing also shows that LCPFACs and short-chain PFCAs leach from fluorinated containers to their contents

The evidence from these studies also indicates that LCPFAC and short-chain PFCAs readily leach from HDPE containers into their contents. Chemically and materially distinct solvents like methanol, acetone, and water, as well as household products and foodstuffs like insecticides, carpet cleaners, and mayonnaise, have all been shown to contain PFCAs from fluorinated containers. Adding to the risk of exposure for consumers, over time, the concentration of PFCAs in the contents of these containers increases due to continual leaching from the containers. Heating of container contents, a common occurrence at different stages of the container lifecycle, such as shipping and storage, also increases PFCA levels.

Combined PFAS levels in container leachate have consistently been in parts per billion (ppb) levels as shown in Table 3.

Table 3. Sum of PFAS concentrations (ng/g plastic, ppb) reported in extracts and leachate from fluorinated HDPE bottles.

Sum of PFAS Concentration	Whitehead and Peaslee (2023)[1]	Vitale et al. (2022)[2]	EPA (2022)[3]	EPA (2021)[4]
Fluorinated bottle extracted with methanol	63.75 ± 13.12	N/A	N/A	20-50
Methanol	69.72 ± 7.75	9.7	0.977 - 14.720	N/A
Acetone	50.13 ± 4.41	N/A	N/A	N/A
Water	0.99 ± 0.46	N/A	0.016 - 2.888	N/A

1. Results reported as the average sum of PFAS concentrations ± 1 standard deviation. Methanol, water, and acetone were used in 7-day leaching experiments.
2. Results reported as the maximum sum of PFAS concentration measured in methanol held in post-mold fluorinated containers for 4 weeks.
3. Results reported as the range of sum of PFAS concentrations measured during a 20-week leaching experiment using water and methanol held in fluorinated HDPE containers.
4. Results reported as the range of sum of PFAS concentrations measured in methanol rinsate from fluorinated HDPE containers.

D. Inhance's fluorinated fuel tanks leach high levels of LCPFACs into the fuel.

Nine of Inhance's 18 SNUNs are related to the use of its fluorinated containers for "fuel uses." Table 4[21] shows which SNUNs are applicable to fuel tanks and which are related to other non-fuel containers.

Table 4

[21] March 17, 2023 letter to EPA from an Inhance consultant, toXcel, entitled "Suspension of Review Period for SN-23-0002 thru SN-23-0021."

Species #	Compound Abbreviation	CAS Number	Fuel Uses	Consolidated groupings		Container Uses
1	PFOA	335-67-1	SN-23-0002	Fuel SNUNs 1	Container SNUNs 1	SN-23-0017
2	PFNA	375-95-1	SN-23-0003			SN-23-0018
3	PFDA	335-76-2	SN-23-0004			SN-23-0019
4	PFuDA	2058-94-8	SN-23-0005			SN-23-0020
5	PFDoA	307-55-1	SN-23-0006			SN-23-0021
6	PFtrDA	72629-94-8	SN-23-0013	Fuel SNUNs 2	Container SNUNs 2	SN-23-0008
7	PFteDA	376-06-7	SN-23-0014			SN-23-0009
8	PFHxDA	67905-19-5	SN-23-0015			SN-23-0010
9	PFODA	16517-11-6	SN-23-0016			SN-23-0011

The SNUNs describe testing conducted by Inhance to determine concentrations of LCPFACs in small engine fluorinated fuel tanks and their fuel contents. In addition to finding high LCPFAC levels in tank materials, Inhance found substantial concentrations of LCPFAC leaching to the fuel itself, with the exact amount depending on the level of fluorination (high, medium and low) used to treat the tank. Thus, for tanks receiving high levels of fluorination, combined LCPFAC levels in fuel totaled 138 ug/L (ppb), as shown below in Figure 1.

Figure 1

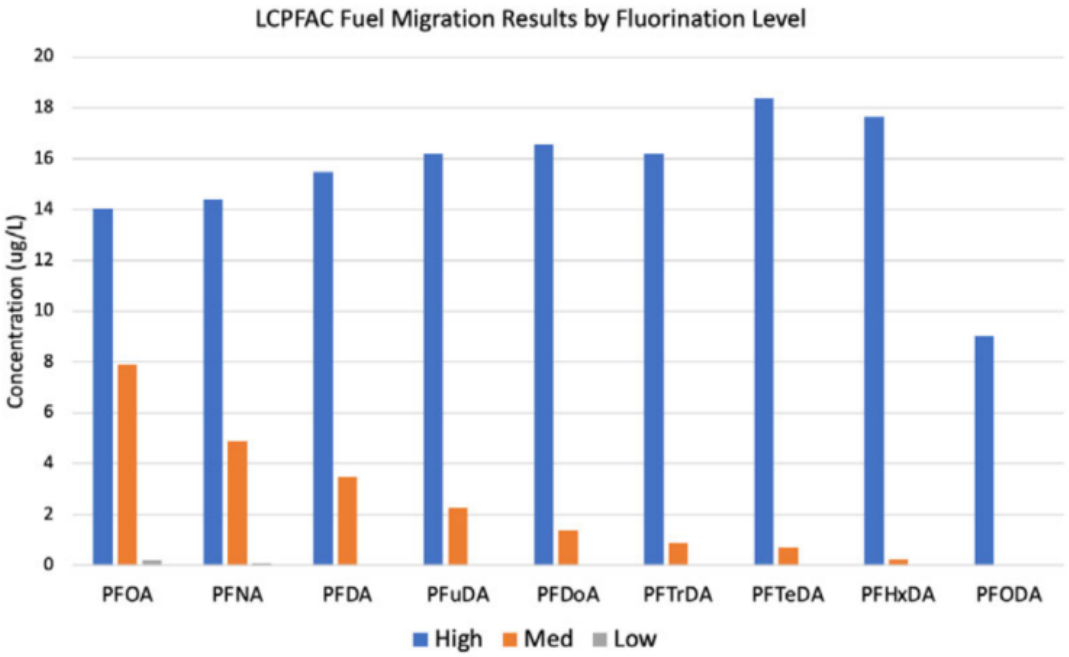


Figure 4. LCPFAC fuel concentrations by fluorination level from land-based small combustion engine fuel tanks

These levels are substantially higher than LCPFAC levels measured by Peaslee and Whitehead in solvents and foods due to leaching from containers and raise heightened concern about the health risks from fuels in fluorinated tanks.

E. Recent data from Notre Dame and Eurofins measuring PFAS levels in fluorinated containers and their contents are representative of products in the marketplaces today and should be the basis for EPA'S SNUN risk assessments

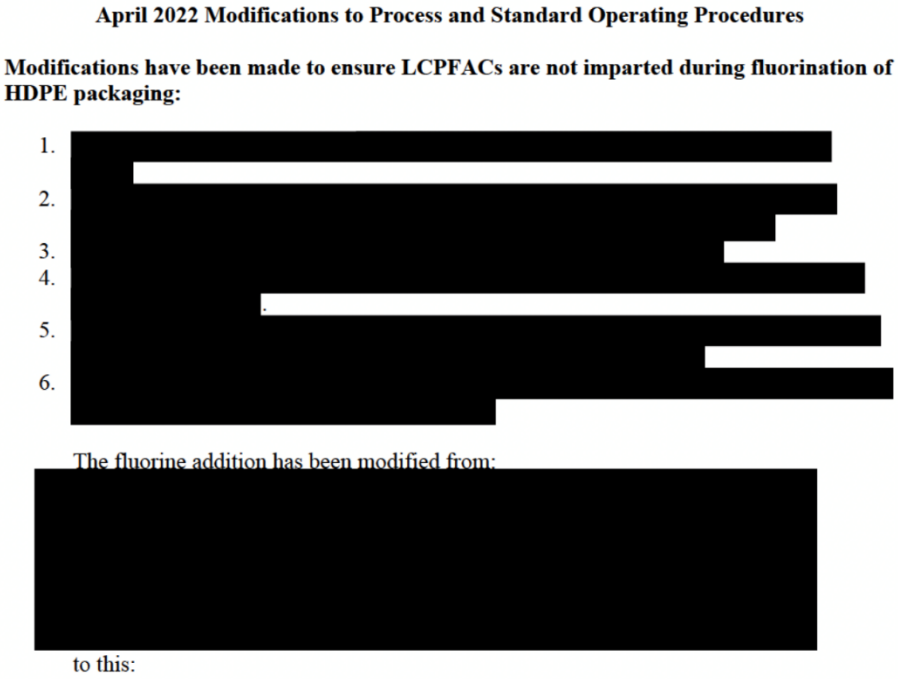
The Notre Dame[22] and Eurofins[23] data document levels of PFCAs in the contents of fluorinated containers that were purchased through normal commercial channels within the last nine months and therefore are likely representative of fluorinated containers now in the stream of commerce. The results of these studies are consistent with 2021 and 2022 EPA findings, adding to the weight of evidence. However, the SNUNs report data from Inhance testing that purports to show much lower (and in some cases non-detectable) levels of PFCAs.[24] These Inhance data should receive little or no weight in EPA's SNUN risk assessments.

The Inhance data have not been published in the peer reviewed literature, unlike the Peaslee and Whitehead (2023) results. The Inhance studies examined migration from fluorinated containers to water and mineral spirits; it did not use methanol (which was used in the other studies described above) or other strong solvents characteristic of the products stored in many fluorinated containers. In addition, it does not appear that measurements of PFCAs were made over long periods or under elevated temperature conditions, as in previous studies. It is similarly uncertain whether the containers tested represented the highest level of fluorination, a key determinant of the degree of PFCA formation. Finally, the much higher levels of LCPFACs (described above) that Inhance measured in migration studies on fuel tanks with high levels of fluorination call into question the validity of test results on other fluorinated containers showing much lower levels of leaching.

Inhance claims that the 2022 EPA results are "not likely representative of the potential for LCPF AC migration resulting from current Company HDPE container fluorination processes" because they do not reflect the impact of changes in its fluorination process that Inhance purportedly made in April of 2022. However, the SNUNs redact details of these process enhancements so it is impossible to evaluate their effectiveness in reducing PFAS formation (see Figure 2).

[22] The Notre Dame analysis was done on containers purchased on or about August 8, 2022.
[23] The Eurofins analysis was done on containers purchased on January 17, 2023.
[24] SNUN Attachment Number 026: Analytical Results Comparisons

Figure 2



Thus, PEER and CEH cannot evaluate whether the lower LCPFAC concentrations reported in the Inhance testing can be attributed to these process enhancements, or are a function of unrealistic test procedures. Finally, the SNUNs do not indicate when fluorinated containers entering commerce first embodied the Inhance process changes; the Peaslee and Whitehead and Eurofins testing would suggest that the new process has either not yet been fully implemented or is not reliably reducing PFAS formation.

II. SERIOUS HEALTH EFFECTS OF LCPFACs AT LEVELS FOUND IN CONTAINERS AND THEIR CONTENTS

A. The 2020 SNUR Is Based on Serious Concerns about PFOA and other LCPFACs

Two decades ago, LCPFACs were recognized by EPA and industry as presenting unusually serious health and environmental concerns that warranted elimination of manufacture and use. In the early 2000s, one member of this class -- perfluorooctanoic acid (PFOA) – was implicated in large-scale contamination of drinking water near a DuPont facility in West Virginia.[25] Follow-up studies funded by the company as part of a legal settlement demonstrated links to a host of health problems in the exposed population.[26]

[25] Hill, P., Carper, Bee & Deitzler, PLLC. *The Brookmar C8 Health Project (CO)*, 2020, https://www.hpcbd.com/Personal-Injury/DuPont-C8/The-Brookmar-C8-Health-Project- CO.shtml

[26] Emmett, E. A. *et al.* Community exposure to perfluorooctanoate: relationships between serum levels and certain health parameters. *J Occup Environ Med* 48, 771-779, doi:10.1097/01.jom.0000233380.13087.37 (2006). Nolan, L. A., Nolan, J. M., Shofer, F. S., Rodway, N.

Against this backdrop, at EPA's urging, in 2006, the principal manufacturers and processors of PFOA and other LCPFACs formed a PFOA Stewardship Program with "a goal of reducing facility emissions and product content of LCPFAC chemical substances on a global basis by 95%, no later than 2010, and to eliminate emissions and product content of these chemical substances by 2015."[27] The 2015 proposed SNUR was prompted by EPA's concern that "commencement of manufacture or processing for any new uses, including resumption of past uses, of LCPFAC … substances could increase the magnitude and duration of exposure to humans and the environment."[28] As a result of the restrictions imposed by the SNUR, "EPA expect[ed] the presence of LCPFAC substances in humans and the environment to decline over time as has been observed in the past when production and use of persistent chemicals have ceased."[29] EPA stated (erroneously as it turned out) that, it "believes all uses of PFOA and its salts were phased out by December 31, 2013."[30]

In July of 2020, EPA finalized the 2015 SNUR proposal, as directed by Congress in the National Defense Authorization Act of 2020 (Public Law No. 116-92). As a rationale, EPA reiterated its concerns about health impacts from these PFAS, and concluded, "While most studies of perfluoroalkyl sulfonate chemical substances to date have focused primarily on perfluorooctane sulfonate (PFOS), structure-activity relationship analysis indicates that the results of those studies are applicable to the entire category [of LCPFACs]."[31]

The 2020 SNUR indicates that LCPFAC substances "have been found in the blood of the general human population, as well as in wildlife, indicating that exposure to these chemical substances is widespread."[32] It also explains that "PFOA and its salts, which are considered LCPFAC chemical substances, have been a primary focus of studies related to the LCPFAC class of chemical substances" and that "PFOA is persistent, widely present in humans and the environment, has a half-life in humans of 2.3–3.8 years, and can cause adverse effects in laboratory animals, including cancer and developmental and systemic toxicity."[33] According to EPA, "[h]uman epidemiology data report associations between PFOA exposure and high cholesterol, increased liver enzymes, decreased vaccination response, thyroid disorders, pregnancy-induced hypertension and preeclampsia, and cancer (testicular and kidney)." In addition, "PFOA precursors, chemicals which degrade or may degrade to PFOA, are also present worldwide in humans and the environment and, in some cases, might be more toxic and be present at higher concentrations than PFOA."[34]

V. & Emmett, E. A. The relationship between birth weight, gestational age and perfluorooctanoic acid (PFOA)-contaminated public drinking water. *Reprod Toxicol* 27, 231-238, doi:10.1016/j.reprotox.2008.11.001 (2009).

[27] 80 Fed. Reg. 2890.
[28] 80 Fed. Reg. at 2890.
[29] 80 Fed. Reg. at 2890
[30] 80 Fed. Reg. at 2887.
[31] 80 Fed. Reg. at 45113.
[32] Id. at 45113.
[33] Id. at 45113.
[34] Id.

To summarize, EPA has been concerned about the human health and environmental impacts of PFOA and other LCPFACs since at least 2006; and it believed its voluntary stewardship program had phased out the use of PFOA and its salts by 2013. And yet in 2023, ten years after EPA believed that PFOA was no longer being manufactured in the United States, Inhance is attempting to justify its current and ongoing manufacture of PFOA in products that span numerous sectors of commerce and are potentially contaminating our food, water, air, and soil all across the country.

B. The Latest EPA Toxicity Assessments for PFOA and PFNA Set Zero r Near-Zero Levels of Acceptable Exposure

1. Outdated and Unprotective Health-Based Protection Levels (HBLVs) in Inhance SNUNs

Inhance based its risk assessments[35] on the following "health-based protection levels" (HBPLs) for PFOA and the other eight LCPFACs (see Figure 3).[36]

Figure 3

Table 2. Human health-based protection levels (HBPLs) for the LCPFACs

Species Number	HBPL (RfD) (mg/kg-day)	HBPL for Resident Soil (mg/kg)*	HBPL for Soil to Protect Groundwater (mg/kg)	HBPL for Drinking Water (µg/L)	Reference
1	3×10^{-6}	0.19	9.1×10^{-4}	6.0×10^{-2}	RfD from ATSDR MRL; EPA RSL (total hazard quotient = 1)
2	3×10^{-6}	0.19	2.5×10^{-4}	5.9×10^{-2}	RfD from ATSDR MRL; EPA RSL (total hazard quotient = 1)
3	1.5×10^{-5}	0.99	0.022*	3.7×10^{-4} **	TCEQ (*= 0.5 acre site); **TCEQ PCL for Groundwater (ingestion)
4	1.2×10^{-5}	0.80	0.018*	2.9×10^{-4} **	TCEQ (*= 0.5 acre site); **TCEQ PCL for Groundwater (ingestion)
5	1.2×10^{-5}	0.80	0.034*	2.9×10^{-4} **	TCEQ (*= 0.5 acre site); **TCEQ PCL for Groundwater (ingestion)
6	1.2×10^{-5}	0.60	0.061*	2.9×10^{-4} **	TCEQ (*= 0.5 acre site); **TCEQ PCL for Groundwater (ingestion)
7	1.2×10^{-5}	0.50	0.011*	2.9×10^{-4} **	TCEQ (*= 0.5 acre site); **TCEQ PCL for Groundwater (ingestion)
8	3×10^{-6}	0.19	9.1×10^{-4}	6.0×10^{-2}	EPA RSLs for Species 1 used as a surrogate
9	3×10^{-6}	0.19	9.1×10^{-4}	6.0×10^{-2}	EPA RSLs for Species 1 used as a surrogate

[35] Note that it is unusual for SNUN submitters to supply their own risk assessments. EPA can adopt or reject Inhance's risk assessments, so long as they provide a rationale for doing so. However, it is entirely possible that Inhance conducted its own risk assessments – which are seriously flawed – in an attempt to persuade EPA to adopt their reasoning; we urge EPA to review the failings of these risk assessments carefully.

[36] SNUN, Attachment 012, Risk Assessment for Fluorinated HDPE Containers, p. 14

These levels are not health-protective and do not take into account findings of the latest EPA toxicity assessments for PFOA and PFNA. For example, for PFOA (Species 1 in Figure 3, above), Inhance uses the Agency for Toxic Substances and Disease Registry's (ATSDR) Minimal Risk Levels (MRLs) as a reference dose. They then use EPA's Regional Screening Levels (RSLs) extrapolated from these MRLs as the HBPLs used for soil, soil to protect groundwater, and drinking water. The ATSDR MRL for PFOA is 3 ng/kg/day (3 x 10^{-6} mg/kg/day),[37] but this is not based on the most recent science – and is therefore not the best available science. On March 29, 2023, EPA adopted a reference dose (RfD) of 3 x 10^{-8} mg/kg/day in its toxicity assessment for proposed PFOA drinking water regulations.[38] Therefore, EPA found risk for PFOA in drinking water at a level 100 times lower than what Inhance describes in its risk assessment. Inhance's HBPLs are therefore based on older science and do not reflect EPA's current assessment of the toxicity of these chemicals.

2. Health-Based Levels for PFOA and PFNA in EPA's Proposed March 2023 Drinking Water Maximum Contaminant Levels (MCLs)

On March 29, 2023, EPA proposed National Primary Drinking Water Regulations (NPDWRs) and health-based Maximum Contaminant Level Goals (MCLGs) for six PFAS under the Safe Drinking Water Act (SDWA).[39] Two of these PFAS, PFOA and perfluorononanoic acid (PFNA), are subject to the 2020 SNUR and have been measured in fluorinated containers and their contents.

As defined by the SDWA, an MCLG is the "maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, allowing an adequate margin of safety."[40] A Maximum Contaminant Level (MCL) is "the maximum level allowed of a contaminant or a group of contaminants (*i.e.,* mixture of contaminants) in water which is delivered to any user of a public water system."[41] The SDWA generally requires EPA to set an MCL "as close as feasible to" the MCLG.[42] To determine the MCLG for PFOA, EPA's NPDWR examines both cancer and non-cancer health effects, drawing on previous toxicity assessments peer reviewed by EPA's Science Advisory Board (SAB).

For carcinogenicity, EPA determined that:

> PFOA is *Likely to be Carcinogenic to Humans* based on sufficient evidence of carcinogenicity in humans and animals and has also determined that a linear default extrapolation approach is appropriate as there is no evidence demonstrating a threshold level of exposure below which there is no appreciable cancer risk (USEPA, 2005) and therefore, it is assumed that there is no known threshold for carcinogenicity... Based upon

[37] https://www.atsdr.cdc.gov/mrls/pdfs/ATSDR%20MRLs%20-%20January%202023%20-%20H.pdf
[38] https://www.regulations.gov/document/EPA-HQ-OW-2022-0114-0915
[39] 88 Fed. Reg. 18638
[40] 40 CFR § 141.2
[41] 88 Fed. Reg. 18
[42] 88 Fed. Reg. 18639

> a consideration of the best available peer reviewed science and a consideration of an adequate margin of safety, EPA proposes a MCLG of zero for PFOA in drinking water.[43]

Based on this determination, *any* level of exposure to PFOA in fluorinated containers that would be ingested or end up in drinking water would present an unacceptable cancer risk. Similarly, as a non-threshold carcinogen, exposure to PFOA by other routes of exposure would likely be deemed a significant cancer risk as well.

To evaluate the non-cancer effects of PFOA, EPA determined an RfD, which is "an estimate of daily exposure to the human population (including sensitive populations) that is likely to be without an appreciable risk of deleterious effects during a lifetime."[44] As summarized in the attached report of Dr. Drake Phelps and Dr. Jamie DeWitt, EPA:

> considered multiple endpoints for derivation of a reference dose: immunotoxicity (as determined by decreased antibody levels), developmental toxicity (as determined by decreased birth weight), and cardiovascular toxicity (as determined by increased total cholesterol). Ultimately, this allowed for derivation of a reference dose at 3×10^{-8} mg/kg/day, equivalent to 0.03 ng/kg/day (see Attachment 1).

As determined by EPA, "the available evidence indicates there are effects across immune, developmental, cardiovascular, and hepatic organ systems at the same or approximately the same level of PFOA exposure" and the selected RfD is "protective of effects that may occur in sensitive populations (*i.e.,* infants and children), as well as hepatic effects that may result from PFOA exposure."[45] According to Drs. Phelps and DeWitt, after taking into account the body weight of the average American, an acceptable level of exposure via drinking water would be 2.4 ng per day. By contrast, the maximum amount of PFOA found in fluorinated HDPE by Peaslee and Whitehead was 7.25 ng/g. In other words, one gram of fluorinated HDPE may contain more than *triple* the acceptable levels of PFOA being considered for drinking water.

In its proposal, EPA "determined that 4.0 ppt is the lowest concentration that PFOA … can be reliably quantified within specific limits of precision and accuracy during routine laboratory operating conditions."[46] On this basis, it proposed 4.0 ppt as the MCL for PFOA on the ground that it was the concentration "close as feasible to the MCLG" of zero.[47] By comparison, as Dr. Diaz Leiva notes in her report, PFOA was consistently found in extracts and solvents in fluorinated containers at significantly higher levels ranging from 0.13 ppb to 4.49 ppb, between 32.5 and 1,122.5 times higher than the proposed MCL (see Table 2, above).

While PEER and CEH understand that the proposed MCLs are specific to drinking water, research by EPA, Notre Dame, and Eurofins has shown that the PFOA in these fluorinated containers readily leach out into the contents. Some of these contents (food, water, flavorings)

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[43] 88 Fed. Reg. at 18660
[44] 88 Fed. Reg at 18652-3
[45] 88 Fed. Reg. at 18659
[46] Note that Eurofins and other commercial laboratories can achieve reliable measurements down to 2.0 ppt, but for purposes of these comments, we will use EPA's proposed 4.0 ppt concentration.
[47] 88 Fed. Reg. at 18666-8

are ingested, while others will ultimately be discharged into or leach into drinking water supplies at later stages of the container life-cycle. As the SNUNs recognize, jncidental ingestion of LCPFACs is also a significant route of exposure in the workplace. Moreover, the adverse health effects that inform the RfD and MCL are likely not limited to ingestion of LCPFACs but are relevant to other routes of exposure.

EPA's proposed MCLs also reviewed the adverse health effects of PFNA, concluding that "[a]nimal toxicity studies have reported adverse health effects, specifically on development, reproduction, immune function, and the liver, after oral exposure to PFNA."[48] The report of Dr. Drake Phelps and Dr. Jamie DeWitt provides more details on the reported studies, highlighting the following adverse effects:

- Reproductive and developmental toxicity, including increased odds of endometriosis, decreased sperm quality, early onset puberty in females, delayed puberty in males, decreased birth weight and/or birth length;
- Immunotoxicity, including increased odds of allergic disease and asthma, increased autoimmune-related antibodies, decreased antibody titers, and increased risk of certain infections;
- Hepatotoxicity, including higher alanine transaminase (ALT) levels, a marker of liver injury;
- Endocrine disruption, including altered levels of testosterone and thyroid hormones;
- Metabolic disorders, including decreased bone parameters[32] and an increased marker of gestational diabetes;
- Neurotoxicity, including decreased personal-social skills[34] and impaired neurodevelopment;
- Cardiovascular toxicity, including increased total cholesterol and low-density lipoprotein, increased odds of heart attack and coronary heart disease[36], increased blood pressure, and decreased pulmonary function in asthmatic patients.

As explained by Drs. Phelps and DeWitt, based on developmental toxicity in rodents, EPA derived a health-based water concentration for PFNA of 0.00001 mg/L or 10 ppt. From the Whitehead and Peaslee report,[1] PFNA was measured at concentrations up to 3.61 ng/g in fluorinated HDPE, equivalent to 3.61 ppb or 3,610 ppt. In one gram of fluorinated HDPE, there is more than 360 times the acceptable level of PFNA, according to EPA's calculations.

C. To be health protective, EPA's risk assessment should treat all the LCPFACs as having equivalent health effects to PFOA

1. Health Effects Data for Other LCPFACs

The report of Dr. Phelps and Dr. DeWitt also reviews the literature on the reported health effects of the other seven LCPFACs found in fluorinated containers and their contents. While data are limited for two of these substances, the remainder have toxicity profiles similar to those of PFOA

[48] 88 Fed. Reg. at 18646

and PFNA. As described in the Phelps/DeWitt report, the health effects linked to the seven LCPFACs are as follows:

PFDA

- Immunotoxicity, including increased odds of allergic disease[7], increased autoimmune-related antibodies[10], decreased antibody titers[12,13,37], and increased risk of certain infections[16]
- Reproductive and developmental toxicity, including decreased sperm quality[26], decreased birth weight and/or length[18,30], early onset of puberty in females, and delayed puberty in males[29]
- Endocrine disruption, including decreased anogenital distance[38] and testosterone levels in males[31], altered thyroid hormones[10], and increased aromatase levels in placentas of prenatally exposed infants[21]
- Neurotoxicity, including decreased personal-social skills[34]
- Cardiovascular toxicity, including increased odds of coronary heart disease[36]
- Metabolic disorders, including an increased marker of gestational diabetes[33]

PFUnDA

- Metabolic disorders, including an increased marker of gestational diabetes[33]
- Immunotoxicity, including increased odds of allergic disease[7], decreased antibody titers[37], and increased risk of certain infections[15]
- Reproductive toxicity, including decreased sperm quality[26]
- Endocrine disruption, including decreased anogenital distance in males[38], increased testosterone[21], decreased follicle stimulating hormone in females[23], and altered thyroid hormones[10]
- Cardiovascular toxicity, including increased odds of coronary heart disease and angina pectoris[36]

PFDoDA

- Endocrine disruption, including increased anogenital distance[39], decreased testosterone in females[31], and altered thyroid hormones[10]
- Immunotoxicity, including increased odds of allergic disease[7], decreased antibody titers[37], and increased risk of certain infections[16]
- Cardiovascular toxicity, including increased odds of congestive heart failure and angina pectoris[36]
- Metabolic disorders, including an increased marker of gestational diabetes[33]

PFTrDA

- Endocrine disruption, including increased anogenital distance[39] and altered thyroid hormone levels[19,40]

- Immunotoxicity, including increased odds of allergic disease[7] and asthma[9]
- Developmental toxicity, including decreased birth weight for females[30]

PFTeDA

- cardiovascular toxicity, including increased cholesterol and increased low-density lipoprotein (LDL).[6]

PFHxDA/PFODA

- Limited data available.

2. Use of PFOA as an Analogue for Other LCPFACs

Because of the common health effects of PFOA and the eight other LCPFACs and the greater availability of data for PFOA, EPA's SNUN risk assessment should assume that these LCPFACs have toxicity profiles similar to that of PFOA. The PFOA Voluntary Stewardship Program and EPA SNUR likewise treat PFOA as a representative of the LCPFAC class and assume that less studied members of the class have the same general toxicity as PFOA. Drs. Phelps and DeWitt endorse this as a prudent and health-protective approach for reviewing the SNUNs.

Under this approach, all the LCPFASs should be assumed to be non-threshold carcinogens with no safe level of exposure, consistent with EPA's recently proposed MCLG for PFOA. For non-cancer effects, EPA's PFOA RfD should be assumed to apply to the other eight LCPFACs, indicating risks for these other endpoints as well.

Even if EPA does not believe that PFOA should be used as an analogue for the other eight LCPFACs, it is critical to remember that these nine LCPFACs are all formed together, and Inhance cannot simply halt the manufacture of PFOA. The presence of PFOA in these fluorinated containers, contents, and rinsates is sufficient for EPA to determine that the fluorination of HDPE containers presents an unreasonable risk to human health and the environment.

3. Comparison of LCPFAC levels in containers with human blood levels in epidemiology studies demonstrating adverse health effects

In the DeWitt/Phelps report, "data from Whitehead and Peaslee were compared to data in the scientific literature reporting statistically significant adverse health outcomes in human populations." In this analysis, "the minimum and maximum concentrations for each PFAS were identified from the Whitehead and Peaslee dataset . . . to establish a range of concentrations to which humans may be exposed." These concentrations "were then compared to the published human epidemiological studies where statistically significant adverse health outcomes were observed and reported in association with each of the nine PFAS in question. As done with the data from the Whitehead and Peaslee report, the minimum and maximum serum concentrations were used to establish a range of serum concentrations for each human epidemiological report.

To compare between the Whitehead and Peaslee data and human serum concentrations, the concentrations were converted to parts per billion (ppb)" (footnotes omitted).

The literature review conducted by DeWitt/Phelps identified six LCPFACs for which available human studies reported statistically significant adverse health effects and LCPFAC in human blood (serum) associated with these effects: PFOA, PFNA, PFDA, PFUnDA, PFDoDA and PFTrDA. In each case, "adverse health outcomes were observed at serum concentrations that overlap with or are exceeded by the range of concentrations reported for . . . fluorinated HDPE by Whitehead and Peaslee."

This provides further perspective on the potential health impacts of levels of LCPFACs measured in fluorinated containers and their contents.

D. The health effects of the nine LCPFACs should be treated as additive because of their co-occurrence in fluorinated containers and their contents

For PFNA and three other PFAS, EPA's proposed drinking water limits sets MCLGs and MCLs based on a Hazard Index (HI) methodology that accounts for their combined health effects when they co-occur as a mixture in drinking water. As EPA explains:

> Studies with PFAS and other classes of chemicals support the health protective assumption that a mixture of chemicals with similar observed effects should be assumed to also act in a dose additive manner unless data demonstrate otherwise (USEPA, 2023d). Dose additivity means that each of the component chemicals in the mixture (in this case, PFHxS, HFPO–DA, PFNA, and PFBS) behaves as a concentration or dilution of every other chemical in the mixture differing only in relative toxicity.[49]

According to the proposed rule:

> EPA's SAB opined that where the health effects of the chosen compounds are similar, 'the HI methodology is a reasonable approach for estimating the potential aggregate health hazards associated with the occurrence of chemical mixtures in environmental media. The HI is an approach based on dose additivity (DA) that has been validated and used by EPA.' (USEPA, 2022a). This proposal is based on the Agency's finding that the general HI approach is the most efficient and effective approach for establishing an MCLG for PFAS mixtures.[50]

EPA elaborated that an assumption of additivity "provides the most health protective endpoint for multiple PFAS in a mixture to ensure there would be no known or anticipated adverse effects on the health of persons."[51] EPA further emphasized that "[i]f the Agency only established an individual MCLG, the Agency would not provide any protection against dose-additivity from regulated co-occurring PFAS."[52]

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[49] 88 Fed. Reg. at 18647
[50] 88 Fed. Reg. at 18654
[51] 88 Fed. Reg. at 18654
[52] 88 Fed. Reg. at 18655

As concluded by Drs. Phelps and DeWitt, a dose-additivity approach is justified for the nine LCPFACs found in fluorinated containers and their contents because they are similar in chemical structure, exhibit similar adverse effects in human and animal studies, and co-occur during fluorination and the use of fluorinated containers, resulting in simultaneous exposure to all nine substances by workers and consumers who come in contact with these containers. By contrast, the Inhance SNUNs compare toxicity values for each individual LCPFAC to its level in containers in isolation – an approach that greatly understates health risks by failing to consider the additive toxicities of multiple LCPFACs to which container users are exposed.

E. EPA's risk assessment should also reflect the additive effects of co-occurring short-chain PFCAs because they contribute to the overall risk to container users

As described in Dr. Diaz Leiva's declaration, four short-chain PFCAs were consistently detected in fluorinated containers in addition to the nine LCPFACs subject to the EPA SNUR: perfluorobutanoic acid (PFBA), perfluoropentanoic acid (PFPeA), perfluorohexanoic acid (PFHxA) and perfluoroheptanoic acid (PFHpA). As discussed in the report of Dr. DeWitt and Dr. Phelps, these short-chain PFCAs have caused many of the same health effects as the LCPFACs. For example, it has been reported that PFBA and PFHxA are equally potent to PFOA for hepatoxicity in rodents.[53] EPA's Integrated Risk Assessment System (IRIS) reviewed the evidence on the potential noncancer and cancer human health effects resulting from exposure to PFBA and found that sufficient oral exposure to PFBA likely causes thyroid, liver, and developmental effects.[54] An RfD of 1×10^{-3} mg PFBA per kilogram of body weight per day was derived based on hepatoxicity and disrupted thyroid hormone levels. According to the EPA IRIS review, similar effects have been reported for PFHxA.[55] Thus, a subchronic RfD of 5×10^{-4} mg PFHxA per kilogram body weight per day was derived for this substance based on developmental toxicity.

Drs. DeWitt and Phelps emphasize that, "[w]hile not covered under the SNURs in this case, the presence of these compounds [in fluorinated containers] may also prove problematic in terms of their individual toxicity and their toxicity as part of a PFAS mixture." Thus, a health-protective risk assessment for the SNUNs should be based on the combined health effects of the nine LCPFACs and the four short-chain PFCAs.

A simple illustration puts in perspective the level of risk from PFAS in fluorinated containers if one assumes that all 13 long- and short-chain carboxylates found in fluorinated containers and their contents are as toxic as PFOA. The total PFAS measured in HDPE by Whitehead and Peaslee[1] ranged from 0.47 ppb to 94.81 ppb. If PFOA is used as a surrogate to represent all PFAS in HDPE, in the absence of complete toxicity data for all compounds, the total sum of all PFAS exceeds the RfD for PFOA used by the EPA to derive the proposed MCL by more than 15,000 – 3,000,000 fold on a ng/g (ppb) basis.

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[53] Gomis, M. I., Vestergren, R., Borg, D. & Cousins, I. T. Comparing the toxic potency in vivo of long-chain perfluoroalkyl acids and fluorinated alternatives. *Environ Int* **113**, 1-9, doi:10.1016/j.envint.2018.01.011 (2018).
[54] https://www.epa.gov/system/files/documents/2022-12/10945-%20PFBA%20ToxReview%20Final%20December%202022-HERO_partial-508%20%28updated%20page%20100%29.pdf
[55] https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=CPHEA&dirEntryId=357314

For the PFCAs that Inhance found in fuels stored in fluorinated tanks, measured levels were significantly higher than those found by Peaslee and Whitehead, resulting in an even greater differential between total PFAS exposure from fluorination and PFAS levels that may cause adverse effects.

Moreover, this comparison only considers PFOA's non-cancer effects. EPA's proposed drinking water standard sets a MCLG of zero based on PFOA's carcinogenicity, which would mean that, assuming equivalent carcinogenic potency by the other PFCAs, any level of these substances in fluorinated containers would be unsafe. Even using EPA's proposed PFOA MCL of 4 ppt as a point of comparison, total PFCA concentrations in fluorinated containers would be orders of magnitude greater than permitted PFOA levels in drinking water. While the levels of PFCAs in the containers are not directly comparable to EPA's proposed MCLs, we know the PFAS leach into containers' contents, and some of these fluorinated containers are used for products that are ingested.

While the comparison between PFCA levels in drinking water and fluorinated containers is not exact, it reinforces EPA's heightened concern about exposure to even minuscule concentration of LCPFACs and other PFCAs and confirms that the presence of these substances in fluorinated containers exceeds levels that EPA has deemed unsafe.

III. EXPOSURE OF WORKERS AND CONSUMERS TO PFAS FORMED DURING FLUORINATION

The magnitude of the health threat from the continued presence of PFAS in fluorinated containers is underscored by the many pathways for human exposure to these containers and their contents. Given the diverse use profile of fluorinated containers, the tens of millions of containers fluorinated each year, and their widespread distribution in commerce, there are multiple opportunities for significant worker and consumer exposure throughout the container life-cycle. The large population at risk from exposure to LCPFACs and short-chain PFCAs should weigh heavily in determining that PFAS formation during fluorination presents an unreasonable risk of injury to human health under TSCA.

A. Fluorinated Containers Have a Broad Array of Uses Throughout the Economy

Inhance fluorinates over 200 million containers and other items each year. Fluorinated containers are widely used for a variety of consumer, commercial and industrial products found in nearly every sector of the economy. Examples cited by Inhance in the SNUNs and its marketing materials include household spray cleaners, household countertop polish, floor cleaners and polish, furniture wipes, spray pesticides and herbicides, hose-end sprayer herbicides, commercial pesticides, and industrial chemical storage. Other major applications of fluorinated containers include degreasers, fuel tanks, shampoos and conditioners, medical skin adhesives, foods, fuel additives, automotive maintenance fluids, paint and coating removers, and solvents.

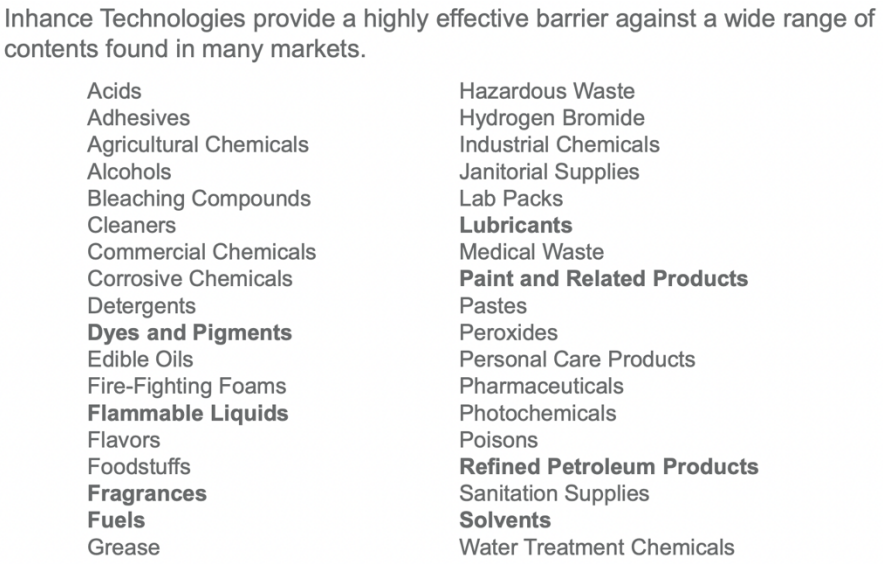
While Inhance does not acknowledge that its containers are used for food, the U.S. Food and Drug Administration (FDA) stated that it was "concerned that such [fluorinated] containers could

also be used in contact with food."[56] The FDA cautioned manufacturers, distributors, and food manufacturers that use fluorinated polyethylene food contact articles that:

> …fluorinated polyethylene containers for food contact use may only be manufactured by modifying the surface of the molded container using fluorine gas in combination with gaseous nitrogen as an inert diluent. The regulation does not authorize fluorination in the presence of water, oxygen, or gases other than nitrogen.[57]

Inhance itself has boasted about the utility of its fluorination for food products. In a presentation made by Inhance to the Petroleum Packaging Council (PPC) in 2015, it stated that their fluorinated containers "provide a highly effective barrier" for products such as alcohols, edible oils, flavors, and foodstuffs[58] (see Figure 4).

Figure 4



Inhance also claimed that its fluorinated containers are, "Especially useful in the storage and transportation of bulk foodstuffs… Effective against tomato stains, turmeric, beet, mustard, ketchup…" (see Figure 5).[59]

[56] https://www.fda.gov/media/151326/download
[57] https://www.fda.gov/media/151326/download
[58] The Benefits of Fluorination for the Petroleum Industry, Presented to PCC by Steve Banko, March 17, 2015.
[59] The Benefits of Fluorination for the Petroleum Industry, Presented to PCC by Steve Banko, March 17, 2015.

Figure 5

Ebooks currently available on Inhance's website also mention that their barrier technology is suitable for "flavors" (see Figure 6).[60]

Figure 6

Because Inhance's risk assessments failed to mention the use of its fluorinated containers for foods or other ingestible items, such as flavorings, we believe it is vastly underestimating the

[60] Inhance Sustainability Ebook, p. 4

impacts of its PFAS on consumers. EPA must take this route of exposure into account when reviewing the SNUNs.

Even more troubling is Inhance's statement that its fluorinated containers are used for "water treatment chemicals" (see Figure 4, above). EPA estimates the relative source contribution (RSC) for the general population as 20% from drinking water, and 80% from all other sources.[61] Water purification typically relies on chlorine, chloramines, or chlorine dioxide, but may also include algaecides, neutralizing agents, scale or corrosion inhibitors, flocculants, pH adjusters, etc.

Inhance did not provide any information in its SNUNs about the number of fluorinated containers used for water treatment chemicals, but the potential for PFAS to leach into these products could drastically increase Americans' PFAS exposure from drinking water. Since there are domestic water treatment chemicals for homeowners – where treatment would be at a consumer's residence rather than at a water treatment plant – PFAS contamination would not be captured by municipal or state testing of water supplies. This, in turn, may require a reassessment of the RSC for drinking water, which would necessitate a reduction in MCLs for drinking water. Inhance did also not address the fact that 20% to 30% of plastic containers within the agricultural sector are fluorinated.[62] This route of exposure through pesticide application, fertilizers, and the like, is troubling. Moreover, more than 236 million pounds of agricultural plastics have been recycled in the past 30 years.[63] Since fluorination of polyethylene containers began in 1983, it is entirely possible that our recycling stream is contaminated with PFAS from these fluorinated containers. Indeed, Inhance boasts that its fluorinated containers are "fully recyclable."[64]

It is important to note that triple rinsing or pressure washing of plastic containers that held dilutable pesticides prior to recycling is *required* by federal law.[65] Inhance does not disclose, let alone consider, the release of PFAS from this legally required rinsing in its risk or exposure assessments, despite its repeated claims about recyclability of the fluorinated containers.

Even more disturbing, recycled HDPE containers are used for groundwater pipes[66] and irrigation pipes.[67] High levels of PFAS compounds have been found in recycled HDPE from fluorinated containers (see Figure 7).[68]

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[61] https://www.epa.gov/system/files/documents/2022-06/interim-pfoa-2022.pdf
[62] https://www.maine.gov/dacf/php/pesticides/documents2/bd_mtgs/Oct22/Combined_Agenda_Oct22.pdf
[63] https://www.agrecycling.org/
[64] https://www.inhancetechnologies.com/brands-and-products/barrier-packaging/fully-recyclable-barrier-packaging
[65] 40 CFR § 156.146; 40 CFR § 165
[66] https://www.drainagecontractor.com/making-pipe-from-recycled-plastic-to-reduce-plastic-waste-2466/
[67] https://www.fao.org/3/cb7856en/cb7856en.pdf
[68] Pace Analytical Report, August 22, 2021, this information was provided to EPA employees Ed Messina, Michael Goodis, Jeffrey Dawson, and Kimberly Nesci on August 25, 2021.

Figure 7

PACE ANALYTICAL SERVICES, LLC

Detection Summary
BP Polymers
Lot Number: WG21045
Project Name: ATTORNEY- CLIENT PRIVILEGED
Project Number:

Sample	Sample ID	Matrix	Parameter	Method	Result	Q	Units	Page
001	One Bag of PCR	Solid	PFBA	PFAS by ID	20	S	ug/kg	5
001	One Bag of PCR	Solid	PFDA	PFAS by ID	0.16	J	ug/kg	5
001	One Bag of PCR	Solid	PFHpA	PFAS by ID	1.5		ug/kg	5
001	One Bag of PCR	Solid	PFHxA	PFAS by ID	3.5		ug/kg	5
001	One Bag of PCR	Solid	PFNA	PFAS by ID	0.35	J	ug/kg	5
001	One Bag of PCR	Solid	PFOA	PFAS by ID	0.72	J	ug/kg	5
001	One Bag of PCR	Solid	PFPeA	PFAS by ID	7.9		ug/kg	5

(7 detections)

Moreover, given that the PFAS from these fluorinated containers readily migrate into the contents, it is likely that the PFAS from the recycled plastic will migrate into irrigation and groundwater pipes, presenting another route of exposure to humans and the environment.

As described in the SNUNs, the use of fluorinated containers for portable fuel storage also involves a wide variety of fuel-using products with widespread consumer exposure. Examples of consumer items that use these fuels are weed whackers, lawnmowers, leaf blowers, boats, snowmobiles, all-terrain vehicles, and portable fuel storage. Our discussion of the fate of the PFAS in these products is found in Section III D(4), below.

B. Multiple pathways of human exposure and environmental release exist during fluorination itself and during processing, end-use and disposal of fluorinated containers

The container life-cycle begins with fluorination at Inhance's 11 facilities. Once fluorinated, plastic containers are shipped to product manufacturers, who add liquid or solid contents, or to container distributors, who then supply the containers to processors who either use the containers themselves to package products or further distribute them in commerce. Filled containers are supplied to end-use commercial or industry users or placed in consumer channels for retail sale. After end-use, tens of millions of containers are landfilled or sent to recycling facilities, where they may be melted and converted into pellets or sheets and reintroduced into the resin manufacturing stream.

The Inhance SNUNs depict the many opportunities for exposure to PFAS during the container life-cycle as shown in Figure 8.[69]

[69] SNUN, Attachment 012, Risk Assessment for Fluorinated HDPE Containers, p. 17

Figure 8

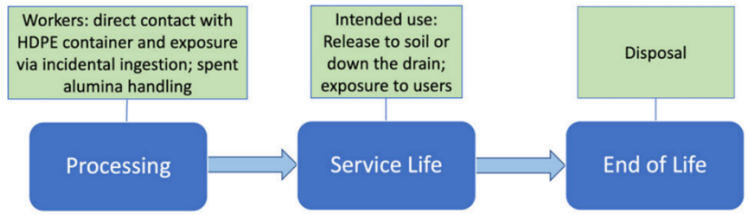

Figure 1 Conceptual exposure model throughout life cycle

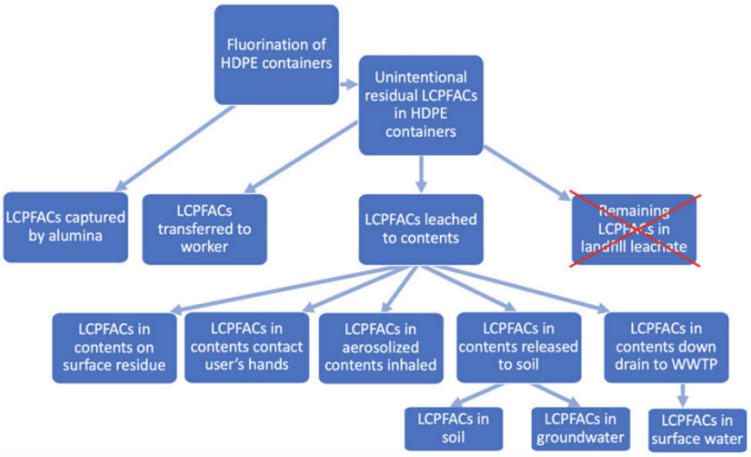

Figure 2 Exposure scenarios modeled by mass balance on HDPE container unit basis

The SNUNs also describe the pathways of exposure for a number of specific fluorinated container applications. An example is this exposure model for fluorinated floor products used by consumers, depicted in Figure 9 (labeled as Figure 4 in the SNUN).[70]

[70] Id. at 47

Figure 9

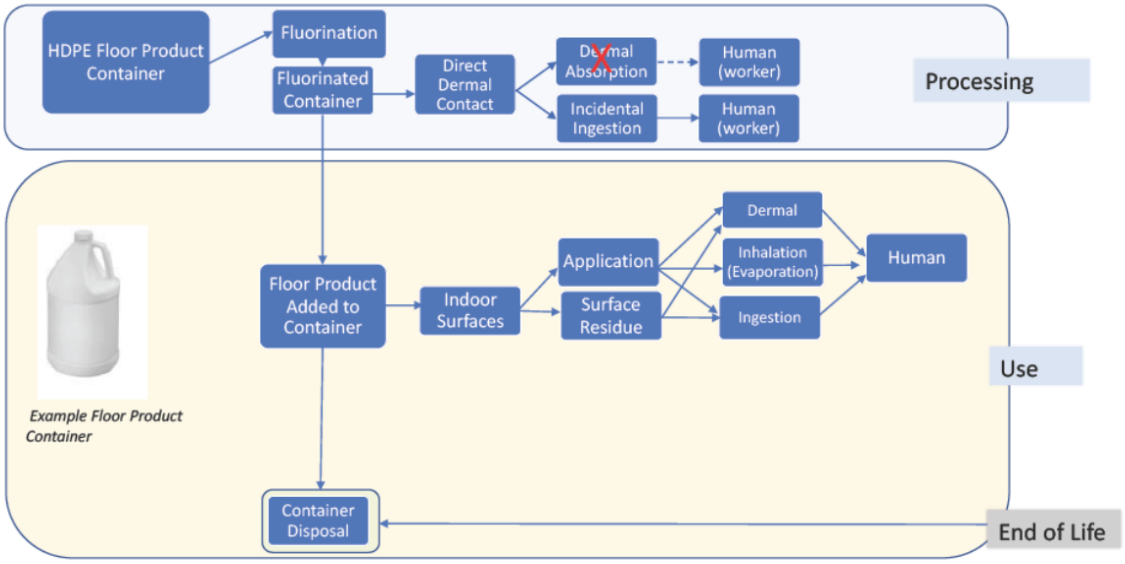

Figure 4. Conceptual exposure model for fluorinated HDPE container used for floor products

As described in the SNUNs, many other household applications for fluorinated containers have similar consumer or commercial exposure profiles. These include products used for cleaning or degreasing surfaces inside the home, such as household trigger-spray bathroom and kitchen cleaners; liquid concentrate or spray products used to seal, deodorize, or degrease carpet, hardwood, and other types of indoor flooring; products that require direct hand contact with an applicator, such as single-use furniture wipes and furniture or countertop polish or color restorer applied with a microfiber cloth or mitt; and products applied at the end of a hose, such as pesticides and herbicides applied to lawns and gardens.[71]

C. Worker and Consumer Subpopulations Exposed to PFAS in Fluorinated Containers are Large and Diverse

Given the many points in the container life-cycle with opportunities for exposure to PFAS, there are numerous exposed worker and consumer subpopulations, including:

- Workers directly engaged in fluorination at Inhance's 11 U.S. treatment facilities or exposed to LCPFACs during equipment cleanup and maintenance and handling of fluorinated containers;
- Fenceline communities, including environmental justice communities, living near Inhance's 11 facilities exposed to airborne PFAS and PFAS in the wastewater coming out of these facilities;
- Inhance workers who ship fluorinated containers to distributors or packaging sites;

[71] Id. at 16

- Workers at packaging sites who fill fluorinated containers with liquid or solid products and prepare them for shipment to downstream users;
- Workers at end-use sites who handle fluorinated containers and access their contents during commercial or industrial tasks;
- Workers in container recycling and disposal operations;
- Consumers who purchase or otherwise use fluorinated containers in residences or commercial establishments and may be exposed to PFAS when handling or discarding containers and their contents;
- People living near farms or pesticide applicators who are spraying pesticides from fluorinated containers;
- People living near landfills where fluorinated containers are disposed, given that the PFAS will end up in the landfill leachate and subsequently in the groundwater; and
- People with private wells near a landfill with fluorinated containers, a recycling facility, or people who drink water from a source where Inhance is discharging to a wastewater treatment plant (WWTP).

The SNUNs do not quantify the number of exposed workers engaged in downstream processing, distribution, end-use and disposal of fluorinated containers or the number of consumers who come into contact with fluorinated containers. However, since over 200 million fluorinated containers or other items are placed in commerce annually, the workers and consumers with likely exposure to PFAS in these containers and their contents likely number in the tens of millions and represent a large segment of the U.S. population.

The SNUNs provide no information about the worker protections at downstream facilities where exposure to PFAS may occur. However, since downstream facilities and their workforces have not been informed and are likely unaware of the presence of PFAS in fluorinated containers and their contents, it is unlikely that process controls or personal protective equipment (PPE) are in use to prevent or reduce PFAS exposure.

D. The SNUNs insupportably claim that incidental ingestion is the only route of human exposure to PFAS present in fluorinated containers and their contents

Although the SNUNs provide PFAS exposure estimates for Inhance employees, they do not provide any information on the levels and duration of PFAS exposure by the many workers and consumers who handle fluorinated containers and their contents during processing, distribution and end-use. Equally troubling, the SNUNs recklessly claim that workers and consumers are only exposed to PFAS through incidental ingestion and not by dermal contact or inhalation. The SNUNs further assert that PFAS which migrate to fuels from fluorinated containers are destroyed during fuel combustion and cannot result in exposure during fuel use. These assertions are contrary to prevailing scientific understanding and greatly understate the magnitude of PFAS exposure and risk. As Drs. Phelps and DeWitt emphasize, "[t]he ubiquity of PFAS in the environment leads to exposure via ingestion, dermal absorption, and inhalation concurrently." EPA's risk assessments for the SNUNs should reject Inhance's claims of limited exposure and presume that ingestion, dermal absorption and inhalation of vapors, dust and combustion byproducts are all significant pathways of PFAS exposure from fluorinated containers.

1. Dermal absorption to PFAS in fluorinated containers and their contents

As the SNUNs recognize, handling of fluorinated containers and their contents at all levels of distribution and use is a common and frequent mode of dermal contact with PFAS. The SNUNs recognize that incidental ingestion of liquids packaged in fluorinated containers is a likely route of exposure when these liquids contact skin surfaces during normal product use or inadvertent spills or releases from containers. However, the SNUNs question whether PFOA and other LCPFACs penetrate skin, citing a statement by the Agency for Toxic Substances and Disease Registry (ATSDR) that "the available data suggest that absorption of PFOA and PFOS through the skin is limited."[72]

This non-specific statement is not necessarily in reference to workers who have regular dermal contact with PFAS. Indeed, ATSDR's current website states, "Workers involved in making or processing PFAS and PFAS-containing materials ***are more likely to be exposed than the general population.*** Workers may be exposed to PFAS by inhaling them, getting them on their skin, and swallowing them, but inhaling them is the most likely route for exposure" (emphasis added).[73]

The claimed absence of dermal absorption of PFAS is in conflict with a large body of information. Data from a 2012 study "suggest that PFOA is dermally absorbed and that under certain conditions the skin may be a significant route of exposure."[74] In a 2007 study, PFOA "was demonstrated to be immunotoxic following dermal exposure, with an enhancement of the hypersensitivity response to OVA, suggesting that PFOA [dermal] exposure may augment the IgE response to environmental allergens."[75] Two more recent studies examined the effects of topically applied PFOA and PFBS in murine models and found significant effects on a number of biological parameters, raising concern about the potential adverse effects of dermal exposure and the immunotoxicity of PFOA after dermal absorption.[76] EPA's Science Advisory Board (SAB) recently concluded that "[e]vidence that PFOA is absorbed following dermal exposure remains unchanged since 2005, with in vitro percutaneous absorption studies of PFOA through rat and human skin allowing calculation of permeability coefficients for PFOA in rat skin to be 3.25 × 10−5 cm/hr, and that of human skin to be 9.49 × 10−7 cm/hr (Fasano et al., 2005)."[77]

More dermal absorption data for PFOA and other PFCAs would be valuable but the available data provides sufficient evidence that PFAS are dermally absorbed following contact with the skin and that dermal penetration is an important exposure route for PFCAs formed during

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[72] https://www.atsdr.cdc.gov/toxprofiles/tp200-c3.pdf
[73] https://www.atsdr.cdc.gov/pfas/health-effects/exposure.html
[74] Jennifer Franko, B. J. Meade, H. Frederick Frasch, Ana M. Barbero, Stacey E. Anderson, Dermal Penetration Potential of Perfluorooctanoic Acid (PFOA) In Human And Mouse Skin, J. Toxicol. Environ Health A., 2012;75(1):50-62, DOI: 10.1080/15287394.2011.615108.
[75] Kimberly J. Fairley et al., Exposure to the Immunosuppresant, Perfluorooctanoic Acid, Enhances the Murine IgE and Airway Hyperreactivity Response to Ovalbumin, Toxicol Sci. 2007 Jun; 97(2):375-83, DOI: 10.1093/toxsci/kfm053.
[76] Shane, H.L., Baur, R., Lukomska, E., Weatherly, L., Anderson, S.E., 2020. Immunotoxicity and allergenic potential induced by topical application of perfluorooctanoic acid (PFOA) in a murine model. Food Chem. Toxicol. 136, 111114. https://doi.org/ 10.1016/j.fct.2020.111114; Weatherly, L.M., Shane, H.L., Lukomska, E., Baur, R., Anderson, S.E., 2021. Systemic toxicity induced by topical application of heptafluorobutyric acid (PFBA) in a murine model. Food Chem. Toxicol. 156, 112528. https://doi.org/10.1016/j. fct.2021.112528.
[77] https://sab.epa.gov/ords/sab/f?p=100:19:7777001557924:::19:P19_ID:963#doc

fluorination. As emphasized by Drs. Phelps and DeWitt, "[t]hese data underscore that dermal absorption of PFAS – long- and short-chain – occurs and can induce adverse health outcomes."

While claiming that LCPFACs in pure form are not dermally absorbed, the SNUN risk assessment concedes that solvents, fuels and oily mixtures packaged in fluorinated containers may penetrate skin and PFOA and other LCPFACs that leach into these liquids from containers may undergo dermal absorption as a consequence of skin contact.[78] Since solvents and other liquids are commonly packaged in fluorinated containers, uptake through skin by this route could be significant. However, the SNUN assessment does not meaningfully characterize the level of LCPFAC exposure by workers or consumers who handle PFAS-containing liquid mixtures packaged in fluorinated containers.

Workers in container processing and end-use activities are unlikely to wear gloves protecting them from dermal contact with PFAS since their employers are likely unaware of the presence of PFAS and either do not mandate any glove use or do not require gloves that are impervious to PFAS. Since consumers using common household products packaged in fluorinated containers will also be ignorant of possible PFAS exposure, they will likewise fail to use protective gloves or other skin protection. EPA's SNUN assessment should recognize these realities and account for risks to workers and consumers from dermal exposure in the absence of PPE.

2. Inhalation exposure to PFAS -containing vapors or dusts generated during use of fluorinated containers

Evaporation of the contents of consumer and commercial products during use can release PFAS-containing vapors or aerosol particles which are inhaled. Many of these products are exposed to elevated temperatures during processing, distribution and use, which would increase volatilization of their contents. Inhalation of PFAS is also likely when fuels, oils and other transportation products stored in fluorinated containers are combusted, releasing fumes and particles containing PFAS.

The SNUNs dismiss inhalation of PFAS, claiming that "inhalation is unlikely [because] LCPFACs have low volatility."[79] However, based on a comprehensive literature review, EPA's SAB recently found that "[s]everal studies suggest that PFOA and its precursors in indoor air and/or house dust may be an important exposure source for some individuals"[80] and that "PFOA is generally a dominant ionic PFAS constituent in indoor air and dust, frequently occurring above detection limits and at relatively high concentrations in all or most samples."[81]

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[78] The SNUN risk assessment for non-fuel containers acknowledges that "LCPFAC dermal absorption behavior in the presence of solvents is less understood." Noting "that Franko et al. (2012) reported approximately 48% of PFOA in acetone may absorb in human skin, . . . this risk assessment conservatively assumed that 50% of LCPFACs in liquid products would be dermally absorbed through the skin (i.e., solvent-mediated uptake factor of 0.5)." Risk Assessment at 32

[79] SNUNs, Fuel Tank Risk Assessment at B-1

[80] "Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal Goal for Perfluorooctanoic Acid (PFOA) at 358, found at https://sab.epa.gov/ords/sab/f?p=100:19:7777001557924:::19:P19_ID:963#doc

[81] "Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal Goal for Perfluorooctanoic Acid (PFOA) at 358, found at https://sab.epa.gov/ords/sab/f?p=100:19:7777001557924:::19:P19_ID:963#doc

As Drs. Phelps and DeWitt note, a "systematic review of occupational PFAS exposure across different sectors reviewed the presence of PFOA, PFNA, PFDA, PFDoDA, and PFTeDA in dust."[82] In addition, in a study of rats exposed to PFOA-coated dust that was administered by inhalation, three hours after exposure, bioavailability of PFOA was four times higher in rats that inhaled PFOA rather than ingested PFOA.[83] According to some studies, there is also a high correlation between serum PFOA concentrations and exposure to indoor dust. EPA's SAB finds that "[p]erfluoroalkyl chemicals have been found in ambient air globally, with the highest concentrations observed or expected in urban areas and nearest to industrial facilities."[84] The SAB notes that studies show that "PFOA plasma concentrations increased proportional to aerosol exposure concentrations," demonstrating "absorption of PFOA via inhalation." [85]

Because the Inhance SNUNs assume no inhalation of PFOA and other PFCAs, they do not examine the presence of these substances in vapors, aerosols or other dust in indoor air as a result of the extensive use of household products packaged in fluorinated containers. EPA should not ignore these exposure scenarios but should model them fully as part of its SNUN risk assessments.

3. Inhalation exposure to PFAS during the fluorination process

Inhance does not provide respiratory protection to workers at its facilities because of its assumption that its "packing and assembly processes do not generate fluorinated particulates or dust, making LCPFAC inhalation among Company workers unlikely."[86] However, there is no indication in the SNUNs that Inhance has conducted air monitoring for PFAS to test whether this assumption is correct.

In fact, immediately after fluorination of HDPE containers, including fuel tanks, workers are almost certainly exposed to high concentrations of volatile precursors to perfluorocarboxylic acids. These substances will be inhaled by workers, absorbed onto their skin and clothing, and contaminate the workplace and external environment and will then be transformed into perfluorocarboxylic acids. This is in sharp contrast to information provided in Inhance's SNUNs, which state that there is no worker or environmental exposure to PFCAs because of non-volatility.

At the end of each fluorination treatment, after the containers are removed from the reactors and into the workspace for packaging for shipment, PEER and CEH have been informed that there is a fairly strong odor that comes off the containers. This odor is unique and different from the normal odors associated with plastics, and it diminishes in strength over time but remains

[82] Paris-Davila, T., Gaines, L. G. T., Lucas, K. & Nylander-French, L. A. Occupational exposures to airborne per- and polyfluoroalkyl substances (PFAS)-A review. *Am J Ind Med* **66**, 393-410, doi:10.1002/ajim.23461 (2023).
[83] Gustafsson, Å., Wang, B., Gerde, P., Bergman, Å. & Yeung, L. W. Y. Bioavailability of inhaled or ingested PFOA adsorbed to house dust. *Environ Sci Pollut Res Int* **29**, 78698-78710, doi:10.1007/s11356-022-20829-3 (2022).
[84] "Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctanoic Acid (PFOA) at 359, found at https://sab.epa.gov/ords/sab/f?p=100:19:7777001557924:::19:P19_ID:963#doc
[85] "Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal Goal for Perfluorooctanoic Acid (PFOA) at D-3, found at https://sab.epa.gov/ords/sab/f?p=100:19:7777001557924:::19:P19_ID:963#doc
[86] Attachment 012, Risk Assessment for Fluorinated HDPE Containers at 19

detectable for hours after each treatment. It is reasonable to hypothesize that these odors are from poly- and perfluoro acyl fluorides.

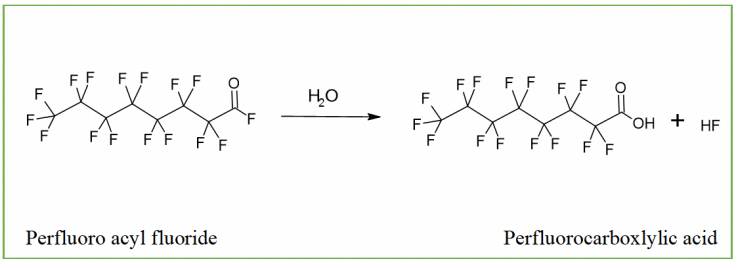
During fluorination, the presence of oxygen, moisture, oxidized polymer structures and other oxygen-containing substances, such as additives, will lead to formation of acyl fluorides. Acyl fluorides are much more volatile than are the corresponding carboxylic acids, as shown in Table 5.

Table 5: Data showing that acyl fluorides are considerably more volatile than the corresponding carboxylic acids, as indicated by much lower boiling points.[87]

Acid Name	# Carbon Atoms	Acid Boiling Point	Acyl Fluoride Boiling Point
Perfluoropentanoic acid	5	140 ˚ C	36 ˚ C
Perfluorohexanoic acid	6	157 ˚ C	77 ˚C
Perfluoroheptanloc acid	7	175 ˚ C	101 ˚C
Perfluorooctanoic acid	8	190 ˚ C	103 ˚ C

Acyl fluorides react with water, such as atmospheric moisture, to form the corresponding carboxylic acids (see Figure 10).

Figure 10: Reaction of acyl fluoride with moisture to form perfluoro carboxylic acid

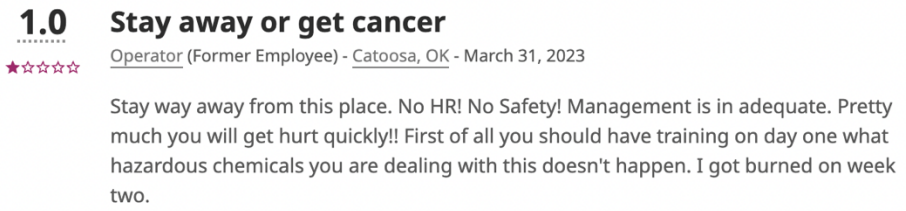


[87] https://www.sigmaaldrich.com/US/en/product/aldrich/396575; http://amp.chemicalbook.com/ProductChemicalPropertiesCB5501153_EN.htm; https://en.wikipedia.org/wiki/Perfluorohexanoic_acid; https://www.chemsrc.com/en/cas/355-38-4_749313.html; https://www.sigmaaldrich.com/US/en/product/aldrich/342041; https://www.alfa-chemistry.com/cas_375-84-8.htm; https://en.wikipedia.org/wiki/Perfluorooctanoic_acid; and https://us.vwr.com/store/product/8980246/perfluorooctanoyl-fluoride-98#

Acyl fluorides hydrolyze at a slower rate than do the corresponding acyl chlorides. This means that volatile acyl fluorides probably remain in the ambient air for a longer period of time than might be expected, resulting in inhalable PFAS in the Inhance workplace.

Although the SNUNs tout the worker protection measures in Inhance facilities, former employees have a different perspective; reviews by Inhance workers indicate that safety training may not be adequate (see Figure 11).[88]

Figure 11



4. Exposure pathways from incineration/combustion of PFAS during use of fuels stored in tanks and portable containers fluorinated by Inhance

A large portion of the containers fluorinated by Inhance are used as fuel tanks and portable fuel storage containers for engines in boats, lawn mowers and other household products. Exhaust from fuel combustion in these engines is a potentially significant pathway for inhalation exposure to PFCAs in light of the Inhance testing (described above) demonstrating high concentrations of all nine LCPFACs in fuel stored in fluorinated tanks and portable fuel containers. Remarkably, however, the SNUNs claim that exposure to PFCAs in engine exhaust is not a concern because, "Engine exhaust is considered an incomplete exposure pathway for LCPFACs in fuel, because fuel is combusted in a small engine."[89] Inhance cites no test data or other studies concerning the combustion of PFAS in small engines. Moreover, a lengthy consultant report attached to the SNUN risk assessment for fuel tanks and portable containers underscores that "data specific to the fate of PFAS during combustion in small engines are not available" and that the "effects of high combustion temperatures and short residence times characteristic of these engines on the fate of PFAS would need to be evaluated."[90]

The sole basis for Inhance's claim of PFAS destruction during fuel combustion is a "confidential memo" purportedly received from EPA that "agrees that the LCPFAC that originate from the fluorinated container could be incinerated during fuel combustion." Because the list of references in the SNUN risk assessment redacts any identifying information about this "confidential memo," it is impossible to determine its author(s) and why it was prepared. Withholding from

[88] https://www.indeed.com/cmp/Inhance-Technologies-1/reviews ; While we realize that these anonymous online reviews may be from disgruntled employees, there are a number of these allegations online and they may be reflective of workplace conditions and practices.
[89] SNUN, Fuel Risk Assessment at 17.
[90] TRC, *Combustion/Incineration of PFAS Compounds (C_8-C_{18} Carboxylic Acid Substituted),* October 2022 (APPENDIX E to Risk Assessment for Fluorinated Fuel Tanks and Fuel Storage Containers).

the public an EPA technical document that was shared with a SNUN submitter is highly suspicious and violates elementary principles of open government. If the "confidential memo" is not placed in the EPA docket, the Agency should give it no weight in its SNUN review.

In any case, there is considerable debate over the effectiveness and safety of combustion technologies in destroying PFAS and EPA's technical experts have raised significant concerns about relying on this disposal method to prevent PFAS exposure. A 2020 survey of PFAS disposal methods emphasizes that "[i]ncineration of PFAS-containing wastes can emit harmful air pollutants, such as fluorinated greenhouse gases and products of incomplete combustion, and some PFAS may remain in the incinerator ash."[91] EPA's 2020 "Interim Guidance on Destruction and Disposal of PFAS" recognizes that "PFAS are difficult to destroy due to the strength of the carbon-fluorine bond—a result of fluorine's electronegativity and the chemical stability of fluorinated compounds. Incomplete destruction or recombination of reactive intermediates can potentially result in the formation of new PFAS or other PICs [Products of Incomplete Combustion] of concern."[92] The Guidance underscores that "significant uncertainties remain with respect to the potential for migration to the environment associated with the destruction and disposal of PFAS and PFAS-containing materials using [thermal] technologies" and that, "based on the unique characteristics of fluorine combustion chemistry, it needs to be determined whether thermal treatment devices and their associated post-combustion control devices are controlling fluorinated PICs."[93]

EPA has found that one PIC known to be generated during incineration and other thermal oxidation processes used for treating PFAS-containing waste is hydrogen fluoride (HF), a Clean Air Act-listed Hazardous Air Pollutant that causes severe respiratory damage and skin burns following inhalation or dermal contact.[94]

Similarly, a March 2023 report of the President's National Science and Technology Council observes that, "Incomplete thermal degradation via incineration of PFAS wastes can release toxic air pollutants, such as 1,4 dioxane, and greenhouse gases like shorter-chained tetrafluoromethane and hexafluoroethane, potent greenhouse gases with long atmospheric half-lives known to contribute to global warming."[95]

If such doubts exist about well-studied and heavily regulated combustion facilities like thermal oxidizers, commercial incinerators and cement kilns, there's absolutely no basis to assume that PFAS in gasoline and diesel fuel are destroyed when burned in small engines, which are an unregulated emissions source for which PFAS combustion data are totally lacking. Indeed, more than 5 million gas-powered mowers are sold in the United States each year[96]; in 2011, EPA

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[91] Tasha Stoiber, Sydney Evans, Olga V. Naidenko, *Disposal of products and materials containing per- and polyfluoroalkyl substances (PFAS): A cyclical problem*, Chemosphere, Volume 260, 2020, 127659, ISSN 0045-6535, https://doi.org/10.1016/j.chemosphere.2020.127659.

[92] https://www.epa.gov/system/files/documents/2021-11/epa-hq-olem-2020-0527-0002_content.pdf

[93] Id.

[94] Id.

[95] https://www.whitehouse.gov/wp-content/uploads/2023/03/OSTP-March-2023-PFAS-Report.pdf

[96] http://www.peoplepoweredmachines.com/faq-environment.htm#:~:text=Statistics%20for%20Gas%20Power%20Lawn,miles%2C%20according%20to%20the%20EPA.

estimated that gas-powered landscape maintenance equipment was responsible for 24%−45% of all nonroad gasoline emissions.[97]

In the SNUR context, EPA should not make a no-exposure finding based on speculation. The only scientific and health-protective approach is to assume that PFAS in fuels are present in engine exhaust until there is definitive evidence to the contrary. The absence of evidence does not mean the evidence of absence; given the sheer number of these small engines in use throughout the United States, it is incumbent on EPA to examine this exposure pathway closely.

5. Exposure to PFAS in recycled fluorinated plastics

Although Inhance has touted the recyclability of fluorinated containers in its marketing materials, the SNUNs do not address the potential for exposure to PFAS during recycling operations and the reuse of recycled plastics.

Significant volumes of HDPE plastics are recycled and the recycling stream includes a large quantity of discarded fluorinated containers. Recycling facilities apply high heat to HDPE plastic wastes so they can be melted and formed into sheets or pellets that can be remolded into containers or other articles. As with exhaust from small engines, there is no evidence that PFAS present in recycled plastic is destroyed when subjected to high temperatures at these facilities. Thus, the PFAS may be present in vapors or aerosols emitted from the facility, resulting in inhalation exposure to PFAS or harmful combustion byproducts by workers and nearby communities.

When recycled HPDE sheets or pellets containing PFAS are reintroduced into the plastic manufacturing process, the PFAS are further distributed throughout the economy, including in containers that are not fluorinated. This creates further opportunities for substantial PFAS exposure by numerous workers and consumers.

IV. RELEASES OF PFAS TO THE ENVIRONMMENT

Environmental releases provide additional pathways of human exposure to PFAS, including:

- Stack emissions and wastewater discharges from Inhance treatment facilities or sites where fluorinated containers are processed or used;
- Releases from wastewater treatment operations;
- Releases to soil and groundwater from recycling or landfilling of used containers.

The Inhance SNUNs generally downplay the release of PFAS to environmental media. However, air emissions and discharges to water at Inhance facilities are not adequately controlled and are a source of PFAS exposure. In addition, the SNUNs provide no information on pollution control equipment at downstream facilities and effective controls of PFAS releases are likely non-existent or ineffective because of lack of knowledge of the presence of PFAS by these facilities.

[97] https://www.epa.gov/sites/default/files/2015-09/documents/banks.pdf

A. Scrubbers at Inhance facilities do not prevent PFAS releases to ambient air

Inhance claims its activated alumina scrubbers effectively capture LCPFACs formed in fluorination and prevent their release into the atmosphere. Specifically, the SNUNs state, "stack emissions are not likely exposure pathways for LCPFACs."[98] They also state that excess fluorine is captured in scrubbers "in accordance with air permit requirements."[99] However, a review of Inhance's air permits in Illinois, Pennsylvania, Georgia, and Texas[100] reveal that there are no limits for LCPFACs; rather, there are limits on hydrogen fluoride (HF) and F_2. In addition, the SNUNs provide no data to support this assertion, and we can find no relevant data in the literature.

It is also worth noting that Inhance provides no information on how much volatile LCPFACs are accumulated in the gas phase during fluorination, and subsequently exhausted through the scrubber system. LCPFACs created in the fluorination process will mostly be acyl fluorides, and these are much more volatile than are the corresponding carboxylic acids. It is unreasonable for Inhance to simply assume that its alumina scrubbers capture all LCPFACs, particularly given that no actual monitoring for them is conducted.

Moreover, given that LCPFACs have been found by EPA to leach from containers into pesticides, and pesticide drift "can pose health risks when sprays and dusts are carried by the wind and deposited on other areas,"[101] inhalation of pesticides must be evaluation as a route of exposure to LCPFACs.

B. PFAS are released to waters from Inhance facilities

Inhance's SNUNs show a table regarding "estimated" discharge of LCPFACs to WWTPs (see Figure 12).[102]

Figure 12

Table 1. Calculations of estimated maximum LCPFAC mass [redacted] into WWTP

Species Number	[redacted] Concentration (µg/g)	Total LCPFAC mass in all [redacted] per day (g/day)	Estimated maximum LCPFAC mass [redacted] per day (kg/day)
1	0.36	0.26	0.000026
2	0.32	0.23	0.000023
3	0.32	0.23	0.000023
4	0.39	0.28	0.000028
5	0.38	0.27	0.000027
6	0.41	0.30	0.000030
7	0.43	0.31	0.000031
8	0.81	0.58	0.000058
9	0.51	0.37	0.000037

[98] Fuel Risk Assessment at 27
[99] Id. at 26.
[100] SNUN Attachments 17, 19, 21 and 22
[101] https://www.epa.gov/reducing-pesticide-drift/introduction-pesticide-drift
[102] Note that this table was in Inhance's initial December 2022 submissions; however, PEER and CEH have been unable to find it in the supplemental submissions. Nevertheless, we believe it is important to discuss.

The concentrations of LCPFACs discharged into a WWTP show concentrations in ug/g (parts per million). It is concerning that these estimated discharges are this high; however, it is likely an underestimate. EPA should assess in its risk assessment whether there are WWTP discharges from all 11 Inhance plants, and what the precise level of PFAS discharges are to these waters. If any receiving waters are drinking water sources, this would increase human exposure to these dangerous chemicals.

V. AVAILABILITY OF ALTERNATIVES TO FLUORINATION

The Inhance SNUNs emphasize that fluorination is a "critical technology" to reduce the permeability of plastic containers and prevent leakage of their contents and that its beneficial properties should be "balanced" against the "limited risk from the unintentional formation of LCPFACs."[103] However, the benefits of fluorination are not relevant to EPA's determinations of risk for SNUNs under TSCA section 5(a)(3), because these determinations cannot consider "costs or other nonrisk factors."

While the SNUNs point to EPA and DOT standards for the permeability of containers used to store fuels, certain chemicals and pesticides, these standards define allowable levels of permeation but do not require plastic containers to achieve them by fluorination. EPA and DOT may have identified post-mold fluorination as an effective compliance strategy when these standards were developed but the link between fluorination and PFAS formation was not known at that time and the tradeoffs between permeability and the harmful effects of PFAS on health and the environment were not considered.

Since the DOT and EPA permeability standards do not prescribe post-mold fluorination, container users are free to use other methods to control permeation to required limits. Thus, the National Science and Technology Council (NSTC) issued a report in March of 2023 which stated:

> Regarding pesticide packaging, diluted fluorine gas is used to fluorinate high density polyethylene (HDPE) plastic packaging to improve container stability, and to make containers less permeable, reactive and dissolvable. PFAS may migrate from these containers and contaminate the pesticide formulation itself. Steel drums and non-PFAS coated HDPE containers are alternatives to PFAS-containing packaging. There are also alternative fluorination processes that reduce the potential for unintentional manufacture of PFAS, which the EPA and United States Department of Agriculture (USDA) have communicated to manufacturers.[104]

At least one company has developed a barrier for HDPE containers that does not involve fluorinated chemistry.[105] Specifically, the company Baritainer uses a proprietary barrier resin additive that creates a laminar microstructure; it forms stacks of overlapping layers within the walls of the containers, creating a 'tortuous path' preventing hydrocarbon permeation.[106]

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[103] SNUN, Attachment 010, Pollution Prevention Statement, at 2
[104] https://www.whitehouse.gov/wp-content/uploads/2023/03/OSTP-March-2023-PFAS-Report.pdf at 13
[105] https://baritainer.com/
[106] https://baritainer.com/news/hello-world-2/

Thus, when PEER first discovered PFAS in Anvil 10+10®, the insecticide used in at least 26 states to combat arboviruses, EPA required Clarke,[107] the manufacturer of Anvil, to discontinue use of Inhance's fluorinated containers. Clarke switched to containers with the non-fluorinated barrier, and EPA determined that it was "unlikely that the use of non-fluorinated containers including Baritainer (Kortrax®) would contribute to the contamination of PFAS in products stored in these containers. The acceptability of the new container type is confirmed."[108]

Moreover, NSTC mentioned "alternative fluorination processes that reduce the potential" for the formation of PFAS. At least one study shows that "in-mold fluorination of barrier packaging avoids inadvertent PFAS creation."[109] While PEER and CEH believe that more research needs to be done on in-mold fluorination and PFAS formation,[110] it is possible that this type of barrier may be an acceptable alternative to post-mold fluorination by Inhance.

In summary, alternatives to post-mold fluorination exist; steel drums, non-fluorinated barriers, and possibly in-mold fluorination can meet the requirements of EPA, FDA, and other regulatory agencies without the serious human health and environmental impacts from PFAS creation during in-mold fluorination.

VI. ISSUANCE OF AN ORDER PROHIBITING PFAS FORMATION DURING FLUORINATION UNDER TSCA SECTION 5(f)

Sections 5(e) and 5(f) of TSCA provide alternate paths to address the risks of new chemicals or significant new uses of existing chemicals like LCPFACs. The trigger for issuing an order under section 5(e) is a determination under section 5(a)(3)(B) that (1) the available information on the new chemical or new use is "insufficient to permit a reasoned evaluation" of its health or environmental effects or (2) the chemical or use "may present an unreasonable risk on injury . . . in the absence of sufficient information." By contrast, action under section 5(f) is required where EPA determines under section 5(a)(3)(B) that the new chemical or new use" presents an unreasonable risk of injury to health or the environment." Under both provisions, EPA's determinations cannot consider "costs or other nonrisk factors."

In short, section 5(e) addresses cases where an unreasonable risk is not definitively demonstrated based on available information, whereas section 5(f) applies where the evidence demonstrates that an unreasonable risk in fact exists.

Here, the formation of the nine LCPFACs during in-mold fluorination is undisputed and the science demonstrating their adverse health effects is extensive and clearcut. The evidence also is unequivocal that millions of consumers and workers are exposed to LCPFACs in fluorinated containers at unsafe levels, particularly given EPA's recent findings that there are no safe levels of at least one of these LCPFACs (PFOA) in drinking water. Thus, there is a compelling basis for

[107] https://www.clarke.com/
[108] https://www3.epa.gov/pesticides/chem_search/ppls/008329-00062-20210412.pdf
[109] Rock J. Vitale, Jared K. Acker, Stephen E. Somerville, An assessment of the potential for leaching of per- and polyfluoroalkyl substances from fluorinated and non-fluorinated high-density polyethylene containers, Environmental Advances, Volume 9, 2022, 100309,ISSN 2666-7657, https://doi.org/10.1016/j.envadv.2022.100309.
[110] This particular study was funded by a manufacturer of in-mold fluorination products.

determining that the LCPFAC uses described in the SNUNs present an unreasonable risk of injury and require action under section 5(f) rather than section 5(e).

Section 5(f) directs EPA to issue an immediately effective proposed rule or order "to prohibit or limit the manufacture, processing, or distribution in commerce" of a chemical or new use determined to present an unreasonable risk of injury. The rule or order must be issued "before the expiration of the applicable review period." The requirements in the rule or order must be those which are "necessary to protect against [the unreasonable] risk."

As shown in these comments, the formation of LCPFACs during the in-mold fluorination process is unavoidable by Inhance's own admission and there are no safe levels of PFOA (and likely other LCPFACs) that are achievable during fluorination according to the latest EPA science. Accordingly, only a prohibition on PFAS formation during in-mold fluorination will effectively "protect against the unreasonable risk" presented by fluorinated containers, Thus, the section 5(f) rule or order issued by EPA should immediately: 1) prohibit the production of PFAS during post-mold fluorination; 2) bar further processing or distribution of post-mold fluorinated containers by Inhance or others; and 3) notify users and consumers receiving such containers of the presence of PFAS and the risks to health and the environment they present.

CONCLUSION

PFAS contamination has become a national crisis: roughly 97% of Americans have PFAS in their blood;[111] PFAS is in our rain;[112] in our food;[113] our drinking water;[114] and a vast array of consumer products.[115] PEER and CEH believe that Inhance's fluorination of millions of containers is contributing to this worldwide contamination, and but for PEER's discovery of PFAS in Anvil 10+10®, EPA may not have become aware of this potentially significant source of PFAS in products and our environment. We therefore urge EPA to use its authority under TSCA section 5(f) to immediately prohibit the manufacture and processing of LCPFACs for the uses described in these SNUNs, for the reasons discussed above.

[111] Lewis RC, Johns LE, Meeker JD. 2015. Serum Biomarkers of Exposure to Perfluoroalkyl Substances in Relation to Serum Testosterone and Measures of Thyroid Function among Adults and Adolescents from NHANES 2011–2012. Int J Environ Res Public Health. 12(6): 6098–6114.

[112] Kim, Yubin et al, Non-targeted identification and semi-quantification of emerging per-and polyfluoralkyl substances (PFAS) in US rainwater, Envir. Sci.: Processes and Impacts, 2023 (Advance article)

[113] Katya S. Cronin, FDA-Approved: How PFAS-laden Food Contact Materials are Poisoning Consumers and What to do About it, 6 BUS. ENTREPRENEURSHIP & TAX L. REV. 117 (2022).

[114] https://www.scientificamerican.com/article/forever-chemicals-are-widespread-in-u-s-drinking-water/

[115] Gaines LGT. Historical and current usage of per- and polyfluoroalkyl substances (PFAS): a literature review. Am J Ind Med. 2023;66:353-378. doi:10.1002/ajim.23362

ATTACHMENT 1

Brief overview of the toxicity of long-chain perfluoroalkyl carboxylic acids identified in fluorinated high-density polyethylene

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(Affiliation is for identification purposes only)

Center for Environmental Health (CEH) and Public Employees for Environmental Responsibility (PEER) have asked Drs. Jamie DeWitt and Drake Phelps to provide expertise regarding the toxicity of various long-chain per- and polyfluoroalkyl substances (PFAS) that have been identified in fluorinated high-density polyethylene (HDPE) containers through work performed by Whitehead and Peaslee[1]. The long-chain PFASs in question are all part of a subgroup of PFAS known as perfluoroalkyl carboxylic acids (PFCAs); these compounds each contain a carboxylic acid head group and an aliphatic organofluorine tail group consisting of at least 7 fully fluorinated carbon atoms (Table 1).

Table 1. List of long-chain PFCAs of concern for this report.

Name	Abbreviation	CAS-RN	Chain-length[#]
Perfluorooctanoic acid	PFOA	335-67-1	8
Perfluorononanoic acid	PFNA	375-95-1	9
Perfluorodecanoic acid	PFDA	335-76-2	10
Perfluoroundecanoic acid	PFUnDA	2058-94-8	11
Perfluorododecanoic acid	PFDoDA	307-55-1	12
Perfluorotridecanoic acid	PFTrDA	72629-94-8	13
Perfluorotetradecanoic acid	PFTeDA	376-06-7	14
Perfluorohexadecanoic acid	PFHxDA	67905-19-5	16
Perfluorooctadecanoic acid	PFODA	16517-11-6	18

[#]Chain length was defined using the definition from Kotlarz et al.[2]

To begin identifying known or anticipated hazards of these compounds, these PFAS were searched, by CAS-RN, within the United States Environmental Protection Agency's Computational Toxicology Dashboard (USEPA CompTox Dashboard; accessed 16 March 2023). Hazard data from the Toxicity Values Database (ToxValDB) were obtained along with data from the Toxicity Forecast (ToxCast) testing pipeline. ToxCast is a cross-agency program among USEPA, USFDA, and Institutes at NIH that works to develop, optimize, and utilize new approach methodologies (NAMs) for high-throughput screening for hazard identification purposes[3,4]. In performing this search and cross-referencing the results with various lists on the USEPA CompTox Dashboard, we found the following:

- Each of these long-chain PFAS have entries in ToxValDB, indicating that they have been evaluated in standard rodent models and/or ecotoxicity tests. However, only five have data in human health-relevant studies in this database: PFOA, PFNA, PFDA, PFUnDA, and PFDoDA. These studies utilized mammalian models, such as mice, rats, rabbits, or clinical studies of humans.

- Six of these PFAS have been tested in USEPA's ToxCast Assays: PFOA, PFNA, PFDA, PFUnDA, PFTrDA, PFTeDA. PFTeDA has the lowest reported bioactivity in these assays, with positive hits in 5.62% of the 463 assays where it has been tested. Conversely, PFDA has the highest tested bioactivity in these assays, with positive hits in 22.89% of the 1,075 assays where it has been tested.
- All but one (PFODA) of these PFAS have been detected in human blood, according to the Blood Exposome Project[5].
- All but two (PFUnDA and PFTrDA) appear on the Toxics Release Inventory and are considered "active" under TSCA.

Next, data from Whitehead and Peaslee[1] were compared to data published in scientific literature reporting statistically significant adverse health outcomes in human populations. To do this, first, the minimum and maximum concentrations for each PFAS were identified from the Whitehead and Peaslee dataset[1], regardless of experiment type (extraction or migration into food/food simulant) to establish a range of concentrations to which humans may be exposed.

A search of the literature was then conducted using PubMed and the bibliographies of published reviews, including reviews from federal agencies, to identify primary literature describing adverse health outcomes after exposure to the PFAS listed in Table 1. Studies that reported statistically significant findings of adverse health outcomes that also reported internal PFAS concentrations from serum (or other fluids) were included, regardless of study location, size, age of cohort, route of exposure, etc. Quality of each study, including statistical power and analysis, methods for detecting PFAS, and methods for measuring biological endpoints, was not

assessed. It should be noted that our review of the literature was not a systematic review or meta-analysis. This review should also not be considered comprehensive.

Concentrations from Whitehead and Peaslee[1] were then compared to the published human epidemiological studies where statistically significant adverse health outcomes were observed and reported in association with each of the nine PFAS in question. As done with the data from the Whitehead and Peaslee report[1], the minimum and maximum serum concentrations were used to establish a range of serum concentrations for each human epidemiological report. To compare between the Whitehead and Peaslee data[1] and human serum concentrations, the concentrations were converted to parts per billion (ppb). Concentrations used from Whitehead and Peaslee[1] can be found in Appendix A. Studies, along with serum concentrations and reported adverse health effects, can be found in Appendix A.

We acknowledge this approach is limited by comparing potential exposure levels directly to serum levels. While estimating exposure levels based on serum concentrations has been done previously for PFOA[6], these estimations have not yet been performed for the other long-chain PFCAs. Given the limited toxicokinetic data in humans for long-chain PFCAs and the complexity involved in these models, we found it inappropriate to estimate exposure concentrations for the serum levels for these studies.

PFOA

The toxicity of PFOA has been well established and extensively reviewed previously. Most of what is known about the toxicity of PFAS comes from studies of exposed humans and from

studies of animal models exposed to PFOA. In our review of the literature, we found evidence for the following adverse health outcomes related to exposure to PFOA:

- Cardiovascular toxicity, including increased total cholesterol, low-density lipoprotein (LDL), and triglycerides[7]
- Immunotoxicity, including increased odds of allergic disease[8,9] and asthma[10], increased autoimmune-related antibodies[11], decreased antibody titers[12-15], increased risk of certain infections[16,17], and markers of infection (e.g., fever)[18]
- Endocrine disruption, including altered thyroid hormone levels[19-21], increased estrogen levels[22], increased luteinizing hormone and follicle-stimulating hormone levels[23], and decreased levels of sex hormone transporter proteins[24]
- Hepatotoxicity, including higher alanine transaminase (ALT), aspartate aminotransferase (AST), and gamma-glutamyl transferase (GGT) levels[25], all of which are markers of liver injury
- Reproductive and developmental toxicity, including increased odds of endometriosis[26], decreased sperm concentration, count[23], and quality[27], decreased birth weight[19]
- Obesogenic activity, including increased body mass index (BMI)[28] and increased odds for childhood obesity[29]

For each of these endpoints, adverse health outcomes were observed at serum concentrations that overlap with or are exceeded by the range of concentrations reported for PFOA in fluorinated HDPE by Whitehead and Peaslee[1].

The USEPA has proposed classifying PFOA as a likely human carcinogen, which means that "evidence is adequate to demonstrate carcinogenic potential to humans but does not reach the

weight of evidence for the descriptor Carcinogenic to Humans." This designation is based on evidence of kidney cancer from a highly exposed community and kidney cancer in the general population, as well as evidence from rodent bioassays.[30]

PFNA

In our review of the literature, we found evidence for the following adverse health outcomes related to exposure to PFNA:

- Reproductive and developmental toxicity, including increased odds of endometriosis[26], decreased sperm quality[27], early onset puberty in females, delayed puberty in males[31], decreased birth weight and/or birth length[19,32]
- Immunotoxicity, including increased odds of allergic disease[8] and asthma[10], increased autoimmune-related antibodies[11], decreased antibody titers[14], and increased risk of certain infections[15,16]
- Hepatotoxicity, including higher alanine transaminase (ALT) levels[25], a marker of liver injury
- Endocrine disruption, including altered levels of testosterone[22,33] and thyroid hormones[19]
- Metabolic disorders, including decreased bone parameters[34] and an increased marker of gestational diabetes[35]
- Neurotoxicity, including decreased personal-social skills[36] and impaired neurodevelopment[37]

- Cardiovascular toxicity, including increased total cholesterol and low-density lipoprotein[34], increased odds of heart attack and coronary heart disease[38], increased blood pressure[34], and decreased pulmonary function in asthmatic patients[10]

For each of these endpoints, adverse health outcomes were observed at serum concentrations that overlap with or are exceeded by the range of concentrations reported for PFNA in fluorinated HDPE by Whitehead and Peaslee[1].

PFDA

In our review of the literature, we found evidence for the following adverse health outcomes related to exposure to PFDA:

- Immunotoxicity, including increased odds of allergic disease[8], increased autoimmune-related antibodies[11], decreased antibody titers[13,14,39], and increased risk of certain infections[17]
- Reproductive and developmental toxicity, including decreased sperm quality[27], decreased birth weight and/or length[19,32], early onset of puberty in females, and delayed puberty in males[31]
- Endocrine disruption, including decreased anogenital distance[40] and testosterone levels in males[33], altered thyroid hormones[11], and increased aromatase levels in placentas of prenatally exposed infants[22]
- Neurotoxicity, including decreased personal-social skills[36]
- Cardiovascular toxicity, including increased odds of coronary heart disease[38]
- Metabolic disorders, including an increased marker of gestational diabetes[35]

For each of these endpoints, adverse health outcomes were observed at serum concentrations that overlap with or are exceeded by the range of concentrations reported for PFDA in fluorinated HDPE by Whitehead and Peaslee[1].

Recently, USEPA's Integrated Risk Information System (IRIS) program released a draft assessment of PFDA.[41] This document summarized a myriad of health effects that were associated with exposure to PFDA from both human epidemiology studies and experimental animal studies. After selecting key endpoints, USEPA derived a subchronic reference dose (RfD) of 4 x 10^{-10} mg (0.0004 ng) PFDA per kilogram of body weight per day based on immunotoxicity and developmental toxicity. In this report, USEPA noted that the lowest serum concentration of PFDA at 5 years of age in one of the studies cited for immunotoxicity was 0.05 ng/mL (ppb) whereas the 10th percentile was 0.2 ng/mL (ppb). From the Whitehead and Peaslee report[1], the maximum concentration of PFDA in fluorinated HDPE was 2.24 ng/g (ppb). In other words, the concentrations of PFDA in fluorinated HDPE are more than 11 times greater than serum concentrations in a study where USEPA deemed there was significant risk to human health after exposure. While these values cannot be directly compared as we do not know if concentrations of PFDA in fluorinated HDPE will lead to exposures that will result in equivalent blood levels, the levels of PFDA in HDPE are higher than serum levels used by the USEPA to derive a RfD.

PFUnDA

In our review of the literature, we found evidence for the following adverse health outcomes related to exposure to PFUnDA:

- Metabolic disorders, including an increased marker of gestational diabetes[35]

- Immunotoxicity, including increased odds of allergic disease[8], decreased antibody titers[39], and increased risk of certain infections[16]
- Reproductive toxicity, including decreased sperm quality[27]
- Endocrine disruption, including decreased anogenital distance in males[40], increased testosterone[22], decreased follicle stimulating hormone in females[24], and altered thyroid hormones[11]
- Cardiovascular toxicity, including increased odds of coronary heart disease and angina pectoris[38]

For each of these endpoints, adverse health outcomes were observed at serum concentrations that overlap with or are exceeded by the range of concentrations reported for PFUnDA in fluorinated HDPE by Whitehead and Peaslee[1].

It has also been reported that PFUnDA decreased follicle stimulating hormone in females among all quartiles of exposure[24]; however, it should be noted that the concentrations of PFUnDA in all quartiles exceeded the concentration of PFUnDA reported by Whitehead and Peaslee[1].

PFDoDA

In our review of the literature, we found evidence for the following adverse health outcomes related to exposure to PFDoDA:

- Endocrine disruption, including increased anogenital distance[42], decreased testosterone in females[33], and altered thyroid hormones[11]

- Immunotoxicity, including increased odds of allergic disease[8], decreased antibody titers[39], and increased risk of certain infections[17]
- Cardiovascular toxicity, including increased odds of congestive heart failure and angina pectoris[38]
- Metabolic disorders, including an increased marker of gestational diabetes[35]

For each of these endpoints, adverse health outcomes were observed at serum concentrations that overlap with or are exceeded by the range of concentrations reported for PFDoDA in fluorinated HDPE by Whitehead and Peaslee[1].

PFTrDA

In our review of the literature, we found evidence for the following adverse health outcomes related to exposure to PFTrDA:

- Endocrine disruption, including increased anogenital distance[42] and altered thyroid hormone levels[20,43]
- Immunotoxicity, including increased odds of allergic disease[8] and asthma[10]
- Developmental toxicity, including decreased birth weight for females[32]

For each of these endpoints, adverse health outcomes were observed at serum concentrations that overlap with or are exceeded by the range of concentrations reported for PFTrDA in fluorinated HDPE by Whitehead and Peaslee[1].

PFTeDA

In our review of the literature, we found evidence for cardiovascular toxicity, including increased cholesterol and increased low-density lipoprotein (LDL).[7] However, these endpoints were observed at concentrations exceeding the concentrations of PFTeDA reported in fluorinated HDPE by Whitehead and Peaslee[1].

Because human epidemiological data for PFTeDA are limited, we also searched for studies in rodent models of this compound to aid in the identification of hazard of PFTeDA. To our knowledge, only two studies have investigated the hazard of PFTeDA in standard rodent models. Zhang et al. [44] observed that PFTeDA, at 20 mg/kg over 10 days via ingestion in rats, caused a reduction in serum testosterone and downregulation of several genes in Leydig cells – the primary source of testosterone in males – as well as decreased sperm count. In a follow-up study, the same research group performed a longer exposure (17 days) to lower concentrations (1, 5, 10 mg/kg) in adult male rats. Here, they observed decreased testosterone in serum and decreased sperm counts at all administered doses. Serum luteinizing hormone and follicle stimulating hormone were increased. The authors also noted various gene expression changes and attributed the impaired reproductive parameters to oxidative stress and apoptosis induced by PFTeDA exposure[45]. Given that the toxicokinetics of PFTeDA were not assessed in these studies and are currently unknown in rodents and humans, determination of risk of PFTeDA to human health is difficult to ascertain. For this reason, we encourage further study of PFTeDA to protect human health from its potential toxicity.

PFHxDA

To our knowledge, there are no studies of human health effects after exposure to PFHxDA in human epidemiological studies. Similarly, there are no rodent studies for hazard identification of PFHxDA. To date, two studies using *in vitro* systems have found that PFHxDA can increase permeability of the vasculature in human endothelial cells[46] and bind to the human thyroid hormone receptor[47]. More studies of PFHxDA are needed to properly assess its risk to human health.

PFODA

To our knowledge, there are no studies of human health effects after exposure to PFODA in human epidemiological studies. There appears to only be one study of its toxicity in standard rodent models.[48] In this study, male and female rats were dosed with 40, 200, or 1,000 mg/kg via ingestion for 14 days, and rats of the same dose group were then paired for mating. Females were then dosed throughout gestation and for five days of lactation. Males were dosed after mating for a total of 42 days of exposure. Upon necropsy, hepatotoxicity, as determined by liver centrilobular hypertrophy and necrosis, was observed at 200 mg/kg and 1,000 mg/kg in males and 1,000 mg/kg in females. At 1,000 mg/kg, systemic toxicity, as determined by loss in body weight, was observed in both sexes exposed to 1,000 mg/kg. Reproductive and developmental toxicity was also observed at 1,000 mg/kg as determined by decreases in corpora lutea, implanted embryos, number of pups born, and the number of surviving pups. Birth weights of pups was also decreased, and weight gain of pups was impaired. Given that the toxicokinetics of PFODA were not assessed in these studies and are currently unknown in rodents and humans,

determination of risk of PFODA to human health is difficult to ascertain. For this reason, we encourage further study of PFODA to protect human health from its potential toxicity.

Recent developments from USEPA regarding the regulation of PFAS in drinking water

In March 2023, USEPA released their public drafts of proposed maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs) for PFOA, perfluorooctane sulfonic acid (PFOS), PFNA, perfluorohexane sulfonic acid (PFHxS), perfluorobutane sulfonic acid (PFBS), and hexafluoropropylene dimer acid (HFPO-DA, also known as a GenX chemical) [30,49]. PFOA and PFNA are two chemicals found in fluorinated HDPE as reported by Whitehead and Peaslee[1]. For PFOA, USEPA considered multiple endpoints for derivation of a reference dose: immunotoxicity (as determined by decreased antibody levels), developmental toxicity (as determined by decreased birth weight), and cardiovascular toxicity (as determined by increased total cholesterol). Ultimately, this allowed for derivation of a reference dose at 3×10^{-8} mg/kg/day, equivalent to 0.03 ng/kg/day. Assuming that the average American weighs 80 kg (~176 lbs), an acceptable level of exposure via drinking water would be 2.4 ng per day. In comparing this to the Whitehead and Peaslee data[1], the maximum amount of PFOA found in fluorinated HDPE was 7.25 ng/g. In other words, 1 gram of fluorinated HDPE may contain more than triple the acceptable levels of PFOA being considered for drinking water. However, in deriving an MCLG, USEPA discusses that it has classified PFOA as "likely to be carcinogenic in humans." Because of its carcinogenicity, USEPA has proposed a MCLG of zero for PFOA in drinking water. Extrapolating this to the fluorinated HDPE, this means that no PFOA should be present in this material to protect human health from this risk. Bartell[50] developed an online tool to allow individuals to

estimate serum concentrations for PFOA exposure. Using this tool, a hypothetical person with an exposure of 7.25 ppb PFOA via drinking water could attain a serum concentration of 223.25 ppb after just one year, even when exposures from other sources are not considered. While it is not possible to directly compare these exposure scenarios, but this comparison to drinking water levels provides some perspective with respect to the concentration of PFOA measured in fluorinated HDPE.

USEPA utilized a hazard index approach to derive the MCLG for PFNA and three other PFAS as a mixture. Based on developmental toxicity in rodents, USEPA derived a health-based water concentration for PFNA as part of the hazard index; this concentration was calculated at 0.00001 mg/L or 10 ppt. From the Whitehead and Peaslee report[1], PFNA was measured at concentrations up to 3.61 ng/g in fluorinated HDPE, equivalent to 3.61 ppb or 3,610 ppt. In 1 gram of fluorinated HDPE, there is more than 360 times the acceptable level of PFNA, according to USEPA's calculations. Bartell[50] originally developed the serum calculator for PFOA, and it was recently updated to calculate serum concentrations of PFNA as well. Using this calculator, a hypothetical person with an exposure of 3.61 ppb PFNA via drinking water could attain a serum concentration of 117.96 ppb after just one year, even when exposures from other sources are not considered. While it is not possible to directly compare these exposure scenarios, this comparison to drinking water levels provides some perspective with respect to the concentration of PFNA measured in fluorinated HDPE.

Mixtures of PFAS

The long-chain PFCAs found in Whitehead and Peaslee[1] are not isolated from one another. Upon the fluorination of HDPE, these PFAS are created as a mixture; therefore, the toxicity of the mixtures must be considered. However, to date, studies of mixtures of PFAS in standard rodent models are limited. Even with the mixtures that have been studied, they are often binary mixtures of PFAS rather than complex mixtures that recapitulate the wide range of human exposures that have been documented. Regardless, decisionmakers globally have recognized this data gap and have worked to design policy that addresses it, as reviewed by Cousins et al[51]. For example, Denmark set a drinking water guideline for 12 different PFAS of 100 ppt under the assumption that each of the PFAS (including PFOA, PFNA, and PFDA) were similarly toxic to PFOS. Sweden used a similar approach for 11 different PFAS (including PFOA, PFNA, and PFDA) to establish a 90 ppt limit. Even within the United States, some states have used a similar approach; Connecticut, Maine, and Massachusetts each applied their drinking water standards to a mixture of PFAS under the assumption that the PFAS that were regulated were similarly toxic to PFOA and/or PFOS.

In the recently released public draft of the maximum contaminant level goal for four PFAS (GenX, perfluorobutane sulfonic acid, PFNA, and perfluorohexane sulfonic acid), USEPA assumed something known as “dose additivity,” which is the concept that chemicals with common modes of action with work together to produce toxicity that is greater than the toxicity produced by a single chemical alone. This concept was used create a hazard index approach for the mixture of these four PFAS. The hazard index takes into account this dose additivity approach and reflects the ratio between the proposed maximum contaminant level and the drinking water

concentration; if the hazard index exceeds a value of one, for any single one of these four PFAS or for the sum of the four PFAS, the regulatory level is exceeded. In doing this, the USEPA is acknowledging that PFAS, as mixtures, induce toxic effects as a sum rather than acting individually. Indeed, data published by USEPA researchers supports this notion for PFOA and PFOS in rodent models of developmental toxicity.[52]

Mixtures of PFAS have also been used to manage risk for other sources of exposure, namely food and food packaging. For example, in 2020, the European Food Safety Authority (EFSA) established a recommended tolerable weekly intake (TWI) of 4.4 ng/kg/week for a mixture of four PFAS as a mixture: PFOA, PFNA, PFOS, and PFHxS. The EFSA TWI is similar to a health advisory used by the USEPA in that it is non-regulatory and exists to derive health-based management policies to protect human health. This TWI from EFSA was derived based on studies that described decreased vaccine efficacy in children, but authors also noted that this TWI would also be protective of other adverse health outcomes. Currently, 11 States have addressed PFAS in food packaging using a class-based approach by banning all PFAS from paper-based food packaging[53-58] or all food packaging, regardless of food contact material[59-63]. Thus, these class-based approaches support addressing all PFAS, regardless of known or unknown toxicity. The class-based approach for PFAS is not a novel concept[64], and the European Chemicals Agency is currently reviewing a restriction proposal to restrict manufacture, sale, and use of 10,000 PFAS[65].

In a recently published Guidance on PFAS Exposure, Testing, and Clinical Follow-Up report[66], recommendations for clinicians include to use PFAS serum concentrations (only for a group of seven PFAS that were evaluated for this report) for patients “to inform clinical care of exposed patients.” The report indicates that for PFAS serum concentrations between 2 and 20

ppb, there is a risk for adverse health effects and it is recommended that clinicians prioritize screening for the linked diseases, including increased serum lipids, increased blood pressure, and breast cancer, especially in those who are pregnant. For patients who have PFAS serum concentrations above 20 ppb, there also is an increased risk of adverse health outcomes, especially for the sum of PFOA, PFNA, PFDA, and PFUnDA, as well as other PFAS not covered by the significant new use rules (SNURs) of concern in this case. For this serum concentration level, it is recommended that clinicians prioritize screening for the linked diseases, including increased serum lipids, altered thyroid function, kidney and testicular cancer, and ulcerative colitis. In comparing the PFAS serum concentrations linked to suggestions for expanded standards of health care to those of the estimated PFOA and PFNA concentrations above, there is a significant risk to human health based solely off of those two PFAS individually, regardless of mixtures or presence of other PFAS identified in fluorinated HDPE. The total PFAS measured in HDPE by Whitehead and Peaslee[1] ranged from 0.47 ppb to 94.81 ppb. If PFOA is used as a surrogate to represent all PFAS in HDPE, in the absence of complete toxicity data for all compounds, the total sum of all PFAS exceeds the RfD for PFOA used by the USEPA to derive the proposed MCL by more than 15,000 – 3,000,000 fold on a ng/g basis.

For the purposes of the nine long-chain PFCAs of concern in this report, we agree that a class-based approach should be utilized in addressing these compounds in fluorinated HDPE as toxicity data for all compounds (especially PFTeDA, PFHxDA, and PFODA) are limited. In the absence of toxicity data, a protective approach would be to assume toxicity of the mixture is as potent as PFOA.

Presence of short-chain PFAS in fluorinated HDPE

Briefly, we'd like to comment on the presence of short-chain PFCAs in fluorinated HDPE. Whitehead and Peaslee also identified perfluorobutanoic acid (PFBA), perfluoropentanoic acid (PFPeA), perfluorohexanoic acid (PFHxA), and perfluoroheptanoic acid (PFHpA) in fluorinated HDPE samples. While not covered under the SNURs in this case, the presence of these compounds may also prove problematic in terms of their individual toxicity and their toxicity as part of a PFAS mixture. For example, it has been reported that PFBA and PFHxA are equally potent to PFOA for hepatoxicity in rodents.[67] Recently, USEPA's IRIS program published draft assessments for PFBA and PFHxA, detailing studies where adverse health outcomes were documented in human and experimental animal studies.[68,69] For PFBA, a RfD of 1×10^{-3} mg PFBA per kilogram of body weight per day was derived based on hepatoxicity and disrupted thyroid hormone levels. For PFHxA, a subchronic RfD of 5×10^{-4} mg PFHxA per kilogram body weight per day was derived based on developmental toxicity. The derivation of these reference doses indicates that, for short-chain PFCAs, toxic effects are observed at low doses. Furthermore, when mixtures are considered, dose additivity may play a role, as described above; a mixture with GenX, a short-chain perfluoroether carboxylic acid, and two long-chain PFAS, resulted in a dose additive model for developmental toxicity in rats.[70] While this study investigated PFAS that are not covered by the SNURs in this case, it underscores critical findings of mixtures studies and supports that PFAS mixtures often produce toxicity greater than the individual PFAS alone.

Dermal and inhalation exposure

In this report, the focus has largely been on the adverse health effects induced by PFAS after ingestion. However, fluorinated HDPE may also present health risks via other exposure routes, including dermal absorption and inhalation. Human epidemiological studies and experimental studies on PFAS regarding these routes are limited but should be considered when working to protect public health.

Studies of PFAS exposure via dermal absorption are uncommon but still provide insight to their toxicity. Despite the differences between human skin and rodent skin, dermal absorption of PFAS has been observed in both.[71-75] Exposure can occur through direct contact, and some have hypothesized sweat may play a role.[73,76,77] Toxicity data after dermal exposure are limited, but studies of mice exposed dermally have reported hepatotoxicity and/or immunotoxicity for PFBA[78], PFPeA, PFHxA, PFHpA,[75], and PFOA[79]. These data underscore that dermal absorption of PFAS – long- and short-chain – occurs and can induce adverse health outcomes.

Studies of inhaled PFAS are limited but remain informative. A systematic review of occupational PFAS exposure across different sectors reviewed the presence of PFOA, PFNA, PFDA, PFDoDA, and PFTeDA in dust.[80] In a study of rats exposed to PFOA-coated dust that was administered by inhalation, three hours after exposure, bioavailability of PFOA was four times higher in rats that inhaled PFOA rather that ingested PFOA. However, 48 hours post exposure, plasma concentrations of PFOA were equivalent regardless of exposure route.[81] Even with limited inhalation data, Monnot et al. concluded that extrapolating ingestion RfDs to inhalation is supported for PFOA.[82] Volatility of many PFAS has been investigated[83], but given that PFAS can adsorb to dust, their volatility may be immaterial in discussing exposure via inhalation. To date,

however, there are too few studies to ascertain the toxicity of inhaled PFAS, albeit one study reported a pro-inflammatory response and altered surfactant function in lung cells exposed *in vitro*.[84] Taken together, inhalation of long-chain PFCAs should be considered when assessing their risk to human health.

The ubiquity of PFAS in the environment leads to exposure via ingestion, dermal absorption, and inhalation concurrently. At this time, it is impossible to distinguish whether PFAS identified in human serum were initially exposed via ingestion, dermal absorption, and/or inhalation, further complicating risk assessment.

Conclusion

In closing, there is sufficient evidence from our literature search, along with USEPA's recently proposed drinking water standards for PFOA and PFNA and USEPA's IRIS assessments, to support that the PFAS found in fluorinated HDPE pose a potential risk to human health. While some PFAS may lack sufficient toxicity data for more formal risk assessment, the absence of evidence does not indicate safety. Should further testing be pursued on understudied PFAS, sensitive endpoints of PFAS exposure, such as immunotoxicity or developmental toxicity, should be used to assess the potential risks posed to human health.

Literature Cited

1 Whitehead, H. D. & Peaslee, G. F. Directly Fluorinated Containers as a Source of Perfluoroalkyl Carboxylic Acids. *Environmental Science & Technology Letters*, doi:10.1021/acs.estlett.3c00083 (2023).

2 Kotlarz, N. *et al.* Measurement of Novel, Drinking Water-Associated PFAS in Blood from Adults and Children in Wilmington, North Carolina. *Environmental Health Perspectives* **128**, 077005, doi:10.1289/EHP6837 (2020).

3 Judson, R. S. *et al.* In Vitro Screening of Environmental Chemicals for Targeted Testing Prioritization: The ToxCast Project. *Environmental Health Perspectives* **118**, 485-492 (2010).

4 Dix, D. J. *et al.* The ToxCast Program for Prioritizing Toxicity Testing of Environmental Chemicals. *Toxicological Sciences* **95**, 5-12, doi:10.1093/toxsci/kfl103 (2006).

5 Rappaport, S. M., Barupal, D. K., Wishart, D., Vineis, P. & Scalbert, A. The blood exposome and its role in discovering causes of disease. *Environ Health Perspect* **122**, 769-774, doi:10.1289/ehp.1308015 (2014).

6 Shin, H. M., Vieira, V. M., Ryan, P. B., Steenland, K. & Bartell, S. M. Retrospective exposure estimation and predicted versus observed serum perfluorooctanoic acid concentrations for participants in the C8 Health Project. *Environ Health Perspect* **119**, 1760-1765, doi:10.1289/ehp.1103729 (2011).

7 Zeng, X.-W. *et al.* Association of polyfluoroalkyl chemical exposure with serum lipids in children. *Science of The Total Environment* **512-513**, 364-370, doi:10.1016/j.scitotenv.2015.01.042 (2015).

8 Okada, E. *et al.* Prenatal exposure to perfluoroalkyl acids and allergic diseases in early childhood. *Environment International* **65**, 127-134, doi:10.1016/j.envint.2014.01.007 (2014).

9 Buser, M. C. & Scinicariello, F. Perfluoroalkyl substances and food allergies in adolescents. *Environment International* **88**, 74-79, doi:10.1016/j.envint.2015.12.020 (2016).

10 Qin, X.-D. *et al.* Association of perfluoroalkyl substances exposure with impaired lung function in children. *Environmental Research* **155**, 15-21, doi:10.1016/j.envres.2017.01.025 (2017).

11 Itoh, S. *et al.* Association between perfluoroalkyl substance exposure and thyroid hormone/thyroid antibody levels in maternal and cord blood: The Hokkaido Study. *Environment International* **133**, 105139, doi:10.1016/j.envint.2019.105139 (2019).

12 Abraham, K. *et al.* Internal exposure to perfluoroalkyl substances (PFASs) and biological markers in 101 healthy 1-year-old children: associations between levels of perfluorooctanoic acid (PFOA) and vaccine response. *Archives of Toxicology* **94**, 2131-2147, doi:10.1007/s00204-020-02715-4 (2020).

13 Grandjean, P. *et al.* Serum Vaccine Antibody Concentrations in Adolescents Exposed to Perfluorinated Compounds. *Environmental Health Perspectives* **125**, 077018, doi:10.1289/EHP275 (2017).

14 Grandjean, P. *et al.* Estimated exposures to perfluorinated compounds in infancy predict attenuated vaccine antibody concentrations at age 5-years. *Journal of Immunotoxicology* **14**, 188-195, doi:10.1080/1547691X.2017.1360968 (2017).

15 Granum, B. *et al.* Pre-natal exposure to perfluoroalkyl substances may be associated with altered vaccine antibody levels and immune-related health outcomes in early childhood. *Journal of Immunotoxicology* **10**, 373-379, doi:10.3109/1547691X.2012.755580 (2013).

16 Impinen, A. *et al.* Prenatal exposure to perfluoralkyl substances (PFASs) associated with respiratory tract infections but not allergy- and asthma-related health outcomes in childhood. *Environmental Research* **160**, 518-523, doi:10.1016/j.envres.2017.10.012 (2018).

17 Ait Bamai, Y. *et al.* Effect of prenatal exposure to per- and polyfluoroalkyl substances on childhood allergies and common infectious diseases in children up to age 7 years: The Hokkaido study on environment and children's health. *Environment International* **143**, 105979, doi:10.1016/j.envint.2020.105979 (2020).

18 Dalsager, L. *et al.* Association between prenatal exposure to perfluorinated compounds and symptoms of infections at age 1–4years among 359 children in the Odense Child Cohort. *Environment International* **96**, 58-64, doi:10.1016/j.envint.2016.08.026 (2016).

19 Xiao, C. *et al.* Associations of Exposure to Perfluoroalkyl Substances With Thyroid Hormone Concentrations and Birth Size. *J Clin Endocrinol Metab* **105**, 735-745, doi:10.1210/clinem/dgz147 (2020).

20 Kim, S. *et al.* Trans-Placental Transfer of Thirteen Perfluorinated Compounds and Relations with Fetal Thyroid Hormones. *Environmental Science & Technology* **45**, 7465-7472, doi:10.1021/es202408a (2011).

21 Preston, E. V. *et al.* Maternal Plasma per- and Polyfluoroalkyl Substance Concentrations in Early Pregnancy and Maternal and Neonatal Thyroid Function in a Prospective Birth

Cohort: Project Viva (USA). *Environmental Health Perspectives* **126**, 027013, doi:10.1289/EHP2534 (2018).

22 Yao, Q. *et al.* Cord blood Per- and polyfluoroalkyl substances, placental steroidogenic enzyme, and cord blood reproductive hormone. *Environment International* **129**, 573-582, doi:10.1016/j.envint.2019.03.047 (2019).

23 Vested, A. *et al.* Associations of in Utero Exposure to Perfluorinated Alkyl Acids with Human Semen Quality and Reproductive Hormones in Adult Men. *Environmental Health Perspectives* **121**, 453-458, doi:10.1289/ehp.1205118 (2013).

24 Tsai, M.-S. *et al.* Association between perfluoroalkyl substances and reproductive hormones in adolescents and young adults. *International Journal of Hygiene and Environmental Health* **218**, 437-443, doi:10.1016/j.ijheh.2015.03.008 (2015).

25 Costello, E. *et al.* Exposure to per- and Polyfluoroalkyl Substances and Markers of Liver Injury: A Systematic Review and Meta-Analysis. *Environmental Health Perspectives* **130**, 046001, doi:10.1289/EHP10092 (2022).

26 Campbell, S., Raza, M. & Pollack, A. Z. Perfluoroalkyl substances and endometriosis in US women in NHANES 2003–2006. *Reproductive Toxicology* **65**, 230-235, doi:10.1016/j.reprotox.2016.08.009 (2016).

27 Pan, Y. *et al.* Profiles of Emerging and Legacy Per-/Polyfluoroalkyl Substances in Matched Serum and Semen Samples: New Implications for Human Semen Quality. *Environmental Health Perspectives* **127**, 127005, doi:10.1289/EHP4431 (2019).

28 Hartman, T. J. *et al.* Prenatal Exposure to Perfluoroalkyl Substances and Body Fatness in Girls. *Child Obes* **13**, 222-230, doi:10.1089/chi.2016.0126 (2017).

29 Lauritzen, H. B. *et al.* Prenatal exposure to persistent organic pollutants and child overweight/obesity at 5-year follow-up: a prospective cohort study. *Environmental Health* **17**, 9, doi:10.1186/s12940-017-0338-x (2018).

30 USEPA. *PUBLIC COMMENT DRAFT: Toxicity Assessment and Proposed Maximum Contaminant Level Goal for Perfluorooctanoic Acid (PFOA) in Drinking Water. EPA Document No. 822P23005.*, <https://www.epa.gov/system/files/documents/2023-03/MAIN_Proposed%20MCLG%20for%20PFOA%20in%20Drinking%20Water_3.9.23_For%20Proposal.pdf> (2023).

31 Ernst, A. *et al.* Exposure to Perfluoroalkyl Substances during Fetal Life and Pubertal Development in Boys and Girls from the Danish National Birth Cohort. *Environmental Health Perspectives* **127**, 017004, doi:10.1289/EHP3567 (2019).

32 Kashino, I. *et al.* Prenatal exposure to 11 perfluoroalkyl substances and fetal growth: A large-scale, prospective birth cohort study. *Environment International* **136**, 105355, doi:10.1016/j.envint.2019.105355 (2020).

33 Zhou, Y. *et al.* Association of perfluoroalkyl substances exposure with reproductive hormone levels in adolescents: By sex status. *Environment International* **94**, 189-195, doi:10.1016/j.envint.2016.05.018 (2016).

34 Khalil, N. *et al.* Perfluoroalkyl substances, bone density, and cardio-metabolic risk factors in obese 8–12 year old children: A pilot study. *Environmental Research* **160**, 314-321, doi:10.1016/j.envres.2017.10.014 (2018).

35 Ren, Y. *et al.* Concentrations of perfluoroalkyl and polyfluoroalkyl substances and blood glucose in pregnant women. *Environmental Health* **19**, 88, doi:10.1186/s12940-020-00640-8 (2020).

36 Niu, J. *et al.* Prenatal plasma concentrations of Perfluoroalkyl and polyfluoroalkyl substances and neuropsychological development in children at four years of age. *Environmental Health* **18**, 53, doi:10.1186/s12940-019-0493-3 (2019).

37 Spratlen, M. J. *et al.* The association between prenatal exposure to perfluoroalkyl substances and childhood neurodevelopment. *Environmental Pollution* **263**, 114444, doi:10.1016/j.envpol.2020.114444 (2020).

38 Huang, M. *et al.* Serum polyfluoroalkyl chemicals are associated with risk of cardiovascular diseases in national US population. *Environment International* **119**, 37-46, doi:10.1016/j.envint.2018.05.051 (2018).

39 Kielsen, K. *et al.* Antibody response to booster vaccination with tetanus and diphtheria in adults exposed to perfluorinated alkylates. *Journal of Immunotoxicology* **13**, 270-273, doi:10.3109/1547691X.2015.1067259 (2016).

40 Tian, Y. *et al.* Maternal plasma concentrations of perfluoroalkyl and polyfluoroalkyl substances during pregnancy and anogenital distance in male infants. *Human Reproduction* **34**, 1356-1368, doi:10.1093/humrep/dez058 (2019).

41 USEPA. *IRIS Toxicological Review of Perfluorodecanoic Acid [PFDA, CASRN 335- 76-2] and Related Salts - External Review Draft*, <https://cfpub.epa.gov/ncea/iris_drafts/recordisplay.cfm?deid=354408> (2023).

42 Li, J. *et al.* Association between prenatal exposure to perfluoroalkyl substances and anogenital distance in female neonates. *Ecotoxicology and Environmental Safety* **245**, 114130, doi:10.1016/j.ecoenv.2022.114130 (2022).

43 Ji, K. *et al.* Serum concentrations of major perfluorinated compounds among the general population in Korea: Dietary sources and potential impact on thyroid hormones. *Environment International* **45**, 78-85, doi:10.1016/j.envint.2012.03.007 (2012).

44 Zhang, S. *et al.* Short-term exposure to perfluorotetradecanoic acid affects the late-stage regeneration of Leydig cells in adult male rats. *Toxicol Appl Pharmacol* **433**, 115777, doi:10.1016/j.taap.2021.115777 (2021).

45 Tang, Y. *et al.* Leydig cell function in adult male rats is disrupted by perfluorotetradecanoic acid through increasing oxidative stress and apoptosis. *Environmental Toxicology* **37**, 1790-1802, doi:10.1002/tox.23526 (2022).

46 Liu, Q. S. *et al.* Perfluorohexadecanoic acid increases paracellular permeability in endothelial cells through the activation of plasma kallikrein-kinin system. *Chemosphere* **190**, 191-200, doi:10.1016/j.chemosphere.2017.10.002 (2018).

47 Ren, X. M. *et al.* Structure-activity relations in binding of perfluoroalkyl compounds to human thyroid hormone T3 receptor. *Arch Toxicol* **89**, 233-242, doi:10.1007/s00204-014-1258-y (2015).

48 Hirata-Koizumi, M., Fujii, S., Furukawa, M., Ono, A. & Hirose, A. Repeated dose and reproductive/developmental toxicity of perfluorooctadecanoic acid in rats. *J Toxicol Sci* **37**, 63-79, doi:10.2131/jts.37.63 (2012).

49 USEPA. *PUBLIC REVIEW DRAFT: Maximum Contaminant Level Goal (MCLG) Summary Document for a Mixture of Four Per- and Polyfluoroalkyl Substances (PFAS): HFPO-DA and its Ammonium Salt (also known as GenX Chemicals), PFBS, PFNA, and PFHxS. EPA-822-P-23-004.*, <https://www.epa.gov/system/files/documents/2023-03/PFAS%20HI%20MCLG%20Public%20Review%20Draft%2009%20March%202023.pdf> (2023).

50 Bartell Scott, M. Online Serum PFOA Calculator for Adults. *Environmental Health Perspectives* **125**, 104502, doi:10.1289/EHP2820.

51 Cousins, I. T. *et al.* Strategies for grouping per- and polyfluoroalkyl substances (PFAS) to protect human and environmental health. *Environmental Science: Processes & Impacts* **22**, 1444-1460, doi:10.1039/D0EM00147C (2020).

52 Conley, J. M. *et al.* Cumulative maternal and neonatal effects of combined exposure to a mixture of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) during pregnancy in the Sprague-Dawley rat. *Environment International* **170**, 107631, doi:10.1016/j.envint.2022.107631 (2022).

53 Control, C. D. o. T. S. *Safer Products - Food Packaging Containing PFASs* <https://dtsc.ca.gov/scp/food-packaging-containing-pfass/> (2021).

54 Conservation, N. D. o. E. *PFAS in Food Packaging*, <https://www.dec.ny.gov/chemical/124367.html> (2022).

55 Ecology, W. D. o. *PFAS in food packaging*, <https://ecology.wa.gov/Waste-Toxics/Reducing-toxic-chemicals/Addressing-priority-toxic-chemicals/PFAS/Food-packaging> (2018).

56 Assembly, C. G. *HB22-1345*, <https://leg.colorado.gov/bills/hb22-1345> (2022).

57 Assembly, M. G. *House Bill 275*, <https://mgaleg.maryland.gov/mgawebsite/Legislation/Details/hb0275?ys=2022rs> (2022).

58 Legislature, H. S. *House Bill 1644*, <https://www.capitol.hawaii.gov/sessions/session2022/bills/HB1644_CD1_.htm> (2022).

59 Assembly, V. G. *Chemicals of Concern in Food Packaging* <https://legislature.vermont.gov/statutes/fullchapter/18/033A> (2021).

60 Assembly, C. G. *Act No. 21-191*, <https://www.cga.ct.gov/2021/ACT/PA/PDF/2021PA-00191-R00SB-00837-PA.PDF> (2021).

61 Protection, M. D. o. E. *Maine Toxics in Food Packaging Program*, <https://www.maine.gov/dep/safechem/packaging/index.html> (2019).

62 Legislature, M. *SF 20*, <https://www.revisor.mn.gov/statutes/cite/325F.075> (2022).

63 Assembly, R. G. *Bill signed to ban toxic chemicals from food packaging*, <https://www.rilegislature.gov/pressrelease/_layouts/15/ril.pressrelease.inputform/DisplayForm.aspx?List=c8baae31-3c10-431c-8dcd-9dbbe21ce3e9&ID=372954> (2022).

64 Kwiatkowski, C. F. *et al.* Scientific Basis for Managing PFAS as a Chemical Class. *Environmental Science & Technology Letters* **7**, 532-543, doi:10.1021/acs.estlett.0c00255 (2020).

65 ECHA. *Annex XV Restriction Report: Proposal for a Restriction of Per- and polyfluoroalkyl substances*, <https://www.echa.europa.eu/documents/10162/f605d4b5-7c17-7414-8823-b49b9fd43aea> (2023).

66 NASEM. Guidance on PFAS Exposure, Testing, and Clinical Follow-Up. doi:10.17226/26156 (2022).

67 Gomis, M. I., Vestergren, R., Borg, D. & Cousins, I. T. Comparing the toxic potency in vivo of long-chain perfluoroalkyl acids and fluorinated alternatives. *Environ Int* **113**, 1-9, doi:10.1016/j.envint.2018.01.011 (2018).

68 USEPA. *IRIS Toxicological Review of Perfluorobutanoic Acid (PFBA, CASRN 375-22-4) and Related Salts*, <https://www.epa.gov/chemical-research/iris-toxicological-review-perfluorobutanoic-acid-pfba-and-related-salts-final> (2022).

69 USEPA. *IRIS Toxicological Review of Perfluorohexanoic Acid (PFHxA) and Related Salts - External Review Draft*, <https://cfpub.epa.gov/ncea/iris_drafts/recordisplay.cfm?deid=352767> (2022).

70 Gray, E. C., J. *Characterization of developmental toxicity and Adverse Outcome Pathways (AOPs) for emerging PFAS – individual compounds and mixtures: Webinar*, <https://www.toxicology.org/groups/ss/mix/docs/Conley_Gray_2021_SOT_RASS_MixSS_webinar_20210108.pdf> (2021).

71 Abraham, K. & Monien, B. H. Transdermal absorption of (13)C(4)-perfluorooctanoic acid ((13)C(4)-PFOA) from a sunscreen in a male volunteer - What could be the contribution of cosmetics to the internal exposure of perfluoroalkyl substances (PFAS)? *Environ Int* **169**, 107549, doi:10.1016/j.envint.2022.107549 (2022).

72 Kissel, J. C., Titaley, I. A., Muensterman, D. J. & Field, J. A. Evaluating Neutral PFAS for Potential Dermal Absorption from the Gas Phase. *Environmental Science & Technology* **57**, 4951-4958, doi:10.1021/acs.est.2c08835 (2023).

73 Xia, C. *et al.* Per- and Polyfluoroalkyl Substances in North American School Uniforms. *Environ Sci Technol* **56**, 13845-13857, doi:10.1021/acs.est.2c02111 (2022).

74 Chen, Q. *et al.* Insights into the Dermal Absorption, Deposition, and Elimination of Poly- and Perfluoroalkyl Substances in Rats: The Importance of Skin Exposure. *Environ Sci Technol* **56**, 16975-16984, doi:10.1021/acs.est.2c03181 (2022).

75 Weatherly, L. M., Shane, H. L., Lukomska, E., Baur, R. & Anderson, S. E. Systemic toxicity induced by topical application of perfluoroheptanoic acid (PFHpA), perfluorohexanoic acid (PFHxA), and perfluoropentanoic acid (PFPeA) in a murine model. *Food Chem Toxicol* **171**, 113515, doi:10.1016/j.fct.2022.113515 (2023).

76 Wu, Y., Miller, G. Z., Gearhart, J., Peaslee, G. & Venier, M. Side-chain fluorotelomer-based polymers in children car seats. *Environ Pollut* **268**, 115477, doi:10.1016/j.envpol.2020.115477 (2021).

77 Poothong, S. *et al.* Hand Wipes: A Useful Tool for Assessing Human Exposure to Poly- and Perfluoroalkyl Substances (PFASs) through Hand-to-Mouth and Dermal Contacts. *Environ Sci Technol* **53**, 1985-1993, doi:10.1021/acs.est.8b05303 (2019).

78 Weatherly, L. M., Shane, H. L., Lukomska, E., Baur, R. & Anderson, S. E. Systemic toxicity induced by topical application of heptafluorobutyric acid (PFBA) in a murine model. *Food Chem Toxicol* **156**, 112528, doi:10.1016/j.fct.2021.112528 (2021).

79 Shane, H. L., Baur, R., Lukomska, E., Weatherly, L. & Anderson, S. E. Immunotoxicity and allergenic potential induced by topical application of perfluorooctanoic acid (PFOA) in a murine model. *Food Chem Toxicol* **136**, 111114, doi:10.1016/j.fct.2020.111114 (2020).

80 Paris-Davila, T., Gaines, L. G. T., Lucas, K. & Nylander-French, L. A. Occupational exposures to airborne per- and polyfluoroalkyl substances (PFAS)-A review. *Am J Ind Med* **66**, 393-410, doi:10.1002/ajim.23461 (2023).

81 Gustafsson, Å., Wang, B., Gerde, P., Bergman, Å. & Yeung, L. W. Y. Bioavailability of inhaled or ingested PFOA adsorbed to house dust. *Environ Sci Pollut Res Int* **29**, 78698-78710, doi:10.1007/s11356-022-20829-3 (2022).

82 Monnot, A. D., Massarsky, A., Garnick, L., Bandara, S. B. & Unice, K. M. Can oral toxicity data for PFAS inform on toxicity via inhalation? *Risk Analysis* **n/a**, doi:10.1111/risa.14039 (2022).

83 Hammer, J. & Endo, S. Volatility and Nonspecific van der Waals Interaction Properties of Per- and Polyfluoroalkyl Substances (PFAS): Evaluation Using Hexadecane/Air Partition Coefficients. *Environmental Science & Technology* **56**, 15737-15745, doi:10.1021/acs.est.2c05804 (2022).

84 Sørli, J. B. *et al.* Per- and polyfluoroalkyl substances (PFASs) modify lung surfactant function and pro-inflammatory responses in human bronchial epithelial cells. *Toxicol In Vitro* **62**, 104656, doi:10.1016/j.tiv.2019.104656 (2020).

APPENDIX A

This Appendix contains a table of the concentrations of long-chain PFCAs extracted from Whitehead and Peaslee[1].

Species	Name	CAS	Minimum Concentration (ng/g = ppb)	Maximum Concentration (ng/g=ppb)
1	PFOA	335-67-1	0.02	7.25
2	PFNA	375-95-1	0.02	3.61
3	PFDA	335-76-2	0.04	2.24
4	PFUnDA	2058-94-8	0.01	0.96
5	PFDoDA	307-55-1	0.01	0.71
6	PFTrDA	72629-94-8	0.05	0.46
7	PFTeDA	376-06-7	0.08	0.28
8	PFHxDA	67905-19-5	0.28	0.52
9	PFODA	16517-11-6	0.02	0.03

APPENDIX B

This Appendix contains a table of all the peer-reviewed studies cited in this report and the associated serum concentrations used for analysis.

Author	Year	Population	Chemical	Serum concentration range	Effects	Grade
Abraham	2020	1 year old children	PFOA	1.6 - 36.7 ug/L (ppb)	decreased antibody titers and decreased IFN-gamma production	Peaslee data within range
Bamai	2020	Prenatally exposed children	PFOA	1.30 - 24.9 ng/mL (ppb)	increased risk of RSV infection	Peaslee data within range
Bamai	2020	Prenatally exposed children	PFDA	0.38 - 2.79 ng/mL (ppb)	increased risk of pneumonia	Peaslee data within range
Bamai	2020	Prenatally exposed children	PFDoDA	0.13 - 0.73 ng/mL (ppb)	increased risk of pneumonia	Peaslee data within range
Buser	2016	12-19 year olds	PFOA	3.27 +/- 0.09 ng/mL - geometric mean	increased risk of food allergy	Peaslee data within range
Campbell	2016	Adult women	PFOA	0.07 - 20.60 ng/mL (ppb)	increased odds of endometriosis	Peaslee data within range
Campbell	2016	Adult women	PFNA	0.07 - 15.40 ng mL (ppb)	increased odds of endometriosis	Peaslee data within range
Dalsager	2016	Prenatally exposed children	PFOA	0.32–10.12 ng/mL (ppb)	increased risk of fever	Peaslee data within range
Ernst	2019	Teens exposed during development	PFNA	0.14 - 2.23 ng/mL (ppb)	lower age of onset of puberty in girls; delayed puberty in boys (although NMDR was observed with boys)	Peaslee data exceeds these values
Ernst	2019	Teens exposed during development	PFDA	0.08 - 0.9 ng/mL (ppb)	lower age of onset of puberty in girls; delayed puberty in boys (although NMDR was observed with boys)	Peaslee data exceeds these values
Grandjean	2017	Infants	PFOA	1.8 -4.5 ng/mL (ppb)	decreased antibody titers	Peaslee data exceeds these values
Grandjean	2017	Infants	PFNA	0.6 - 1.6 ng/mL (ppb)	decreased antibody titers	Peaslee data exceeds these values
Grandjean	2017	Infants	PFDA	0.2 - 0.5 ng/mL (ppb)	decreased antibody titers	Peaslee data exceeds these values
Grandjean	2017	13 year olds	PFDA	0.2 - 0.6 ng/mL (ppb)	decreased antibody titers	Peaslee data exceeds these values
Grandjean	2017	13 year olds	PFOA	1.6 - 5.7 ng/mL (ppb)	decreased antibody titers	Peaslee data exceeds these values
Granum	2013	Prenatally exposed children	PFOA	0.2 - 2.7 ng/mL (ppb)	decreased antibody titers and increased episodes of infections	Peaslee data exceeds these values
Granum	2013	Prenatally exposed children	PFNA	0.05 - 0.9 ng/mL (ppb)	decreased antibody titers and increased episodes of infections	Peaslee data exceeds these values
Hartman	2017	Teen girls exposed prenatally	PFOA	2.9 - 4.8 ng/mL (ppb)	increased Body Mass Index	Peaslee data exceeds these values
Huang	2018	NHANES Adults	PFUnDA	0.07 - 0.8 ng/mL (ppb)	increased odds of coronary heart disease, angina pectoris	Peaslee data exceeds these values
Huang	2018	NHANES Adults	PFDoDA	0.07 - 0.7 ng/mL (ppb)	increased odds of congestive heart failure, angina pectoris	Peaslee data exceeds these values
Huang	2018	NHANES Adults	PFNA	0.3 - 3.12 ng/mL (ppb)	increased odds of heart attack, coronary heart disease	Peaslee data exceeds these values
Huang	2018	NHANES Adults	PFDA	0.07 - 1.00 ng/mL (ppb)	increased odds of coronary heart disease	Peaslee data exceeds these values
Impinen	2018	Prenatally exposed children	PFUnDA	0.05 - 0.4 ng/mL	increased common colds and lower-respiratory tract infections	Peaslee data exceeds these values

Impinen	2018	Prenatally exposed children	PFOA	0.1 - 11 ng/mL (ppb)	increased lower respiratory tract infections	Peaslee data within range
Impinen	2018	Prenatally exposed children	PFNA	0.05 - 5.0 ng/mL	increased lower respiratory tract infections	Peaslee data within range
Itoh	2019	Paired moms and infants	PFDA	0.1 - 1.59 ng /mL (ppb)	altered thyroid hormones; increased anti-self antibodies	Peaslee data exceeds these values
Itoh	2019	Paired moms and infants	PFUnDA	0.1 - 5.89 ng/mL (ppb)	altered thyroid hormones	Peaslee data within range
Itoh	2019	Paired moms and infants	PFDoDA	0.1 - 0.65 ng/mL (ppb)	altered thyroid hormones	Peaslee data exceeds these values
Itoh	2019	Paired moms and infants	PFOA	0.2 - 12.37 ng/mL (ppb)	increased anti-self antibodies	Peaslee data within range
Itoh	2019	Paired moms and infants	PFNA	0.3 - 6.64 ng/mL (ppb)	increased anti-self antibodies	Peaslee data within range
Ji	2012	Adults	PFTrDA	0.27 - 0.57 ng /mL	decreased T4 and increased TSH	Peaslee data within range
Kashino	2020	Prenatally exposed infants	PFNA	0.9 - 13.2 ng/mL (ppb)	decreased birth weight and birth length	Peaslee data within range
Kashino	2020	Prenatally exposed infants	PFDA	0.4 - 2.4 ng/mL (ppb)	decreased birth weight	Peaslee data within range
Kashino	2020	Prenatally exposed infants	PFTrDA	0.2 - 1.3 ng/mL (ppb)	decreased birth weight for females	Peaslee data within range
Khalil	2018	Children (8-12 years old)	PFNA	0.24 +/- 0.15 ng/mL (ppb) - median +/- IQR	decreased bone parameter; increased blood pressure, LDL cholesterol, and total cholesterol	Peaslee data exceeds these values
Kielsen	2015	Adults	PFNA	0.46 – 0.80 ng/mL - IQR	decreased antibody titers	Peaslee data exceeds these values
Kielsen	2015	Adults	PFDA	0.2 - 0.32 ng/mL - IQR	decreased antibody titers	Peaslee data exceeds these values
Kielsen	2015	Adults	PFUnDA	0.18 - 0.27 ng/ mL - IQR	decreased antibody titers	Peaslee data exceeds these values
Kielsen	2015	Adults	PFDoDA	0.035 - 0.048 ng/mL - IQR	decreased antibody titers	Peaslee data exceeds these values
Kim	2011	Prenatally exposed infants	PFOA	0.03 - 0.07 ng/mL in breast milk 1.15 - 1.91 ng/mL in maternal serum 0.95 - 1.86 ng /mL in fetal serum	increased TSH	Peaslee data exceeds these values
Kim	2011	Prenatally exposed infants	PFTrDA	0.17 - 0.31 ng/mL in maternal serum 0.06 - 0.11 ng /mL in fetal serum	decreased T3 and T4	Peaslee data exceeds these values
Lauritzen	2018	Paired moms and children	PFOA	0.82 - 3.54 ng/mL	increased odds of childhood obsesity	Peaslee data exceeds these values
Li	2022	Prenatally exposed infants	PFDoDA	0.06 - 0.36 ng/mL (ppb)	increased anogenital distance	Peaslee data exceeds these values
Li	2022	Prenatally exposed infants	PFTrDA	0.05 - 0.37 ng/mL (ppb)	increased anogenital distance	Peaslee data exceeds these values
Niu	2019	Prenatally exposed children (4 years old)	PFNA	0.8 - 3.9 ng /mL (ppb)	decreased personal-social skills	Peaslee data within range
Niu	2019	Prenatally exposed children (4 years old)	PFDA	0.7 - 6.3 ng/mL (ppb)	decreased personal-social skills	Peaslee data within range
Okada	2014	Prenatally exposed infants	PFOA	0.2 - 24.9 ng/mL (ppb)	increased odds of allergic disease in all infants and female infants	Peaslee data within range

Okada	2014	Prenatally exposed infants	PFNA	0.3 - 13.2 ng/mL (ppb)	increased odds of allergic disease in all infants and female infants	Peaslee data within range
Okada	2014	Prenatally exposed infants	PFDA	0.1 - 2.43 ng/mL (ppb)	increased odds of allergic disease in all infants and female infants	Peaslee data within range
Okada	2014	Prenatally exposed infants	PFUnDA	0.1 - 5.89 ng/mL (ppb)	increased odds of allergic disease in female infants	Peaslee data within range
Okada	2014	Prenatally exposed infants	PFDoDA	0.1 - 0.729 ng/mL (ppb)	increased odds of allergic disease in female infants	Peaslee data within range
Okada	2014	Prenatally exposed infants	PFTrDA	0.1 - 1.33 ng/mL (ppb)	increased odds of allergic disease in all infants and female infants	Peaslee data within range
Pan	2019	Adult men	PFOA	1.66 - 95.69 ng/mL (ppb)	decreased sperm quality	Peaslee data within range
Pan	2019	Adult men	PFNA	0.274 - 17.3 ng/mL (ppb)	decreased sperm quality	Peaslee data within range
Pan	2019	Adult men	PFUnDA	0.049 - 7.788 ng/mL (ppb)	decreased sperm quality	Peaslee data within range
Pan	2019	Adult men	PFDA	0.014 - 20.24 ng/mL (ppb)	decreased sperm quality	Peaslee data within range
Preston	2018	Paired moms and infants	PFOA	0.3-36.7 ng/mL - maternal 4.0 -7.6 ng/mL - neonatal	altered thyroid hormones	Peaslee data within range
Preston	2018	Paired moms and infants	PFNA	0.5 - 6.0 ng/mL - maternal and neonatal	altered thyroid hormones	Peaslee data within range
Qin	2017	Children	PFOA	0.48 – 2.13 ng/mL (ppb)	increased odds of asthma; decreased pulmonary function in asthmatics	Peaslee data exceeds these values
Qin	2017	Children	PFNA	0.70 - 1.25 ng/mL (ppb)	increased odds of asthma; decreased pulmonary function in asthmatics	Peaslee data exceeds these values
Qin	2017	Children	PFTrDA	0.20 - 12.12 ng/mL (ppb)	increased odds of asthma	Peaslee data within range
Ren	2020	Pregnant women	PFNA	0.8 - 4.0 ng/mL (ppb)	increased one-hour plasma glucose (indicator of gestational diabetes)	Peaslee data within range
Ren	2020	Pregnant women	PFDA	0.7 - 6.2 ng/mL (ppb)	increased one-hour plasma glucose (indicator of gestational diabetes)	Peaslee data within range
Ren	2020	Pregnant women	PFUnDA	0.5 - 4.5 ng/mL (ppb)	increased one-hour plasma glucose (indicator of gestational diabetes)	Peaslee data within range
Ren	2020	Pregnant women	PFDoDA	0.1 - 0.4 ng/mL (ppb)	increased one-hour plasma glucose (indicator of gestational diabetes)	Peaslee data exceeds these values
Spratlen	2020	Prenatally exposed children (1-3 years old)	PFNA	0.2 - 10.3	impaired neurodevelopment	Peaslee data within range
Tian	2019	Prenatally exposed male infants	PFDA	0.72 - 5.79 ng/mL (ppb)	decreased anogenital distance	Peaslee data within range
Tian	2019	Prenatally exposed male infants	PFUnDA	0.55 - 4.55 ng/mL (ppb)	decreased anogenital distance	Peaslee data within range
Tsai	2015	12-30 year olds	PFOA	no range explicitly reported but significant among all quartiles; compared ranges for quartiles to the Peaslee	decreased sex hormone transporter protein in females 12-17	Peaslee data within range

Tsai	2015	12-30 year olds	PFUnDA	no range explicitly reported but significant among all quartiles; compared ranges for quartiles to the Peaslee	decreased FSH in females	Greater than Peaslee
Vested	2013	prenatally exposed adults	PFOA	2.8 – 4.7 ng/mL (ppb)	decreased sperm concentration and count; increased LH and FSH	Peaslee data exceeds these values
Xiao	2019	Paired moms and infants	PFNA	0.2 - 1.6 ng/mL (ppb)	decreased birth weight; altered thyroid hormones	Peaslee data exceeds these values
Xiao	2019	Paired moms and infants	PFDA	0.1 - 0.9 ng/mL (ppb)	decreased birth weight; decreased birth length; altered thyroid hormones	Peaslee data exceeds these values
Xiao	2019	Paired moms and infants	PFOA	0.8 - 6.9 ng/mL (ppb)	decreased birth weight; altered thyroid hormones	Peaslee data exceeds these values
Yao	2019	Infants	PFOA	1.52 – 291.60 ng/mL (ppb)	increased estrogen	Peaslee data within range
Yao	2019	Infants	PFUnDA	< 0.65 ng/mL (ppb)	increased testosterone	Peaslee data exceeds these values
Yao	2019	Infants	PFNA	0.08 – 1.76 ng/mL (ppb)	increased testosterone	Peaslee data exceeds these values
Yao	2019	Infants	PFDA	< 0.87 ng/mL (ppb)	increased aromatase levels in placenta	Peaslee data exceeds these values
Zeng	2015	Children (12-15 years old)	PFOA	0.4 - 2.1 ng/mL (ppb)	increased cholesterol; increased LDL; increased triglycerides	Peaslee data exceeds these values
Zeng	2015	Children (12-15 years old)	PFTeDA	2.5 - 53 ng/mL (ppb)	increased cholesterol; increased LDL	Greater than Peaslee
Zhou	2016	13-15 year old children	PFDA	0.8 – 1.2 ng/mL (ppb)	decreased testosterone in males	Peaslee data exceeds these values
Zhou	2016	13-15 year old children	PFNA	0.6 – 1.1 ng/mL (ppb)	decreased testosterone in males	Peaslee data exceeds these values
Zhou	2016	13-15 year old children	PFOA	0.4 – 1.3 ng/mL (ppb)	increased estrogen in males	Peaslee data exceeds these values
Zhou	2016	13-15 year old children	PFDoDA	0.8–6.0 ng/mL (ppb)	decreased testosterone in females	Peaslee data within range

APPENDIX C

This Appendix contains the curricula vitae of Drs. DeWitt and Phelps.

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EDUCATION & CERTIFICATIONS

Diplomate, American Board of Toxicology. 2017.

Ph.D., Environmental Science and Neural Science.
School of Public and Environmental Affairs and Program in Neural Science. Indiana University, Bloomington, IN. 2004.
Concentrations: Environmental and developmental neurotoxicology and risk assessment
Dissertation title: Developmental intoxication of dioxins and polychlorinated biphenyls in an avian model: Correlations of brain asymmetry, behavior, and related developmental effects

B.S., Environmental Science and Biology.
Lyman Briggs College. 1992. Michigan State University, East Lansing, MI. 1992.

PROFESSIONAL EXPERIENCE

Professor of Pharmacology and Toxicology
Department of Pharmacology and Toxicology, Brody School of Medicine, East Carolina University, Greenville, NC.
July 2021-present.

Adjunct Professor
Toxicology Program, Biological Sciences, North Carolina State University, Raleigh, NC.
March 2023-present.

Adjunct Associate Professor
Toxicology Program, Biological Sciences, North Carolina State University, Raleigh, NC.
March 2018-2023.

Associate Professor of Pharmacology and Toxicology
Department of Pharmacology and Toxicology, Brody School of Medicine, East Carolina University, Greenville, NC.
July 2015-July 2021.

Adjunct Associate Professor of Public Health
Department of Public Health, Brody School of Medicine, East Carolina University, Greenville, NC.
July 2015-July 2017.

Adjunct Assistant Professor of Public Health

Department of Public Health, Brody School of Medicine, East Carolina University, Greenville, NC.
July 2012-July 2014.

Affiliated Member

The Harriet and John Wooten Laboratory for Alzheimer's and Neurodegenerative Disease Research, East Carolina University, Greenville, NC.
July 2011-present.

Assistant Professor of Pharmacology and Toxicology

Department of Pharmacology and Toxicology, Brody School of Medicine, East Carolina University, Greenville, NC.
July 2008-July 2015.

Postdoctoral Trainee in Immunotoxicology

University of North Carolina at Chapel Hill in cooperation with the U.S. Environmental Protection Agency (Training Agreement CT829472), National Health and Environmental Effects Research Laboratory, Experimental Toxicology Division, Immunotoxicology Branch, Research Triangle Park, NC (Advisor: Dr. Robert Luebke). Evaluation of immune function and exploration of immunotoxic mechanisms, including use of knock-out models and molecular techniques, of various xenobiotics (organotins and perfluoroalkyl acids) in rodent models.
June 2004-June 2008.

Postdoctoral Research Associate in Environmental and Ecotoxicology

Developmental Neurobiology and Environmental Toxicology Laboratory, School of Public and Environmental Affairs, Indiana University, in cooperation with the U.S. Fish and Wildlife Service Bloomington Ecological Services Field Office, Bloomington, IN (Advisors: Dr. Diane Henshel and Daniel Sparks). Cardiotoxic effects in wild passerine birds developmentally exposed to PCBs.
September 2003-May 2004.

Research Assistant in Environmental and Ecotoxicology

Developmental Neurobiology and Environmental Toxicology Laboratory, School of Public and Environmental Affairs, Indiana University, Bloomington, IN (Advisor: Dr. Diane Henshel). Toxicological effects of dioxin and polychlorinated biphenyls after developmental exposure in an avian model, wild birds, and wild fish.
August 1995-August 2003.

Field Assistant in Limnology

Lake Lemon Conservancy District, Unionville, IN. Canada goose control, littoral zone revegetation, and monitoring of native and exotic aquatic plant populations.
June 2000-May 2003.

Field Assistant in Ecotoxicology

U.S. Fish and Wildlife Service-Bloomington Ecological Services Field Office, Bloomington, IN. Wild bird and macroinvertebrate population monitoring in a metal-contaminated lake, including assessment of fertile eggs for embryonic abnormalities.
April 1997-October 1997.

Research Associate in Entomology
Landscape Entomology Division, Department of Entomology, Michigan State University, East Lansing, MI. Research and efficacy tests for forest, ornamental and turf entomological studies for the Michigan Department of Agriculture and Turf Foundation.
September 1992-August 1995.

Research Assistant in Entomology
Medical Entomology Division, Department of Entomology, Michigan State University, East Lansing, MI. Assessment of Lyme disease prevalence in deer and dog ticks collected from a Lyme disease endemic area in Michigan.
May 1992-May 1993.

PUBLICATIONS

Primary Research Manuscripts

Taylor KD, Woodlief TL, Ahmed A, Hu Q, Duncker PC, and **DeWitt JC**. 2023. Quantifying the impact of PFOA exposure on B cell development and antibody production. *Accepted by Toxicological Sciences*.

Phelps DW, Palekar AI, Conley HE, Gerrero G, Driggers JH, Linder KE, Kullman SW, Reif DM, Sheats MK, **DeWitt JC**, and Yoder JA. 2023. Legacy and emerging per- and polyfluoroalkyl substances suppress the neutrophil respiratory burst. *Journal of Immunotoxicology*. 20:1 DOI: 10.1080/1547691X.2023.2176953.

Barton KE, Zell-Baran LM, **DeWitt JC**, Brindley S, McDonough CA, Higgins CP, Adgate JL, and Starling AP. 2022. Cross-sectional associations between serum PFASs and inflammatory biomarkers in a population exposed to AFFF-contaminated drinking water. *International Journal of Hygiene and Environmental Health*. 240:113905.

Woodlief T, Vance S, Hu Q, **DeWitt J**. 2021. Immunotoxicity of per- and polyfluoroalkyl substances: Insights into short-chain PFAS exposure. *Toxics*. 9:100.

Zhou J, Baumann K, Mead RN, Skrabal SA, Kieber RJ, Avery GB, Shimizu M, **DeWitt JC**, Sun M, Vance SA, Bodnar W, Zhang Z. 2021. PFOS dominates PFAS composition in ambient fine particulate matter ($PM_{2.5}$) collected across North Carolina nearly 20 years after the end of its US production. *Environmental Science: Processes and Impacts*. 23:580-587.

Jiang Q, Xu X, **DeWitt JC**, Zheng Y. 2021. Using chicken embryo as a powerful tool in assessment of developmental cardiotoxicities. *Journal of Visualized Experiments*, 21:doi: 10.3791/62189.

McDonough C, Ward C, Hu Q, Vance S, Higgins C, **DeWitt J**. 2020. Immunotoxicity of an electrochemically fluorinated aqueous film-forming foam. *Toxicological Sciences*, 178:104-114.

vonderEmbse A, Hu Q, **DeWitt J**. 2020. Postnatal toxicant exposure in 3xTgAD mice promotes gene x environment-related early alterations to neuroimmune epigenetic profiles. *Neuroimmunology and Neuroinflammation*, 7:345-359.

Kotlarz N, McCord J, Collier D, Lea CS, Strynar M, Lindstrom AB, Wilkie AA, Islam JY, Matney K, Tarte P, Polera ME, Burdette K, **DeWitt J**, May K, Smart RC, Knappe DRU, Hoppin JA. 2020. Poorly understood PFAS generated as byproducts of fluorochemical manufacturing are in

the blood of children and adults living in Wilmington, North Carolina. *Environmental Health Perspectives*, 128: https://doi.org/10.1289/EHP6837.

McDonough C, Choyke S, Ferguson PL, **DeWitt J**, Higgins C. 2020. Bioaccumulation of novel per- and polyfluoroalkyl substances (PFASs) in mice dosed with an aqueous film-forming foam (AFFF). 2020. *Environmental Science & Technology*. 54:5700-5709.

vonderEmbse AN, Hu Q, **DeWitt JC.** 2019. Dysfunctional microglia:neuron interactions with significant female bias in a developmental gene x environment rodent model of Alzheimer's disease. *International Immunopharmacology*. 71:241-250.

Keil DE, Buck B, Goossens D, McLaurin B, Murphy L, Leetham-Spencer M, Teng Y, Pollard J, Gerads R, and **DeWitt JC**. 2018. Nevada desert dust with heavy metals suppresses IgM antibody production. *Toxicology Reports*. 5:258-269.

vonderEmbse AN, Hu Q, and **DeWitt JC.** 2017. Developmental toxicant exposure in a mouse model of Alzheimer's disease induces differential sex-associated microglial activation and increased susceptibility to amyloid accumulation. *Journal of Developmental Origins of Health and Disease.* 2:1-9.

Meadows JR, Parker C, Gilbert KM, Blossom SJ, and **DeWitt JC**. 2017. A single dose of trichloroethylene given during development does not substantially alter markers of neuroinflammation in brains of adult mice. *Journal of Immunotoxicology.* 14:95-109.

DeWitt JC, Buck BJ, Goossens D, Teng Y, Pollard J, McLaurin B, Gerads R, and DE Keil. 2017. Health effects following subacute exposure to geogenic dust collected from active drainage surfaces (Nellis Dunes Recreation Area, Las Vegas, NV). *Toxicology Reports*. 4:19-31.

Rushing BR, Hu Q, Franklin JN, McMahen R, Dagnino S, Higgins CP, Strynar MJ, and **DeWitt JC**. 2017. Evaluation of the immunomodulatory effects of 2,3,3,3-tetrafluoro-2-(heptafluoropropoxy)-propanoate in C57BL/6 mice. *Toxicological Sciences*. 156:179-189.

Keil DE, Buck B, Goossens D, Teng Y, Pollard J, McLaurin B, Gerads R, **DeWitt JC**. 2016. Health effects from exposure to atmospheric mineral dust near Las Vegas, NV, USA. *Toxicology Reports*. 3:785-795.

Jusko TA, Oktapoda M, Murinová LP, Babjaková J, Verner M-A, **DeWitt JC**, Babinská, Thevenet-Morrison K, Conka K, Drobná B, Thurston SW, Lawrence BP, Dozier AM, Jarvinene-Seppo KM, Patayová H, Trnovec T, Legler J, Hertz-Picciotto I, and Lamoree MH. 2016. Demographic, reproductive, and dietary determinants of perfluorooctane sulfonic (PFOS) and perfluooctanoic acid (PFOA) concentrations in human colostrum. *Environmental Science & Technology*. 50:7152-7162.

DeWitt JC, Buck B, Goossens D, Hu Q, Chow R, David W, Young S, Teng Y, Leetham-Spencer M, Murphy L, Pollard J, McLaurin B, Gerads R, and Keil D. 2016. Health effects following subacute exposure to dusts from arsenic-rich sediment at the Nellis Dunes Recreation Area, Las Vegas, NV. *Toxicology and Applied Pharmacology*. 304:79-89.

Leetham M, **DeWitt J**, Buck B, Goossens D, Teng Y, Pollard J, McLaurin B, Gerads R, and Keil D. 2016. Oxidative stress and lung pathology following geogenic dust exposure. *Journal of Applied Toxicology*. 36:1276-1283.

Keil D, Buck B, Goossens D, Teng Y, Spencer M, Murphy L, Pollard J, Eggers M, Gerards R, and **DeWitt J**. 2016. Immunotoxicological and neurotoxicological profile of health effects following subacute exposure to geogenic dust from sand dunes at the Nellis Dunes Recreation Area, Las Vegas, NV. *Toxicology and Applied Pharmacology,* 291:1-12.

DeWitt JC, Williams W, Creech NJ, and Luebke RW. 2016. Suppression of antigen-specific antibody responses in mice exposed to perfluorooctanoic acid: Role of PPARα and B cell targeting. *Journal of Immunotoxicology*. 13:38-45.

Jiang Q, Ma W, Wu J, Wingard CJ, and **DeWitt JC**. 2016. Perfluorooctanoic acid-induced toxicity in primary cultures of chicken embryo cardiomyocytes. *Environmental Toxicology*. 31:1580-1590.

Khalil N, Chen A, Lee M, Czerwinski SA, Ebert JR, **DeWitt JC**, and Kannan K. 2016. Association of perfluoroalkyl substances, bone mineral density, and osteoporosis in the US population in NHANES 2009-2010. *Environmental Health Perspectives*. 124:81-87.

Wambaugh JF, Setzer W, Pitruzzello AM, Liu J, Reif D, Kleinstreuer N, Ching N, Wang Y, Sipes N, Martin M, Das K, **DeWitt J**, Strynar M, Judson R, Houck K, and Lau C. 2013. Dosimetric anchoring of in vivo and in vitro studies for perfluorooctanoate and perfluorooctanesulfonate. *Toxicological Sciences*. 136:308-327.

Jiang Q, Lust R, and **DeWitt JC**. 2013. Perflurooctanoic acid induced-developmental cardiotoxicity: Are peroxisome proliferator activated receptor α (PPARα) and bone morphorgenic protein 2 (BMP2) pathways involved? *Journal of Toxicology and Environmental Health Part A*. 76:635-650.

Hu Q, Franklin JN, Bryan I, Morris E, Wood A, and **DeWitt JC**. 2012. Does developmental exposure to perflurooctanoic acid (PFOA) induce immunopathologies commonly observed in neurodevelopmental disorders? *NeuroToxicology*. 33:1491-1498.

Jiang Q, Lust R, Strynar MJ, and **DeWitt JC**. 2012. Perflurooctanoic acid induces developmental cardiotoxicity in chicken embryos and hatchlings. *Toxicology*. 293:97-106.

Fair PA, Stavros H-C, Mollenhauer MAM, **DeWitt JC**, Henry N, Kannan K, Mitchum G, Y SH, Bossart GD, Keil DE, and Peden-Adams MM. 2012. Immune function in female B6C3F1 mice is modulated by DE-71, a commercial polybrominated diphenyl ether mixture. *Journal of Immunotoxicology*. 9:96-107.

Hu Q, Strynar MJ, and **DeWitt JC**. 2010. Are developmentally exposed C57BL/6 mice insensitive to suppression of TDAR by PFOA? *Journal of Immunotoxicology*. 7:344-349.

DeWitt JC, Copeland CB, and Luebke RW. 2009. Suppression of humoral immunity by perfluorooctanoic acid is independent of elevated serum corticosterone concentration in mice. *Toxicological Sciences*. 109:106-112.

Peden-Adams MM, Stuckey JE, Gaworecki K, Berger-Ritchie J, Bryant K, Jodice PG, Scott TR, Boone S, McGuinn WD, **DeWitt JC**, and Keil DE. 2009. Developmental toxicity in white leghorn chickens following in ovo exposure to perfluorooctane sulfonate (PFOS). *Reproductive Toxicology*. 27:307-318.

Whalen MM, **DeWitt JC**, Luebke RW. 2008. Serum supplementation modulates the effects of dibutyltin on human natural killer cell function. *Toxicological Sciences*. 104:312-319.

DeWitt JC, Copeland CB, Strynar MJ, and Luebke RW. 2008. Perflurooctanoic acid-induced immunomodulation in adult C57BL/6J or C57BL/6N female mice. *Environmental Health Perspectives*. 116:644-650.

DeWitt JC, Copeland CB, and Luebke RW. 2008. An organotin mixture found in polyvinyl chloride (PVC) pipe is not immunotoxic to adult Sprague-Dawley rats. *Journal of Toxicology and Environmental Health Part A.* 71:276-282.

DeWitt JC, Copeland CB, and Luebke RW. 2007. Immune function is not impaired in Sprague-Dawley rats exposed to dimethyltin dichloride (DMTC) during development or adulthood. *Toxicology.* 232:303-310.

Lim J, **DeWitt JC**, Sanders RA, Watkins JB III, and Henshel DS. 2007. Suppression of endogenous anti-oxidant enzymes by 2,3,7,8-tetrachlorodibenzo-*p*-dioxin-Induced oxidative stress in chicken liver during development. *Archives of Environmental Contamination and Toxicology.* 52:590-595.

DeWitt JC, Copeland CB, and Luebke RW. 2006. Developmental exposure to 1.0 or 2.5 mg/kg of dibutyltin dichloride does not impair immune function in Sprague-Dawley rats. *Journal of Immunotoxicology*. 3:245-252.

DeWitt JC, Millsap DS, Yeager RL, Heise SS, Sparks DW, and Henshel, DS. 2006. External heart deformities in passerine birds exposed to environmental mixtures of polychlorinated biphenyls during development. *Environmental Toxicology and Chemistry.* 25:541-551.

DeWitt JC, Copeland CB, and Luebke RW. 2005. Immune responses in Sprague-Dawley rats exposed to dibutyltin dichloride in drinking water as adults. *Journal of Immunotoxicology*. 2:151-160.

DeWitt JC, Meyer EB, and Henshel DS. 2005. Environmental toxicity studies using chickens as surrogates for wildlife: Effects of vehicle volume. *Archives of Environmental Contamination and Toxicology*. 48:260-269.

DeWitt JC, Meyer EB, Watkins JB, and Henshel DS. 2005. Environmental toxicity studies using chickens as surrogates for wildlife: Effects of day of injection. *Archives of Environmental Contamination and Toxicology*. 48:270-277.

Stanton B, **DeWitt J**, Henshel D, Watkins S, and Lasley B. 2003. Fatty acid metabolism in neonatal chickens (*Gallus domesticus*) treated with 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) or 3,3',4,4',5-pentachlorobiphenyl (PCB-126) *in ovo*. *Comparative Biochemistry and Physiology C - Pharmacology and Toxicology,* 136(1):73-84.

Henshel DS, **DeWitt JC**, and Troutman, A. 2002. Using chicken embryos for teratology studies. In: *Current Protocols in Toxicology* (M.D. Maines, L.G. Costa, E. Hodgson, D.J. Reed, and I.G. Sipes, Eds.), Supplement 14, pp. 13.4.1-13.4.19.

Henshel DS, Martin JW and **DeWitt JC**. 1997. Brain asymmetry as a potential biomarker for developmental TCDD intoxication: A dose-response study. *Environmental Health Perspectives*. 105:718-725.

Henshel DS, Martin JW, Norstrom RJ, Elliot J, Cheng KM and **DeWitt JC**. 1997. Morphometric brain abnormalities in double-crested cormorant chicks exposed to polychlorinated dibenzo-*p*-dioxins, dibenzofurans, and biphenyls. *Journal of Great Lakes Research*. 23:11-26.

Walker ED, Smith TW, **DeWitt J**, Beaudo DC, McLean RG. 1994. Prevalence of *Borrelia burgdorferi* in host-seeking ticks (Acari: Ixodidae) from a Lyme disease endemic area in northern Michigan. *Journal of Medical Entomology*. 31(4):524-8.

Reviews/Commentaries

Arnold WA, Blum A, Branyan J, Bruton TA, Carignan CC, Cortopassi G, Datta S, **DeWitt J**, Doherty A-C, Halden RU, Harari H, Hartmann EM, Hrubec TC, Iyer S, Kwiatkowski CF, LaPier J, Li D, Li L, Muñiz Ortiz JG, Salamova A, Schettler T, Seguin RP, Soehl A, Sutton R, Xu L, and Zheng G. 2023. Quaternary ammonium compounds: A chemical class of emerging concern. *Environmental Science & Technology*. doi: 10.1021/acs.est.2c08244.

DeWitt JC and Walker LM. 2022. Invited perspective: Key characteristics as a starting point for improved hazard identification of immunotoxic agents. *Environmental Health Perspectives*. 130:101301.

Post GB, Birnbaum LS, **DeWitt JC**, Goeden H, Heiger-Bernays WJ, Schlezinger JJ. 2022. Letter to the editors regarding "The conundrum of the PFOA human half-life, an international collaboration." *Regulatory Toxicology and Pharmacology*. 134:105240.

Ducatman A, LaPier J, Fuoco R, **DeWitt JC**. 2022. Official health communications are failing PFAS-contaminated communities. *Environmental Health*. 21:51.

McDonough C, Wenting L, Bischel H, DeSilva A, and **DeWitt J**. 2022. Widening the lens on PFASs: Direct human exposure on perfluoroalkyl precursors (pre-PFAAs). *Environmental Science and Technology*. 17:6004-6013.

Anderson JK, Brecher RW, Cousins IT, **DeWitt J**, Fiedler H, Kannan K, Kirman CR, Lipscomb J, Priestly B, Schoeny R, Seed J, Verner M, Hays SM. 2022. Grouping of PFAS for human health risk assessment: Findings from an independent panel of experts. *Regulatory Toxicology and Pharmacology*. 134:105226.

Glüge J, London R, Cousins IT, **DeWitt J**, Goldenman G, Herzke D, Lohmann R, Miller M, Ng CA, Patton S, Trier X, Wang Z, and Scheringer M. 2021. Information requirements under the essential-use concept: PFAS case studies. *Environmental Science and Technology*. https://doi.org/10.1021/acs.est.1c03732.

Cousins IT, **DeWitt JC**, Glüge J, Goldenman G, Herzke D, Lohmann R, Miller M, Ng CA, Patton S, Scheringer M, Trier X, and Wang Z. 2021. Finding essentiality feasible: Common questions and misinterpretations concerning the "essential use" concept. *Environmental Science: Processes & Impacts*. 23:1079-1087.

Ng C, Cousins IT, **DeWitt JC**, Glüge J, Goldenman G, Herzke D, Lohmann R, Miller M, Patton S, Scheringer M, Trier X, and Wang Z. 2021. Addressing urgent questions for PFAS in the 21st century. *Environmental Science & Technology*. https://doi.org/10.1021/acs.est.1c03386.

Cousins IT, **DeWitt JC**, Lohmann R, Glüge J, Goldenman G, Herzke D, Ng CA, Scheringer M, Wang Z. 2020. The high persistence of PFAS is sufficient for their management as a chemical class. *Environmental Science: Processes & Impacts*. 22:2307-2312.

Lohman R, Cousins I, **DeWitt J**, Glüge J, Goldenman G, Herzke D, Lindstrom A, Miller M, Ng C, Patton S, Scheringer M, Trier X, Wang Z. 2020. Are fluoropolymers really of low concern for human and environmental health and separate from other PFAS? *Environmental Science & Technology*. 54:12820-12828.

Glüge J, Scheringer S, Cousins IT, **DeWitt JC**, Goldenman G, Herzke D, Lindstrom AB, Lohmann R, Ng CA, Trier X, Wang Z. 2020. An overview of the uses of per- and polyfluoroalkyl substances (PFAS). *Environmental Science: Processes & Impacts*. 22:2345-2373.

Fenton SE, Ducatman A, Boobis A, **DeWitt JC**, Lau C, Ng C, Smith JS, and Roberts SM. 2020. Per- and polyfluoroalkyl substance toxicity and human health review: Current state of knowledge and strategies for informing future research. *Environmental Toxicology and Chemistry*. https://doi.org/10.1002/etc.4890.

Kwiatkowski C, Andrews D, Birnbaum L, Bruton T, **DeWitt J**, Knappe D, Maffini M, Miller M, Pelch K, Reade A, Soehl A, Trier X, Venier M, Wagner C, Wang Z, and Blum A. 2020. The scientific basis for managing PFAS as a chemical class. *Environmental Science & Technology Letters*. 7:532-543.

Cousins IT, **DeWitt JC**, Glüge J, Goldenman G, Herzke D, Lohmann R, Miller M, Ng CA, Scheringer M, Vierke L, and Wang Z. 2020. Strategies for grouping per- and polyfluoroalkyl substances (PFAS) to protect human and environmental health. *Environmental Science: Processes & Impacts.* 22:1444-1460.

Cousins IT, Goldenman G, Herzke D, Lohmann R, Miller M, Ng CA, Patton S, Scheringer M, Trier X, Vierke L, Wang Z, **DeWitt JC**. 2019. The concept of essential use for determining when uses of PFASs can be phased out. *Environmental Science: Processes & Impacts*. 21:1803-1815.

DeWitt JC, Blossom SJ, and Schaider L. 2019. Exposure to per- and polyfluoroalkyl substances leads to immunotoxicity: Epidemiological and toxicological evidence. *Journal of Exposure Science and Environmental Epidemiology.* 29:148-156.

Hopkins Z, Sun M, **DeWitt J**, and Knappe D. 2018. Recently detected drinking water contaminants: GenX and other per- and polyfluoroalkyl ether acids. *Journal of the American Water Works Association*. 110:13-28.

DeWitt JC and Patisaul HB. 2018. Endocrine disruptors and the developing immune system. *Current Opinion in Toxicology*. 10:31-36.

Ritscher A, Wang Z, Scheringer M, Boucher JM, Ahrens L, Berger U, et al. 2018. Zürich statement on future actions on per- and polyfluoroalkyl substances (PFASs). *Environmental Health Perspectives*. 126: https://doi.org/10.1289/EHP4158.

Wang Z, **DeWitt JC**, Higgins CP, and Cousins IT. 2017. A never-ending story of per- and polyfluoroalkyl substances (PFASs)? *Environmental Science & Technology*. 51:2508-2518.

Hessel EVS, Ezendam J, van Broekhuizen FA, Hakkert B, **DeWitt JC**, Granum B, Guzylack L, Lawrence BP, Penninks A, Rooney AA, Piersma AH, and van Loveren H. 2016. Assessment of recent developmental immunotoxicity studies with bisphenol A in the context of the 2015 EFSA t-TDI. *Reproductive Toxicology*. 65:448-456.

Corsini E, Luebke RW, Germolec DR, and **DeWitt JC**. 2014. Perfluorinated compounds: emerging POPs with potential immunotoxicity. *Toxicology Letters*, 230:263-270.

DeWitt J, Peden-Adams M, Keller J, and Germolec D. 2012. The immunotoxicity of perfluorinated compounds: Recent developments. *Toxicologic Pathology,* 40:300-311.

DeWitt J, Peden-Adams M, Keil D, and Dietert R. 2012. Current status of developmental immunotoxicity: Early-life patterns and testing. *Toxicologic Pathology*, 40:230-236.

Dietert RR, Dietert J, and **DeWitt JC**. 2011. Environmental risk factors for autism. *Emerging Health Threats Journal* (invited review). 4:7111.

Dietert RR, **DeWitt JC**, Germolec DR, and Zelikoff JT. 2010. Breaking patterns of environmentally influenced disease for health risk reduction: Immune perspectives. *Environmental Health Perspectives* 118:1091-1099.

DeWitt JC, Shnyra A, Badr MZ, Loveless SE, Hoban D, Frame SR, Cunard R, Anderson SE, Meade BJ, Peden-Adams MM, Luebke RW, and Luster MI. 2009. Immunotoxicity of perfluorooctanoic acid and perfluorooctane sulfonate and the role of peroxisome proliferator activated receptor alpha. *Critical Reviews in Toxicology* 39:76-94.

Edited Books

DeWitt JC, Rockwell CE, and Bowman CC (eds). 2018. *Immunotoxicity Testing: Methods and Protocols,* Methods in Molecular Biology Series. Springer Science + Business Media, LLC (Invited).

DeWitt JC (ed). 2015. *Toxicological Effects of Perfluoroalkyl and Polyfluoroalkyl Substances*. Springer Science + Business Media, LLC (Invited).

Book Chapters

vonderEmbse AN and **DeWitt JC**. 2018. Developmental immunotoxicity (DIT) testing: Current recommendations and the future of DIT testing. In: *Immunotoxicity Testing: Methods and Protocols* (DeWitt JC, Rockwell CE, and Bowman CC, eds), Methods in Molecular Biology Series. Springer Science + Business Media, LLC.

Meadows JR, **DeWitt JC**, and Rooney AA. 2018. Ecoimmunotoxicology – An overview. In: *Comprehensive Toxicology* (McQueen CA, ed) 3rd edition. Elsevier Ltd., Oxford.

DeWitt JC and Keil DE. 2017. Current issues in developmental immunotoxicity. In: *Immunopathology in Toxicology and Drug Development* (Parker GA, ed). Springer International Publishing, Switzerland.

DeWitt JC, Germolec DR, Luebke RW, and Johnson, VJ. 2016. Associating changes in the immune system with clinical diseases for interpretation of risk assessment. In: *Current Protocols in Toxicology*. 67:18.1.1-18.1.22.

DeWitt JC, Peden-Adams MM, and Keil DE. 2015. Immunotoxic effects of perfluoroalkylated compounds: Mechanisms of action. In: *Molecular Immunotoxicology* (Corsini E and van Loveren H, eds). Wiley-VCH GmbH & Co., Weinheim.

DeWitt JC and Dietert RR. 2014. Immunotoxicity in autism spectrum disorders. In: *The Comprehensive Guide to Autism* (Patel VB, Martin CR, Preedy V, and Preedy VR, eds). Springer Reference, New York, NY.

Dietert RR, **DeWitt JC**, and Luebke RW. 2012. Reducing the prevalence of immune-based chronic disease. In: *Immunotoxicity, Immune Dysfunction, and Chronic Diseases* (Dietert RR and Luebke RW, eds), Molecular and Integrative Toxicology, Springer Science + Business Media, LLC. pp 419-440.

DeWitt J, Peden-Adams M, Keil D, and Dietert R. 2012. Developmental immunotoxicity (DIT): Assays for evaluating effects of exogenous agents on development of the immune system. In: *Current Protocols in Toxicology*. Chapter 18: Unit 18.15.

Luebke RW, **DeWitt JC**, Germolec DR, Salazar KD, and Kerkvliet NI. 2012. Immunomodulation by persistent organic pollutants. In: *Dioxins and Health, Including Other Persistent Organic Pollutants and Endocrine Disruptors, 3nd Edition* (Schecter A, ed), John Wiley and Sons, Inc., Hoboken, NJ. pp 171-192.

DeWitt JC and Dietert RR. 2012. Postnatal immune dysfunction and its impact on growth parameters. In: *Handbook of Growth and Growth Monitoring in Health and Disease* (Preedy VR, ed), Springer, New York, NY. pp 741-755.

DeWitt JC and Luebke RW. 2010. Immunological Aging. In: *Comprehensive Toxicology*, 2nd Edition, Volume 5 (Lawrence D, ed), Elsevier Limited, Oxford, UK. pp 455-465.

Dietert RR and **DeWitt J**. 2010. Developmental immunotoxicity (DIT): The why, where and how of DIT testing. In: *Immunotoxicity Testing: Methods and Protocols* (Dietert RR, ed), Methods in Molecular Biology. Humana Press, Inc., Totowa, NJ. 598:17-25.

Luebke RW, Beamer CA, Bowman C, **DeWitt JC**, Gowdy K, Johnson VJ, Shepherd DM, and Germolec DR. 2009. Immunotoxicology (developmental immunotoxicology section). In: *General and Applied Toxicology*, 3rd Edition (Marrs T, Ballantyne B, Syversen T, eds.), John Wiley & Sons, Ltd., Chichester, UK, pp 1561-1583.

Other Scholarly Contributions

Portier CJ et al. (90+ co-authors). 2016. Differences in the carcinogenic evaluation of glyphosate between the International Agency for Research on Cancer (IARC) and the European Food Safety Authority (EFSA). *Journal of Epidemiology and Community Health*. 70:741-745.

DeWitt JC and Luebke RW. 2014. Immunological Aging. *Online Reference Database Biomedical Science*.

Benbrahim-Tallaa L, Lauby-Secretan B, Loomis D, Guyton KZ, Grosse Y, El Ghissassi F, Bouvard V, Guha N, Mattock H, and Straif K *on behalf of the International Agency for Research on Cancer Monograph Working Group* (**DeWitt JC**, Mechanisms Subgroup Member). 2014. Carcinogenicity of perfluorooctanoic acid, tetrafluoroethylene, dichloromethane, 1,2-dichloropropane, and 1,3-propane sultone. *The Lancet Oncology*. 15:924-925.

IARC. 2014 Perfluoro-octanoic acid, Tetrafluoroethylene, Dichloromethane, 1,2-Dichloropropane, and 1,3-Propane sultone. *IARC Monogr Eval Carcinog Risks Hum* (**DeWitt JC**, Mechanisms Subgroup Member). *Monograph 110*.

DeWitt JC and Dietert RR. 2011. Response to "Theoretical aspects of autism: Causes - a review" by Ratajczak, HV (*Journal of Immunotoxicology* 8:68-79, 2011). *Journal of Immunotoxicology.* 8:195-197.

Non-Refereed Articles

DeWitt JC, Brown P, Carignan C, Kasper S, Schaider L, Osimo C, Fitzstevens M. Op-ed: PFAS chemicals – the other immune system threat. *Environmental Health News.* July 6, 2020.

"Toxicant induced brain asymmetry: More than just a bird-brained scheme?" Learned Discourses, *SETAC Globe*, Jan/Feb 2001 (invited).

RESEARCH FUNDING

North Carolina Biotechnology Center 1 year
Development of a high throughput screening assay for functional immunotoxicity
Role on project: Principal Investigator
Status: Award notification June 2022. Direct costs: $25,249

North Carolina Policy Collaboratory 2 years
Per- and Polyfluoroalkyl Substances (PFAS) in North Carolina: Descriptive Toxicological Needs II
Role on project: Principal Investigator
Status: Award notification May 2022. Direct costs: $300,000

North Carolina Policy Collaboratory
Instrumentation Award (Seahorse XF Pro)
Role on project: Principal Investigator
Status: Award notification March 2022. Direct costs: $226,054

North Carolina Policy Collaboratory 1 year
Per- and Polyfluoroalkyl Substances (PFAS) in North Carolina: Descriptive Toxicological Needs I
Role on project: Principal Investigator
Status: Award notification August 2020. Direct costs: $83,446

Center for Human Health and the Environment at North Carolina State University 1 year
Uncovering PFOA-Induced Metabolic Changes and their Association with B-cell Metabolic Function
Role on project: Principal Investigator of Record (Mentor to Dr. Tracey Woodlief, who wrote and received award)
Status: Award notification April 2020. Direct costs: $25,000

Brody Brothers Endowment Foundation 1 year
Do Per- and Polyfluoroalkyl Substances found in the Cape Fear River of North Carolina Pose a Risk to the Immune System?
Role on project: Principal Investigator
Status: Award notification December 2019. Direct costs: $32,000

National Institute of Environmental Health Sciences Superfund Research Program (P42) via subcontract from North Carolina State University 5 years
Center for Environmental and Health Effects of PFAS. BMRP2: Uncovering the Mechanisms of PFAS-Induced Immunotoxicity: An Important Public Health endpoint
Role on project: Co-Principal Investigator (C. Mattingly and D. Knappe, PIs, NCSU)
Status: Award notification December 2019. Direct costs to ECU: $684,005

Department of Defense 3 years
New Approaches for the Treatment of Neuroinflammatory and Behavioral Consequences of Exposure to Gulf War Illness Chemicals
Role on project: Principal Investigator
Status: Award notification March 2019. Direct costs: $699,564.

United States Environmental Protection Agency via subcontract from Oregon State University 3 years
System Toxicological Approaches to Define and Predict Toxicity of Per- and Polyfluoroalkyl Substances
Role on project: Co-Principal Investigator (R. Tanguay, PI, OSU)
Status: Award notification September 2018. Direct costs to ECU: $465,000.

North Carolina Policy Collaboratory 2 years
Per- and Polyfluoroalkyl Substance Testing (PFAST) Network: Effects of novel PFASs on immune function
Role on project: Co-Principal Investigator and Team Co-Lead (with R. Fry, UNC-CH)
Status: Award notification September 2018. Direct costs to ECU: $168,068.

North Carolina Policy Collaboratory 6 months
Emerging contaminants in North Carolina, including PFASs, 1,4-dioxiane, and bromide, in air and water
Role on project: Co- Principal Investigator
Status: Award notification July 2018. Direct costs to ECU: $12,000.

National Institutes of Health/National Institute of Environmental Health Sciences via subcontract with North Carolina State University 2 years
Assessing Impact of Drinking Water Exposure to GenX in the Cape Fear River Basin
Role on project: Co-Investigator (J. Hoppin, NCSU, PI)
Status: Award notification November 2017. Direct costs to ECU: $20,000

Brody Brothers Endowment Foundation 1 year
Immunomodulatory Effects of Aqueous Film Forming Foam (AFFF): An Effective Fire Suppressant or a Persistent Environmental Contaminant with Unknown Health Consequences?
Role on project: Principal Investigator
Status: Award notification November 2016. Direct costs: $20,000

Center for Human Health and Environment at NCSU Pilot Project Program 1 year
Discovery of Biomarkers of Effect following Environmentally-Relevant Exposure to Pharmaceutical Pollutants
Role on project: Co-Principal Investigator (E. Hvastkovs and K. McCoy, ECU, co-PIs)
Status: Award notification August 2015. Direct costs: $25,000

Brody School of Medicine Internal Seed/Bridge Grant Program 1 year
Post-translational Modifications to Potassium Channels in Alzheimer's Disease: Triggers of Onset and Progression?
Role on project: Co-Principal Investigator (R. Schwalbe, ECU, co-PI)
Status: Award notification August 2015. Direct costs: $25,000

The Harriet and John Wooten Laboratory for Alzheimer's and Neurodegenerative Disease Research 1 year
Microglia as a Target of Environment x Gene Interactions Part II: Digging into the Biochemistry of Alzheimer's Disease
Role on project: Principal Investigator (R. Schwalbe, ECU, co-PI)
Status: Award notification November 2014. Direct costs: $12,000

Interdisciplinary Research Collaboration Award (East Carolina University) 6 months
Pharmaceutical and Personal Care Product Contaminants in Fresh Water
Role on Project: Corresponding Faculty PI
Status: Award notification August 2014. Direct costs: $23,000

Alzheimer's North Carolina 1 year
A Multidisciplinary Approach to Fight Senior Dementia
Role on Project: Co-Investigator (Q. Lu, ECU, PI)
Status: Award notification February 2014. Direct costs: $50,000

East-West Research Collaboration Award (East Carolina University) 6 months
Pharmaceutical and Personal Care Product Contaminants in Fresh Water
Role on Project: Corresponding Faculty PI
Status: Award notification December 2013. Direct costs: $23,000

The Harriet and John Wooten Laboratory for Alzheimer's and Neurodegenerative Disease Research 1 year
Microglia as a Target of Environment x Gene Interactions: Exacerbation of Alzheimer's Pathology by Early-life Exposure to Lead
Role on project: Principal Investigator
Status: Award notification April 2013. Direct costs: $12,000

Bureau of Land Management via subcontract from University of Nevada-LV 3 years
Nellis Dunes Recreation Area Dust Exposure and Human Health Risk Assessment
Role on project: Co-Principal Investigator (B. Buck, UNLV, PI)
Status: Award notification March 2011. Direct costs to ECU: $105,699

Department of Defense 1 year
Immunopathogenesis in autism: Regulatory T cells and autoimmunity in neurodevelopment
Role on project: Principal Investigator
Status: Award notification December 2009. Direct costs: $75,000

School of Public and Environmental Affairs, Indiana University. Ph.D. Student Travel Award and Graduate Student Organization Travel Award. 2001. Funded amount: $500.00
Ohio Valley Chapter of the Society of Environmental Toxicology and Chemistry. Student Travel Grant. 1997, 1998, 2001. Funded amounts: $300.00 each year

EDITORIAL BOARDS/AD HOC MANUSCRIPT REVIEWER

Editorial Board Member, *Journal of Immunotoxicology*. 2010-
Editorial Board Member, *Journal of Toxicology and Environmental Health Part A.* 2013-
Associate Editor, *Toxicology and Applied Pharmacology*. 2016-
Series co-Editor (with Sarah Blossom), *Molecular and Integrative Toxicology*. 2016-2022
Editorial Board Member, *Environmental Health Perspectives*. 2017-
Editorial Board Member, *NeuroToxicology*. 2018-
Editorial Board Member, *Reproductive Toxicology*, 2019-
Editorial Board Member, *Chemosphere*, 2023-
Co-Editor, *Food and Chemical Toxicology*, 2023-

Ad Hoc Reviewer (summary of most common journals):

Advances in Physiology Education
Archives of Toxicology
Chemosphere
Environmental Health
Environmental Health Perspectives
Environmental Research
Environmental Science & Technology
Food and Chemical Toxicology
Human & Experimental Toxicology
International Immunopharmacology
International Journal of Tropical Biology
Journal of Toxicology & Environmental Health
Pharmacological Research
Regulatory Toxicology & Pharmacology
Science of the Total Environment
Toxicology & Applied Pharmacology
Toxicology Reports
Archives of Environmental Contamination & Toxicology
Chemical Research in Toxicology
Drug and Chemical Toxicology
Environment International
Environmental Science & Pollution Research
Epidemiology
GENE
International Aquatic Research
Journal of Environmental Immunology & Toxicology
Journal of Immunotoxicology
NeuroToxicology
PLoS One
Reproductive Toxicology
Southeastern Naturalist
Toxicology Letters
Toxicological Sciences

GRANT REVIEWER & REVIEW PANEL CHAIR

American Institute of Biological Sciences, 2023
Department of Defense Strategic Environmental Research and Development Program, 2021-present
National Institute of Environmental Health Sciences, 2020-present
University of North Carolina at Chapel Hill pilot funding programs, 2020
Wisconsin SeaGrant, 2019, 2021
Hudson River Foundation, 2019
Department of Defense Congressionally Directed Medical Research Programs, Review Panel Chair, 2018-2021
CORIS, Consorzio per la Ricerca Sanitaria, 2018
Department of Defense Congressionally Directed Medical Research Programs, 2013-present
Graduate Women in Science Graduate Fellowships, 2011, 2014-2018, 2022
CDC-NIOSH, 2010, 2013, 2016

EXTERNAL REVIEWER

California Environmental Protection Agency (product), 2019-2022
US Environmental Protection Agency (product), 2019
ATSDR, 2017-2022 (manuscripts, Toxicological Profile, and other documents)
New York State Department of Public Health, 2017 (Cancer incidence investigation: Village of Hoosick Falls, Rensselaer County, New York)

ORAL PRESENTATIONS (Invited)

"Human health effects of PFAS exposure." Webinar. N*ASEM Board on Agriculture and Natural Resources: Exploring linkages between soil health and human health Meeting 3*. May 16, 2023.

"Impact of early-life exposure to per- and polyfluoroalkyl substances (PFAS) and implications for later life immune-based diseases." *NIEHS Symposium: H owe the latest advances in immunology inform the field of developmental immunotoxicology: A panel discussion*. American Association for Immunology annual meeting. May 14, 2023.

"Challenges with optimizing DIT tests." *Alternatives to in vivo DIT Workshop 4*. Johns Hopkins University Center for Alternatives to Animal Testing. May 9, 2023.

"Human health effects related to draft rule." Webinar. *First National Primary Drinking Water Standards for Six PFAS*. AAAS EpiCenter. May 2, 2023.

"Toxicological investigations of PFAS and implications for human health." *Strategies for Managing and Remediating PFAS and Other Emerging Contaminants.* Webinar. Environment Analyst UK. April 27, 2023.

"Understanding effects of PFAS exposure on the immune system and what it means for public health." *University of Florida Department of Environmental and Global Health Seminar Series*. University of Florida, Gainesville, FL. March 8, 2023.

"Overview of PFAS research and outreach in NC." *UNC Chapel Hill Workshop on PFAS Characterization, Removal, and Replacement*. UNC Chapel Hill, Chapel Hill, NC. January 6, 2023.

"Health effects of PFAS – Focus on the immune system." *AAAS EPICenter/ASTHO/RESOLVE Webinar on The Science of PFAS Exposure and Effects on Human Health*. Virtual, December 8, 2022.

"The ABCs of PFAS and their immunotoxicity. *Baylor University Department of Environmental Science Seminar Series*. Virtual, December 7, 2022.

"Let's talk immunotoxicity: Approaches for determining adverse immune effects across the lifespan." *Northland Regional Chapter SOT Fall 2022 Meeting.* Virtual, October 28, 2022.

"The expanding world of PFAS toxicity and what it could mean for environmental health." *University of Pennsylvania Center for Excellence in Environmental Toxicology Seminar Series*. University of Pennsylvania, Philadelphia, PA. October 20, 2022.

"PFAS toxicology: The ABCs of PFAS and their toxicology." *New Mexico Water Law CLE*. Santa Fe, NM. September 30, 2022.

"(Eco)toxicology of fluorinated polymers: A few highlights" (with Rainer Lohmann from University of Rhode Island). *Europe's PFAS problem: Situation briefings by independent experts. Session 9 Webinar*. Virtual, September 15, 2022.

"Protecting public health from per- and polyfluoroalkyl substances: Focus on immunotoxicity." *Japanese Society of Immunotoxicology Annual Meeting* and *Special Lecture at Hokkaido University*. Sapporo, Hokkaido, Japan. September 12 and 14, 2022.

"Forever in our water: The toxicity of forever chemicals known as PFAS." *ECU Coastal Studies Institute Lunch and Learn*. Wanchese, NC. August 18, 2022.

"Strategies for grouping PFAS based on toxicological understanding." *NASEM Committee on Toxicology Annual Meeting 2022*. Virtual, July 21, 2022.

"PFAS 101: A basic primer on per- and polyfluoroalkyl substances." *Geoscience Teaching Outdoors*. Greenville, NC. June 23, 2022.

"Longer-term health effects: Immune system and experimental animal data." *3rd Annual PFAS Meeting*. Wilmington, NC. June 16, 2022.

"What do we know about PFAS and human health? A brief overview with a focus on the immune system." *Environmental Health Project Webinar on PFAS, Pregnancy, and Public Health: Experts Weigh in*. Virtual, May 24, 2022.

"Getting to the bottom of PFAS-induced immune dysfunction." *Northeast Waste Management Officials' Association Conference on The Science of PFAS: Public Health and the Environment*. Marlborough, MA. April 6, 2022.

"Effects of perfluoroether acids, understudied PFAS, on the developing immune system." *Society of Toxicology Annual Meeting Symposium Session on "Developmental origins of inflammatory and immune diseases: Identifying the effects of in utero stress on immunological competency."* San Diego, CA. March 29, 2022.

"How toxicological data are used for protecting human health from per- and polyfluoroalkyl substances: Focus on immunotoxicity." *Society of Toxicology Annual Meeting Undergraduate Diversity Program*. San Diego, CA. March 27, 2022.

"What do we know about PFAS and human health? The toxicology of PFAS." *IDEA Learners Design Institute*. Chapel Hill, NC. March 14, 2022.

"Zurich I to Zurich II: In the past five years we haven't done enough to protect public & environmental health." *Zurich II On-Line Workshop*. February 10-11, 2022.

"What are human health concerns of PFAS?" *Orion Expert Network: A Lawyer's Guide to PFAS/AFFF*. Virtual Seminar. February 4, 2022.

"PFAS 101: What are PFAS and why are they health and environmental concerns?" *Ohio FACE Team*. Virtual Seminar. December 22, 2021.

"Properties, applications, and impacts of PFAS on environment, wildlife, and humans." *Lunchlezing, RIVM (The Netherlands)*. Virtual Seminar. November 18, 2021.

"Health effects of PFAS exposure: A summary of major findings." *Firefighter 4th Annual Health & Wellness Conference*. Beavercreek, OH. November 5, 2021.

"The role of a research toxicologist in responding to public health emergencies: An example of PFAS." *Research Triangle Environmental Health Collaborative 2021 Summit on Disaster Research Response and Public Health Emergencies: Creating an Environment for Resilience in North Carolina*. Virtual Seminar. November 3, 2021.

"Per- and polyfluoroalkyl substances – Emerging research for not so emerging contaminants." *Duke Integrated Toxicology and Environmental Health Program's Fall 2021 Series*. Durham, NC. October 1, 2021.

"From the lab bench to the town hall meeting: How studying PFAS has added depth to my research program." *ECU Biology Seminar*. Virtual Seminar. September 16, 2021.

"PFAS 101: A quick primer on why per- and polyfluoroalkyl substances are a problem for occupational and public health." *NFPA 1971 Task Group on Hazardous Substances*. Virtual Talk. July 22, 2021.

"PFAS impacts on the immune system." *Environmental Working Group's Inaugural PFAS Conference: PFAS health harms and solutions session*. Virtual Talk. July 14, 2021.

"Overview of putative health effects of PFAS: Toxicology." *National Academies Committee on Guidance on PFAS Testing and Health Outcomes*. Virtual Talk. July 14, 2021.

"Building capacity through PFAS communication." *SRP Risk Communication Strategies to Reduce Exposures and Improve Health Virtual Workshop.* Virtual Talk (with Katy May). June 21, 2021.

"Human health impacts of PFAS exposure." *The National Governors Association and AAAS EPI Center: Per- and Polyfluoroalkyl Substances (PFAS) and Drinking Water*. Virtual Talk. June 3, 2021.

"Per- and polyfluoroalkyl substances: Emerging research to enhance management." *National Sea Grant Law Center Webinar.* Virtual Talk. May 26, 2021.

"Current efforts and future opportunities." *Center for Human Health and Environment Annual Symposium*. Virtual Talk (with Detlef Knappe). May 15, 2021.

"PFAS toxicity: What we've learned so far." *PFAS Testing Network Virtual Forum*. Virtual Talk. May 4, 2021.

"Current developmental immunotoxicity testing status." *Alternatives to in vivo DIT Workshop, Center for Alternatives to Animal Testing at Johns Hopkins Bloomberg School of Public Health*. Virtual Talk. May 4, 2021.

"The toxicity of PFAS and why it matters." *Cape Fear River Watch First Saturday Seminar*. Virtual Talk. May 1, 2021.

"PFAS Exposure and COVID-19." *The PA Multi-site Health Study Information Session.* Virtual Talk. March 25, 2021.

"From Pollutants to People: How Studying PFAS has given my Laboratory Research Deeper Meaning." *NC Water Resources Research Institute Annual Conference*. Virtual Talk. March 25, 2021.

"An Overview of the Health Effects of PFAS." *Toxic Free NC and Climate Action NC Educational Event.* Virtual Talk. February 16, 2021.

"Unregulated and Emerging Contaminants in North Carolina Waters: Focus on PPCPs and PFAS." *Sierra Club Cypress Group.* Virtual Talk (with Dr. Sid Mitra). January 11, 2021.

"PFAS Immunotoxicity." *Environmental Working Group Press Briefing*. Virtual Talk. December 16, 2020.

"Forever Chemicals." *Tell me about it Tuesdays, Sound Rivers Science Series.* Virtual Talk. December 8, 2020.

"Why Uncovering Immunotoxicological Impacts of Understudied PFAS are Public Health Protective." *PharmTox Seminar, Michigan State University*, Virtual Seminar. November 25, 2020.

"Let's not Forget about the T in the PBMT of PFAS: An Overview of what we know about PFAS Toxicity." *EHSC 8030 Environmental Health Science, College of Public Health, University of Georgia*, Virtual Seminar. November 13, 2020.

"What can Science tell us about Potential Health Effects of PFAS found in NC: Why Understanding Effects of PFAS on the Immune System is Important." *PFAST Network Webinar*. November 6, 2020.

"PFAS 101: A 10-minute Primer on Per- and Polyfluoroalkyl Substances." *NAS Virtual Workshop on Federal Government Human Health PFAS Research.* October 26, 2020.

"Immune Investigations of some of the Understudied PFAS found in the Cape Fear River: What we've learned and were we go from here." *NC Coastal Federation Emerging Contaminants in North Carolina Waters*, Virtual Seminar. October 22, 2020.

"Immunotoxicological Evaluation of Understudied Per- and Polyfluoroalkyl Substances found in North Carolina." *WVU Microbiology & Women in Biomedical Science Seminar,* Virtual Seminar. October 15, 2020.

"PFAS: Why Immune Effects are Relevant Points of Departure for these Multisystem Toxicants." *M-LEEaD Virtual Mini-Symposium on Per- and Polyfluoroalkyl Substances (PFAS): Exposure, Toxicity, and Policy at the University of Michigan*, Virtual Seminar. October 8, 2020.

"Why Uncovering Immunotoxic Outcomes of PFAS can be a Health Protective Strategy." *Department of Environmental Medicine, NIEHS Environmental Health Sciences Center Seminar Series, University of Rochester*, Virtual Seminar. October 1, 2020.

"From Inert to Adverse: What we've learned about PFAS Toxicity in the Past Two Decades." *VME4906 Intro to Water Analysis, University of Florida Gainesville*, Virtual Lecture. September 24, 2020.

"Immunotoxicity of PFAS: Functional Toxicological Outcomes to Support Decision-Making." *Air & Waste Management Association, The Science of PFAS, Chemistry, Health and Multimedia Measurements,* Virtual Conference. September 15, 2020.

"(Eco)toxicology of PFAS: A few Highlights." *Europe's PFAS Problem: Situation Briefings by Independent Experts, European Environmental Bureau,* Virtual Webinar. September 14, 2020.

"Mechanisms of Toxicity for Per- and Polyfluoroalkyl Substances: Are we there yet?" *Chemical Exposures and Impact on Health, ACS Fall 2020 Virtual Meeting & Expo,* Virtual Meeting. August 19, 2020.

"What are PFAS and why should you care about them?" *Climate Action NC*, Virtual Public Meeting. August 13, 2020.

"Biomarkers of Immunotoxicity and Applicability to PFAS and other Environmental Toxicants," *Predicting Human Health Effects from Environmental Exposures: Applying Translatable and Accessible Biomarkers of Effect – A NAS Workshop, National Academies of Science,* Virtual Workshop. 2020.

"Developmental Immunotoxicology." *Society for Birth Defects Research and Prevention Annual Meeting,* Virtual Meeting. 2020.

"Bringing Scientific Evidence to Meet Local Policy Challenges," Session Panelist, *American Association of the Advancement of Science Annual Meeting*, Seattle, WA. February 14, 2020.

"Approaches to Understand Health Risks of Understudied PFAS." *Environmental Health Collaborative 2019 Summit on "PFAS: Integrating Science and Solutions in NC."* Durham, NC. October 23, 2019.

"An Overview of how PFAS are Toxic with the Immune System as a Specific Example." *Michigan Society of Toxicology Fall 2019 Meeting on "PFAS Exposure and Toxicology in Michigan and Beyond."* Ann Arbor, MI. October 18, 2019

"Addressing Public Health Concerns about PFAS: Focus on Immunotoxicology." *Purdue University, Chemical Exposure Research Area, Center for the Environment and School of Health Sciences Seminar Series.* Lafayette, IN. September 10, 2019.

"Immunotoxicological Findings of PFAS: Consistency of Effects between Humans and Rodent Models." *SETAC North America Focused Topic Meting: Environmental Risk Assessment of PFAS.* Durham, NC. August 13, 2019.

"Per- and Polyfluoroalkyl Substances (PFAS): A Lifecycle Perspective." *The Toxicology Forum Summer Meeting*. Alexandria, VA. July 9, 2019.

"What can PFAS do to our Health?" *North Carolina Museum of Natural Sciences Science Café: "Toxic Chemicals and Human Health*." Raleigh, NC. June 20, 2019.

"Immunotoxicological Findings of PFAS: Consistency of Effects between Rodent Models and Humans." *2019 Per- and Polyfluoroalkyl Substances: Second National Conference*. Northeastern University. Boston, MA. June 11, 2019.

"PFAS Testing Network: Team #5: Other Applied R&D." *What's in our Water? A Public Forum on Emerging Contaminants*. NC Coastal Federation. Wilmington, NC. 2019.

"Per- and Polyfluoroalkyl Substances are Immunotoxic: What does this mean for Public Health Protection?" *Environmental and Molecular Toxicology Seminar Series*, Oregon State University. Corvallis, OR. 2019.

"An Overview of what we know about PFAS Toxicology." *PFAS and Other Emerging Contaminants Conference*. American Council of Engineering Companies of North Carolina and Groundwater Professionals of North Carolina. Raleigh, NC. 2019.

"Developmental Immunotoxicology." *American College of Toxicology and Teratology Society Practical Reproductive and Developmental Toxicology*. Gaithersburg, MD. 2019.

"PFAS Toxicity." *North Carolina Waterworks Operators Association Lab Technology Day*. Raleigh, NC. 2019.

"PFAS and Health: What we've learned in the Past Two Years." *Center for Human Health and the Environment Third Annual Symposium*. North Carolina State University, Raleigh, NC. 2019.

"Three Reasons that Per- and Polyfluoroalkyl Substances do not belong in our Bodies." *University of North Carolina Wilmington Department of Chemistry and Biochemistry Seminar*, Wilmington, NC. 2019.

"PFAS Exposure: What are the Health Implications?" *Cape Fear Public Utility Authority Board Workshop*, Wilmington, NC. 2018.

"Impact of Early-Life Environmental Factors on the Developing Immune system." *PPTOX VI*, Faroe Islands. 2018.

"Health Effects of GenX: What do we know and what do we need to know to Protect Public Health?" *45th Annual Meeting of the Cape Fear River Assembly*, Wilmington, NC. 2018.

"How do we know Whether a Chemical is Toxic?" *Osher Lifelong Learning Institute Sea & Coffee Series*, University of North Carolina at Wilmington, Wilmington, NC. 2018.

"PFASs, AFFFs, PFAAs: An Alphabet Soup of Emerging Aquatic Contaminants with Immunotoxic Potential." *NCSU Toxicology Program Seminar Series*, North Carolina State University, Raleigh, NC. 2018.

"How Per- and Polyfluoroalkyl Substances (PFASs), as EDCs, can Fool the Developing Brain's Immune System." *EDC-NC Annual Meeting*. RTP, NC. 2018.

"Research Challenges Associated with PFASs: Ubiquitous Multisystem Toxicants." *The Toxicology Forum Winter Meeting*. Washington DC. 2018.

"Environmental Triggers of Underlying Neuroimmune Susceptibilities: Critical Events in Development." *Webinar*, Autism Research Institute. 2018.

"Are Replacements for the Legacy PFASs Indisputably Safe Alternatives?" *Webinar*, Toxic-Free Future. 2018.

"Per and Polyfluoroalkyl Substances: Complex Chemicals that Challenge Policies for Environmental Health Protection and Risk Communication." *Brown Bag Lunch*, RTI International, RTP, NC. 2018.

"From Legacies to Alternatives: What we know and what we need to know about the Toxicity of Per- and Polyfluoroalkyl Substances." *Weekly Seminar*, NC Department of Health and Human Services, Raleigh, NC. 2017.

"The Never-Ending Story of Per- and Polyfluoroalkyl Substances: Immunotoxicity from Legacies to Alternatives." *Mid Atlantic Society of Toxicology Annual Meeting*, Edison, NJ. 2017.

"A Potential Never-Ending Story of Chemical Water Pollution in LMICs: Proliferation of Legacy and Replacement PFASs." *International Society of Exposure Science*, Research Triangle Park, NC. 2017.

"The Science behind GenX." *Water Wednesday*, Clean Cape Fear, Wilmington, NC. 2017.

"Is it Possible to Untangle Underlying Developmental Susceptibilities from Exogenous Triggers in ASD?" *Autism Think Tank*, Autism Research Institute, Dallas-Fort Worth, TX. 2017.

"Urgent Research Needs for Better Understanding the Toxicity of PFASs." *Northeast Superfund Research Program Meeting*, Northeastern University, Boston, MA. 2017.

"Emerging Toxicological Knowledge and Data Gaps for "Novel" PFASs." *Public Workshop on Perfluoroalkyl and Polyfluoroalkyl Substances (PFASs) in Carpets, Rugs, Indoor Upholstered Furniture, and Their Care and Treatment Products*, Safer Consumer Products Program, Department of Toxic Substances Control, California Environmental Protection Agency, Sacramento, CA. 2017.

"Pharmaceuticals and Personal Care Products as Emerging Pollutants in Coastal Waters (with Dr. Siddhartha Mitra). *Science on the Sound Symposium*, Coastal Studies Institute, Wanchese, NC. 2017.

"Emerging Aquatic Contaminants and Health: Finding Solutions with Transdisciplinary Teams." Coastal Health Initiative, East Carolina University, Greenville, NC. 2016.

"Water Pollution: Is seeing believing?" *Love a Sea Turtle Second Annual Environmental Symposium*, River Park North, Greenville, NC. 2016.

"Developmental Immunotoxicology." *Middle Atlantic Reproduction and Teratology Association*, Covance Research Products, Inc., Denver, PA. 2015.

"A Little Bit of this and a Little Bit of that…How do we Understand Risks of Agents in just a Drop of Water?" *Love a Sea Turtle First Annual Environmental Symposium*, River Park North, Greenville, NC. 2015.

"Updates on Alzheimer's Disease Research in the DeWitt Lab at East Carolina University" (with Annalise vonderEmbse). *Senior Services Community Health Program*, Vidant Medical Center, Greenville, NC. 2015.

"Immunomodulatory Effects of Perfluoroalkyl Substances in Rodents and Humans." *Immunotoxicology in Food and Ingredient Safety Assessment: Approaches and Case Studies, SOT FDA Colloquia on Emerging Toxicological Science Challenges in Food and Ingredient Safety*, Washington, DC. 2015.

"Updates on Alzheimer's Disease Research in the DeWitt Lab at East Carolina University" (with Annalise vonderEmbse). *Alzheimer's Professional Partnership-Greenville*, Greenville, NC. 2015.

"From Sink to Sea: Evaluating Health Impacts of Pills and Perfumes after we Wash them away" (with Krista McCoy). *FaculTea Seminar*, East Carolina University, Greenville NC. 2014.

"Better Living through Chemistry: A Tale of Two Toxicants." *Department of Chemistry Seminar*, East Carolina University, Greenville, NC. 2014.

"The Nuts and Bolts of Interdisciplinary Toxicological Research" (with Christie Sayes). *Western Carolina University Department of Biology Spring Seminar Series*. Cullowhee, NC. 2014.

"Alzheimer's Disease and Neurodegenerative Disorders Research at East Carolina University" (with Annalise vonderEmbse). *Alzheimer's Professional Partnership-Goldsboro*, Goldsboro, NC. 2015.

"Endocrine Disruption of the Neuro-immune Interface." *The Collaborative on Health and the Environment Partnership Call* (Teleseminar). 2014
"Contaminated Drinking Water: A Case Study of Perfluorinated Compounds." *Coastal Water Resources Center*, East Carolina University, Greenville, NC. 2013.

"Villains and Heroes in the Battle for Clean Water" (with Siddhartha Mitra and Anthony Cannon). *STEM at Starlight*, Greenville, NC. 2013.

"The Nuts and Bolts of Alzheimer's Disease Research at East Carolina University." *Senior Services Community Health Program*, Vidant Medical Center, Greenville, NC. 2013.

"Alzheimer's Disease and Neurodegenerative Disorders Research at East Carolina University." *Alzheimer's Professional Partnership-Greenville*, Greenville, NC. 2013.

"A Neuroimmune Investigation of an Endocrine-Disrupting Compound". *Department of Biology Seminar*, East Carolina University, Greenville, NC. 2013.

"A Neuroimmune Investigation of an Endocrine-Disrupting Compound: How Bisphenol A may Disrupt Learning and Memory through Immunomodulation." *Endocrine Disrupting Chemicals Forum*, Research Triangle Park, NC. 2013.

"Undecafluoro-2-methyl-3-oxahexanoic Acid Versus Perfluorooctanoic Acid: Is Polyfluorination a Less Immunotoxic Option than Perfluorination?" *Department of Environmental and Molecular Toxicology Seminar*, North Carolina State University, Raleigh, NC. 2013.

"Early Life Triggers of Developmental Immunotoxicity." *Society for Toxicologic Pathology*, Annual Meeting, Denver, CO. 2011.

"Is the Pathway to Autism Paved with Environmental Chemicals?" *Department of Comparative Medicine seminar*. East Carolina University, Greenville, NC. 2011.

"PPAR Involvement in PFAA Immunotoxicity." *U.S. EPA PFAA Days III Workshop*, U.S. Environmental Protection Agency, Research Triangle Park, NC. 2010.

"Are Environmental Contaminants (Developmental) Immunotoxicants? A Case Study of a Fluorinated Compound." *Department of Microbiology and Immunology Seminar*, East Carolina University, Greenville, NC. 2010.

"Developmental Immunotoxicity of PFOA, an Emerging Contaminant." *Department of Biology Seminar*, East Carolina University, Greenville, NC. 2009.

"The Immunotoxicity of Perfluorooctanoic Acid (PFOA)." *Department of Physiology Seminar*, Brody School of Medicine, East Carolina University, Greenville, NC. 2008.

"Immunotoxic Potentials of PFOA." *U.S. EPA PFAA Days II Workshop*, U.S. Environmental Protection Agency, Research Triangle Park, NC. 2008.

"Chasing Down the Mechanism of Perfluorooctanoic Acid-Induced Immunomodulation: Knock-outs and Adrenalectomies." *National Health and Environmental Effects Research Laboratory Work in Progress*, U.S. Environmental Protection Agency, Research Triangle Park, NC. 2007.

"Wildlife Immunotoxicology." Immunotoxicology course. College of Veterinary Medicine, North Carolina State University. 2006.

"Immunotoxicity of Individual Organotin Compounds in Sprague-Dawley Rats." *Society for Risk Analysis* 25th Annual Meeting, Orlando, FL. 2005.

"Immune Function in Rats Exposed to Organotins as Adults or During Development." *National Health and Environmental Effects Research Laboratory Work in Progress*, U.S. Environmental Protection Agency, Research Triangle Park, NC. 2005.

"Brain Asymmetry in Domestic Hatchling Chickens Developmentally Exposed to TCDD: A Histological Examination." *Society of Environmental Toxicology and Chemistry* 24th Annual Meeting, Austin, TX. 2003.

"Service Learning and Scientific Research." Indiana University Community Outreach and Partnerships in Service-Learning Workshop, Indiana University, Bloomington, IN. 2004.

"Toxic Effects of Mercury." Clean Air Indiana Speak out on the Clear Skies Initiative, Indiana University, Bloomington, IN. 2003.

"Environmental Health Concerns for Toxics in Indiana Superfund Sites." Indiana Public Interest Research Group (INPIRG) Teach-In on Indiana Superfund Issues, Indiana University, Bloomington, IN. 2002.

"Introduction to Environmental Toxicology." Techniques in Environmental Science and Environmental and People courses. School of Public and Environmental Affairs, Indiana University-Bloomington. 2000, 2001, 2003.

"Bioaccumulation and Biomagnification of Environmental Chemicals in Colonial Fish-eating Waterbirds." Introduction to Environmental Sciences course. School of Public and Environmental Affairs, Indiana University-Bloomington. 2000 and 2001.

"Women in the Sciences: Abolishing Gender Apartheid." IU Skills for Leadership Conference, Office of Women's Affairs, Indiana University, Bloomington, IN. 1999.

ORAL PRESENTATIONS

"Immunomodulation associated with perfluoroether acids, understudied PFAS." *Society of Environmental Toxicology and Chemistry Annual Meeting.* Virtual Meeting. November 10, 2021.

"Developing an Understanding of the Effects of PFAS on the Immature Immune System." *Symposium on Developmental toxicity of per- and polyfluoroalkyl substances (PFAS): Current in vivo approaches and application to human health risk assessment, Society of Toxicology Annual Meeting*, Virtual Meeting. 2020.

"Immunotoxicity Evaluation as a Tool for Protecting Public and Environmental Health from PFAS." *Society of Environmental Toxicology and Chemistry* 40th Annual Meeting, Toronto, Ontario. 2019.

"Immunotoxicological Findings of an Aqueous Film-Forming Foam Formulation." *Society of Environmental Toxicology and Chemistry annual meeting*, Sacramento, CA. 2018.

"Perspectives from the AAMC Mid-Career Women Faculty Professional Development Seminar "MIDWIMS"). *Brody Women Faculty Committee*. Greenville, NC. 2017.

"Immunopathogenesis in Autism: Regulatory T Cells and Markers of Autoimmunity in Mice Developmentally Exposed to Perflurooctanoic Acid (PFOA). *27th Annual NeuroToxicology Conference*, Annual Meeting, Durham, NC. 2011.

"PFOA-induced Immunomodulation in mice: An Overview." *Society of Toxicology* 48th Annual Meeting, Baltimore, MD. 2009.

"Pathways of PFOA-mediated Immunosuppression." *Society of Toxicology* 48th Annual Meeting, Baltimore, MD. 2009.

"Dose-response of Perfluorooctanoic Acid-Induced Immunomodulation in Adult C57BL/6 Mice." *Society of Toxicology* 46th Annual Meeting, Charlotte, NC. 2007.

"Immune Function in Rats Developmentally Exposed to Dibutyltin Dichloride." *Society of Toxicology* 45th Annual Meeting, San Diego, CA. 2006.
"Neurotoxic Effects in Avian Species: Implications for Human and Ecological Health." School of Public and Environmental Affairs *2nd Annual Young Researchers Conference*, Indiana University, Bloomington, IN. 2002.

"TCDD-Induced Brain Asymmetry and Behavior: What do Individual Chicks Have to Say?" *Ohio Valley Chapter of the Society of Environmental Toxicology and Chemistry*, Hueston Woods State Park, College Corner, OH. 2000.

"Behavioral and Morphological Changes in Domestic Chicks Exposed to TCDD or PCB-126 at Embryonic Day 0 or Embryonic Day 4." *Ohio Valley Chapter of the Society of Environmental Toxicology and Chemistry*, Indiana University, Bloomington, IN. 1997.

"Behavioral Changes in Domestic Hatchling Chicks Exposed to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD) *in ovo*." *Conference on Chlorine in the Environment*, Massachusetts Institute of Technology, Boston, MA. 1996.

"Behavioral Assessment of Hatchling Chicks Exposed to TCDD *in ovo*: Preliminary Results." *Great Lakes Bioeffects Workgroup*. Wright State University, Dayton, OH and *Ohio Valley Chapter of the Society of Environmental Toxicology and Chemistry*, Eastern Kentucky University, Richmond, KY. 1996.

CONTINUING EDUCATION COURSES

Mid-Career Women Faculty Leadership Development Seminar
Stress as a Confounding Factor in Toxicology Studies
Rodent Pathology (Immunopathology)
Basic Embryology and Developmental Toxicology

Grants 101: Professional Grant Writing Workshop
Immunology for Toxicologists
Risk Communication for the General Public
Estrogen Mimics in Health and Disease
Methods for Assessment of Neurotoxicity

PROFESSIONAL ORGANIZATIONS

2019-present	The Toxicology Forum
2017-2018	International Society of Exposure Science
2009-Present	Carolinas Society of Environmental Toxicology and Chemistry
2005-Present	Society of Toxicology (SOT)
2005-Present	North Carolina Chapter of the Society of Toxicology
1997-Present	Society of Environmental Toxicology and Chemistry (SETAC)
1996-2004	Ohio Valley Chapter of the Society of Environmental Toxicology and Chemistry
1996-2004	Great Lakes Bioeffects Workgroup

AWARDS AND HONORS

- *Public Communications Award*, Society of Toxicology. 2023.
- *Scholar-Teacher Award,* East Carolina University, Office of Faculty Excellence. 2021-2022.
- *Engagement and Outreach Scholars Academy Scholar*, East Carolina University, Office of Community Engagement and Research. 2019-2020.
- *The Faculty Mentor Award*, East Carolina University Honors College. 2017.
- *Outstanding Young Investigator Award*, Immunotoxicology Specialty Section, Society of Toxicology. 2013.
- *Outstanding Teaching Award*, School of Public and Environmental Affairs, Indiana University. 1999 and 2002.
- *Future Faculty Teaching Fellowship*, Preparing Future Faculty program, Indiana University. 2002.
- *Marian Vinegar Award*, Outstanding Student Presentation at the annual meeting, Ohio Valley Chapter of the Society of Environmental Toxicology and Chemistry. 2000.
- *Outstanding Educational Volunteer*, Monroe County Humane Association, Bloomington, IN. 2000.
- *Outstanding Student Poster Award*, Society of Environmental Toxicology and Chemistry 19th Annual Meeting (3rd place). 1998.
- *Teaching Excellence Recognition Award*, School of Public and Environmental Affairs, Indiana University. 1998.

PROFESSIONAL PRACTICE

IAFF Cancer Research Committee. 2022-present.

- Committee of the International Association of Fire Fighters (IAFF) charged with evaluating cancer research projects and providing insight to the IAFF's plan of action regarding cancer research.

U.S. Environmental Protection Agency PFAS Science Advisory Board. 2021-2022.

- External review board charged with reviewing draft documents developed by the US EPA to support National Primary Drinking Water Rulemaking for PFAS.

Flemish Parliamentary Committee of Inquiry PFAS-PFOS Testimony. 2021.

- Provided overview of human health effects of PFAS exposure with a focus on PFOS. July, 2021.

Guidance on PFAS Testing and Health Outcomes Community Liaison, National Academies of Science, Engineering, and Medicine (NASEM). 2021-2022.

- Community Liaisons charged with providing information to the Committee on various aspects of PFAS, including health and environmental effects as well as personal stories.

Emerging Science for Environmental Health Decisions Standing Committee Member, National Academies of Science, Engineering, and Medicine (NASEM). 2021-present.

- Charged with convening several workshops each year to explore how new scientific advances, technologies, and research methodologies could deepen understanding of effects of environment on human health.

North Carolina Secretaries Science Advisory Board Member, NC Department of Environmental Quality (DEQ) and NC Department of Health and Human Services (DHHS). 2019-present.

- Charged with advising the DEQ and DHHS on toxicological effects of contaminants and levels of control necessary for protection of human health and the environment.

North Carolina Cancer Advisory Research Panel Member, NC Policy Collaboratory. 2019-2020.

- Charged by the NC General Assembly with recommending strategies for assessing cancer incidence and mortality rates with respect to temporal and spatial patterns within NC.

Tennessee PFAS External Advisory Group Member, Tennessee Departments of Environment and Conservation and Health. 2019-present.

- Charged with informing the state of Tennessee about PFAS, including compound characteristics, identification, sampling and measurement, remediation, etc.

U.S. House of Representatives Congressional Testimony. 2019, 2021.

- Committee on Energy and Commerce, *Subcommittee on Environment and Climate Change*, "Protecting Americans at Risk of PFAS Contamination and Exposure." May 15, 2019.
- Committee on Oversight and Reform, *Subcommittee on Environment*, "The Devil they Knew – PFAS Contamination and the Need for Corporate Accountability." July 24, 2019.
- Committee on Appropriations, *Subcommittee on Military Construction, Veterans Affairs, and Related Agencies,* "Remediation and Impact of PFAS." March 24, 2021.

Michigan Science Advisory Workgroup Member, Michigan PFAS Action Response Team (MPART). 2019.

- Charged with advising the state of Michigan on Maximum Contaminant Level recommendations for PFAS.

PFAS Testing Network Executive Advisory Committee Member and Team 5 Co-Lead, NC Policy Collaboratory. 2018-present.

- Responsible for advising the Network on addressing occurrence and effects of PFAS in drinking water resources in the state of NC.

- Responsible for co-leading Team 5 (with Dr. Rebecca Fry from University of North Carolina at Chapel Hill) charged with addressing "other research opportunities" for understanding PFAS in NC.

Workshop Participant, Sustainability consequences of chemical exposures: connecting environment, health, and economic assessments. Organized by the European Environmental Agency, Copenhagen, Denmark. June 2018.

- Panelist representing the toxicological sciences.

Global PFAS Science Panel Member. Established from the co-authors of the Zurich Statement (Ritscher et al., 2018). 2017-present.

- Group of academic and government scientists dedicated to fostering development of high-quality scientific research, stewarding information exchange, and coordinating advancement of science and policy to address the class of per- and polyfluoroalkyl substances (PFASs) as a global concern.

Plaintiff Expert Witness, various legal firms, to provide toxicological expertise regarding per- and polyfluoroalkyl substances (PFAS). 2016-present.

- Involved in several settled and ongoing cases involving personal injury, class action, and public utilities across different sites within the U.S. Provide expert reports. Have been deposed in several cases but have not yet testified in a court of law.

Pro-bono Consultation, various environmental protection and advocacy organizations, 2015-present.

- Provide scientific interpretation and opinion regarding toxicity of per- and polyfluoroalkyl substances to individual community members as well as organizations.
- Organizations include *California Environmental Protection Agency, Cape Fear Public Utility Authority, Center for Environmental Health, Green Science Policy Institute, Massachusetts Toxic Use Reduction Program, Silent Spring Institute, Toxic Free Future, Amigos Bravos, and other community-based and occupationally-based organizations.*

Workshop Participant, Is the European Food Safety Authority (EFSA) standard for bisphenol A sufficiently protective of the immune system and should the Dutch government consider a different standard? Organized by representatives of RIVM (National Institute for Public Health and the Environment), Amsterdam, The Netherlands. September 2015.

- Provided immunotoxicological guidance for regulatory consideration of bisphenol A (BPA).

Consultant, CZR Incorporated, Wilmington, NC. May-July, 2014-2019.

- Provided toxicological interpretation of stream water quality monitoring data for heavy metals.

Technical Advisor, Office of Health Assessment and Translation (OHAT), National Toxicology Program, National Institute of Environmental Health Sciences. March 2013. March 2015. April 2016.

- Evaluated OHAT protocol for evaluation of PFOS-PFOA immunotoxicity.

External Peer Reviewer, U.S. Environmental Protection Agency, External peer review of EPA's Draft Health Effects Documents for Perfluorooctanoic acid (PFOA) and Perfluorooctane Sulfonate (PFOS). 2014.

- Scientific peer reviewer of the health effects documents. Nominated and selected.

Working Group Member, International Agency for Research on Cancer (IARC), IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Volume 110: Perfluorooctanoic acid, Tetrafluoroethylene, Dichloromethane, 1,2-Dichloropropane, and 1,3-Propane sultone. 2014.

- Member of Mechanistic and Other Relevant Data Working Group for perfluorooctanoic acid and tetrafluoroethylene. Invited.

Consultant, Constella Group, LLC, Durham, NC. October 2004-December 2005.

- Summarized immunotoxicology of atrazine for the National Toxicology Program's Report on Carcinogens.

Consultant, Henshel EnviroComm, Bloomington, IN. June 1999-May 2004.

- Representative of the Restoration Advisory Board for Jefferson Proving Ground (Department of Defense) through the Technical Assistance for Public Participation program.
- Interpreted risk assessment documents associated with base clean-up for the general public.

Consultant, Dinosaur Inc., Bloomington, IN. June 2000-September 2000.

- Summarized the potential health and environmental effects of land-applied paper mill sludge.

Consultant, Integrated Pest Management in Schools and Childcare Centers, School of Public and Environmental Affairs Information Clearinghouse, Bloomington, IN. April 2000-September 2000.

- Summarized the potential health effects of pesticides commonly used in schools and childcare centers.

Co-Director, *Summer Program for Exploration of Complex Issues in Environmental Science for Teachers (SPECIES-Teachers)* and *Environmental Education 99*, School of Public and Environmental Affairs, Indiana University, Bloomington, IN. Summer 1999 and 2001.

- Directed hands-on environmental science summer field workshop for Indiana teachers.

Consultant, Brownstown Elementary Fourth Grade, Brownstown, IN. September 1999-May 2000.

- Served as environmental science expert during weekly videoconferences in a "students as environmental scientists" program.

Associate Director, *Research Experience for High School Students*, College of Arts and Sciences, Indiana University, Bloomington, IN. February 1999-October 1999.

- Mentored high school students participating in research in university laboratories, provided weekly counseling, and oversaw development of final research reports and presentations.

Co-Director, *Environment 98* and *Environment 99*, School of Public and Environmental Affairs, Indiana University, Bloomington, IN. Summer 1998 and 1999.

- Directed hands-on environmental science summer field workshop for Indiana students.

Chemical Safety Assistant, Office of Radiation, Chemical and Biological Safety, Michigan State University, East Lansing, MI. August 1993-June 1995.

- Developed Michigan State University's Chemical Hygiene Plan, performed university-wide laboratory safety inspections, and trained new science employees in chemical and laboratory safety.

TEACHING EXPERIENCE

Instructor, East Carolina University

- Foundations in Biomedical Science. Graduate (topical: drug safety, endocrine pharmacology, toxicology). 2020-present.
- Pandemic Crisis Management. Third year medical students (small group facilitator). 2020.
- Practical Problems in Biometry. Graduate (course director). 2010-present (co-director 2021).
- General Toxicology. Graduate (course co-director). 2009-present.
- Advanced Toxicology. Graduate (course co-director). 2016-present.
- Medical Pharmacology. Graduate physician assistant students (topical: endocrine pharmacology, toxicology). 2010-2018.
- Medical Pharmacology. Second year medical students (topical: endocrine pharmacology, toxicology). 2012-present.
- Pharmacology Mini-Course. First and second year dental students (topical: toxicology, management of poisoned patients, endocrine pharmacology, pharmacokinetics I & II; variable and shared among other instructors). 2012-present.
- Foundations of Medicine/Problem Based Learning Mini-Course. First and second year medical students (small group facilitator). 2011-2013.
- Foundations of Medicine/PirateMD. First and second year medical students (small group facilitator). 2013-2019.

Instructor, Indiana University

- Analytical Problem Solving (statistics). Undergraduate, honors, 2 semesters.
- Environment and People. Undergraduate (co-instructor), 1 semester.
- Introduction to Statistical Techniques. Undergraduate, 1 semester.
- Introduction to Environmental Sciences. Undergraduate, 1 semester.
- Environmental Risk Analysis. Graduate, 1 semester.
- Outdoor Environmental Awareness (Public land management). Undergraduate recruitment course, 6 semesters.
- Introduction to Risk Assessment and Risk Communication. Undergraduate, 1 semester.
- Environmental Toxicology. Combined undergraduate/graduate, 1 semester.
- Techniques in Environmental Science (field/lab techniques). Undergraduate, 3 semesters.

Teaching Assistant/Coordinator, Indiana University

- Aquatic Habitat Analysis (field techniques). Combined undergraduate/graduate, 3 semesters.
- Terrestrial Habitat Analysis (field techniques). Combined undergraduate/graduate, 3 semesters.
- Environmental Toxicology. Undergraduate and graduate, 3 semesters.
- Teaching Assistant and Undergraduate Teaching Intern Training Workshop. Combined undergraduate and graduate, 6 sessions.

Laboratory Mentor, East Carolina University

High school students

- Megan McKeel, Medical Honors Program (high school laboratory research). Project: Developmental effects of PFAS in a rodent model. 2021-2022.

- Abigail Yoon and Andrew Gallagher, Medical Honors Program (high school laboratory research). Project: Body and liver weight changes in rodents exposed to a binary PFAS mixture (virtual). 2020-2021.
- Javier Limon and John Mallett, Medical Honors Program (high school laboratory research). Project: Liver lipid accumulation in livers from rodents exposed to PFAS. 2019-2020.
- Catherine Wondra and Anushka Nandy, Summer Ventures Program (high school laboratory research). Project: Liver lipid accumulation in livers from rodents exposed to PFAS. 2019.
- Alex Beaver and Margarita Anayiotou, Summer Ventures Program (high school laboratory research). Project: Neuroinflammation in a rodent model of Gulf War Illness. 2018.
- Allison Gallagher and Sophie Villani, Medical Honors Program (high school laboratory research). Project Developmental effects of pharmaceutical pollutants in an avian model. 2017-2018.
- Sunnie Li and Alex Reulbach, Summer Ventures Program (high school laboratory research). Project: Neuroinflammation in a rodent model of Gulf War Illness. 2017.
- Matthew Clayton, high school laboratory research for the NC Science Fair. Project: Developmental effects of pharmaceutical pollutants in an avian model. 2016.
- Virginia Billings, Summer Ventures Program (high school laboratory research). Project: Developmental effects of pharmaceutical pollutants in an avian model. 2016.
- Jaein Yoon, Medical Honors Program (high school laboratory research). Project: Developmental effects of pharmaceutical pollutants in an avian model. 2015-2016.
- Chevonne Parker, Summer Ventures Program (high school laboratory research). Project: Neuronal T-cell infiltration following developmental trichloroethylene exposure. 2015.
- Catherine Taylor and Jessi Zhou, Medical Honors Program (high school laboratory research). Project: Microglial responses in an Alzheimer's mouse model developmentally exposed to lead. 2014-2015.
- Janelle Neal, Summer Ventures Program (high school laboratory research). Project: Microglial responses following inhalation exposure to natural dusts. 2014.
- Brian Alloway, Medical Honors Program (high school laboratory research). Project: Peroxisome proliferation in livers of C57BL/6 mice exposed to undecafluoro-2-methyl-oxahexanoic acid (U2M3-OHxA) gavage. 2013-2014.
- Kortney Wager, Summer Ventures Program (high school laboratory research). Project: Developmental effects of BPA on immune responses. 2013.
- Brian Ennis and Jonathan Reed, Medical Honors Program (high school laboratory research). Project: Teratogenicity of PFOS in early chicken embryos. 2012-2013.
- Willa Chen, Summer Ventures Program (high school laboratory research). Project: Developmental effects of PFOA in primary cardiomyocyte cultures from chickens. 2012.
- Elizabeth Fox and Samantha Rouse, Medical Honors Program (high school laboratory research). Project: Teratogenicity of PFOS in early chicken embryos. 2011-2012.
- Pranavi Sanka, Summer Ventures Program (high school laboratory research). Project: Developmental effects of PFOS: T cell infiltration into mouse brains. 2011.
- Erin Morris and Andrew Wood, Medical Honors Program (high school laboratory research). Project: Developmental effects of PFOA on T cell infiltration and myelin basic protein levels in mouse brains. 2010-2011.
- Jillian Loftis, Summer Ventures Program (high school laboratory research). Project: Developmental effects of PFOA on glycogen deposition in a chicken model. 2010.
- Clarissa Morrissey, Medical Honors Program (high school laboratory research). Project: Teratogenicity of PFOA in early chicken embryos. 2009-2010.
- Taylor Brundage, Summer Ventures Program (high school laboratory research). Project: Developmental teratogenic effects of PFOA in a chicken model. 2009.
- Ian Bryan, Medical Honors Program (high school laboratory research). Project: Developmental effects of PFOA on liver glucocorticoid receptor levels, and pancreatic alpha and beta cells in a mouse model. 2008-2009.

Undergraduate students

- Sadie Graham, Biology (undergraduate laboratory research): Peroxisome proliferation following PFAS exposure in a rodent model. 2023.
- Jessica Bartram and Yveonna West, Program in Neuroscience (undergraduate laboratory research): Neurotoxic effects of PFAS in a rodent model. 2022-2023.
- Megan Harmon, Biology (undergraduate laboratory research): PFAS neurobehavioral effects. 2021-2023.
- Nia Moore, Summer Biomedical Research Program and Public Health (undergraduate laboratory research). Project: Developmental immunotoxicity of PFAS in rodent model. 2022-present.
- Matthew Wittenborn, Biology (undergraduate laboratory research): Quality assurance and quality control. 2021-2022. NCBC intern 2022-present.
- Olivia Glazer, Program in Neuroscience (undergraduate laboratory research): Inflammatory biomarkers in a rodent model of Gulf War Illness. 2021-2023.
- Cierra Robbins, and Mackenzie Morrow, Program in Neuroscience (undergraduate laboratory research): Inflammatory biomarkers in a rodent model of Gulf War Illness. 2021-2022.
- Jasmine Clark, University Studies (undergraduate laboratory research): PFAS as air pollutants. 2019-2021.
- Jeffery Ayala, and Mark Ibrahim, Program in Neuroscience (undergraduate laboratory research): Microglial morphology in a rodent model of Alzheimer's disease. 2018-2021.
- Payton Anders, Jeffery Ayala, and Mark Ibrahim, Program in Neuroscience (undergraduate laboratory research): Microglial morphology in a rodent model of Alzheimer's disease. 2018.
- Alexis Liberatore, Program in Neuroscience (undergraduate laboratory research): Glucocorticoid receptor expression in avian brains following developmental exposure to pharmaceutical pollutants. 2018-2019.
- Kathleen Ferris, Biology (undergraduate laboratory research): Peroxisome proliferation in livers of rodents exposed to aqueous film forming foam. 2018-2019.
- Robert Strickland, General Studies/Program in Neuroscience (undergraduate laboratory research). Project: Neuroinflammation in a rodent model of Gulf War Illness. 2017.
- Chastity Ward, Summer Biomedical Research Program (undergraduate laboratory research). Project: Immunotoxic effects of AFFF in a rodent model. 2017.
- Christopher Hamby, Mutidisciplinary Studies Program in Neuroscience (undergraduate laboratory research/senior thesis advisor). Project: Microglial morphology in a rodent model of Gulf War Illness. 2016-2017.
- Ishmael Gomez, Summer Biomedical Research Program (undergraduate laboratory research). Project: DAP12 microglial signaling in a rodent model of Alzheimer's disease. 2016.
- Brianna Davidson, Multidisciplinary Studies Program in Neuroscience (undergraduate laboratory research). Project: Synaptic degeneration in a rodent model of Alzheimer's disease. 2016.
- Samuel Vance, Mutidisciplinary Studies Program in Neuroscience (undergraduate laboratory research/senior thesis advisor). Project: Project: Post-translational modifications and Alzheimer's pathology. 2015-2017.
- Waeya Lin, Summer Biomedical Research Program (undergraduate laboratory research). Project: Exacerbation of Alzheimer's pathology by prenatal exposure to lead; Dystrophic microglia. 2015.
- Giovana Fernanda Cosi Bento, Brazil Scientific Mobility Program (undergraduate laboratory research). Project: Exacerbation of Alzheimer's pathology by prenatal exposure to lead; Synaptosomes. 2015.
- Zoe Hinton, Mutidisciplinary Studies Program in Neuroscience (undergraduate laboratory research/senior thesis advisor). Project I: Exacerbation of Alzheimer's pathology by prenatal

exposure to lead; Synaptosomes. 2015. Project II: Microglial morphology in a rodent model of Gulf War Illness. 2016-2017.

- Andrew Wood, Biology (undergraduate honors thesis advisor). Project: Exacerbation of Alzheimer's pathology by prenatal exposure to lead; Measurement of amyloid beta. 2014-2015.
- Dakota Johnson, Biology (undergraduate honors thesis advisor). Project: Exacerbation of Alzheimer's pathology by early-life exposure to lead; Measurement of amyloid beta. 2013-2014.
- Sydney Henry, Summer Biomedical Research Program (undergraduate laboratory research). Project: Neurotoxic effects of dust collected from the Nellis Dunes Recreation Area. 2014.
- Andrew Wood, Biology undergraduate student. Project: Developmental effects of BPA on serum IL-4 and IgG. 2013.
- Dominique Baldwin, Biology undergraduate student. Project: Neurotoxic effects of dust collected from the Nellis Dunes Recreation Area. 2013.
- Megan Biller, Summer Biomedical Research Program (undergraduate laboratory research). Project: Microglia in Alzheimer's-prone triple transgenic mice. 2013.
- Blake Rushing, Summer Biomedical Research Program (undergraduate laboratory research). Project: Blood distribution, urinary excretion, and T cell-dependent immunotoxicity of undecafluoro-2-methyl-oxahexanoic acid (U2M3-OHxA) in C57BL/6 mice exposed via gavage. 2012.
- Alvin-Ming-Yun Tsang, Psychology (undergraduate honors thesis advisor). Project: Developmental effects of nanoparticles in a rodent model. 2011-2012.
- Nick Creech, Summer Biomedical Research Program (undergraduate laboratory research). Project: Immunological effects of PFOA on a T-cell independent antigen (DNP-Ficcol) in an adult mouse model. 2010-2011.
- Hatel Patel, Biochemistry undergraduate student. Project 1: Developmental effects of PFOA on liver peroxisomes proliferation in a chicken model. Project 2: Effects of PFOA on myelin basic protein levels in the brains of developmentally-exposed mice. 2009.
- Ian Bryan, Biology and Chemistry undergraduate student. Project: Developmental effects of PFOA and PROS in a chicken model, including early embryo teratogenesis and hatchling glycogen levels. 2009-2012.

Master's students

- Kellyn Trowse, Biomedical Sciences Master's Student. Project: Developmental neurotoxic effects of PFAS. 2023-.
- Erica Stewart, Biomedical Sciences Master's Student. Project: Developmental immunotoxicological effects of PFAS. 2020-2021.
- Emma Tobin, Biomedical Sciences Master's Student. Project: Immunotoxicological effects of PFAS of emerging concern in the Cape Fear River. 2019-2021.
- Samuel Vance, Biomedical Sciences Master's Student. Project: Immunotoxicological effects of PFMOAA, a contaminant of emerging concern in the Cape Fear River. 2018-2019.
- Carmen Davis, Environmental Health Master's Student. Project: Developmental effects of Triclosan in an avian model. 2015-2016.
- Cory Boles, Biomedical Sciences Master's Student. Project: Exacerbation of Alzheimer's pathology by early-life exposure to lead. 2013-2015.
- Annalise vonderEmbse, Biomedical Sciences Master's Student. Project: Exacerbation of Alzheimer's pathology by early-life exposure to lead; Effects on microglia. 2012-2014.

Doctoral students

- Aya Ahmed, Interdisciplinary Doctoral Program in Biology, Biomedicine, and Chemistry Ph.D. Student. Project: B-cell bioenergetics and antibody production. 2022-

- Krystal Taylor, Pharmacology and Toxicology Ph.D. Student. Project: Mechanisms of B-cell directed immunotoxicity of PFAS. 2020-.
- Jacqueline Meadows, Pharmacology and Toxicology Ph.D. Student. Project: Developmental effects of pharmaceutical pollutants in an avian model. 2015-2019.
- Annalise vonderEmbse, Pharmacology and Toxicology Ph.D. Student. Project: Exacerbation of Alzheimer's pathology by early-life exposure to lead; Effects on microglia. 2014-2017.
- Jason Franklin, Pharmacology and Toxicology Ph.D. Student. Project: Developmental neuroimmunotoxicity of bisphenol a in a rodent model. 2010-2014.
- Qixiao Jiang. Pharmacology and Toxicology Ph.D. Student. Project: Developmental cardiotoxicity of perfluorinated compounds in an avian model. 2009-2013.
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Medical students

- Amie McPherson and Danesh Ghiassi, Medical students. Project: Isolation and stimulation of regulatory T cells from spleens of PFOA-exposed mice. 2009.

Postdoctoral Scholars

- Dr. Drake Phelps. Project: Immunotoxicological mechanisms of PFAS. 2023-present.
- Dr. Tracey Woodlief. Project: Immunotoxicological mechanisms of PFAS. 2019-2020.

Research Instructor

- Dr. Tracey Woodlief. 2021-present.

Advisory, East Carolina University

- Maddison Salois, Biochemistry and Molecular Biology Ph.D. Student (Dissertation committee; Advisor: Maranke Koster). 2022-
- Alexander Bastian, Microbiology and Immunology Ph.D. Student (Dissertation committee; Advisor: Mark Mannie). 2022.
- Hannah Woolard, Physiology/ Biomedical Sciences Master's Student (Thesis committee; Advisor: Stefan Clemens). 2021.
- Valeria Fuentes, Chemistry Master's Student (Thesis committee, Advisor: Eli Hvastkovs). 2021-2022.
- Mandee Schaub, Physiology/Biomedical Sciences Master's Student (Thesis committee; Advisor: Stefan Clemens). 2021-2022.
- Sarah Lowe, Microbiology and Immunology Ph.D. Student (Dissertation committee; Advisor: Michelle Ratliff). 2021-present.
- Cody Hatchet, Biochemistry/Biomedical Sciences Master's Student (Thesis committee; Advisor: Ruth Schwalbe). 2020-2021.
- David Ogden, Internal Medicine/Biomedical Sciences Master's Student (Thesis committee; Advisor: Mary Jane Thomassen). 2021.
- Rebecca Nickle, Microbiology and Immunology Ph.D. Student (Dissertation committee; Advisor: Mark Mannie). 2020-2021.
- Rohan Parek, Pharmacology & Toxicology Ph.D. Student (Dissertation committee, Advisor: Srinivas Sriramula). 2019-2022.
- Christopher Norton, Microbiology and Immunology Master's Student (Thesis committee; Advisor: Isabelle Lemasson). 2019-2020.
- Danielle Dillane (Carter), Public Health Ph.D. Student (Dissertation committee; Advisor: Jo Anne Balanay). 2020-2022.
- Heidi Knecht and Danielle Carter, Public Health Ph.D. Students (Dissertation committee; Advisor: Stephanie Richards). 2018-2020.
- Megan Rhyne, Environmental Health and Health Education & Promotion Master's Student (Thesis committee; Advisor: Stephanie Richards). 2018.

- Dariel Hopersberger, Microbiology and Immunology Ph.D. Student (Dissertation committee; Advisor: Marty Roop). 2018-2022.
- Alexandra Hayes, Microbiology and Immunology Master's Student (Thesis committee; Advisor: Rachel Roper). 2018-2019.
- Kayla DeOca, Microbiology and Immunology Ph.D. Student (Dissertation committee; Advisor: Mark Mannie). 2018-2021.
- Henry Raab, Coastal Resource Management Ph.D. Student (Dissertation committee; Advisor: Joe Luczkovich). 2017-2020.
- Ariel Myers, Pharmacology and Toxicology Ph.D. Student (Dissertation committee; Advisor: Rukiyah Van Dross). 2017-2022.
- Khoa Do, Biomedical Sciences Master's Student (Thesis committee; Advisor: Hu Huang). 2016-2017.
- John Atkinson, Biology Master's Student (Thesis committee; Advisor: David Rudell). 2015-2016.
- Blake Rushing, Pharmacology and Toxicology Ph.D. Student (Dissertation committee; Advisor: Mustafa Selim). 2015-2018.
- Ahmed Aldhafiri, Pharmacology and Toxicology Ph.D. Student (Dissertation committee; Advisor: Ken Soderstrom). 2014-2019.
- Jason Hoggard, Biomedical Sciences Master's Student (Thesis committee; Advisor: Lance Bridges). 2014-2015.
- Matthew Edwards, Biology Master's Student (Thesis committee; Advisor: Krista McCoy). 2014-2015.
- Bevin Blake, Biology Master's Student (Thesis committee; Advisor: Krista McCoy). 2013-2015.
- Anastasia Weeks, Microbiology and Immunology Master's Student (Thesis committee; Advisor: Mark Mannie). 2013-2017.
- Samar Rezq, Pharmacology and Toxicology Ph.D. Student (Dissertation committee; Advisor: Abdel Abdel-Rahman). 2013-2016.
- Partha Nagchowdhuri, Pharmacology and Toxicology Ph.D. Student (Dissertation committee; Advisor: Brian McMillen). 2013-2018.
- Suelen Demor, Biology Ph.D. Student (Dissertation committee; Advisor: David Chalcraft). 2013-2017.
- Tessa Holland, Pharmacology and Toxicology Ph.D. Student (Dissertation committee; Advisor: Ken Soderstrom). 2013-2019.
- Samantha Sellers, Anatomy and Cell Biology Ph.D. Student (Dissertation committee). 2013.
- Alvin Ming-Yun Tsang, Psychology Undergraduate Student (Honors Thesis Advisor). 2011-2012.
- Abdullah Aldossari, Pharmacology and Toxicology Ph.D. Student (Dissertation committee; Advisor: Jared Brown). 2011-2018.
- Michael Smith, Biology Master's Student (Thesis committee; Advisor: Xiaoping Pan). 2010-2011.
- Pranita Katwa, Pharmacology and Toxicology Ph.D. Student (Dissertation committee; Advisor: Jared Brown). 2009-2012.

PROFESSIONAL SERVICE

Scientific Community

- Society of Toxicology Membership Committee, 2022-present.
- Co-Chair, Timing is Everything: Developmental Exposure Alters the Path of Immune Cell Maturation and Function continuing education course. 2020 Annual Meeting, Society of Toxicology, Virtual.

- Society of Toxicology Faculty United for Toxicology Undergraduate Recruitment and Education (FUTURE) Committee. 2019-2022.
- Past-President, Society of Toxicology Immunotoxicology Specialty Section. 2019-2020.
- Chair, Program Planning Committee, The Toxicology Forum 45th Annual Summer Meeting (2019), Alexandria, VA.
- Co-Chair, Advanced Immunotoxicity Testing continuing education course. 2019 Annual Meeting, Society of Toxicology, Baltimore, MD.
- President, Society of Toxicology Immunotoxicology Specialty Section. 2018-2019.
- Co-Chair, Introduction to Immunotoxicity Testing continuing education course. 2018 Annual Meeting, Society of Toxicology, San Antonio, TX.
- Society of Toxicology Career Resource and Development Committee. 2018-2019.
- Society of Toxicology Specialty Section Collaboration and Communication Group. 2017-2019.
- Vice-President, Society of Toxicology Immunotoxicology Specialty Section. 2017-2018.
- Program Planning Committee, Volunteers Sub-committee, 2017 Annual Meeting, Society of Environmental Toxicology and Chemistry. 2016-2017.
- Vice-President Elect, Society of Toxicology Immunotoxicology Specialty Section. 2016-2017.
- Program Committee, Society of Toxicology Immunotoxicology Specialty Section. 2015-2016.
- Moderator for Toxicology, Epidemiology, and Human Health session, FLUOROS 2015 meeting, Golden, CO. 2015.
- Program Planning Committee, 2015 Annual Meeting, Society of Environmental Toxicology and Chemistry. 2014-2015.
- Senior Councilor, Immunotoxicology Specialty Section Society of Toxicology. 2014-2015.
- Past-President, North Carolina Society of Toxicology. 2014-2015.
- Junior Councilor, Immunotoxicology Specialty Section Society of Toxicology. 2013-2014.
- President, North Carolina Society of Toxicology. 2013-2014.
- Research Funding Committee, Society of Toxicology. 2012-2014.
- Vice President, North Carolina Society of Toxicology. 2012-2013.
- Vice President-Elect, North Carolina Society of Toxicology. 2011-2012.
- Program Committee, Society of Toxicology Immunotoxicology Specialty Section. 2010-2011.
- Councilor, North Carolina Society of Toxicology. 2009-2011.
- Workshop co-chair and organizer, "Is Modulation of the Immune System by Perfluoroalkyl Acids a Human Health Concern?" Society of Toxicology Annual Meeting, Baltimore, MD. 2009.
- Symposium co-chair and organizer, "Immune Biomarkers in Alternative Species: Implications for Risk Assessment," Society of Toxicology Annual Meeting, Charlotte, NC. 2007.
- Platform session co-chair, "Immunotoxicology: Immune Modulation and Cell Specific Responses," Society of Toxicology Annual Meeting, Charlotte, NC. 2007.
- Postdoctoral Representative and Program Committee member, Immunotoxicology Specialty Section of the Society of Toxicology. 2005-2007.
- Mentor, Association of Women in Science Program (WISP) Mentoring Project, Office of Women's Affairs, Indiana University, Bloomington, IN. 2000-2002.
- Student Board Member, Ohio Valley Chapter of Environmental Toxicology and Chemistry. 2000-2001.

Workplace Community

- Interim Director of Postdoctoral Affairs, Office of Postdoctoral Affairs, Division of Research, Economic Development and Engagement, 2023-present.
- BSOM Promotion and Tenure Committee, 2020-present.
- Department of Comparative Medicine Promotion and Tenure Committee Chair, 2020-present.
- Department Pharmacology & Toxicology Personnel Committee Chair, 2019-present

- Faculty Research Advisory Committee, Division of Research, Economic Development and Engagement, 2019-2021.
- Vice-Chair, Institutional Animal Care and Use Committee, 2019-present.
- BSOM Research Committee, 2019-present.
- Diversity and Equity Leadership Program, Division of Research, Economic Development and Engagement, 2019.
- Postdoctoral Program Liaison, Office of Postdoctoral Affairs, Division of Research, Economic Development and Engagement, 2019-2022.
- LCME Steering Committee and Co-Chair of Academic Environment Sub-Committee, Brody School of Medicine, 2018-2019.
- Department of Comparative Medicine Promotion and Tenure Committee, 2017-present.
- Coastal Strategic Planning Committee, 2016-2017.
- BSOM Promotion and Tenure Committee, 2015-2018.
- Secretary/Treasurer, Brody Women Faculty Committee, 2015-2017.
- Planning committee for the joint PhD program in Integrated Coastal and Marine Sciences, 2015-2017.
- School of Dental Medicine Admissions Committee, 2014-2018.
- BSOM Sustainability Committee, 2014-2016.
- Committee member, BSOM Research Committee, 2014-2015.
- Five-Year Review Committee for Dean Paul Cunningham, Dean of the Brody School of Medicine (appointed by the Vice Chancellor for Health Sciences). 2014.
- Institutional Animal Use and Care Committee. 2013-present.
- M1 Curriculum Committee, Brody School of Medicine, East Carolina University. 2013-2016.
- Master Educator Committee, Brody School of Medicine, East Carolina University. 2012-2016.
- Chair, Brody Women Faculty Committee. 2012-2013.
- Brody Vision, Innovation, Achievement (VIA) group. 2011-2015.
- Undergraduate Research and Creative Activity Biomedical Sciences Grant Review Committee. 2011-2018.
- Chair-elect, Brody Women Faculty Committee. 2011-2012.
- Coastal Maritime Council, East Carolina University. 2010-present.
- Five-Year Review Committee for Dr. David Taylor, Chair of the Department of Pharmacology and Toxicology (appointed by the Dean of the School of Medicine). 2010.
- Shared Resources Committee, Brody School of Medicine, East Carolina University. 2008-2012.
- Faculty of the Interdisciplinary Doctoral Program in Biological Sciences, East Carolina University. 2009-present.
- Brody Women Faculty Committee, East Carolina University. 2008-present.
- Graduate Faculty, Division of Research and Graduate Studies, East Carolina University. 2008-present.
- Vice-President and at-large member, EPA RTP Networking and Leadership Training Organization, USEPA. 2004-2008.
- Organizing Committee, 2007 NIEHS Biomedical Career Fair. 2006-2007.
- Vice-chair, Environmental Science program representative, Association of SPEA Ph.D. Students, School of Public and Environmental Affairs, Indiana University. 2001-2002.
- Environmental Science program representative, Dean's Student Advisory Committee, School of Public and Environmental Affairs, Indiana University. 1997-2002.

Other

- Science Olympiad (regional) Event C-Coordinator, "Potions and Poisons." 2018, 2019.
- Science Event Co-Coordinator, "ADdMe to Tox Town," Girl Scouts TechnoQuest Event. 2017.
- Science Event Co-Coordinator, "Biometry in Action," Brody Girl's STEM Day. 2016.

- Science Event Coordinator, “The Water Cycle,” Youth Ocean Conservation Summit. 2016.
- STEM volunteer, various events, Love a Sea Turtle, NC Estuarium Sound Rivers. 2015-present.
- Science Event Coordinator, “Marshmallow Genetics” and “DNA Necklaces,” ECU Girl’s STEM Day. 2014-2016.
- Scientific Expert, Alzheimer’s North Carolina fundraising walk, Washington, NC. 2014-2016.
- Über Judge, Blue Heron Bowl, Regional Competition for the National Ocean Sciences Bowl. 2012.
- Judge, North Carolina Region 1 Science and Engineering Fair. 2010. 2011.
- North Carolina Estuarium Docent. 2009-present.

Drake Phelps, PhD

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ORCiD: 0000-0001-8350-5626

Education

NORTH CAROLINA STATE UNIVERSITY
RALEIGH, NC | AUGUST 2017 TO AUGUST 2022

- Doctor of Philosophy in Comparative Biomedical Sciences with Concentration in Immunology.
- Dissertation title: "Investigating the Neutrophil Respiratory Burst as a Target of Xenobiotics"
- Minor in Biotechnology

NORTH CAROLINA STATE UNIVERSITY
RALEIGH, NC | AUGUST 2012 TO DECEMBER 2015

- Bachelor of Science in Microbiology.
- Minors in Biotechnology and French Language.
- Cumulative GPA of 3.88. Summa Cum Laude honors, Dean's List.

DANVILLE COMMUNITY COLLEGE
DANVILLE, VA | AUGUST 2010 TO JULY 2012

- Associate of Arts and Sciences.
- Cumulative GPA of 4.0. Summa Cum Laude honors, Good Standing, President's Honors List.

Experience and Employment

POSTDOCTORAL RESEARCH SCHOLAR | EAST CAROLINA UNIVERSITY | GREENVILLE, NC
MARCH 2023 TO PRESENT

- Research mentor: Dr. Jamie DeWitt
- Currently working to characterize adverse immunotoxic outcomes in mice developmentally exposed to per- and polyfluoroalkyl substances (PFAS) as well as determining the microglial contribution to the development of Gulf War Illness
- Gaining proficiency in mouse handling, husbandry, gavaging, and necropsy as well as performing enzyme-linked immunosorbent assays (ELISAs) for measuring the T cell-dependent antibody response (TDAR) and cytokine expression

INDEPENDENT CONSULTANT | FOOD PACKAGING FORUM FOUNDATION | ZURICH, SWITZERLAND
NOVEMBER 2022 TO MARCH 2023

- Conducted a systematic literature review as part of AURORA to determine the contribution of food contact materials and food contact articles to the presence of micro- and nanoplastics in food
- Conducted a systematic literature review to update FCCmigex, a database and online resource to identify chemicals found in food contact materials and food contact articles

- Collaborated as part of an interdisciplinary team to perform screening of titles, abstracts, and full-texts of peer-reviewed literature and to extract data from screened literature
- Gained proficiency in conducting systematic reviews and relevant online tools, such as Cadima, SciExtract, and Tagtog

POSTDOCTORAL RESEARCH SCHOLAR | NORTH CAROLINA STATE UNIVERSITY | RALEIGH, NC
APRIL 2022 TO SEPTEMBER 2022

- Research mentor: Dr. Jeffrey Yoder
- Collaborated with another postdoctoral researcher to develop high-throughput cytolysis assays in human Natural Killer cell lines
- Performed acellular, enzymatic assays to determine how chemical exposure impacts enzyme function using an enzyme purified from human neutrophils
- Collaborated with an undergraduate student to develop a high-throughput infection model in larval zebrafish
- Gained proficiency in maintaining transgenic human cell lines, NK cell cytolysis assays, high-throughput luminometric measurements, infecting larval zebrafish with bacterial pathogens, high-throughput functional enzyme-based assays

GRADUATE RESEARCH ASSISTANT | NORTH CAROLINA STATE UNIVERSITY | RALEIGH, NC
JANUARY 2017 TO APRIL 2022

- Research mentor: Dr. Jeffrey Yoder
- Worked to develop high-throughput assays to determine the toxicity of environmental chemicals, such as per- and polyfluoroalkyl substances (PFAS), on the innate immune system using larval zebrafish, human cell lines, and primary human cells
- Assisted in teaching a selective course for veterinary students focused on transgenic models, including maintenance and transfection of human cell lines with fluorescent reporters
- Gained proficiency in quantifying reactive oxygen species *in vivo, in vitro,* and *ex vivo*, high-throughput cytotoxicity assays, automated morphological measurements of larval zebrafish, data visualization and analysis in GraphPad Prism, grant writing, dose response modeling, programming in R, maintenance of transgenic zebrafish lines, flow cytometry

GRADUATE INTERN | CENTER FOR ENVIRONMENTAL HEALTH | DURHAM, NC
MAY 2019 TO AUGUST 2019

- Worked with advocates, lawyers, and community members to write a petition to USEPA under the Toxic Substances Control Act (TSCA) regarding testing of PFAS
- Served as a scientific advisor, providing technical and scientific expertise to the team to inform them on current PFAS research, toxicological testing methods, existing data gaps, and regulatory documents as related to the petition, synthesizing this information, and making it understandable for advocates and non-scientists
- Met with Assistant Administrator of USEPA Office of Chemical Safety and Pollution Prevention (OCSPP) and other OCSPP senior officials to discuss the petition
- Served on internal committee to improve principles of diversity, equity, inclusion, and justice inside and outside of the organization

GRADUATE TEACHING ASSISTANT | NORTH CAROLINA STATE UNIVERSITY | RALEIGH, NC
FALL 2018 SEMESTER

- Taught one laboratory section of ZO 250 (Animal Anatomy and Physiology)
- Introduced laboratory topics and demonstrated laboratory procedures for students and handled grading of laboratory quizzes and laboratory practicals as well as laboratory reports and case studies

ORISE FELLOW | UNITED STATES ENVIRONMENTAL PROTECTION AGENCY | DURHAM, NC
JANUARY 2016 TO AUGUST 2017

- Research mentor: Dr. Tamara Tal
- Worked to determine whether host-associated microbiota mediate toxicity of environmental chemicals in the developing nervous system of larval zebrafish
- Gained proficiency in zebrafish breeding and embryo collection, deriving and maintaining axenic (microbe-free) zebrafish, *in vivo* chemical exposures of larval zebrafish, colonizing larval zebrafish with single strains and complex mixtures of bacteria, developmental toxicology assays in zebrafish, automated capture and analysis of larval zebrafish behavior data, nucleic acid isolation from larval zebrafish, preparation of larval zebrafish tissue for mass spectrometry, and 16S rRNA gene analysis of host-associated microbiota community structures

UNDERGRADUATE RESEARCH ASSISTANT | NORTH CAROLINA STATE UNIVERSITY | RALEIGH, NC
SEPTEMBER 2015 TO DECEMBER 2015

- Research mentors: Dr. Hosni Hassan and Dr. Bryan Troxell
- Worked to understand the underlying genetic mechanisms of a non-virulent, patented vaccine for *Salmonella enterica*
- Gained proficiency in isolation of genomic DNA from bacterial cultures, genotyping via PCR, designing PCR primers, and agarose gel electrophoresis

UNDERGRADUATE RESEARCH ASSISTANT | NORTH CAROLINA STATE UNIVERSITY | RALEIGH, NC
JANUARY 2014 TO APRIL 2015

- Research mentors: Dr. David Aylor and Dr. Tiffany Garbutt
- Worked to understand the growth and differentiation of induced pluripotent stem cells through genetic and epigenetic mechanisms
- Gained proficiency in aseptic technique, mammalian cell culture, karyotyping by fluorescent microscopy, isolating genomic DNA from mammalian cells, and cryopreservation of mammalian cells

RESEARCH ASSISTANT | THE INSTITUTE FOR SUSTAINABLE AND RENEWABLE RESOURCES | DANVILLE, VA
JUNE 2011 TO MARCH 2012

- Research mentor: Dr. Yinghui Dan
- Worked to enhance phytonutrients in tomatoes through forward genetics and chemical mutagenesis
- Met with Dr. John Holdren, Assistant to President Barack Obama for Science and Technology, to discuss this research
- Gained proficiency in tomato husbandry, phenotyping mutants of interest, and preservation of plant material for mass spectrometry

Publications

1. *In preparation* - **Phelps D**, Connors A, Ferrero G, DeWitt J, Yoder J. Per- and polyfluoroalkyl substances alter innate immune function: evidence and data gaps.
2. *Submitted* - **Phelps D**, Geueke B, Boucher J, Muncke J. Per- and polyfluoroalkyl substances in food packaging: Migration, toxicity, and management strategies.
3. *Accepted* - Geueke B, **Phelps D**, Parkinson LV, Muncke J. Hazardous chemicals in recycled and reusable plastic food packaging. *Cambridge Prisms: Plastics*.
4. **Phelps D**, Palekar A, Conley H, Ferrero G, Driggers J, Linder K, Kullman S, Reif D, Sheats MK, DeWitt J, Yoder J. Legacy and emerging per- and polyfluoroalkyl substances suppress the neutrophil respiratory burst. *Journal of Immunotoxicology*. doi: 10.1080/1547691X.2023.2176953
5. Weitekamp C*, Kvasnicka A*, Keely S, Brinkman N, Howey XM, Gaballah S, **Phelps D**, Catron T, Wheaton E, Zurlinden T, and Tal T. 2021. Monoassociation with bacterial isolates reveals the role of colonization, community complexity and abundance on locomotor behavior in larval zebrafish. *Animal Microbiome*. doi: 10.1186/s42523-020-00069-x **These authors contributed equally.*
6. Garbutt T, Konganti K, Konneker T, Hillhouse A, **Phelps D**, Jones A, Aylor D, and Threadgill D. 2020. Derivation of stable embryonic stem cell-like, but transcriptionally heterogenous, induced pluripotent stem cells from non-permissive mouse strains. *Mammalian Genome*. doi: 10.1007/s00335-020-09849-x
7. **Phelps D***, Fletcher A*, Rodriguez-Nunez I*, Balik-Meisner M, Tokarz D, Reif D, Germolec D, and Yoder J. 2020. In vivo Assessment of Respiratory Burst Inhibition by Xenobiotic Exposure Using Larval Zebrafish. *Journal of Immunotoxicology*. doi: 10.1080/1547691X.2020.1748772 **These authors contributed equally.*
8. Weitekamp C*, **Phelps D***, Swank A, McCord J, Sobus J, Catron T, Keely S, Brinkman N, Zurlinden T, Wheaton E, Strynar M, McQueen C, Wood C, and Tal T. 2019. Triclosan-resistant host-associated microbiota perform xenobiotic biotransformations in larval zebrafish. *Toxicological Sciences*. doi: 10.1093/toxsci/kfz166 **These authors contributed equally.*
9. Catron T, Swank A, Wehmas L, **Phelps D**, Keely S, Brinkman N, Sobus J, McCord J, Wood C, Strynar M, and Tal T. 2019. Behavior in colonized and microbe-free zebrafish larvae following developmental exposure to 17-βestradiol. *Scientific Reports*. doi: 10.1038/s41598-019-43346-9
10. Catron T, Keely S, Brinkman N, Zurlinden T, Wood C, Wright J, **Phelps D**, Wheaton E, Kvasnicka A, Gaballah S, Lamendella R, and Tal T. 2018. Host developmental toxicity of BPA and BPA alternatives is inversely related to microbiota disruption in zebrafish. *Toxicological Sciences*. doi: 10.1093/toxsci/kfy261
11. Garbutt T, Konneker T, Konganti K, Hillhouse AE, Swift-Haire F, Jones A, **Phelps D**, Aylor DL, Threadgill DW. 2018. Permissiveness to form pluripotent stem cells may be an evolutionarily derived characteristic in *Mus musculus*. *Scientific Reports*. doi: 10.1038/s41598-018-32116-8
12. **Phelps D**, Brinkman N, Keely S, Anneken E, Catron, T, Betancourt D, Wood C, Espenschied S, Rawls F, and Tal T. 2017. Microbial colonization is required for normal neurobehavioral development in zebrafish. *Scientific Reports*. doi: 10.1038/s41598-017-10517-5
13. Dan Y, Yousef G, Campbell F, **Phelps D**, Burnett C, Kekkonen A, and Lila M. 2017. Development and genetic and metabolic characterization of new tomato mutants with enhanced and deficient carotenoid content. *The Journal of Horticultural Science & Biotechnology*. doi: 10.1080/14620316.2017.1301223

Scientific Presentations

INVITED SEMINARS

1. Food Packaging Forum 3rd Annual Consumer Organizations and Analytical Chemists Meeting. June 5, 2023. Seminar Title: *PFASs in food packaging: Migration, toxicity, and management strategies*.
2. USEPA PFAS Research Workshop 2023. April 27, 2023. Seminar Title: *Developmental Immunotoxicity of Novel and Emerging Per- and Polyfluoroalkyl Substances*.
3. Society for Environmental Toxicology and Chemistry 2021 Annual Meeting Immunotoxicology Session. November 17, 2021. Seminar Title: *Flash Talk: Comparing the Respiratory Burst In Vivo and In Vitro After Exposure to Per- and Polyfluoroalkyl Substances*.
4. Society of Toxicology Molecular and Systems Biology Specialty Section Paper of the Year Award Webinar. October 14, 2020. Seminar Title: *Triclosan-Selected Host-Associated Microbiota Perform Xenobiotic Biotransformations in Larval Zebrafish*.
5. North Carolina Academy of Laboratory Animal Medicine Virtual Meeting. September 29, 2020. Seminar Title: *Utilizing Larval Zebrafish to Assess Immunotoxicity of Environmental Contaminants*.

MEETING ABSTRACTS AND PRESENTATIONS

1. **Phelps D** Conley H, Sheats MK, and Yoder J. Comparing the Respiratory Burst In Vivo, In Vitro, and Ex Vivo After Exposure to Per- and Polyfluoroalkyl Substances. Poster presented at 35th Annual Superfund Research Program Meeting, Raleigh, NC, USA.
2. **Phelps D** Conley H, Sheats MK, and Yoder J. Comparing the Respiratory Burst In Vivo, In Vitro, and Ex Vivo After Exposure to Per- and Polyfluoroalkyl Substances. Platform presentation given at Society for Environmental Toxicology and Chemistry 2022 Annual Meeting, Pittsburgh, PA, USA.
3. **Phelps D** Conley H, Sheats MK, and Yoder J. Comparing the Respiratory Burst In Vivo, In Vitro, and Ex Vivo After Exposure to Per- and Polyfluoroalkyl Substances. Poster presented at North Carolina Society of Toxicology 2022 Annual Meeting, Durham, NC, USA.
4. **Phelps D** Conley H, Sheats MK, and Yoder J. Comparing the Respiratory Burst In Vivo, In Vitro, and Ex Vivo After Exposure to Per- and Polyfluoroalkyl Substances. Poster presented at 3rd Annual PFAS Conference, Wilmington, NC, USA.
5. **Phelps D** Conley H, Sheats MK, and Yoder J. Comparing the Respiratory Burst In Vivo, In Vitro, and Ex Vivo After Exposure to Per- and Polyfluoroalkyl Substances. Poster presented at Southeast Immunology Symposium 2022, Durham, NC, USA.
6. **Phelps D** Conley H, Sheats MK, and Yoder J. Comparing the Respiratory Burst In Vivo, In Vitro, and Ex Vivo After Exposure to Per- and Polyfluoroalkyl Substances. Poster presented at FutureTox V 2022 Meeting, Chapel Hill, NC, USA.
7. **Phelps D** Conley H, Sheats MK, and Yoder J. Comparing the Respiratory Burst In Vivo, In Vitro, and Ex Vivo After Exposure to Per- and Polyfluoroalkyl Substances. Poster presented at Society of Toxicology 2022 Annual Meeting, San Diego, CA, USA.
8. **Phelps D** and Yoder J. Comparing the Respiratory Burst In Vivo and In Vitro After Exposure to Per- and Polyfluoroalkyl Substances. Poster presented at North Carolina Society of Toxicology 2022 Annual Meeting. *Meeting was held virtually due to COVID-19*.
9. **Phelps D** and Yoder J. Comparing the Respiratory Burst In Vivo and In Vitro After Exposure to Per- and Polyfluoroalkyl Substances. Platform presentation given at Society for Environmental Toxicology and Chemistry 2021 Annual Meeting. *Meeting was held virtually due to COVID-19*.

10. **Phelps D** and Yoder J. Comparing the Respiratory Burst In Vivo and In Vitro After Exposure to Per- and Polyfluoroalkyl Substances. Platform presentation given at Zebrafish Disease Models Society 2021 Annual Meeting. *Meeting was held virtually due to COVID-19*.
11. **Phelps D**, Palekar A, Driggers J, and Yoder J. Per- and Polyfluoroalkyl Substances Inhibit the Phagocytic Respiratory Burst. Poster presented at 2021 Society of Toxicology Meeting. *Meeting was held virtually due to COVID-19*.
12. **Phelps D**, Palekar A, Driggers J, and Yoder J. Per- and Polyfluoroalkyl Substances Inhibit the Phagocytic Respiratory Burst. Poster presented at 2020 Annual Meeting of the Superfund Research Program. *Meeting was held virtually due to COVID-19*.
13. **Phelps D**, Palekar A, Driggers J, and Yoder J. Per- and Polyfluoroalkyl Substances Inhibit the Phagocytic Respiratory Burst. Platform presentation given at Society for Environmental Toxicology and Chemistry 2020 Annual Meeting. *Meeting was held virtually due to COVID-19*.
14. **Phelps D**, Palekar A, Driggers J, and Yoder J. Per- and Polyfluoroalkyl Substances Inhibit the Phagocytic Respiratory Burst. Platform presentation and poster given at 2020 North Carolina State University Molecular Biotechnology Training Program Symposium. *Meeting was held virtually due to COVID-19*.
15. **Phelps D**, Fletcher A, Rodriguez-Nunez I, Balik-Meisner M, Tokarz D, Reif D, Germolec D, and Yoder J. Assessment of immunotoxicity by xenobiotic exposure using larval zebrafish. Platform presentation given during Carolinas Society for Toxicology and Chemistry 2020 Annual Meeting. *Meeting was held virtually due to COVID-19*.
16. **Phelps D**, Driggers J, Palekar A, and Yoder J. Inhibition of the respiratory burst by six per- and polyfluoroalkyl substances (PFASs). Poster to be presented at 2020 Triangle Zebrafish Symposium, Raleigh, NC, USA. *Meeting was canceled due to COVID-19*.
17. **Phelps D**, Driggers J, Palekar A, and Yoder J. Inhibition of the respiratory burst by six per- and polyfluoroalkyl substances (PFASs). Poster to be presented at North Carolina State University 2020 Graduate Research Symposium, Raleigh, NC, USA. *Meeting was canceled due to COVID-19*.
18. **Phelps D**, Driggers J, Palekar A, and Yoder J. Inhibition of the respiratory burst by six per- and polyfluoroalkyl substances (PFASs). Poster presented at Society of Toxicology 2020 Meeting, Anaheim, CA, USA. *Meeting was canceled due to COVID-19*.
19. **Phelps D**, Driggers J, Palekar A, and Yoder J. Inhibition of the respiratory burst by six per- and polyfluoroalkyl substances (PFASs). Poster presented at 2019 North Carolina State University Molecular Biotechnology Training Program Symposium, Raleigh, NC, USA.
20. **Phelps D**, Driggers J, Palekar A, and Yoder J. Inhibition of the respiratory burst by six per- and polyfluoroalkyl substances (PFASs). Poster presented at North Carolina Society of Toxicology 2019 Meeting, Durham, NC, USA.
21. **Phelps D**, Fletcher A, Rodriguez-Nunez I, Balik-Meisner M, Tokarz D, Reif D, Germolec D, and Yoder J. Assessment of immunotoxicity by xenobiotic exposure using larval zebrafish. Platform presentation given during NC State College of Veterinary Medicine 2019 Annual Research Day, Raleigh, NC, USA.
22. **Phelps D**, Fletcher A, Rodriguez-Nunez I, Balik-Meisner M, Tokarz D, Reif D, Germolec D, and Yoder J. Assessment of immunotoxicity by xenobiotic exposure using larval zebrafish. Platform presentation given during 2019 NC State BioLunch Graduate Seminar Series, Raleigh, NC, USA.
23. **Phelps D**, Fletcher A, Rodriguez-Nunez I, Balik-Meisner M, Tokarz D, Reif D, Germolec D, and Yoder J. Assessment of immunotoxicity by xenobiotic exposure using larval zebrafish. Platform presentation given at 2019 Triangle Zebrafish Symposium meeting, Durham, NC, USA.
24. **Phelps D**, Fletcher A, Rodriguez-Nunez I, Balik-Meisner M, Tokarz D, Reif D, Germolec D, and Yoder J. Assessment of immunotoxicity by xenobiotic exposure using larval zebrafish. Poster presented at Society of Toxicology 2019 meeting, Baltimore, MD, USA.

25. **Phelps D**, Fletcher A, Rodriguez-Nunez I, Balik-Meisner M, Tokarz D, Reif D, Germolec D, and Yoder J. Assessment of immunotoxicity by xenobiotic exposure using larval zebrafish. Poster presented at 2018 North Carolina State University Molecular Biotechnology Training Program Symposium, Raleigh, NC, USA.
26. **Phelps D**, Fletcher A, Rodriguez-Nunez I, Balik-Meisner M, Tokarz D, Reif D, Germolec D, and Yoder J. Assessment of immunotoxicity by xenobiotic exposure using larval zebrafish. Poster presented at North Carolina Society of Toxicology 2018 Meeting, Durham, NC, USA.
27. **Phelps D**, Brinkman N, Keely S, Anneken E, Catron T, Betancourt D, Wood C, Espenschied S, Rawls J, and Tal T. Normal neurobehavioral development is dependent upon colonization by host-associated microbiota in zebrafish. Poster presented at North Carolina Society of Toxicology 2017 Meeting, Durham, NC, USA.
28. **Phelps D**, Brinkman N, Keely S, Anneken E, Catron T, Betancourt D, Wood C, Espenschied S, Rawls J, and Tal T. Colonization by host-associated microbiota is necessary for normal neurobehavioral development in zebrafish. Platform presentation given at North Carolina State University Center for Human Health and the Environment Zebrafish Interest Group Mini-Symposium, Raleigh, NC, USA.
29. **Phelps D**, Brinkman N, Keely S, Anneken E, Catron T, Betancourt D, Wood C, Espenschied S, Rawls J, and Tal T. Host-associated microbiota is necessary for proper neurobehavioral development in zebrafish. Poster presented at North Carolina Branch of the American Society of Microbiology 2017 Meeting, Raleigh, NC, USA.
30. **Phelps D**, Brinkman N, Keely S, Hunter D, Gearhart A, Betancourt D, Wood C , and Tal T. Microbial colonization is required for normal neurobehavioral development in zebrafish. Poster presented at Society of Toxicology 2017 meeting, Baltimore, MD, USA.
31. **Phelps D**, Brinkman N, Keely S, Hunter D, Gearhart A, Betancourt D, Wood C, and Tal T. 2016. Microbiota is required for normal neurobehavioral development in zebrafish. Poster presented at Research Triangle Park Drug Metabolism Discussion Group Winter Symposium 2017, Durham, NC, USA.
32. **Phelps D**, Brinkman N, Keely S, Hunter D, Gearhart A, Betancourt D, Wood C, and Tal T. 2016. Developmental requirement for host-associated microbiota in zebrafish. Poster presented at North Carolina Society of Toxicology 2016 Meeting, Durham, NC, USA.

Honors and Awards

- FutureTox V Trainee Travel Award | Society of Toxicology | 2022
- Best PhD Student Platform Presentation Award: First Place | Society of Environmental Toxicology and Chemistry | 2021
- Best Graduate Student Platform Presentation Award: Second Place | Carolinas Society of Environmental Toxicology and Chemistry | 2020
- Paper of the Year Award | Society of Toxicology Molecular and Systems Biology Specialty Section | 2020
- Graduate Student Travel Support Award | Society of Toxicology | 2020
- Graduate Student Poster Award | North Carolina State University Molecular Biotechnology Training Program Symposium | 2019
- National Science Foundation Graduate Research Fellowship Program: Honorable Mention | 2019
- National Institutes of Health/North Carolina State University Molecular Biotechnology Training Program (NIH T32 GM008776) | 2018 - 2020
- Best Graduate Student Poster Award: Second Place | North Carolina Society of Toxicology 2017 Meeting | October 2017
- Best Poster Award Finalist | North Carolina Branch of the American Society of Microbiology 2017 Meeting | October 2017

- Best Graduate Student Poster Award: Honorable Mention | Reproductive and Developmental Toxicology Specialty Section at Society of Toxicology 2017 Meeting | 2017
- Student Research Travel Award | Research Triangle Park Drug Metabolism Discussion Group Winter Symposium | 2017
- Outstanding Field Supervisor | Meredith College Psychology Internship Program | 2016

Student Mentoring

NOTABLE SUPERVISION OF UNDERGRADUATE RESEARCH

- Jacob Driggers - Major: Microbiology, Minor: Global Health | January 2020 - September 2022
- Anika Palekar - Majors: Biology and Statistics | January 2020 - January 2022
- Allison Kvasnicka - Majors: Biology and Psychology, Meredith College | May 2017 - August 2017
- Katlyn Johnson - Majors: Biology and Psychology, Meredith College | May 2016 - August 2016

NOTABLE SUPERVISION OF HIGH SCHOOL STUDENT RESEARCH

- Jacob Driggers - Triangle Math and Science Academy, Math/Science Education Network Participant | June 2018 to May 2019
- Anika Palekar - Panther Creek High School, Math/Science Education Network Participant | June 2018 to May 2019

Workshops Attended

- Data Matters - Visualization for Data Science Using R | March 2023
- North Carolina State University: University Communications - "Media Relations Basics" | November 2019
- North Carolina State University: University Communications - "Communicating Science to the Public" | October 2019
- Data Matters - "Intermediate Programming in R" | August 2019
- Data Matters - "Introduction to R for Data Science" | August 2019

Professional Affiliations

PROFESSIONAL ORGANIZATIONS

- Society of Toxicology - Graduate Student Member | 2017 to present
- North Carolina Society of Toxicology - Graduate Student Member | 2017 to present
- Zebrafish Disease Models Society - Trainee Member | 2019 to present
- Society of Environmental Toxicology and Chemistry - North America
    - Student Member | 2019 to 2022
    - Recent Graduate Member | 2022 to present
- Society of Environmental Toxicology and Chemistry - Carolinas
    - Student Member | 2019 to 2022
    - Recent Graduate Member | 2022 to present
- Out in Science, Technology, Engineering and Mathematics (oSTEM) - Student Member | 2019 to present
- NC State University Center for Environmental and Health Effects of PFAS - Trainee | 2020 to 2022
- NC State University Comparative Medicine Institute - Associate Member | 2018 to 2022

UNIVERSITY ORGANIZATIONS

- NC State University Comparative Biomedical Sciences Graduate Student Association
    - Social Chair | 2018 to 2019
    - Vice President | 2019 to 2020
    - President | 2020 to 2021
- NC State University College of Veterinary Medicine PrideVMC ("Broad Spectrum") Graduate Student Representative | 2018 to 2021
- NC State University Out in Science, Technology, Engineering and Mathematics (oSTEM)
    - Executive Board Member | 2018 to 2019
    - President | 2019 to 2020

Service and Outreach

- Reviewer for peer-reviewed journals
    - Toxicology and Applied Pharmacology | 2020 to present
    - Toxicology | 2023 to present
- Session Co-chair, "Complexity of the Immune System and Challenges on the Applicability of Immunotoxicology to Risk Assessment" at upcoming Society of Environmental Toxicology and Chemistry 44th Annual Meeting
- Panelist - "Emerging Environmental Risks: Why a Discussion about PFAS is Important?" panel at 31st Annual Toxic Tort and Environmental Law Spring Conference
- Judge for North Carolina Society of Toxicology 2022 Annual Meeting trainee posters | October 2022
- Judge for 1st Annual Toxicology Symposium at NC State University trainee presentations | May 2022
- Organizing Committee Member, Triangle Zebrafish Symposium | 2020 - *Meeting was cancelled due to COVID-19*.
- Judge for 7th Annual Triangle Math and Science Academy Science Fair | November 2018
- Judge for Freds Old Elementary School Science Fair | January 2018
- Conducted multiple public tours of Dr. Tamara Tal's lab | 2016-2017
- Panelist for BIT 495/595 – Professional Development "Government Careers" Career Panel at North Carolina State University's Program of Biotechnology | April 2016

ATTACHMENT 2

Overview of Testing to Determine PFAS Levels in Fluorinated Containers and their Contents

Dr. Jimena Diaz Leiva, Center for Environmental Health

Summary of Qualifications

Since 2021, I have been the Science Director at Center for Environmental Health (CEH) in Oakland, California. In that capacity, I regularly read and interpret peer reviewed academic literature on the uses, persistence, environmental health impacts, and environmental fate of per- and polyfluoroalkyl substances (PFAS). I have presented on the health effects of exposure to PFAS chemicals, giving talks to the public, consumer advocacy groups, and private interest groups such as purchasers. In my position as Science Director at CEH, I also interpret and analyze results from independent, third-party testing of consumer products suspected to contain PFAS chemicals. As part of this work, I regularly prepare exposure assessments to support notices of violation that are sent to responsible entities that expose consumers to PFAS compounds listed under Proposition 65 in the State of California. I also regularly read and summarize new literature pertaining to PFAS in consumer products and routes of human exposure as part of my work.

I also hold a PhD in environmental science from UC Berkeley, where I completed my dissertation research on mercury pollution from artisanal and small-scale gold mining in the Peruvian Amazon. As part of my dissertation work, I learned analytical chemistry methods such as cold-vapor atomic spectroscopy and isotope analysis by mass spectroscopy.

Summary of Findings

In this report, I summarize the literature on the formation of per- and polyfluoroalkyl substances (PFAS) during the direct fluorination of plastic containers. This report discusses the presence in fluorinated containers and their contents of perfluoroalkyl carboxylic acids (PFCAs), with a specific focus on long-chain perfluoroalkyl carboxylate (LCPFAC) substances subject to a July 2020 significant new use rule (SNUR) promulgated by the Environmental Protection Agency under the Toxic Substances Control Act (TSCA). 40 C.F.R. § 721.10536. The SNUR defines LCPFACs as "the long-chain category of perfluorinated carboxylate chemical substances with perfluorinated carbon chain lengths equal to or greater than seven carbons and less than or equal to 20 carbons," including, "the salts and precursors of these perfluorinated carboxylates."

The evidence from the literature presented in this report demonstrates that Inhance Technologies' direct, post-mold fluorination process causes PFCAs to form in the surface layer of high-density polyethylene (HDPE) containers. These PFCAs have been found to leach into a variety of solvents, including methanol, water, and even food. The ability for PFCAs to leach

into the contents of fluorinated containers constitutes an important exposure pathway for workers and consumers that come into contact with or consume products held in these containers. Across the various studies, 15 PFCAs have been found in fluorinated containers and their contents, including 9 LCPFACs subject to EPA's SNUR. I understand that Inhance has filed significant new use notices (SNUNs) under the SNUR for these 9 LCPFACs.

Direct post-mold fluorination of plastic containers is used to impart chemical resistance and improve barrier properties without using more expensive, fluoropolymer plastics. However, the literature reviewed in this report demonstrates that this process results in the formation of hazardous PFAS chemicals. As shown below, studies by the EPA, contract laboratories, and academic researchers positively identified PFCAs in extracts from fluorinated HDPE containers. The consensus amongst these studies is that the application of fluorine gas generates PFCAs in the surface layer (0-10 um) of plastic containers. These PFCAs, as will be discussed, are then readily able to leach from the containers into their contents. In what follows, I review five existing studies on the topic of direct fluorination of plastics and present evidence indicating that fluorination results in the formation of LCPFACs and other PFCAs.

Perfluorinated carboxylic acids in directly fluorinated high-density polyethylene material
Amy A. Rand and Scott A. Mabury

Rand and Mabury (2011) presented the first evidence in the peer-reviewed literature of the formation of PFCAs in directly fluorinated plastic containers. Studies from the EPA (2021, 2022), Vitale et al. (2022), and Whitehead and Peaslee (2023), build off of this work and provide further evidence of the potential for PFCAs to leach from directly fluorinated plastic containers into solvents and foodstuffs held in these containers. Rand and Mabury extracted PFCAs from directly fluorinated HDPE bottles treated with differing levels of fluorination. They compared their results to unfluorinated bottles, finding that the total concentration of PFCAs from fluorinated bottles increased with level of fluorination and was significantly higher than the levels in unfluorinated bottles. The authors note that,

> The amount of PFCAs formed on directly fluorinated HDPE is proportional to the amount of fluorination the HDPE receives, and presumably the amount of oxygen within the fluorination chamber… (p. 8057).

In the fluorinated bottles, the authors reported total PFCA concentrations in methanol extract ranging from 8.5 ± 0.53 ng/cm^2 in the least fluorinated bottles (Level 1) up to 113 ± 2.5 ng/cm^2 in the most fluorinated bottles (Level 5). Many of the PFCAs identified in the methanol extract were LCPFCAs including PFOA, PFNA, and PFDA. These long-chain PFCAs were more common in the extracts from higher fluorination levels. After identifying and quantifying PFCAs in extract from fluorinated HDPE bottles, Rand and Mabury performed a one-year leaching experiment using water to show that these PFCAs migrate into solvents held in the bottles.

After one year, the total concentration of PFCAs in water held in fluorinated HDPE bottles (Level 3), exceeded the total concentration of PFCAs in methanol extracts from bottles treated with all levels of fluorination. While long-chain PFCAs were not detected in the water leachate, short-chain carboxylic acids like perfluoropropanoic acid (PFPrA) were identified. The average total PFCA concentration in the water was 314 ± 12 ng/cm^2 or more than double the concentration from the methanol extract of Level 5 fluorinated HDPE bottles. Rand and Mabury (2011) posit that PFCAs continued to leach from the bottles into water throughout the year-long residence time, resulting in higher concentrations in the water than in the methanol extracts.

The work of Rand and Mabury (2011) also provided additional lines of evidence that prove that direct fluorination of plastics results in the formation of PFAS compounds. In particular, the authors provide the first evidence that different levels of fluorination directly correlate to the formation of long-chain PFCA compounds, with higher levels of fluorination resulting in the formation of longer-chain PFCA compounds like perfluorooctanoic acid (PFOA) and perfluorononanoic acid (PFNA). Using attenuated total reflectance infrared spectroscopy (ATR-IR) and other spectroscopic methods, the authors were able to identify characteristic carbon-fluorine bonds in the spectra from the surface layer of fluorinated bottles.

Rand and Mabury (2011) used ATR-IR to measure the intensity of carbon-fluorine bonds (C-F) in each level of fluorination treatment. These bonds characterize PFAS compounds and are further evidence of the generation of PFAS chemicals from the direct fluorination process. Moreover, the spectra from bottles with different levels of fluorination were distinguishable from one another, indicating that higher levels of fluorination result in the formation of long-chain PFCAs with more C-F bonds. Rand and Mabury compared the spectra of two sides of an individual fluorinated bottle, finding that the side that was treated with fluorine gas had a distinct spectral signature from the side that was untreated. This evidence proves that the fluorination process directly modifies the surface layer of plastics and generates PFAS compounds in this surface layer that are visible through spectroscopic analysis.

EPA's Analytical Chemistry Branch PFAS Testing Rinses from Selected Fluorinated and Non-Fluorinated HDPE Containers

On March 4, 2021, a decade after Rand and Mabury's (2011) seminal study, the US EPA released a memorandum describing their results from testing fluorinated HDPE containers. This testing followed reports of PFAS compounds detected in a mosquito pesticide held in a fluorinated HDPE container. The EPA tested fluorinated containers by rinsing them with methanol and then analyzing the rinsate for PFAS compounds. The agency tested both used and unused, fluorinated and non-fluorinated containers, and found that the rinsate from all fluorinated containers had detectable concentrations of PFAS, including PFOA and other PFCAs. In non-fluorinated containers, the agency found PFAS concentrations in the rinsate from the containers of 1 ppb or less. In fluorinated containers, the EPA found PFAS concentrations that ranged from 20-50 ppb in the rinsate. The agency found a greater number of PFAS compounds in the rinsate

of the fluorinated containers. All of the compounds detected were PFCAs, with 5 of the 8 compounds being LCPFCAs. EPA's analysis of these results indicate that the agency believes that the fluorination process results in the formation of PFCAs. They state,

> Based on the results of the rinsate samples as described above and the preliminary results of the product samples…the EPA believes that through the fluorination process of HDPE containers, PFAS compounds may be formed and then partly leach into the products inside the containers (p. 3).

Results of EPA's Analytical Chemistry Branch Laboratory Study of PFAS Leaching from Fluorinated HDPE Containers

On August 12, 2022, EPA released a second memorandum which presented the results of studies following up on the results of their 2021 fluorinated container testing. Through this additional testing, the Agency set out to determine whether PFAS compounds leached into different solvents held in fluorinated HDPE containers. EPA filled fluorinated and non-fluorinated containers with water and methanol and held these solvents in the containers for a 20-week period to determine whether PFAS would leach into the solvents from the container and whether longer residence times would lead to greater concentrations of PFAS. The agency analyzed an aliquot of the solvents held in these containers after 1 day, 1 week, 4 weeks, 10 weeks, and 20 weeks. The EPA detected PFAS compounds in both water and methanol at every interval but noted that the methanol contained higher concentrations of PFAS compared to water. Of the 31 PFAS compounds screened, the agency positively identified eight compounds in the leachate from fluorinated bottles. These eight compounds were all PFCAs, and five were LCPFCAs including PFOA (Table 1).

Importantly, the Agency noted that while the sum concentration of PFAS analyzed in the leachate from fluorinated containers varied amongst the three types of HDPE containers that they tested, in comparison to unfluorinated containers, the concentration of PFAS was elevated in all fluorinated containers. Moreover, EPA found that with increasing residence time, the sum concentration of PFAS in both solvents increased, indicating that PFAS continued to leach from the containers over time. For the containers holding water, the total PFAS concentration ranged from 0.016 ppb to 2.888 ppb whereas for the methanol the total PFAS concentration ranged from 0.977 to 14.720 ppb. The Agency's two memorandums are in agreement with the findings of Rand and Mabury (2011), showing that PFCAs leach from fluorinated containers into their contents and will continue to leach over time.

An Assessment of the Potential for Leaching of Per- and Polyfluoroalkyl Substances from Fluorinated and Non-Fluorinated High-Density Polyethylene Containers

Rock J. Vitale, Jared K. Acker, and Stephen E. Somerville

Following the EPA's investigation into fluorinated HDPE containers manufactured through different fluorination processes, Vitale et al. (2022) conducted a series of leaching experiments using fluorinated and non-fluorinated HDPE bottles. For the fluorinated bottles, the authors evaluated whether different types of fluorination processes including in-mold fluorination, post-mold plasma fluorination, and post-mold fluorination, like that used by Inhance Technologies, resulted in the leaching of PFAS compounds into methanol. Aliquots of methanol leachate were analyzed after one week, 4 weeks, 8 weeks, and 12 weeks. The authors found no detectable concentrations of 19 target PFAS compounds in the methanol leachate from in-mold fluorinated bottles. However, in agreement with the findings from Rand and Mabury (2011) and EPA (2022), the authors did detect the presence of several PFCAs in the methanol leachate of post-mold fluorinated bottles and post-mold plasma fluorinated bottles (Table 1).

In accordance with the findings from Rand and Mabury (2011) and EPA (2022), Vitale et al. (2022) found that post-mold fluorinated HDPE bottles leached PFCAs at every interval during the 12-week study period. At each interval, PFCAs including PFOA, were detected in the methanol leachate. The most frequently detected PFCAs from the post-mold fluorinated leachate were those in the C5-C7 chain length. Consistent with the results from EPA (2022), the sum concentration of PFAS increased in the leachate with longer residence periods. After 12 weeks, the total PFAS concentration in the leachate from post-mold fluorinated bottles reached up to 9,700 ng/L or 9.7 ppb. The authors did not measure PFAS compounds above the limit of quantitation of any specific analyte in HDPE bottles treated with in-mold fluorination. The authors postulate that the inadvertent introduction of oxygen during post-mold fluorination is likely the determining factor that results in the formation of PFCAs in the surface layer of these bottles.

Directly Fluorinated Containers as a Source of Perfluoroalkyl Carboxylic Acids

Heather D. Whitehead and Graham H. Peaslee

Most recently, Whitehead and Peaslee (2023), provided evidence of leaching of PFCAs from directly fluorinated HDPE containers into different solvents and foodstuffs that may be held in these types of containers. The researchers exposed the fluorinated containers to different solvents including water, methanol, and acetone and measured the sum of PFAS chemicals leaching from the containers into their contents. They also exposed the containers to foodstuffs such as ketchup and mayonnaise to quantify the leaching rate from plastic containers into food that might be held in the containers. Finally, the authors analyzed the effect of high temperatures on the leaching of PFCAs from the containers into solvents and foodstuffs.

Whitehead and Peaslee found that the sum of PFAS concentrations in fluorinated containers was greater than 200 times the concentrations in non-fluorinated containers. In fluorinated containers, the sum of PFAS concentrations was 63.75 ± 13.12 ng/g (ppb) plastic compared to 0.29 ± 0.30 ng/g (ppb) plastic in non-fluorinated containers. These data confirm that plastic containers subjected to direct, post-mold fluorination, contain high concentrations of PFAS chemicals. The authors identified 20 different PFAS chemicals including many short-chain carboxylic acids like PFBA and PFPeA, as well as 10 long-chain compounds including PFOA and PFNA. While these PFAS compounds were detected in the fluorinated plastic containers themselves, the authors also conducted numerous leaching experiments to determine whether these compounds migrated from the containers into solvents and foodstuffs.

Whitehead and Peaslee (2023) present evidence of PFCA leaching from fluorinated containers into water, acetone, and methanol. After a seven-day leaching experiment, they found that each of these three solvents contained PFCAs, with the highest concentration of PFCAs found in methanol. The sum of PFAS concentrations that they measured in the solvents were comparable to the results obtained from the EPA (2022) studies. Finally, the authors conducted a leach test using common foods that might be stored in fluorinated containers such as olive oil, mayonnaise, and ketchup. The results of this experiment are perhaps most concerning for the uses of fluorinated containers that involve food contact. After seven days, PFAS were found in each of the three foodstuffs and in particular, short-chain PFCAs were found to have leached into all foods. In the olive oil, ketchup, and mayonnaise, the sum of PFAS concentrations were 2.66 ± 0.82, 5.95 ± 1.59, and 7.19 ± 3.39 ng/g (ppb), respectively. The sum of PFAS concentrations for these foodstuffs also exceeded the sum of PFAS concentrations that leached into water after seven days indicating that these foodstuffs acted as better solvents to pull out PFCAs from the fluorinated plastic containers. The authors used the sum of PFAS concentrations in foodstuffs to derive an estimated value for PFAS that would be consumed by an average weight adult, using guidance on serving sizes. They found that,

> Using an estimated five servings per week and the average body weight of a North American adult (80.7 kg), the weekly intake of PFAS from these containers in just one food container would range between 0.77−2.68 ng/kg body weight per week (p. D).

Whitehead and Peaslee's (2023) results underscore the concerns surrounding individuals' exposure to hazardous PFCAs from coming into contact with or ingesting products held in fluorinated containers.

Building off the leaching experiment using foodstuffs, Whitehead (2023) measured the amount of PFAS that would leach from fluorinated HDPE containers into five different indoor and outdoor home products, including indoor wood glue, an outdoor patio and deck cleaner, an indoor carpet cleaner, an indoor/outdoor insecticide, and an indoor multi-purpose cleaner. The study aimed to determine the extent to which PFCAs leach into commonly available household products held in fluorinated HDPE containers. The products were held in the containers for 28 days and then the sum of PFAS concentrations in these products were measured. The authors

were unable to analyze the indoor wood glue, outdoor patio and deck cleaner, and the indoor multi-purpose cleaner due to incompatibility with their sample extraction method and low internal standard recoveries. The indoor carpet cleaner and the indoor/outdoor insecticide were found to contain PFCAs of the same chain length and identities as observed in the extraction of containers and solvent leaching experiments described in Whitehead and Peaslee (2023). The average sum of PFAS concentration in the indoor carpet cleaner was 20.7 ± 4.9 ng/g (ppb) plastic and was 6.9 ± 2.5 ng/g (ppb) plastic in the insecticide. Between the carpet cleaner and insecticide, Whitehead detected 13 different PFCAs, including 9 LCPFACs. These findings confirm that PFCAs can leach from fluorinated containers into a wide variety of products held in these types of containers.

Whitehead (2023) also evaluated whether in-mold fluorinated HDPE containers contained PFCAs by performing targeted analyte extracts of these containers. In line with the findings of Vitale et al. (2022), Whitehead found that none of the target analytes measured above their limit of quantitation in the extracts from in-mold fluorinated containers. Only one short-chain PFCA, perfluoro-heptanoic acid (PFHpA), was measured just above the limit of quantitation in this level 3 in-mold fluorinated container. These results when considered alongside those of Vitale et al. (2022) suggest that the in-mold fluorination process generates minimal amounts of PFAS in comparison to the post-mold fluorination process.

Most recently, fluorinated and non-fluorinated HDPE containers were sent by PEER to Eurofins Lancaster Laboratories Environment Testing, LLC - a third-party accredited analytical laboratory – to corroborate the results of Whitehead and Peaslee's (2023) study. Seven day leaching experiments were conducted with water, methanol, and acetone to determine whether PFCAs leached from fluorinated containers into the contents. Eight different PFCAs were detected in the leachate, including five LCPFCAs. The highest concentrations of PFCAs were detected in the acetone followed by the methanol solvent. PFOA was detected in all three replicate samples of methanol and acetone at an average concentration of 4.07 ± 0.96 ppb and 4.93 ± 0.50 ppb, respectively Table 2). The results from Eurofins' testing strongly validates Whitehead and Peaslee's findings and provide further confirmation of the presence of PFCAs in fluorinated containers and their ability to leach into the contents held in these containers.

Taken together the studies reviewed in this report all substantiate the claim that Inhance Technologies' post-mold fluorination process results in the formation of PFCAs in the surface layer of plastics. Long-chain PFCAs such as PFOA, that are subject to the SNUR promulgated by EPA, were also found in each of the studies reported herein. There is a high level of concurrence amongst the results from these studies. For PFOA, the concentrations of this analyte measured in extracts from fluorinated HDPE containers and in different solvents held in these containers, are all comparable across studies where specific analyte concentrations are reported (Table 2). Moreover, the evidence from these studies indicates that hazardous PFCAs are readily able to leach from HDPE containers into their contents. Chemically and materially distinct solvents like methanol, acetone, and water, as well as household products and foodstuffs like insecticides, carpet cleaners, and mayonnaise, have all been shown to contain PFCAs from

fluorinated containers. Adding to the risk of exposure for consumers, over time, the concentration of PFCAs in the contents of these containers increases due to continual leaching from the containers.

References

Eurofins Lancaster Laboratories Environment Testing, LLC. (2023). Analytical Report: PFAS in containers. Lancaster, PA.

Rand, A. A., & Mabury, S. A. (2011). Perfluorinated carboxylic acids in directly fluorinated high-density polyethylene material. *Environmental science & technology*, *45*(19), 8053-8059.

US EPA. (2021). Memorandum - EPA's analytical chemistry branch PFAS testing rinses from selected fluorinated and non-fluorinated HDPE containers https://www.epa.gov/sites/default/files/2021-03/documents/results-of-rinsates-samples_03042021.pdf. March 4, 2021 (Accessed 10 March 2023).

US EPA. (2022). Results of EPA's analytical chemistry branch laboratory study of PFAS leaching from fluorinated HDPE containers https://www.epa.gov/system/files/documents/2022-09/EPA%20PFAS%20Container%20Leaching%20Study%2008122022_0.pdf. Updated August 12, 2022. (Accessed 10 March 2023).

Vitale, R. J., Acker, J. K., & Somerville, S. E. (2022). An assessment of the potential for leaching of per- and polyfluoroalkyl substances from fluorinated and non-fluorinated high-density polyethylene containers. *Environmental Advances*, *9*, 100309.

Whitehead, H. D., & Peaslee, G. F. (2023). Directly Fluorinated Containers as a Source of Perfluoroalkyl Carboxylic Acids. *Environmental Science & Technology Letters*.

Whitehead, H.D. (2023)

Table 1. Perfluoroalkyl carboxylic acids (PFCAs) positively identified in extracts from post-mold fluorinated HDPE plastic containers by study. PFCAs ordered by carbon chain length.

PFAS Compound (C-chain length)	Eurofins (2023)	Whitehead and Peaslee (2023)	Vitale et al. (2022)	EPA (2022)	EPA (2021)	Rand and Mabury (2011)
TFA (C2)						X
PFPrA (C3)						X
PFBA (C4)	X	X	X	X	X	X
PFPeA (C5)	X	X	X	X	X	X
PFHxA (C6)	X	X	X	X	X	X
PFHpA (C7)	X	X	X	X	X	X
PFOA (C8)	X	X	X	X	X	X
PFNA (C9)	X	X	X	X	X	X
PFDA (C10)	X	X	X	X	X	X
PFUnDA (C11)	X	X	X	X	X	
PFDoDA (C12)		X	X			
PFTrDA (C13)		X	X			
PFTDA (C14)		X	X			
PFHxDA (C16)		X				
PFODA (C18)		X				

Table 2. Comparison of the concentrations of PFOA (ng/g plastic, ppb) found in extracts and solvents held within fluorinated HDPE containers reported across studies reviewed herein that listed specific analyte concentrations.

Solvent used for Leaching Experiment	Eurofins (2023)[1]	Whitehead and Peaslee (2023)[2]	Vitale et al. (2022)	EPA (2021)
Methanol (Extraction)		4.49		0.22 - 1.59**
Methanol	4.07 ± 0.96	< LOD	0.13 - 3.1*	
Water	<LOD	0.29		
Acetone	4.93 ± 0.50	3.64		
Olive Oil		< LOD		
Ketchup		<LOD		
Mayonnaise		1.4		

*Results reported as the range of PFOA concentrations for leaching experiments using methanol held in containers over a 4-week period.
** Results reported as the range of PFOA concentrations in methanol rinsate from different fluorinated HDPE containers.

1. Average concentrations of PFOA ± 1 standard deviation derived from three replicate results reported in Eurofins (2023). All leaching experiments were conducted over a 7-day period.
2. Average concentrations of PFOA derived from replicate results reported in Whitehead and Peaslee (2023). All leaching experiments were conducted over a 7-day period.

Table 3. Sum of PFAS concentrations (ng/g plastic, ppb) reported in extracts and leachate from fluorinated HDPE bottles.

Sum of PFAS Concentration	Whitehead and Peaslee (2023)[1]	Vitale et al. (2022)[2]	EPA (2022)[3]	EPA (2021)[4]
Fluorinated bottle extracted with methanol	63.75 ± 13.12	N/A	N/A	20-50
Methanol	69.72 ± 7.75	9.7	0.977 - 14.720	N/A
Acetone	50.13 ± 4.41	N/A	N/A	N/A
Water	0.99 ± 0.46	N/A	0.016 - 2.888	N/A

1. Results reported as the average sum of PFAS concentrations ± 1 standard deviation. Methanol, water, and acetone were used in 7-day leaching experiments.
2. Results reported as the maximum sum of PFAS concentration measured in methanol held in post-mold fluorinated containers for 4 weeks.
3. Results reported as the range of sum of PFAS concentrations measured during a 20-week leaching experiment using water and methanol held in fluorinated HDPE containers.
4. Results reported as the range of sum of PFAS concentrations measured in methanol rinsate from fluorinated HDPE containers.

eurofins | Environment Testing

ANALYTICAL REPORT

PREPARED FOR

Attn: Kyla Bennett
PEER
962 Wayne Avenue
Suite 610
Silver Spring, Maryland 20910

Generated 4/24/2023 11:18:28 AM

JOB DESCRIPTION

PFAS in containers

JOB NUMBER

410-114570-1

Eurofins Lancaster Laboratories Environment Testing, LLC
2425 New Holland Pike
Lancaster PA 17601

See page two for job notes and contact information.

Job Notes

This report may not be reproduced except in full, and with written approval from the laboratory. The results relate only to the samples tested. For questions please contact the Project Manager at the e-mail address or telephone number listed on this page.

Analytical test results meet all requirements of the associated regulatory program (i.e., NELAC (TNI), DoD, and ISO 17025) unless otherwise noted under the individual analysis.

Authorization

Generated
4/24/2023 11:18:28 AM

Authorized for release by
Dana Kauffman, Project Manager
Dana.Kauffman@et.eurofinsus.com
(717)556-7219

Compliance Statement

Analytical test results meet all requirements of the associated regulatory program (e.g., NELAC (TNI), DoD, and ISO 17025) unless otherwise noted under the individual analysis. Data qualifiers are applied to note exceptions. Noncompliant quality control (QC) is further explained in narrative comments.
· QC results that exceed the upper limits and are associated with non-detect samples are qualified but further narration is not required since the bias is high and does not change a non-detect result. Further narration is also not required with QC blank detection when the associated sample concentration is non-detect or more than ten times the level in the blank.
· Matrix QC may not be reported if insufficient sample or site-specific QC samples were not submitted. In these situations, to demonstrate precision and accuracy at a batch level, a LCS/LCSD is performed, unless otherwise specified in the method.
· Surrogate and/or isotope dilution analyte recoveries (if applicable) which are outside of the QC window are confirmed unless attributed to a dilution or otherwise noted in the narrative.
Regulated compliance samples (e.g. SDWA, NPDES) must comply with the associated agency requirements/permits.

Measurement uncertainty values, as applicable, are available upon request.

Test results relate only to the sample tested. Clients should be aware that a critical step in a chemical or microbiological analysis is the collection of the sample. Unless the sample analyzed is truly representative of the bulk of material involved, the test results will be meaningless. If you have questions regarding the proper techniques of collecting samples, please contact us. We cannot be held responsible for sample integrity, however, unless sampling has been performed by a member of our staff. Times are local to the area of activity. Parameters listed in the 40 CFR Part 136 Table II as "analyze immediately" and tested in the laboratory are not performed within 15 minutes of collection.

WARRANTY AND LIMITS OF LIABILITY - In accepting analytical work, we warrant the accuracy of test results for the sample as submitted. The foregoing express warranty is exclusive and is given in lieu of all other warranties, expressed or implied, except as otherwise agreed. We disclaim any other warranties, expressed or implied, including a warranty of fitness for particular purpose and warranty of merchantability. In no event shall Eurofins Lancaster Laboratories Environmental, LLC be liable for indirect, special, consequential, or incidental damages including, but not limited to, damages for loss of profit or goodwill regardless of (A) the negligence (either sole or concurrent) of Eurofins Lancaster Laboratories Environmental and (B) whether Eurofins Lancaster Laboratories Environmental has been informed of the possibility of such damages. We accept no legal responsibility for the purposes for which the client uses the test results. Except as otherwise agreed, no purchase order or other order for work shall be accepted by Eurofins Lancaster Laboratories Environmental which includes any conditions that vary from the Standard Terms and Conditions, and Eurofins Lancaster Laboratories Environmental hereby objects to any conflicting terms contained in any acceptance or order submitted by client.

Table of Contents

Definitions/Glossary

Client: PEER
Job ID: 410-114570-1
Project/Site: PFAS in containers

Qualifiers

LCMS

Qualifier	Qualifier Description
*-	LCS and/or LCSD is outside acceptance limits, low biased.
*+	LCS and/or LCSD is outside acceptance limits, high biased.
*5-	Isotope dilution analyte is outside acceptance limits, low biased.
*5+	Isotope dilution analyte is outside acceptance limits, high biased.
cn	Refer to Case Narrative for further detail
H	Sample was prepped or analyzed beyond the specified holding time

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
¤	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CFU	Colony Forming Unit
CNF	Contains No Free Liquid
DER	Duplicate Error Ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL	Detection Limit (DoD/DOE)
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision Level Concentration (Radiochemistry)
EDL	Estimated Detection Limit (Dioxin)
LOD	Limit of Detection (DoD/DOE)
LOQ	Limit of Quantitation (DoD/DOE)
MCL	EPA recommended "Maximum Contaminant Level"
MDA	Minimum Detectable Activity (Radiochemistry)
MDC	Minimum Detectable Concentration (Radiochemistry)
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
MPN	Most Probable Number
MQL	Method Quantitation Limit
NC	Not Calculated
ND	Not Detected at the reporting limit (or MDL or EDL if shown)
NEG	Negative / Absent
POS	Positive / Present
PQL	Practical Quantitation Limit
PRES	Presumptive
QC	Quality Control
RER	Relative Error Ratio (Radiochemistry)
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)
TNTC	Too Numerous To Count

Job ID: 410-114570-1

Laboratory: Eurofins Lancaster Laboratories Environment Testing, LLC

Narrative

Job Narrative
410-114570-1

Receipt
The samples were received on 1/20/2023 9:30 AM. Unless otherwise noted below, the samples arrived in good condition, and, where required, properly preserved and on ice.

Receipt Exceptions
A Chain-of-Custody (COC) was not received with these samples: FLPE - Room Temp, Water, Trial #1 (410-114570-1), FLPE - Room Temp, Water, Trial #2 (410-114570-2), FLPE - Room Temp, Water, Trial #3 (410-114570-3), HDPE - Room Temp, Water, Trial #1 (410-114570-4), HDPE - Room Temp, Water, Trial #2 (410-114570-5), HDPE - Room Temp, Water, Trial #3 (410-114570-6), Blank - Room Temp, Water (410-114570-7), FLPE - Room Temp, Methanol, Trial #1 (410-114570-8), FLPE - Room Temp, Methanol, Trial #2 (410-114570-9), FLPE - Room Temp, Methanol, Trial #3 (410-114570-10), HDPE - Room Temp, Methanol, Trial #1 (410-114570-11), HDPE - Room Temp, Methanol, Trial #2 (410-114570-12), HDPE - Room Temp, Methanol, Trial #3 (410-114570-13), Blank - Room Temp, Methanol (410-114570-14), FLPE - Room Temp, Acetone, Trial #1 (410-114570-15), FLPE - Room Temp, Acetone, Trial #2 (410-114570-16), FLPE - Room Temp, Acetone, Trial #3 (410-114570-17), HDPE - Room Temp, Acetone, Trial #1 (410-114570-18), HDPE - Room Temp, Acetone, Trial #2 (410-114570-19), HDPE - Room Temp, Acetone, Trial #3 (410-114570-20) and Blank - Room Temp, Acetone (410-114570-21).

The following samples were received at the laboratory without a sample collection time documented on the chain of containers: FLPE - Room Temp, Water, Trial #1 (410-114570-1), FLPE - Room Temp, Water, Trial #2 (410-114570-2), FLPE - Room Temp, Water, Trial #3 (410-114570-3), HDPE - Room Temp, Water, Trial #1 (410-114570-4), HDPE - Room Temp, Water, Trial #2 (410-114570-5), HDPE - Room Temp, Water, Trial #3 (410-114570-6), Blank - Room Temp, Water (410-114570-7), FLPE - Room Temp, Methanol, Trial #1 (410-114570-8), FLPE - Room Temp, Methanol, Trial #2 (410-114570-9), FLPE - Room Temp, Methanol, Trial #3 (410-114570-10), HDPE - Room Temp, Methanol, Trial #1 (410-114570-11), HDPE - Room Temp, Methanol, Trial #2 (410-114570-12), HDPE - Room Temp, Methanol, Trial #3 (410-114570-13), Blank - Room Temp, Methanol (410-114570-14), FLPE - Room Temp, Acetone, Trial #1 (410-114570-15), FLPE - Room Temp, Acetone, Trial #2 (410-114570-16), FLPE - Room Temp, Acetone, Trial #3 (410-114570-17), HDPE - Room Temp, Acetone, Trial #1 (410-114570-18), HDPE - Room Temp, Acetone, Trial #2 (410-114570-19), HDPE - Room Temp, Acetone, Trial #3 (410-114570-20) and Blank - Room Temp, Acetone (410-114570-21). Entered as 01/19/23 @ 00:00.

PFAS
Method 537_DI: The recovery for the labeled isotope(s): 13C2 PFTeDA in the following samples: FLPE - Room Temp, Methanol, Trial #1 (410-114570-8) and FLPE - Room Temp, Methanol, Trial #2 (410-114570-9) is outside the QC acceptance limits. Since the recovery is high and the native analyte is not detected in the sample, the data is reported.

Method 537_DI: The holding time was not met. FLPE - Room Temp, Methanol, Trial #1 (410-114570-8), FLPE - Room Temp, Methanol, Trial #2 (410-114570-9), FLPE - Room Temp, Methanol, Trial #3 (410-114570-10), HDPE - Room Temp, Methanol, Trial #1 (410-114570-11), HDPE - Room Temp, Methanol, Trial #2 (410-114570-12), HDPE - Room Temp, Methanol, Trial #3 (410-114570-13) and Blank - Room Temp, Methanol (410-114570-14) was submitted to the laboratory with insufficient time remaining in the hold.

Method 537_DI: The recovery for the labeled isotope(s) 13C8 FOSA in the following samples: FLPE - Room Temp, Water, Trial #1 (410-114570-1), FLPE - Room Temp, Water, Trial #2 (410-114570-2), HDPE - Room Temp, Water, Trial #1 (410-114570-4) and HDPE - Room Temp, Water, Trial #2 (410-114570-5) is outside the QC acceptance limits due to the matrix of the sample.

Method 537_DI: The recovery for the labeled isotope(s) M2-6:2 FTS, 13C3 PFHxS, d3-NMeFOSAA, d5-NEtFOSAA and 13C8 FOSA in the following samples: FLPE - Room Temp, Water, Trial #3 (410-114570-3) is outside the QC acceptance limits due to the matrix of the sample.

Method 537_DI: The recovery for the labeled isotope(s) 13C6 PFDA, d5-NEtFOSAA and 13C8 FOSA in the following samples: HDPE - Room Temp, Water, Trial #3 (410-114570-6) is outside the QC acceptance limits due to the matrix of the sample.

Method 537_DI: The recovery for the labeled isotope(s) 13C9 PFNA, 13C6 PFDA, d3-NMeFOSAA, d5-NEtFOSAA and 13C8 FOSA in the following samples: Blank - Room Temp, Water (410-114570-7) is outside the QC acceptance limits due to the matrix of the sample.

Job ID: 410-114570-1 (Continued)

Laboratory: Eurofins Lancaster Laboratories Environment Testing, LLC (Continued)

Method 537_DI: The recovery for the labeled isotope(s) 13C6 PFDA, d3-NMeFOSAA, d5-NEtFOSAA, 13C8 FOSA, 13C4 PFBA and 13C5 PFPeA in the method blank/laboratory control spike samples associated with the following samples: FLPE - Room Temp, Water, Trial #1 (410-114570-1), FLPE - Room Temp, Water, Trial #2 (410-114570-2), FLPE - Room Temp, Water, Trial #3 (410-114570-3), HDPE - Room Temp, Water, Trial #1 (410-114570-4), HDPE - Room Temp, Water, Trial #2 (410-114570-5), HDPE - Room Temp, Water, Trial #3 (410-114570-6) and Blank - Room Temp, Water (410-114570-7) is outside the QC acceptance limits. No further action was taken.

Method 537_DI: The recovery for a target analyte(s) Perfluorodecanoic acid, Perfluorotridecanoic acid, Perfluorotetradecanoic acid, NEtFOSAA, NMeFOSAA, Perfluorooctanesulfonamide, Perfluorohexadecanoic acid, Perfluoroundecanoic acid and Perfluorododecanoic acid in the laboratory control spike samples associated with the following samples: FLPE - Room Temp, Water, Trial #1 (410-114570-1), FLPE - Room Temp, Water, Trial #2 (410-114570-2), FLPE - Room Temp, Water, Trial #3 (410-114570-3), HDPE - Room Temp, Water, Trial #1 (410-114570-4), HDPE - Room Temp, Water, Trial #2 (410-114570-5), HDPE - Room Temp, Water, Trial #3 (410-114570-6) and Blank - Room Temp, Water (410-114570-7) is outside the QC acceptance limits. No further action was taken.

Method 537_DI: The recovery for the labeled isotope(s) 13C8 FOSA in the laboratory control spike samples associated with the following samples: FLPE - Room Temp, Methanol, Trial #1 (410-114570-8), FLPE - Room Temp, Methanol, Trial #2 (410-114570-9), FLPE - Room Temp, Methanol, Trial #3 (410-114570-10), HDPE - Room Temp, Methanol, Trial #1 (410-114570-11), HDPE - Room Temp, Methanol, Trial #2 (410-114570-12), HDPE - Room Temp, Methanol, Trial #3 (410-114570-13) and Blank - Room Temp, Methanol (410-114570-14) is outside the QC acceptance limits. Since the recovery for the associated target analyte perfluorooctanesulfonamide is within the limits, the data is reported.

Method 537_DI: The recovery for the labeled isotope(s) 13C9 PFNA, 13C6 PFDA, 13C2 PFTeDA and 13C8 PFOS in the following samples: FLPE - Room Temp, Methanol, Trial #3 (410-114570-10) is outside the QC acceptance limits due to the matrix of the sample.

Method 537_DI: The holding time was not met. FLPE - Room Temp, Acetone, Trial #1 (410-114570-15), FLPE - Room Temp, Acetone, Trial #2 (410-114570-16), FLPE - Room Temp, Acetone, Trial #3 (410-114570-17), HDPE - Room Temp, Acetone, Trial #1 (410-114570-18), HDPE - Room Temp, Acetone, Trial #2 (410-114570-19), HDPE - Room Temp, Acetone, Trial #3 (410-114570-20) and Blank - Room Temp, Acetone (410-114570-21) was submitted to the laboratory with insufficient time remaining in the hold.

Method 537_DI: The recovery for the labeled isotope(s) 13C2 PFTeDA and 13C8 PFOS in the following samples: FLPE - Room Temp, Acetone, Trial #2 (410-114570-16) is outside the QC acceptance limits due to the matrix of the sample.

Method 537_DI: The recovery for the labeled isotope: 13C2 PFTeDA in the following samples: FLPE - Room Temp, Acetone, Trial #3 (410-114570-17) and HDPE - Room Temp, Acetone, Trial #1 (410-114570-18) is outside the QC acceptance limits. Since the recovery is high and the native analyte is not detected in the sample, the data is reported.

Method 537_DI: The recovery for the labeled isotope: 13C2 PFTeDA and 13C8 PFOS in the following samples: HDPE - Room Temp, Acetone, Trial #2 (410-114570-19) and HDPE - Room Temp, Acetone, Trial #3 (410-114570-20) is outside the QC acceptance limits. Since the recovery is high and the native analyte is not detected in the sample, the data is reported.

Method 537_DI: The recovery for a target analyte(s) 13C2 PFTeDA, 13C4 PFBA and 13C5 PFPeA in the laboratory control spike(s) associated with the following samples: Blank - Room Temp, Acetone (410-114570-21) is outside the QC acceptance limits. Sufficient sample was not available to re-extract this sample.

Method 537_DI: The holding time was not met. HDPE - Room Temp, Water, Trial #3 (410-114570-6) was submitted to the laboratory with insufficient time remaining in the hold.

Method 537_DI: The holding time was not met. FLPE - Room Temp, Water, Trial #1 (410-114570-1), FLPE - Room Temp, Water, Trial #2 (410-114570-2), FLPE - Room Temp, Water, Trial #3 (410-114570-3), HDPE - Room Temp, Water, Trial #1 (410-114570-4), HDPE - Room Temp, Water, Trial #2 (410-114570-5) and Blank - Room Temp, Water (410-114570-7) was submitted to the laboratory with insufficient time remaining in the hold.

Job ID: 410-114570-1 (Continued)

Laboratory: Eurofins Lancaster Laboratories Environment Testing, LLC (Continued)

Method 537_DI: The recovery for the labeled isotope(s) M2-4:2 FTS, M2-8:2 FTS, M2-6:2 FTS, 13C5 PFHxA, 13C4 PFHpA, 13C8 PFOA, 13C9 PFNA, 13C6 PFDA, 13C7 PFUnA, 13C2-PFDoDA, 13C2 PFTeDA, 13C3 PFBS, 13C3 PFHxS, 13C8 PFOS, d3-NMeFOSAA, d5-NEtFOSAA, 13C8 FOSA, 13C4 PFBA and 13C5 PFPeA in the method blank/laboratory control spike samples associated with the following samples: FLPE - Room Temp, Acetone, Trial #1 (410-114570-15), FLPE - Room Temp, Acetone, Trial #2 (410-114570-16), FLPE - Room Temp, Acetone, Trial #3 (410-114570-17), HDPE - Room Temp, Acetone, Trial #1 (410-114570-18), HDPE - Room Temp, Acetone, Trial #2 (410-114570-19), HDPE - Room Temp, Acetone, Trial #3 (410-114570-20) and Blank - Room Temp, Acetone (410-114570-21) is outside the QC acceptance limits. No further action was taken.

Method 537_DI: The recovery for a target analyte(s) Perfluoroheptanoic acid, Perfluorotridecanoic acid, NMeFOSAA, Perfluorooctanesulfonamide, Perfluorohexadecanoic acid, Perfluorooctadecanoic acid and Perfluorobutanoic acid in the laboratory control spike samples associated with the following samples: FLPE - Room Temp, Acetone, Trial #1 (410-114570-15), FLPE - Room Temp, Acetone, Trial #2 (410-114570-16), FLPE - Room Temp, Acetone, Trial #3 (410-114570-17), HDPE - Room Temp, Acetone, Trial #1 (410-114570-18), HDPE - Room Temp, Acetone, Trial #2 (410-114570-19), HDPE - Room Temp, Acetone, Trial #3 (410-114570-20) and Blank - Room Temp, Acetone (410-114570-21) is outside the QC acceptance limits. No further action was taken.

No additional analytical or quality issues were noted, other than those described above or in the Definitions/ Glossary page.

Detection Summary

Client: PEER
Project/Site: PFAS in containers

Job ID: 410-114570-1

Client Sample ID: FLPE - Room Temp, Water, Trial #1 — Lab Sample ID: 410-114570-1

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Perfluorobutanoic acid	2600	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluoropentanoic acid	1600	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA

Client Sample ID: FLPE - Room Temp, Water, Trial #2 — Lab Sample ID: 410-114570-2

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Perfluorobutanoic acid	1400	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA

Client Sample ID: FLPE - Room Temp, Water, Trial #3 — Lab Sample ID: 410-114570-3

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Perfluorobutanoic acid	1400	H cn	1200	1200	ng/L	1		EPA 537 (mod)	Total/NA

Client Sample ID: HDPE - Room Temp, Water, Trial #1 — Lab Sample ID: 410-114570-4

No Detections.

Client Sample ID: HDPE - Room Temp, Water, Trial #2 — Lab Sample ID: 410-114570-5

No Detections.

Client Sample ID: HDPE - Room Temp, Water, Trial #3 — Lab Sample ID: 410-114570-6

No Detections.

Client Sample ID: Blank - Room Temp, Water — Lab Sample ID: 410-114570-7

No Detections.

Client Sample ID: FLPE - Room Temp, Methanol, Trial #1 — Lab Sample ID: 410-114570-8

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Perfluorohexanoic acid	13000	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluoroheptanoic acid	9000	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorooctanoic acid	5400	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorononanoic acid	3400	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorodecanoic acid	1900	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorobutanoic acid	19000	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluoropentanoic acid	19000	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluoroundecanoic acid	1500	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA

Client Sample ID: FLPE - Room Temp, Methanol, Trial #2 — Lab Sample ID: 410-114570-9

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Perfluorohexanoic acid	12000	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluoroheptanoic acid	8200	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorooctanoic acid	3600	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorononanoic acid	3000	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorodecanoic acid	1600	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorobutanoic acid	14000	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluoropentanoic acid	16000	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA

Client Sample ID: FLPE - Room Temp, Methanol, Trial #3 — Lab Sample ID: 410-114570-10

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Perfluorohexanoic acid	9200	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA

This Detection Summary does not include radiochemical test results.

Client Sample ID: FLPE - Room Temp, Methanol, Trial #3 (Continued)
Lab Sample ID: 410-114570-10

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Perfluoroheptanoic acid	6700	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorooctanoic acid	3200	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorononanoic acid	2500	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorodecanoic acid	1400	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorobutanoic acid	12000	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluoropentanoic acid	13000	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA

Client Sample ID: HDPE - Room Temp, Methanol, Trial #1
Lab Sample ID: 410-114570-11

No Detections.

Client Sample ID: HDPE - Room Temp, Methanol, Trial #2
Lab Sample ID: 410-114570-12

No Detections.

Client Sample ID: HDPE - Room Temp, Methanol, Trial #3
Lab Sample ID: 410-114570-13

No Detections.

Client Sample ID: Blank - Room Temp, Methanol
Lab Sample ID: 410-114570-14

No Detections.

Client Sample ID: FLPE - Room Temp, Acetone, Trial #1
Lab Sample ID: 410-114570-15

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Perfluorohexanoic acid	14000	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluoroheptanoic acid	8900	H *- cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorooctanoic acid	4800	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorononanoic acid	4100	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorodecanoic acid	2000	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorobutanoic acid	18000	H *- cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluoropentanoic acid	19000	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluoroundecanoic acid	1500	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA

Client Sample ID: FLPE - Room Temp, Acetone, Trial #2
Lab Sample ID: 410-114570-16

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Perfluorohexanoic acid	15000	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluoroheptanoic acid	11000	H *- cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorooctanoic acid	5600	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorononanoic acid	3900	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorodecanoic acid	2400	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorobutanoic acid	17000	H *- cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluoropentanoic acid	20000	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluoroundecanoic acid	1400	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA

Client Sample ID: FLPE - Room Temp, Acetone, Trial #3
Lab Sample ID: 410-114570-17

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Perfluorohexanoic acid	13000	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluoroheptanoic acid	8000	H *- cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorooctanoic acid	4400	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorononanoic acid	3700	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA

This Detection Summary does not include radiochemical test results.

Detection Summary

Client: PEER
Job ID: 410-114570-1
Project/Site: PFAS in containers

Client Sample ID: FLPE - Room Temp, Acetone, Trial #3 (Continued)
Lab Sample ID: 410-114570-17

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Perfluorodecanoic acid	2000	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluorobutanoic acid	15000	H *- cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA
Perfluoropentanoic acid	18000	H cn	1300	1300	ng/L	1		EPA 537 (mod)	Total/NA

Client Sample ID: HDPE - Room Temp, Acetone, Trial #1
Lab Sample ID: 410-114570-18

No Detections.

Client Sample ID: HDPE - Room Temp, Acetone, Trial #2
Lab Sample ID: 410-114570-19

No Detections.

Client Sample ID: HDPE - Room Temp, Acetone, Trial #3
Lab Sample ID: 410-114570-20

No Detections.

Client Sample ID: Blank - Room Temp, Acetone
Lab Sample ID: 410-114570-21

No Detections.

This Detection Summary does not include radiochemical test results.

Client Sample ID: FLPE - Room Temp, Water, Trial #1

Lab Sample ID: 410-114570-1
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluoroheptanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluorooctanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluorononanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluorodecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluorotridecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluorotetradecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluorohexadecanoic acid	ND	H *+ cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluorooctadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluorobutanoic acid	**2600**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluoropentanoic acid	**1600**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluoroundecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1
Perfluorododecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:48	1

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C5 PFHxA	*125*	*cn*	*50 - 156*	*03/21/23 12:10*	*04/18/23 21:48*	*1*
13C4 PFHpA	*121*	*cn*	*60 - 150*	*03/21/23 12:10*	*04/18/23 21:48*	*1*
13C8 PFOA	*123*	*cn*	*62 - 146*	*03/21/23 12:10*	*04/18/23 21:48*	*1*
13C9 PFNA	*110*	*cn*	*60 - 142*	*03/21/23 12:10*	*04/18/23 21:48*	*1*
13C6 PFDA	*99*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/18/23 21:48*	*1*
13C7 PFUnA	*92*	*cn*	*27 - 168*	*03/21/23 12:10*	*04/18/23 21:48*	*1*
13C2-PFDoDA	*77*	*cn*	*29 - 158*	*03/21/23 12:10*	*04/18/23 21:48*	*1*
13C2 PFTeDA	*96*	*cn*	*33 - 150*	*03/21/23 12:10*	*04/18/23 21:48*	*1*
13C3 PFBS	*135*	*cn*	*63 - 160*	*03/21/23 12:10*	*04/18/23 21:48*	*1*
13C3 PFHxS	*139*	*cn*	*57 - 159*	*03/21/23 12:10*	*04/18/23 21:48*	*1*
13C8 PFOS	*127*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/18/23 21:48*	*1*
13C4 PFBA	*122*	*cn*	*67 - 136*	*03/21/23 12:10*	*04/18/23 21:48*	*1*
13C5 PFPeA	*126*	*cn*	*63 - 139*	*03/21/23 12:10*	*04/18/23 21:48*	*1*

Client Sample ID: FLPE - Room Temp, Water, Trial #2

Lab Sample ID: 410-114570-2
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluoroheptanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluorooctanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluorononanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluorodecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluorotridecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluorotetradecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1

Client Sample ID: FLPE - Room Temp, Water, Trial #2

Lab Sample ID: 410-114570-2

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluorohexadecanoic acid	ND	H *+ cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluorooctadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluorobutanoic acid	**1400**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluoropentanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluoroundecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1
Perfluorododecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 21:59	1

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C5 PFHxA	*121*	*cn*	*50 - 156*	*03/21/23 12:10*	*04/18/23 21:59*	*1*
13C4 PFHpA	*124*	*cn*	*60 - 150*	*03/21/23 12:10*	*04/18/23 21:59*	*1*
13C8 PFOA	*120*	*cn*	*62 - 146*	*03/21/23 12:10*	*04/18/23 21:59*	*1*
13C9 PFNA	*94*	*cn*	*60 - 142*	*03/21/23 12:10*	*04/18/23 21:59*	*1*
13C6 PFDA	*86*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/18/23 21:59*	*1*
13C7 PFUnA	*79*	*cn*	*27 - 168*	*03/21/23 12:10*	*04/18/23 21:59*	*1*
13C2-PFDoDA	*78*	*cn*	*29 - 158*	*03/21/23 12:10*	*04/18/23 21:59*	*1*
13C2 PFTeDA	*97*	*cn*	*33 - 150*	*03/21/23 12:10*	*04/18/23 21:59*	*1*
13C3 PFBS	*137*	*cn*	*63 - 160*	*03/21/23 12:10*	*04/18/23 21:59*	*1*
13C3 PFHxS	*154*	*cn*	*57 - 159*	*03/21/23 12:10*	*04/18/23 21:59*	*1*
13C8 PFOS	*133*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/18/23 21:59*	*1*
13C4 PFBA	*102*	*cn*	*67 - 136*	*03/21/23 12:10*	*04/18/23 21:59*	*1*
13C5 PFPeA	*110*	*cn*	*63 - 139*	*03/21/23 12:10*	*04/18/23 21:59*	*1*

Client Sample ID: FLPE - Room Temp, Water, Trial #3

Lab Sample ID: 410-114570-3

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluoroheptanoic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluorooctanoic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluorononanoic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluorodecanoic acid	ND	*+ H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluorotridecanoic acid	ND	*+ H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluorotetradecanoic acid	ND	*+ H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluorobutanesulfonic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluorohexanesulfonic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluorooctanesulfonic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluoropentanesulfonic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluoroheptanesulfonic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluorononanesulfonic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluorodecanesulfonic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1

Client Sample ID: FLPE - Room Temp, Water, Trial #3

Lab Sample ID: 410-114570-3

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluorohexadecanoic acid	ND	H *+ cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluorooctadecanoic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluorobutanoic acid	**1400**	**H cn**	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluoropentanoic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluoroundecanoic acid	ND	*+ H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1
Perfluorododecanoic acid	ND	*+ H cn	1200	1200	ng/L		03/21/23 12:10	04/18/23 22:10	1

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C5 PFHxA	*136*	*cn*	*50 - 156*	*03/21/23 12:10*	*04/18/23 22:10*	*1*
13C4 PFHpA	*127*	*cn*	*60 - 150*	*03/21/23 12:10*	*04/18/23 22:10*	*1*
13C8 PFOA	*129*	*cn*	*62 - 146*	*03/21/23 12:10*	*04/18/23 22:10*	*1*
13C9 PFNA	*104*	*cn*	*60 - 142*	*03/21/23 12:10*	*04/18/23 22:10*	*1*
13C6 PFDA	*76*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/18/23 22:10*	*1*
13C7 PFUnA	*58*	*cn*	*27 - 168*	*03/21/23 12:10*	*04/18/23 22:10*	*1*
13C2-PFDoDA	*57*	*cn*	*29 - 158*	*03/21/23 12:10*	*04/18/23 22:10*	*1*
13C2 PFTeDA	*85*	*cn*	*33 - 150*	*03/21/23 12:10*	*04/18/23 22:10*	*1*
13C3 PFBS	*144*	*cn*	*63 - 160*	*03/21/23 12:10*	*04/18/23 22:10*	*1*
13C3 PFHxS	*166*	**5+ cn*	*57 - 159*	*03/21/23 12:10*	*04/18/23 22:10*	*1*
13C8 PFOS	*139*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/18/23 22:10*	*1*
13C4 PFBA	*110*	*cn*	*67 - 136*	*03/21/23 12:10*	*04/18/23 22:10*	*1*
13C5 PFPeA	*121*	*cn*	*63 - 139*	*03/21/23 12:10*	*04/18/23 22:10*	*1*

Client Sample ID: HDPE - Room Temp, Water, Trial #1

Lab Sample ID: 410-114570-4

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluoroheptanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluorooctanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluorononanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluorodecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluorotridecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluorotetradecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluorohexadecanoic acid	ND	H *+ cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluorooctadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluorobutanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluoropentanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1
Perfluoroundecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1

Client Sample ID: HDPE - Room Temp, Water, Trial #1

Lab Sample ID: 410-114570-4

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorododecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:21	1

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C5 PFHxA	*132*	*cn*	*50 - 156*	*03/21/23 12:10*	*04/18/23 22:21*	*1*
13C4 PFHpA	*127*	*cn*	*60 - 150*	*03/21/23 12:10*	*04/18/23 22:21*	*1*
13C8 PFOA	*123*	*cn*	*62 - 146*	*03/21/23 12:10*	*04/18/23 22:21*	*1*
13C9 PFNA	*101*	*cn*	*60 - 142*	*03/21/23 12:10*	*04/18/23 22:21*	*1*
13C6 PFDA	*71*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/18/23 22:21*	*1*
13C7 PFUnA	*61*	*cn*	*27 - 168*	*03/21/23 12:10*	*04/18/23 22:21*	*1*
13C2-PFDoDA	*61*	*cn*	*29 - 158*	*03/21/23 12:10*	*04/18/23 22:21*	*1*
13C2 PFTeDA	*86*	*cn*	*33 - 150*	*03/21/23 12:10*	*04/18/23 22:21*	*1*
13C3 PFBS	*134*	*cn*	*63 - 160*	*03/21/23 12:10*	*04/18/23 22:21*	*1*
13C3 PFHxS	*149*	*cn*	*57 - 159*	*03/21/23 12:10*	*04/18/23 22:21*	*1*
13C8 PFOS	*130*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/18/23 22:21*	*1*
13C4 PFBA	*124*	*cn*	*67 - 136*	*03/21/23 12:10*	*04/18/23 22:21*	*1*
13C5 PFPeA	*128*	*cn*	*63 - 139*	*03/21/23 12:10*	*04/18/23 22:21*	*1*

Client Sample ID: HDPE - Room Temp, Water, Trial #2

Lab Sample ID: 410-114570-5

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluoroheptanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluorooctanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluorononanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluorodecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluorotridecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluorotetradecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluorohexadecanoic acid	ND	H *+ cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluorooctadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluorobutanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluoropentanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluoroundecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1
Perfluorododecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:32	1

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C5 PFHxA	*124*	*cn*	*50 - 156*	*03/21/23 12:10*	*04/18/23 22:32*	*1*
13C4 PFHpA	*118*	*cn*	*60 - 150*	*03/21/23 12:10*	*04/18/23 22:32*	*1*
13C8 PFOA	*127*	*cn*	*62 - 146*	*03/21/23 12:10*	*04/18/23 22:32*	*1*
13C9 PFNA	*107*	*cn*	*60 - 142*	*03/21/23 12:10*	*04/18/23 22:32*	*1*
13C6 PFDA	*91*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/18/23 22:32*	*1*

Client Sample ID: HDPE - Room Temp, Water, Trial #2

Lab Sample ID: 410-114570-5

Date Collected: 01/19/23 00:00

Matrix: Water

Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C7 PFUnA	82	cn	27 - 168	03/21/23 12:10	04/18/23 22:32	1
13C2-PFDoDA	73	cn	29 - 158	03/21/23 12:10	04/18/23 22:32	1
13C2 PFTeDA	96	cn	33 - 150	03/21/23 12:10	04/18/23 22:32	1
13C3 PFBS	131	cn	63 - 160	03/21/23 12:10	04/18/23 22:32	1
13C3 PFHxS	146	cn	57 - 159	03/21/23 12:10	04/18/23 22:32	1
13C8 PFOS	126	cn	64 - 141	03/21/23 12:10	04/18/23 22:32	1
13C4 PFBA	121	cn	67 - 136	03/21/23 12:10	04/18/23 22:32	1
13C5 PFPeA	121	cn	63 - 139	03/21/23 12:10	04/18/23 22:32	1

Client Sample ID: HDPE - Room Temp, Water, Trial #3

Lab Sample ID: 410-114570-6

Date Collected: 01/19/23 00:00

Matrix: Water

Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluoroheptanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluorooctanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluorononanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluorodecanoic acid	ND	H *+ cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluorotridecanoic acid	ND	H *+ cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluorotetradecanoic acid	ND	H *+ cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluorohexadecanoic acid	ND	H *+ cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluorooctadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluorobutanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluoropentanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluoroundecanoic acid	ND	H *+ cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1
Perfluorododecanoic acid	ND	H *+ cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 22:58	1

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C5 PFHxA	77	cn	50 - 156	03/21/23 12:10	04/19/23 22:58	1
13C4 PFHpA	87	cn	60 - 150	03/21/23 12:10	04/19/23 22:58	1
13C8 PFOA	87	cn	62 - 146	03/21/23 12:10	04/19/23 22:58	1
13C9 PFNA	79	cn	60 - 142	03/21/23 12:10	04/19/23 22:58	1
13C6 PFDA	60	*5- cn	64 - 141	03/21/23 12:10	04/19/23 22:58	1
13C7 PFUnA	47	cn	27 - 168	03/21/23 12:10	04/19/23 22:58	1
13C2-PFDoDA	45	cn	29 - 158	03/21/23 12:10	04/19/23 22:58	1
13C2 PFTeDA	71	cn	33 - 150	03/21/23 12:10	04/19/23 22:58	1
13C3 PFBS	114	cn	63 - 160	03/21/23 12:10	04/19/23 22:58	1
13C3 PFHxS	105	cn	57 - 159	03/21/23 12:10	04/19/23 22:58	1
13C8 PFOS	106	cn	64 - 141	03/21/23 12:10	04/19/23 22:58	1
13C4 PFBA	72	cn	67 - 136	03/21/23 12:10	04/19/23 22:58	1

Client Sample ID: HDPE - Room Temp, Water, Trial #3

Lab Sample ID: 410-114570-6
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C5 PFPeA	82	cn	63 - 139	03/21/23 12:10	04/19/23 22:58	1

Client Sample ID: Blank - Room Temp, Water

Lab Sample ID: 410-114570-7
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluoroheptanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluorooctanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluorononanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluorodecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluorotridecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluorotetradecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluorohexadecanoic acid	ND	H *+ cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluorooctadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluorobutanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluoropentanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluoroundecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1
Perfluorododecanoic acid	ND	*+ H cn	1300	1300	ng/L		03/21/23 12:10	04/18/23 22:55	1

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C5 PFHxA	105	cn	50 - 156	03/21/23 12:10	04/18/23 22:55	1
13C4 PFHpA	90	cn	60 - 150	03/21/23 12:10	04/18/23 22:55	1
13C8 PFOA	65	cn	62 - 146	03/21/23 12:10	04/18/23 22:55	1
13C9 PFNA	43	*5- cn	60 - 142	03/21/23 12:10	04/18/23 22:55	1
13C6 PFDA	43	*5- cn	64 - 141	03/21/23 12:10	04/18/23 22:55	1
13C7 PFUnA	55	cn	27 - 168	03/21/23 12:10	04/18/23 22:55	1
13C2-PFDoDA	66	cn	29 - 158	03/21/23 12:10	04/18/23 22:55	1
13C2 PFTeDA	99	cn	33 - 150	03/21/23 12:10	04/18/23 22:55	1
13C3 PFBS	122	cn	63 - 160	03/21/23 12:10	04/18/23 22:55	1
13C3 PFHxS	123	cn	57 - 159	03/21/23 12:10	04/18/23 22:55	1
13C8 PFOS	85	cn	64 - 141	03/21/23 12:10	04/18/23 22:55	1
13C4 PFBA	109	cn	67 - 136	03/21/23 12:10	04/18/23 22:55	1
13C5 PFPeA	112	cn	63 - 139	03/21/23 12:10	04/18/23 22:55	1

Client Sample ID: FLPE - Room Temp, Methanol, Trial #1

Lab Sample ID: 410-114570-8

Date Collected: 01/19/23 00:00

Matrix: Water

Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	**13000**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluoroheptanoic acid	**9000**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluorooctanoic acid	**5400**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluorononanoic acid	**3400**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluorodecanoic acid	**1900**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluorotridecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluorotetradecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluorooctanesulfonamide	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluorohexadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluorooctadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluorobutanoic acid	**19000**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluoropentanoic acid	**19000**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluoroundecanoic acid	**1500**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1
Perfluorododecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:11	1

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C5 PFHxA	*114*	*cn*	*50 - 156*	*03/21/23 12:10*	*04/19/23 09:11*	*1*
13C4 PFHpA	*124*	*cn*	*60 - 150*	*03/21/23 12:10*	*04/19/23 09:11*	*1*
13C8 PFOA	*122*	*cn*	*62 - 146*	*03/21/23 12:10*	*04/19/23 09:11*	*1*
13C9 PFNA	*125*	*cn*	*60 - 142*	*03/21/23 12:10*	*04/19/23 09:11*	*1*
13C6 PFDA	*127*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/19/23 09:11*	*1*
13C7 PFUnA	*122*	*cn*	*27 - 168*	*03/21/23 12:10*	*04/19/23 09:11*	*1*
13C2-PFDoDA	*125*	*cn*	*29 - 158*	*03/21/23 12:10*	*04/19/23 09:11*	*1*
13C2 PFTeDA	*154*	**5+ cn*	*33 - 150*	*03/21/23 12:10*	*04/19/23 09:11*	*1*
13C3 PFBS	*134*	*cn*	*63 - 160*	*03/21/23 12:10*	*04/19/23 09:11*	*1*
13C3 PFHxS	*133*	*cn*	*57 - 159*	*03/21/23 12:10*	*04/19/23 09:11*	*1*
13C8 PFOS	*121*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/19/23 09:11*	*1*
13C4 PFBA	*103*	*cn*	*67 - 136*	*03/21/23 12:10*	*04/19/23 09:11*	*1*
13C5 PFPeA	*106*	*cn*	*63 - 139*	*03/21/23 12:10*	*04/19/23 09:11*	*1*

Client Sample ID: FLPE - Room Temp, Methanol, Trial #2

Lab Sample ID: 410-114570-9

Date Collected: 01/19/23 00:00

Matrix: Water

Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	**12000**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluoroheptanoic acid	**8200**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluorooctanoic acid	**3600**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluorononanoic acid	**3000**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluorodecanoic acid	**1600**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluorotridecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1

Client Sample ID: FLPE - Room Temp, Methanol, Trial #2

Lab Sample ID: 410-114570-9

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorotetradecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluorooctanesulfonamide	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluorohexadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluorooctadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluorobutanoic acid	**14000**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluoropentanoic acid	**16000**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluoroundecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1
Perfluorododecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:22	1

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C5 PFHxA	*104*	*cn*	*50 - 156*	*03/21/23 12:10*	*04/19/23 09:22*	*1*
13C4 PFHpA	*119*	*cn*	*60 - 150*	*03/21/23 12:10*	*04/19/23 09:22*	*1*
13C8 PFOA	*123*	*cn*	*62 - 146*	*03/21/23 12:10*	*04/19/23 09:22*	*1*
13C9 PFNA	*133*	*cn*	*60 - 142*	*03/21/23 12:10*	*04/19/23 09:22*	*1*
13C6 PFDA	*135*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/19/23 09:22*	*1*
13C7 PFUnA	*136*	*cn*	*27 - 168*	*03/21/23 12:10*	*04/19/23 09:22*	*1*
13C2-PFDoDA	*142*	*cn*	*29 - 158*	*03/21/23 12:10*	*04/19/23 09:22*	*1*
13C2 PFTeDA	*164*	**5+ cn*	*33 - 150*	*03/21/23 12:10*	*04/19/23 09:22*	*1*
13C3 PFBS	*135*	*cn*	*63 - 160*	*03/21/23 12:10*	*04/19/23 09:22*	*1*
13C3 PFHxS	*132*	*cn*	*57 - 159*	*03/21/23 12:10*	*04/19/23 09:22*	*1*
13C8 PFOS	*129*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/19/23 09:22*	*1*
13C4 PFBA	*84*	*cn*	*67 - 136*	*03/21/23 12:10*	*04/19/23 09:22*	*1*
13C5 PFPeA	*98*	*cn*	*63 - 139*	*03/21/23 12:10*	*04/19/23 09:22*	*1*

Client Sample ID: FLPE - Room Temp, Methanol, Trial #3

Lab Sample ID: 410-114570-10

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	**9200**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluoroheptanoic acid	**6700**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluorooctanoic acid	**3200**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluorononanoic acid	**2500**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluorodecanoic acid	**1400**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluorotridecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluorotetradecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1

Client Sample ID: FLPE - Room Temp, Methanol, Trial #3

Lab Sample ID: 410-114570-10

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluorooctanesulfonamide	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluorohexadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluorooctadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluorobutanoic acid	**12000**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluoropentanoic acid	**13000**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluoroundecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1
Perfluorododecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:33	1

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C5 PFHxA	*123*	*cn*	*50 - 156*	*03/21/23 12:10*	*04/19/23 09:33*	*1*
13C4 PFHpA	*130*	*cn*	*60 - 150*	*03/21/23 12:10*	*04/19/23 09:33*	*1*
13C8 PFOA	*134*	*cn*	*62 - 146*	*03/21/23 12:10*	*04/19/23 09:33*	*1*
13C9 PFNA	*146*	**5+ cn*	*60 - 142*	*03/21/23 12:10*	*04/19/23 09:33*	*1*
13C6 PFDA	*145*	**5+ cn*	*64 - 141*	*03/21/23 12:10*	*04/19/23 09:33*	*1*
13C7 PFUnA	*143*	*cn*	*27 - 168*	*03/21/23 12:10*	*04/19/23 09:33*	*1*
13C2-PFDoDA	*145*	*cn*	*29 - 158*	*03/21/23 12:10*	*04/19/23 09:33*	*1*
13C2 PFTeDA	*170*	**5+ cn*	*33 - 150*	*03/21/23 12:10*	*04/19/23 09:33*	*1*
13C3 PFBS	*150*	*cn*	*63 - 160*	*03/21/23 12:10*	*04/19/23 09:33*	*1*
13C3 PFHxS	*148*	*cn*	*57 - 159*	*03/21/23 12:10*	*04/19/23 09:33*	*1*
13C8 PFOS	*148*	**5+ cn*	*64 - 141*	*03/21/23 12:10*	*04/19/23 09:33*	*1*
13C4 PFBA	*92*	*cn*	*67 - 136*	*03/21/23 12:10*	*04/19/23 09:33*	*1*
13C5 PFPeA	*109*	*cn*	*63 - 139*	*03/21/23 12:10*	*04/19/23 09:33*	*1*

Client Sample ID: HDPE - Room Temp, Methanol, Trial #1

Lab Sample ID: 410-114570-11

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluoroheptanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluorooctanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluorononanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluorodecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluorotridecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluorotetradecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluorooctanesulfonamide	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluorohexadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1

Client Sample ID: HDPE - Room Temp, Methanol, Trial #1
Lab Sample ID: 410-114570-11

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorooctadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluorobutanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluoropentanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluoroundecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1
Perfluorododecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:44	1

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C5 PFHxA	*97*	*cn*	*50 - 156*	*03/21/23 12:10*	*04/19/23 09:44*	*1*
13C4 PFHpA	*112*	*cn*	*60 - 150*	*03/21/23 12:10*	*04/19/23 09:44*	*1*
13C8 PFOA	*121*	*cn*	*62 - 146*	*03/21/23 12:10*	*04/19/23 09:44*	*1*
13C9 PFNA	*131*	*cn*	*60 - 142*	*03/21/23 12:10*	*04/19/23 09:44*	*1*
13C6 PFDA	*123*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/19/23 09:44*	*1*
13C7 PFUnA	*124*	*cn*	*27 - 168*	*03/21/23 12:10*	*04/19/23 09:44*	*1*
13C2-PFDoDA	*120*	*cn*	*29 - 158*	*03/21/23 12:10*	*04/19/23 09:44*	*1*
13C2 PFTeDA	*143*	*cn*	*33 - 150*	*03/21/23 12:10*	*04/19/23 09:44*	*1*
13C3 PFBS	*129*	*cn*	*63 - 160*	*03/21/23 12:10*	*04/19/23 09:44*	*1*
13C3 PFHxS	*131*	*cn*	*57 - 159*	*03/21/23 12:10*	*04/19/23 09:44*	*1*
13C8 PFOS	*128*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/19/23 09:44*	*1*
13C4 PFBA	*77*	*cn*	*67 - 136*	*03/21/23 12:10*	*04/19/23 09:44*	*1*
13C5 PFPeA	*94*	*cn*	*63 - 139*	*03/21/23 12:10*	*04/19/23 09:44*	*1*

Client Sample ID: HDPE - Room Temp, Methanol, Trial #2
Lab Sample ID: 410-114570-12

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluoroheptanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluorooctanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluorononanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluorodecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluorotridecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluorotetradecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluorooctanesulfonamide	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluorohexadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluorooctadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluorobutanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluoropentanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluoroundecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1
Perfluorododecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 09:55	1

Client Sample ID: HDPE - Room Temp, Methanol, Trial #2

Lab Sample ID: 410-114570-12

Date Collected: 01/19/23 00:00

Matrix: Water

Date Received: 01/20/23 09:30

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C5 PFHxA	97	cn	50 - 156	03/21/23 12:10	04/19/23 09:55	1
13C4 PFHpA	113	cn	60 - 150	03/21/23 12:10	04/19/23 09:55	1
13C8 PFOA	115	cn	62 - 146	03/21/23 12:10	04/19/23 09:55	1
13C9 PFNA	122	cn	60 - 142	03/21/23 12:10	04/19/23 09:55	1
13C6 PFDA	116	cn	64 - 141	03/21/23 12:10	04/19/23 09:55	1
13C7 PFUnA	120	cn	27 - 168	03/21/23 12:10	04/19/23 09:55	1
13C2-PFDoDA	111	cn	29 - 158	03/21/23 12:10	04/19/23 09:55	1
13C2 PFTeDA	132	cn	33 - 150	03/21/23 12:10	04/19/23 09:55	1
13C3 PFBS	132	cn	63 - 160	03/21/23 12:10	04/19/23 09:55	1
13C3 PFHxS	124	cn	57 - 159	03/21/23 12:10	04/19/23 09:55	1
13C8 PFOS	124	cn	64 - 141	03/21/23 12:10	04/19/23 09:55	1
13C4 PFBA	76	cn	67 - 136	03/21/23 12:10	04/19/23 09:55	1
13C5 PFPeA	95	cn	63 - 139	03/21/23 12:10	04/19/23 09:55	1

Client Sample ID: HDPE - Room Temp, Methanol, Trial #3

Lab Sample ID: 410-114570-13

Date Collected: 01/19/23 00:00

Matrix: Water

Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluoroheptanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluorooctanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluorononanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluorodecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluorotridecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluorotetradecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluorooctanesulfonamide	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluorohexadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluorooctadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluorobutanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluoropentanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluoroundecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1
Perfluorododecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:06	1

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C5 PFHxA	104	cn	50 - 156	03/21/23 12:10	04/19/23 10:06	1
13C4 PFHpA	115	cn	60 - 150	03/21/23 12:10	04/19/23 10:06	1
13C8 PFOA	116	cn	62 - 146	03/21/23 12:10	04/19/23 10:06	1
13C9 PFNA	135	cn	60 - 142	03/21/23 12:10	04/19/23 10:06	1
13C6 PFDA	126	cn	64 - 141	03/21/23 12:10	04/19/23 10:06	1
13C7 PFUnA	138	cn	27 - 168	03/21/23 12:10	04/19/23 10:06	1
13C2-PFDoDA	128	cn	29 - 158	03/21/23 12:10	04/19/23 10:06	1

Client Sample ID: HDPE - Room Temp, Methanol, Trial #3
Lab Sample ID: 410-114570-13

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C2 PFTeDA	149	cn	33 - 150	03/21/23 12:10	04/19/23 10:06	1
13C3 PFBS	133	cn	63 - 160	03/21/23 12:10	04/19/23 10:06	1
13C3 PFHxS	123	cn	57 - 159	03/21/23 12:10	04/19/23 10:06	1
13C8 PFOS	126	cn	64 - 141	03/21/23 12:10	04/19/23 10:06	1
13C4 PFBA	93	cn	67 - 136	03/21/23 12:10	04/19/23 10:06	1
13C5 PFPeA	96	cn	63 - 139	03/21/23 12:10	04/19/23 10:06	1

Client Sample ID: Blank - Room Temp, Methanol
Lab Sample ID: 410-114570-14

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluoroheptanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluorooctanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluorononanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluorodecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluorotridecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluorotetradecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluorohexadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluorooctadecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluorobutanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluoropentanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluoroundecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1
Perfluorododecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 10:17	1

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C5 PFHxA	82	cn	50 - 156	03/21/23 12:10	04/19/23 10:17	1
13C4 PFHpA	98	cn	60 - 150	03/21/23 12:10	04/19/23 10:17	1
13C8 PFOA	104	cn	62 - 146	03/21/23 12:10	04/19/23 10:17	1
13C9 PFNA	116	cn	60 - 142	03/21/23 12:10	04/19/23 10:17	1
13C6 PFDA	117	cn	64 - 141	03/21/23 12:10	04/19/23 10:17	1
13C7 PFUnA	127	cn	27 - 168	03/21/23 12:10	04/19/23 10:17	1
13C2-PFDoDA	116	cn	29 - 158	03/21/23 12:10	04/19/23 10:17	1
13C2 PFTeDA	142	cn	33 - 150	03/21/23 12:10	04/19/23 10:17	1
13C3 PFBS	121	cn	63 - 160	03/21/23 12:10	04/19/23 10:17	1
13C3 PFHxS	108	cn	57 - 159	03/21/23 12:10	04/19/23 10:17	1
13C8 PFOS	119	cn	64 - 141	03/21/23 12:10	04/19/23 10:17	1
13C4 PFBA	68	cn	67 - 136	03/21/23 12:10	04/19/23 10:17	1
13C5 PFPeA	79	cn	63 - 139	03/21/23 12:10	04/19/23 10:17	1

Client Sample ID: FLPE - Room Temp, Acetone, Trial #1

Lab Sample ID: 410-114570-15

Date Collected: 01/19/23 00:00

Matrix: Water

Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	**14000**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluoroheptanoic acid	**8900**	**H *- cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluorooctanoic acid	**4800**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluorononanoic acid	**4100**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluorodecanoic acid	**2000**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluorotridecanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluorotetradecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluorohexadecanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluorooctadecanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluorobutanoic acid	**18000**	**H *- cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluoropentanoic acid	**19000**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluoroundecanoic acid	**1500**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1
Perfluorododecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:12	1

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C5 PFHxA	*97*	*cn*	*50 - 156*	*03/21/23 12:10*	*04/19/23 11:12*	*1*
13C4 PFHpA	*107*	*cn*	*60 - 150*	*03/21/23 12:10*	*04/19/23 11:12*	*1*
13C8 PFOA	*113*	*cn*	*62 - 146*	*03/21/23 12:10*	*04/19/23 11:12*	*1*
13C9 PFNA	*112*	*cn*	*60 - 142*	*03/21/23 12:10*	*04/19/23 11:12*	*1*
13C6 PFDA	*121*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/19/23 11:12*	*1*
13C7 PFUnA	*126*	*cn*	*27 - 168*	*03/21/23 12:10*	*04/19/23 11:12*	*1*
13C2-PFDoDA	*119*	*cn*	*29 - 158*	*03/21/23 12:10*	*04/19/23 11:12*	*1*
13C2 PFTeDA	*144*	*cn*	*33 - 150*	*03/21/23 12:10*	*04/19/23 11:12*	*1*
13C3 PFBS	*133*	*cn*	*63 - 160*	*03/21/23 12:10*	*04/19/23 11:12*	*1*
13C3 PFHxS	*128*	*cn*	*57 - 159*	*03/21/23 12:10*	*04/19/23 11:12*	*1*
13C8 PFOS	*127*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/19/23 11:12*	*1*
13C4 PFBA	*100*	*cn*	*67 - 136*	*03/21/23 12:10*	*04/19/23 11:12*	*1*
13C5 PFPeA	*103*	*cn*	*63 - 139*	*03/21/23 12:10*	*04/19/23 11:12*	*1*

Client Sample ID: FLPE - Room Temp, Acetone, Trial #2

Lab Sample ID: 410-114570-16

Date Collected: 01/19/23 00:00

Matrix: Water

Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	**15000**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluoroheptanoic acid	**11000**	**H *- cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluorooctanoic acid	**5600**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluorononanoic acid	**3900**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluorodecanoic acid	**2400**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluorotridecanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluorotetradecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1

Client Sample ID: FLPE - Room Temp, Acetone, Trial #2

Lab Sample ID: 410-114570-16

Date Collected: 01/19/23 00:00

Matrix: Water

Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluorohexadecanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluorooctadecanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluorobutanoic acid	**17000**	**H *- cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluoropentanoic acid	**20000**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluoroundecanoic acid	**1400**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1
Perfluorododecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:24	1

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C5 PFHxA	*117*	*cn*	*50 - 156*	*03/21/23 12:10*	*04/19/23 11:24*	*1*
13C4 PFHpA	*120*	*cn*	*60 - 150*	*03/21/23 12:10*	*04/19/23 11:24*	*1*
13C8 PFOA	*129*	*cn*	*62 - 146*	*03/21/23 12:10*	*04/19/23 11:24*	*1*
13C9 PFNA	*138*	*cn*	*60 - 142*	*03/21/23 12:10*	*04/19/23 11:24*	*1*
13C6 PFDA	*132*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/19/23 11:24*	*1*
13C7 PFUnA	*146*	*cn*	*27 - 168*	*03/21/23 12:10*	*04/19/23 11:24*	*1*
13C2-PFDoDA	*139*	*cn*	*29 - 158*	*03/21/23 12:10*	*04/19/23 11:24*	*1*
13C2 PFTeDA	*158*	**5+ cn*	*33 - 150*	*03/21/23 12:10*	*04/19/23 11:24*	*1*
13C3 PFBS	*156*	*cn*	*63 - 160*	*03/21/23 12:10*	*04/19/23 11:24*	*1*
13C3 PFHxS	*153*	*cn*	*57 - 159*	*03/21/23 12:10*	*04/19/23 11:24*	*1*
13C8 PFOS	*156*	**5+ cn*	*64 - 141*	*03/21/23 12:10*	*04/19/23 11:24*	*1*
13C4 PFBA	*114*	*cn*	*67 - 136*	*03/21/23 12:10*	*04/19/23 11:24*	*1*
13C5 PFPeA	*120*	*cn*	*63 - 139*	*03/21/23 12:10*	*04/19/23 11:24*	*1*

Client Sample ID: FLPE - Room Temp, Acetone, Trial #3

Lab Sample ID: 410-114570-17

Date Collected: 01/19/23 00:00

Matrix: Water

Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	**13000**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluoroheptanoic acid	**8000**	**H *- cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluorooctanoic acid	**4400**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluorononanoic acid	**3700**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluorodecanoic acid	**2000**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluorotridecanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluorotetradecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1

Client Sample ID: FLPE - Room Temp, Acetone, Trial #3

Lab Sample ID: 410-114570-17

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluorohexadecanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluorooctadecanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluorobutanoic acid	**15000**	**H *- cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluoropentanoic acid	**18000**	**H cn**	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluoroundecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1
Perfluorododecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:35	1

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C5 PFHxA	*103*	*cn*	*50 - 156*	*03/21/23 12:10*	*04/19/23 11:35*	*1*
13C4 PFHpA	*116*	*cn*	*60 - 150*	*03/21/23 12:10*	*04/19/23 11:35*	*1*
13C8 PFOA	*120*	*cn*	*62 - 146*	*03/21/23 12:10*	*04/19/23 11:35*	*1*
13C9 PFNA	*126*	*cn*	*60 - 142*	*03/21/23 12:10*	*04/19/23 11:35*	*1*
13C6 PFDA	*125*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/19/23 11:35*	*1*
13C7 PFUnA	*139*	*cn*	*27 - 168*	*03/21/23 12:10*	*04/19/23 11:35*	*1*
13C2-PFDoDA	*132*	*cn*	*29 - 158*	*03/21/23 12:10*	*04/19/23 11:35*	*1*
13C2 PFTeDA	*158*	**5+ cn*	*33 - 150*	*03/21/23 12:10*	*04/19/23 11:35*	*1*
13C3 PFBS	*138*	*cn*	*63 - 160*	*03/21/23 12:10*	*04/19/23 11:35*	*1*
13C3 PFHxS	*135*	*cn*	*57 - 159*	*03/21/23 12:10*	*04/19/23 11:35*	*1*
13C8 PFOS	*137*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/19/23 11:35*	*1*
13C4 PFBA	*108*	*cn*	*67 - 136*	*03/21/23 12:10*	*04/19/23 11:35*	*1*
13C5 PFPeA	*108*	*cn*	*63 - 139*	*03/21/23 12:10*	*04/19/23 11:35*	*1*

Client Sample ID: HDPE - Room Temp, Acetone, Trial #1

Lab Sample ID: 410-114570-18

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluoroheptanoic acid	ND	H *- cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluorooctanoic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluorononanoic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluorodecanoic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluorotridecanoic acid	ND	H *- cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluorotetradecanoic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluorobutanesulfonic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluorohexanesulfonic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluorooctanesulfonic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluoropentanesulfonic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluoroheptanesulfonic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluorononanesulfonic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluorodecanesulfonic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluorohexadecanoic acid	ND	H *- cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluorooctadecanoic acid	ND	H *- cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluorobutanoic acid	ND	H *- cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluoropentanoic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1
Perfluoroundecanoic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1

Client Sample ID: HDPE - Room Temp, Acetone, Trial #1
Lab Sample ID: 410-114570-18

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorododecanoic acid	ND	H cn	1200	1200	ng/L		03/21/23 12:10	04/19/23 11:46	1

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C5 PFHxA	*99*	*cn*	*50 - 156*	*03/21/23 12:10*	*04/19/23 11:46*	*1*
13C4 PFHpA	*104*	*cn*	*60 - 150*	*03/21/23 12:10*	*04/19/23 11:46*	*1*
13C8 PFOA	*113*	*cn*	*62 - 146*	*03/21/23 12:10*	*04/19/23 11:46*	*1*
13C9 PFNA	*130*	*cn*	*60 - 142*	*03/21/23 12:10*	*04/19/23 11:46*	*1*
13C6 PFDA	*137*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/19/23 11:46*	*1*
13C7 PFUnA	*143*	*cn*	*27 - 168*	*03/21/23 12:10*	*04/19/23 11:46*	*1*
13C2-PFDoDA	*137*	*cn*	*29 - 158*	*03/21/23 12:10*	*04/19/23 11:46*	*1*
13C2 PFTeDA	*166*	**5+ cn*	*33 - 150*	*03/21/23 12:10*	*04/19/23 11:46*	*1*
13C3 PFBS	*131*	*cn*	*63 - 160*	*03/21/23 12:10*	*04/19/23 11:46*	*1*
13C3 PFHxS	*118*	*cn*	*57 - 159*	*03/21/23 12:10*	*04/19/23 11:46*	*1*
13C8 PFOS	*131*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/19/23 11:46*	*1*
13C4 PFBA	*94*	*cn*	*67 - 136*	*03/21/23 12:10*	*04/19/23 11:46*	*1*
13C5 PFPeA	*100*	*cn*	*63 - 139*	*03/21/23 12:10*	*04/19/23 11:46*	*1*

Client Sample ID: HDPE - Room Temp, Acetone, Trial #2
Lab Sample ID: 410-114570-19

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluoroheptanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluorooctanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluorononanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluorodecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluorotridecanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluorotetradecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluorohexadecanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluorooctadecanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluorobutanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluoropentanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluoroundecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1
Perfluorododecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 11:57	1

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C5 PFHxA	*111*	*cn*	*50 - 156*	*03/21/23 12:10*	*04/19/23 11:57*	*1*
13C4 PFHpA	*118*	*cn*	*60 - 150*	*03/21/23 12:10*	*04/19/23 11:57*	*1*
13C8 PFOA	*123*	*cn*	*62 - 146*	*03/21/23 12:10*	*04/19/23 11:57*	*1*
13C9 PFNA	*128*	*cn*	*60 - 142*	*03/21/23 12:10*	*04/19/23 11:57*	*1*
13C6 PFDA	*133*	*cn*	*64 - 141*	*03/21/23 12:10*	*04/19/23 11:57*	*1*

Client Sample ID: HDPE - Room Temp, Acetone, Trial #2

Lab Sample ID: 410-114570-19

Date Collected: 01/19/23 00:00

Matrix: Water

Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C7 PFUnA	137	cn	27 - 168	03/21/23 12:10	04/19/23 11:57	1
13C2-PFDoDA	127	cn	29 - 158	03/21/23 12:10	04/19/23 11:57	1
13C2 PFTeDA	156	*5+ cn	33 - 150	03/21/23 12:10	04/19/23 11:57	1
13C3 PFBS	132	cn	63 - 160	03/21/23 12:10	04/19/23 11:57	1
13C3 PFHxS	136	cn	57 - 159	03/21/23 12:10	04/19/23 11:57	1
13C8 PFOS	144	*5+ cn	64 - 141	03/21/23 12:10	04/19/23 11:57	1
13C4 PFBA	110	cn	67 - 136	03/21/23 12:10	04/19/23 11:57	1
13C5 PFPeA	112	cn	63 - 139	03/21/23 12:10	04/19/23 11:57	1

Client Sample ID: HDPE - Room Temp, Acetone, Trial #3

Lab Sample ID: 410-114570-20

Date Collected: 01/19/23 00:00

Matrix: Water

Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluoroheptanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluorooctanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluorononanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluorodecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluorotridecanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluorotetradecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluorohexadecanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluorooctadecanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluorobutanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluoropentanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluoroundecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1
Perfluorododecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:08	1

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C5 PFHxA	116	cn	50 - 156	03/21/23 12:10	04/19/23 12:08	1
13C4 PFHpA	122	cn	60 - 150	03/21/23 12:10	04/19/23 12:08	1
13C8 PFOA	128	cn	62 - 146	03/21/23 12:10	04/19/23 12:08	1
13C9 PFNA	132	cn	60 - 142	03/21/23 12:10	04/19/23 12:08	1
13C6 PFDA	131	cn	64 - 141	03/21/23 12:10	04/19/23 12:08	1
13C7 PFUnA	137	cn	27 - 168	03/21/23 12:10	04/19/23 12:08	1
13C2-PFDoDA	145	cn	29 - 158	03/21/23 12:10	04/19/23 12:08	1
13C2 PFTeDA	164	*5+ cn	33 - 150	03/21/23 12:10	04/19/23 12:08	1
13C3 PFBS	147	cn	63 - 160	03/21/23 12:10	04/19/23 12:08	1
13C3 PFHxS	140	cn	57 - 159	03/21/23 12:10	04/19/23 12:08	1
13C8 PFOS	144	*5+ cn	64 - 141	03/21/23 12:10	04/19/23 12:08	1
13C4 PFBA	107	cn	67 - 136	03/21/23 12:10	04/19/23 12:08	1

Client Sample ID: HDPE - Room Temp, Acetone, Trial #3

Lab Sample ID: 410-114570-20

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C5 PFPeA	118	cn	63 - 139	03/21/23 12:10	04/19/23 12:08	1

Client Sample ID: Blank - Room Temp, Acetone

Lab Sample ID: 410-114570-21

Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluoroheptanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluorooctanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluorononanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluorodecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluorotridecanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluorotetradecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluorobutanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluorohexanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluorooctanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluoropentanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluoroheptanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluorononanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluorodecanesulfonic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluorododecanesulfonic acid (PFDoS)	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluorohexadecanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluorooctadecanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluorobutanoic acid	ND	H *- cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluoropentanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluoroundecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1
Perfluorododecanoic acid	ND	H cn	1300	1300	ng/L		03/21/23 12:10	04/19/23 12:19	1

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C5 PFHxA	69	cn	50 - 156	03/21/23 12:10	04/19/23 12:19	1
13C4 PFHpA	83	cn	60 - 150	03/21/23 12:10	04/19/23 12:19	1
13C8 PFOA	97	cn	62 - 146	03/21/23 12:10	04/19/23 12:19	1
13C9 PFNA	115	cn	60 - 142	03/21/23 12:10	04/19/23 12:19	1
13C6 PFDA	120	cn	64 - 141	03/21/23 12:10	04/19/23 12:19	1
13C7 PFUnA	125	cn	27 - 168	03/21/23 12:10	04/19/23 12:19	1
13C2-PFDoDA	128	cn	29 - 158	03/21/23 12:10	04/19/23 12:19	1
13C2 PFTeDA	159	*5+ cn	33 - 150	03/21/23 12:10	04/19/23 12:19	1
13C3 PFBS	131	cn	63 - 160	03/21/23 12:10	04/19/23 12:19	1
13C3 PFHxS	125	cn	57 - 159	03/21/23 12:10	04/19/23 12:19	1
13C8 PFOS	130	cn	64 - 141	03/21/23 12:10	04/19/23 12:19	1
13C4 PFBA	51	*5- cn	67 - 136	03/21/23 12:10	04/19/23 12:19	1
13C5 PFPeA	61	*5- cn	63 - 139	03/21/23 12:10	04/19/23 12:19	1

Isotope Dilution Summary

Client: PEER
Job ID: 410-114570-1
Project/Site: PFAS in containers

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Matrix: Water **Prep Type: Total/NA**

		Percent Isotope Dilution Recovery (Acceptance Limits)							
		13C5PHA	C4PFHA	C8PFOA	C9PFNA	C6PFDA	13C7PUA	PFDoDA	PFTDA
Lab Sample ID	Client Sample ID	(50-156)	(60-150)	(62-146)	(60-142)	(64-141)	(27-168)	(29-158)	(33-150)
410-114570-1	FLPE - Room Temp, Water, Trial #1	125 cn	121 cn	123 cn	110 cn	99 cn	92 cn	77 cn	96 cn
410-114570-2	FLPE - Room Temp, Water, Trial #2	121 cn	124 cn	120 cn	94 cn	86 cn	79 cn	78 cn	97 cn
410-114570-3	FLPE - Room Temp, Water, Trial #3	136 cn	127 cn	129 cn	104 cn	76 cn	58 cn	57 cn	85 cn
410-114570-4	HDPE - Room Temp, Water, Trial #1	132 cn	127 cn	123 cn	101 cn	71 cn	61 cn	61 cn	86 cn
410-114570-5	HDPE - Room Temp, Water, Trial #2	124 cn	118 cn	127 cn	107 cn	91 cn	82 cn	73 cn	96 cn
410-114570-6	HDPE - Room Temp, Water, Trial #3	77 cn	87 cn	87 cn	79 cn	60 *5- cn	47 cn	45 cn	71 cn
410-114570-7	Blank - Room Temp, Water	105 cn	90 cn	65 cn	43 *5- cn	43 *5- cn	55 cn	66 cn	99 cn
410-114570-8	FLPE - Room Temp, Methanol, Trial #1	114 cn	124 cn	122 cn	125 cn	127 cn	122 cn	125 cn	154 *5+ cn
410-114570-9	FLPE - Room Temp, Methanol, Trial #2	104 cn	119 cn	123 cn	133 cn	135 cn	136 cn	142 cn	164 *5+ cn
410-114570-10	FLPE - Room Temp, Methanol, Trial #3	123 cn	130 cn	134 cn	146 *5+ cn	145 *5+ cn	143 cn	145 cn	170 *5+ cn
410-114570-11	HDPE - Room Temp, Methanol, Trial #1	97 cn	112 cn	121 cn	131 cn	123 cn	124 cn	120 cn	143 cn
410-114570-12	HDPE - Room Temp, Methanol, Trial #2	97 cn	113 cn	115 cn	122 cn	116 cn	120 cn	111 cn	132 cn
410-114570-13	HDPE - Room Temp, Methanol, Trial #3	104 cn	115 cn	116 cn	135 cn	126 cn	138 cn	128 cn	149 cn
410-114570-14	Blank - Room Temp, Methanol	82 cn	98 cn	104 cn	116 cn	117 cn	127 cn	116 cn	142 cn
410-114570-15	FLPE - Room Temp, Acetone, Trial #1	97 cn	107 cn	113 cn	112 cn	121 cn	126 cn	119 cn	144 cn
410-114570-16	FLPE - Room Temp, Acetone, Trial #2	117 cn	120 cn	129 cn	138 cn	132 cn	146 cn	139 cn	158 *5+ cn
410-114570-17	FLPE - Room Temp, Acetone, Trial #3	103 cn	116 cn	120 cn	126 cn	125 cn	139 cn	132 cn	158 *5+ cn
410-114570-18	HDPE - Room Temp, Acetone, Trial #1	99 cn	104 cn	113 cn	130 cn	137 cn	143 cn	137 cn	166 *5+ cn
410-114570-19	HDPE - Room Temp, Acetone, Trial #2	111 cn	118 cn	123 cn	128 cn	133 cn	137 cn	127 cn	156 *5+ cn
410-114570-20	HDPE - Room Temp, Acetone, Trial #3	116 cn	122 cn	128 cn	132 cn	131 cn	137 cn	145 cn	164 *5+ cn
410-114570-21	Blank - Room Temp, Acetone	69 cn	83 cn	97 cn	115 cn	120 cn	125 cn	128 cn	159 *5+ cn
LCS 410-362725/2-A	Lab Control Sample	109	116	120	126	116	121	114	126
LCS 410-362726/2-A	Lab Control Sample	183 *5+	188 *5+	188 *5+	181 *5+	174 *5+	181 *5+	185 *5+	217 *5+
LCS 410-362731/2-A	Lab Control Sample	88	86	90	77	70	61	52	71
LCSD 410-362725/3-A	Lab Control Sample Dup	113	122	130	129	119	129	118	127
LCSD 410-362726/3-A	Lab Control Sample Dup	173 *5+	180 *5+	181 *5+	190 *5+	173 *5+	190 *5+	172 *5+	206 *5+
LCSD 410-362731/3-A	Lab Control Sample Dup	102	92	102	88	69	58	56	82
MB 410-362725/1-A	Method Blank	112	127	118	125	133	122	127	128
MB 410-362726/1-A	Method Blank	197 *5+	207 *5+	210 *5+	207 *5+	202 *5+	219 *5+	202 *5+	266 *5+
MB 410-362731/1-A	Method Blank	79	70	79	60	53 *5-	49	48	70

		Percent Isotope Dilution Recovery (Acceptance Limits)							
		C3PFBS	C3PFHS	C8PFOS	PFBA	PFPeA			
Lab Sample ID	Client Sample ID	(63-160)	(57-159)	(64-141)	(67-136)	(63-139)			
410-114570-1	FLPE - Room Temp, Water, Trial #1	135 cn	139 cn	127 cn	122 cn	126 cn			
410-114570-2	FLPE - Room Temp, Water, Trial #2	137 cn	154 cn	133 cn	102 cn	110 cn			

Isotope Dilution Summary

Client: PEER
Job ID: 410-114570-1
Project/Site: PFAS in containers

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Matrix: Water
Prep Type: Total/NA

		Percent Isotope Dilution Recovery (Acceptance Limits)				
Lab Sample ID	Client Sample ID	C3PFBS (63-160)	C3PFHS (57-159)	C8PFOS (64-141)	PFBA (67-136)	PFPeA (63-139)
410-114570-3	FLPE - Room Temp, Water, Trial #3	144 cn	166 *5+ cn	139 cn	110 cn	121 cn
410-114570-4	HDPE - Room Temp, Water, Trial #1	134 cn	149 cn	130 cn	124 cn	128 cn
410-114570-5	HDPE - Room Temp, Water, Trial #2	131 cn	146 cn	126 cn	121 cn	121 cn
410-114570-6	HDPE - Room Temp, Water, Trial #3	114 cn	105 cn	106 cn	72 cn	82 cn
410-114570-7	Blank - Room Temp, Water	122 cn	123 cn	85 cn	109 cn	112 cn
410-114570-8	FLPE - Room Temp, Methanol, Trial #1	134 cn	133 cn	121 cn	103 cn	106 cn
410-114570-9	FLPE - Room Temp, Methanol, Trial #2	135 cn	132 cn	129 cn	84 cn	98 cn
410-114570-10	FLPE - Room Temp, Methanol, Trial #3	150 cn	148 cn	148 *5+ cn	92 cn	109 cn
410-114570-11	HDPE - Room Temp, Methanol, Trial #1	129 cn	131 cn	128 cn	77 cn	94 cn
410-114570-12	HDPE - Room Temp, Methanol, Trial #2	132 cn	124 cn	124 cn	76 cn	95 cn
410-114570-13	HDPE - Room Temp, Methanol, Trial #3	133 cn	123 cn	126 cn	93 cn	96 cn
410-114570-14	Blank - Room Temp, Methanol	121 cn	108 cn	119 cn	68 cn	79 cn
410-114570-15	FLPE - Room Temp, Acetone, Trial #1	133 cn	128 cn	127 cn	100 cn	103 cn
410-114570-16	FLPE - Room Temp, Acetone, Trial #2	156 cn	153 cn	156 *5+ cn	114 cn	120 cn
410-114570-17	FLPE - Room Temp, Acetone, Trial #3	138 cn	135 cn	137 cn	108 cn	108 cn
410-114570-18	HDPE - Room Temp, Acetone, Trial #1	131 cn	118 cn	131 cn	94 cn	100 cn
410-114570-19	HDPE - Room Temp, Acetone, Trial #2	132 cn	136 cn	144 *5+ cn	110 cn	112 cn
410-114570-20	HDPE - Room Temp, Acetone, Trial #3	147 cn	140 cn	144 *5+ cn	107 cn	118 cn
410-114570-21	Blank - Room Temp, Acetone	131 cn	125 cn	130 cn	51 *5- cn	61 *5- cn
LCS 410-362725/2-A	Lab Control Sample	122	116	121	97	106
LCS 410-362726/2-A	Lab Control Sample	188 *5+	189 *5+	181 *5+	169 *5+	169 *5+
LCS 410-362731/2-A	Lab Control Sample	128	146	122	61 *5-	74
LCSD 410-362725/3-A	Lab Control Sample Dup	125	127	126	106	111
LCSD 410-362726/3-A	Lab Control Sample Dup	175 *5+	181 *5+	181 *5+	168 *5+	163 *5+
LCSD 410-362731/3-A	Lab Control Sample Dup	133	143	127	79	87
MB 410-362725/1-A	Method Blank	130	125	119	103	119
MB 410-362726/1-A	Method Blank	199 *5+	206 *5+	201 *5+	194 *5+	194 *5+
MB 410-362731/1-A	Method Blank	126	145	121	50 *5-	60 *5-

Surrogate Legend

13C5PHA = 13C5 PFHxA
C4PFHA = 13C4 PFHpA
C8PFOA = 13C8 PFOA
C9PFNA = 13C9 PFNA
C6PFDA = 13C6 PFDA
13C7PUA = 13C7 PFUnA
PFDoDA = 13C2-PFDoDA
PFTDA = 13C2 PFTeDA

Isotope Dilution Summary

Client: PEER

Job ID: 410-114570-1

Project/Site: PFAS in containers

C3PFBS = 13C3 PFBS

C3PFHS = 13C3 PFHxS

C8PFOS = 13C8 PFOS

PFBA = 13C4 PFBA

PFPeA = 13C5 PFPeA

Method: EPA 537 (mod) - EPA 537 Isotope Dilution

Lab Sample ID: MB 410-362725/1-A
Matrix: Water
Analysis Batch: 365789

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 362725

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluoroheptanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluorooctanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluorononanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluorodecanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluorotridecanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluorotetradecanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluorobutanesulfonic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluorohexanesulfonic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluorooctanesulfonic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluoropentanesulfonic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluoroheptanesulfonic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluorononanesulfonic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluorodecanesulfonic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluorododecanesulfonic acid (PFDoS)	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluorooctanesulfonamide	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluorohexadecanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluorooctadecanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluorobutanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluoropentanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluoroundecanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1
Perfluorododecanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/19/23 08:37	1

Isotope Dilution	*MB %Recovery*	*MB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C5 PFHxA	*112*		*50 - 156*	*03/21/23 12:10*	*04/19/23 08:37*	*1*
13C4 PFHpA	*127*		*60 - 150*	*03/21/23 12:10*	*04/19/23 08:37*	*1*
13C8 PFOA	*118*		*62 - 146*	*03/21/23 12:10*	*04/19/23 08:37*	*1*
13C9 PFNA	*125*		*60 - 142*	*03/21/23 12:10*	*04/19/23 08:37*	*1*
13C6 PFDA	*133*		*64 - 141*	*03/21/23 12:10*	*04/19/23 08:37*	*1*
13C7 PFUnA	*122*		*27 - 168*	*03/21/23 12:10*	*04/19/23 08:37*	*1*
13C2-PFDoDA	*127*		*29 - 158*	*03/21/23 12:10*	*04/19/23 08:37*	*1*
13C2 PFTeDA	*128*		*33 - 150*	*03/21/23 12:10*	*04/19/23 08:37*	*1*
13C3 PFBS	*130*		*63 - 160*	*03/21/23 12:10*	*04/19/23 08:37*	*1*
13C3 PFHxS	*125*		*57 - 159*	*03/21/23 12:10*	*04/19/23 08:37*	*1*
13C8 PFOS	*119*		*64 - 141*	*03/21/23 12:10*	*04/19/23 08:37*	*1*
13C4 PFBA	*103*		*67 - 136*	*03/21/23 12:10*	*04/19/23 08:37*	*1*
13C5 PFPeA	*119*		*63 - 139*	*03/21/23 12:10*	*04/19/23 08:37*	*1*

Lab Sample ID: LCS 410-362725/2-A
Matrix: Water
Analysis Batch: 365789

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 362725

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Perfluorohexanoic acid	6400	6600		ng/L		103	52 - 133
Perfluoroheptanoic acid	6400	6860		ng/L		107	59 - 135
Perfluorooctanoic acid	6400	6730		ng/L		105	54 - 130
Perfluorononanoic acid	6400	6880		ng/L		107	54 - 137
Perfluorodecanoic acid	6400	6660		ng/L		104	57 - 129

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Lab Sample ID: LCS 410-362725/2-A
Matrix: Water
Analysis Batch: 365789

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 362725

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits		
Perfluorotridecanoic acid			6400	6230		ng/L		97	57 - 140		
Perfluorotetradecanoic acid			6400	6470		ng/L		101	56 - 137		
Perfluorobutanesulfonic acid			5660	6580		ng/L		116	44 - 131		
Perfluorohexanesulfonic acid			5840	6220		ng/L		107	51 - 129		
Perfluorooctanesulfonic acid			5920	6180		ng/L		104	54 - 125		
Perfluoropentanesulfonic acid			6000	7070		ng/L		118	54 - 140		
Perfluoroheptanesulfonic acid			6090	6580		ng/L		108	54 - 138		
Perfluorononanesulfonic acid			6140	6570		ng/L		107	57 - 139		
Perfluorodecanesulfonic acid			6170	6490		ng/L		105	51 - 146		
Perfluorododecanesulfonic acid (PFDoS)			6200	6230		ng/L		101	51 - 142		
Perfluorooctanesulfonamide			6400	7150		ng/L		112	38 - 132		
Perfluorohexadecanoic acid			6400	6100		ng/L		95	50 - 148		
Perfluorooctadecanoic acid			6400	6430		ng/L		100	49 - 148		
Perfluorobutanoic acid			6400	6600		ng/L		103	53 - 144		
Perfluoropentanoic acid			6400	6760		ng/L		106	53 - 150		
Perfluoroundecanoic acid			6400	6580		ng/L		103	58 - 133		
Perfluorododecanoic acid			6400	7370		ng/L		115	59 - 133		

Isotope Dilution	*LCS %Recovery*	*LCS Qualifier*	*Limits*
13C5 PFHxA	*109*		*50 - 156*
13C4 PFHpA	*116*		*60 - 150*
13C8 PFOA	*120*		*62 - 146*
13C9 PFNA	*126*		*60 - 142*
13C6 PFDA	*116*		*64 - 141*
13C7 PFUnA	*121*		*27 - 168*
13C2-PFDoDA	*114*		*29 - 158*
13C2 PFTeDA	*126*		*33 - 150*
13C3 PFBS	*122*		*63 - 160*
13C3 PFHxS	*116*		*57 - 159*
13C8 PFOS	*121*		*64 - 141*
13C4 PFBA	*97*		*67 - 136*
13C5 PFPeA	*106*		*63 - 139*

Lab Sample ID: LCSD 410-362725/3-A
Matrix: Water
Analysis Batch: 365789

Client Sample ID: Lab Control Sample Dup
Prep Type: Total/NA
Prep Batch: 362725

Analyte			Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Perfluorohexanoic acid			6400	6220		ng/L		97	52 - 133	6	30
Perfluoroheptanoic acid			6400	6960		ng/L		109	59 - 135	1	30
Perfluorooctanoic acid			6400	6250		ng/L		98	54 - 130	7	30
Perfluorononanoic acid			6400	6340		ng/L		99	54 - 137	8	30
Perfluorodecanoic acid			6400	6520		ng/L		102	57 - 129	2	30
Perfluorotridecanoic acid			6400	6200		ng/L		97	57 - 140	0	30
Perfluorotetradecanoic acid			6400	6190		ng/L		97	56 - 137	5	30
Perfluorobutanesulfonic acid			5660	6190		ng/L		109	44 - 131	6	30
Perfluorohexanesulfonic acid			5840	5990		ng/L		103	51 - 129	4	30
Perfluorooctanesulfonic acid			5920	5690		ng/L		96	54 - 125	8	30

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Lab Sample ID: LCSD 410-362725/3-A
Matrix: Water
Analysis Batch: 365789

Client Sample ID: Lab Control Sample Dup
Prep Type: Total/NA
Prep Batch: 362725

Analyte			Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Perfluoropentanesulfonic acid			6000	6700		ng/L		112	54 - 140	5	30
Perfluoroheptanesulfonic acid			6090	6230		ng/L		102	54 - 138	6	30
Perfluorononanesulfonic acid			6140	6410		ng/L		104	57 - 139	2	30
Perfluorodecanesulfonic acid			6170	6000		ng/L		97	51 - 146	8	30
Perfluorododecanesulfonic acid (PFDoS)			6200	5860		ng/L		95	51 - 142	6	30
Perfluorooctanesulfonamide			6400	6810		ng/L		106	38 - 132	5	30
Perfluorohexadecanoic acid			6400	5850		ng/L		91	50 - 148	4	30
Perfluorooctadecanoic acid			6400	6520		ng/L		102	49 - 148	1	30
Perfluorobutanoic acid			6400	6310		ng/L		99	53 - 144	5	30
Perfluoropentanoic acid			6400	6890		ng/L		108	53 - 150	2	30
Perfluoroundecanoic acid			6400	6710		ng/L		105	58 - 133	2	30
Perfluorododecanoic acid			6400	6690		ng/L		105	59 - 133	10	30

Isotope Dilution	*LCSD %Recovery*	*LCSD Qualifier*	*Limits*
13C5 PFHxA	*113*		*50 - 156*
13C4 PFHpA	*122*		*60 - 150*
13C8 PFOA	*130*		*62 - 146*
13C9 PFNA	*129*		*60 - 142*
13C6 PFDA	*119*		*64 - 141*
13C7 PFUnA	*129*		*27 - 168*
13C2-PFDoDA	*118*		*29 - 158*
13C2 PFTeDA	*127*		*33 - 150*
13C3 PFBS	*125*		*63 - 160*
13C3 PFHxS	*127*		*57 - 159*
13C8 PFOS	*126*		*64 - 141*
13C4 PFBA	*106*		*67 - 136*
13C5 PFPeA	*111*		*63 - 139*

Lab Sample ID: MB 410-362726/1-A
Matrix: Water
Analysis Batch: 366615

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 362726

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluoroheptanoic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluorooctanoic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluorononanoic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluorodecanoic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluorotridecanoic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluorotetradecanoic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluorobutanesulfonic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluorohexanesulfonic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluorooctanesulfonic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluoropentanesulfonic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluoroheptanesulfonic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluorononanesulfonic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluorodecanesulfonic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Lab Sample ID: MB 410-362726/1-A
Matrix: Water
Analysis Batch: 366615

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 362726

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorododecanesulfonic acid (PFDoS)	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluorohexadecanoic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluorooctadecanoic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluorobutanoic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluoropentanoic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluoroundecanoic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1
Perfluorododecanoic acid	ND		330	330	ng/L		03/21/23 12:10	04/20/23 13:48	1

Isotope Dilution	*MB %Recovery*	*MB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C5 PFHxA	*197*	**5+*	*50 - 156*	*03/21/23 12:10*	*04/20/23 13:48*	*1*
13C4 PFHpA	*207*	**5+*	*60 - 150*	*03/21/23 12:10*	*04/20/23 13:48*	*1*
13C8 PFOA	*210*	**5+*	*62 - 146*	*03/21/23 12:10*	*04/20/23 13:48*	*1*
13C9 PFNA	*207*	**5+*	*60 - 142*	*03/21/23 12:10*	*04/20/23 13:48*	*1*
13C6 PFDA	*202*	**5+*	*64 - 141*	*03/21/23 12:10*	*04/20/23 13:48*	*1*
13C7 PFUnA	*219*	**5+*	*27 - 168*	*03/21/23 12:10*	*04/20/23 13:48*	*1*
13C2-PFDoDA	*202*	**5+*	*29 - 158*	*03/21/23 12:10*	*04/20/23 13:48*	*1*
13C2 PFTeDA	*266*	**5+*	*33 - 150*	*03/21/23 12:10*	*04/20/23 13:48*	*1*
13C3 PFBS	*199*	**5+*	*63 - 160*	*03/21/23 12:10*	*04/20/23 13:48*	*1*
13C3 PFHxS	*206*	**5+*	*57 - 159*	*03/21/23 12:10*	*04/20/23 13:48*	*1*
13C8 PFOS	*201*	**5+*	*64 - 141*	*03/21/23 12:10*	*04/20/23 13:48*	*1*
13C4 PFBA	*194*	**5+*	*67 - 136*	*03/21/23 12:10*	*04/20/23 13:48*	*1*
13C5 PFPeA	*194*	**5+*	*63 - 139*	*03/21/23 12:10*	*04/20/23 13:48*	*1*

Lab Sample ID: LCS 410-362726/2-A
Matrix: Water
Analysis Batch: 366615

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 362726

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Perfluorohexanoic acid	10700	5750		ng/L		54	52 - 133
Perfluoroheptanoic acid	10700	5930	*-	ng/L		56	59 - 135
Perfluorooctanoic acid	10700	6120		ng/L		57	54 - 130
Perfluorononanoic acid	10700	6210		ng/L		58	54 - 137
Perfluorodecanoic acid	10700	6140		ng/L		58	57 - 129
Perfluorotridecanoic acid	10700	5540	*-	ng/L		52	57 - 140
Perfluorotetradecanoic acid	10700	5930		ng/L		56	56 - 137
Perfluorobutanesulfonic acid	9440	5510		ng/L		58	44 - 131
Perfluorohexanesulfonic acid	9730	5490		ng/L		56	51 - 129
Perfluorooctanesulfonic acid	9870	5830		ng/L		59	54 - 125
Perfluoropentanesulfonic acid	10000	6000		ng/L		60	54 - 140
Perfluoroheptanesulfonic acid	10200	6010		ng/L		59	54 - 138
Perfluorononanesulfonic acid	10200	6180		ng/L		60	57 - 139
Perfluorodecanesulfonic acid	10300	6230		ng/L		61	51 - 146
Perfluorododecanesulfonic acid (PFDoS)	10300	5900		ng/L		57	51 - 142
Perfluorohexadecanoic acid	10700	4610	*-	ng/L		43	50 - 148
Perfluorooctadecanoic acid	10700	5150	*-	ng/L		48	49 - 148
Perfluorobutanoic acid	10700	5320	*-	ng/L		50	53 - 144
Perfluoropentanoic acid	10700	5800		ng/L		54	53 - 150

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Lab Sample ID: LCS 410-362726/2-A
Matrix: Water
Analysis Batch: 366615

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 362726

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits		
Perfluoroundecanoic acid			10700	6730		ng/L		63	58 - 133		
Perfluorododecanoic acid			10700	6280		ng/L		59	59 - 133		

Isotope Dilution	*LCS %Recovery*	*LCS Qualifier*	*Limits*
13C5 PFHxA	*183*	**5+*	*50 - 156*
13C4 PFHpA	*188*	**5+*	*60 - 150*
13C8 PFOA	*188*	**5+*	*62 - 146*
13C9 PFNA	*181*	**5+*	*60 - 142*
13C6 PFDA	*174*	**5+*	*64 - 141*
13C7 PFUnA	*181*	**5+*	*27 - 168*
13C2-PFDoDA	*185*	**5+*	*29 - 158*
13C2 PFTeDA	*217*	**5+*	*33 - 150*
13C3 PFBS	*188*	**5+*	*63 - 160*
13C3 PFHxS	*189*	**5+*	*57 - 159*
13C8 PFOS	*181*	**5+*	*64 - 141*
13C4 PFBA	*169*	**5+*	*67 - 136*
13C5 PFPeA	*169*	**5+*	*63 - 139*

Lab Sample ID: LCSD 410-362726/3-A
Matrix: Water
Analysis Batch: 366615

Client Sample ID: Lab Control Sample Dup
Prep Type: Total/NA
Prep Batch: 362726

Analyte			Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Perfluorohexanoic acid			10700	6380		ng/L		60	52 - 133	10	30
Perfluoroheptanoic acid			10700	6560		ng/L		62	59 - 135	10	30
Perfluorooctanoic acid			10700	6630		ng/L		62	54 - 130	8	30
Perfluorononanoic acid			10700	6450		ng/L		60	54 - 137	4	30
Perfluorodecanoic acid			10700	6560		ng/L		61	57 - 129	7	30
Perfluorotridecanoic acid			10700	6630		ng/L		62	57 - 140	18	30
Perfluorotetradecanoic acid			10700	6400		ng/L		60	56 - 137	8	30
Perfluorobutanesulfonic acid			9440	5940		ng/L		63	44 - 131	7	30
Perfluorohexanesulfonic acid			9730	5930		ng/L		61	51 - 129	8	30
Perfluorooctanesulfonic acid			9870	6210		ng/L		63	54 - 125	6	30
Perfluoropentanesulfonic acid			10000	6400		ng/L		64	54 - 140	7	30
Perfluoroheptanesulfonic acid			10200	6590		ng/L		65	54 - 138	9	30
Perfluorononanesulfonic acid			10200	6650		ng/L		65	57 - 139	7	30
Perfluorodecanesulfonic acid			10300	6460		ng/L		63	51 - 146	4	30
Perfluorododecanesulfonic acid (PFDoS)			10300	6380		ng/L		62	51 - 142	8	30
Perfluorohexadecanoic acid			10700	5370		ng/L		50	50 - 148	15	30
Perfluorooctadecanoic acid			10700	5590		ng/L		52	49 - 148	8	30
Perfluorobutanoic acid			10700	5870		ng/L		55	53 - 144	10	30
Perfluoropentanoic acid			10700	6400		ng/L		60	53 - 150	10	30
Perfluoroundecanoic acid			10700	6420		ng/L		60	58 - 133	5	30
Perfluorododecanoic acid			10700	6860		ng/L		64	59 - 133	9	30

Isotope Dilution	*LCSD %Recovery*	*LCSD Qualifier*	*Limits*
13C5 PFHxA	*173*	**5+*	*50 - 156*
13C4 PFHpA	*180*	**5+*	*60 - 150*

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Lab Sample ID: LCSD 410-362726/3-A
Matrix: Water
Analysis Batch: 366615

Client Sample ID: Lab Control Sample Dup
Prep Type: Total/NA
Prep Batch: 362726

Isotope Dilution	LCSD %Recovery	LCSD Qualifier	Limits
13C8 PFOA	181	*5+	62 - 146
13C9 PFNA	190	*5+	60 - 142
13C6 PFDA	173	*5+	64 - 141
13C7 PFUnA	190	*5+	27 - 168
13C2-PFDoDA	172	*5+	29 - 158
13C2 PFTeDA	206	*5+	33 - 150
13C3 PFBS	175	*5+	63 - 160
13C3 PFHxS	181	*5+	57 - 159
13C8 PFOS	181	*5+	64 - 141
13C4 PFBA	168	*5+	67 - 136
13C5 PFPeA	163	*5+	63 - 139

Lab Sample ID: MB 410-362731/1-A
Matrix: Water
Analysis Batch: 365770

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 362731

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorohexanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluoroheptanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluorooctanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluorononanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluorodecanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluorotridecanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluorotetradecanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluorobutanesulfonic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluorohexanesulfonic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluorooctanesulfonic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluoropentanesulfonic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluoroheptanesulfonic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluorononanesulfonic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluorodecanesulfonic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluorododecanesulfonic acid (PFDoS)	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluorohexadecanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluorooctadecanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluorobutanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluoropentanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluoroundecanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1
Perfluorododecanoic acid	ND		200	200	ng/L		03/21/23 12:10	04/18/23 21:15	1

Isotope Dilution	MB %Recovery	MB Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C5 PFHxA	79		50 - 156	03/21/23 12:10	04/18/23 21:15	1
13C4 PFHpA	70		60 - 150	03/21/23 12:10	04/18/23 21:15	1
13C8 PFOA	79		62 - 146	03/21/23 12:10	04/18/23 21:15	1
13C9 PFNA	60		60 - 142	03/21/23 12:10	04/18/23 21:15	1
13C6 PFDA	53	*5-	64 - 141	03/21/23 12:10	04/18/23 21:15	1
13C7 PFUnA	49		27 - 168	03/21/23 12:10	04/18/23 21:15	1
13C2-PFDoDA	48		29 - 158	03/21/23 12:10	04/18/23 21:15	1
13C2 PFTeDA	70		33 - 150	03/21/23 12:10	04/18/23 21:15	1

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Lab Sample ID: MB 410-362731/1-A
Matrix: Water
Analysis Batch: 365770

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 362731

Isotope Dilution	MB %Recovery	MB Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C3 PFBS	126		63 - 160	03/21/23 12:10	04/18/23 21:15	1
13C3 PFHxS	145		57 - 159	03/21/23 12:10	04/18/23 21:15	1
13C8 PFOS	121		64 - 141	03/21/23 12:10	04/18/23 21:15	1
13C4 PFBA	50	*5-	67 - 136	03/21/23 12:10	04/18/23 21:15	1
13C5 PFPeA	60	*5-	63 - 139	03/21/23 12:10	04/18/23 21:15	1

Lab Sample ID: LCS 410-362731/2-A
Matrix: Water
Analysis Batch: 365770

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 362731

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Perfluorohexanoic acid	6400	7110		ng/L		111	52 - 133
Perfluoroheptanoic acid	6400	7810		ng/L		122	59 - 135
Perfluorooctanoic acid	6400	7050		ng/L		110	54 - 130
Perfluorononanoic acid	6400	8350		ng/L		130	54 - 137
Perfluorodecanoic acid	6400	9410	*+	ng/L		147	57 - 129
Perfluorotridecanoic acid	6400	15100	*+	ng/L		236	57 - 140
Perfluorotetradecanoic acid	6400	11400	*+	ng/L		178	56 - 137
Perfluorobutanesulfonic acid	5660	5280		ng/L		93	44 - 131
Perfluorohexanesulfonic acid	5840	5010		ng/L		86	51 - 129
Perfluorooctanesulfonic acid	5920	5210		ng/L		88	54 - 125
Perfluoropentanesulfonic acid	6000	5870		ng/L		98	54 - 140
Perfluoroheptanesulfonic acid	6090	5620		ng/L		92	54 - 138
Perfluorononanesulfonic acid	6140	5670		ng/L		92	57 - 139
Perfluorodecanesulfonic acid	6170	6120		ng/L		99	51 - 146
Perfluorododecanesulfonic acid (PFDoS)	6200	6160		ng/L		99	51 - 142
Perfluorohexadecanoic acid	6400	9580	*+	ng/L		150	50 - 148
Perfluorooctadecanoic acid	6400	9420		ng/L		147	49 - 148
Perfluorobutanoic acid	6400	7100		ng/L		111	53 - 144
Perfluoropentanoic acid	6400	7340		ng/L		115	53 - 150
Perfluoroundecanoic acid	6400	14000	*+	ng/L		219	58 - 133
Perfluorododecanoic acid	6400	16800	*+	ng/L		262	59 - 133

Isotope Dilution	LCS %Recovery	LCS Qualifier	Limits
13C5 PFHxA	88		50 - 156
13C4 PFHpA	86		60 - 150
13C8 PFOA	90		62 - 146
13C9 PFNA	77		60 - 142
13C6 PFDA	70		64 - 141
13C7 PFUnA	61		27 - 168
13C2-PFDoDA	52		29 - 158
13C2 PFTeDA	71		33 - 150
13C3 PFBS	128		63 - 160
13C3 PFHxS	146		57 - 159
13C8 PFOS	122		64 - 141
13C4 PFBA	61	*5-	67 - 136
13C5 PFPeA	74		63 - 139

Method: EPA 537 (mod) - EPA 537 Isotope Dilution (Continued)

Lab Sample ID: LCSD 410-362731/3-A
Matrix: Water
Analysis Batch: 365770

Client Sample ID: Lab Control Sample Dup
Prep Type: Total/NA
Prep Batch: 362731

Analyte			Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Perfluorohexanoic acid			6400	6970		ng/L		109	52 - 133	2	30
Perfluoroheptanoic acid			6400	8260		ng/L		129	59 - 135	6	30
Perfluorooctanoic acid			6400	6200		ng/L		97	54 - 130	13	30
Perfluorononanoic acid			6400	7940		ng/L		124	54 - 137	5	30
Perfluorodecanoic acid			6400	9550	*+	ng/L		149	57 - 129	1	30
Perfluorotridecanoic acid			6400	15500	*+	ng/L		243	57 - 140	3	30
Perfluorotetradecanoic acid			6400	10300	*+	ng/L		161	56 - 137	10	30
Perfluorobutanesulfonic acid			5660	5360		ng/L		95	44 - 131	1	30
Perfluorohexanesulfonic acid			5840	5210		ng/L		89	51 - 129	4	30
Perfluorooctanesulfonic acid			5920	5200		ng/L		88	54 - 125	0	30
Perfluoropentanesulfonic acid			6000	6030		ng/L		100	54 - 140	3	30
Perfluoroheptanesulfonic acid			6090	5460		ng/L		90	54 - 138	3	30
Perfluorononanesulfonic acid			6140	5860		ng/L		95	57 - 139	3	30
Perfluorodecanesulfonic acid			6170	6320		ng/L		102	51 - 146	3	30
Perfluorododecanesulfonic acid (PFDoS)			6200	6160		ng/L		99	51 - 142	0	30
Perfluorohexadecanoic acid			6400	8860		ng/L		138	50 - 148	8	30
Perfluorooctadecanoic acid			6400	8720		ng/L		136	49 - 148	8	30
Perfluorobutanoic acid			6400	8050		ng/L		126	53 - 144	13	30
Perfluoropentanoic acid			6400	8000		ng/L		125	53 - 150	9	30
Perfluoroundecanoic acid			6400	15900	*+	ng/L		248	58 - 133	12	30
Perfluorododecanoic acid			6400	16700	*+	ng/L		261	59 - 133	0	30

Isotope Dilution	*LCSD %Recovery*	*LCSD Qualifier*	*Limits*
13C5 PFHxA	*102*		*50 - 156*
13C4 PFHpA	*92*		*60 - 150*
13C8 PFOA	*102*		*62 - 146*
13C9 PFNA	*88*		*60 - 142*
13C6 PFDA	*69*		*64 - 141*
13C7 PFUnA	*58*		*27 - 168*
13C2-PFDoDA	*56*		*29 - 158*
13C2 PFTeDA	*82*		*33 - 150*
13C3 PFBS	*133*		*63 - 160*
13C3 PFHxS	*143*		*57 - 159*
13C8 PFOS	*127*		*64 - 141*
13C4 PFBA	*79*		*67 - 136*
13C5 PFPeA	*87*		*63 - 139*

LCMS

Prep Batch: 362725

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
410-114570-8	FLPE - Room Temp, Methanol, Trial #1	Total/NA	Water	537	
410-114570-9	FLPE - Room Temp, Methanol, Trial #2	Total/NA	Water	537	
410-114570-10	FLPE - Room Temp, Methanol, Trial #3	Total/NA	Water	537	
410-114570-11	HDPE - Room Temp, Methanol, Trial #1	Total/NA	Water	537	
410-114570-12	HDPE - Room Temp, Methanol, Trial #2	Total/NA	Water	537	
410-114570-13	HDPE - Room Temp, Methanol, Trial #3	Total/NA	Water	537	
410-114570-14	Blank - Room Temp, Methanol	Total/NA	Water	537	
MB 410-362725/1-A	Method Blank	Total/NA	Water	537	
LCS 410-362725/2-A	Lab Control Sample	Total/NA	Water	537	
LCSD 410-362725/3-A	Lab Control Sample Dup	Total/NA	Water	537	

Prep Batch: 362726

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
410-114570-15	FLPE - Room Temp, Acetone, Trial #1	Total/NA	Water	537	
410-114570-16	FLPE - Room Temp, Acetone, Trial #2	Total/NA	Water	537	
410-114570-17	FLPE - Room Temp, Acetone, Trial #3	Total/NA	Water	537	
410-114570-18	HDPE - Room Temp, Acetone, Trial #1	Total/NA	Water	537	
410-114570-19	HDPE - Room Temp, Acetone, Trial #2	Total/NA	Water	537	
410-114570-20	HDPE - Room Temp, Acetone, Trial #3	Total/NA	Water	537	
410-114570-21	Blank - Room Temp, Acetone	Total/NA	Water	537	
MB 410-362726/1-A	Method Blank	Total/NA	Water	537	
LCS 410-362726/2-A	Lab Control Sample	Total/NA	Water	537	
LCSD 410-362726/3-A	Lab Control Sample Dup	Total/NA	Water	537	

Prep Batch: 362731

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
410-114570-1	FLPE - Room Temp, Water, Trial #1	Total/NA	Water	537	
410-114570-2	FLPE - Room Temp, Water, Trial #2	Total/NA	Water	537	
410-114570-3	FLPE - Room Temp, Water, Trial #3	Total/NA	Water	537	
410-114570-4	HDPE - Room Temp, Water, Trial #1	Total/NA	Water	537	
410-114570-5	HDPE - Room Temp, Water, Trial #2	Total/NA	Water	537	
410-114570-6	HDPE - Room Temp, Water, Trial #3	Total/NA	Water	537	
410-114570-7	Blank - Room Temp, Water	Total/NA	Water	537	
MB 410-362731/1-A	Method Blank	Total/NA	Water	537	
LCS 410-362731/2-A	Lab Control Sample	Total/NA	Water	537	
LCSD 410-362731/3-A	Lab Control Sample Dup	Total/NA	Water	537	

Analysis Batch: 365770

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
410-114570-1	FLPE - Room Temp, Water, Trial #1	Total/NA	Water	EPA 537 (mod)	362731
410-114570-2	FLPE - Room Temp, Water, Trial #2	Total/NA	Water	EPA 537 (mod)	362731
410-114570-3	FLPE - Room Temp, Water, Trial #3	Total/NA	Water	EPA 537 (mod)	362731
410-114570-4	HDPE - Room Temp, Water, Trial #1	Total/NA	Water	EPA 537 (mod)	362731
410-114570-5	HDPE - Room Temp, Water, Trial #2	Total/NA	Water	EPA 537 (mod)	362731
410-114570-7	Blank - Room Temp, Water	Total/NA	Water	EPA 537 (mod)	362731
MB 410-362731/1-A	Method Blank	Total/NA	Water	EPA 537 (mod)	362731
LCS 410-362731/2-A	Lab Control Sample	Total/NA	Water	EPA 537 (mod)	362731
LCSD 410-362731/3-A	Lab Control Sample Dup	Total/NA	Water	EPA 537 (mod)	362731

Client: PEER
Job ID: 410-114570-1
Project/Site: PFAS in containers

LCMS

Analysis Batch: 365789

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
410-114570-8	FLPE - Room Temp, Methanol, Trial #1	Total/NA	Water	EPA 537 (mod)	362725
410-114570-9	FLPE - Room Temp, Methanol, Trial #2	Total/NA	Water	EPA 537 (mod)	362725
410-114570-10	FLPE - Room Temp, Methanol, Trial #3	Total/NA	Water	EPA 537 (mod)	362725
410-114570-11	HDPE - Room Temp, Methanol, Trial #1	Total/NA	Water	EPA 537 (mod)	362725
410-114570-12	HDPE - Room Temp, Methanol, Trial #2	Total/NA	Water	EPA 537 (mod)	362725
410-114570-13	HDPE - Room Temp, Methanol, Trial #3	Total/NA	Water	EPA 537 (mod)	362725
410-114570-14	Blank - Room Temp, Methanol	Total/NA	Water	EPA 537 (mod)	362725
410-114570-15	FLPE - Room Temp, Acetone, Trial #1	Total/NA	Water	EPA 537 (mod)	362726
410-114570-16	FLPE - Room Temp, Acetone, Trial #2	Total/NA	Water	EPA 537 (mod)	362726
410-114570-17	FLPE - Room Temp, Acetone, Trial #3	Total/NA	Water	EPA 537 (mod)	362726
410-114570-18	HDPE - Room Temp, Acetone, Trial #1	Total/NA	Water	EPA 537 (mod)	362726
410-114570-19	HDPE - Room Temp, Acetone, Trial #2	Total/NA	Water	EPA 537 (mod)	362726
410-114570-20	HDPE - Room Temp, Acetone, Trial #3	Total/NA	Water	EPA 537 (mod)	362726
410-114570-21	Blank - Room Temp, Acetone	Total/NA	Water	EPA 537 (mod)	362726
MB 410-362725/1-A	Method Blank	Total/NA	Water	EPA 537 (mod)	362725
LCS 410-362725/2-A	Lab Control Sample	Total/NA	Water	EPA 537 (mod)	362725
LCSD 410-362725/3-A	Lab Control Sample Dup	Total/NA	Water	EPA 537 (mod)	362725

Analysis Batch: 366121

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
410-114570-6	HDPE - Room Temp, Water, Trial #3	Total/NA	Water	EPA 537 (mod)	362731

Analysis Batch: 366615

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
MB 410-362726/1-A	Method Blank	Total/NA	Water	EPA 537 (mod)	362726
LCS 410-362726/2-A	Lab Control Sample	Total/NA	Water	EPA 537 (mod)	362726
LCSD 410-362726/3-A	Lab Control Sample Dup	Total/NA	Water	EPA 537 (mod)	362726

Lab Chronicle

Client: PEER
Job ID: 410-114570-1
Project/Site: PFAS in containers

Client Sample ID: FLPE - Room Temp, Water, Trial #1
Lab Sample ID: 410-114570-1
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362731	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365770	VK3G	ELLE	04/18/23 21:48

Client Sample ID: FLPE - Room Temp, Water, Trial #2
Lab Sample ID: 410-114570-2
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362731	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365770	VK3G	ELLE	04/18/23 21:59

Client Sample ID: FLPE - Room Temp, Water, Trial #3
Lab Sample ID: 410-114570-3
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362731	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365770	VK3G	ELLE	04/18/23 22:10

Client Sample ID: HDPE - Room Temp, Water, Trial #1
Lab Sample ID: 410-114570-4
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362731	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365770	VK3G	ELLE	04/18/23 22:21

Client Sample ID: HDPE - Room Temp, Water, Trial #2
Lab Sample ID: 410-114570-5
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362731	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365770	VK3G	ELLE	04/18/23 22:32

Client Sample ID: HDPE - Room Temp, Water, Trial #3
Lab Sample ID: 410-114570-6
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362731	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	366121	I5JH	ELLE	04/19/23 22:58

Lab Chronicle

Client: PEER
Job ID: 410-114570-1
Project/Site: PFAS in containers

Client Sample ID: Blank - Room Temp, Water
Lab Sample ID: 410-114570-7
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362731	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365770	VK3G	ELLE	04/18/23 22:55

Client Sample ID: FLPE - Room Temp, Methanol, Trial #1
Lab Sample ID: 410-114570-8
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362725	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365789	DQV6	ELLE	04/19/23 09:11

Client Sample ID: FLPE - Room Temp, Methanol, Trial #2
Lab Sample ID: 410-114570-9
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362725	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365789	DQV6	ELLE	04/19/23 09:22

Client Sample ID: FLPE - Room Temp, Methanol, Trial #3
Lab Sample ID: 410-114570-10
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362725	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365789	DQV6	ELLE	04/19/23 09:33

Client Sample ID: HDPE - Room Temp, Methanol, Trial #1
Lab Sample ID: 410-114570-11
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362725	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365789	DQV6	ELLE	04/19/23 09:44

Client Sample ID: HDPE - Room Temp, Methanol, Trial #2
Lab Sample ID: 410-114570-12
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362725	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365789	DQV6	ELLE	04/19/23 09:55

Lab Chronicle

Client: PEER
Job ID: 410-114570-1
Project/Site: PFAS in containers

Client Sample ID: HDPE - Room Temp, Methanol, Trial #3
Lab Sample ID: 410-114570-13
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362725	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365789	DQV6	ELLE	04/19/23 10:06

Client Sample ID: Blank - Room Temp, Methanol
Lab Sample ID: 410-114570-14
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362725	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365789	DQV6	ELLE	04/19/23 10:17

Client Sample ID: FLPE - Room Temp, Acetone, Trial #1
Lab Sample ID: 410-114570-15
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362726	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365789	DQV6	ELLE	04/19/23 11:12

Client Sample ID: FLPE - Room Temp, Acetone, Trial #2
Lab Sample ID: 410-114570-16
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362726	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365789	DQV6	ELLE	04/19/23 11:24

Client Sample ID: FLPE - Room Temp, Acetone, Trial #3
Lab Sample ID: 410-114570-17
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362726	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365789	DQV6	ELLE	04/19/23 11:35

Client Sample ID: HDPE - Room Temp, Acetone, Trial #1
Lab Sample ID: 410-114570-18
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362726	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365789	DQV6	ELLE	04/19/23 11:46

Lab Chronicle

Client: PEER
Job ID: 410-114570-1
Project/Site: PFAS in containers

Client Sample ID: HDPE - Room Temp, Acetone, Trial #2
Lab Sample ID: 410-114570-19
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362726	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365789	DQV6	ELLE	04/19/23 11:57

Client Sample ID: HDPE - Room Temp, Acetone, Trial #3
Lab Sample ID: 410-114570-20
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362726	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365789	DQV6	ELLE	04/19/23 12:08

Client Sample ID: Blank - Room Temp, Acetone
Lab Sample ID: 410-114570-21
Date Collected: 01/19/23 00:00
Matrix: Water
Date Received: 01/20/23 09:30

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	537			362726	Q5YX	ELLE	03/21/23 12:10
Total/NA	Analysis	EPA 537 (mod)		1	365789	DQV6	ELLE	04/19/23 12:19

Laboratory References:

ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC, 2425 New Holland Pike, Lancaster, PA 17601, TEL (717)656-2300

Accreditation/Certification Summary

Client: PEER
Job ID: 410-114570-1
Project/Site: PFAS in containers

Laboratory: Eurofins Lancaster Laboratories Environment Testing, LLC

Unless otherwise noted, all analytes for this laboratory were covered under each accreditation/certification below.

Authority	Program	Identification Number	Expiration Date
Pennsylvania	NELAP	36-00037	01-31-24

The following analytes are included in this report, but the laboratory is not certified by the governing authority. This list may include analytes for which the agency does not offer certification.

Analysis Method	Prep Method	Matrix	Analyte
EPA 537 (mod)	537	Water	Perfluorobutanoic acid
EPA 537 (mod)	537	Water	Perfluorodecanesulfonic acid
EPA 537 (mod)	537	Water	Perfluorododecanesulfonic acid (PFDoS)
EPA 537 (mod)	537	Water	Perfluoroheptanesulfonic acid
EPA 537 (mod)	537	Water	Perfluorohexadecanoic acid
EPA 537 (mod)	537	Water	Perfluorononanesulfonic acid
EPA 537 (mod)	537	Water	Perfluorooctadecanoic acid
EPA 537 (mod)	537	Water	Perfluorooctanesulfonamide
EPA 537 (mod)	537	Water	Perfluoropentanesulfonic acid
EPA 537 (mod)	537	Water	Perfluoropentanoic acid

Method Summary

Client: PEER
Job ID: 410-114570-1
Project/Site: PFAS in containers

Method	Method Description	Protocol	Laboratory
EPA 537 (mod)	EPA 537 Isotope DIlution	EPA	ELLE
537	537 Isotope Dilution	EPA	ELLE

Protocol References:

EPA = US Environmental Protection Agency

Laboratory References:

ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC, 2425 New Holland Pike, Lancaster, PA 17601, TEL (717)656-2300

Sample Summary

Client: PEER
Job ID: 410-114570-1
Project/Site: PFAS in containers

Lab Sample ID	Client Sample ID	Matrix	Collected	Received
410-114570-1	FLPE - Room Temp, Water, Trial #1	Water	01/19/23 00:00	01/20/23 09:30
410-114570-2	FLPE - Room Temp, Water, Trial #2	Water	01/19/23 00:00	01/20/23 09:30
410-114570-3	FLPE - Room Temp, Water, Trial #3	Water	01/19/23 00:00	01/20/23 09:30
410-114570-4	HDPE - Room Temp, Water, Trial #1	Water	01/19/23 00:00	01/20/23 09:30
410-114570-5	HDPE - Room Temp, Water, Trial #2	Water	01/19/23 00:00	01/20/23 09:30
410-114570-6	HDPE - Room Temp, Water, Trial #3	Water	01/19/23 00:00	01/20/23 09:30
410-114570-7	Blank - Room Temp, Water	Water	01/19/23 00:00	01/20/23 09:30
410-114570-8	FLPE - Room Temp, Methanol, Trial #1	Water	01/19/23 00:00	01/20/23 09:30
410-114570-9	FLPE - Room Temp, Methanol, Trial #2	Water	01/19/23 00:00	01/20/23 09:30
410-114570-10	FLPE - Room Temp, Methanol, Trial #3	Water	01/19/23 00:00	01/20/23 09:30
410-114570-11	HDPE - Room Temp, Methanol, Trial #1	Water	01/19/23 00:00	01/20/23 09:30
410-114570-12	HDPE - Room Temp, Methanol, Trial #2	Water	01/19/23 00:00	01/20/23 09:30
410-114570-13	HDPE - Room Temp, Methanol, Trial #3	Water	01/19/23 00:00	01/20/23 09:30
410-114570-14	Blank - Room Temp, Methanol	Water	01/19/23 00:00	01/20/23 09:30
410-114570-15	FLPE - Room Temp, Acetone, Trial #1	Water	01/19/23 00:00	01/20/23 09:30
410-114570-16	FLPE - Room Temp, Acetone, Trial #2	Water	01/19/23 00:00	01/20/23 09:30
410-114570-17	FLPE - Room Temp, Acetone, Trial #3	Water	01/19/23 00:00	01/20/23 09:30
410-114570-18	HDPE - Room Temp, Acetone, Trial #1	Water	01/19/23 00:00	01/20/23 09:30
410-114570-19	HDPE - Room Temp, Acetone, Trial #2	Water	01/19/23 00:00	01/20/23 09:30
410-114570-20	HDPE - Room Temp, Acetone, Trial #3	Water	01/19/23 00:00	01/20/23 09:30
410-114570-21	Blank - Room Temp, Acetone	Water	01/19/23 00:00	01/20/23 09:30

Col ...acking List

410-114570 Chain of Custody

Phone: 1-800-323-4340
Fax: 1-847-247-2929
E-mail: SALES@COLEPARMER.COM
Web: WWW.COLEPARMER.COM

01/18/2023 09:51:22

Shipping Address	704945-02
EUROFINS FOOD CHEMISTRY TESTING DANA KAUFFMAN ENV SAMPLE ENTRY 2425 NEW HOLLAND PIKE LANCASTER, PA 17601-5994 U.S.A.	

Billing Address	955175-01
EVE BENNETT 2 CHICKADEE LN NORTH EASTON, MA 02356-1764 U.S.A.	

Order Date	Customer PO#
01/17/2023	KBENNETT01172301
Reference #	**Web Order#/Division**
1329089-00	WO20230117N0108/04

Thank you for choosing Cole-Parmer!

Shipping Comments: UPS GND - UNITED PARCEL SERVICE - CC

Order Comments: **SHIP COMPLETE**

PO Line	Catalog No.	Description	Shipped	Unit	Quantity Ordered	Back Ordered	Shipped Wt Lbs
2	**EW-62150-20**	WM BTL TRANS HDPE 500ML 12/PK 01-12-34-13-3 (1) IPC0500N SERIAL#:_____	1	PK	1	0	1.80
1	**EW-62500-10**	NM BOTTLE FLR HDPE 500ML 12/PK 01-14-25-13-4 (1) FCE0500N SERIAL#:_____	1	PK	1	0	1.50

NOTES: ALL ITEMS NOT INDICATED OTHERWISE TO BE SHIPPED FROM STOCK.
FOR ANY PROBLEMS WITH THIS SHIPMENT PLEASE CONTACT US FOR RETURN AUTHORIZATION AT 800-323-4340

1/20/23 9:30

OT#
996

Picker	Picker	Carton	Size Cu Ft	Est Wt Lbs
			.77	3.30

Login Sample Receipt Checklist

Client: PEER

Job Number: 410-114570-1

Login Number: 114570
List Number: 1
Creator: Hollinger, Zane T

List Source: Eurofins Lancaster Laboratories Environment Testing, LLC

Question	Answer	Comment
The cooler's custody seal is intact.	N/A	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	False	Thermal preservation not required.
Cooler Temperature is acceptable (</=6C, not frozen).	N/A	
Cooler Temperature is recorded.	False	Thermal preservation not required.
WV: Container Temperature is acceptable (</=6C, not frozen).	N/A	
WV: Container Temperature is recorded.	N/A	
COC is present.	False	Refer to Job Narrative for details.
COC is filled out in ink and legible.	N/A	
COC is filled out with all pertinent information.	N/A	
There are no discrepancies between the containers received and the COC.	N/A	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	False	Refer to Job Narrative for details.
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
There is sufficient vol. for all requested analyses.	True	
Is the Field Sampler's name present on COC?	N/A	
Sample custody seals are intact.	N/A	
VOA sample vials do not have headspace >6mm in diameter (none, if from WV)?	N/A	