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RE: Draft National Pollutant Discharge Elimination System Permit No. MA0103284 (MWRA Deer Island Treatment Plant)

Thank you for the opportunity to provide comments on the Massachusetts Water Resources Authority ("MWRA") Deer Island Treatment Plant ("DITP") Draft National Pollutant Discharge Elimination System Permit No. 0103284 ("Draft Permit") and accompanying fact sheet. These comments are submitted on behalf of Just Zero, and 47 environmental organizations, scientists, public health advocates, and farmers.[1]

Located on a peninsula in Boston Harbor, the DITP is one of the largest wastewater treatment facilities ("WWTF") in the United States. This plant manages approximately 360 million gallons per day of sewage from 43 communities in the Boston metropolitan area; stormwater and other precipitation from roadways, rooftops, parking lots, and other surfaces; as well as wastewater from industrial users, commercial companies, manufacturers, and nearly every other conceivable entity with a drainpipe. In heavy rain, the flow of sewage, industrial waste, and rainwater can – and sometimes does – exceed a billion gallons in a day. Altogether, this makes the DITP a significant source of polyfluoroalkyl substances ("PFAS"), a wide range of toxic chemicals, and microplastic pollution in Massachusetts, as well as the entire country.

Just Zero and the undersigned organizations are concerned with several aspects of the Draft Permit as they fall short of the overarching goal of protecting water quality and public health – especially when it comes to addressing the presence of contaminants of emerging concern such as PFAS and microplastics.[2]

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[1] Hereinafter these organizations are collectively referred to as "Just Zero and the undersigned organizations" or "we."
[2] MWRA Draft NPDES Permit No. MA0103284, and Factsheet

To better account for the presence of these contaminants in the influent, effluent, and sewage sludge[3], we are calling on EPA to include the following in the final permit:

(1) Provisions that allow the Agency to expand the list of PFAS that are subject to quarterly sampling and monitoring requirements when additional compounds are detectable by Method 1633 or an improved method.
(2) Increased monitoring and sampling for PFAS from industrial discharges that utilize the DITP. The current requirement for annual monitoring and sampling is insufficient to provide a clear picture of the concentrations of PFAS in the influent from industrial and other dischargers.
(3) A requirement that landfill leachate must be pretreated to remove and/or reduce the concentration of PFAS in the leachate prior to being sent to the DITP. Many states are considering and exploring landfill leachate pretreatment technologies and systems to reduce the concentration of PFAS entering the environment from this known source.
(4) A prohibition on the land application of sewage sludge generated at the DITP. This prohibition must apply to all sludge, regardless of how it is processed and whether it is identified as a fertilizer by DITP or any other entity. Should EPA fail to include this requirement in the final permit, the Agency must, at a minimum, include robust tracking and reporting to better understand where this material is being applied.
(5) Quarterly monitoring and sampling for microplastics in the influent, effluent, and sewage sludge. The results of this sampling must be made available to the public.
(6) Assurance that EPA will continue to maintain the Outfall Monitoring Science Advisory Panel ("OMSAP").

These requirements are necessary to better understand the sources and concentrations of PFAS and microplastics in the influent entering the DITP, as well as to reduce the release of these contaminants into the environment, thereby better protecting water quality and public health.

I. EPA Should Strengthen the Draft Permit to Minimize the Release of PFAS from the DITP.

The Draft Permit acknowledges PFAS as chemicals of concern. This is a welcome addition to the permit; however, EPA should go further and use this permit

[3] "Sewage sludge," "sludge," and "biosolids" are used interchangeably in these comments.

renewal as an opportunity to take a more active and protective approach to minimize the release of PFAS from this facility.

The undersigned urge EPA to address the significant environmental and public health threats posed by the release of PFAS from the DITP by: 1) expanding the list of PFAS compounds subject to quarterly monitoring and sampling requirements as they become detectable by Method 1633 or other EPA approved methods; 2) increasing monitoring and sampling requirements for PFAS from industrial discharges that utilize the DITP; 3) requiring in the permit that landfill leachate must be pretreated to remove or reduce the concentration of PFAS in the leachate prior to being sent to the DITP; and 4) prohibiting the land application of sewage sludge generated at the DITP.

Individually and collectively, these requirements will better protect the water quality of the receiving waters, as well as the health of those who live, work, and recreate near the DITP and the areas where effluent is released and contaminated sludge is spread.

A. PFAS Pose a Serious Threat to Public Health and the Environment.

PFAS are a group of approximately 15,000 synthetic chemicals.[4] A 2001 class action lawsuit against DuPont involving perfluorooctanoic acid ("PFOA," one of the most well-studied PFAS) released into the environment from its West Virginia Washington Works Plant resulted in a settlement that established a large epidemiological study of PFAS-exposed residents near the plant.[5] Blood samples from 69,000 people found that the PFOA exposure was linked to kidney cancer, testicular cancer, thyroid disease, ulcerative colitis, high cholesterol (hypercholesterolemia), and pregnancy-induced hypertension and preeclampsia.[6]

The U.S. Department of Health and Human Services' National Toxicology Program has confirmed PFAS' toxicity to the immune systems of both human and non-human animals.[7] A sister agency, the Agency for Toxic Substances and Disease

[4] U.S. Environmental Protection Agency, CompTox Chemicals Dashboard.
[5] Leach v. E.I. Du Pont de Nemours Co., et al., No. 01-C-608, 2002 WL 1270121, at *1. (W.Va. Cir. Ct. April 10, 2002).
[6] *Id.*
[7] Division of the National Toxicology Program, Monograph on Immunotoxicity Association with Exposure to Perfluorooctanoic Acid (PFOA) or Perfluorooctane sulfonate (PFOS), U.S. Department of Health and Human Servies. (Sept. 2016).

Registry ("ATSDR"), published toxicological profiles of PFAS in 2021.[8] It presented strong evidence that PFAS are harmful to human health, reflecting the evidence from a large number of studies that show PFAS linked to increased cholesterol levels, decreased vaccine response in children, liver disease, preeclampsia in pregnant women, decreases in infant birth weights, and increased risk of kidney or testicular cancer.[9] The Interstate Technology Regulatory Council ("ITRC") has similarly recognized that PFAS exposure carries numerous and significant human and ecological effects, including liver effects, increased serum cholesterol, immunological effects, cardiovascular effects, and cancer.[10]

In 2023, EPA acted on the vast amount of research that shows the profound harm to human health from PFAS exposure by proposing new regulations for the National Primary Drinking Water Regulation ("NPDWR") for six PFAS: PFOA, PFOS, perfluorononanoic acid ("PFNA"), hexafluoropropylene oxide dimer acid ("HFPO-DA", also known as "GenX"), perfluorohexane sulfonic acid ("PFHxS"), and perfluorobutane sulfonic acid ("PFBS").[11] This proposed rulemaking would establish legally enforceable levels in drinking water, called Maximum Contaminant Levels ("MCLs") for these compounds. The MCLs for PFOA and PFOS are 4 parts per trillion ("ppt").[12] The other four PFAS will be regulated as a PFAS mixture and their MCLs determined by a Hazard Index set at 1.0.[13] Additionally, the Maximum Contaminant Levels Goals ("MCLGs") for both PFOA and PFOS are zero, meaning there is no safe level of contamination in drinking water.[14]

The Commonwealth of Massachusetts moved faster than EPA on PFAS regulation in drinking water. In 2020, the Massachusetts Department of Environmental Protection ("MassDEP") published drinking water standards for PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA, with an MCL of 20 ppt for the combined six PFAS and an MCLG of zero.[15]

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[8] Agency for Toxic Substances and Disease Registry, Toxicological Profile for Perfluoroalkyls, U.S. Department of Health and Human Services. (May 2021)
[9] *Id.*
[10] Interstate Technology Regulatory Council, Human and Ecological Health Effects and Risk Assessment of PFAS. (Sept. 2023).
[11] U.S. EPA, Perfluorooctanoic Acid and Perfluorooctanesulfonic Acid National Primary Drinking Water Regulation Rulemaking, Docket ID: EPA-HQ-OW-2022-0114. (Mar. 14, 2023).
[12] *Id.*
[13] *Id.*
[14] *Id.*
[15] 310 CMR § 22.07G(3)(d).

EPA has also proposed regulating PFOA and PFOS under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, ("CERCLA" or "Superfund"), designating both as hazardous substances.[16] EPA states that these chemicals "may present substantial danger to the public health or welfare or the environment."[17] Importantly, MassDEP, unlike other commenters, did not include any carveout for PFAS in sludge or sludge derived products.[18]

There is no question that PFAS chemicals pose a serious threat to public health and the environment. Through this permit and others like it, EPA must begin implementing requirements that will help identify the source of PFAS into WWTFs and reduce the release of these chemicals into the environment.

B. Wastewater Treatment Facilities, Including the DITP, are Significant Sources of PFAS.

PFAS enter the DITP from a variety of commercial and industrial sources such as wastewater from metal finishers and other manufacturing plants, electronic industries, and landfill leachate.[19] WWTFs, including the DITP, are not designed or equipped to remove or destroy these compounds, especially synthetic petrochemicals. As a result, effluent containing these chemicals is discharged into the receiving waters where it can bioaccumulate and threaten the environment and public health. A significant portion of the PFAS in the influent is also transferred to the sludge generated at these facilities.[20]

Moreover, growing evidence demonstrates that WWTFs actually generate additional PFAS in both effluent and sewage sludge, rather than simply serving as

[16] EPA, Designation of Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS) as CERCLA Hazardous Substances, Proposed Rule, 87 Fed. Reg. 54415 (Sept. 6, 2022).
[17] *Id.*
[18] Massachusetts Department of Environmental Protection, Comments on the Designation of Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS) as CERCLA Hazardous Substances, EPA-HQ-OLEM-2019-0341. (Nov. 9, 2022).
[19] Heidler, J., & Halden, R. U. (2008). Meta-analysis of mass balances examining chemical fate during wastewater treatment. Environmental Science & Technology, 42(17), 6324–6332. https://doi.org/10.1021/es703008y
[20] Lenka, S.P., Kah, M., Padhye, L.P., 2021. A review of the occurrence, transformation, and removal of poly- and perfluoroalkyl substances (PFAS) in wastewater treatment plants. Water Res. 199, 117187. doi.org/10.1016/j.watres.2021.117187.

a conduit.[21] Studies have shown that the PFAS in the effluent at WWTFs can be 19 times greater than the PFAS in the influent.[22] Discharges into the DITP also contain precursors (chemicals that eventually become PFAS) such as perfluorooctane sulfonamide, fluorotelomer-based compounds, fluorinated surfactants, and fluorotelomer alcohols.[23]

Precursors in the sewage sludge can also transform into other PFAS.[24] This occurs during composting, heat treatment, lime treatment, anaerobic digestion, and when land applied.[25] Therefore, PFAS levels in sludge will change depending on when, where, and how the sludge is tested.[26] As a result, although it is clear that sludge contains PFAS, the PFAS levels are likely underrepresented in monitoring and sampling.[27]

When this sludge is either land applied or processed to create a "fertilizer," contaminants – including PFAS - can bioaccumulate in the soil and mobilize and enter groundwater.

Given that PFAS and their precursors enter WWTFs as influent, multiply, and leave WWTFs via the effluent and sewage sludge in even greater amounts than previously documented, additional, stricter regulation, and more comprehensive testing of WWTFs is overdue and necessary to protect public health and the environment.

C. EPA Should Expand the List of PFAS That Are Subject to Quarterly Sampling and Monitoring Requirements When Additional Compounds Are Detectable.

The Draft Permit requires quarterly influent, effluent, and sludge sampling PFAS and annual sampling for "certain industrial users" with the stated purpose to

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[21] Helmer, R. W., Reeves, D. M., & Cassidy, D. P. (2022). Per- and polyfluorinated alkyl substances (PFAS) cycling within Michigan: Contaminated sites, landfills and wastewater treatment plants. Water Research, 210, 117983. https://doi.org/10.1016/j.watres.2021.117983
[22] *Id.*
[23] *Id.*
[24] Thompson, J., Robey, N., Tolaymat, T., Bowden, J., Solo-Gabriele, H., & Townsend, T. (2023). Underestimation of Per- and Polyfluoroalkyl Substances in Biosolids: Precursor Transformation During Conventional Treatment.. Environmental science & technology. https://doi.org/10.1021/acs.est.2c06189
[25] Id.
[26] *Id.*
[27] *Id.*

"better understand potential discharges of PFAS from this facility and to inform future permitting decisions."[28] We support these requirements.

Quarterly monitoring of the 40 PFAS parameters detectable by Method 1633 is a strong starting point and necessary contribution to our understanding of PFAS entering and leaving the DITP. However, given the dynamic regulatory, scientific, and public health related landscape for PFAS, the Draft Permit should require that when other PFAS compounds are detectable by Method 1633 or an improved EPA method (such as total organic fluorine), they too should be monitored and reported quarterly. This is especially important given that the permit the DITP is currently operating under is over twenty years old.[29] EPA cannot wait another twenty years to require testing for additional PFAS compounds.

EPA published Method 1633 this year. It was developed in a four-year collaboration with the Department of Defense. EPA has confirmed this is not the end of the road in terms of developing testing methodology for PFAS.[30] EPA has stated that there are "hundreds" of PFAS and that it needs to test for more than 40 of them in drinking water and in waste matrices such as sewage sludge and landfill leachate and that it is also developing new methods for detecting organic fluorine, a useful indicator of PFAS.[31]

Given that 22 states have MCLs for PFAS that add several PFAS concentrations together, such as Massachusetts' regulation that adds six PFAS concentrations to determine whether they surpass the MCL of 20 ppt, it is not unreasonable to assume that as testing expands, additional PFAS will be added to state and federal drinking water and other health-related regulations.[32] These regulations will be informed by expanded PFAS measurements at major sources of the chemicals, like the DITP.

Therefore, when other PFAS compounds are detectable by Method 1633 or an improved EPA method, the newly detectable compounds should also be subject to the permit's monitoring and reporting requirements.

[28] NPDES Permit No. MA0103284, Fact Sheet. Pg. 90.
[29] U.S. EPA, Authorization to Discharge Under the National Pollutant Discharge Elimination System – Massachusetts Water Resources Authority, Permit No. MA0103284. (July 10, 2000).
[30] U.S. EPA, Clean Water Act Analytical Methods for Per- and Polyfluorinated Alkyl Substances.
[31] *Id.*
[32] National Conference of State Legislatures, Per- and Polyfluoroalkyl Substances (PFAS) | State Legislation and Federal Action. (Mar. 23, 2023)

D. EPA Should Require Increased Monitoring and Sampling for PFAS From Industrial Discharges That Utilize the DITP.

The Draft Permit currently requires annual monitoring of various industrial discharges to quantify the PFAS from these sources.[33] The list of industrial discharges includes, among others, landfill leachate.[34] Although this is a welcome addition to the permit, it does not go far enough. More frequent testing is necessary to better understand and quantify the PFAS from these sources.

This is especially true for discharges such as landfill leachate that are known to have high concentrations of PFAS.[35] It is estimated that 750 kg of PFAS leave U.S. municipal solid waste in landfill leachate annually. Moreover, the concentration of PFAS in landfill leachate is likely significantly underestimated because of limited analyte testing.[36] For example, one study of PFAS at a Vermont landfill found that approximately 7% of the PFAS load entering the landfill is released via leachate.[37] However, the study only tested for 24 PFAS compounds of the thousands contained in landfill leachate.[38] National surveys have found that as much as 11% of the PFAS may be released via leachate.[39] Moreover, observed PFAS concentrations in landfill leachate, as well as those in the influent, effluent, and sewage sludge from WWTFs, can vary significantly by season.[40] This is likely true for other industrial discharges as well.

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[33] Draft Permit Part I.G.4

[34] *Id.*

[35] Tolaymat, T., Robey, N., Krause, M., Larson, J., Weitz, K., Parvathikar, S., Phelps, L., Linak, W., Burden, S., Speth, T., & Krug, J. (2023). A critical review of perfluoroalkyl and polyfluoroalkyl substances landfill disposal in the United States. *Science of the Total Environment,* 905, 167185. https://doi.org/10.1016/j.scitotenv.2023.167185

[36] *Id.*

[37] Estabrooks, M., Zemba, S., PFAS Waste Source Testing Report – New England Waste Services of Vermont, Inc., Sanborn Head & Associates. (Oct. 2019).

[38] *Id.*

[39] Tolaymat, T., Robey, N., Krause, M., Larson, J., Weitz, K., Parvathikar, S., Phelps, L., Linak, W., Burden, S., Speth, T., & Krug, J. (2023). A critical review of perfluoroalkyl and polyfluoroalkyl substances (PFAS) landfill disposal in the United States. Science of The Total Environment, 905, 167185. https://doi.org/10.1016/j.scitotenv.2023.167185

[40] *See,* Tavasoli, E., Luek, J. L., Malley, J. P., & Mouser, P. J. (2021). Distribution and fate of per-and polyfluoroalkyl substances (PFAS) in wastewater treatment facilities. Environmental Science: Processes & Impacts, 23(6), 903-913. Thompson, K. A., Mortazavian, S., Gonzalez, D. J., Bott, C., Hooper, J., Schaefer, C. E., & Dickenson, E. R. (2022). Poly- and perfluoroalkyl substances in municipal wastewater treatment plants in the United States: Seasonal patterns and meta-analysis of long-term trends and average concentrations. ACS ES&T Water, 2(5), 690–700. https://doi.org/10.1021/acsestwater.1c00377

To better understand the dangerous, significant concentrations of PFAS entering the DITP from industrial users, EPA should require more frequent and standardized testing. This will provide a clearer understanding of the major sources of PFAS into the facility.

E. EPA Should Prohibit Acceptance of Landfill Leachate That Has Not Been Pretreated to Remove or Reduce PFAS.

WWTFs and landfill leachate are two of the greatest contributors to PFAS pollution in the United States.[41] Because many landfills in the U.S. send their leachate to WWTFs, they add a considerable PFAS burden to these publicly owned treatment works, like the DITP.

To reduce the quantity of PFAS entering the DITP, EPA should require all landfill leachate discharged into the facility to be pretreated to address PFAS. The pretreatment process or processes should utilize the Massachusetts MCL for PFAS in drinking water as the benchmark for successful pretreatment. Given that the DITP is not equipped or required to treat landfill leachate to reduce or remove PFAS, this pretreatment requirement is necessary to reduce the spread of PFAS into the receiving waters from a discharge source that is known to consistently contain high levels of these harmful chemicals.

States across the country, including states in New England, are beginning to evaluate and require pretreatment of landfill leachate to reduce the release of PFAS into the environment. Currently, Vermont is in the process of reviewing a pilot project that will treat landfill leachate to minimize the concentration of PFAS before it is sent to publicly owned treatment facilities.[42] The pilot project will be used to determine the design conditions of a pretreatment system that can manage all leachate generated in the state.[43] The development of the pilot project is a direct result over growing concern about the environmental and public health

[41] Andrews, D. Q., Hayes, J., Stoiber, T., Brewer, B., Campbell, C., & Naidenko, O. V. (2021). Identification of point source dischargers of per- and Polyfluoroalkyl Substances in the United States. AWWA Water Science, 3(5). https://doi.org/10.1002/aws2.1252

[42] Vermont Department of Environmental Conservation, Pretreatment Discharge Permit No. 3-1406 – New England Waste Management Services, Inc. Section 5. (Dec. 21, 2022).

[43] *Id.*

impacts associated with exposure to PFAS, and the failure of WWTFs to address these compounds in landfill leachate.[44]

Additionally, the Maine Legislature recently commissioned a report to evaluate and assess treatment methods for reducing PFAS in leachate from state-owned landfills.[45] The report, which was finalized in January 2023, found that there are four readily available treatment technologies that can considerably reduce the concentrations of PFAS in landfill leachate.[46]

There is clear interest at the state level to find solutions to the known concentrations of PFAS in landfill leachate and the inability of publicly owned treatment works to address the presence of these compounds in this material. Failure to include a pretreatment requirement would essentially allow for the continued spread of PFAS into both the receiving waters and onto farmlands across the region through land application of sewage sludge. In effect this would permit the continued contamination of surface water, soil, and groundwater with these highly dangerous compounds.

EPA can and should bolster these state-level efforts by only allowing landfill leachate to be sent to the largest WWTF in the region if it is first treated to address the presence of PFAS.

F. EPA Should Take Action to Address PFAS Contamination Arising from the Land Application of Sewage Sludge and Sludge Derived Products.

The Agency should – at a minimum – require robust tracking and reporting to identify where sewage sludge is being applied. This information should be recorded in a publicly available database which includes the date of application, amount of material land applied, and the address of the land application. The database should also include the address and name of all sludge and sludge-derived product storage facilities. The database should also include a monthly accounting of how many bags of sludge were sold and to whom. Although this tracking and reporting will not help reduce the release of PFAS into the

[44] Emma Cotton, State Requires Casella to Build a Pilot Project to Reduce PFAS in Leachate, Vermont Digger. (Dec. 21, 2022).
[45] State of Maine, Resolve to Address PFAS Pollution at State-Owned Solid Waste Landfills. (Enacted - May 2, 2022)
[46] State of Maine Bureau of General Services, Study to Assess Treatment Alternatives for Reducing PFAS in Leachate From State-Owned Landfills. (January 2023).

environment, it will help track where the releases occur which is important for remediation efforts and to limit further contamination.

However, it is more important that EPA amend the Draft Permit to prohibit the land application of DITP's sludge and any products derived from this sludge, thereby reducing the spread of PFAS onto farmland throughout the region. Enough is known about the concentration of PFAS in sewage sludge and products derived from this material to warrant protective action to prevent the land application of this highly contaminated material.[47]

The DITP generated 27,263 dry metric tons of sewage sludge (equivalent to 60,104,627 pounds, which would fill 2,147 large dump trucks) in 2022.[48] The majority of the sludge from DITP is either directly land applied or land applied after processing which does not reduce or remove the concentration of PFAS. Some of the sludge generated by the DITP is bagged and sold at retail as "Bay State Fertilizer."

Since August 2020, MassDEP has required quarterly monitoring of PFAS in sludge generated at the DITP. For two of the most concerning PFAS compounds, PFOS and PFOA, the combined average concentration is 15,000 parts per trillion.[49] This is more than ten times the PFAS concentration threshold that Connecticut recommends for farmers, and Connecticut is combining five specific PFAS chemicals, not two.[50] It would be irresponsible and egregious for EPA to continue to allow for the land application of this material.

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[47] The most recent EPA report determined that "a total of 739 chemicals have been identified in biosolids to date; of which about 250 of these are dioxins, furans, and PCBs." Others include plastics (such as polyethylene terephthalate), pesticides (such as DDT), pharmaceuticals (such as fentanyl), and industrial chemicals (such as trichlorobenzene). United States Environmental Protection Agency, Office of Science and Technology, Office of Water, "Biosolids Biennial Report No.9 (Reporting Period 2020–2021), December 2022." https://www.epa.gov/system/files/documents/2022-12/2020-2021-biennial-report.pdf

[48] NPDES Permit No. MA0103284, Fact Sheet. Pg. 22.

[49] Barbara Moran, Our Sewage Sludge Often Becomes Fertilizer. Problem Is, It's Tainted with PFAS, WBUR. (Mar. 30, 2023).

[50] Connecticut Department of Agriculture, PFAS in Biosolids Guidance. The Connecticut Department of Agriculture advises farmers not to apply any sludge that has a combined PFAS concentration of 1.4 ppb to farmland.

Land application of sewage sludge presents a significant threat of PFAS migration to surface and groundwater.[51] A 2022 study showed PFAS from land application of sewage sludge migrating as far as 17 meters to underlying groundwater.[52] Once spread, the PFAS that does not move to water can remain for years, adding to the PFAS burden in the soil from multiple land applications.[53]

EPA can look to the approach taken by Maine as instructive. In 2019, reports regarding PFAS contamination at Stoneridge Farm in Maine became public. In response, the Maine Department of Environmental Protection ("Maine DEP") halted the spread of sludge until it was tested for three types of PFAS (PFOA, PFOS, and PFBS).[54] When Maine DEP began testing sludge for those three PFAS, over 95% of the sludge tested exceeded the Department's screening levels.[55] The results of the testing coincided with additional findings of extremely high levels of PFAS contamination in areas where sludge application was routine.[56] Importantly, PFAS contamination was not limited to farmland and soil. Over 200 wells and water sources have been identified as contaminated.[57] Additionally a "do not eat" advisory was issued for deer harvested in the Fort Fairfield area where sludge was previously land applied.[58]

As a result, In 2022, Maine became the first state to ban the spreading of sludge as a fertilizer after statewide sampling and testing of areas where the practice had occurred found extremely high concentrations of PFAS in both the soil and groundwater.[59] The contamination was so significant, Maine also included $60 million in its budget to help impacted farmers whose farmland whose

[51] Scearce, A. E., Goossen, C. P., Schattman, R. E., Mallory, E. B., & MacRae, J. D. (2023). Linking drivers of plant per- and polyfluoroalkyl substance (PFAS) uptake to agricultural land management decisions. Biointerphases, 18(4). https://doi.org/10.1116/6.0002772
[52] Johnson, G. R. (2022). PFAS in soil and groundwater following historical land application of biosolids. Water Research, 211, 118035.
[53] Venkatesan, A. K., & Halden, R. U. (2014). Loss and in situ production of perfluoroalkyl chemicals in outdoor biosolids–soil mesocosms. Environmental research, 132, 321-327.
[54] Maine DEP. Requirement to Analyze for PFAS Compounds. March 22, 2019.
[55] Tom Perkins, I Don't Know How We'll Survive: The Farmers Facing Ruin in America's Forever Chemicals Crisis, The Guardian. (Mar. 22, 2022).
[56] *Id.*
[57] Kevin Miller, Maine DEP Identifies 34 Towns with High-Priority Sites PFAS Chemical Testing, Maine Public. (Oct. 22, 2021).
[58] Meaghan Bellavance, MDIFW Reduces Size of PFAS Do Not Eat Advisory Area in Fairfield, News Center Maine. (Apr. 24, 2023).
[59] 38 M.R.S.A. §1304(20).

contaminated land is now unusable and unsellable.[60] Several other states are expected to follow Maine's leadership and seek similar bans.

The draft permit simply requires the DITP to comply with the standards for sewage sludge use or disposal under Section 405(d) of the Clean Water Act, and its implementing regulations. The implementing regulations were finalized in February 1993.[61] These rules are out of date and fail to protect water quality, soil quality, farmer, farmland, and public health.

Moreover, although the draft permit does require sampling to evaluate the presence and concentrations of PFAS in the sludge generated at the DITP, the sampling is also based on outdated guidance. The draft permit requires sludge sampling to be representative based on the POTW Sludge Sampling and Analysis Guidance Document.[62] This guidance is from 1989 and does not include the science and methods needed to address EPA and other's concerns about PFAS and other toxicants in sewage sludge. For example, as explained above, PFAS concentrations and compounds can change depending on where and when the sludge sample is taken. PFAS concentrations and compounds will be different in sewage sludge than in sludge-derived compost made from the same sludge. Testing standards and methodology should be updated to reflect our improved understanding of PFAS compounds.

Given the high concentrations of chemicals such as PFOA and PFOS in the DITP sludge, EPA should no longer allow the sludge generated by the DITP to be land applied or sold and used as fertilizer. Alternatively, should EPA fail to include this necessary prohibition, the Agency must – at a minimum – include requirements which monitor and track where the material is land applied.

II. EPA Should Require Monitoring for Microplastics in the DITP's Influent, Effluent, and Sludge to Better Understand the Presence and Release of These Materials.

In addition to strengthening the Draft Permit to better address PFAS, EPA must also amend the permit to address microplastics. Specifically, we urge EPA to

[60] Penelope Overton, State Adopts $70 Million Plan to Help Farmers Deal with PFAS Contamination, Portland Press Herald. (Jul. 13, 2023).
[61] U.S. EPA, Standards for the Use or Disposal of Sewage Sludge, 40 CFR § 257.
[62] NPDES Permit No. MA0103284 – Footnote 22.

require the quarterly monitoring of the influent, effluent, and sludge to provide an understanding of the presence of microplastic in each of these materials.

Microplastics are plastic particles less than 5 mm. They can be directly manufactured and used – for example, as microbeads in cosmetics – or they can form from the degradation of plastic. They can enter municipal wastewater treatment plants from the wash water from the laundering of synthetic clothing, such as polyester and nylon, and from other sources such as landfill leachate, and stormwater.

Because WWTFs concentrate microplastics and discharge them in effluent and sludge, they are a significant source of microplastics in the environment.[63] Most microplastics in a WWTF accumulate in the sewage sludge.[64] However, some microplastics are released into receiving waters through the effluent.[65]

A 2021 study on microplastics in sludge stated that "the land application of biosolids in the U.S. alone could annually release 785-1080 trillion microplastics and that the concentration of microplastics in biosolids could be significantly underestimated."[66] Another study showed the microplastic load in sludge from one WWTF ranging from 37.7–97.2 microplastics/g of sludge (dry weight).[67] This would translate to the DITP releasing between 34 million and 97 million microplastics per day in its sewage sludge (at 100 tons per day). Other research demonstrated that a WWTF collecting the sewage from 650,000 people released 65 million microplastics into the receiving water every day.[68] DITP treats the

[63] Sun, J., Dai, X., Wang, Q., Loosdrecht, M., & Ni, B. (2019). Microplastics in wastewater treatment plants: detection, occurrence and removal. Water Research, 152, 21-37. https://doi.org/10.1016/j.watres.2018.12.050
[64] Gatidou, G., Arvaniti, O. S., & Stasinakis, A. S. (2019). Review on the occurrence and fate of microplastics in Sewage Treatment Plants. Journal of hazardous materials, 367, 504-512.
[65] *Id.*
[66] Koutnik, V. S., Alkidim, S., Leonard, J., DePrima, F., Cao, S., Hoek, E. M., & Mohanty, S. K. (2021). Unaccounted microplastics in wastewater sludge: Where do they go? ACS ES&T Water, 1(5), 1086–1097. https://doi.org/10.1021/acsestwater.0c00267
[67] Harley-Nyang, D., Memon, F. A., Jones, N., & Galloway, T. (2022). Investigation and analysis of microplastics in Sewage Sludge and biosolids: A case study from one wastewater treatment works in the UK. Science of The Total Environment, 823, 153735. https://doi.org/10.1016/j.scitotenv.2022.153735
[68] Murphy, F., Ewins, C., Carbonnier, F., & Quinn, B. (2016). Wastewater Treatment Works (WwTW) as a Source of Microplastics in the Aquatic Environment.. Environmental science & technology, 50 11, 5800-8. https://doi.org/10.1021/acs.est.5b05416.

sewage from not only commercial and industrial facilities, but from 2.3 million people per day.

When sludge is land applied, these microplastics are distributed in the soil and make their way to plants, surface water, and groundwater.[69] Once in the environment, microplastics can negatively affect the health of animals and marine species.[70] They can interact with terrestrial organisms that mediate essential ecosystem services and functions, such as soil dwelling invertebrates, terrestrial fungi, and plant-pollinators.[71] Microplastics can also affect the abundance and diversity of soil fauna, including soil microarthropods and nematodes.[72] Microplastics also pose a threat to human health. Humans are primarily exposed to microplastics through ingestion, inhalation, and dermal contact.[73] A recent review of potential health risks of microplastics on the human body included findings that exposure could lead to cytotoxicity, disruption of homeostasis and metabolism, disruption of immune function, neurotoxicity, and inflammation.[74] Prolonged exposure to microplastics is also connected with tissue damage, fibrosis, and cancer.[75]

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[69] Machado, A., Kloas, W., Zarfl, C., Hempel, S., & Rillig, M. (2018). Microplastics as an emerging threat to terrestrial ecosystems. Global Change Biology, 24(4), 1405-1416. https://doi.org/10.1111/gcb.14020
[70] Sana, S. S., Dogiparthi, L. K., Gangadhar, L., Chakravorty, A., & Abhishek, N. (2020). Effects of microplastics and nanoplastics on marine environment and human health. Environmental Science and Pollution Research, 27, 44743-44756.
[71] *Id.*
[72] Lin, D., Gao, Y., Dou, P., Qian, S., Zhao, L., Yang, Y., ... & Fanin, N. (2020). Microplastics negatively affect soil fauna but stimulate microbial activity: insights from a field-based microplastic addition experiment. Proceedings of the Royal Society B: Biological Sciences, 287(1934), 20201268. https://doi.org/10.1098/rspb.2020.1268
[73] Prata, J. C., da Costa, J. P., Lopes, I., Duarte, A. C., & Rocha-Santos, T. (2020). Environmental exposure to microplastics: An overview on possible human health effects. Science of The Total Environment, 702, 134455. https://doi.org/10.1016/j.scitotenv.2019.134455
[74] Prata, J. C., da Costa, J. P., Lopes, I., Duarte, A. C., & Rocha-Santos, T. (2020). Environmental exposure to microplastics: An overview on possible human health effects. Science of The Total Environment, 702, 134455. https://doi.org/10.1016/j.scitotenv.2019.134455
[75] See, e.g., David Azoulay et al., Plastic & Health: The Hidden Costs of a Plastic Planet (Feb. 2019), available at https://www.ciel.org/wp-content/uploads/2019/02/Plastic-and-Health-The-Hidden-Costs-of-a-Plastic-PlanetFebruary-2019.pdf

Additionally, given their relatively large surface area, microplastics can absorb a variety of pollutants.[76] They essentially act as transportation vehicles for metals and toxicants.[77] Microplastic degradation can trigger the release of additives in plastics (e.g. phthalates) and absorbed contaminants (e.g. persistent organic pollutants) which can concentrate on the microplastics, up to a million times stronger than levels in the surrounding environment.[78]

Although recent research has indicated that microplastic concentrations from the DITP were "significantly lower" than concentrations from the New Bedford WWTF, this is misleading.[79] The study only evaluated microplastics in the effluent and did not include sampling of the sewage sludge.[80] More and consistent research is necessary to understand the full scope of microplastics entering and leaving the facility.

Routine monitoring of microplastics in the influent, effluent, and sludge at the DITP will help identify the quantity of microplastics entering the facility, where these microplastics are concentrating, and where they are being released. This information is critical to informing a better understanding of potential regulatory action to reduce the release of these contaminants.

The Draft Permit indicates that there are no National Recommended Water Quality Criteria for microplastics, and therefore, no basis for establishing effluent limitations.[81] We strongly support the development of Water Quality Criteria for microplastics. ***Until Water Quality Criteria are developed, EPA must require monitoring of wastewater treatment facilities to understand how microplastics are entering the facilities, and where they are ultimately being discharged and aggregated.***

[76] Chang, X., Fang, Y., Wang, Y., Wang, F., Shang, L., & Zhong, R. (2022). Microplastic pollution in soils, plants, and animals: a review of distributions, effects and potential mechanisms. Science of The Total Environment, 850, 157857.
[77] Xiong, X., Wang, J., Liu, J., & Xiao, T. (2023). Microplastics and potentially toxic elements: A review of interactions, fate and bioavailability in the environment. Environmental Pollution, 122754.
[78] Rolsky, C., Kelkar, V., Driver, E., & Halden, R. U. (2020). Municipal sewage sludge as a source of microplastics in the environment. Current Opinion in Environmental Science & Health, 14, 16-22.
[79] NPDES Permit No. MA0103284 Fact Sheet. Section 5.1.14.2
[80] Outfall Monitoring Science Advisory Panel, Annual Review of the MWRA Outfall Monitoring Program. (Feb. 10, 2023).
[81] NPDES Permit No. MA0103284 Fact Sheet. Section 5.1.15.

III. EPA Should Maintain the Outfall Monitoring Science Advisory Panel.

The Draft Permit eliminates the Outfall Monitoring Science Advisory Panel ("OMSAP").[82] We strongly oppose the elimination of this independent scientific body and urge EPA to maintain the OMSAP.

The 2000 permit created the OMSAP to advise both EPA and MassDEP on issues related to the effects of the DITP on the surrounding environment.[83] Specifically, the OMSAP was charged with reviewing and providing recommendations for revisions of the outfall monitoring program, to ensure that it is capable of detecting changes at an early enough stage to allow action to prevent any unacceptable impacts on public health or on the marine environment and its biota, and to advise EPA and MassDEP when there are any permit or contingency plan threshold exceedances and provide advice on any actions that may be needed to protect human health and ecosystem health.[84] These tasks remain vitally important today, especially as it relates to better understanding contaminants of emerging concern including PFAS and Microplastics.

In 2018, MIT Sea Grant, Save the Harbor/Save the Bay and OMSAP identified PFAS, pharmaceuticals and personal care products (PPCPs), and microplastics, as needing further investigation.[85] OMSAP reiterated this need in its 2022 Framework for Understanding Contaminants of Emerging Concern in Marine Waters.[86]

EPA apparently eliminated OMSAP in the Draft Permit because "[w]hile OMSAP served a very important role in the design and implementation of the Ambient Monitoring Plan and Contingency Plan, data collected over the past 30 plus years, including the 20 years since the outfall was completed, has indicated to EPA that the primary questions OMSAP was tasked with responding to (regarding the impact of the discharge on aquatic life in the vicinity of the outfall) have been answered."[87] We disagree with this assessment and concur with OMSAP that PFAS and microplastics need further assessment for the reasons cited in these comments.

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[82] *Id.* at Section 5.14
[83] *Id.* at Section 5.12
[84] *Id.*
[85] Judith Pederson, Executive Summary of the Outfall Monitoring Science Advisory Panel Workshop. (Nov. 13, 2018).
[86] Outfall Monitoring Science Advisory Panel, Framework for Understanding Contaminants of Emerging Concern. (July 7, 2022).
[87] MWRA Deer Island Fact Sheet; MA0103284.

The research value of the OMSAP is invaluable. This is especially true when it comes to contaminants of emerging concern such as PFAS and microplastics. As the Draft Permit notes, several subcommittees of the OMSAP have since authored white papers for various categories of contaminants of emerging concern.[88] In fact, all research related to microplastics and the DITP has been conducted by the OMSAP. Now is not the time for the elimination of this necessary independent scientific body.

EPA should not eliminate this critical actor – instead, it must expand the scope of the OMSAP to better understand and address contaminants of emerging concern and this impact on the marine environments.

IV. Conclusion

Thank you for the opportunity to provide comments on the Draft Permit. WWTFs, including the DITP, are known to release both PFAS and microplastics into the environment. These contaminants are highly concerning and must be more comprehensively addressed in this permit.

Although PFAS and microplastics pollution must ultimately be reduced at their source, in the meantime, the flow of these toxic contaminants into the environment can and must be reduced. The DITP cannot get a pass when it comes to its role in releasing these contaminants. The recommendations we have made will both provide a greater understanding of how these contaminants enter the DITP, and how they can be reduced. We strongly urge EPA to make these targeted changes.

Thank you for your time and consideration of these comments.

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[88] NPDES Permit No. MA0103284 Fact Sheet. Section 5.1.15.

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The Story of Stuff Project

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President
Environmental League of Massachusetts

Appendix – Selected Studies

I. PFAS Impact on Ecosystems and Human Health

General toxicity

Agency for Toxic Substances and Disease Registry (ATSDR). 2021. Toxicological profile for Perfluoroalkyls. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. DOI: 10.15620/cdc:59198

Brunn, H., Arnold, G., Körner, W. *et al.* PFAS: forever chemicals—persistent, bioaccumulative and mobile. Reviewing the status and the need for their phase out and remediation of contaminated sites. *Environ Sci Eur* 35, 20 (2023). https://doi.org/10.1186/s12302-023-00721-8

Pearson, T. W., & Renfrew, D. (2023). When toxic heritage is forever: Confronting pfas contamination and toxicity as lived experience. *Toxic Heritage*, 50–61. https://doi.org/10.4324/9781003365259-6

Pelch, K.E., Reade, A., Kwiatkowski, C.F., Merced-Nieves, F.M., Cavalier, H., Schultz, K., Wolffe, T., Varshavsky, J. (2022). The PFAS-Tox Database: A systematic evidence map of health studies on 29 per- and polyfluoroalkyl substances. Environment International, 167, 107408. https://doi.org/10.1016/j.envint.2022.107408.

PFAS-Tox Database available online at https://pfastoxdatabase.org

Immunotoxicity

Division of the National Toxicology Program, NTP Monograph on immunotoxicity associated with exposure to perfluorooctanoic acid (PFOA) or perfluorooctane sulfonate (PFOS) (2016). Research Triangle Park, NC.

Ehrlich, V., Bil, W., Vandebriel, R. *et al.* Consideration of pathways for immunotoxicity of per- and polyfluoroalkyl substances (PFAS). *Environ Health* 22, 19 (2023). https://doi.org/10.1186/s12940-022-00958-5

Wang, L. Q., Liu, T., Yang, S., Sun, L., Zhao, Z. Y., Li, L. Y., She, Y. C., Zheng, Y. Y., Ye, X. Y., Bao, Q., Dong, G. H., Li, C. W., & Cui, J. (2021). Perfluoroalkyl substance pollutants activate the innate immune system through the AIM2 inflammasome. Nature Communications, 12, 2915. https://doi.org/10.1038/s41467-021-23201-0

Woodlief, T., Vance, S., Hu, Q., & DeWitt, J. (2021). Immunotoxicity of Per- and Polyfluoroalkyl Substances: Insights into Short-Chain PFAS Exposure. Toxics, 9(5), 100. https://doi.org/10.3390/toxics9050100

Zhang, Y., Mustieles, V., Sun, Y., Oulhote, Y., Wang, Y. X., & Messerlian, C. (2022). Association between serum per- and polyfluoroalkyl substances concentrations and common cold among children and adolescents in the United States. Environment International, 164, 107239. https://doi.org/10.1016/j.envint.2022.107239

Liver toxicity

Costello, E., Rock, S., Stratakis, N., Eckel, S. P., Walker, D. I., Valvi, D., Cserbik, D., Jenkins, T., Xanthakos, S. A., Kohli, R., Sisley, S., Vasiliou, V., La Merrill, M. A., Rosen, H., Conti, D. V., McConnell, R., & Chatzi, L. (2022). Exposure to per- and Polyfluoroalkyl Substances and Markers of Liver Injury: A Systematic Review and Meta-Analysis. Environmental Health Perspectives, 130(4), 46001. https://doi.org/10.1289/EHP10092

Ducatman, A., & Fenton, S. E. (2022). Invited Perspective: PFAS and Liver Disease: Bringing All the Evidence Together. Environmental Health Perspectives, 130(4), 41303. https://doi.org/10.1289/EHP11149

Roth, K., Yang, Z., Agarwal, M., Liu, W., Peng, Z., Long, Z., Birbeck, J., Westrick, J., Liu, W., & Petriello, M. C. (2021). Exposure to a mixture of legacy, alternative, and replacement per- and polyfluoroalkyl substances (PFAS) results in sex-dependent modulation of cholesterol metabolism and liver injury. Environment International, 157, 106843. https://doi.org/10.1016/j.envint.2021.106843

Sen, P., Qadri, S., Luukkonen, P. K., Ragnarsdottir, O., McGlinchey, A., Jäntti, S., Juuti, A., Arola, J., Schlezinger, J. J., Webster, T. F., Orešič, M., Yki-Järvinen, H., & Hyötyläinen, T. (2022). Exposure to environmental contaminants is associated with altered hepatic lipid metabolism in non-alcoholic fatty liver disease. Journal of Hepatology, 76(2), 283–293. https://doi.org/10.1016/j.jhep.2021.09.039

Cancer

Alsen, M., Leung, A. M., & van Gerwen, M. (2023). Per- and polyfluoroalkyl substances (PFAS) in Community Water Systems (CWS) and the risk of thyroid cancer: An ecological study. *Toxics*, *11*(9), 786. https://doi.org/10.3390/toxics11090786

Bartell, S. M., & Vieira, V. M. (2021). Critical review on PFOA, kidney cancer, and testicular cancer. Journal of the Air & Waste Management Association, 71(6), 663–679. https://doi.org/10.1080/10962247.2021.1909668

Cao, L., Guo, Y., Chen, Y., Hong, J., Wu, J., & Hangbiao, J. (2022). Per-/polyfluoroalkyl substance concentrations in human serum and their associations with liver cancer. Chemosphere, 296, 134083. https://doi.org/10.1016/j.chemosphere.2022.134083

Goodrich, Jesse A. et al. (2022). Exposure to perfluoroalkyl substances and risk of hepatocellular carcinoma in a multiethnic cohort. JHEP Reports, 4(10), 100550. https://www.jhep-reports.eu/article/S2589-5559(22)00122-7/fulltext

Liu, H., Sun, Y., Ran, L., Li, J., Shi, Y., Mu, C., & Hao, C. (2023). Endocrine-disrupting chemicals and breast cancer: A meta-analysis. *Frontiers in Oncology*, *13*. https://doi.org/10.3389/fonc.2023.1282651

Messmer, M. F., Salloway, J., Shara, N., Locwin, B., Harvey, M. W., & Traviss, N. (2022). Risk of Cancer in a Community Exposed to Per- and Poly-Fluoroalkyl Substances. Environmental Health Insights, 16. https://doi.org/10.1177/11786302221076707

Singh, N., & Hsieh, C. (2021). Exploring Potential Carcinogenic Activity of Per- and Polyfluorinated Alkyl Substances Utilizing High-Throughput Toxicity Screening Data. International Journal of Toxicology, 40(4), 355–366. https://doi.org/10.1177/10915818211010490

Velarde, M. C., Chan, A., Sajo, M., Zakharevich, I., Melamed, J., Uy, G., Teves, J., Corachea, A., Valparaiso, A. P., Macalindong, S. S., Cabaluna, N. D., Dofitas, R. B., Giudice, L. C., & Gerona, R. R. (2022). Elevated levels of perfluoroalkyl substances in breast cancer patients within the Greater Manila Area. Chemosphere, 286(Pt 1), https://doi.org/10.1016/j.chemosphere.2021.131545

Xie, M. Y., Sun, X. F., Wu, C. C., Huang, G. L., Wang, P., Lin, Z. Y., Liu, Y. W., Liu, L. Y., & Zeng, E. Y. (2023). Glioma is associated with exposure to legacy and alternative per- and polyfluoroalkyl substances. *Journal of hazardous materials*, *441*, 129819. https://doi.org/10.1016/j.jhazmat.2022.129819

Metabolic toxicity

Birru, R. L., Liang, H. W., Farooq, F., Bedi, M., Feghali, M., Haggerty, C. L., Mendez, D.D., Catov, J. M., Ng, C. A., & Adibi, J. J. (2021). A pathway level analysis of PFAS exposure and risk of gestational diabetes mellitus. Environmental Health, 20(1), 63. https://doi.org/10.1186/s12940-021-00740-z

Canova, C., Di Nisio, A., Barbieri, G., Russo, F., Fletcher, T., Batzella, E., Dalla Zuanna, T., & Pitter, G. (2021). PFAS Concentrations and Cardiometabolic Traits in Highly Exposed Children and Adolescents. International Journal of Environmental Research and Public Health, 18(24), 12881. https://doi.org/10.3390/ijerph182412881

Chen, J., Li, H., Yao, J., Guo, H., Zhang, H., Guo, Y., Sheng, N., Wang, J., & Dai, J. (2021). Chronic exposure to PFO4DA and PFO5DoDA, two perfluoroalkyl ether carboxylic acids (PFECAs), suppresses hepatic stress signals and disturbs glucose and lipid metabolism in male mice. Journal of Hazardous Materials, 411, 124963. https://doi.org/10.1016/j.jhazmat.2020.124963

Liu, X., Zhang, L., Chen, L., Li, J., Wang, J., Zhao, Y., Liu, L., & Wu, Y. (2021). Identification and prioritization of the potent components for combined exposure of multiple persistent organic pollutants associated with gestational diabetes mellitus. Journal of Hazardous Materials, 409, 124905. https://doi.org/10.1016/j.jhazmat.2020.124905

Yu, G., Jin, M., Huang, Y., Aimuzi, R., Zheng, T., Nian, M., Tian, Y., Wang, W., Luo, Z., Shen, L., Wang, X., Du, Q., Xu, W., Zhang, J., & Shanghai Birth Cohort Study (2021). Environmental exposure to perfluoroalkyl substances in early pregnancy, maternal glucose homeostasis and the risk of gestational diabetes: A prospective cohort study. Environment International, 156, 106621. https://doi.org/10.1016/j.envint.2021.106621

Cardiovascular toxicity

Ding, N., Karvonen-Gutierrez, C. A., Mukherjee, B., Calafat, A. M., Harlow, S. D., & Park, S. K. (2022). Per- and Polyfluoroalkyl Substances and Incident Hypertension in Multi-Racial/Ethnic Women: The Study of Women's Health Across the Nation. Hypertension, 79(8), 1876–1886. https://doi.org/10.1161/HYPERTENSIONAHA.121.18809

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Schillemans, T., Donat-Vargas, C., & Åkesson, A. (2023). Per-and polyfluoroalkyl substances and cardiometabolic diseases: a review. *Basic & Clinical Pharmacology & Toxicology*.
https://doi.org/10.1111/bcpt.13949

Developmental toxicity

Blake, B. E., Rickard, B. P., & Fenton, S. E. (2022). A High-Throughput Toxicity Screen of 42 Per- and Polyfluoroalkyl Substances (PFAS) and Functional Assessment of Migration and Gene Expression in Human Placental Trophoblast Cells. Frontiers in Toxicology, 4, 881347.
https://doi.org/10.3389/ftox.2022.881347

Cope, H. A., Blake, B. E., Love, C., McCord, J., Elmore, S. A., Harvey, J. B., Chappell,
V.A., & Fenton, S. E. (2021). Latent, sex-specific metabolic health effects in CD-1 mouse offspring exposed to PFOA or HFPO-DA (GenX) during gestation. Emerging Contaminants, 7, 219–235. https://doi.org/10.1016/j.emcon.2021.10.004

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Sun, M., Cao, X., Wu, Y., Shen, L., & Wei, G. (2022). Prenatal exposure to endocrine-disrupting chemicals and thyroid function in neonates: A systematic review and meta-analysis. Ecotoxicology and Environmental Safety, 231, 113215. https://doi.org/10.1016/j.ecoenv.2022.113215

Yao, Q., Vinturache, A., Lei, X., Wang, Z., Pan, C., Shi, R., Yuan, T., Gao, Y., & Tian, Y. (2022). Prenatal exposure to per- and polyfluoroalkyl substances, fetal thyroid hormones, and infant neurodevelopment. Environmental Research, 206, 112561. https://doi.org/10.1016/j.envres.2021.112561

Reproductive toxicity

Chambers, W. S., Hopkins, J. G., & Richards, S. M. (2021). A Review of Per- and Polyfluorinated Alkyl Substance Impairment of Reproduction. Frontiers in Toxicology, 3, 732436. https://doi.org/10.3389/ftox.2021.732436

Erinc, A., Davis, M. B., Padmanabhan, V., Langen, E., & Goodrich, J. M. (2021). Considering environmental exposures to per- and polyfluoroalkyl substances (PFAS) as risk factors for hypertensive disorders of pregnancy. Environmental Research, 197, 111113. https://doi.org/10.1016/j.envres.2021.111113

Hammarstrand, S., Jakobsson, K., Andersson, E., Xu, Y., Li, Y., Olovsson, M., & Andersson, E. M. (2021). Perfluoroalkyl substances (PFAS) in drinking water and risk for polycystic ovarian syndrome, uterine leiomyoma, and endometriosis: A Swedish cohort study. Environment International, 157, 106819. https://doi.org/10.1016/j.envint.2021.106819

Luo, K., Liu, X., Nian, M., Wang, Y., Qiu, J., Yu, H., Chen, X., Zhang, J., & Shanghai Birth Cohort (2021). Environmental exposure to per- and polyfluoroalkyl substances mixture and male reproductive hormones. Environment International, 152, 106496. https://doi.org/10.1016/j.envint.2021.106496

Petersen, K. U., Hærvig, K. K., Flachs, E. M., Bonde, J. P., Lindh, C., Hougaard, K. S., Toft, G., Ramlau-Hansen, C. H., & Tøttenborg, S. S. (2022). Per- and polyfluoroalkyl substances (PFAS) and male reproductive function in young adulthood; a cross-sectional study. Environmental Research, 212(Pt A), 113157. https://doi.org/10.1016/j.envres.2022.113157

Rickard, B. P., Rizvi, I., & Fenton, S. E. (2022). Per- and poly-fluoroalkyl substances

(PFAS) and female reproductive outcomes: PFAS elimination, endocrine-mediated effects, and disease. Toxicology, 465, 153031. https://doi.org/10.1016/j.tox.2021.153031

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