

“FOREVER CHEMICALS”: FOREVER ALTERING THE LEGAL LANDSCAPE

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“But man is a part of nature, and his war against nature is inevitably a war against himself.”

— Rachel Carson, *Silent Spring*, 1962.

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INTRODUCTION

Per- and polyfluoroalkyl substances, more commonly known as PFAS,¹ have become the talk of the town in recent years for good reason.² Once considered a miracle substance, PFAS has worked its way into most everyday products used by the average American. Its water-soluble properties seemingly solved many minor inconveniences of everyday life. Nevertheless, PFAS is yet another example of industry putting profit over people and planet, thus failing to take the necessary scientific and legal precautions to prevent harm to humans and the environment.

The dangerous accumulative properties of PFAS chemicals became apparent early on after its introduction into the global marketplace resulting

1. This paper will refer to “PFAS” as a class. PFAS “consist of perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), perfluorobutanoic acid (PFBA), perfluorobutane sulfonate (PFBS), perfluorohexanoic acid (PFHxA), perfluorohexane sulfonate (PFHxS), and perfluorononanoic acid (PFNA), as well as GenX, ADONA, fluorotelomer alcohols (FTOH), and fluorotelomer sulfonates (FTS). These are the most commonly studied compounds of a large group of synthetic chemicals referred to as poly- and perfluoroalkyl substances (PFAS, formerly referred to as perfluorinated compounds, or PFCs). PFAS exhibit both oleophobic/lipophobic (oil/lipid-repellent) and hydrophobic (water-repellent) properties. In addition, they provide exceptional chemical and heat stability.” *Poly- and Perfluoroalkyl Substances (PFAS): Environmental, Health, Ecological, and Regulatory Consulting*, EXPONENT, <https://www.exponent.com/services/practices/environmental-sciences/environmental--earth-sciences/capabilities/pfas/?serviceId=db980b76-2799-47a2-92d6-3531d62ce57e&loadAllByPageSize=true&knowledgePageSize=3&knowledgePageNum=0&newseventPageSize=3&newseventPageNum=0> [https://perma.cc/Z9P2-GKQQ].

2. PFAS contamination is even the inspiration for the widely released motion picture, *Dark Waters* (2019). Film synopsis: A tenacious attorney uncovers a dark secret that connects a growing number of unexplained deaths to one of the world’s largest corporations. While trying to expose the truth, he soon finds himself risking his future, his family and his own life. Anthony D’Alessandro, *Todd Haynes’ ‘Dark Waters’ Will Start to Bubble in Late Fall*, DEADLINE (Aug. 26, 2019, 2:50 PM), <https://deadline.com/2019/08/todd-haynes-dark-waters-will-start-to-bubble-in-late-fall-1202704619/#> [https://perma.cc/E2V6-R3VU].

in manufacturers' conducting internal studies of the effects of these chemicals.³ However, it was only after its widespread implementation that the discovery of its bioaccumulation in ground, surface, and drinking water was shared with government agencies, and it was even longer before the news reached the general public.⁴ While more research is needed for an accurate identification of the most contaminated areas, initial maps are indicating that, as expected, PFAS is the latest in a long history of environmental justice concerns.⁵

Drawing from previous experience with other contaminants, such as lead, it is apparent that the law must stay up-to-date with the latest available research to prevent backward-looking, reactionary approaches. Looking to the legal history of lead exposure in the United States as an example, there are some troubling similarities both to the physical effects of the toxins and the legal handling of it. Today it is well-known that exposure to lead can result in developmental, learning, and behavioral problems.⁶ This paper argues that, like lead, disparate exposure to PFAS chemicals leads to harmful effects on human health, as well as behavioral development. Legally speaking, unlike the approach to lead, precaution must be taken to not only avoid potential physical harm to humans and the environment, but also account for the potential behavioral disorders that can result from PFAS exposure at early ages.

This paper will show how taking a precautionary approach to laws and policies that regulate PFAS chemicals will both protect human and environmental health as well as ensure economic and social progress is not stalled in the process. It will also explore the relationship between early exposure to PFAS and its potential impact on criminality and environmental justice issues. Finally, through an analysis of the current legal approach to PFAS in the United States, this paper will discuss the successes and failures thus far as well as propose the recommended course of action going forward.

3. In a 1950 study, 3M determined that PFAS bioaccumulates in the blood. Env'tl. Working Group, *For 50 Years, Polluters Knew PFAS Chemicals Were Dangerous but Hid Risks from Public*, https://static.ewg.org/reports/2019/pfa-timeline/3M-DuPont-Timeline_sm.pdf?_ga=2.230061662.339423941.1571840814-235200328.1562959090 [<https://perma.cc/98G8-N6PP>].

4. EPA, *E.I. DuPont de Nemours and Company PFOA Settlements*, <https://www.epa.gov/enforcement/ei-dupont-de-nemours-and-company-pfoa-settlements> [<https://perma.cc/MG5C-N239>].

5. Env'tl. Working Group & The Soc. Sci. Env'tl. Health Res. Inst. (SSEHRI) at Northeastern Univ., *PFAS Contamination in the U.S.*, https://www.ewg.org/interactive-maps/2019_pfas_contamination/map/ (last updated Oct. 2019).

6. LaToria S. Whitehead & Sharunda Buchanan, *Childhood Lead Poisoning: A Perpetual Environmental Justice Issue?*, 25 J. OF PUB. HEALTH MGMT. & PRAC., S115, S115 (2019).

I. PFAS: WHAT MAKES IT “FOREVER”

Per- and polyfluoroalkyl substances, commonly known as PFAS, are a highly persistent group of synthetic chemicals that have been widely used in manufacturing over the past sixty years.⁷ The appealing property of this chemical was its ability to make products resistant to heat, water, and stains.⁸ Due to the widespread use and long half-life of these chemicals, over 95% of the United States population has some measurable level of PFAS blood serum levels.⁹ PFAS has been found in both industrial and consumer products such as electronics, automotive supplies, food packaging, non-stick cookware (Teflon), stain- and water-resistant coatings, firefighting foams, and in waxes and cleaners.¹⁰ According to a 2017 study on the detection of fluorinated compounds in U.S. fast food packaging, “The most commonly used PFASs have been detected globally in water, soil, sediment, wildlife, and human blood samples.”¹¹

Since the 1940s, thousands of varieties of these ever-developing chemicals have been manufactured and used in various industries.¹² The chemical structure of PFAS is a short, but very strong carbon-fluorine bond.¹³ Short-chain PFAS, or those with fewer C-F bonds, are organically eliminated faster than long-chain PFAS.¹⁴ This C-F bond is one of the strongest chemical bonds making it very stable, persistent, and resistant to organic breakdown.¹⁵ This is what allows the chemicals to bioaccumulate over time. They have even been known to undergo “global distillation,” meaning they can be

7. Elsie M. Sunderland et al., *A Review of the Pathways of Human Exposure to Poly- and Perfluoroalkyl Substances (PFASs) and Present Understanding of Health Effects*, 29 J. OF EXPOSURE SCI. & ENVTL. EPIDEMIOLOGY 131, 132 (2018).

8. Robert C. Buck et al., *Perfluoroalkyl and Polyfluoroalkyl Substances in the Environment: Terminology, Classification, and Origins*, 7 INTEGRATED ENVTL. ASSESSMENT & MGMT. 513, 513 (2011).

9. Ryan C. Lewis et al., *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*, 12 INT’L J. ENVTL. RES. & PUB. HEALTH 6098, 6099 (2015).

10. EPA, *Long-Chain Perfluorinated Chemicals (PFCs) Action Plan*, www.epa.gov/assessing-and-managing-chemicals-under-tsca/long-chain-perfluorinated-chemicals-pfcs-action-plan [https://perma.cc/NEZ5-EEMB].

11. Laurel A. Schaidt et al., *Fluorinated Compounds in U.S. Fast Food Packaging*, 4 ENVTL. SCI. & TECH. LETTERS 105, 105–11 (2017).

12. Sunderland, *supra* note 7, at 131.

13. CHRISTY A. BARLOW ET AL., PFAS TOXICOLOGY—WHAT IS DRIVING THE VARIATION IN DRINKING WATER STANDARDS, GZA 1–2 (2019).

14. *Per- and Polyfluoroalkyl Substances (PFAS): Overview and Prevalence*, AM. WATER WORKS ASS’N (Aug. 12, 2019), [https://www.awwa.org/Portals/0/AWWA/ETS/Resources/Per-andPolyfluoroalkylSubstances\(PFAS\)-OverviewandPrevalence.pdf?ver=2019-08-14-090234-873](https://www.awwa.org/Portals/0/AWWA/ETS/Resources/Per-andPolyfluoroalkylSubstances(PFAS)-OverviewandPrevalence.pdf?ver=2019-08-14-090234-873) [https://perma.cc/4F58-TCNC].

15. Ian Ross & Jake Hurst, *Managing Risks and Liabilities Associated with Per- and Polyfluoroalkyl Substances (PFASs)* CL:AIRE TECHNICAL BULL. TB19 (Feb. 2019), *available for download at* <https://www.claire.co.uk/component/phocadownload/category/17-technical-bulletins> [https://perma.cc/WB7Y-JUWT].

transported and accumulated in environments long distances away from the original source.¹⁶ The very features that made these chemicals so appealing are what produce the “forever” quality that makes them an environmental and health concern.

Until the early 2000s, the most commonly used PFAS were perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS).¹⁷ However, in 2006, eight major PFAS manufacturers committed to the PFOA Stewardship Program and agreed to phase out the use of PFOA by 2015.¹⁸ Still, the United States Environmental Protection Agency (EPA) has identified approximately 600 PFAS-like compounds that are currently in use in the United States with an additional 600 that were previously used, but are not yet out of production domestically.¹⁹ Furthermore, in 2009 the EPA examined 116 products containing PFAS chemicals and found they all contained a mixture of long and short-chain PFAS chemicals, meaning the decrease in measurable levels of PFOA and PFOS in isolation does not fully address the issue.²⁰ However, due to lax reporting requirements, it is unknown exactly what products have contained PFAS and just how much exposure there has been.²¹

What made the chemicals so appealing is also what makes them so detrimental to human and environmental health.²² Production of these

16. Andrew B. Lindstrom, Mark J. Strynar & E. Laurence Libelo, *Polyfluorinated Compounds: Past, Present, and Future*, 45 ENVTL. SCI. & TECH. 7954, 7954–61 (2011).

17. Philippe Grandjean, *Delayed Discovery, Dissemination, and Decisions on Intervention in Environmental Health: A Case Study on Immunotoxicity of Prefluorinated Alkylate Substances*, 17 ENVTL. HEALTH 62, 62 (2018); EXPONENT, *supra* note 1.

18. In 2006, EPA invited eight major leading companies in the PFAS industry to join in a global stewardship program with two goals: (1) To commit to achieve, no later than 2010, a 95 percent reduction, measured from a year 2000 baseline, in both facility emissions to all media of PFOA, precursor chemicals that can break down to PFOA, and related higher homologue chemicals, and product content levels of these chemicals; (2) To commit to working toward the elimination of these chemicals from emissions and products by 2015. Participating companies included: Arkema, Asahi, BASF Corporation (successor to Ciba), Clariant, Daikin, 3M/Dyneon, DuPont, Solvay Solexis. All companies have met the PFOA Stewardship Program goals. EPA, *Risk Management for Per- and Polyfluoroalkyl Substances (PFASs) Under TSCA*, <https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/risk-management-and-polyfluoroalkyl-substances-pfass#tab-3> [<https://perma.cc/7PVU-3QF3>].

19. AM. WATER WORKS ASS'N, *supra* note 14.

20. Ross & Hurst, *supra* note 15 (citing GUO ET AL., PERFLUOROCARBOXYLIC ACID CONTENT IN 116 ARTICLES OF COMMERCE, EPA (2009), <http://www.oecd.org/env/48125746.pdf> [<https://perma.cc/8T48-QHL6>]).

21. Kevin Loria, *Should You Be Concerned About PFAS Chemicals?*, CONSUMER REPORTS (Apr. 8, 2019), <https://www.consumerreports.org/toxic-chemicals-substances/pfas-chemicals-should-you-be-concerned/> [<https://perma.cc/T4ZU-6M5W>].

22. PFAS chemicals are used for their nonstick properties in many consumer products including popcorn bags and pizza boxes. In 2018, the Center for Environmental Health tested microwave popcorn from major brands ACT II, Pop Secret, Orville Redenbacher's, Popweaver, Regal Cinemas, and Clover Valley. All brands tested contained PFAS. *Toxic Chemicals Found in Microwave Bag Popcorn*, CTR. FOR ENVTL. HEALTH (Mar. 23, 2018),

“forever chemicals” began in 1947.²³ Shortly after the chemicals’ widespread application in everyday products, companies began conducting internal studies to determine the extent of PFAS bioaccumulation in their workers’ blood and drinking water.²⁴ In 2005, the EPA designated PFOA as a “likely carcinogen,”²⁵ and in 2012, the chemical manufacturer DuPont paid a settlement for withholding the findings of its studies showing the accumulation of PFAS in its workers’ blood and drinking water.²⁶ Before examining the potential legal approaches available to regulating this dangerous and prevalent toxin, it is important to have an understanding of what makes it so dangerous and prevalent.

II. SOCIETAL HAZARD: PFAS EFFECTS ON BEHAVIORAL, PHYSICAL, AND ENVIRONMENTAL HEALTH

A. Behavioral Health Effects: Impacts on IQ, Behavior, and Criminality

1. PFAS and Behavior Regulation

With the available research on the effects of other toxic chemicals, there is great concern regarding exposure to PFAS during pregnancy and critical developmental years. Some research has found PFAS in blood serum, amniotic fluid, breastmilk, and maternal and umbilical cord blood.²⁷ Due to its bioaccumulative nature, PFAS poses a significant risk in the prenatal period due to the “rapid structural and functional changes” taking place.²⁸ Since infants and children consume more water per body weight than adults, their exposures may be higher than adults in communities with PFAS-contaminated drinking water.²⁹

While more studies are needed, this early developmental exposure to PFAS and other “forever chemicals” has the potential to affect both fetal and early childhood development, causing not only physical effects but

<https://www.ceh.org/get-involved/take-action/content/toxic-chemicals-found-microwave-popcorn/> [<https://perma.cc/N5ZK-C5YS>].

23. Philippe Grandjean et al., *Perfluorinated Alkyl Substances: Emerging Insights into Health Risks*, 25 *NEW SOLUTIONS* 147, 147–63 (2015).

24. Nathaniel Rich, *The Lawyer Who Became DuPont’s Worst Nightmare*, *N.Y. TIMES* (Jan. 6, 2016), <https://www.nytimes.com/2016/01/10/magazine/the-lawyer-who-became-duponts-worst-nightmare.html> [<https://perma.cc/WQ3P-XKYP>].

25. Kyle Steenland et al., *Epidemiologic Evidence on the Health Effects of Perfluorooctanoic Acid (PFOA)*, 118 *ENVTL. HEALTH PERSP.* 1100, 1100 (2010).

26. EPA, *supra* note 4.

27. Ilona Quaak et al., *Prenatal Exposure to Perfluoroalkyl Substances and Behavioral Development in Children*, 13 *INT’L J. ENVTL. RES. & PUB. HEALTH* 511, 512 (2016).

28. *Id.*

29. Kerstin Winkens et al., *Early Life Exposure to Per- and Polyfluoroalkyl Substances (PFASs): A Critical Review*, 3 *EMERGING CONTAMINANTS* 55, 55 (2017).

behavioral ones as well.³⁰ The Agency for Toxic Substances and Disease Registry (ATSDR) determined that certain PFAS may affect growth, learning, and behavior of infants and older children.³¹ As was the case with lead, potential behavioral effects of PFAS exposure will have multiple legal ramifications, not only in the area of toxic torts and toxic regulations, but also in potential mitigating circumstances for criminal behavior. Environmental toxins have been identified as the “Invisible Threat” to physical and behavioral health.³² Low IQ stemming from childhood and/or prenatal exposure to environmental toxins has been identified as a possible link to future criminal behavior.³³ This link, known as the “Neurotoxicity Hypothesis,” was tested by calculating the occurrence of criminal incidences as it correlated to the distribution of environmental pollutants.³⁴ The results from the study showed a strong correlation between toxins and violent criminal behavior.³⁵

Numerous studies have focused on the relationship between PFAS and the neurological outcomes as well as the developmental behavior in children.³⁶ One study published in the *Journal of Pediatrics* in 2014 observed an increase odds ratios (OR) for hypotonicity, low muscle tone, or “floppy baby syndrome,” with increases in PFOA in the maternal serum.³⁷ The Health Outcomes and Measures of the Environment (HOME) Study found that the increases in maternal serum of PFOS were associated with increased odds of poorer behavioral regulation, metacognition, and global executive functions, while other PFAS were not.³⁸ While some studies have failed to find this link to a degree of scientific certainty, it should be noted that these studies have typically had limiting factors. For example, a study in children seven years of age found no association with behavioral and motor coordination problems. However, as the study stated, “effects on other developmental end

30. Quaak et al., *supra* note 27.

31. *What are the Health Effects?*, AGENCY FOR TOXIC SUBSTANCES & DISEASE REGISTRY (Jan. 10, 2018), <https://www.atsdr.cdc.gov/pfas/health-effects.html> [https://perma.cc/JK5B-N6YG].

32. Bryan Warner, *Environmental Toxins Affect IQ and Criminal Behavior*, HEALTHY BALANCE MD (Aug. 19, 2015), <https://www.healthybalancemd.com/environmental-toxins-affect-iq-criminal-behavior/> [https://perma.cc/JTX4-53GS].

33. *Id.*

34. *Id.*

35. *Id.*

36. Kristen M. Rappazzo et al., *Exposure to Perfluorinated Alkyl Substances and Health Outcomes in Children: A Systematic Review of the Epidemiology Literature*, INT’L J. ENVTL. RES. PUB. HEALTH, June 27, 2017, 3, at 3.

37. Stephanie Donauer et al., *Prenatal Exposure to Polybrominated Diphenyl Ethers and Polyfluoroalkyl Chemicals and Infant Neurobehavior*, 166 J. OF PEDIATRICS 736, 736–42 (2015).

38. Ann M. Vuong et al., *Prenatal Polybrominated Diphenyl Ether and Perfluoroalkyl Substance Exposures and Executive Function in School-age Children*, 147 ENVTL. RES. 556, 556–64 (2016).

points, including cognitive, attentional, and clinical mental disorder” were not measured in the study and therefore cannot be ruled out.³⁹

Other studies that have focused on ADHD or related indicators of impulsivity and PFAS have found that a lower response inhibition or impulsivity was associated with the increase of PFAS exposures in the blood⁴⁰ and increased odds of parent-reported ADHD with increased serum PFOA.⁴¹ Other studies showed positive as well as negative association between higher PFAS quartiles and ADHD, but the estimates were imprecise.⁴² Thus, much more research in this area is needed to solve the inconsistencies across the studies.

While studies have also shown neurodevelopmental impairments in animals exposed to PFAS, the findings are not as informative as further human testing would be.⁴³ Adult mice showed “neurobehavioral deficits after neonatal PFOA and PFOS exposure, where spontaneous behavior of adult mice manifested as hyperactivity and inability to habituate.”⁴⁴ Fish showed elevated spontaneous activity with exposure to PFOS.⁴⁵ However, the inherent weakness of animal studies is that their results may have limited relevance to humans.⁴⁶ More importantly, there are significant differences in the elimination processes of PFAS from the human body. For example, “PFOA and PFOS have half-lives of several years in people, but only a few days in rats and a few weeks in mice.”⁴⁷ The potential implications PFAS exposure may have on the issues presented in this paper require further, more targeted study to determine the full extent and impact of such exposure.

In their article “Environmental Causes of Violence,” David Carpenter and Rick Nevin make the following striking conclusion:

39. Chunyuan Fei & Jorn Olsen, *Prenatal Exposure to Perfluorinated Chemicals and Behavioral or Coordination Problems at Age 7 Years*, 119 ENVTL. HEALTH PERSP. 573, 573 (2011).

40. Brooks B. Gump et al., *Perfluorochemical (PFC) Exposure in Children: Associations with Impaired Response Inhibition*, 45 ENVTL. SCI. & TECH. 8151, 8151–59 (2011).

41. Kate Hoffman et al., *Exposure to Polyfluoroalkyl Chemicals and Attention Deficit/Hyperactivity Disorder in U.S. Children 12–15 Years of Age*, 118 ENVTL. HEALTH PERSP. 1762, 1762–66 (2010).

42. Zeyan Liew et al., *Attention Deficit/Hyperactivity Disorder and Childhood Autism in Association with Prenatal Exposure to Perfluoroalkyl Substances: A Nested Case–Control Study in the Danish National Birth Cohort*, 123 ENVTL. HEALTH PERSP. 367, 367 (2015).

43. Rappazzo et al., *supra* note 36, at 5.

44. *Id.*; Niclas Johansson et al., *Neonatal Exposure to PFOS and PFOA in Mice Results in Changes in Proteins Which are Important for Neuronal Growth and Synaptogenesis in the Developing Brain*, 108 TOXICOLOGICAL SCI. 412, 412–18 (2009).

45. Stefan Spulber et al., *PFOS Induces Behavioral Alterations, Including Spontaneous Hyperactivity that is Corrected by Dexamfetamine in Zebrafish Larvae*, PUB. LIBR. OF SCI. ONE, April 2014, at 1, 2.

46. Stephen Zemba & Russell Abell, *Emergence of PFAS: A Public Health Concern?*, 18 ENVTL. LITIG. & TOXIC TORTS COMMITTEE NEWSL. 23, 25 (2017).

47. *Id.*

There is widespread belief that criminal behavior is the result of character defects and willful voluntary actions [of] which society does not approve. Our observations suggest that at least one factor leading to criminal behavior is early life exposure to chemical contaminants that cause irreversible alteration in brain function and behavior, making the individual more likely to take risks and less able to deal with the frustrations of life. . . . There is without question clear evidence that criminal behavior is more common in populations that are poor, often are minority, often individuals who grew up in inner cities where housing and education are below the standards found in suburban communities. The point is that these are also the areas which are more contaminated, leading to exposure to contaminants associated with reduced IQ and behavioral changes.⁴⁸

This and other studies indicate that PFAS has a high probability of causing similar behavioral issues.⁴⁹ Nevertheless, the extent of damage from PFAS on the brains of infants or young adults is still unknown.⁵⁰ In fact, the ATSDR also points out that scientists are still learning about the health and behavioral effects of exposure to PFAS.⁵¹ This further supports the need for sufficient precaution in the legal approach to PFAS as the requisite data is collected and analyzed.

2. *Toxic Behavior: Potential Mitigation and Criminal Defense*

This correlation between PFAS exposure and ability to regulate behavior could have potential implications for criminal culpability as the link becomes more established. Criminal behavior has been linked to exposure to environmental toxins.⁵² Direct causation is difficult to establish, however studies show that low IQ and deficits in other cognitive processes leads to a higher rate of criminal behavior.⁵³ Early childhood development (ECD)⁵⁴ is extremely vulnerable to the effects of deleterious environmental toxins. This

48. David O. Carpenter & Rick Nevin, *Environmental Causes of Violence*, 99 *PHYSIOLOGY & BEHAV.* 260, 260–68 (2010).

49. Warner, *supra* note 32.

50. *Id.*

51. *Id.*

52. Carpenter & Nevin, *supra* note 48, at 260–68.

53. James Freeman, *The Relationship Between Lower Intelligence, Crime and Custodial Outcomes: A Brief Literary Review of a Vulnerable Group*, *VULNERABLE GROUPS & INCLUSION*, June 2012, at 1, 2–11.

54. According to the World Health Organization, early childhood development (ECD) encompasses physical, socio-emotional, cognitive and motor development between 0 and 8 years of age. *Early Childhood Development*, WORLD HEALTH ORG., <https://www.who.int/topics/early-child-development/en/> (last visited Mar. 5, 2020).

theory has been widely researched in the case of lead. Exposure to lead has been shown to negatively impact IQ and other cerebral functions, including behavior.⁵⁵ As such, much has been theorized regarding the exposure to lead and increased criminal behavior.⁵⁶ A 1998 study showed that violent criminals exhibited higher levels of lead in their bodies than non-violent criminals or the general population.⁵⁷

Scientists continue to explore and posit a direct relationship of environmental toxins to increased crime rates. The basis is neurological damage, whether in the form of low IQ or any other impact. Because minority and lower social economic communities live in areas of greatest exposure to environmental toxins, they are often disparately impacted by this exposure. This exposure could provide one explanation as to why people of color appear to be implicated in crimes at a higher rate than other groups of people.⁵⁸

Given the evidence and causal links to criminal activity and environmental toxins, comprehensive regulations addressing the potential harm of contaminants like PFAS, a known neurotoxin, must be implemented to prevent a disastrous outcome for the disenfranchised. Former presidential candidate and Washington governor, Jay Inslee, even cited environmental justice concerns regarding PFAS in his platform. In announcing a plan to address environmental justice for low-income and minority populations disproportionately affected by air pollution, water contamination, and other environmental issues, Governor Inslee included PFAS, specifically a PFAS ban, as a focal point to be addressed.⁵⁹

55. MARGARET MEYER & CHRISTINE ROGERS, *THE RELATIONSHIP BETWEEN EXPOSURE TO LEAD AND CRIMINAL BEHAVIOR* (2018), <https://digitalcommons.augustana.edu/swliscott2017/4/> [<https://perma.cc/8RJK-KS3W>].

56. One study analyzed trends in violent crime in the United States and compared it with the amount of lead being added to gasoline; researchers found that the more lead added to gasoline, the higher the rates of violent crime arrests roughly 20 years later. In other words, the more lead that was added to gasoline while pregnant, the higher the chance that individual would be arrested for a violent offense. Every additional 5 micrograms of lead per deciliter in early childhood blood measurement increases the rate of arrest by 1.5 times. Kenneth Padowitz, *Should We Be More Concerned with Prenatal Exposure in the Prevention of Crime?* PSYCHOL. L. & CRIM. BEHAV. BLOG, <http://www.psychology-criminalbehavior-law.com/2015/04/should-we-be-more-concerned-with-prenatal-exposure-in-the-prevention-of-crime/> [<https://perma.cc/7U2R-99R9>].

57. Roger D. Masters et al., *Environmental Pollution, Neurotoxicity and Criminal Violence*, 7 ENVTL. TOXICOLOGY: CURRENT DEV. 11, 11–46 (2005).

58. *Biological Theories of Crime*, CRIM. JUST. RES., <http://criminal-justice.iresearchnet.com/criminology/theories/biological-theories-of-crime/16/> [<https://perma.cc/MB7R-DUTS>].

59. Gavin Bade, *How Jay Inslee Would Address Environmental Justice*, POLITICO (July 29, 2019, 1:07 PM), <https://www.politico.com/story/2019/07/29/how-jay-inslee-would-address-environmental-justice-1439543> [<https://perma.cc/VM7Y-26RF>].

3. *Obligation to Determine Exposure*

The legal implications of this type of chemical exposure are numerous and not unheard of. When a defendant's acute or chronic exposure to neurotoxicants is known, failure to argue this as a mitigating factor can lead to a finding of ineffectiveness of counsel. In *Caro v. Calderon*, the Ninth Circuit Court held that counsel had an obligation to find any necessary experts regarding the potential mitigating factor of neurotoxic chemical exposure, and the attorney's failure to investigate rendered the penalty phase unreliable.⁶⁰ The court held that imposition of the death penalty without adequate consideration of mitigating factors was unconstitutional, regardless of overwhelming proof of guilt. All of his life, Caro was exposed to "acute and chronic exposure to neurotoxic chemicals,"⁶¹ which were documented to cause "otherwise inexplicable aggressive behavior."⁶² Caro's family had used water laced with pesticides in their household and in the fields for drinking, bathing, cleaning. He had worked and played in these fields. As a child, Caro drank a bottle of Clorox and suffered side effects. He also played on a tank of ammonia and lost consciousness from the fumes. He worked as a "flagger" in high school without protective clothing and spent all day in pesticide-drenched clothes. As an adult, Caro worked as a maintenance worker for a corporation that produced toxic pesticides without respiratory devices. He worked with polychlorinated biphenyls (PCBs), which are now illegal. One of the medical doctors who examined Caro declared that, had he known of Caro's "extraordinary exposure" to these chemicals, he would have testified that Caro had diminished mental capacity.⁶³

The court in *Caro* reasoned, "It has been demonstrated that such poisoning causes inexplicable and aggressive behavior. . . .the jury here was never presented with the most important evidence of mitigation—the chemical poisoning of Caro's brain." The court further explained that "the Constitution prohibits imposition of the death penalty without adequate consideration of factors which might evoke mercy," determining that exposure to neurotoxic chemicals is one of those factors.

Long term exposure to neurotoxic chemicals has been identified as a potential mitigating factor in other cases as well. In *Allen v. United States*, the petitioner, in the penalty phase, used early childhood exposure to neurotoxins and argued a "potential causal relationship between [Mr. Allen's] employment at a chemical plant and neurological disorders Brain damage per the mitigation checklist."⁶⁴ In *Marks v. Chappel*, counsel for the defendant introduced evidence in the penalty phase of his murder case

60. *Caro v. Calderon*, 165 F.3d 1223 (9th Cir. 1999), *cert. denied*, 527 U.S. 1049.

61. *Id.* at 1228.

62. *Id.* at 1225.

63. *Id.* at 1226.

64. *Allen v. United States*, No. 4:07CV00027 ERW, 2014 U.S. Dist. LEXIS 87415 (E.D. Mo. June 25, 2014).

that he had life-long exposure to a multitude of neurotoxic chemicals because he grew up where the Navy abandoned toxic materials, affecting 700 acres of land. He also alleged that he was residing in a home with lead-based paint and asbestos.⁶⁵ The effect that this type of exposure can have on one's ability to regulate behavior, and therefore avoid criminality, has been both documented and used in previous cases. In *United States v. Frank*, the defendant presented a defense of temporary insanity caused by neurotoxicity due to long-term uranium exposure resulting in the jury returning a conviction for a lesser charge not requiring the same level of premeditation.⁶⁶ Cases arguing chemical exposure for the purposes of establishing mitigating factors are mostly doing so to prove intellectual disability within the meaning of *Atkins v. Virginia*.⁶⁷ Due to the ongoing debate following *Atkins* as to what constitutes an intellectual disability, precaution should be taken to ensure the most equitable legal outcomes as they pertain to such exposure.⁶⁸ As more and more cases arise, environmental exposure could present a mitigating defense in its own right. As the effects of PFAS chemical exposure are determined with greater scientific certainty, there are multiple legal implications to consider as to whether PFAS, given its ubiquitous character, should be used as a mitigating factor in criminal cases where the defendant has both been exposed and exhibits symptoms such as aggression or diminished capacity.

Returning again to the comparison of the legal approach to lead exposure, it has been proposed that “[l]ead poisoning would be best considered not as a complete defense, but rather as one contributing factor to an individual's delinquency that should be considered in determining a fair punishment in many or most cases.”⁶⁹ This argument has been used in death penalty cases like those previously discussed, but it can, and most likely should, extend to lesser criminal offenses as well.⁷⁰ As far back as 1993, researchers determined that advances in neuroscience indicate that “lead poisoning affects the brain and body to such a degree that it is considered an internal rather than external condition.” The now well-established science concurs that lead exposure becomes internalized in the form of diminished

65. Marks v. Chappel, No. 11-CV-02458-LHK, 2017 WL 4156200 (N.D. Cal. Sept. 18, 2017).

66. United State v. Frank, 933 F.2d 1491 (9th Cir. 1991).

67. Atkins v. Virginia, 536 U.S. 304 (2002).

68. Cortney Kohberger & Stephen Noffsinger, *Determining Intellectual Disability in a Post-Atkins Death Penalty Case*, 43 J. AM. ACAD. PSYCHIATRY & L. ONLINE 526, 528 (2015) (“In *Atkins*, the Supreme Court held that executing a person with an intellectual disability is unconstitutional, reasoning that persons with intellectual disabilities are at special risk of wrongful execution. However, the Court left states to devise procedures to determine what constitutes an intellectual disability and therefore who should be excluded from capital punishment.”).

69. Elanor Kittilstad, *Reduced Culpability Without Reduced Punishment: A Case for Why Lead Poisoning Should Be Considered a Mitigating Factor in Criminal Sentencing*, 108 J. CRIM. L. & CRIMINOLOGY 569, 575–76 (2018).

70. *Id.* at 576.

IQ and behavioral disabilities.⁷¹ Considering the legal implications of this, if a client has been exposed to toxins, such as lead or agricultural chemicals, in utero or during the developmental years, a toxicologist should be called for mitigation purposes.⁷²

In 2003, the *New York Times* published a piece on the effects of chemical exposure on criminality.⁷³ In that case, the Pentagon sent defendant Jones a letter indicating that he had been exposed to chemical agents such as sarin and cyclosarin as a soldier in the Persian Gulf War.⁷⁴ He received the letter after he was found guilty at trial and the jury recommended death. His attorney said that the chemicals he was exposed to in Iraq “changed his personality, unbalanced his mind, and played a significant role in the crimes he was convicted of committing.”⁷⁵ Evidence of his exposure to nerve agents was not available at his trial in 1995.⁷⁶ The court ultimately declined to overturn his death sentence in 1999.⁷⁷ However, this case still demonstrates the potential legal consideration for exposure to toxic chemicals and the effect it has on the regulation of human behavior.⁷⁸

A host of common chemicals (pesticides, herbicides, solvents, and heavy metals) are known to cause neurological impairment.⁷⁹ Occupational exposure is prevalent, but virtually all Americans are exposed to a “chemical soup of neurotoxic agents.”⁸⁰ Neurotoxins can damage the peripheral nervous system, central nervous system, or both, and with enough resources and study, this exposure is measurable.⁸¹ Researchers have identified a link between the central nervous system and violent crime, and this connection may satisfy the mental disease or defect mitigation consideration in criminal cases.⁸² For example, exposure to copper can result in Wilson’s disease, an organic brain disorder, which leads to lying, stealing, etc.⁸³ Since mitigating factors are not required to be the sole causes of criminal behavior, their role in criminal actions is important to establish. “If the defendant can show that

71. *Id.*

72. Jill Miller, *The Defense Team in Capital Cases*, 31 HOFSTRA L. REV. 1117, 1117–41 (2013).

73. Adam Liptak, *Condemned Killer Exposed to Nerve Gas Seeks Mercy*, N.Y. TIMES (Mar. 16, 2003), <https://www.nytimes.com/2003/03/16/us/condemned-killer-exposed-to-nerve-gas-seeks-mercy.html> [<https://perma.cc/F3AB-CLNT>].

74. *Id.*

75. *Id.*

76. *Id.*

77. *Id.*

78. *Id.*

79. David B. McConnell, *The Sevin Made Me Do It: Mental Non-Responsibility and the Neurotoxic Damage Defense*, 14 VA. ENVTL. L.J. 151, 154 (1994).

80. *Id.*

81. *Id.* at 155.

82. *Id.* at 152, 182.

83. *Id.* at 158.

toxic neuropathy played some role in the commission of actus reus, the disease should be entitled to mitigating consideration.”⁸⁴

The behavioral effects of neurotoxic chemicals like PFAS will have serious implications for future criminal law cases. It is important that as scientific certainty is being established, a precautionary approach is implemented in legal considerations for the overall effects of PFAS chemicals on human health and behavior.

B. PFAS Contamination and Human Health

“There is evidence that continued exposure above specific levels to certain PFAS may lead to adverse health effects.”⁸⁵

Due to the widespread use and long half-life of PFAS chemicals, over 95% of the United States population has some measurable level of PFAS blood serum levels.⁸⁶ Because its chemical bonds make it water-soluble, the chemicals are found in human blood serum but not body fat.⁸⁷ While the use of certain PFAS has been phased out in United States manufacturing and there has been a decrease in the PFAS levels in blood serum, PFAS bioaccumulates and does not degrade quickly in the environment, making it a persistent source of continued exposure.⁸⁸ Blood serum is used as a long-term measure of exposure and can indicate whether there is an increased risk of physical harms to local populations.⁸⁹ Blood serums are also helpful for tracking changes in accumulation. For example, samples have shown that even though PFAS manufacturing is being phased out, there is an increasing trend of undefined organofluorine in blood, which indicates that humans have been exposed to new and unidentified PFAS that have not been phased out.⁹⁰ In 2014 and 2015, researchers collected 407 samples of paper and paperboard food wrappers and related food packaging at U.S. fast food

84. *Id.* at 183.

85. EPA, *EPA’s Per- and Polyfluoroalkyl Substances (PFAS) Action Plan*, <http://www.epa.gov/pfas/epas-pfas-action-plan> [<https://perma.cc/9BMA-44MA>] (emphasis added).

86. Centers for Disease Control and Prevention, *Fourth National Report on Human Exposure to Environmental Chemicals*, https://www.cdc.gov/exposurereport/pdf/Fourth_Report_UpdatedTables_Volume1_Mar2018.pdf [<https://perma.cc/XS6W-8C69>].

87. Gloria B. Post et al., *Key Scientific Issues in Developing Drinking Water Guidelines for Perfluoroalkyl Acids: Contaminants of Emerging Concern*, 15 PUB. LIBR. OF SCI. BIOLOGY 1, 3–4 (2017).

88. Centers for Disease Control and Prevention, *An Overview of Perfluoroalkyl and Polyfluoroalkyl Substances and Interim Guidance for Clinicians Responding to Patient*, https://www.atsdr.cdc.gov/pfas/docs/pfas_clinician_fact_sheet_508.pdf [<https://perma.cc/7M-TL-H63K>].

89. *See generally* Centers for Disease Control & Prevention, *supra* note 86.

90. Anna Reade et al., *Michigan PFAS 2019: Scientific and Policy Assessment for Addressing Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water*, NAT. RESOURCES DEF. COUNCIL 1, 6 (Mar. 15, 2019).

restaurants and found that 33% had detectable concentrations of PFAS chemicals.⁹¹

The C8⁹² Science Panel⁹³ established as a result of a class action lawsuit against the chemical manufacturer DuPont to assess probable links between PFAS exposure and diseases, identified PFAS as a probable carcinogen.⁹⁴ The International Agency for Research on Cancer (IARC) also classified PFAS as a possible carcinogen. The EPA has concluded that PFAS demonstrates likely or suggestive evidence of carcinogenic potential.⁹⁵ According to the C8 Health Project, there is an increased risk of testicular and kidney cancers with higher PFAS exposures. In addition, the effects of PFAS on the immune system have also been studied showing impacts ranging from the molecular level, including antibody productivity, to organ or system level, including infections and asthma exacerbation.⁹⁶ There have also been associations between PFAS and elevated cholesterol, diabetes, insulin resistance, thyroid issues, obesity, and other metabolic diseases.⁹⁷

PFAS may influence antibody response to vaccination as a result of adverse effects on the human immune system.⁹⁸ The National Toxicology Program conducted a review of PFAS immunotoxicology in which it found that two of the most studied chemicals in the family of PFAS, PFOA and PFOS, pose “an immune hazard to humans based on a high level of evidence that PFOA (and PFOS) suppressed the antibody response from animal studies and a moderate level of evidence from studies in humans.”⁹⁹ Studies in children and adults have shown a connection between reduced antibody production and higher blood levels of PFAS after vaccinations.¹⁰⁰ Infants in

91. Schaider et al., *supra* note 11.

92. “C8” is another name for PFOA due to its 8-carbon chain. It is the essential ingredient in Teflon.

93. “During 2005–2013, the C8 Science Panel carried out exposure and health studies in the Mid-Ohio Valley communities, which had been potentially affected by the releases of PFOA (or C8) emitted since the 1950s from the Washington Works plant in Parkersburg, West Virginia. They then assessed the links between C8 exposure and a number of diseases. The C8 Science Panel has completed its work and no longer exists.” *The Science Panel Website*, C8 SCIENCE PANEL, <http://www.c8sciencepanel.org/index.html> [https://perma.cc/P2Z5-7MQT] (last updated Jan. 4, 2017).

94. *Id.*

95. EPA, *SAB Review of EPA’s Draft Risk Assessment of Potential Human Health Effects Associated with PFOA and Its Salts*, (May 30, 2006), <https://nepis.epa.gov/Exec/tiff2png.cgi/901S0J00.PNG?-r+75+-g+7+D%3A%5CZYFILES%5CINDEX%20DATA%5C06THRU10%5CTIFF%5C00000072%5C901S0J00.TIF> [https://perma.cc/72FD-UKTQ].

96. Sunderland et al., *supra* note 7, at 131–47.

97. *Id.*

98. Rappazzo, *supra* note 36, at 8–9.

99. Andrew Rooney, *NTP Monograph on Immunotoxicity Associated with Exposure to Perfluorooctanoic Acid (PFOA) or Perfluorooctane Sulfonate (PFOS)*, NAT’L TOXICOLOGY PROGRAM, Sept. 2016, 1, at 1, <https://oehha.ca.gov/media/downloads/water/presentation/rooney111519.pdf> [https://perma.cc/JW2B-QTCM].

100. *Id.*

their first six months of life with high levels of PFAS were associated with weaker responses to tetanus vaccinations.¹⁰¹ A study presented at a national conference on PFAS in June 2019 showed that 237 children from West Africa had a reduced response to the measles vaccine by about one-fourth among those who had been exposed to even low levels of PFOA and PFOS.¹⁰²

Given the significant and well-documented effects PFAS exposure has on physical health, comprehensive regulations are inevitable. The question becomes, how long will it take and what level of legal scientific certainty will be required before implementing those regulations? The precautionary approach proposed later in this paper will provide a possible answer to these questions.

C. PFAS and the Natural World

In order to understand the environmental effects of PFAS, it is important to revisit its chemical structure. Because PFAS are synthetic fluorochemicals with water-soluble and oil-repellent properties, they have high thermal stability and resistance to degradation. This makes them very persistent in the environment, and they are even found in treated drinking water.¹⁰³

PFAS has been found in air, water, sediment, plants, wildlife, rain, snow, groundwater, rivers, lakes, and seawater.¹⁰⁴ These types of chemicals are a global concern, as they deleteriously impact the environment, including plants and animals. For example, because they accumulate in animals, specifically those that breathe contaminated air and consume contaminated fish, concentrations of PFAS-type toxins are found in the blood and organs of animals going up the food chain. PFAS are able to migrate from contaminated soil, contaminated surfaces, and ground water to contiguous environments.¹⁰⁵ An official from the Center for Disease Control and Prevention (CDC) has discussed the amount of PFAS in drinking water as “one of the most seminal public health challenges for the next decades.”¹⁰⁶

101. Philippe Grandjean et al., *Estimated Exposures to Perfluorinated Compounds in Infancy Predict Attenuated Vaccine Antibody Concentrations at Age 5 Years*, 14 J. IMMUNOTOXICOLOGY 188, 188–95 (2017).

102. Amelia Timmermann et al., *Decreased Vaccine Response in Guinea-Bissau Children Exposed to Perfluoroalkyl Substances*, in *Per- and Polyfluoroalkyl Substances: Second National Conference, Scientific Poster Sessions* (2019).

103. Susan D. Richardson & Thomas A. Ternes, *Water Analysis: Emerging Contaminants and Current Issues*, 90 ANALYTIC CHEMISTRY 398, 407 (2017).

104. PFAS Free, <https://www.pfasfree.org.uk> [<https://perma.cc/GJQ7-3AL2>].

105. *Per- and Poly-fluoroalkyl Substances (PFASs)*, AUSTL. GOV'T: DEP'T OF ENV'T & ENERGY, <http://www.environment.gov.au/protection/chemicals-management/pfas> [<https://perma.cc/5KEN-QG7Y>].

106. *Breaking Down Toxic PFAS: What PFAS Are, Why They're Harmful, and What We Can Do to Protect Ourselves From Them*, EARTHJUSTICE (Jun. 28, 2019), <https://earthjustice.org/features/breaking-down-toxic-pfas> [<https://perma.cc/9JWF-JMV3>].

The variable properties of PFAS have made it difficult to identify a single method of removal from drinking water.¹⁰⁷ This makes the environmental effects of PFAS exposure significant.

III. ENVIRONMENTAL JUSTICE CONCERNS: LEGAL AND MORAL RAMIFICATIONS

A. A Lesson from the Past

Impacts of chemical exposure are particularly difficult to establish. Harm can occur anywhere from the cellular level to large ecosystem changes and everywhere in between. Given the properties of PFAS and its geographical prevalence, it poses a significant threat to environmental justice.¹⁰⁸

The environmental justice movement, which began in the 1980s, focused on social justice through human rights and alleviating the disproportionate burden of environmental hazards experienced by people of color and low-income communities.¹⁰⁹ In 1987, the Commission for Racial Justice of the United Church of Christ spearheaded a movement that shed light on the disparate impact environmental hazards had on communities of color.¹¹⁰ The First National People of Color Environmental Leadership Summit was held in 1991, where the principles of environmental justice were broadened.¹¹¹ In 1994, the Clinton Administration issued Executive Order 12898: Federal Actions to Address Environmental Justice in Minority and Low-Income Populations.¹¹² These actions and others were intended to create

107. Viraj deSilva, *The Environmental Dangers of PFAS and Technologies for Removing Them*, WASTE ADVANTAGE MAG. (Mar. 1, 2019), <https://wasteadvantagemag.com/the-environmental-dangers-of-pfas-and-technologies-for-removing-them/> [https://perma.cc/8KYT-3GLB].

108. “Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. This goal will be achieved when everyone enjoys (a) the same degree of protection from environmental and health hazards, and (b) equal access to the decision-making process to have a healthy environment in which to live, learn, and work.” EPA, *Environmental Justice*, <https://www.epa.gov/environmentaljustice> [https://perma.cc/M2TZ-2SJJ].

109. ROBERT D. BULLARD, *DUMPING IN DIXIE: RACE, CLASS, AND ENVIRONMENTAL QUALITY* 1–12 (3rd ed. 1990).

110. Commission for Racial Justice, United Church of Christ, *Toxic Wastes and Race in the United States: A National Report on the Racial and Socio-Economic Characteristics of Communities with Hazardous Waste Sites* (1987), <http://uccfiles.com/pdf/ToxicWastes&Race.pdf>.

111. *Principles of Environmental Justice*, DELEGATES TO THE FIRST NAT’L PEOPLE OF COLOR ENVNTL. LEADERSHIP SUMMIT (Oct. 24–27, 1991), <https://www.ejnet.org/ej/principles.pdf> [https://perma.cc/DSL5-6TNW].

112. “To the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each Federal agency

a framework that would address disparate environmental impact, like that of lead, on low-income families. In 1994, economist James K. Boyce published a paper advancing two hypotheses: (1) the extent of an environmentally degrading economic activity is a function of the balance of power between the winners, who derive net benefits from the activity, and the losers, who bear net costs; and (2) greater inequalities of power and wealth, all else being equal, lead to more environmental degradation.¹¹³

It is well documented that marginalized communities are more likely to live near contaminated sites.¹¹⁴ While only consisting of one quarter of the U.S. population in 1990, people of color made up 40% of the population living within one mile of a hazardous waste treatment, storage, and disposal facility (TSDF).¹¹⁵ According to a 2015 study seeking to explain this disparate impact:

That the racial composition of areas tends to be an independent and stronger predictor than socioeconomic characteristics of which areas receive hazardous waste TSDFs provides especially strong support for racial explanations of disparate siting. Racial disparities at the time of siting can readily occur when people of color live in highly segregated residential areas that can be targeted for new facilities siting and that may also already have other industrial land uses. Such land use patterns—created in part by past racial discrimination in zoning, property law and housing—continue to persist into the present day.¹¹⁶

shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of the Mariana Islands.” *Presidential Documents: Federal Action to Address Environmental Justice in Minority Populations and Low-Income Populations*, 59 Fed. Reg. 7629 (Feb. 16, 1994).

113. James K. Boyce, *Inequality as a Cause of Environmental Degradation*, *ECOLOGICAL ECON.*, Vol. 11 (1994).

114. “The extent to which congressional districts are gerrymandered and exposure to environmental pollution was also telling. The more a district is gerrymandered, the less exposure to environmental pollution. To understand the true weight of this finding, it should be combined with the last question we answered that the more gerrymandering in a district, the less African Americans in that district.” David E. Kramar et. al., *A Spatially Informed Analysis of Environmental Justice: Analyzing the Effects of Gerrymandering and the Proximity of Minority Populations to U.S. Superfund Sites*, 11 *ENVTL. JUST.* 29, 36 (2018).

115. Paul Mohai & Robin Saha, *Racial Inequity in the Distribution of Hazardous Waste: A National-Level Reassessment*, 54 *SOC. PROBS.* 343, 361 (2007).

116. Paul Mohai & Robin Saha, *Which Came First, People or Pollution? Assessing the Disparate Siting and Post-Siting Demographic Change Hypotheses of Environmental Injustice*, *ENVTL. RES. LETTERS*, Nov. 18, 2015, at 1, 16.

Examining one of the major environmental justice cases of the past few decades can provide guidance on how to proceed with this ever-expanding issue.

Like PFAS, lead exposure comes from many different sources, such as manufacturing, household paint, gasoline, and pipes used for drinking water. Another similarity is the persistent nature of the toxin even after it was phased out of circulation. The most prevalent exposure to lead is through lead-based paint in older homes in low-income communities.¹¹⁷ The EPA estimates that roughly 6.5–10 million homes and buildings have service lines that are at least partially made of lead.¹¹⁸ Unlike lead, PFAS is still in need of significant research to determine exactly where the greatest impacts are to be found. After decades of research, the CDC has determined that victims of lead exposure are most likely younger than three years old, of non-Hispanic black race, and residing in lower-income households.¹¹⁹

While the dangers of lead exposure have been well-known in the United States since the 1700s,¹²⁰ the first piece of comprehensive legislation focusing on lead was not signed until 1971. The Lead-Based Paint Poisoning Prevention Act¹²¹ restricted the use of lead-based paint. In 1976, the Consumer Product Safety Commission effectively banned its use altogether. The 1990 Clean Air Act amendments banned the use of lead in gasoline. However, this was 15 years after the CDC created the Childhood Lead Poisoning Program that recommended “all children who live in . . . poorly maintained housing units constructed prior to the 1960s should be screened at least once a year.” Then, in 2008, the EPA implemented stricter air emissions rules for lead, requiring all industries to reduce levels to .15 µg/cubic meter. The delayed response to this well-known and destructive contaminant resulted in continued health problems associated with lead exposure. The National Health and Nutrition Examination Survey (NHANES) conducted between 1976 and 1980 found that about 700,000 children under age six had elevated lead levels.¹²² The numbers are even worse across different races and ethnicities. A survey between 1999–2002

117. David E. Jacobs et al., *The Prevalence of Lead Based Paint Hazards in U.S. Housing*, ENVTL. HEALTH PERSP., Oct. 2002, at A599, A599-A606.

118. EPA, *Lead and Copper Rule Revisions White Paper* (Oct. 2016), https://www.epa.gov/sites/production/files/2016-10/documents/508_lcr_revisions_white_paper_final_10.26.16.pdf [<https://perma.cc/9WT9-F55D>].

119. Kathleen L. Caldwell et al., *Measurement Challenges at Low Blood Levels*, PEDIATRICS, Aug. 2017, at 1, 7.

120. Benjamin Franklin wrote to a friend in 1786, describing his concerns of the toxicity of lead. *The Famous Letter of Benjamin Franklin on Lead Poisoning*, ENVTL. EDUC. ASSOCIATES, <http://environmentaleducation.com/wp-content/uploads/userfiles/Ben%20Franklin%20Letter%20on%20EPA%281%29.pdf?fbclid=IwAR22LrbVeFTMw2PGdL-cbnXgMUGw7BtO9H4Uk7uhVTqmVi4AQoxJbKzCnU> [<https://perma.cc/9QRP-JMW6>].

121. 42 U.S.C. § 4822 (2012).

122. Kathryn R. Mahaffey et al., *National Estimates of Blood Lead Levels: United States, 1976–1980: Association with Selected Demographic and Socioeconomic Factors*, NEW ENG. J. OF MED., 149–59 (1982).

found that although the blood lead levels (BLLs) had decreased significantly since the legislative enactments mentioned above, BLLs for “non-Hispanic black children remain[] higher than [those] for Mexican-American and non-Hispanic white children, indicating that differences in risk for exposure still persist.”¹²³ Lead exposure remains a concern today, with high profile examples such as the Flint Water Crisis,¹²⁴ demonstrating the long-term, disparate impacts of contamination when delayed regulatory action is enacted.

B. Applications for the Present

While the research is woefully lacking in this area, there are already indications that certain populations are more likely to be exposed to PFAS. While PFAS exposure through fish consumption is greater among higher-income white individuals,¹²⁵ a Child Health and Development Studies Program study found that for African American women, higher levels of PFAS exposure were associated with frequent consumption of food in coated cardboard containers.¹²⁶ Since PFAS is more commonly used in paper food packaging, populations with high consumptions of prepared food will be more likely to ingest PFAS chemicals.¹²⁷ According to a 2016 study of dietary intake among California children, “White children have been shown to have lower rates of sugar-sweetened beverage, fruit juice and fast food consumption, and higher rates of fruit and vegetable intake when compared to minority groups of children.”¹²⁸ Additionally, location and transportation are predominant factors in access to healthy, fresh food. Low-income and

123. *Blood Lead Levels—United States, 1999–2002*, CENTERS FOR DISEASE CONTROL AND PREVENTION: MMWR WEEKLY (May 27, 2005), <https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5420a5.htm> [<https://perma.cc/EQZ5-U7VS>].

124. “On April 25, 2014, officials looking to save money switched Flint, Michigan’s drinking water supply from the Detroit city system to the Flint River. This new water was highly corrosive. Because city and state officials broke federal law by failing to treat the water properly, lead leached out from aging pipes into thousands of homes. Soon after the switch, Flint residents complained about dark-colored, foul-tasting, smelly water as well as skin rashes and hair loss. Independent tests found that a significant proportion of samples had lead levels well above the “action level” for lead set by the U.S. Environmental Protection Agency. In fact, some samples showed lead levels more than 100 times the action level. Some 9,000 children, who are particularly sensitive to lead and its effects, were exposed to contaminated water.” *What’s at Stake: Fighting for Safe Drinking Water in Flint Michigan*, NAT. RESOURCES DEF. COUNCIL, <https://www.nrdc.org/flint> [<https://perma.cc/P5TC-Z5VX>].

125. Centers for Disease Control & Prevention, *supra* note 86.

126. Katherine E. Boronow et. al., *Serum Concentration of PFASs and Exposure-Related Behaviors in African American and Non-Hispanic White Women*, 29 J. OF EXPOSURE SCI. & ENVTL. EPIDEMIOLOGY 206, 206–15 (2019).

127. Schaidler et al., *supra* note 11.

128. Alma D. Guerrero & Paul J. Chung, *Racial and Ethnic Disparities in Dietary Intake Among California Children*, 116 J. ACAD. NUTRITION & DIETETICS 439, 439–48 (2016).

minority neighborhoods are more commonly found to be “food deserts,”¹²⁹ meaning they are less likely to have access to grocery stores and are more likely to be saturated with fast and prepackaged foods.¹³⁰ Both of which are likely to have packaging containing PFAS. In fact, according to a piece prepared by the University of Wisconsin-Extension’s Center for Community and Economic Development, “Dollar General tries to locate in ‘food deserts,’ where grocery stores are not very accessible.”¹³¹ Additionally, the majority of sales at discount stores like dollar stores are “consumable goods, such as cleaning, food, and paper products.”¹³² This poses a significant environmental justice concern as it pertains to PFAS contamination. According to a 2018 Report Card prepared by Safer Chemicals Healthy Families, dollar stores received an “F” average for three retailers when evaluated for progress in promoting safer chemicals in products, packaging, and global supply chains.¹³³ Given its chemical nature and customary usage, it is likely that the more studies performed in this area, the more likely there will be a stronger connection between PFAS contamination and marginalized communities.

In addition to exposure through consumption, many materials containing PFAS are eventually discarded into landfills. The Vermont General Assembly has actually proposed requiring the state to report on management of landfill leachate containing PFAS and other chemicals of concern.¹³⁴ This is a significant source of contamination for the low-income and minority populations living near landfills.¹³⁵ A 2018 study explained that “depending on their physio-chemical properties, some anionic, water soluble PFASs can be released with the landfill leachate . . . on the other hand, neutral PFASs with low water solubilit[y] and relatively high vapor pressures

129. According to the United States Department of Agriculture: Food deserts are defined as parts of the country void of fresh fruit, vegetables, and other healthful whole foods, usually found in impoverished areas. This is largely due to a lack of grocery stores, farmers’ markets, and healthy food providers. Christina Manian, *Maintaining a Healthy Diet in a Food Desert*, DIGNITY HEALTH (Apr. 20, 2016), <https://www.dignityhealth.org/articles/maintaining-a-healthy-diet-in-a-food-desert> [<https://perma.cc/ZCJ4-2MY8>].

130. Nicole I. Larson et al., *Neighborhood Environments: Disparities in Access to Health Foods in the U.S.* *American Journal of Preventative Medicine*, 36 AM. J. OF HEALTHY MED. 74, 74–81 (2009).

131. Jonathan Wolfrath et al., *Dollar Stores in Small Communities: Are They a Good Fit for Your Town? Downtown Economic: Ideas for Increasing Vitality in Community Business Districts*, CTR. FOR COMMUNITY & ECON. DEV. (Dec. 2018), <https://fyi.extension.wisc.edu/downtowneconomics/files/2018/11/DE1218a.pdf> [<https://perma.cc/YM3W-BCMZ>].

132. *Id.*

133. “Retailer Report Card, Safer Chemicals, Healthy Families graded the chemical policies and practices of forty major retailers that sell products in North America, as part of its Mind the Store campaign.” Mike Schade, *Who’s Minding the Store? – A Report Card on Retailer Actions to Eliminate Toxic Chemicals*, RETAILER REP. CARD (2018), <https://retailerreportcard.com/2018/10/executive-summary-2018/> [<https://perma.cc/F42U-927A>].

134. Vt. Gen. Assemb. H.98 (2019), <https://legislature.vermont.gov/bill/status/2020/H.98> [<https://perma.cc/3G9X-GF2R>].

135. *Id.*

partition with landfill gas and are subsequently released to the atmosphere, if not captured efficiently by a gas collection system.”¹³⁶ This disparate proximity to such a concentrated source of potential contamination, combined with the persistent nature of PFAS, creates the potential for a significant environmental justice issue in the coming decades.

An analysis of the data currently available indicates that PFAS contamination will likely become a serious environmental justice concern in terms of both exposure and mitigation. Because exposure is shown to disparately impact minority and low-income populations, the effects of exposure will too. The substantial physical and behavioral effects of PFAS contamination will not only expose these populations to significant health effects, but also contribute to potential criminal behavior over time. With the requisite data still being collected, and given the lessons of the past, it is important that legal precaution is taken going forward to ensure meaningful and equitable results.

IV. CURRENT ENVIRONMENTAL LAW APPROACH

Given what is known about the chemical composition and the customary usage of PFAS, how has it been dealt with legally? Internationally, there has been much more direct action taken in regards to PFAS regulation and mitigation. In 2019, the Stockholm Convention on Persistent Organic Pollutants¹³⁷ agreed to list PFOA in Annex A of the Convention meaning parties must take measures to *eliminate* its production and use.¹³⁸ This follows the listing of PFOS, which was listed in Annex B, meaning the parties must take measures to *restrict* production and use.¹³⁹ Denmark became the first country to ban the use of PFAS chemicals in food packaging in 2019

136. Hanna Hamid et al., *Review of the Fate and Transformation of Per- and Polyfluoroalkyl Substances (PFASs) in Landfills*, 235 ENVTL. POLLUTION 74, 74–84 (2018).

137. “The Stockholm Convention on Persistent Organic Pollutants is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment.” Stockholm Convention, *Overview*, SECRETARIAT OF THE STOCKHOLM CONVENTION, <http://chm.pops.int/TheConvention/Overview/tabid/3351/Default.aspx> [https://perma.cc/5SSK-ALQT].

138. Stockholm Convention, *All POPs Listed in the Stockholm Convention*, SECRETARIAT OF THE STOCKHOLM CONVENTION, <http://chm.pops.int/TheConvention/ThePOPs/AllPOPs/tabid/2509/Default.aspx> [https://perma.cc/7XBG-FS4V]; Stockholm Convention, *The New POPs Under the Stockholm Convention*, SECRETARIAT OF THE STOCKHOLM CONVENTION, <http://chm.pops.int/TheConvention/ThePOPs/TheNewPOPs/tabid/2511/Default.aspx> [https://perma.cc/75JC-QATL].

139. U.N. Environment Programme, *All POPs Listed in the Stockholm Convention*, STOCKHOLM CONVENTION, <http://www.pops.int/TheConvention/ThePOPs/AllPOPs/tabid/2509/Default.aspx> [https://perma.cc/T8D9-JEH6]; U.N. Environment Programme, *The New POPs Under the Stockholm Convention*, STOCKHOLM CONVENTION, <http://www.pops.int/TheConvention/ThePOPs/TheNewPOPs/tabid/2511/Default.aspx> [https://perma.cc/9W2V-DV4J].

when its Ministry of Environment and Food announced the ban would take effect by July 2020.¹⁴⁰ In the United States, which is not a party to the Stockholm Convention, the dangers of PFAS contamination have been addressed at multiple levels. Unfortunately, as of publication, nothing substantial has been passed to address this prevalent issue. Starting at the federal level, there have been some significant strides made in addressing PFAS, but they just do not go far enough.

A. Federal Approach¹⁴¹

1. *Toxic Substances Control Act (TSCA)*

Currently, PFAS is addressed under the Toxic Substances Control Act (TSCA), which regulates the production, importation, use, and disposal of specific chemicals.¹⁴² Unfortunately, TSCA is “widely regarded as a serious under-performer among U.S. environmental laws, despite having itself been based on a thoughtful white paper, *Toxic Substances*, written by the U.S. Council on Environmental Quality (CEQ) five years earlier to accompany the original legislative proposal.”¹⁴³ In any case, the Act provides the EPA with authority to require reporting, record-keeping and testing requirements, and restrictions relating to chemical substances and/or mixtures.¹⁴⁴ Certain substances are generally excluded from TSCA,

140. Deirdre Appel, *Denmark Strives to Ban Harmful Chemicals in Food Packaging*, HUNTER COLLEGE N.Y. CITY FOOD POL’Y CTR. (Sep. 26, 2019), <https://www.nycfoodpolicy.org/denmark-strives-to-ban-harmful-chemicals-in-food-packaging-2/> [<https://perma.cc/4MNR-ENCD>].

141. The regulation and control of PFAS contamination is an ever-expanding area due to the growing awareness of its dangerous properties. In the 2019–2020 Congressional Session, there were sixty-five bills or amendments proposed directly addressing or relating to PFAS. On January 28, 2020, Senator Bernie Sanders introduced the “Prevent Future American Sickness (PFAS) Act of 2020” that, as of publication, has been read twice and referred to the Committee on Environment and Public Works. This bill would “require the Administrator of the Environmental Protection Agency to designate per- and polyfluoroalkyl substances as hazardous substances under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, and for other purposes.” S. 3227, 116th Cong. (2020), <https://www.congress.gov/bill/116th-congress/senate-bill/3227?q=%7B%22search%22%3A%5B%22PFAS%22%5D%7D&r=1&s=3> [<https://perma.cc/7VFC-YFWY>].

142. 15 U.S.C. § 2601 (2018).

143. John S. Applegate, *Synthesizing TSCA and REACH: Practical Principles for Chemical Regulation Reform*, 35 *ECOLOGY L. Q.* 721, 723 (2008).

144. Toxic Substances Control Act of 1976, Pub. L. No. 94-469, § 8(e), 15 U.S.C. § 2607(e) (2018) (“Any person who manufactures, processes, or distributes in commerce a chemical substance or mixture and who obtains information which reasonably supports the conclusion that such substance or mixture presents a substantial risk to health or the environment shall immediately inform the Administrator of such information unless such person has actual knowledge that the Administrator has been adequately informed of such information.”).

including, among others, food, drugs, cosmetics, and pesticides.¹⁴⁵ Section 5 of TSCA gives the EPA the authority to issue Significant New Use Rules (SNURs) which identify a “significant new use” that could result in exposures to, or release of, a substance of concern. In 2002, the EPA issued a SNUR requiring manufacturers and importers of seventy-five different PFAS chemicals to notify the EPA before any future use of the chemical.¹⁴⁶ In 2013, the EPA issued a new SNUR regulating the use of PFOA in carpet manufacturing.¹⁴⁷ In 2015, the EPA proposed another SNUR requiring companies to report any new uses of PFOA and PFOA-related chemicals to the EPA at least ninety days before the chemicals’ use or import.¹⁴⁸ According to the 2019 EPA PFAS Action Plan, the EPA is “considering the public comments received on the 2015 proposed SNUR as well as the new statutory requirements added by the Frank R. Lautenberg Chemical Safety for the 21st Century Act¹⁴⁹ as it works to issue a supplemental proposed SNUR on PFAS for the manufacture (including import) of certain long-chain perfluoroalkyl carboxylate (LCPFAC) chemical substances”¹⁵⁰ While the EPA has taken some type of action over at least 300 PFAS chemicals, the results of these actions are unclear.

2. *Safe Drinking Water Act (SDWA)*

In addition to TSCA, the Safe Drinking Water Act (SDWA) has addressed concern with PFAS. SDWA requires the EPA to promulgate regulations that include enforceable standards and monitoring requirements for contaminants in water provided by public water systems.¹⁵¹ For

145. EPA, *Summary of Toxic Substances Control Act*, <https://www.epa.gov/laws-regulations/summary-toxic-substances-control-act> [<https://perma.cc/9RF6-F4FM>]. Many of these are governed by the FDA, discussed later.

146. EPA, *Fact Sheet: PFOA & PFOS Drinking Water Health Advisories*, 1, 2 (Nov. 2016) https://www.epa.gov/sites/production/files/2016-06/documents/drinkingwaterhealthadvisories_pfoa_pfos_updated_5.31.16.pdf [<https://perma.cc/TVM8-8DM2>].

147. *Id.* at 1.

148. *Id.* at 3.

149. On June 22, 2016, the Frank R. Lautenberg Chemical Safety for the 21st Century Act was signed into law amending TSCA to include a requirement that EPA evaluate existing chemicals with clear and enforceable deadlines, risk-based chemical assessments, increased public transparency for chemical information, and consistent sources of funding for EPA to carry out these requirements. EPA, *The Frank R. Lautenberg Chemical Safety for the 21st Century Act*, <https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/frank-r-lautenberg-chemical-safety-21st-century-act> [<https://perma.cc/24JY-CFUU>].

150. EPA, *EPA’s Per- and Polyfluoroalkyl Substances (PFAS) Action Plan* 1,14 (Feb. 2019), <http://www.epa.gov/pfas/epas-pfas-action-plan> [<https://perma.cc/KP6Y-ZNSA>].

151. Safe Drinking Water Act of 1944, Pub. L. No. 115–270, § 1412(b), 42 U.S.C. § 300g-1(b) (2018) When developing regulations, SDWA requires EPA to (1) use the best available peer-reviewed science and supporting studies and data and (2) make publicly available a risk assessment document that discusses estimated risks, uncertainties, and studies used in the assessment. When proposing drinking water regulations, EPA must publish a “health risk reduction and cost analysis.” For each drinking water standard and each

contaminants that are not regulated under the Act, SDWA authorizes the EPA to issue contaminant-specific Health Advisories (HAs) that include technical guidance and identify concentrations that are expected to be protective of sensitive populations.¹⁵² In 2018, the EPA added PFOA and PFOS to the fourth Containment Candidate List (CCL), a list of drinking water contaminants that are known or anticipated to occur in public water systems and are not currently subject to EPA drinking water regulations.¹⁵³ While there are currently no Maximum Containment Levels (MCLs) set for PFAS chemicals, under SDWA, the EPA has issued HAs for PFOA and PFOS at 70 parts per trillion (ppt).¹⁵⁴ It is important to note that the EPA does not regulate domestic self-supplied water withdrawals.¹⁵⁵ According to the United States Geological Survey, in 2015 approximately 42.5 million people or 13 percent of the population in the United States provided their own water for domestic use and 98 percent of those withdrawals were from fresh groundwater sources.¹⁵⁶

3. *Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)*

Tackling the “foreverness” of PFAS will require addressing not only its future use, but the results of its past use. The Comprehensive Environmental Response, Compensation, and Liability Act, or CERCLA, was established in 1980 to provide federal funds to “clean up uncontrolled or abandoned hazardous waste sites as well as accidents, spills, and other emergency releases of pollutants and contaminants into the environment.”¹⁵⁷ This Act focuses on past contamination, a major issue when considering the bioaccumulative properties of PFAS. It is meant to both prevent future contamination and provide remediation after it has occurred. The CERCLA process is begun once a hazardous substance is released into the environment.

alternative standard being considered for a contaminant, EPA must publish and take comment on quantifiable and nonquantifiable health risk reduction benefits and costs and also conduct other specified analyses.

152. Safe Drinking Water Act § 1412(b)(1)(F); 42 U.S.C. § 300g-1(b)(1)(F) (2018).

153. EPA, *Contaminant Candidate List (CCL) and Regulatory Determination*, <https://www.epa.gov/ccl/chemical-contaminants-ccl-4> [<https://perma.cc/NRY9-HQ88>].

154. EPA, *Fact Sheet: PFOA & PFOS Drinking Water Health Advisories* 1, 2 (Nov. 2016), https://www.epa.gov/sites/production/files/2016-06/documents/drinkingwaterhealthadvisories_pfoa_pfos_updated_5.31.16.pdf [<https://perma.cc/DGK3-ST2R>].

155. EPA, *Private Drinking Water Wells*, <https://www.epa.gov/privatewells> [<https://perma.cc/GD6F-3NL6>].

156. Cheryl A. Dieter et al., *Estimated Use of Water in the United States in 2015*, 1441 U.S. GEOLOGICAL SURVEY CIRCULAR 1, 22 (2018), <https://pubs.usgs.gov/circ/1441/circ1441.pdf> [<https://perma.cc/6M88-L2AQ>].

157. EPA, *Summary of the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)*, <https://www.epa.gov/laws-regulations/summary-comprehensive-environmental-response-compensation-and-liability-act> [<https://perma.cc/AL8Y-XR58>].

Currently, PFOA and PFOS are considered pollutants or contaminants under CERCLA, but not hazardous substances. This designation is important because without being listed as a hazardous substance, the EPA has limited power to prevent and cleanup PFAS contamination. As a pollutant or contaminant, the substance must be proven to pose an “imminent and substantial danger” to public health.¹⁵⁸ In contrast, once a substance is designated as hazardous under CERCLA there are reporting requirements, investigations, and the potential for clean-up requirements. According to the 2019 EPA PFAS Action Plan, “the EPA has initiated the regulatory development process to designate PFOA and PFOS as CERCLA ‘hazardous substances.’”¹⁵⁹ This would extend authority under CERCLA to respond to sites affected by PFAS contamination.

4. Food and Drug Administration (FDA)

In addition to the issue of water and ground contamination, exposure through food consumption is also a concern. The United States Food and Drug Administration regulates the safety of substances added to food as well as how most food is processed, packaged, and labeled.¹⁶⁰

In 1966, the Food and Drug Administration rejected a petition from the chemical manufacturer DuPont to use PFAS chemicals as a food additive due to the established concerns of potential liver damage.¹⁶¹ However, as of this publication, there are currently fifty-nine Food Contract Notifications (FCNs) containing PFAS chemicals.¹⁶² Additionally, the FDA currently approves “more than 90 unique monomer and polymer PFASs for use in food contact materials (FCMs) such as paper and paperboard”¹⁶³ Currently, the FDA is evaluating the potential harm presented from PFAS exposure through food. While the “findings did not detect PFAS in the vast majority of the food tested,” it is important to note that the sampling conducted to date has been very limited.¹⁶⁴ Under the Food Drug and Cosmetic Act, the FDA

158. 42 U.S.C. § 9604 (2018).

159. EPA, *EPA’s Per- and Polyfluoroalkyl Substances (PFAS) Action Plan*, Feb. 2019, 1, at 15, https://www.epa.gov/sites/production/files/2019-02/documents/pfas_action_plan_021319_508compliant_1.pdf [<https://perma.cc/HP4Q-83ZC>].

160. U.S. Food & Drug Admin., *Food Ingredients & Packaging* (Sept. 6, 2019), <https://www.fda.gov/food/food-ingredients-packaging> [<https://perma.cc/955P-9WXE>].

161. DuPont de Neumors & Co., *Food Additive Petition No. 5B1747*, 1,1 (Mar. 23, 1966), <https://ewgorg.app.box.com/s/vyaosrw2syafj3uv5wkoawv0sappmr48> [<https://perma.cc/Z9UG-3MXY>].

162. On August 8, 2019, it was reported that Chemours asked the FDA to withdraw three of its PFAS FCNs. Catherine Boudreau, *Exclusive: Maker of ‘Forever Chemicals’ Cuts Food Packaging Products*, POLITICO (Aug. 9, 2019, 9:36 AM), <https://www.politico.com/story/2019/08/09/exclusive-maker-of-forever-chemicals-cuts-food-packaging-products-1648303> [<https://perma.cc/97NT-8HVZ>].

163. Schaider et al., *supra* note 11, at 106.

164. FDA, *Statement on FDA’s Scientific Work to Understand Per- and Polyfluoroalkyl Substances (PFAS) in Food, and Findings from Recent FDA Surveys* (June 11, 2019),

requires notification of any food-contact substance, defined as any substance intended for use in manufacturing, packing, packaging, transporting, or holding food if such use is not intended to have a technical effect in such food, through a FCN.¹⁶⁵

5. Federal Funding

A looming issue with PFAS contamination is both its prevalence and seeming enormity of mitigation efforts. Still, the necessity of ensuring that PFAS contamination is controlled and, to the extent possible, eliminated going forward has been recognized. In January 2019, a bipartisan task force entitled the PFAS Task Force was created in the United States House of Representatives. Following the creation of this Task Force, the PFAS Registry Act and the Veterans Exposed to Toxic (VET) PFAS Acts were introduced but have not progressed in the United State Congress.

Later in 2019, the House approved amendments to the 2020 National Defense Authorization Act that included significant provisions for addressing the growing concern of PFAS contamination, including the banning of PFAS in military food packaging, phasing out the use of firefighting foam by 2025, including PFAS as a toxic pollutant under section 307 of the Clean Water Act,¹⁶⁶ and allocating \$5 million for the Agency for Toxic Substances and Disease Registry and \$5 million for the United States Geological Survey to study PFAS.¹⁶⁷ It also requires the EPA to list PFAS as a hazardous substance under CERCLA. However, the portions concerning PFAS regulation were removed from the proposed Act in December 2019.

In January 2020, the House passed the PFAS Action Act of 2019, requiring the EPA to review PFAS discharges under the Clean Water Act and enact regulations to address what has already been introduced into the environment. However, there is no progress in listing PFAS as a hazardous substance under CERCLA.

At the federal level, a potential risk to human health and the environment has been identified. However, the approach is very disjointed and ineffective as no binding regulations have been established. According to the ATSDR, since companies began phasing out the use of PFOS and

<https://www.fda.gov/news-events/press-announcements/statement-fdas-scientific-work-understand-and-polyfluoroalkyl-substances-pfas-food-and-findings> [<https://perma.cc/G6BF-UKVX>].

165. 21 C.F.R. § 170.3(e)(3) (2016).

166. 33 U.S.C. § 1317(a)(1)–(2) (2012). “On and after December 27, 1977, the list of toxic pollutants or combination of pollutants subject to this chapter shall consist of those toxic pollutants listed in table 1 [E]ach toxic pollutant listed in accordance with paragraph (1) of this subsection shall be subject to effluent limitations resulting from the application of the best available technology economically achievable for the applicable category or class of point sources established in accordance with sections 1311(b)(2)(A) and 1314(b)(2) of this title.”

167. *National Defense Authorization Act for Fiscal Year 2020*, H.R. 2500, 116th Cong. (2019).

PFOA in 2002, blood PFOS levels have declined 80% and blood PFOA levels have declined 60%.¹⁶⁸ This indicates that more adequate regulations on the use of these persistent substances will generate the necessary results of reducing toxic exposure and its accompanying effects. However, for a comprehensive approach to this pervasive problem, precautionary measures must be implemented while scientific research is conducted.

B. State Approach

Many states are not waiting for the federal government to act and are instead enacting their own regulations of PFAS. State regulations address a variety of PFAS contamination concerns, including water contamination, food additives, child products, cosmetics, firefighting tools, and administrative actions such as listing and reporting requirements and funding allocations.

While the federal government, through the SDWA, has provided an advisory level of 70 ppt for PFAS contamination in water, some states are going even further.¹⁶⁹ For example, California has proposed adding PFAS to the list of potential water contaminants in the California Safe Drinking Water Act, which would require the adoption of a work plan to determine if any PFAS chemicals should be identified as a risk to human health.¹⁷⁰ Michigan and Pennsylvania have also been very proactive in controlling PFAS within these states. Michigan's state senate has introduced a bill that would set a Maximum Contaminant Level in drinking water to the lowest suggested amount at 5 ppt¹⁷¹ while Pennsylvania has proposed 10 ppt.¹⁷² MCLs have also been proposed or adopted in North Carolina, Rhode Island, Vermont, Washington, and Wisconsin. However, based on the carcinogenic potential and association to cancer, the NRDC has recommended a MCLG of zero for PFAS.¹⁷³ This same report recommends regulating PFAS chemicals as a class and not chemical-by-chemical as has been customary in attempts thus far.

Aqueous film forming foam (AFFF) has been regarded as a very effective tool for extinguishing fires due to its ability to quickly cut off the oxygen supply to open flames.¹⁷⁴ While this foam has not been manufactured

168. Agency for Toxic Substances and Disease Registry, *PFAS in the U.S. Population* (Aug. 21, 2017), https://www.atsdr.cdc.gov/pfas/docs/PFAS_in_People.pdf [<https://perma.cc/FR2Q-2R9R>].

169. EPA, *Fact Sheet: PFOA & PFOS Drinking Water Health Advisories*, 1, 2 (Nov. 2016) https://www.epa.gov/sites/production/files/2016-06/documents/drinkingwaterhealthadvisories_pfoa_pfes_updated_5.31.16.pdf [<https://perma.cc/TVM8-8DM2>].

170. *Drinking water: contaminants: perfluoroalkyl and polyfluoroalkyl substances*, A.B. 841, 2019 Assemb. Reg. Sess. (Cal. 2019).

171. S.B. 0014, 2019 S. Reg. Sess. (Mich. 2019).

172. H.B. 674, 2019 Gen. Assemb. Reg. Sess. (Pa. 2019).

173. Reade et al., *supra* note 90.

174. ITRC: Interstate Technology Regulatory Council, *Aqueous Film-Forming Foam (AFFF)* (2018), <https://pfas-1.itrcweb.org/wp-content/uploads/2019/03/pfas-fact-sheet-afff-10-3-18.pdf> [<https://perma.cc/J5BE-DEZB>].

with the original PFOS composition since 2001, it still contains C8 that breaks down into PFOA and thus still carries the same health and environmental concerns associated with PFAS contamination.¹⁷⁵ Many states, including Arizona,¹⁷⁶ Colorado, Connecticut, Georgia, Kentucky, Michigan,¹⁷⁷ Minnesota, North Carolina, Virginia, Washington, and Wisconsin have proposed or adopted bans on the use of AFFF in training exercises in order to protect the health of firefighters and prevent contamination from runoff.¹⁷⁸

The remaining proposed or adopted laws vary a great degree. For example, California is the only state to date that has proposed the banning of PFAS chemicals in cosmetics. Massachusetts, Maine, Minnesota, New Jersey, New York, and Oregon have singled out PFAS use in children's products, identifying children as a vulnerable class. New York even specifies banning PFAS use in animal products. In addition to water contamination and AFFF use, states are mostly concerned with food wrappers and their effect on human health. Iowa, Maine, Massachusetts, Minnesota, New Jersey, New York, Rhode Island, Vermont, and Washington have all proposed or adopted regulations on food packaging containing PFAS chemicals. Since 2008, Maine has identified PFAS as a chemical of high concern and has required reporting on usage and replacement with safer alternatives.¹⁷⁹

Reporting, listing, and funding goals have also been proposed or adopted in multiple states. Wisconsin requires the state to set health-based groundwater standards for PFOA and PFOS contamination.¹⁸⁰ New Jersey has taken a practical approach requiring all public water systems to begin quarterly monitoring of certain PFAS chemicals by 2021 with maximum

175. Sharon Lerner, *The U.S. Military is Spending Millions to Replace Toxic Firefighting Foam with Toxic Firefighting Foam*, THE INTERCEPT (Feb. 10, 2018, 9:00 AM), <https://theintercept.com/2018/02/10/firefighting-foam-afff-pfos-pfoa-epa/> [<https://perma.cc/TFG4-8K8Q>].

176. Since 2019, Arizona prohibits the use PFAS-containing firefighting foam for training purposes. A.R.S. § 36-1696 (West, Westlaw through First Reg. Sess. of Fifty-Fourth Leg.).

177. 2019 Mich. Pub. Acts H.B. 4389 (Oct. 8, 2019), <http://legislature.mi.gov/doc.aspx?2019-HB-4389> [<https://perma.cc/5QBS-KVVS>]; 2019 Mich. Pub. Acts H.B. 4390 (Oct. 8, 2019), <http://legislature.mi.gov/doc.aspx?2019-HB-4390> [<https://perma.cc/FHU6-28GA>]; 2019 Mich. Pub. Acts H.B. 4391 (Oct. 8, 2019), <http://legislature.mi.gov/doc.aspx?2019-HB-4391> [<https://perma.cc/9BFT-S9LZ>].

178. Charles M. Denton et al., *Expert Focus: US States Outpace EPA on PFAS Firefighting Foam Laws*, NAT'L L. REV. (July 13, 2019), <https://www.natlawreview.com/article/expert-focus-us-states-outpace-epa-pfas-firefighting-foam-laws> [<https://perma.cc/ZY C2-9LDP>].

179. *Maine*, SAFER STATES (2019), <http://www.saferstates.org/states-in-the-lead/maine/> [<https://perma.cc/6ZS7-VB4W>].

180. A.B. 85 (Wis. 2019), <https://docs.legis.wisconsin.gov/2019/proposals/reg/asm/bill/ab85> [<https://perma.cc/5UZ9-RQTF>].

allowable levels between 13 and 14 ppt.¹⁸¹ In 2008, California established a process to identify, prioritize, and evaluate chemicals of concern in consumer products, determine how best to limit exposure or reduce the level of hazard,¹⁸² and establish green chemistry challenge grants and a Green Ribbon Science Panel.¹⁸³ In 2019, the Washington state legislature directed the Department of Ecology to identify and take regulatory action on consumer products that are a significant source of chemicals that are a concern for sensitive populations and species.¹⁸⁴ It prioritizes PFAS for initial consideration.¹⁸⁵ Vermont and New Hampshire have strict liability provisions to hold companies who release toxic chemicals accountable for costs of cleanup and medical monitoring, regardless of whether the releases were intentional, unintentional, permitted, or unpermitted.¹⁸⁶ Pennsylvania has proposed amending the definition of hazardous waste in its Hazardous Site Cleanup Act to include PFAS chemicals for the purposes of cleanup of hazardous sites.¹⁸⁷ It also has bills in both the House and Senate proposing the classification of PFAS as a hazardous substance for purposes of cleaning up hazardous sites.¹⁸⁸ For next steps, Maine has earmarked \$15 million for cleanup of uncontrolled hazardous substances, including PFAS chemicals.¹⁸⁹

This expansive list of varying state regulations is significant for multiple reasons. First, it illustrates that not only has a problem been

181. N.J. Dep't of Env'tl. Prot., *Site Remediation Program* (Mar. 13, 2019) <https://www.nj.gov/dep/srp/emerging-contaminants/> [<https://perma.cc/XNP6-6F5R>].

182. A.B. 1879 (Cal. 2007), https://leginfo.ca.gov/faces/billTextClient.xhtml?bill_id=200720080AB1879 [<https://perma.cc/G2CW-E629>].

183. The Green Ribbon Science Panel (GRSP) acts as a resource and provides advice to the California Department of Toxic Substances Control on a variety of scientific and technical matters related to developing green chemistry and chemicals policy recommendations and implementation strategies. The GRSP must be made up of experts to provide advice on scientific matters, chemical policy recommendations, and implementation strategies. Panel duties and expertise were established in Health and Safety Code 25254 and 25255. DTSC: Dept. of Toxic Substances Control, *Safer Products: What Is the Green Ribbon Science Panel (GRSP)?*, <https://dtsc.ca.gov/grsp/what-is-the-green-ribbon-science-panel-grsp/> [<https://perma.cc/TW2C-7KWD>].

184. WASH. REV. CODE § 70.365.020 (West, Westlaw through 2019 Reg. Sess. of Wash. Leg.).

185. S.B. 5135 (Wash. 2019–2020), <https://app.leg.wa.gov/billsummary?BillNumber=5135&Chamber=Senate&Year=2019> [<https://perma.cc/YN4M-DVGM>].

186. S.37 (Vt. 2019), <https://legislature.vermont.gov/bill/status/2020/S.37> [<https://perma.cc/T8F9-4PSW>].

187. H.R. 1226, 2019 Leg., Reg. Sess. (Pa. 2019), <https://www.legis.state.pa.us/cfdocs/billinfo/billinfo.cfm?year=2019&sind=0&body=H&type=B&bn=1226> [<https://perma.cc/H9SL-TTFB>].

188. H.R. 1364, 2019 Leg., Reg. Sess. (Pa. 2019), <https://www.legis.state.pa.us/cfdocs/billinfo/billinfo.cfm?year=2019&sind=0&body=H&type=B&bn=1364> [<https://perma.cc/2Y2Z-2VGR>]; S. 582, 2019 Leg., Reg. Sess. (Pa. 2019), <https://www.legis.state.pa.us/cfdocs/billinfo/billinfo.cfm?year=2019&sind=0&body=S&type=B&bn=582> [<https://perma.cc/YWH6-CVJH>].

189. 2019 Me. Laws L.D. 1836 (June 20, 2019), <http://legislature.maine.gov/LawMakerWeb/summary.asp?ID=280074498> [<https://perma.cc/SR2N-8MUJ>].

identified, but that multiple state actors recognize the importance of quick, preventative action. Second, it demonstrates the necessity for more well-established scientific consensus on just what the healthy levels, if any, of PFAS exposure are. It is important to note the varying limits of 5 ppt to 70 ppt. Finally, the variety of approaches signifies the need for a comprehensive, uniform, and more precautionary approach until a scientific consensus on the effects of PFAS chemical exposure can be reached.

V. TAKING PRECAUTION GOING FORWARD

Given the speed, or lack thereof, of regulatory action, the significant cost and time to acquire scientific certainty, and the appeal of short-term monetary gains, new products and processes are generally given the benefit of the doubt when introduced into the marketplace. However, this has historically led to backward-looking legal considerations that are aimed at fixing or mitigating the results rather than preventing the problem to begin with. As the full implications of widespread PFAS usage become clear through more study, a more comprehensive legal approach must be implemented to ensure the damage to human health and the environment is either mitigated or minimized. This paper proposes utilizing the Precautionary Principle in subsequent policy developments while the requisite studies are conducted and concluded.

The Precautionary Principle is a widely accepted legal approach that allows for economic and scientific advancement, while also protecting human and environmental health.¹⁹⁰ The Principle states that when an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically.¹⁹¹

Although it has been strongly opposed in the United States, precautionary language and principles can be found in many local ordinances and even in federal legislation, including the National Environmental Policy

190. World Health Org., *The Precautionary Principle: Protecting Public Health, the Environment, and the Future of Our Children*, EUR. WORLD HEALTH ORG. (2009), http://www.euro.who.int/__data/assets/pdf_file/0003/91173/E83079.pdf [<https://perma.cc/VG8X-PBVM>].

191. A.W. Hayes, *The Precautionary Principle*, DEP'T. OF ENVTL. HEALTH, HARV. SCH. OF PUB. HEALTH (2005), <https://pdfs.semanticscholar.org/ad27/4c8ba95e1a25b49f2b9f5f4b54a9ba8b978f.pdf> [<https://perma.cc/F5VZ-59ZL>].

Act,¹⁹² the Clean Air Act,¹⁹³ and the Endangered Species Act.¹⁹⁴ However, as environmental law scholar John Applegate has explained, it is more accurate to describe the United States approach as more of a preference than a principle because it often favors considerations of costs over wellbeing.¹⁹⁵

Internationally, the Precautionary Principle has been more widely applied. The Principle was codified on a global level for the first time in June 1992 by the United Nations Conference on Environment and Development (UNCED) (also known as the “Earth Summit” or the “Rio Conference”), held in Rio de Janeiro. Principle 15 of the Rio Declaration states: “In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damages, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.”¹⁹⁶

In addition, the preamble of the Montreal Protocol to the Vienna Convention 70 endorses a precautionary approach: The parties are “determined to protect the ozone layer by taking precautionary measures to control equitably total global emissions of substances that deplete it.”¹⁹⁷

This principle has been accepted and adopted in many countries as well. The Ecuadorian Constitution requires that the “State will apply precaution and restriction measures in all the activities that can lead to the extinction of species, the destruction of the ecosystems or the permanent alternation of the natural cycles.”¹⁹⁸ In 2004, the Charter for the Environment was adopted into the preamble of the French Constitution. Article 5 of the Charter states:

192. *Calvert Cliffs Coordinating Comm. v. United States Atomic Energy Comm.*, 449 F.2d 1109, 1112 (D.C. Cir. 1971) (“Congress did not establish environmental protection as an exclusive goal; rather, it desired a reordering of priorities, so that environmental costs and benefits will assume their proper place along with other considerations.”).

193. 42 U.S.C. § 7412(b)(3)(C) (2000) (“The Administrator shall delete a substance from the list upon a showing by the petitioner or on the Administrator’s own determination that there is adequate data on the health and environmental effects of the substance to determine that emissions, ambient concentrations, bioaccumulation or deposition of the substance may not reasonably be anticipated to cause any adverse effects to the human health or adverse environmental effects.”).

194. The term “threatened species” means any species which is *likely to become* an endangered species within the foreseeable future throughout all or a significant portion of its range. The language used is precautionary in nature as it refers to occurrences likely to happen and calls for policies to prevent that probable eventuality. *See* 16 U.S.C. § 1532(20) (2018).

195. John S. Applegate, *The Precautionary Preference: An American Perspective on the Precautionary Principle*, 6 HUMAN & ECOLOGICAL RISK ASSESSMENT 13, 13 (2000).

196. Conference Report, United Nations Conf. on Env’t and Dev., Rio Declaration on Env’t and Dev. (June 3–14, 1992), https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_CONF.151_26_Vol.I_Declaration.pdf [<https://perma.cc/N676-SBJB>].

197. The Montreal Protocol, Sept. 16, 1987, <https://ozone.unep.org/sites/default/files/2019-04/Montreal-Protocol-English-2018.pdf> [<https://perma.cc/3STQ-64SB>].

198. REPÚBLICA DEL ECUADOR [CONSTITUTION] Oct. 20, 2008, art. 73.

When there is a risk of damage, however uncertain given the latest state of scientific knowledge, of serious and irreversible impact on the environment, public authorities, applying the precautionary principle, will assure, in their respective areas of competence, that the procedures to assess risk and adopt provisional and proportionate measures to counter possible damage are duly applied and enforced.¹⁹⁹

The Supreme Court of Pakistan has also identified the necessity for a precautionary approach in the case of *Shehla Zia v. WAPDA, P.L.D.* In this case, a coalition of residents opposed the construction of an electricity grid near their homes due to the potential harm to human health and the environment. The Court explained:

There is a state of uncertainty and in such a situation, the authorities should observe the rules of prudence and precaution. The rule of prudence is to adopt such measure which may avert the so-called danger, if it occurs. The rule of precautionary policy is to first consider the welfare and safety of the human beings and the environment and then to pick up a policy and execute the plan which is more suited to obviate the possible danger or make such alternate precautionary measures which may ensure safety.²⁰⁰

Ultimately, this Principle is predominantly rooted in knowledge, specifically, taking precaution until all the requisite knowledge is obtained, thereby making informed and just policies. A popular opposition to regulating activity is the lack of certainty that the proposed action is directly causing the undesired result. Essentially, the burden of proof is placed on the victim to empirically prove the causal relationship between the harm and activity before any redress becomes available. The Precautionary Principle flips that burden of proof, requiring that the proposed activity is treated as potentially harmful until it is proven safe.

In the case of PFAS, the first precautionary step to legally dealing with “forever chemicals” would be to have them officially listed. All PFAS are similar in chemical structure and in certain quantities are known to be toxic. In order to begin the large-scale regulatory approach needed to control the contamination caused by PFAS, it must be properly regulated as a “class” of chemicals and included on the EPA’s Toxics Release Inventory (TRI).²⁰¹

199. *Charter for the Environment*, COUNSEIL CONSTITUTIONNEL, <https://www.conseil-constitutionnel.fr/en/charter-for-the-environment> [<https://perma.cc/P7X4-TSS2>].

200. *Shehla Zia v. WAPDA, P.L.D.*, 1994 S.C. 693.

201. The Toxics Release Inventory (TRI) is a resource for learning about toxic chemical releases and pollution prevention activities reported by industrial and federal facilities. TRI data support informed decision-making by communities, government agencies, companies, and others. Section 313 of the Emergency Planning and Community Right-to-Know Act

The TRI “informs people about releases of toxic chemicals to the environment; assists governmental agencies, researchers, and other persons in the conduct of research and data gathering; and aids in the development of appropriate regulations, guidelines, and standards.”²⁰² There are three reporting criteria under the TRI. If a company is in a specific industry section, such as manufacturing, employs ten or more full-time equivalent employees, and manufactures, processes, or otherwise uses a TRI-listed chemical in quantities above threshold levels in a given year, that company must report to the TRI Program.²⁰³ The only requirement missing from companies that produce and utilize PFAS chemicals is manufacturing a listed chemical.

Once on the TRI, there will be a better understanding of where the greatest concentrations of PFAS contaminations are and what communities are experiencing what effects. Manufacturers will be required to report the amount of PFAS being released into the air, water, and soil annually. This provides the data and information needed to take informed steps with future legal approaches to the regulation of this dangerous and prevalent chemical. It will help determine appropriate next steps such as listing PFAS as a hazardous substance under CERCLA, including it as a toxic pollutant under section 307 of the Clean Water Act, or simply banning its usage until a variation of the chemical compound can be determined both useful and safe.

As the determination concerning PFAS and effects on human and environmental health still contains language such as “probable,” “possible,” “likely,” and “suggestive,” the precautionary approach allows for considerably more protection from harm while still allowing possible productions and scientific advancement. This approach allows for more comprehensive legal and scientific certainty to be achieved while simultaneously protecting the physical and behavioral health of humans and the environment.

CONCLUSION

The time and costs associated with acquiring the requisite data for informed decision-making almost guarantee environmental problems such as chemical contamination are difficult to address legally. However, as that data is collected, environmental degradation and contamination continues to occur. The insufficient federal approaches and vast variety of state regulations are creating a regulatory landscape that will not adequately address the physical and behavioral health concerns nor the potential legal implications of PFAS exposure. This issue affects everything from criminal culpability to clean-up costs, to say nothing of the environmental justice

(EPCRA) created the TRI Program. U.S. Env'tl Prot. Agency, *Toxics Release Inventory (TRI) Program*, <https://www.epa.gov/toxics-release-inventory-tri-program> [<https://perma.cc/RQX6-F723>].

202. 42 U.S.C. § 11023(h) (2012).

203. *Toxics Release Inventory (TRI) Reporting*, *supra* note 201.

issues that the United States has been required to prevent since the 1990s. With an issue as expansive and pervasive as PFAS chemical exposure, the Precautionary Principle must be employed while the requisite information is acquired to prevent further accumulation of this potentially and very likely dangerous substance.