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NOTE

DON'T GO NEAR THE WATER: HOW PFAS REGULATION IN NORTH CAROLINA IS FALLING DRASTICALLY SHORT, AND HOW TECHNOLOGY CAN BRIDGE THE GAP

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Per- and polyfluoroalkyl substances ("PFAS") present one of the greatest global challenges in environmental regulation today. Their vast presence and persistence across virtually the entire world has resulted in a staggering 99% of humans having detectable levels of PFAS in their blood. These man-made chemicals have been linked to several diseases and health issues, including cancer and birth defects. Despite all of this, the United States only recently issued its first enforceable limit on PFAS in 2024. This Note will take a critical view of the current state of PFAS regulation both federally and in North Carolina, as well as proposed solutions on how we can use technology to bridge the regulatory gaps.

TABLE OF CONTENTS

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I. INTRODUCTION

In 1974, Johnny Cash debuted a poignant protest song, "Don't Go Near the Water," which resonated with an era steeped in environmentalist movements and emphasized a clear message: Clean the water and keep it clean.[1] While a catchy song, Cash's warnings have seemingly gone unheard by polluters and regulators. Fifty years after the release of Cash's song, the United Nations issued a press release, declaring that the release of per- and polyfluoroalkyl substances ("PFAS") by chemical companies DuPont and Chemours "completely disregard[ed] the rights and well-being of residents along the lower Cape Fear River in North Carolina."[2]

PFAS, also known as "forever chemicals," are a unique class of man-made chain polymers and non-polymers with 12,034 known variants.[3] The nickname "forever chemicals" comes from the very slow

1. JOHNNY CASH, *Don't Go Near the Water*, RAGED OLD FLAG (Columbia Recs. 1974).
2. Press Release, U.N. Council for Human Rights, US Companies DuPont and Chemours Generated Extensive Contamination with Toxic "Forever Chemicals" in North Carolina: UN Experts (Feb. 21, 2024), https://www.ohchr.org/en/press-releases/2024/02/us-companies-dupont-and-chemours-generated-extensive-contamination-toxic [https://perma.cc/P7CD-K57S (staff-uploaded)].
3. Nadia Gaber, Lisa Bero & Tracey J Woodruff, *The Devil They Knew: Chemical Documents Analysis of Industry Influence on PFAS Science*, 89 ANNALS GLOB. HEALTH 2, 2 (2023).

breakdown of PFAS, resulting in the buildup of the man-made chemicals in people, animals, and the environment in great quantities over time.[4] Industries use PFAS because of their useful properties.[5] PFAS can be found in products such as fire extinguishing foam ("aqueous film-forming foams" or "AFFFs"), food packaging, clothing, carpets, cleaning products, non-stick cookware, paints, and beauty products.[6]

While most research focuses on the two most widely used PFAS variants, perfluorooctanoic acid ("PFOA" or "C-8") and perfluorooctane sulfonate ("PFOS"), peer-reviewed scientific studies have linked exposure to PFAS to several adverse health effects in humans.[7] These effects include: decreased fertility, developmental defects in children, increased risk of certain cancers, reduced immune response, hormonal interference, and increased risk of obesity.[8] Moreover, researchers still have many questions about the totality of the effects of PFAS, as the great number of variants, differences in exposure, and differences in PFAS use can make it hard to conduct complete and accurate studies.[9]

Humans are not uniquely impacted. The persistence of PFAS in air, water, and soil results in the presence and buildup of these chemicals throughout food chains.[10] PFAS have been found in birds, fish, amphibians, reptiles, and mammals worldwide.[11] PFAS have the

4. *Our Current Understanding of the Human Health and Environmental Risks of PFAS*, EPA, https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas [https://perma.cc/3TDT-B3LL] (last updated Feb. 10, 2026).

5. *Id.*

6. *Id.*

7. *Id.*

8. *Id.*

9. *Id.*

10. Gerald T Ankley et al., *Assessing the Ecological Risks of Per- and Polyfluoroalkyl Substances: Current State-of-the Science and a Proposed Path Forward*, 40 ENV'T TOXICOLOGY & CHEMISTRY 631, 644 (2020).

11. Amila O. De Silva et al., *PFAS Exposure Pathways for Humans and Wildlife: A Synthesis of Current Knowledge and Key Gaps in Understanding*, 40 ENV'T TOXICOLOGY & CHEMISTRY 631, 644 (2021).

tendency to bioaccumulate[12] and biomagnify.[13] These traits have been linked to tumors, liver and kidney issues, and immunological effects in animals.[14]

However, even with harmful effects of PFAS being known by agencies for at least 20 years, U.S. regulators have been glacially slow to respond.[15] The Environmental Protection Agency ("EPA") took until 2024 to establish any enforceable limitations to PFAS, with a national drinking water standard for PFAS and the designation of PFAS as a hazardous substance under the Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA").[16] Currently, North Carolina has only three widely applicable enforceable regulation related to PFAS, which is a 2 parts per trillion interim maximum allowable concentration of PFOA in groundwater.[17]

12. *Bioaccumulation*, MERRIAM-WEBSTER, https://www.merriam-webster.com/dictionary/bioaccumulation [https://perma.cc/HH9P-XCHP] (last visited Mar. 31, 2026) (defines bioaccumulation as "the accumulation over time of a substance and especially a contaminant . . . in a living organism").

13. De Silva et al., *supra* note 11, at 644; *Biomagnification*, MERRIAM-WEBSTER, https://www.merriam-webster.com/dictionary/biomagnify [https://perma.cc/L4U5-JZUX] (last visited Mar. 31, 2026) (defines biomagnification as "the process by which a compound (such as a pollutant or pesticide) increases its concentration in the tissues of organisms as it travels up the food chain").

14. NAT'L WILDLIFE FED'R, THE PFAS CRISIS: LONG-LASTING CHEMICALS THREATEN THE GREAT LAKES REGION 1, https://www.nwf.org/-/media/Documents/PDFs/Waters/The-PFAS-Crisis-Fact-Sheet.pdf [https://perma.cc/42JX-6KUG] (last visited Apr. 4, 2026).

15. Scott Faber, *For 20-plus Years, EPA Has Failed to Regulate 'Forever Chemicals'*, ENV'T WORKING GRP. (Jan. 9, 2020), https://www.ewg.org/research/20-plus-years-epa-has-failed-regulate-forever-chemicals [https://perma.cc/STN7-96KS].

16. *Key EPA Actions to Address PFAS*, EPA, https://www.epa.gov/pfas/key-epa-actions-address-pfas [https://perma.cc/3RDV-8D5Q] (last updated July 29, 2025) [hereinafter *Key EPA Actions*].

17. 15A N.C. ADMIN. CODE 2L.0202 (2025); *EWG Proposes PFAS Standards That Fully Protect Children's Health*, ENV'T WORKING GRP. (May 6, 2019), https://www.ewg.org/research/ewg-proposes-pfas-standards-fully-protect-childrens-health [https://perma.cc/7FCF-DP84] (explaining a study that shows while carbon filtration can lower levels to detection limits of 2 parts per trillion, research shows that truly safe levels should be to strive to be as close to zero as possible).

This Note is divided into six Parts, providing an overview of the dangers of PFAS and of the shortcomings and lack of regulation for "forever chemicals," and proposes that the regulatory landscape would benefit from incorporating technological and legal tools into its arsenal. Part II provides a brief primer on the history of PFAS, the development of scientific studies showing the harms of PFAS, the legal battles which led to where the United States is today, and an in-depth look at PFAS production in North Carolina. Part III will dive deeper into both the federal and state regulations that affect North Carolina. Part IV examines the current role of technology in PFAS monitoring, regulation, and remediation, focusing on the gaps between regulating polluters and regulating utilities. Part V will consider how developing technologies may result in safer water. Finally, Part VI will briefly summarize the regulations and their connection to technology and make policy recommendations moving forward.

II. A Brief Primer on the History of PFAS

A. The Development and Widespread Use of PFAS

PFAS were first discovered accidentally by a DuPont scientist in 1938 when he created polytetrafluoroethylene ("PTFE"), now commonly known as Teflon.[18] The creation of Teflon requires the use of PFOA in the production process.[19] Teflon is so versatile and useful that the scientists of the Manhattan Project used it because it resisted corrosion from the materials used in uranium enrichment.[20] By the 1940s, Teflon hit the open market, and the profits were high and long lasting—in a 2005 Securities Exchange Commission filing, DuPont disclosed that the company earned $1 billion per year in revenue from

18. James B. Pollack, Isabel Q. Carey & Victor Y. Xu, PFAS Deskbook 5 (2023).

19. Greta Stieger, *Repercussions of PFOA at Teflon Production Site*, Food Packaging F. (Jan. 12, 2016), https://foodpackagingforum.org/news/repercussions-of-pfoa-at-teflon-production-site [https://perma.cc/3UP6-BGKN].

20. Colleen Leahy, *PFAS Were Originally Used to Contain Nuclear Chemicals, New Book Finds*, Wis. Pub. Radio (July 11, 2025), https://www.wpr.org/news/pfas-were-originally-used-to-contain-nuclear-chemicals-new-book-finds [https://perma.cc/ZZC6-D95R].

Teflon.[21] Soon after DuPont's discovery of Teflon and PFOA, 3M discovered a different PFAS variant called PFOS, marketed in the 1950s as Scotchgard.[22] This compound was used for preventing food packing from getting soggy, extinguishing jet fuel fires, and protecting clothes from stains.[23] Within the span of nearly half a century, 3M produced over a 100 million pounds of products containing PFOS.[24]

Companies such as DuPont and 3M have long known about the dangers of the PFAS that they were producing.[25] Internal studies by the companies, ranging from 1961 to 1994, show evidence of PFAS toxicity in both animal and occupational studies; however, these studies were not published, and DuPont failed to report these findings to the EPA as required by the Toxic Substance Control Act ("TSCA").[26] These reports showed concerning effects, including liver enlargement in rats, cellular damage and resulting death in dogs, birth defects in the children of female employees, and a potential increase in prostate cancers.[27]

B. The Birth of the Legal Battle Against PFAS

The birthplace of the battle against PFAS began with an unlikely duo: a concerned farmer in Parkersburg, West Virginia and a chemical defense lawyer.[28] Wilbur Tennant and his family ran a 600-acre farm with over 200 cows.[29] In the early 1980s, Tennant's brother sold part of

21. *Id.; For DuPont, $1B a Year Rides on Teflon*, EWG (Nov. 7, 2005), https://www.ewg.org/news-insights/news/dupont-1b-year-rides-teflon [https://perma.cc/HL3N-5D2P].

22. Pollack, Carey & Xu, *supra* note 18, at 5.

23. Sharon Learner, *How 3M Discovered, then Concealed, the Dangers of Forever Chemicals*, The New Yorker (May 20, 2024), https://www.newyorker.com/magazine/2024/05/27/3m-forever-chemicals-pfas-pfos-toxic [https://perma.cc/6R8X-L9MD].

24. *Id.*

25. *See generally* Gaber et al., *supra* note 3 (discusses how the chemical industry knew about the dangers of PFAS as early as the 1960s).

26. *Id.* at 9.

27. *Id.* at 9–10.

28. Nathaniel Rich, *The Lawyer Who Became DuPont's Worst Nightmare*, N.Y. Times Mag. (Jan. 6, 2016), https://www.nytimes.com/2016/01/10/magazine/the-lawyer-who-became-duponts-worst-nightmare.html [https://perma.cc/3YBA-2A3P].

29. *Id.*

the farm's original acreage to DuPont, where DuPont used the plot as a corporate dump named Dry Run Landfill, serving the company's Washington Works plant located in Parkersburg.[30] Tennant approached Rob Bilott, a new partner at Taft Stettinius & Hollister, after Tennant began observing behavioral shifts, deformities, and death in his herd of cattle.[31] Tennant believed that these effects were caused by the discharge running off from DuPont's adjacent landfill.[32] Even though Bilott and his firm worked for the "other side" of environmental law in chemical defense, he decided to take a look at the case since the Tennants had a connection to his grandmother, who lived in a neighboring West Virginia town.[33]

Deciding to take the case, Bilott filed suit in the Southern District of West Virginia.[34] As the suit progressed and Bilott began sorting through discovery, he uncovered the dark truth: studies showing the dangers of the PFOA being produced at the plant, documents showing that 7,100 tons of PFOA sludge were dumped into unlined pits on the Washington Works property, and evidence of contaminated powder being dumped into the Ohio River.[35] This information resulted in an easy settlement in the Tennant case, but Bilott did not stop there.[36]

Bilott spent the months following the Tennant settlement creating a public brief against DuPont, demanding that federal regulatory agencies such as the EPA take immediate action to regulate PFOA.[37] Sent in 2001, the letter resulted in a $16.5 million settlement with the EPA over DuPont's violation of TSCA by concealing PFOA's presence and toxicity.[38]

A class-action suit on behalf of six water districts that had been exposed to PFOA by the Washington Works plant followed.[39] The settlement of this suit resulted in DuPont installing filtration at the

30. *Id.*
31. *Id.*
32. *Id.*
33. *Id.*
34. *Id.*
35. *Id.*
36. *Id.*
37. *Id.*
38. *Id.*
39. *Id.*

water districts effected and the payment of a cash award of $70 million.[40] This money funded a "C-8 Science Panel," a group created to determine if there was a "probable link" between PFOA and any diseases.[41] Any connection would result in medical monitoring of the affected groups in perpetuity.[42] This panel conducted one of the largest epidemiological studies ever completed, with nearly 70,000 West Virginians donating blood for testing.[43] After *seven years*, the panel finally released its findings: PFOA exposure had a probable link to kidney cancer, testicular cancer, thyroid disease, high cholesterol, preeclampsia, and ulcerative colitis.[44] At the end of this suit, DuPont agreed to provide up to $235 million for medical monitoring for the citizens living in the six affected water districts.[45] By 2014, over 3,500 affected residents brought lawsuits against DuPont because of diseases alleged to be caused by PFOA.[46] The suits settled for $671 million in 2017, though DuPont denied any wrongdoing.[47]

While DuPont ceased production of PFOA in 2013, and the five other companies that produce PFOA are also phasing out production, these companies are still producing other PFAS variants.[48] DuPont entered a merger with Dow Chemical, creating a new chemical

40. *Id.*
41. *Id.*
42. *Id.*
43. *Id.*
44. *C-8 Probably Link Reports*, C-8 SCI. PANEL, http://www.c8sciencepanel.org/prob_link.html [https://perma.cc/UDW5-B9FL] (last visited Feb. 28, 2026).
45. *DuPont Lawsuits (re PFOA Pollution in USA)*, BUS. & HUM. RTS. CTR., https://www.business-humanrights.org/en/latest-news/dupont-lawsuits-re-pfoa-pollution-in-usa/ [https://perma.cc/K3N3-L3TE] (last visited Feb. 28, 2026).
46. *Id.*
47. *Id.*
48. Rich, *supra* note 28.

company called Chemours,[49] which now produces at least twelve detected variants of PFAS.[50]

C. PFAS Production in North Carolina

The Chemours/DuPont Fayetteville Works facility in Fayetteville, North Carolina, is in the hot seat for manufacturing "GenX," a different form of PFAS, and for contaminating the Cape Fear River and adjacent water supplies.[51] As previously mentioned, the contamination in North Carolina raised concern for the United Nations Office of the High Commissioner of Human Rights, which issued a formal statement highlighting that DuPont and Chemours "completely disregard[ed] the rights and wellbeing of residents along the lower Cape Fear River."[52] Opened in the 1970s, the Fayetteville Works facility has polluted the drinking water of at least eight different Eastern North Carolina counties: New Hanover, Pender, Brunswick, Sampson, Cumberland, Bladen, Robeson, and Columbus County.[53] The polluted water makes up the drinking water for more than half a million North Carolinians.[54]

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49. Al Greenwood, *DuPont Used Chemours, Dow Merger to Shield Itself from PFAS Claims-Suit*, INDEP. COMMODITY INTEL. SERVS. (Oct. 15, 2020), https://www.icis.com/explore/resources/news/2020/10/15/10563956/dupont-used-chemours-dow-merger-to-shield-itself-from-pfas-claims-suit/ [https://perma.cc/5SE8-3DQK].

50. *Our Position on PFAS*, CHEMOURS, https://www.chemours.com/en/pfas-advocacy [https://perma.cc/87KS-W8Z8] (last visited Mar. 31, 2026); Evey Weisblat, *PFAS Found in Dust of Homes Near Fayetteville Chemical Plant*, CITYVIEW (Apr. 1, 2025), https://www.cityviewnc.com/stories/pfas-found-in-dust-of-homes-near-fayetteville-chemical-plant [https://perma.cc/UYV7-TPHW].

51. *PFAS*, CAPE FEAR RIVER WATCH, https://capefearriverwatch.org/genx [https://perma.cc/FU82-XNJP] (last visited Mar. 20, 2026).

52. U.N. Council for Human Rights, *supra* note 2.

53. Press Release, Southern Environmental Law Center, SELC Objects to Chemours and DuPont Hiding Information About Their Toxic PFAS Pollution (Apr. 14, 2025), https://www.selc.org/press-release/selc-objects-to-chemours-and-dupont-hiding-information-about-their-toxic-pfas-pollution [https://perma.cc/JT7D-JXHY].

54. *Id.*

In response to widespread PFAS concern, companies developed "PFAS alternatives."[55] One of these alternatives is hexafluoropropylene oxide dimer acid ("HFPO-DA"), commercially known as GenX.[56] Though specially designed to serve as a replacement for PFOS, GenX is still a PFAS variant.[57] This chemical was expected to break down more easily due to the presence of oxygen in its perfluorocarbon chain, unlike longer-chain PFAS.[58] After the introduction of GenX in 2010, Chemours widely produced the compound, with much of this production occurring at the Fayetteville Works facility.[59] Within one year, the Fayetteville facility was estimated to have discharged more than 1.22 tons of GenX into the Cape Fear River.[60]

This alternative chemical is just as harmful—in October 2021, the EPA released a human health toxicity assessment for GenX.[61] The assessment showed that in animal studies, oral exposure to GenX resulted in health effects concerning the liver, kidneys, immune system, and fetal development, as well as cancer.[62] Additionally, despite is shorter chain, GenX chemicals were found to "have similar persistence in the environment as longer chain PFAS, such as PFOA and PFOS."[63] GenX is also "more mobile than longer chain PFAS," which can result in "exposure at greater distances than legacy PFAS in off-site transport or in groundwater."[64] While the EPA found that GenX does "not appear to accumulate as much in humans as longer chain PFAS," the EPA notes that it has not considered the effect of

55. Wanqian Guo, Weidong Hao & Wusheng Xiao, *Emerging Perfluorinated Chemical GenX: Environmental and Biological Fates and Risks*, 3 ENV'T & HEALTH 388, 388 (2025).

56. *Id.*

57. *Id.*

58. *Id.*

59. *Id.*

60. *Id.*

61. *Human Health Toxicity Assessments for GenX Chemicals*, EPA, https://www.epa.gov/chemical-research/human-health-toxicity-assessments-genx-chemicals [https://perma.cc/DJ4X-YTCX] (last updated Nov. 12, 2025).

62. *Id.*

63. *Id.*

64. *Id.*

GenX in human bodies in aggregate with other forms of PFAS or other chemicals often found in humans.[65]

The release of PFAS and GenX into the Cape Fear River has been the subject of much public and legal scrutiny. In 2019, the North Carolina Department of Environmental Quality ("NC DEQ"), Cape Fear River Watch, and Chemours entered into a consent order.[66] The order lays out several steps that Chemours must take regarding PFAS contamination, including testing private wells for PFAS, providing drinking water supplies, implementing remedial technology both for water discharge and air emissions, conducting assessments of groundwater contamination, and implementing technology and other measures to reduce the emissions of PFAS from the Fayetteville Works facility.[67]

A year after this order was signed, the court created an addendum to the consent order, which established measures intended to address more than 90% of the PFAS contamination that enters the Cape Fear River specifically through the groundwater surrounding the site.[68] In 2021, the NC DEQ determined that Chemours was additionally responsible for monitoring wells in New Hanover County, and by 2022 NC DEQ found that Chemours is additionally required to monitor wells in three more counties: Brunswick, Columbus, and Pender.[69]

In 2020, North Carolina Attorney General Josh Stein filed a lawsuit against DuPont, Chemours, and related companies, that alleged that the manufacturing, use, and disposal of PFAS variants at the Fayetteville Works facility caused damage to North Carolina's natural resources, including groundwater, surface water, soil,

65. *Id.*

66. *Chemours Consent Order*, N.C. DEP'T ENV'T QUALITY, https://www.deq.nc.gov/news/key-issues/genx-investigation/chemours-consent-order [https://perma.cc/XN68-CMZF] (last visited Jan. 31, 2025); *Consent Order*, CORNELL L. SCH.: LEGAL INFO. INST., https://www.law.cornell.edu/wex/consent_order [https://perma.cc/M2JF-PM55] ("A consent order (also known as a consent decree) is a decree or order made by a judge with the consent of all parties. It is not strictly a judgment, but rather a settlement agreement approved by the court.").

67. *Id.*

68. *Id.*

69. *Id.*

wetlands, air, and animals.[70] Additionally, the complaint pointed to the harmful impact of PFAS on both the health of humans and the environment, focusing on the "bioaccumulat[ion], biopersist[ance], and biomagnifi[cation] in humans and other organisms."[71] At the Supreme Court of North Carolina, the court held that the "New DuPont" created via merger could be held liable for the actions of "Old DuPont."[72] The case is now back at the Supreme Court of North Carolina, and the "New DuPont" (i.e. Chemours) was granted a temporary stay in October of 2025.[73]

Additionally, groups of North Carolina residents have filed at least nine lawsuits against Chemours, DuPont, and Corteva (another local PFAS producer) regarding contamination of the Cape Fear River with PFAS.[74] Two North Carolina counties, Cumberland[75] and Brunswick,[76] have also filed.

North Carolina communities are making their voices heard. In 2022, Wilmington residents gathered at a Chemours public information session protesting a proposed expansion of the

70. Complaint at 10–18, North Carolina v. E.I. DuPont de Nemours & Co., 2021 NCBC 54 (2020), https://ncdoj.gov/wp-content/uploads/2020/10/Signed-Final-Complaint.pdf [https://perma.cc/LGG7-7TNH].

71. *Id.* at 16–18.

72. State *ex rel.* Stein v. E.I. DuPont de Nemours & Co., 382 N.C. 549, 564 (2022).

73. State *ex rel.* Jackson v. E.I. DuPont de Nemours & Co., 921 S.E.2d 158, 158 (N.C. 2025).

74. Weisblat, *supra* note 50.

75. Press Release, Cumberland County, Cumberland County Files Lawsuit Against Chemours and DuPont (Mar. 18, 2022), https://www.cumberlandcountync.gov/home/2022/03/18/cumberland-county-files-lawsuit-against-chemours-and-dupont [https://perma.cc/7HT9-VDH3]; Complaint, Cumberland County. v. Chemours Co., 2022 EDNC 46 (2020), https://cases.justia.com/federal/district-courts/north-carolina/ncedce/5:2022cv00157/193836/46/0.pdf [https://perma.cc/4MYC-97JE].

76. Charlie Shelton-Ormond & Frank Stasio, *Lawsuits Roll in Against Chemours Over GenX in the Cape Fear River*, WUNC NEWS (Nov. 2, 2017, at 12:05 ET) https://www.wunc.org/environment/2017-11-02/lawsuits-roll-in-against-chemours-over-genx-in-the-cape-fear-river [https://perma.cc/49E2-A669]; *Toxic Substance Control Act (TSCA)*, CLEAN CAPE FEAR, https://www.cleancapefear.org/legal [https://perma.cc/4UBL-C79A] (last visited Mar. 31, 2026) (explaining that Brunswick county suit was consolidated with the Cape Fear Public Utility Authority suit).

Fayetteville Works facility.[77] Fayetteville residents protested at the entrance of the facility itself, calling for an end to the pollution and attempting to raise awareness of GenX.[78] Despite all of the lawsuits and community outcry, regulation still falls short.

III. Regulation, and Lack Thereof, of PFAS

A. Federal Regulations

Federal PFAS regulation has been slow to come about. The EPA did not finalize the first enforceable PFAS limit until April 2024, with a national drinking water standard under the Safe Drinking Water Act.[79] Additionally, in the same month, the EPA finalized a rule designating PFOA and PFOS as hazardous substances under CERCLA.[80] Other PFAS regulations do not necessarily create any enforceable limits to PFAS pollution.[81] For example, in January 2024, the EPA finalized a rule that prevents PFAS manufacturers from resuming making or processing 329 PFAS variants that have not been made or used for several years without a complete EPA review and risk determination.[82] Other rules and actions include reporting and monitoring requirements, funds for infrastructure to eliminate contaminants such as PFAS, and the addition of five PFAS compounds to risk-based values for site clean ups.[83] While the EPA has issued guidance on PFAS destruction and disposal, testing and monitoring

77. Grace Vitaglione, *"Chemours, Don't Be Bad Guys": Residents Protest Proposed Fayetteville Works Expansion*, WHQR Media (Sep. 22, 2022, at 16:42 ET), https://www.whqr.org/local/2022-09-22/chemours-dont-be-bad-guys-residents-protest-proposed-fayetteville-works-expansion [https://perma.cc/5DL3-JCQX].

78. Paul Woolverton, *Protesters Aim to Stop Chemours*, Fayetteville Observer, https://www.fayobserver.com/story/news/politics/county/2019/10/27/protesters-aim-to-stop-chemours-plant-near-fayetteville/2437197007 [https://perma.cc/EPG9-EFXY] (last updated Oct. 26, 2019).

79. *Key EPA Actions*, *supra* note 16.

80. *Id.*

81. *Id.*

82. *Id.*

83. *Id.*

strategies, toxicity assessments, and strategic road maps, this guidance are simply that; not commanding law, but mere guidance.[84]

Though a big step, the only enforceable PFAS limit has a rather narrow scope. The requirements laid out by the national primary drinking water regulations for PFAS apply to community water systems and non-transient, non-community water systems—boiling down to public and private water utilities.[85] These regulations require water providers maintain analytical, reporting, monitoring, and Maximum Contaminant Level ("MCL") limits.[86] Of the more ambitious goals, MCL compliance of 4 parts per trillion for PFOA and PFOS and 10 parts per trillion for three other PFAS variants, including GenX, was required by April 26, 2029.[87] However, the EPA recently announced that, while it is keeping the same MCLs for these PFAS variants, it is proposing to extend the compliance deadline to 2031.[88]

Worse, the regulation of companies manufacturing, discharging, and disposing of PFAS is even narrower. In 2022, the EPA released a memorandum regarding PFAS discharges addressed in National Pollutant Discharge Elimination System ("NPDES") permits.[89] NPDES permits under the Clean Water Act ("CWA") regulate point sources that discharge pollutants into the waters of the United States ("WOTUS").[90] WOTUS are the "navigable waters" that the United States has federal jurisdiction over according to the CWA.[91] Within

84. *Id.*

85. 40 C.F.R. § 141.900(a) (2024).

86. *Id.*

87. *Id.*; *id.* § 141.61(c)(2); *Per- and Polyfluoroalkyl Substances (PFAS): Final PFAS National Primary Drinking Water Regulation*, EPA, https://www.epa.gov/sdwa/and-polyfluoroalkyl-substances-pfas [https://perma.cc/8YNZ-D6KG] (last updated Dec. 4, 2025).

88. Press Release, EPA, EPA Announces It Will Keep Maximum Contaminant Levels for PFOA, PFOS (May 12, 2025), https://www.epa.gov/newsreleases/epa-announces-it-will-keep-maximum-contaminant-levels-pfoa-pfos [https://perma.cc/FY4R-94AE].

89. Memorandum from the EPA Assistant Administrator to EPA Regional Water Division Directors, Regions 1-10 (Dec. 5, 2022) (on file with author).

90. *Id.*

91. *About Waters of the United States*, EPA, https://www.epa.gov/wotus/about-waters-united-states [https://perma.cc/97KA-TGLD] (last updated Nov. 17, 2025).

the CWA, pollutants are widely defined as "dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water."[92] The memorandum provides guidance "for addressing PFAS discharges when they are authorized to administer the NPDES permitting program."[93] While this memorandum does not create enforceable limits or standards, it encourages permitting authorities to be stringent in their permitting and monitoring of PFAS from point sources into WOTUS.[94]

However, the Supreme Court has weakened the strength of NPDES permitting over recent years. Before 2023, WOTUS was defined in *Rapanos*[95] as having a "significant nexus," which requires that waters in question be "significantly affect[ed by] the chemical, physical, and biological integrity of other covered waters more readily understood as 'navigable.'"[96] Further, in the recent *Sackett v. EPA* decision, the Court explicitly rejected this formulation of WOTUS, instead adopting a rule that WOTUS only includes water and "wetlands with continuous surface connection to bodies that are 'water of the United States' in their own right" and that these waters must be "indistinguishable" from the established WOTUS.[97] North Carolina quickly adopted the federal WOTUS definition with the North Carolina Farm Act of 2023.[98]

This shift leaves a large regulatory gap, especially in North Carolina. In a recent study, the Environmental Defense Fund found that the total non-tidal wetland area at risk of losing protections post-*Sackett* ranges from 81.4 to 82.8 million acres.[99] North Carolina

92. 33 U.S.C. § 1362(6) (1972).

93. Memorandum from the EPA Assistant Administrator, *supra* note 89.

94. *Id.*

95. 547 U.S. 715 (2006).

96. Rapanos v. United States, 547 U.S. 715, 753 (2006) (citation omitted).

97. Sackett v. EPA, 598 U.S. 651, 684 (2023) (citation omitted).

98. 2023 N.C. Sess. Laws 63, § 15(d).

99. *Estimating Clean Water Act Wetlands Protections*, ENV'T DEF. FUND, https://www.edf.org/maps/wetlands-protections/ [https://perma.cc/8NPF-EPCS] (last visited Feb. 24, 2026).

ranks among the states most affected, with 3.19 to 3.23 million acres of wetlands at risk of losing protections.[100] The reduction of waters considered WOTUS will result in fewer NPDES permits, and thus less opportunity to limit, monitor, and enforce effluent limits on chemicals such as PFAS.

Furthermore, the Court's 2020 *County of Maui v. Hawaii Wildlife Fund*[101] decision created uncertainty for the regulation of groundwater under the CWA. In *County of Maui*, the Court held that a permit is required "if the addition of pollutants through groundwater is the functional equivalent of a direct discharge from the point source into navigable waters."[102] This opinion creates uncertainty in how groundwater will be regulated under NPDES permits.[103]

The CWA requires states, territories, and native tribes to implement water quality standards regarding certain waters identified by the CWA as impaired waters.[104] For these waters, the state must additionally establish a total maximum daily load for pollutants listed by the EPA administrator as a part of the implemented standards.[105] However, these "toxic pollutants" listed do not include any PFAS compounds.[106]

B. North Carolina

North Carolina currently has a few enforceable regulations related to PFAS, including limits for PFOA, PFOS, and GenX in groundwater.[107] Other PFAS legislation and regulations in North Carolina are marginally stronger than their federal counterparts, but North Carolina law focuses only on private drinking wells.[108] In 2023,

100. *Id.*

101. 590 U.S. 165 (2020).

102. *Id* at 170.

103. Julie Schwartzwald Meaders, *Recent Developments in Environmental Law*, 34 TUL. ENV'T L.J. 229, 231 (2021).

104. 33 U.S.C. § 1313(d)(1)(A) (2000).

105. *Id.* § 1313(d)(1)(C).

106. 40 C.F.R. § 131.3(d) (1983); 40 C.F.R. § 401.15 (1981).

107. 15A N.C. ADMIN. CODE 2L.0202(h) (2025).

108. *Action Strategy for PFAS*, N.C. DEP'T ENV'T QUALITY, https://www.deq.nc.gov/news/key-issues/emerging-compounds/action-strategy-pfas [https://perma.cc/C5VR-YZN3] (last visited Feb. 1, 2026).

NC DEQ launched a program under the Bernard Allen Emergency Drinking Water Fund to support North Carolinians who have discovered PFAS contamination in their private drinking wells.[109] Additionally, the Secretary of the NC DEQ has been given authority by statute to require PFAS polluters to pay for owners of private wells to obtain replacement water supplies.[110]

However, the North Carolina Environmental Management Commission ("EMC") has recently proposed new rules regarding PFAS regulation.[111] These proposed "PFOS, PFOA, and GenX Monitoring and Minimization" rules set out certain monitoring requirements, which is important.[112] However the term "minimization" is misleading: The EMC instructed the NC DEQ to prepare the rules in a way which does not require PFAS polluters to reduce their releases into North Carolina drinking water supplies, and even has "no consequence even if polluters *increase* their toxic discharges."[113]

IV. The Current Role of Technology in PFAS Monitoring, Regulation, and Remediation

A. The Technology Gaps

Under the Safe Water Drinking Act, when a drinking water regulation establishes a MCL, the regulation "shall list the technology, treatment techniques, and other means which the Administrator finds to be feasible for purposes of meeting such maximum contaminant level."[114] For all six listed PFAS variants, the Best Available Technology ("BAT") listed is anion exchange, granular activated charcoal ("GAC"), reverse osmosis, and nanofiltration.[115]

109. *Id.*

110. N.C. Gen. Stat. § 143-215.2A (2018).

111. 15A N.C. Admin. Code 02B.0512 (proposed Mar. 10, 2026).

112. *Id.*

113. Press Release, Southern Environmental Law Center, Conservation Groups Object to Polluter-Written PFAS and 14 Dioxane Rules (Dec. 10, 2025), https://www.selc.org/press-release/conservation-groups-object-to-polluter-written-pfas-and-14-dioxane-rules/ [https://perma.cc/6F4E-LCNQ].

114. 42 U.S.C. § 300g-1(b)(4)(E)(i) (1996).

115. 40 C.F.R. § 142.62(a) (2025).

However, the BATs provided by the EPA come with issues of their own. Anion exchange uses a polymeric resin in an aqueous matrix that uses negatively charged counter ions to pull out ions such as sulfate, uranium, nitrate, and now PFAS.[116] This method has even been shown to perform better than other PFAS removal techniques, including GAC, especially when it comes to short-chain PFAS.[117] However, the resin used through anion exchange comes in two forms: single-use-and-dispose and regenerate-reuse models.[118] Single-use-and-dispose systems are easier to implement in smaller systems; however, the need to destroy the PFAS-laden resin after use brings about other environmental concerns, including eutrophication, acidification, carcinogenicity, and ecotoxicity.[119] The regenerate-reuse models can operate for longer durations, however, the production of PFAS-laden brine still creates a PFAS waste disposal issue.[120]

116. Fuhar Dixit et al., *PFAS Removal by Ion Exchange Resins: A Review*, 272 CHEMOSPHERE 1, 5–6 (2021).

117. *Id.* at 6.

118. *Id.* at 11.

119. *Id.*; *What is Eutrophication?*, NAT'L OCEAN SERV., https://oceanservice.noaa.gov/facts/eutrophication.html [https://perma.cc/FC2Y-MQF4] (last visited Mar. 31, 2026) (explaining eutrophication is a process in which an increase load of nutrients results in an increase in the amount of plant and algae which can result in low oxygen levels in water killing fish); *Lake Acidification: Causes, Consequences, and Mitigation*, HOMEWATER (May 2025), https://www.homewater.com/blog/lake-acidification [https://perma.cc/6NG8-TD4U] (explaining that acidification is when the waters pH levels change making difficult for the survival of some plants and animals); *Carcinogenicity*, SCIENCEDIRECT, https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/carinogenicity [https://perma.cc/H82N-Z2VZ] (last visited Mar. 31, 2026) (explaining that carcinogenicity is "the ability of a material to cause cancer"); *Ecotoxicity*, SCIENCEDIRECT, https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/ecotoxicity [https://perma.cc/5L7V-7QR3] (last visited Mar. 31, 2026) (defining ecotoxicity as "the potential of hazardous chemicals to cause harm to various organisms in the environment").

120. Anderson C. Ellis, Treavor H. Boyer & Timothy J. Strathmann, *Regeneration of Conventional and Emerging PFAS-Selective Anion Exchange Resins Used to Treat PFAS-Contaminated Waters*, 355 SEPARATION & PURIFICATION TECH., part B, 2025, at 1, 2, https://www.sciencedirect.com/science/article/pii/S1383586624035287 [https://perma.cc/R96P-H7JJ].

Since GAC is made from more inexpensive materials that contain carbon, such as wood, coconut, coal, and peat, it tends to be the most common tool for PFAS removal.[121] While GAC is great at removing longer-chain PFAS structures, it has two major issues.[122] First, the effective removal of these long chains only lasts until a breakthrough occurs.[123] Second, GAC is less effective for shorter-chain PFAS, and the smaller molecules cause faster breakthroughs.[124] Breakthrough is when the filter is no longer viable and is unable to remove contaminants, such as PFAS, from the water, potentially even introducing more PFAS into the water that is being treated.[125] To prevent this breakthrough, the filter must be changed regularly,[126] which leads to another issue: disposal of the filters once they are removed.[127]

Reverse osmosis and nanofiltration are processes that push water through a tight membrane at high pressure.[128] The only difference between the two is the tightness of the membranes.[129] Nanofiltration allows salts and other minerals through, unlike reverse osmosis.[130] Reverse osmosis has been shown to be highly effective, with studies demonstrating that these membranes are effective at removing

121. C. S. Tshangana et al., *Technology Status to Treat PFAS-Contaminated Water and Limiting Factors for Their Effective Full-Scale Application*, 8 NPJ CLEAN WATER 6, 6 (2025), https://www.nature.com/articles/s41545-025-00457-3 [https://perma.cc/F8SG-2VZN].

122. *Id.*

123. *Id.*

124. *Id.*

125. *Granular Activated Carbon Treatment of Private Well Water*, CONN. DEP'T PUB. HEALTH, https://portal.ct.gov/dph/environmental-health/private-well-water-program/granular-activated-carbon-treatment-of-private-well-water [https://perma.cc/ZEZ7-39SZ] (last visited Feb. 26, 2026).

126. *Id.*

127. EPA, COMMUNITY GUIDE TO GRANULAR ACTIVATED CARBON TREATMENT 2 (2021), https://semspub.epa.gov/work/HQ/401595.pdf [https://perma.cc/MAG9-8XLT].

128. *Reducing PFAS in Drinking Water with Treatment Technologies*, EPA, https://www.epa.gov/sciencematters/reducing-pfas-drinking-water-treatment-technologies [https://perma.cc/N9F8-8WL2] (last updated Feb. 19, 2026) [hereinafter *Reducing PFAS*].

129. *Id.*

130. *Id.*

approximately 90% of PFAS, including short-chain PFAS.[131] However, reverse osmosis comes with challenges as well. First, when the water goes through the membranes, and 80% of the contaminated water is discharged as treated water, 20% of the flow becomes a "high-strength waste stream" that is very difficult to dispose of or treat.[132] Second, reverse osmosis and nanofiltration systems are far more expensive than GAC.[133] As a result, due to the waste stream and the higher costs, reverse osmosis and nanofiltration systems are better suited for homeowners at point-of-use systems.[134]

The EPA's new PFAS standards also provide monitoring requirements. Water utilities that use groundwater and serve more than 10,000 people, and all surface water utilities, must take samples two to four months apart within one year, for each regulated PFAS.[135] Groundwater utilities serving fewer than 10,000 people are required to take samples five to seven months apart within one year.[136] Based on these results, the regulation outlines a monitoring period to ensure compliance.[137] Similarly, for NPDES permits, there are no PFAS monitoring methods approved for assessing permit applications, so applicants may "use any suitable method but shall provide a description of the method."[138] While there are no required PFAS monitoring methods, the EPA has developed Method 1633A for the detection of forty different PFAS variants.[139] This method allows the testing for PFAS in "wastewater, surface water, groundwater, soil,

131. *Id.*

132. *Id.*

133. *Why Is Reverse Osmosis Expensive? Here's What You Need to Know*, REGAL FLOW, https://regalflow.co.uk/blogs/blogs-water-home-care-guides-tips-reviews/why-reverse-osmosis-systems-are-expensive [https://perma.cc/EC8F-CPT7] (last visited Mar. 21, 2026).

134. *Reducing PFAS*, *supra* note 128.

135. 40 C.F.R. § 142.902(b)(1)(i) (2024).

136. *Id.* § 142.902(b)(1)(ii).

137. *Id.* § 142.902(b)(2).

138. 40 C.F.R. § 122.21(e)(3)(ii) (2019).

139. *CWA Analytical Methods for Per- and Polyfluorinated Alkyl Substances (PFAS)*, EPA, https://www.epa.gov/cwa-methods/cwa-analytical-methods-and-polyfluorinated-alkyl-substances-pfas [https://perma.cc/7XEY-5Z23] (last updated Nov. 4, 2025) [hereinafter *CWA Analytical Methods*].

biosolids, sediment, landfill leachate, and fish tissue."[140] For drinking water, the EPA has developed Methods 53, 537, and 537.1, which only detect twenty-nine PFAS variants.[141]

Method 1633A is only able to detect approximately 40 of the nearly 12,000 PFAS variants currently in existence.[142] The approved methods for drinking water detect even less, detecting only twenty-nine PFAS variants.[143] The difficulties do not stop here. The limited EPA-approved tests require specialized equipment, technical expertise, and a controlled environment.[144] Additionally, despite the large demand for PFAS testing, especially in the wake of emerging PFAS regulation, there is a limited lab capacity for this testing to be completed.[145] Additionally, beyond release from industrial sources, sources such as pharmaceuticals,[146] landfills, human waste, land application of biosolids, firefighting foams, and more release PFAS into the environment.[147] These different sources result in "complex mixtures" that can be difficult to monitor, resulting in difficulties detecting and removing them.[148]

140. *Id.*

141. *EPA PFAS Drinking Water Laboratory Methods*, EPA, https://www.epa.gov/pfas/epa-pfas-drinking-water-laboratory-methods [https://perma.cc/93AA-T37L] (last updated Apr. 24, 2025).

142. *CWA Analytical Methods*, *supra* note 139; Gaber, *supra* note 3.

143. *EPA PFAS Drinking Water Laboratory Methods*, *supra* note 141.

144. *Top Challenges in PFAS Analysis (and How to Solve Them)*, INSIDE BATTELLE (June 30, 2025), https://inside.battelle.org/blog-details/top-challenges-in-pfas-analysis-and-how-to-solve-them [https://perma.cc/S8G6-Q6WA].

145. *Id.*

146. Amudalat Ajasa, *These Common Medications Could be Releasing 'Forever Chemicals' into the Environment*, WASH. POST (Jan. 6, 2025), https://www.washingtonpost.com/climateenvironment/2025/01/06/prescription-drugs-toxic-chemicals-pfas-water-supply [https://perma.cc/79QW-9U8S].

147. *Forever Chemicals*, WATERKEEPERS CAROLINA, https://waterkeeperscarolina.org/forever-chemicals/ [https://perma.cc/CUM8-Y54A] (last visited Mar. 31, 2026).

148. Juhe Lui & Joseph A. Charbonnet, *A Critical Review of PFAS Analysis, Occurrence, and Fate in Wastewater Treatment Plants*, 59 ENV'T SCI. & TECH. 25492, 25492–94 (2025).

B. The Implementation Gap

Some public water utilities and other water suppliers, including the Cape Fear Public Utility Authority, have preemptively installed treatment technology after discovering high levels of PFAS.[149] NC DEQ estimates that 320 water systems in North Carolina have PFAS levels exceeding the MCL limits.[150] The EPA allocated close to $1 billion in funding to help implement PFAS treatment for the fiscal year 2025, with nearly $29 million going to North Carolina.[151] However, this is a drop in the bucket compared to what will be needed—the Cape Fear Public Utility Authority spent $43 million adding granular activated carbon filters to just one of its plants to reduce PFAS.[152]

In total, a statewide study estimated that in order for water utilities to comply with the current drinking water MCLs in the state of North Carolina, it will cost up to $3.4 billion in capital expenditure, up to $200 million in annual operating costs, and up to $460 million in annual costs over the span of twenty-five years.[153] These costs affect smaller, rural water treatment facilities the most, with their costs being up to six times greater than their larger counterparts.[154] These costs, in North Carolina and across the country, will ultimately pass

149. Hannah McCloskey, *A Closer Look at PFAS Drinking Water Regulations*, N.C. COLLABORATORY (Jan. 17, 2025), https://collaboratory.unc.edu/news/2025/01/17/a-closer-look-at-pfas-drinking-water-regulations/ [https://perma.cc/79QW-9U8S].

150. *Id.*

151. Memorandum from the Marietta Echeverria Director of Drinking Water Capacity and Compliance Assistance Division of the EPA to EPA Regional Water Division Directors, Regions 1-10 (June 17, 2025) (on file with author).

152. *CFPUA's Legal Action Against Chemours and DuPont*, CAPE FEAR PUB. UTIL. AUTH., https://www.cfpua.org/785/Legal-action-against-Chemours-and-DuPont [https://perma.cc/UNK8-F3NZ] (last visited Feb. 1, 2026).

153. ONE WATER ENGINEERING, N.C. STATE UNIV., HAZEN AND SAWYER, UNC SOG ENV'T FIN. CTR., STATEWIDE COSTS TO COMPLY WITH FEDERAL PFAS DRINKING WATER REGULATIONS 1 (Oct. 14, 2025) (unpublished manuscript) (on file with author).

154. *Minnesota Report Shows Full Cost of PFAS Removal*, AM. PUB. WORKS ASS'N (June 12, 2023), https://www.apwa.org/advocacy/minnesota-report-shows-full-cost-of-pfas-removal/ [https://perma.cc/M88Y-VC4M].

to rate payers.[155] Utilities are trying to recover this money. For example, Cape Fear Public Utility Authority has filed a lawsuit against DuPont and Chemours seeking recovery for the installation of the technology in their water treatment plant.[156]

On the other hand, treating PFAS at industrial sources presents far fewer challenges. Treating small amounts of PFAS-containing effluent is far easier at the pollution source as opposed to treating it once it has become diluted with the millions of gallons of water that filter through wastewater treatment plants each day.[157] In fact, with other contaminants, pretreatment ordinances are an effective way to reduce the burden on water utilities by treating the effluent at the source, as opposed to downstream.[158] The bottom line is that removing PFAS at the industry level, not the water treatment level, is the best financial and technical option.[159]

V. THE FUTURE OF TECHNOLOGY IN PFAS

A. The Clean Water Act as a Technology Forcing Act

The CWA is often called a "technology-forcing statute because of the rigorous demands placed on those who are regulated by it to achieve higher and higher levels of pollution abatement under deadlines specified in the law."[160] The NPDES program "requires

155. *Correcting PFAS Myths: Misperceptions Risk Higher Clean-Up Costs for Water Ratepayers*, NAT'L ASS'N OF CLEAN WATER AGENCIES, https://www.nacwa.org/docs/default-source/resources---public/water-coalition-fact-sheet-202307-v1-2.pdf [https://perma.cc/GP3Q-Z6KD] (last visited Mar. 20, 2026).

156. CAPE FEAR PUBLIC UTIL. AUTH., *supra* note 151.

157. Jeff Keller, *A Holistic Path to Treating PFAS in Water and Wastewater*, BURNS & MCDONNELL, https://info.burnsmcd.com/white-paper/a-holistic-path-to-treating-pfas-in-water-and-wastewater [https://perma.cc/27NY-GPP8] (last visited Feb. 28, 2026).

158. *Id.*

159. Dana Gonzalez, *Tackling the PFAS Puzzle: Challenges and Solutions in Wastewater Treatment*, CAL. WATER ENV'T ASS'N, https://www.cwea.org/news/tackling-the-pfas-puzzle-challenges-and-solutions-in-wastewater-treatment/ [https://perma.cc/NT3N-FLJT] (last visited Feb. 28, 2026).

160. LAURA GATZ, CONG. RSCH. SERV., RL30030, CLEAN WATER ACT: A SUMMARY OF THE LAW 2 (2016),

footnote continued on next page

permits to include technology-based effluent limitations."[161] These technology-based effluent limitations ("TBELs") are especially important for PFAS as they are emerging areas of concern not yet addressed in current national effluent limitation guidelines.[162] The determination of the TBELs is case-by-case, hinging importantly on the early identification of PFAS being released from industrial sites.[163] An important constraint of these TBELs, however, is that these limitations cannot be enforced through a permit unless the "permittee submits a complete permit application, including any appropriate PFAS effluent monitoring data."[164]

The factors used in the case-by-case evaluation of TBELs include the "age of equipment and facilities involved," "process[es] employed," "engineering aspects," "[p]rocess changes," "cost of achieving" the effluent limitation, and "[n]on-water quality environmental impact[s]."[165] The EPA has provided two separate reports to guide the creation of TBELs.[166] These reports, both from 2021, identify the technologies that this Note discussed in Part IV as the current BATs

https://www.congress.gov/crs_external_products/RL/PDF/RL30030/RL30030.23.pdf [https://perma.cc/YU9B-T5VX].

161. *Implementing Case-by-Case Technology-Based Effluent Limitations in NPDES Permits for Pollutants of Emerging Concern*, EPA (Jan. 2025) https://www.epa.gov/system/files/documents/2025-01/case-by-case-tbel-factsheet.pdf [https://perma.cc/LNU3-9NGE] [hereinafter *Implementing Case-by-Case*].

162. *Id.*

163. *Id.*

164. *Id.*

165. *Id.*; 40 C.F.R. 125.3(d)(3) (2019).

166. *Implementing Case-by-Case*, *supra* note 161. *See generally* E. RSCH. GRP., EVALUATION OF INDUSTRIAL WASTEWATER PFAS TREATMENT TECHNOLOGIES REPORT, (Feb. 5, 2021) (study reviewing and evaluating different PFAS treatment options for wastewater treatment); EPA, MULTI-INDUSTRY PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS) STUDY–2021 PRELIMINARY REPORT (Sep. 2021), https://www.epa.gov/system/files/documents/2021-09/multi-industry-pfas-study_preliminary-2021-report_508_2021.09.08.pdf [https://perma.cc/9L2X-H83N] (summarizing data regarding industrial discharges of PFAS from different industrial point sources) [hereinafter MULTI-INDUSTRY].

such as anion exchange, GAC, and membrane filtration (reverse osmosis and nanofiltration).[167]

These guidance and reports have already resulted in NPDES permits requiring industry to consider these TBELs—but not without outside pressure. For example, in November 2022, Southern Environmental Law Center ("SELC") filed a motion to intervene on behalf of the Cape Fear River Watch in the North Carolina Office of Administrative Hearings defending a NPDES permit challenged by the Chemours Fayetteville Works facility.[168] The permit set limits for Chemours based on the capabilities of a GAC filtration treatment system, requiring a "removal efficiency of greater than 99.9%."[169] The challenge regarding the permit ended with a settlement agreement in which Chemours agreed to the final PFAS permit limits based on the technical capabilities of the filtration system.[170]

B. Emerging PFAS Regulation Technologies

The enforcement of TBELs and the use of CWA's technology-forcing features introduce a potential path forward in holding industry accountable for its continuing discharge of PFAS into the environment.[171] These TBELs will only become more important as technology advances—and the field of PFAS filtering and monitoring is making large strides. For example, the North Carolina

167. E. RSCH. GRP., *supra* note 166, at 1-1; MULTI-INDUSTRY, *supra* note 166, at 1–1.

168. Motion to Intervene by Cape Fear River Watch at 1, Chemours Co. FC, LLC v. N.C. Dep't of Env't Quality, 22 EHR 03913 (N.C. Off. of State Admin. Hearings 2022), https://www.selc.org/wp-content/uploads/2022/11/2022.10.11-CFRW-Motion-to-Intervene.pdf [https://perma.cc/S6CA-9QSQ].

169. Press Release, N.C. Dep't of Env't Quality, DEQ Approves Permit to Reduce PFAS Contamination in the Cape Fear River (Sep. 15, 2022), https://www.deq.nc.gov/news/press-releases/2022/09/15/deq-approves-permit-reduce-pfas-contamination-cape-fear-river [https://perma.cc/R79L-HGP9].

170. Settlement Agreement at 2, Chemours Co. FC, LLC, 22 EHR 03913 (N.C. Off. of State Admin. Hearings 2022), https://www.deq.nc.gov/genx/chemours-npdes-agreement/download [https://perma.cc/V8WG-NFVY].

171. Mark McDaniel & Mary Gade, *Regulatory Review: PFAS in Biosolids-Part 3*, A.B.A. (Sep. 19, 2025), https://www.americanbar.org/groups/environment_energy_resources/resources/newsletters/food-agriculture/regulatory-review-pfas-in-biosolids-part-3/ [https://perma.cc/NRW7-X5ZZ].

PFAS University Research Alliance ("NC Pure"), which received $10 million in funding from the North Carolina General Assembly, is developing "novel sorbent technology."[172] Sorbents are insoluble materials or mixtures of material that can be used to absorb liquid, and in some cases filter out certain chemicals.[173] These technologies are in the same vein as GAC and anion exchange, and NC Pure is testing these "leading sorbent technologies" as well as testing new sorbents to "assess performance of a range of technologies in different water matrices."[174] As compared to GAC and anion exchange, these novel sorbents are "designed to specifically bind PFAS over other ions or molecules in water."[175] This binding technology bonds to a wide range of PFAS, such as the troublesome short-chain PFAS, and also allows the sorbents to have a longer lifespan.[176] NC Pure has already deployed these novel sorbents at three different locations within North Carolina at a pilot scale.[177]

Other innovative groups are focusing on the actual *destruction* of PFAS. For example, Tetra Tech contracted with the U.S. Department of Defense Environmental Security Technology Certification Program to create a mobile electron beam system which could break down PFAS into "harmless byproducts."[178] This technology is differentiated by its potential to remove PFAS from several mediums, such as soil, water, and biosolids.[179]

172. *The Project*, N.C. PURE, https://ncpure.collaboratory.unc.edu/project/ [https://perma.cc/ZP2T-7PBD] (last visited Feb. 29, 2026).

173. *Sorbents*, EPA, https://archive.epa.gov/emergencies/content/learning/web/html/sorbents.html [https://perma.cc/KA9A-A3CD] (last updated Feb. 20, 2016).

174. *Sorbent to be Tested*, N.C. PURE, https://ncpure.collaboratory.unc.edu/project/sorbents-to-be-tested/ [https://perma.cc/R7D5-66X8] (last visited Feb. 28, 2026).

175. *How Do Novel Sorbents Work*, N.C. PURE, https://ncpure.collaboratory.unc.edu/science/how-do-novel-sorbents-work/ [https://perma.cc/M3HW-DWW3] (last visited Feb. 28, 2026).

176. *Id.*

177. *The Project*, *supra* note 172.

178. Purshotam Juriasingani, *Developing Innovative Treatment Technologies for PFAS*, TETRA TECH, https://www.tetratech.com/insights/developing-innovative-treatment-technologies-for-pfas/ [https://perma.cc/RV3V-PPLY] (last visited Feb. 28, 2026).

179. *Id.*

This truly just scratches the surface of the research and development surrounding PFAS. The EPA has funds several efforts to develop both novel PFAS detection and treatment/destruction methods.[180] With PFAS as an area of high concern, new technology will be fast to emerge.[181] While these new technologies may be difficult to implement at utility scales, industry provides the perfect venue for these advancements.[182]

C. A Case Study for the Use of TBELs: The European Union

The European Union ("EU") recently reestablished the Drinking Water Directive, which serves as a great example of the implementation of monitoring, limits, and methods based on similar guidelines required in the creation of TBELs.[183] This system of PFAS monitoring requires member states to monitor and report a limited amount of PFAS data to the EU.[184] The directive sets limits to the levels of PFAS that can be in the water.[185] If this amount is exceeded, then the member states must take action to reduce the level of PFAS.[186] The PFAS limits are for any and all variants of PFAS and are set at 0.5 micrograms per liter (equivalent to 500 parts per trillion, notably higher than the federal MCLs and North Carolinas groundwater

180. *EPA's SBIR Support of PFAS Detection and Treatment: Novel Technologies for Reducing PFAS in the Environment*, EPA (Jan. 2025), https://www.epa.gov/sbir/epas-sbir-support-pfas-detection-and-treatment-novel-technologies-reducing-pfas-environment [https://perma.cc/Y94P-QEZN].

181. *See, e.g.*, Timothy Prince Chidike Ezeorba et al., *Emerging Eco-Friendly Technologies for Remediation of Per- and Poly-Fluoroalkyl Substances (PFAS) in Water and Wastewater: A Pathway to Environmental Sustainability*, 364 CHEMOSPHERE (Sep. 2024) (study examining "novel eco-friendly methods" of PFAS remediation and removal).

182. Keller, *supra* note 157.

183. *New EU-Wide Protections Against PFAS in Drinking Water Come into Effect*, EUR. COMM'N, (Jan. 12, 2026) https://environment.ec.europa.eu/news/new-eu-rules-limit-pfas-drinking-water-2026-01-12_en [https://perma.cc/76R2-82L7].

184. *Id.*

185. *Id.*

186. *Id.*

limits), and serve as enforceable mandatory limits, not voluntary goals.[187]

The relevant portion of this new regulatory scheme is that these guidelines were created "based on a technical and socio-economic assessment and were developed in close consultation with Member States."[188] The Drinking Water Directive, like the goal of TBELS, is structured to prevent pollution through technologically achievable controls rather than relying on downstream water quality responses.[189]

D. Using Technology-Based Effluent Limitations as the Solution to Slow Regulation

As previously discussed, PFAS regulation has been slow to come about. From the time that there was likely widespread industry knowledge of the dangers of PFAS to the first enforceable PFAS limit, sixty-three years had passed. Additionally, even though any PFAS regulation is a step in the right direction, the current drinking water MCL is exceptionally narrow, only regulating 6 of over 12,000 variants, and applying only to water utilities.[190] North Carolina is not much more advanced, with the only additional regulations concerning concentrations of PFAS in groundwater.[191] It took the EPA and North Carolina well over half a century to establish these regulations, and the current administration is delaying enforcement deadlines for PFOA and PFOS and reconsidering the regulation of the other four.[192] The future for PFAS regulation does not look bright.

However, TBELs can help fill the gap where there is inadequate, slow, and fluctuating PFAS regulations. Already, state permitting authorities have issued at least sixty-five permits with effluent limitations for PFAS, which can help provide guidance for other

187. Directive 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the Quality of Water Intended for Human Consumption, 2020 O.J. (L 435) annex I, part B.

188. EUR. COMM'N *supra* note 183.

189. Directive 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the Quality of Water Intended for Human Consumption, 2020 O.J. (L 435), art. 8.

190. 40 C.F.R. § 141.900(a) (2024); Gaber, *supra* note 3.

191. 15A N.C. ADMIN. CODE 2L.0202 (2025).

192. EPA, *supra* note 88.

NPDES permits.[193] However, the existence of TBELs is not enough. First, there must be an express emphasis on monitoring and reporting, as these limitations can only be implemented once there is a permit application.[194] Community groups can help pressure these industries to increase compliance monitoring by doing their own monitoring.[195] Second, when NPDES permits are issued, there needs to be public comment and involvement in pushing the permitting agency, which is the NC DEQ, to incorporate these TBELs. Additionally, by using the TBELs, NPDES permits can stay up to date with the latest and greatest technology, ensuring that the most cost-effective forms of PFAS removal, and maybe even destruction in the future, are used.

By communities pushing TBELs, industrial polluters will be held accountable morally and financially, reduce the amount of PFAS released into the environment, and lift the burden from water utilities, many of which have been trying to remedy the PFAS situation well before the MCL was finalized. While this is not the ultimate solution to PFAS, it is a step in the right direction while federal and state agencies begin developing adequate regulations regarding monitoring and treatment of PFAS.

VI. Conclusion

Many North Carolinians currently live in a world that Johnny Cash sang about over fifty years ago, but now it is not only the rivers, ponds, and lakes they must worry about: It is the water coming out of the faucets in their own homes. Water that generations of residents have used to drink, bathe, cook, and clean has and is still silently poisoning them. While in a perfect world, regulation, legislation, lawsuits, and corporate ethics would help remedy this issue, the world is far from perfect. Regulation and legislation are slow and always in flux, lawsuits are a drop in the bucket for big PFAS manufacturers like

193. *Case-by-Case.*, *supra* note 161.

194. *Id.*

195. *See, e.g.*, Kimberly K. Garrett et al., *REACHing for PFAS Solutions: How Two Communities Responded to Drinking Water Contamination*, 15 J. Env't Stud. Sci. 733, 733 (2025) (study using qualitative interviews to compare impacts and responses to PFAS contamination as it relates to community involvement).

DuPont and Chemours, and the history of the Washington Works plant tells us not to rely on industry doing what is right.

However, the use of TBELs presents a unique opportunity for community groups to push for greater accountability with limits that are enforceable. The CWA presents us with a unique opportunity to ensure that NPDES permits can bolster what is missed by current regulations and laws.