TO: Members of the Legislative Committee on Administrative Rules (LCAR)
FROM: Sylvia Knight, Earth Community Advocate
13 Claire Pointe Rd
Burlington, VT 05408. sknightinvt73@gmail.com
DATE: September 30, 2022
SUBJECT: Testimony for October 6, 2022: VT Water Quality Standards - 2022
Proposed Number Assigned by the Secretary of State: 22P 009
https://legislature.vermont.gov/Documents/2022/WorkGroups/LCAR/22-P09%20-%20Vermont%20Water%20Quality%20Standards/W~none~22-P09%20-%20Vermont%20Water%20Quality%20Standards~9-22-2022.pdf

ADOPTING AGENCY: Agency of Natural Resources (ANR)

Quotes from Filing:

"It is the policy of the State of Vermont to *protect and enhance the quality, character and usefulness* of the State's surface waters." (Filing Document at #8)

"The purpose of the triennial review is for the State to update its water quality standards … consistent with new *legal* and *scientific information* …"(Filing Document at #15)

"Residents of the State of Vermont … derive economic and public health benefits from the maintenance of surface waters in such condition that their designated uses may be realized."(Filing Document at #17)

I take this opportunity to share my profound concern for my fellow residents of Vermont, the most profoundly affected stakeholders, and for the waters and community of life we share with our neighbors in Vermont and to the north. Please refer to my comments and references of July 18 on these rules, as well as the comments of my colleagues across the state.

The combined crises of global warming AND pervasive persistent toxins now in our midst are an existential threat to all of us. They exert synergetic effects on water quality, such as extreme precipitation events creating increased combined sewer overflows, increasing pesticide use on new pests carried in runoff to surface waters, extended dry periods affecting streams and aquatic habitats, and challenges to state and municipal water systems trying to keep abreast of testing protocols.

Language in the Water Quality Standards raises the question: just what do these rules actually protect? It is my perception that the definition and use of mixing zones, waste management zones and assimilation capacity depend on a paradigm of using water to dispose of and to dilute toxic waste. This is actually contrary to the intention of the Clean Water Act of 1970. The concept of dilution arises from the federal law that preceded the CWA (1).

Given current State and citizen concerns about per-and polyfluoroalkyl substances (PFAS) and heavy metals and their profound dangers to human and ecological health, reliance upon dilution and mixing zones is unwise, reckless endangerment.

In the September 20 letter from ANR/DEC signed by Hannah Smith as part of this filing, we see the following:

3. Subchapter 1, § 29A-102, *Definitions*
"Mixing zone" means a length or area within waters required for the *dispersion and dilution of waste discharges* adequately treated to meet federal and state treatment requirements and within which it is recognized that specific water use associated with the assigned classification for such waters may not be realized. A mixing zone shall not extend more than 200 feet from the point of discharge."

Question: just how does the State control the mixing zone to 200 ft in a stream? What happens after a big rain, when combined sewer overflows occur?

Does the addition of the proposed language below change what is actually occurring?

"*A mixing zone shall not be used to meet water quality criteria for bioaccumulative toxins." This change is intended to clarify that the Agency does not use mixing zones to meet Water Quality Standards for bioaccumulative toxins*."

The reality is this: the Agency does use mixing zones, waste management zones, and assimilative capacity to dilute toxic effluent while disposing of PFAS and other toxins in streams. Mixing zones are a means of diluting pollution in a stream.

My FOIA request of July 7, 2022 for a list of mixing zones and waste management zones resulted in a list of several hundred such zones affecting most major streams in Vermont, Lake Champlain and Lake Memphramagog, both international waters. (Attached).

Dear Members of LCAR, I urge your deep consideration and questioning of what is happening here.

1. The language to be inserted does *not prevent* dilution; it is wishful thinking without a basis in reality.

2. Discharges from wastewater treatment facilities (WWTFs) are not, cannot yet be adequately treated to prevent discharge of PFAS and heavy metals to streams, according to studies done by the Agency and independent consultants (2).

3. Using waters to carry away persistent, bioaccumulative toxins including PFAS and heavy metals generated by our economy is an unsustainable and dangerous policy which subsidizes industry but harms the lives of citizens and environment you are charged to protect. EPA sought to restrict such practices in the Great Lakes Region 7-10 years ago due to bio-accumulative toxins (3).

4. ANR/DEC has not considered current science: The citations listed by DEC in their filing include no current science on bio-accumulative toxins including PFAS, or recent

documents from EPA on stricter advisory levels for PFAS, or recent documents from EPA on mixing zones.

5. ANR/DEC does not own the water. Industry does not own the water. ANR's reliance upon mixing zones, waste management zones and assimilative capacity commodifies Vermont's waters for short term benefit of industries but with long-term risk and damage to the community of life in Vermont and Canada. Mixing zones and waste management areas do not "protect and enhance the quality, character and usefulness of the State's surface waters.

I urge you to dig deep into your courage and

a) decline to approve of this set of regulations; or,

b) alternatively, require reduction of mixing zones associated with large WWTFs;

c) recommend to VT Legislature that the use of mixing zones and waste management zones be subject to legislative action (see reference #3 below):

d) require separation and sequestration of PFAS and heavy metals.from effluent and rigorous methods of disposal separate from water;

e) work with concerned citizens in honesty and openness to solve the problems of PFAS and other toxins, and develop a comprehensive solid waste management plan;

f) promote the Precautionary Principle and consideration of future generations in your deliberations.

Thank you for your consideration of my concerns on behalf of Earth Community.

References:

1. Stowers, Linda (1991) "Dilution is Not the Solution," Journal of Natural Resources & Environmental Law: Vol. 6 : Iss. 2 , Article 5.
Available at: https://uknowledge.uky.edu/jnrel/vol6/iss2/5

See also: Cohen, G. E. (2000). Mixing Zones: Diluting Pollution under the Clean Water Act. Tulane Environmental Law Journal, v. 14; issue 1; Winter 2000. https://journals.tulane.edu/elj/article/view/2042.

2. Weston & Sampson, Inc. (2019). Wastewater Facility and Landfill PFAS Sampling Summary Report, 2019, wse03.local\WSE\Projects\VT\VTDEC Statewide PFAS WWTF LF\Report 2019\2019 Summary Report.docx

3. U.S.EPA (2015). Water Quality Standards Handbook Chapter 5: General Policies (40 CFR 131.13). See p. 9 on inappropriate uses of mixing zones. See also p.3 where EPA recommends that states adopt a definitive statement on the use of mixing zones.

https://www.epa.gov/sites/default/files/2015-05/documents/appendix_5_cumulative_effects_011311.pdf

COMBINED SEWAGE OVERFLOWS TO VERMONT WATERS WATERS 10/2021-3/2022

CITY /TOWN	FACILITY	STREAM	DATE	AMT-gals	EXPLANATION
Rutland	CSO#1	Otter Creek	03/19/22	**220, 694**	authorized discharge of untreated sewage and stormwater from heavy rain storm
Rutland	CSO#4	East Creek	03/18/22	**12, 858**	authorized wet weather overflow
Rutland	CSO #3 and #4	East Creek	03/07/22	**63, 687**	authorized wet weather overflow high flows caused by heavy rain, discharge of sewage and storm water.
Rutland	CSO #2	East Creek	03/07/22	**64, 386**	authorized wet weather overflow high flows caused by heavy rain,
Rutland	CSO #1	Otter Creek	03/07/22	**300, 970**	authorized discharge of untreated sewage and stormwater from heavy rain, .61 inches

TOTAL RUTLAND DISCHARGES – MARCH 2022 – UNTREATED SEWAGE INTO CHAMPLAIN BASIN = 662,515 GALS.

ADDITIONAL DISCHARGES TO CHAMPLAIN BASIN IN MARCH 2022

Fairfax	142 Hunt st.	Lamoille River	3/08/-3/29/	**100,000--500, 000**	untreated and partially treated effluent **from snow melt and "other situations"**

ADDITIONAL DISCHARGES TO CHAMPLAIN BASIN IN O CTOBER 2021

Middlebury	Frog Hollow	Otter Creek	03/04/22	<100	Discharged untreated sewage obstruction/blockage
Barre	Berlin/Barre town line	Stevens Branch	10/31/21	**1,000-10,000**	**discharged untreated sewage thru manhole**
Barre	Sterling Hill Rd	Stevens Branch	10/31/21	?	**serious foaming in municipal WW system** from Vermont Creamery
Sheldon	369 Mill St	Missisquoi River	10/27/21	**spill**	Material for manufacturing paperboard **Sheens product (PFAS?) in surface water**

OTHER WATERSHEDS 03/01/22

Brighton	Cross St Island Pond	Clyde River	03/05/22	**100-1,000**	**Discharged untreated sewage, crack, hole in pipe crack,hole in pipe**
Windsor	Weston Hgts	Connecticut R	03/04/22	>100-1,000	discharged treated/partially treated effllluent

Source: ANR Watershed Management Division. https://anrweb.vt.gov/DEC/WWInventory/SewageOverflows.aspx

	A	B	C	D	E	F
1	FacilityName	Permittee Name	Permit ID	NPDESPermit Number	Program Category	Ownership Name
172	Swanton	Town of Swanton	3-1292	VT0100501	Municipal Discharge	Municipal
173	Troy & Jay	Towns of Troy and Jay	3-1311	VT0101168	Municipal Discharge	Municipal
174	Vergennes	City of Vergennes	3-0368	VT0100404	Municipal Discharge	Municipal
175	Wallingford FD 1	Wallingford Fire District 1	3-0365	VT0100552	Municipal Discharge	Municipal
176	Waterbury	Village of Waterbury	3-1160	VT0100463	Municipal Discharge	Municipal
177	West Rutland	Town of West Rutland	3-1237	VT0100714	Municipal Discharge	Municipal
178	Whitingham	Town of Whitingham	3-1229	VT0101109	Municipal Discharge	Municipal
179	Whitingham - Jacksonville	Town of Whitingham	3-1230	VT0101044	Municipal Discharge	Municipal
180	Williamstown	Town of Williamstown	3-1176	VT0100722	Municipal Discharge	Municipal
181	Wilmington	Town of Wilmington	3-1281	VT0100706	Municipal Discharge	Municipal
182	Windsor Main	Town of Windsor	3-1253	VT0100919	Municipal Discharge	Municipal
183	Windsor Weston Heights	Town of Windsor	3-1168	VT0100447	Municipal Discharge	Municipal
184	Winooski	City of Winooski	3-1248	VT0100510	Municipal Discharge	Municipal
185	Woodstock	Town of Woodstock	3-1228	VT0100757	Municipal Discharge	Municipal
186	Woodstock - South	Town of Woodstock	3-1178	VT0100749	Municipal Discharge	Municipal
187	Woodstock - Taftsville	Town of Woodstock	3-1179	VT0100765	Municipal Discharge	Municipal
188						

United States Environmental Protection Agency

Office of Water
EPA 822-F-22-002
June 2022

Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS)

Summary

As part of EPA's commitment to safeguard communities from per- and polyfluoroalkyl substances (PFAS), EPA has issued interim updated drinking water health advisories for perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), and final health advisories for hexafluoropropylene oxide (HFPO) dimer acid and its ammonium salt (together referred to as "GenX chemicals") and perfluorobutane sulfonic acid and its related compound potassium perfluorobutane sulfonate (together referred to as "PFBS"). The interim health advisories for PFOA and PFOS are intended to provide information to states and public water systems until the National Primary Drinking Water regulation for PFAS takes effect. All four of these health advisories provide drinking water system operators, and state, tribal, and local officials who have the primary responsibility for overseeing these systems, with information on the health risks of these chemicals, so they can take the appropriate actions to protect their residents.

Background

What Are PFAS?

PFAS are synthetic chemicals that have been manufactured and used by a broad range of industries since the 1940s. PFAS are used in many applications because of their unique physical properties such as resistance to high and low temperatures, resistance to degradation, and nonstick characteristics. PFAS have been detected worldwide in the air, soil, and water. Due to their widespread use and persistence in the environment, most people in the United States have been exposed to PFAS. There is evidence that exposure above specific levels to certain PFAS may cause adverse health effects.

What Are Drinking Water Health Advisories?

Drinking water health advisories (HAs) provide information on contaminants that can cause human health effects and are known or anticipated to occur in drinking water. EPA's HAs are non-enforceable and non-regulatory and provide technical information to drinking water system operators, as well as federal, state, tribal, and local officials on health effects, analytical methods, and treatment technologies associated with drinking water contamination.

Why is EPA Issuing These HAs?

In 2016, EPA published HAs for PFOA and PFOS based on the evidence available at that time (U.S. EPA 2016, a,b). The science has evolved since then and EPA is now replacing the 2016 advisories with interim updated lifetime HAs for PFOA and PFOS that are based on new studies and draft toxicity values from EPA's 2021 draft PFOA and PFOS health effects documents. Fulfilling EPA's commitment in its October 2021 PFAS Strategic Roadmap, EPA has issued final lifetime HAs for GenX chemicals and PFBS.

How Does EPA Calculate HAs?

The following equation is used to derive a lifetime noncancer health advisory. A lifetime noncancer health advisory is designed to be protective of noncancer effects over a lifetime of exposure, including sensitive populations and life stages, and is typically based on data from experimental animal toxicity and/or human studies.

$$\textbf{Lifetime HA} = \left(\frac{\text{RfD}}{\text{DWI-BW}}\right) * \text{RSC}$$

Where:

RfD = chronic reference dose—an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure of the human population to a substance that is likely to be without an appreciable risk of deleterious effects during a lifetime.

DWI-BW = drinking water intake rate adjusted for body weight—the 90th percentile DWI for the selected population or life stage, adjusted for body weight (BW), in units of L/kg bw-day. The DWI-BW considers both direct and indirect consumption of tap water (indirect water consumption encompasses water added in the preparation of foods or beverages, such as tea or coffee).

RSC = relative source contribution—the percentage of the total oral exposure attributed to drinking water sources (U.S. EPA, 2000) where the remainder of the exposure is allocated to all other routes or sources.

What Types of Health Outcomes are Associated with Exposure to These Four PFAS, and How Did EPA Develop the HAs?

PFOA and PFOS

EPA is conducting extensive evaluations of human epidemiological and experimental animal study data to support the Safe Drinking Water Act (SDWA) National Primary Drinking Water Regulation for PFOA and PFOS. In November 2021, EPA released draft documents that summarize the updated health effects analyses for EPA Science Advisory Board (SAB) review (U.S. EPA, 2021a, b). EPA evaluated over 400 studies published since 2016 and used new human health risk assessment approaches, tools, and models. Human studies have found associations between PFOA and/or PFOS exposure and effects on the immune system, the cardiovascular system, development (e.g., decreased birth weight), and cancer. The new published peer-reviewed data and draft EPA analyses (U.S. EPA, 2021a, b) indicate that the levels at which negative health outcomes could occur are much lower than previously understood when the agency issued its 2016 HAs for PFOA and PFOS (70 parts per trillion or ppt). EPA's 2021 draft non-cancer reference doses (RfDs) based on human epidemiology studies for various effects (e.g., developmental/growth, cardiovascular health outcomes, immune health) range from ~10^{-7} to 10^{-9} mg/kg/day. These draft RfDs are two to four orders of magnitude lower than EPA's 2016 RfDs of 2 x 10^{-5} mg/kg/day (U.S. EPA, 2021a, b).

The most sensitive non-cancer effect based on the draft EPA analyses, decreased immunity (i.e., decreased serum antibody concentrations after vaccination) in children in a human epidemiology study, was selected as the basis for the draft RfD (toxicity value) in the PFOA and PFOS health effects draft documents (U.S. EPA, 2021a, b). EPA used the draft RfD to derive the interim updated HAs for PFOA and PFOS. In the critical study, EPA selected the critical effect of decreased serum antibody concentration in children associated with increased serum PFOA and/or PFOS concentrations. EPA expects this critical effect to be protective of all other adverse health effects observed in humans because this adverse effect can reduce the protection afforded by vaccines after exposure to PFOA/PFOS during a sensitive developmental life stage and it yields the lowest point of departure (POD) (U.S. EPA, 2021a, b). For both PFOA and PFOS, an intraspecies uncertainty factor

(UF_H) of 10 was applied to account for variability in the response within the human population (U.S. EPA, 2002). EPA identified children ages 0-5 years as a sensitive life stage, based on the critical study, and selected the corresponding DWI-BW. Based on a literature search of the available information on exposure sources and routes, EPA calculated the interim HAs for PFOA and PFOS using an RSC of 0.20, meaning that 20% of the exposure – equal to the RfD – is allocated to drinking water, and the remaining 80% is attributed to all other potential exposure sources (U.S. EPA, 2022a, b; U.S. EPA, 2000).

While there is evidence that PFOA is likely to be carcinogenic to humans, EPA has not derived a cancer risk concentration in water for PFOA at this time. For PFOS, there is suggestive evidence of carcinogenic potential in humans. Additional analyses of the cancer study data are ongoing for both PFOA and PFOS.

The underlying science that EPA used to develop the interim health advisories is currently undergoing SAB review, and therefore, these interim health advisories are subject to change. After receiving the SAB's final report, EPA will complete its revisions to address their feedback and recommendations, which could lead the agency to draw different conclusions than are reflected in the draft health effects analyses (U.S. EPA, 2021a, b). As a result, the interim health advisory levels for PFOA and PFOS (U.S. EPA, 2022a, b) could change. EPA may update or remove the interim health advisories for PFOA and PFOS upon finalization of the National Primary Drinking Water Regulation.

GenX Chemicals and PFBS

EPA's final health advisories for GenX chemicals and PFBS are based on animal toxicity studies following oral exposure to these chemicals. Studies of exposure to GenX chemicals have reported health effects in the liver, kidney, immune system, development, as well as cancer. The most sensitive non-cancer effect among the available data was an adverse liver effect (constellation of liver lesions) (U.S. EPA, 2021c). This critical effect was the basis for the final chronic RfD which EPA used to derive the final HA for GenX chemicals. To develop the final chronic RfD for GenX chemicals, EPA applied a composite UF of 3,000 (i.e., 10X for intraspecies variability (UF_H), 3X for interspecies differences (UF_A), 10X for extrapolation from a subchronic to a chronic dosing duration (UF_S), and 10X for database deficiencies (UF_D)) (U.S. EPA, 2021c). EPA identified lactating women as an adult life stage with the greatest potential exposure from drinking water, based on the critical study, and selected the corresponding DWI-BW. EPA calculated the final HA for GenX chemicals using an RSC of 0.20, meaning that 20% of the exposure -- equal to the RfD -- is allocated to drinking water, and the remaining 80% is attributed to all other potential exposure sources (U.S. EPA, 2022c). There is suggestive evidence of carcinogenic potential of oral exposure to GenX chemicals in humans and the available data are insufficient to derive a cancer risk concentration in water for GenX chemicals.

For PFBS, animal studies have reported health effects on the thyroid, reproductive system, development, and kidney following oral exposure. The most sensitive non-cancer effect was an adverse effect on the thyroid (i.e., decreased serum total thyroxine) in newborn mice in a study with exposure throughout gestation in the mothers. This critical effect was the basis for the final chronic RfD which EPA used to derive the final HA for PFBS (U.S. EPA, 2021d; U.S. EPA, 2022d). EPA applied a composite UF of 300 (i.e., 10X for intraspecies variability (UF_H), 3X for interspecies differences (UF_A), and 10X for database deficiencies (UF_D)) (U.S. EPA, 2021d). EPA identified women of child-bearing age as a sensitive life stage, based on the critical study, and selected the corresponding DWI-BW. EPA calculated the final HA for PFBS using an RSC of 0.20, meaning that 20% of the exposure – equal to the RfD – is allocated to drinking water, and the remaining 80% is attributed to all other potential exposure sources (U.S. EPA, 2022d). There were no studies identified that evaluated potential cancer effects after PFBS exposure so the potential for cancer effects after PFBS exposure could not be evaluated.

What are the HAs for the four PFAS?

PFOA Interim Updated Health Advisory – Input Parameters and HA Value			
Parameter	**Value**	**Units**	**Source**
Chronic RfD	1.5E-9	mg/kg/day	U.S. EPA, 2021a. *Draft* RfD based on developmental immune health outcome (suppression of tetanus vaccine response in 7-year-old children). Human epidemiological studies.
DWI-BW	0.0701	L/kg-day	U.S. EPA, 2019. 90th percentile direct and indirect consumption of community water, consumers-only population, two-day average, for children ages 0 to <5 years based on 2005−2010 National Health and Nutrition Examination Survey (NHANES).
RSC	0.2	N/A	U.S. EPA, 2021a. RSC based on a review of the current scientific literature.
PFOA Interim Updated Lifetime Health Advisory = 4E-09 mg/L or 0.004 ppt **(EPA 2022a)**			

PFOS Interim Updated Health Advisory – Input Parameters and HA Value			
Parameter	**Value**	**Units**	**Source**
Chronic RfD	7.9E-09	mg/kg/day	U.S. EPA, 2021b. *Draft* RfD based on developmental immune health outcome (suppression of diphtheria vaccine response in 7-year-old children). Human epidemiological studies.
DWI-BW	0.0701	L/kg-day	U.S. EPA, 2019. 90th percentile direct and indirect consumption of community water, consumers-only population, two-day average, for children ages 0 to <5 years based on 2005−2010 NHANES.
RSC	0.2	N/A	U.S. EPA, 2021b. RSC based on a review of the current scientific literature.
PFOS Interim Updated Lifetime Health Advisory = 2E-08 mg/L or 0.02 ppt **(EPA 2022b)**			

GenX Chemicals Final Health Advisory – Input Parameters and HA Value			
Parameter	**Value**	**Units**	**Source**
Chronic RfD	3E-06	mg/kg/day	U.S. EPA, 2021c. Final RfD based on critical liver effects (constellation of liver lesions as defined by the National Toxicology Program Pathology Working Group) in parental female mice exposed to HFPO dimer acid ammonium salt by gavage for 53–64 days.
DWI-BW	0.0469	L/kg-day	U.S. EPA, 2019. 90th percentile two-day average, consumer only estimate of combined direct and indirect community water ingestion for lactating women (13 to <50 years) based on 2005−2010 NHANES.
RSC	0.2	N/A	U.S. EPA, 2021c. Based on a review of the current scientific literature.
GenX Chemicals Final Lifetime Health Advisory = 0.00001 mg/L or 10 ppt **(EPA 2022c)**			

PFBS Final Health Advisory – Input Parameters and HA Value			
Parameter	**Value**	**Units**	**Source**
Chronic RfD	3E-04	mg/kg/day	U.S. EPA, 2021d: Final RfD based on critical effect of decreased serum total thyroxine (T4) in newborn (postnatal day (PND) 1) mice after gestational exposure to the mother.
DWI-BW	0.0354	L/kg-day	U.S. EPA, 2019. 90th percentile two-day average, consumer only estimate of combined direct and indirect community water ingestion for women of childbearing age (13 to <50 years) based on 2005−2010 NHANES.
RSC	0.2	N/A	U.S. EPA, 2021d. Based on a review of the current scientific literature.
PFBS Final Lifetime Health Advisory = 0.002 mg/L or 2,000 ppt **(EPA 2022d)**			

Application of Health Advisories to Different Exposure Scenarios

Because the critical effects identified for PFOA, PFOS, and PFBS are developmental effects that can potentially result from short-term exposure to these PFAS during a critical period of development, EPA guidelines support applying the lifetime health advisories for these three PFAS to both short-term and chronic risk assessment scenarios (U.S. EPA, 1991).

The lifetime health advisory for GenX chemicals used a chronic RfD from the final EPA toxicity assessment (U.S. EPA, 2021c) based on the critical effect of adverse liver effects in adults (parental females) from a subchronic study (53–64 day exposure). In the assessment, a 10X UF_S for subchronic to chronic exposure was applied to derive the chronic RfD (U.S. EPA, 2021c). Because the critical effect identified for GenX chemicals is in adults, the HA applies to chronic exposure scenarios. The HA was based on exposure to lactating women, an adult life stage with the greatest drinking water intake rate. Application of the GenX chemicals HA to a shorter-term risk assessment scenario would provide a conservative, health protective approach in the absence of other information.

Consideration of Noncancer Health Risks from PFAS Mixtures

EPA recently released a *Draft Framework for Estimating Noncancer Health Risks Associated with Mixtures of Per- and Polyfluoroalkyl Substances (PFAS)* that is currently undergoing SAB review (U.S. EPA, 2021e). That draft document provides a flexible, data-driven framework that facilitates practical evaluation of two or more PFAS based on current, available EPA chemical mixtures approaches and methods. Examples are presented for three approaches—Hazard Index (HI), Relative Potency Factor (RPF), and Mixture BMD—to demonstrate application to PFAS mixtures. To use these approaches, specific input values and information for each PFAS are needed or can be developed.

The health advisory documents provide an example of how to use the HI approach to assess the potential noncancer risk of a mixture of PFOA, PFOS, GenX chemicals, and PFBS (U.S. EPA, 2022 a-d). A mixture PFAS HI can be calculated when health-based water concentrations (e.g., HAs, MCLGs) for a set of PFAS are available or can be calculated. In the example, hazard quotients (HQs) are calculated by dividing the measured component PFAS concentration in water (e.g., expressed as ng/L) by the relevant HA (e.g., expressed as ng/L), as shown in the equation below. Component HQs are then summed across the PFAS mixture to yield the mixture PFAS HI. A mixture PFAS HI greater than 1 indicates an exceedance of the health protective level and indicates potential human health risk for noncancer effects from the PFAS mixture in water. When component health-based water concentrations (in this case, HAs) are below the analytical method detection limit, as is the case for PFOA and PFOS, such individual component HQs exceed 1, meaning that any detectable level of PFOA or PFOS will result in an HI greater than 1 for the whole mixture. Further analysis could provide a refined assessment of the potential for health effects associated with the individual PFAS and their contributions to the potential joint toxicity associated with the mixture. For more details, please see U.S. EPA (2021e).

$$HI = \left(\frac{[PFOA_{water}]}{[PFOA_{HA}]}\right) + \left(\frac{[PFOS_{water}]}{[PFOS_{HA}]}\right) + \left(\frac{[GenX_{water}]}{[GenX_{HA}]}\right) + \left(\frac{[PFBS_{water}]}{[PFBS_{HA}]}\right)$$

Where:

HI = hazard index;

[$PFAS_{water}$] = concentration for a given PFAS in water;

[$PFAS_{HA}$] = the HA value for a given PFAS

Where can I find more information?

To view the HA documents, go to: https://www.epa.gov/sdwa/drinking-water-health-advisories-has

To view the PFAS Strategic Roadmap: EPA's Commitments to Action 2021-2024, go to: https://www.epa.gov/pfas/pfas-strategic-roadmap-epas-commitments-action-2021-2024

For information on drinking water, go to: www.epa.gov/safewater

References

U.S. EPA (U.S. Environmental Protection Agency). 1991. *Guidelines for Developmental Toxicity Risk Assessment*. EPA-600-FR-91-001. EPA, Risk Assessment Forum, Washington, DC. Accessed April 2022. https://www.epa.gov/sites/default/files/2014-11/documents/dev_tox.pdf.

U.S. EPA (U.S. Environmental Protection Agency). 2000. Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000). EPA-822-B-00-004. EPA, Office of Water, Washington, DC. https://www.epa.gov/sites/default/files/2018-10/documents/methodology-wqc-protection-hh-2000.pdf.

U.S. EPA (U.S. Environmental Protection Agency). 2002. A Review of the Reference Dose and Reference Concentration Process. EPA/630/P-02/002F. EPA, Risk Assessment Forum, Washington, DC. Accessed May 2022. https://www.epa.gov/sites/default/files/2014-12/documents/rfd-final.pdf.

U.S. EPA (U.S. Environmental Protection Agency). 2016a. Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA). EPA-822-R-16-005. EPA, Office of Water, Washington, DC. Accessed June 2022. https://www.epa.gov/sites/production/files/2016-05/documents/pfoa_health_advisory_final-plain.pdf.

EPA (U.S. Environmental Protection Agency). 2016b. Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS). EPA-822-R-16-004. EPA, Office of Water, Washington, DC. Accessed June 2022. https://www.epa.gov/sites/default/files/2016-05/documents/pfos_health_advisory_final_508.pdf.

U.S. EPA (U.S. Environmental Protection Agency). 2019. Exposure Factors Handbook Chapter 3 (Update): Ingestion of Water and Other Select Liquids. U.S. EPA Office of Research and Development, Washington, DC, EPA/600/R-18/259F. https://www.epa.gov/sites/default/files/2019-02/documents/efh_-_chapter_3_update.pdf.

U.S. EPA (U.S. Environmental Protection Agency). 2021a. *External Peer Review Draft: Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctanoic Acid (PFOA) (CASRN 335-67-1) in Drinking Water*. EPA- 822-D-21-001. EPA, Office of Water, Washington, DC. Accessed April 2022. https://sab.epa.gov/ords/sab/f?p=100:18:16490947993:::RP,18:P18_ID:2601.

U.S. EPA (U.S. Environmental Protection Agency). 2021b. *External Peer Review Draft: Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctane Sulfonic Acid (PFOS) CASRN 1763-23-1 in Drinking Water.* EPA-822-D-21-002. EPA, Office of Water, Washington, DC. Accessed April 2022. https://sab.epa.gov/ords/sab/f?p=100:18:16490947993:::RP,18:P18_ID:2601.

U.S. EPA (U.S. Environmental Protection Agency). 2021c. Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (CASRN 13252-13-6 and CASRN 62037-80-3). Also Known as "GenX Chemicals." EPA/822/R-21/010. EPA, Office of Water, Health and Ecological Criteria Division, Washington, DC. https://www.epa.gov/chemical-research/human-health-

toxicity-assessments-genx-chemicals

U.S. EPA (U.S. Environmental Protection Agency). 2021d. Human Health Toxicity Values for Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-49-3). EPA/600/R-20/345F. EPA, Office of Research and Development, Washington, DC. https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=350888.

U.S. EPA (U.S. Environmental Protection Agency). 2021e. Draft Framework for Estimating Noncancer Health Risks Associated with Mixtures of Per- and Polyfluoroalkyl Substances (PFAS). EPA-822-D-21-003. EPA, Office of Water, Washington, DC. https://sab.epa.gov/ords/sab/f?p=100:18:16490947993:::RP,18:P18_ID:2601

U.S. EPA (U.S. Environmental Protection Agency). 2022a. Interim Drinking Water Health Advisory: Perfluorooctanoic Acid (PFOA) CASRN 335-67-1. EPA/822/R-22/003. EPA, Office of Water, Health and Ecological Criteria Division, Washington, DC. https://www.epa.gov/sdwa/drinking-water-health-advisories-has.

U.S. EPA (U.S. Environmental Protection Agency). 2022b. Interim Drinking Water Health Advisory: Perfluorooctane Sulfonic Acid (PFOS) CASRN 1763-23-1. EPA/822/R-22/004. EPA, Office of Water, Health and Ecological Criteria Division, Washington, DC. https://www.epa.gov/sdwa/drinking-water-health-advisories-has.

U.S. EPA (U.S. Environmental Protection Agency). 2022c. Drinking Water Health Advisory: Hexafluoropropylene Oxide (HFPO) Dimer Acid (CASRN 13252-13-6) and HFPO Dimer Acid Ammonium Salt (CASRN 62037-80-3), Also Known as "GenX Chemicals." EPA/822/R-22/005. EPA, Office of Water, Health and Ecological Criteria Division, Washington, DC. https://www.epa.gov/sdwa/drinking-water-health-advisories-has.

U.S. EPA (U.S. Environmental Protection Agency). 2022d. Drinking Water Health Advisory: Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-49-3). EPA/822/R-22/006. EPA, Office of Water, Health and Ecological Criteria Division, Washington, DC. https://www.epa.gov/sdwa/drinking-water-health-advisories-has.