**New Energy Economy**
**Exhibit A**

**STATE OF NEW MEXICO**
**DEPARTMENT OF ENERGY, MINERALS AND NATURAL RESOURCES**
**OIL CONSERVATION COMISSION**

IN THE MATTER OF PROPOSED
AMENDMENT TO THE COMMISSION'S
RULES TO ADDRESS CHEMICAL DISCLOSURE AND
THE USE OF PERFLUOROALKYL AND
POLYFLUOROALKYL SUBSTANCES AND
IN OIL AND GAS EXTRACTION,
19.15.2, 19.15.7, 19.15.14, 19.15.16 AND 19.15.25 NMAC.

Petitioner.

CASE NO. 23580

DIRECT TECHNICAL TESTIMONY AND EXHIBITS

OF

KRISTEN HANSEN, Ph.D.
Savanna Science Consulting

ON BEHALF OF
NEW ENERGY ECONOMY

October 21, 2024

## Background and Experience

**Q. Please state your name and business address.**

A. My name is Kristen Hansen and my business address is 14675 Afton Blvd S. Afton, MN 55001.

**Q. On whose behalf are you testifying in this proceeding?**

A. I am testifying on behalf of New Energy Economy ("NEE").

**Q. Please summarize your educational background and your professional experience related to the study, analysis and regulation of water.**

A. In 1991, I graduated with Honors from Williams College (Williamstown, MA) with a BA in chemistry. My senior research thesis at Williams, *Quantitative and Qualitative Characterization of Polychlorinated Biphenyls in the Hoosic River Ecosystem* documented a year-long research project based on analytical method development and analysis in tracking polychlorinated biphenyls through various matrices associated with the Hoosic River.

I earned my Ph.D. at the University of Colorado (Boulder, CO) in 1995, following completion of my dissertation, *Supercritical Fluid Extraction and Analysis of Tropospheric Aerosol Particles*. Like my undergraduate thesis, my dissertation involved identifying and tracking low level anthropogenic compounds in the environment. Upon my graduation from University of Colorado, I won a National Research Council Fellowship based on my proposal to apply my expertise in the analysis of trace level organic compounds in the remote Pacific Ocean as part of collaborative field study headed by the National Oceanic and Atmospheric Administration in Seattle, WA.

I was hired by 3M on July 1, 1996 as a Chemistry Post-doc in 3M's Environmental Lab. In October of 1996, my Post-doc was converted to a full-time position at 3M. Between 1997 and 2001 in 3M's Environmental Lab, I was working on the global PFOS contamination issue. In addition to carrying out research around PFAS contamination and routes of exposure, I handled samples for several groups including 1) 3M Toxicology (*e.g.* PFAS characterization in tissue samples collected in support of toxicology studies conducted on rats, monkeys and mice including sera, liver, plasma, placenta and mild curd), 2) 3M Manufacturing Facilities (*e.g.* characterization of various samples originating at or near 3M manufacturing facilities including waste water, sludge, tars, surface wipes), 3) Environmental Samples (*e.g.* characterization of blood from non-occupationally exposed humans, wildlife, surface water, drinking water and animal feed), and 4) Product Exposure (*e.g.* characterization of PFAS transfer from PFAS-coated packaging to food and degradation of PFAS-coated textiles). I had a central role in developing methods and collecting data to support these areas and to identify and characterize the global contamination associated with PFAS compounds. My team developed methods for and primarily used HPSE (high pressure solvent extraction), HPLCS-MSMS, High Resolution HPLC-MS, GCMS, and Total Organic Fluorine and Absorbable Organic Fluorine to support characterization of a variety of samples.

In my role, I problem solved with 3M scientists and engineers engaged in the challenges and questions sparked by my work "discovering" global PFOS contamination including with members of the Medical Division (epidemiology and toxicology) and Plant Engineering

(Decatur, Antwerp, Cottage Grove), as well as with Environmental Scientists, Product Responsibility Managers and 3M Management/Executive Management.

I was the Environmental Lab's technical expert on PFAS methods (especially mass spectrometry, but also HPLC-MSMS, GCMS, SCF and HPS Extraction, Organic Fluorine), leading the transfer of analytical methods to outside contract labs. In addition to supporting researchers in several disciplines within 3M, my group completed method development activities and analysis for at least one academic researcher, providing all of the PFAS-specific data published in several publications.

I authored numerous reports and was the primary author on the 2 publications my Environmental Lab-led team was allowed to submit for publication in peer-reviewed journals. I had responsibility for collection of data and for authoring the analytical method sections of manuscripts in toxicology and epidemiology studies published by 3M, and for manuscripts relating to PFAS in wildlife samples authored by 3M-engaged academics.

Data collected by me and my group were frequently included in 3M's TSCA §8(e) submissions/additions, including in May 1998. On more than one occasion, I met with 3M executives in meetings I understood to be in preparation for their discussions with EPA or FDA.

As the technical lead most central to the development of methods and collection of data associated with relatively low-levels of PFAS compounds in humans, animals, 3M waste streams and the environment, I was in a unique position to review and evaluate many different dimensions of PFAS exposure. My technical partnerships with toxicologists, epidemiologists, industrial engineers, and product responsibility liaisons (and thus, indirectly, customers) allowed me to engage in cross-functional technical discussions with other experts and to connect information across disciplines, using data from one area to help answer questions in another. I understood the limits of the sample preparation methods and analytical technologies in general and of our methods specifically.

Between March 2002 and October 2022, I worked at various positions of increasing responsibility within 3M. I worked in technical roles in new technology development in Health Care, and product development and project management in several industrial businesses.

In 2022, I left 3M and founded Savanna Science Consulting, focusing primarily on researching, educating, and communicating issues related to chemicals in the environment.

Please see Exhibit KH-1 for my Curriculum Vitae, including my scholarly publications and presentations.

**Q. Would you please summarize how, if at all, you have come to study PFAS, their characteristics and effects.**

A. In my role working in 3M's Environmental Lab, I had an intense focus on tracking PFAS in the environment and measuring PFAS compounds in myriad matrices. Analytical method development and environmental tracking depend on an understanding of the chemical characteristics of the target analytes. Additionally, my work was highly collaborative and carried out in a multi-dimensional scientific environment that included epidemiologists, toxicologists, civil engineers, synthetic chemists, and hydrologists, for example. Through these interactions I developed a robust understanding of PFAS in the environment.

Since leaving 3M, I have continued my focus on PFAS, participating in scientific conferences and in professional settings built around the science and policy of PFAS. I also have professional collaborations on-going with researchers in this area.

**Q. Have you appeared before the Oil Conservation Commission before or submitted testimony?**

A. No.

**Q. Were you the subject of a New Yorker article entitled, *How 3M Discovered, Then Concealed, the Dangers of Forever Chemicals*, published May 20, 2024?**

A. Yes. The article is attached as Exhibit KH-2.

**Q. Do you agree or disagree with the statements made in that article?**

A. I agree.

## Executive Summary

I have reviewed the Amended Application for Rulemaking filed on August 23, 2024 by Wild Earth Guardians, entitled "In the Matter of proposed Amendment to the Commission's Rules to Address Chemical Disclosure and the Use of Perfluoroalkyl and Polyfluoroalkyl Substances and in Oil and Gas Extraction, 19.15.2, 19.15.7, 19.15.14, 19.15.16 AND

19.15.25 NMAC." I support a ban on *Perfluoroalkyl* and *polyfluoroalkyl substances* or *PFAS*, defined as: a class of compounds including chemicals with at least one aliphatic perfluorocarbon moiety ($-C_n-F_{2n}-$).

The class of PFAS is estimated to included > 14,000 compounds, many of which have not been identified, much less fully characterized. There are 6 well-characterized PFAS compounds: perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorohexane sulfonic acid (PFHxS), perfluorobutane sulfonic acid (PFBS), perfluorononanoic acid (PFNA) and hexafluoropropylene oxide dimer acid (HPFO-DA or Gen X). These well-characterized PFAS span a range of chemistries and are therefore reasonable surrogates for the thousands of under-studied/unstudied members of the class in considering environmental mobility and toxicity to humans. These six well-characterized PFAS are the basis for EPA's April 2024 rule concerning maximum contaminant levels (MCLs) of PFAS in drinking water. Although other members of the PFAS class are not well studied, emerging evidence suggests potential similarities in toxicity for many members of the class. Emerging evidence also suggests the potential for additive toxicity amongst different members of the class. That is, exposure to more than one PFAS may result in health effects greater than exposure to a single PFAS alone [Conley, 2022]. It is to accommodate the potential for additive toxicity that EPA defined a Health Index (HI) component of the MCL: a limit based on a combination of up to 4 PFAS (PFHxS, PFBS, PFNA, HPFO-DA).

Despite the number of different PFAS, there are several characteristics that apply to all, most or many PFAS:

- The vast majority of PFAS are xenobiotic (human made) and are not found in nature.
- The vast majority of PFAS include some molecular component that is persistent in the environment (> 10 years), resisting breakdown by bacteria, hydrolysis, or photolysis. Thus, the moniker for PFAS as "forever chemicals".
- The vast majority of the perfluoro components of PFAS are not destroyed in conventional water treatment processes.
- Of the well-studied PFAS compounds, all but one (HPFO-DA) bioaccumulate in humans with half-lives ranging from between several weeks (PFBS) to several years (PFOA, PFOS, PFHxS, PFNA).
- According to the CDC's Agency for Toxic Substances and Disease Registry the well-studied PFAS compounds, all are linked to one or several health effects in humans including cancer, developmental toxicity, endocrine disruption, cardiovascular disease, immune system toxicity and liver toxicity.

Pathways of human exposure to PFAS include gestation (via placenta), ingestion (including via breast milk, drinking water and food), inhalation and dermal adsorption. [Sunderland, 2019]

## I. It is Necessary to Ban PFAS in O&G Operations

**Q. In your opinion, is it necessary for public health and the environment to Ban PFAS in O&G Operations?**

A. Yes.

**Q. Why?**

A. Although I do not have experience in the oil and gas industry, I understand that this rule prohibits the introduction or use of any undisclosed chemicals or PFAS in the hydraulic fracturing process meaning, all stages of the treatment of a well by the application of hydraulic fracturing fluid under pressure, which treatment is expressly designed to initiate or propagate fractures in an underground geologic formation to enhance the production of oil and gas. The use of PFAS for this application should be banned for the following reasons:

PFAS compounds are pervasive and persistent in the environment. Many are highly mobile in the environment, many bioaccumulate, many are toxic to humans and to biota at very low levels. Given the widespread nature of PFAS exposure to the global human population and the sheer number of different PFAS, most PFAS are under-studied. According to the US EPA, sufficient data exists on the well-studied PFAS to understand the general risk of PFAS exposure to humans, especially exposure to vulnerable populations including pregnant people, infants and children, the elderly and people living with chronic diseases and/or compromised immune systems.

PFAS are mobile in the environment (e.g. via air, atmospheric deposition, ground water, rain/snow, desorption from soil/sludge, surface water, seafoam) and thus are not easily contained or controlled [Sunderland 2019].

The continued use of PFAS compounds for non-critical applications add more PFAS to the environment both in their use as products and in the course of their manufacture. As per the 2021 report by the EPA, "Multi-Industry Per- and Polyfluoroalkyl Substances (PFAS) Study

– 2021 Preliminary Report," the industrial production of PFAS results in release of PFAS into the environment, as does the disposal of PFAS-associated products.

I understand from industry-experts that the use of PFAS compounds in fracking operations is not a critical component. See Exhibit KH-3.

## II. The definition of PFAS Must be Clear & Broad

**Q. What definition of "PFAS" do you recommend the Oil Conservation Commission Adopt?**

A. The definition for PFAS or per/polyfluoroalkyl substances I recommend the Oil Conservation Commission adopt is: a class of compounds including chemicals with at least one aliphatic perfluorocarbon moiety ($-C_n-F_{2n}-$).

**Q. Please briefly explain the chemistry behind PFAS and what kind of definition would cover the greatest number of compounds possible.**

A. An "aliphatic perfluorocarbon moiety" refers to chemicals that have at least one fully fluorinated carbon atom. The carbon-fluorine bond is exceptionally strong and resists degradation. It is this characteristic of PFAS that have led to their utility in industrial and commercial applications and also to the environmental persistence and global distribution of these compounds. Although some PFAS may include some elements of molecular structure that do not include carbon-fluorine bonds, these chemicals often break down to a terminal perfluorinated moiety that does not degrade further.

The definition for PFAS as *a class of compounds including chemicals with at least one aliphatic perfluorocarbon moiety (-$C_n$-$F_{2n}$-)* would cover the full class of compounds, including those that undergo partial degradation to a persistent PFAS.

The definition of PFAS should NOT be limited to those compounds for which there are specific analytical methods. Given the number of compounds within this class, the uncontrolled nature of the manufacturing process, and the variety of PFAS chemicals in the environment, application of the definition of specific compounds would leave 30-70% unmonitored and uncontrolled.

## III. Per- and polyfluoroalkyl substances (PFAS) are known as "forever chemicals" because they are extremely persistent and can contaminate the environment for decades or centuries. Phasing out "non-essential" uses of PFAS from society and replacing them with suitable alternatives will benefit environmental and human health, now and into the future.

**Q. Please explain the characteristics that all PFAS compounds have in common?**

A. The class of PFAS chemicals is vast including 10,000 - 15,000 different compounds reflecting a diverse set of chemical characteristics. This diversity is also manifested in the industrial and commercial applications of PFAS, from use as an emulsifier and industrial processing aid to incorporation into coating on dental floss to decrease friction during use. Despite the number of different PFAS, there are several characteristics that apply to all, most or many PFAS:

- The vast majority of PFAS are xenobiotic (human made) and are not found in nature.

- The vast majority of PFAS include some molecular component that is persistent in the environment (> 10 years), resisting breakdown by bacteria, hydrolysis, or photolysis. It is this remarkable persistence that leads to the moniker for PFAS as "forever chemicals".
- The vast majority of the perfluoro components of PFAS are not treated or destroyed in conventional water treatment processes.
- Of the well-studied PFAS compounds, all but one (HPFO-DA) bioaccumulate in humans with half-lives ranging from between several weeks (PFBS) to several years (PFOA, PFOS, PFHxS, PFNA).
- Of the well-studied PFAS compounds, all are linked to one or several health effects in humans including cancer, developmental toxicity, endocrine disruption, cardiovascular disease, immune system toxicity and liver toxicity.

Pathways of human exposure to well-studied PFAS include gestation (via placenta), ingestion (including via breast milk, drinking water and food), inhalation (e.g. atmospheric aerosols, household dust) and dermal adsorption. [Sunderland, 2019]

**Q. Why are PFAS known as "forever chemicals"?**

A. The vast majority of PFAS include some molecular component that is persistent in the environment (> 10 years), resisting breakdown by bacteria, hydrolysis, or photolysis. It is this remarkable persistence that leads to the moniker for PFAS as "forever chemicals". The result of this persistence is demonstrated by the presence of PFAS in the blood of children, in snow samples collected from the artic and in nearly 50% of the public drinking water in the US [Sonnenberg 2023].

**Q. Is it your understanding that a significant amount of produced water (PW) is brought to the land surface during oil and gas (O&G) exploration and production?**

A. Yes.

**Q. Does scientific evidence demonstrate that PW, also known as O&G fluid waste, from the Permian Basin, contain PFAS?**

A. Yes.

**Q. How do you know?**

A. A peer-reviewed study [Jiang, 2022] documented levels of several PFAS in produced water samples in the Permian Basin. Additionally, this study underscores the need to establish a comprehensive chemical characterization of PW to better understand environmental and human risk as well as plan for effective treatment of the PW and associated wastes.

**Q. Given what you know about PFAS and how prevalent it is. Would you recommend stopping injection underground to eliminate a possible opportunity of even greater exposure?**

A. All non-essential uses of PFAS should be phased out. The continual release of highly persistent PFAS will result in increasing concentrations and increasing probabilities of the occurrence of known and unknown health effects to human and the environment. Beyond the introduction of PFAS into the environment as a result of product use, the manufacture of PFAS compounds also results in continual PFAS additions to the environment in the form of industrial wastewater, industrial sludge and industrial air emissions.

## IV. The prohibition of undisclosed chemicals and PFAS in downhole operations is necessary.

**Q. Why is the amendment to 19.15.14.9 that "an applicant for a permit to drill, deepen, or plug back shall certify that they will not introduce any undisclosed chemicals or PFAS in downhole operations of the well" necessary?**

A. This provision is necessary because it prohibits the use of undisclosed chemicals and PFAS in downhole operations. Chemical disclosure is needed to verify compliance with the PFAS ban and to provide information necessary for risk assessments and monitoring by regulators, public health professionals, and the public.

## V. PFAS are non-essential in O&G operations.

**Q. Are PFAS non-essential in O&G operations?**

A. In June, 2022, Colorado became the first state to ban the use of PFAS during oil and gas extraction. Colorado also requires chemical disclosure, and refused to allow "trade secrets" to prevent disclosure. My understanding is that O&G continues to operate in Colorado despite these regulations, designed to protect human health and the environment and require transparency from the industry.

Further, on March 2, 2022, Lynn Granger, executive director of API Colorado, a division of the American Petroleum Institute, and Dan Haley, President and CEO of the Colorado Oil & Gas Association, penned an op-ed in the Denver Post, that stated: "Per- and polyfluoroalkyl (PFAS) substances should not be intentionally used in hydraulic fracturing fluid." This op ed is attached as KH-3. This industry statement advocating for a ban on PFAS substances in fracking should apply to the Oil & Gas industry operating in New Mexico as it applies to the Oil & Gas industry operating in Colorado.

**Q. Are you aware of the definition of "hazardous waste" under New Mexico law?**

A. Yes.

**Q. What is it?**

A. Pursuant to NMSA 1978 74-4-3, "hazardous waste" means any solid waste or combination of solid wastes that because of their quantity, concentration or physical, chemical or infectious characteristics may:

(1) cause or significantly contribute to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness; or

(2) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of or otherwise managed.

**Q. Do PFAS fall within this definition?**

A. Yes, they do.

**Q. Why?**

A. As described previously, PFAS compounds are uniformly persistent in the environment and thus have demonstrated the potential to spread widely in the environment, in an exposure risk to whole communities. The majority of the approximately 14,000 members of the class of compounds meeting the definition of PFAS are under studied. However, well studied chemicals in this class cause a variety of adverse health effects in humans and to biota. Data also suggests additive toxicity when one or more PFAS are present in living organisms.

**Q. Does this conclude your direct testimony?**

A. Yes, it does.

**STATE OF NEW MEXICO**
**DEPARTMENT OF ENERGY, MINERALS AND NATURAL RESOURCES**
**OIL CONSERVATION COMISSION**

IN THE MATTER OF PROPOSED
AMENDMENT TO THE COMMISSION'S
RULES TO ADDRESS CHEMICAL DISCLOSURE AND
THE USE OF PERFLUOROALKYL AND
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19.15.2, 19.15.7, 19.15.14, 19.15.16 AND 19.15.25 NMAC.

Petitioner. CASE NO. 23580

SELF AFFIRMATION

Kristen Hansen, expert witness for New Energy Economy, upon penalty of perjury under the laws of the state of Minnesota, affirm and state: I have read the foregoing Direct Technical Testimony & Exhibits of Kristen Hansen and it is true and correct based on my own personal knowledge and belief.

Dated this 21st day of October 2024.

*/s/ Kristen Hansen*
KRISTEN HANSEN

## EXHIBIT LIST FOR THE DIRECT TESTIMONY OF KRISTEN HANSEN

**Exhibit KH-1** – Curriculum Vitae and Publications for Kristen Hansen, Ph.D.

**Exhibit KH-2** – Lerner, Sharon. "How 3M Discovered, Then Concealed, the Dangers of Forever Chemicals," New Yorker, May 20, 2024.

**Exhibit KH-3** – "Opinion: We agree PFAS should note be used in fracking, and it is not" by Lynn Granger & Dan Haley, The Denver Post, March 22, 2022.

## PEER REVIEWED TECHNICAL ARTICLES CITED:

**Cumulative maternal and neonatal effects of combined exposure to a mixture of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) during pregnancy in the Sprague-Dawley rat**
J. M. Conley, C. S. Lambright, N. Evans, E. Medlock-Kakaley, A. Dixon, D. Hill, et al.
Environment International 2022 Vol. 170 Pages 107631
DOI: https://doi.org/10.1016/j.envint.2022.107631

https://www.sciencedirect.com/science/article/pii/S016041202200558X accessed 18 October 2024

**A review of the pathways of human exposure to poly- and perfluoroalkyl substances (PFASs) and present understanding of health effects.** E. M. Sunderland, X. C. Hu, C. Dassuncao, A. K. Tokranov, C. C. Wagner and J. G. Allen; Journal of Exposure Science & Environmental Epidemiology 2019 Vol. 29 Issue 2 Pages 131-147; DOI: 10.1038/s41370-018-0094-1

https://doi.org/10.1038/s41370-018-0094-1 accessed 18 October 2024

**Trends in Serum Per- and Polyfluoroalkyl Substance (PFAS) Concentrations in Teenagers and Adults, 1999–2018 NHANES** N. K. Sonnenberg, A. E. Ojewole, C. O. Ojewole, O. P. Lucky and J. Kusi
International Journal of Environmental Research and Public Health 2023 Vol. 20 Issue 21 Pages 6984 Accession Number: doi:10.3390/ijerph20216984

https://www.mdpi.com/1660-4601/20/21/6984 accessed 18 October 2024

Jiang, Wenbin, et al., "Characterization of produced water and surrounding surface water in the Permian Basin, the United States," *Journal of Hazardous Materials* 430 (2022): 128409, https://www.sciencedirect.com/science/article/abs/pii/S0304389422001972. accessed 18 October 2024

**GOVERNMENT REPORTS CITED**:

United States Environmental Protection Agency, Final PFAS National Primary Drinking Water Regulation, accessed 18 October 2024

United State Environmental Protection Agency, Multi-Industry Per- and Polyfluoroalkyl Substances (PFAS) Study – 2021 Preliminary Report, accessed 18 October 2024.

Center for Disease Control, Agency for Toxic Substances and Disease Registry (ATSDR), Per- and Polyfluoroalkyl Substances (PFAS) and Your Health, accessed 18 October 2024

Exhibit KH-1

**Savanna Science Consulting**
14675 Afton Blvd S * Afton, MN 55001
(445) 400-5640 * kjhansen@savannasci.com

# Kris Hansen, Ph.D.

## SKILLS

Experienced scientific consultant with a background in environmental analysis especially trace-level analysis including perfluoroalkyl substances (PFAS), polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs) and other classes. Trained analytical chemist with industry experience. Skilled writer and speaker for technical and non-technical audiences. Specialties include critical thinking, data interpretation and collaborative problem solving. Experience leading global laboratories and project management organizations, coaching/managing international technical teams. Solving technical challenges with data collection and assessment.

## EXPERIENCE

**Savanna Science Consulting** — *Owner/Consultant*

Jan 2023 - Present

- Provide data review, analysis and education for cities, water authorities, communities
- Cross functional engagement with environmental science communities
- Analyze, assess and summarize relevant data

**3M Food Safety Division** — *Global Director of Application Engineering*

March 2020-October 2022

- Coordinate and direct global AE team (13 countries) providing technical support, education and training to customers and sales team
- Represent AE function in departmental budgetary, prioritization, a resource allocation discussions

**3M Transportation Safety Division** — *Global Lab Manager Pavement Markings & Urban Infrastructure*

January 2017-March 2020

- Product development for urban Infrastructure balancing safety, mobility, climate, cost, accessibility
- Responsible for budget, resource allocation, people management and leadership communication for international lab team

**3M Aerospace & Commercial Transportation Division** — *Manager Product Development Lab & Project Management Organization*

2014-December 2016

- Managed group responsible for product development of FAA certified products; engaged with customers and technical leaders in the industry
- Initiated and managed divisional PMO focused on prioritization and deliverables across over a dozen projects

**3M Drug Delivery System Division** — *Intradermal Delivery Technology & Product Dev Lead*

July 1996-Jan 2001

- Technology and Product Development leader for hollow- and solid-microneedle intradermal delivery program, responsible for technical, regulatory and partner strategy development
- Led cross functional team to take 2 new technologies in to the clinic, including one to Phase 2
- External face of 3M's microneedle drug delivery platform, representing new technologies for international audiences and agencies
- Responsible for strategic and operational management of a multimillion dollar lab budget for intradermal delivery platform

**3M Environmental Lab** — *Postdoc/Sr/Specialist Analytical Chemist*

July 1996-Jan 2001

- Responsible for method development and analysis of PFAS compounds in a variety of matrices including human blood, animal tissues, water, industrial waste, sludge, soil, food products, plants, wildlife
- Responsible for overseeing analytical work supporting critical tox and epidemiological studies via informal and GLP protocols in the role of Principle Analytical Investigator
- Responsible for writing or providing reports, updates and communications to management in crisis situation
- Responsible for communicating results and methods to outside parties as needed including to contact labs, regulatory authorities, lawyers and academic consultants
- Responsible for authoring and/or supporting technical documents for the peer-reviewed literature as directed by executive management
- Responsible for oversight and management of FACT (Fluoringe Analytical Chemistry Team) composed of 3M employees and contract employees
- Responsible for recommending instrumentation needs (specifically Mass Spec) to support emerging analytical needs associated with PFAS crisis

**National Oceanic & Atmospheric Administration** — *National Research Council Fellowship (Postdoc)*

September 1995-July 1996

- System development and data collection supporting analysis of trace level organic compounds in the remote marine atmosphere in conjunction with international effort

## EDUCATION

**University of Colorado, Boulder, CO** — *PhD, Chemistry*

Degree Awarded 1995

*"Supercritical Fluid Extraction and Analysis of Tropospheric Aerosol Particles" (advisor Dr. Robert Sievers)*

**Williams College, Williamstown, MA** — *BA with Honors, Chemistry*

Degree Awarded June 1991

"Qualitative and Quantitative Analysis of PCBs in the Hoosic River Ecosystem" (advisor Dr. Susan Kegley)

## Popular Press

How 3M Discovered and then Concealed the Dangers of Forever Chemicals; The New Yorker, May 20, 2024 by Sharon Lerner

Toxic Gaslighting: How 3M Executives Convinced a Scientist the Forever Chemicals she found in Human Blood were Safe; ProPublica, May 20, 2024 by Sharon Lerner

Profits over Public Health - The Story of Forever Chemicals; ABC Radio National - Rear Vision, Presented by Jennifer Leake, 29 June 2024

Stevens, Lauren R.; *Drainage Ditch is new source of PCB problems at Sprague Plant;* Berkshire Eagle, September 11, 1991

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## Scientific Publications/Presentations

### *PFAS/PCBs/PM2.5*

**K.J. Hansen**; *At the Bench Inside 3M 1997-2001;* National PFAS Conference, Ann Arbor, MI.; 11 June **2024**

**K.J. Hansen** ; *Discovering & Rediscovering Global PFAS Contamination at 3M: "Strategic Science" in Action*; International Society of Exposure Science; Chicago, IL USA; Aug **2023**.

**K.J. Hansen**, Clemen LA, Ellefson ME, Johnson HO. ; Compound-Specific, *Quantitative Characterization of Organic Fluorochemicals in Biological Matrices*; Environ. Sci & Technology, **2001**, *35*, 766-770.

**K.J. Hansen**, H.O. Johnson , J.S. Eldridge , J.L. Butenhoff, L.A. Dick; *Quantitative Characterization of Trace Levels of PFOS and PFOA in the Tennessee River*; Environ. Sci. &Tech, *36*, **2002**, pp. 1681-1685.

Luebker, D.J.; York, R.Y.; **Hansen, K.J**.; Moore, J.A.; Butenhoff, J.L.; *Neonatal mortality from in utero exposure to perfluorooctanesulfonate (PFOS) in Sprague–Dawley rats: Dose–response, and biochemical and pharamacokinetic parameters*; Toxicology, *215*, **2005** pp 149-169.

Luebker, DJ; Case, MT; York, RG; Moore, JA; **Hansen, KJ**, Butenhoff, JL**;** *Two-generation reproduction and cross-foster studies of PFOS in rats***;** Toxicology, *215*, **2005**, pp. 126-148

Olsen GW , Huang HY, Helzlsourer KJ, **Hansen KJ,** Butenhoff J., Mandel JH; *Historical Comparison of PFOS, PFOA and other Fluorochemicals in Human Blood*; Environmental Health Perspectives, *113*, 5, **2005,** pp 539-545

Butenhoff, JL; Kennedy, GL; Hinterliter, PM; Lieder, PH; Jung, R; **Hansen, KJ**; Gorman, GS; Noker, PE; Thomford, PJ. , *Pharmacokinetics of PFOA in Cynomolgus Monkeys*; Toxicological Sciences, *82*, **2004**, pp 394-406.

Olsen, GW; Church, TR; Larson, EB; van Belle, G; Lundberg, JK; **Hansen, KJ**; Burris, JM; Mandel, JH; Zobel, LR; *Serum Concentrations of PFOS and other fluorochemicals in an elderly population from Seattle, Washington*; Chemosphere, *54*, **2004**, pp 1599-1611

Olsen GW, Church T., **Hansen KJ,** Butenhoff J., Mandel JH, Zobel, LR; *Quantitative Evaluation of Perfluorooctanesulfonate (PFOS) and Other Fluorochemicals in the Serum of Children;* Journal of Children's Health, **2004,** 2 (1), pp. 53-76

Olsen GW, **Hansen KJ**, Stevenson LA, Burris J, Mandel JH; *Human Donor Liver Concentrations of PFOS and other Perfluorochemicals*; Environmental Science and Technology, *37*, **2003**, pp. 888-891

Olsen GW, Logan PW, **Hansen KJ**, Simpson CA, Burris JM, Burlew MM, Vorarath SP, Vekateswarlu P, Schumpert JC, Mandel JH; Am Ind Hyg Assoc, **2003,** *64* (5), pp 651-659

Olsen GW, **Hansen KJ,** Mandel JH, Zobel, LR; Environmental Health Perspectives, 11, **2003**, pp. 1892-1901

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Exhibit KH-2

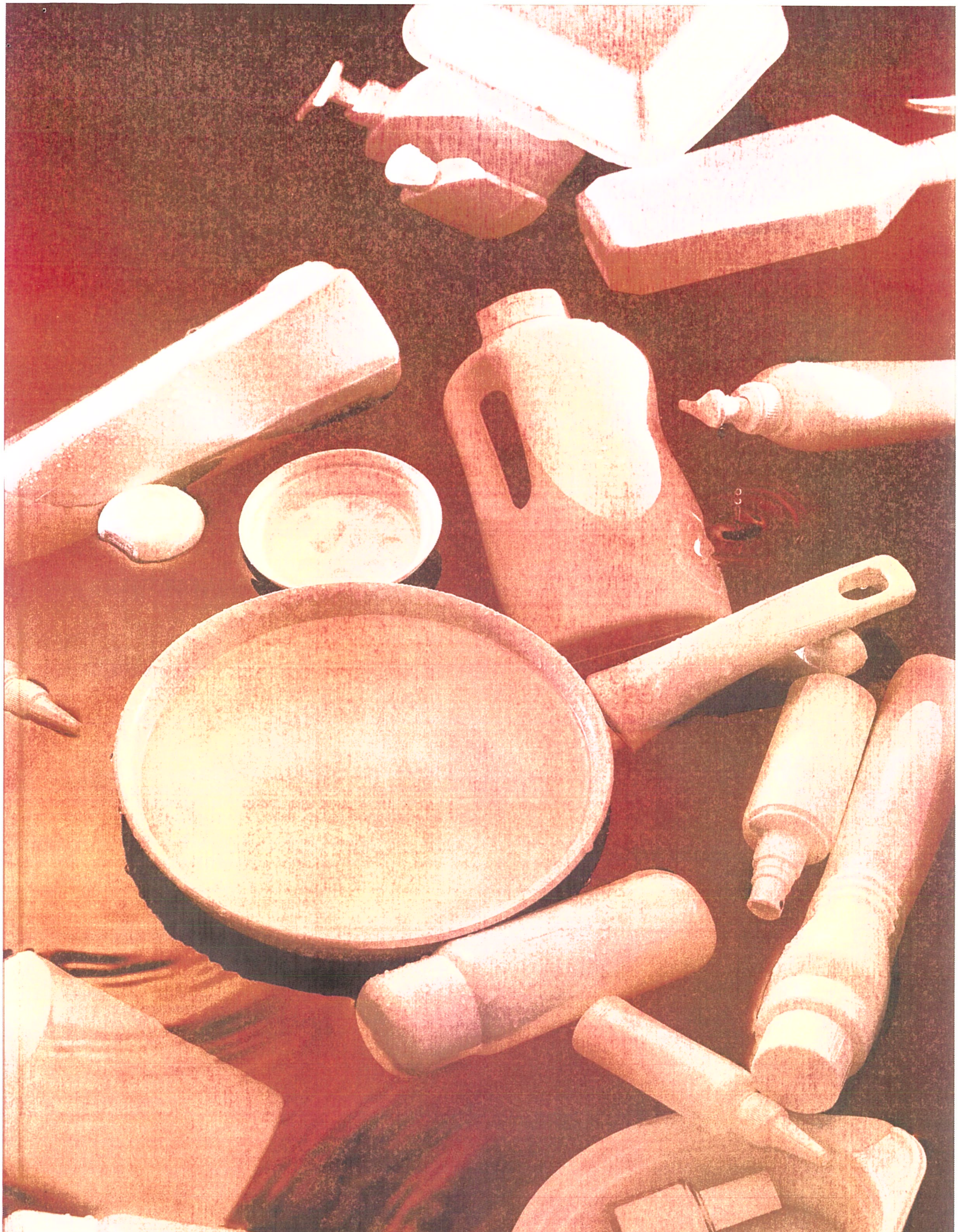
A REPORTER AT LARGE

# HOW 3M DISCOVERED, THEN CONCEALED, THE DANGERS OF FOREVER CHEMICALS

*The company found its own toxic compounds in human blood—and kept selling them.*

By Sharon Lerner

May 20, 2024



In April, the Environmental Protection Agency finalized two historic regulations of forever chemicals, which are found in countless everyday products. Photo illustration by Philotheus Nisch for The New Yorker



*This article is a collaboration between The New Yorker and ProPublica.*

Kris Hansen had worked as a chemist at the 3M Corporation for about a year when her boss, an affable senior scientist named Jim Johnson, gave her a strange assignment. 3M had invented Scotch Tape and Post-it notes; it sold everything from sandpaper to kitchen sponges. But on this day, in 1997, Johnson wanted Hansen to test human blood for chemical contamination.

Several of 3M's most successful products contained man-made compounds called fluorochemicals. In a spray called Scotchgard, fluorochemicals protected leather and fabric from stains. In a coating known as Scotchban, they prevented food packaging from getting soggy. In a soapy foam used by firefighters, they helped extinguish jet-fuel fires. Johnson explained to Hansen that one of the company's fluorochemicals, PFOS—short for perfluorooctanesulfonic acid—often found its way into the bodies of 3M factory workers. Although he said that they were unharmed, he had recently hired an outside lab to measure the levels in their blood. The lab had just reported something odd, however. For the sake of comparison, it had tested blood samples from the American Red Cross, which came from the general population and should have been free of fluorochemicals. Instead, it kept finding a contaminant in the blood.

Johnson asked Hansen to figure out whether the lab had made a mistake. Detecting trace levels of chemicals was her specialty: she had recently written a doctoral dissertation about tiny particles in the atmosphere. Hansen's team of lab technicians and junior scientists fetched a blood sample from a lab-supply company and prepped it for analysis. Then Hansen switched on an oven-size box known as a mass spectrometer, which weighs molecules so that scientists can identify them.

As the lab equipment hummed around her, Hansen loaded a sample into the machine. A graph appeared on the mass spectrometer's display; it suggested that there was a compound in the blood that could be PFOS. That's weird, Hansen thought. Why would a chemical produced by 3M show up in people who had never worked for the company?

Hansen didn't want to share her results until she was certain that they were correct, so she and her team spent several weeks analyzing more blood, often in time-consuming overnight tests. All the samples appeared to be contaminated. When Hansen used a more precise method, liquid chromatography, the results left little doubt that the chemical in the Red Cross blood was PFOS.

Hansen now felt obligated to update her boss. Johnson was a towering, bearded man, and she liked him: he seemed to trust her expertise, and he found something to laugh about in most conversations. But, when she shared her findings, his response was cryptic. "This changes everything," he said. Before she could ask him what he meant, he went into his office and closed the door.

This was not the first time that Hansen had found a chemical where it didn't belong. A wiry woman who grew up skiing competitively, Hansen had always liked to spend time outdoors; for her chemistry thesis at Williams College, she had kayaked around the former site of an electric company on the Hoosic River, collecting crayfish and testing them for industrial pollutants called polychlorinated biphenyls (PCBs). Her research, which showed that a drainage ditch at the site was leaking the chemicals, prompted a news story and contributed to a cleanup effort overseen by the Massachusetts Department of Environmental Protection. At 3M, Hansen assumed that her bosses would respond to her findings with the same kind of diligence and care.

Hansen stayed near Johnson's office for the rest of the day, anxiously waiting for him to react to her research. He never did. In the days that followed, Hansen sensed that Johnson had notified some of his superiors. She remembers his boss, Dale Bacon, a paunchy fellow with gray hair, stopping by her desk and suggesting that she had made a mistake. "I don't think so," she told him. In subsequent weeks, Hansen and her team ordered fresh blood samples from every supplier that 3M worked with. Each of the samples tested positive for PFOS.

In the middle of this testing, Johnson suddenly announced that he would be taking early retirement. After he packed up his office and left, Hansen felt adrift. She was so new to corporate life that her office clothes—pleated pants and dress shirts—still felt like a costume. Johnson had always guided her research, and he hadn't told Hansen what she should do next. She reminded herself of what he had said—that the chemical wasn't harmful in factory workers. But she couldn't be sure that it was harm*less*. She knew that PCBs, for example, were mass-produced for years before studies showed that they accumulate in the food chain and cause a range of health issues, including damage to the brain. The most reliable way to gauge the safety of chemicals is to study them over time, in animals and, if possible, in humans.

What Hansen didn't know was that 3M had already conducted animal studies—two decades earlier. They had shown PFOS to be toxic, yet the results remained secret, even to many at the company. In one early experiment, conducted in the late seventies, a group of 3M scientists fed PFOS to rats on a daily basis. Starting at the second-lowest dose that the scientists tested, about ten milligrams for every kilogram of body weight, the rats showed signs of possible harm to their livers, and half of them died. At higher doses, every rat died. Soon afterward, 3M scientists found that a relatively low daily dose, 4.5 milligrams for every kilogram of body weight, could kill a monkey within weeks. (Based on this result, the chemical would currently fall into the highest of five toxicity levels recognized by the United Nations.) This daily dose of PFOS was orders of magnitude greater than the amount that the average person would ingest, but it was still relatively low—roughly comparable to the dose of aspirin in a standard tablet.

In 1979, an internal company report deemed PFOS "certainly more toxic than anticipated" and recommended longer-term studies. That year, 3M executives flew to San Francisco to consult Harold Hodge, a respected toxicologist. They told Hodge only part of what they knew: that PFOS had sickened and even killed laboratory animals, and had caused liver abnormalities in factory workers. According to a 3M document that was marked "CONFIDENTIAL," Hodge urged the executives to study whether the company's fluorochemicals caused reproductive issues or cancer. After reviewing more data, he told one of them to find out whether the chemicals were present "in man," and he added, "If the levels are high and widespread and the half-life is long, we could have a serious problem." Yet Hodge's warning was omitted from official meeting notes, and the company's fluorochemical production increased over time.

Hansen's bosses never told her that PFOS was toxic. In the weeks after Johnson left 3M, however, she felt that she was under a new level of scrutiny. One of her superiors suggested that her equipment might be contaminated, so she cleaned the mass spectrometer and then the entire lab. Her results didn't change. Another encouraged her to repeatedly analyze her syringes, bags, and test tubes, in case they had tainted the blood. (They had not.) Her managers were less concerned about PFOS, it seemed to Hansen, than about the chance that she was wrong.

Sometimes Hansen doubted herself. She was twenty-eight and had only recently earned her Ph.D. But she continued her experiments, if only to respond to the questions of her managers. 3M bought three additional mass spectrometers, which each cost more than a car, and Hansen used them to test more blood samples. In late 1997, her new boss, Bacon, even had her fly out to the company that manufactured the machines, so that she could repeat her tests there. She studied the blood of hundreds of people, from more than a dozen blood banks in various states. Each sample contained PFOS. The chemical seemed to be everywhere.

When 3M was founded, in 1902, it was known as the Minnesota Mining and Manufacturing Company. After its mining operations flopped, the company pivoted to sandpaper, and then to a series of clever inventions aimed at improving everyday life. An early employee noticed that autoworkers were struggling to paint two-tone cars, which were popular at the time; he eventually invented masking tape, using crêpe paper and cabinetmaker's glue. Another 3M employee created Post-it notes, to help him bookmark passages in his church hymnal. An official history of 3M, published for the company's hundredth anniversary, celebrated its "tolerance for tinkerers."

Fluorochemicals had their origins in the American effort to build the atomic bomb. During the Second World War, scientists for the Manhattan Project developed one of the first safe processes for bonding carbon to fluorine, a dangerously reactive element that experts had nicknamed "the wildest hellcat" of chemistry. After the war, 3M hired some Manhattan Project chemists and began mass-producing chains of carbon atoms bonded to fluorine atoms. The resulting chemicals proved to be astonishingly versatile, in part because they resist oil, water, and heat. They are also incredibly long-lasting, earning them the moniker "forever chemicals."

In the early fifties, 3M began selling one of its fluorochemicals, PFOA, to the chemical company DuPont, for use in Teflon. Then, a couple of years later, a dollop of fluorochemical goo landed on a 3M employee's tennis shoe, where it proved impervious to stains and impossible to wipe off. 3M now had the idea for Scotchgard and Scotchban. By the time Hansen was in elementary school, in the seventies, both products were ubiquitous. Restaurants served French fries in Scotchban-treated packaging. Hansen's mother sprayed Scotchgard on the living-room couch.

Hansen grew up in Lake Elmo, Minnesota, not far from 3M's headquarters. Her father was one of the company's star engineers and was even inducted into its hall of fame, in 1979; he had helped to create Scotch-Brite scouring pads and Coban wrap, a soft alternative to sticky bandages. Once, he molded some fibres into cups, thinking that they might make a good bra. They turned out to be miserably uncomfortable, so he and his colleagues placed them over their mouths, giving the company the inspiration for its signature N95 mask.

Hansen never intended to follow her father to the company. She spent her childhood summers catching turtles and leopard frogs at the lake and hoped to have a career in environmental conservation. Her first job after earning her chemistry Ph.D. was on a boat, which took her to remote parts of the Pacific Ocean. But the voyage left her so seasick that she lost twenty pounds, and she soon retreated to Minnesota. In 1996, at her father's suggestion, Hansen applied for a position in 3M's environmental lab.

After Hansen started her PFOS research, her relationships with some colleagues seemed to deteriorate. One afternoon in 1998, a trim 3M epidemiologist named Geary Olsen arrived with several vials of blood and asked her to test them. The next morning, she read the results to him and several colleagues—positive for PFOS. As Hansen remembers it, Olsen looked triumphant. "Those samples came from my horse," he said—and his horse certainly wasn't eating at McDonald's or trotting on Scotchgarded carpets. Hansen felt that he was trying to humiliate her.

(Olsen did not respond to requests for comment.) What Hansen wanted to know was how PFOS was making its way into animals.

She found an answer in data from lab rats, which also appeared to have fluorochemicals in their blood. Rats that had more fish meal in their diets, she discovered, tended to have higher levels of PFOS, suggesting that the chemical had spread through the food chain, and perhaps through water. In male lab rats, PFOS levels rose with age, indicating that the chemical accumulated in the body. But, curiously, in female rats the levels sometimes fell. Hansen was unsettled when toxicology reports indicated why: mother rats seemed to be off-loading the chemical to their pups. Exposure to PFOS could begin before birth.

Another study confirmed that Scotchban and Scotchgard were sources of the chemical. PFOS wasn't an official ingredient in either product, but both contained other fluorochemicals that, the study showed, broke down into PFOS in the bodies of lab rats. Hansen and her team ultimately found PFOS in eagles, chickens, rabbits, cows, pigs, and other animals. They also found fourteen additional fluorochemicals in human blood, including several produced by 3M. Some were present in wastewater from a 3M factory.

At one point, Hansen told her father, Paul, that she was frustrated by the way senior colleagues kept questioning her work. Paul had recently retired, but he had confidence in 3M's top executives, and he suggested that she take her findings directly to them. But as a relatively new employee—and one of the few women scientists at a company of about seventy-five thousand people—Hansen found the idea preposterous. When Paul offered to talk to some of 3M's executives himself, she was mortified at the idea of her father interceding.

Hansen knew that if she could find a blood sample that *didn't* contain PFOS then she might be able to convince her colleagues that the other samples did. She and her team began to study historical blood from the early decades of PFOS production. They soon found the chemical in blood from a 1969-71 Michigan breast-cancer study. Then they ran an overnight test on blood that had been collected in rural China during the eighties and nineties. If any place were PFOS-free, she figured, it would be somewhere remote, where 3M products weren't in widespread use.

The next morning, anxious to see the results, Hansen arrived at the lab before anyone else. For the first time since she had begun testing blood, some of the samples showed no trace of PFOS. She was so struck that she called her husband. There was nothing wrong with her equipment or methodology; PFOS, a man-made chemical produced by her employer, really *was* in human blood, practically everywhere. Hansen's team found it in Swedish blood samples from 1957 and 1971. After that, her lab analyzed blood that had been collected before 3M created PFOS. It tested negative. Apparently, fluorochemicals had entered human blood after the company started selling products that contained them. They had leached out of 3M's sprays, coatings, and factories—and into all of us.

That summer, an in-house librarian at 3M delivered a surprising article to Hansen's office mailbox. It had been written in 1981, by 3M scientists, and it described a method for measuring fluorine in blood, indicating that even back then the company was testing for fluorochemicals. One scientist mentioned in the article, Richard Newmark, still worked for 3M, in a low-lying structure nicknamed the "nerdy building." Hansen arranged to meet with him there.

Newmark, a collegial man with a compact build, told Hansen that, more than twenty years before, two academic scientists, Donald Taves and Warren Guy, had discovered a fluorochemical in human blood. They had wondered whether Scotchgard might be its source, so they approached 3M. Newmark told her that his subsequent experiments had confirmed their suspicions—the chemical was PFOS—but 3M lawyers had urged his lab not to admit it.

As Hansen wrote all this down in a notebook, she felt anger rising inside her. Why had so many colleagues doubted the soundness of her results if earlier 3M experiments had already proved the same thing? After the meeting, she hurried back to the lab to find Bacon. "He knew!" she told him.

Bacon's face remained expressionless. He told Hansen to type up her notes for him. She remembers him telling her not to e-mail them. (In response to questions about Hansen's account, Bacon said that he didn't remember specifics. When I called Newmark, he told me that he could not remember her or anything about PFOS. "It's been a very long time, and I'm in my mid-eighties, and just do not remember stuff that well," he said.)
A few months later, in early 1999, Bacon invited Hansen to an extraordinary meeting: she would have the chance to present her findings to 3M's C.E.O., Livio D. DeSimone. Hansen spent several days rehearsing while driving and making dinner. On the day of the meeting, she took an elevator up to the executive suite; her stomach turned as a secretary pointed her to a conference room. Men in suits sat around a long table. Her boss, Bacon, was there. DeSimone, a portly man with white hair, sat at the head of the table.

Almost as soon as Hansen placed her first transparency on the projector, the attendees began interrogating her: Why did she do this research? Who directed her to do it? Whom did she inform of the results? The executives seemed to view her diligence as a betrayal: her data could be damaging to the company. She remembers defending herself, mentioning Newmark's similar work in the seventies, and trying, unsuccessfully, to direct the conversation back to her research. While the executives talked over her, Hansen noticed that DeSimone's eyes had closed and that his chin was resting on his dress shirt. The C.E.O. appeared to have fallen asleep. (DeSimone died in 2017. A company spokesperson did not answer my questions about the meeting.)

After that meeting, Hansen remembers learning from Bacon that her job would be changing. She would only be allowed to do experiments that a supervisor had specifically requested, and she was to share her data with only that person. She would spend most of her time analyzing samples for studies that other employees were conducting, and she should not ask questions about what the results meant. Several members of her team were also being reassigned. Bacon explained that a different scientist at 3M would lead research into PFOS going forward. Hansen felt that she was being punished and struggled not to cry.

Even as Hansen was being sidelined, the results of her research were quietly making their way into the files of the Environmental Protection Agency. Since the seventies, federal law has required that companies tell the E.P.A. about any evidence indicating that a company's products present "a substantial risk of injury to health or the environment." In May, 1998, 3M officials notified the agency, without informing Hansen, that the company had measured PFOS in blood samples from around the U.S.—a clear reference to Hansen's work. It did not mention its animal research from the seventies, and it said that the chemical caused "no adverse effects" at the levels the company had measured in its workers. A year later, 3M sent the E.P.A. another letter, again without telling Hansen. This time, it informed the agency about the fourteen other fluorochemicals, several of them made by 3M, that Hansen's team had detected in human blood. The company reiterated that it did not believe that its products presented a substantial risk to human health.

Hansen recalls that in the summer of 1999, at an annual picnic that her parents hosted for 3M scientists, she was grilling corn when one of the creators of Scotchgard, a gray-haired man in glasses, confronted her. He accused her of trying to tear down the work of her colleagues. Did it make her feel powerful ruining other people's careers? he asked. Hansen didn't know how to respond, and he walked away.

Several of Hansen's superiors had stopped greeting her in the hallways. When she presented a poster of her research at a 3M event, nobody asked her about it. She lost her appetite, and her pleated pants grew baggy. She started to worry that an angry co-worker might confront or even harm her in the company's dark parking lot. She got into the habit of calling her husband before walking to her car.

A year after Hansen's meeting with the C.E.O., 3M, under pressure from the E.P.A., made a very costly decision: it was going to discontinue its entire portfolio of PFOS-related chemicals. In May, 2000, for the first time, 3M officials revealed to the press that it had detected the chemical in blood banks. One executive claimed that the discovery was a "complete surprise." The company's medical director told the New York *Times*, "This isn't a health issue now, and it won't be a health issue." But the newspaper also quoted a professor of toxicology. "The real issue is this stuff accumulates," the professor said. "No chemical is totally innocuous, and it seems inconceivable that anything that accumulates would not eventually become toxic."

Hansen was now pregnant with twins. Although she was heartened by 3M's announcement—she saw it as evidence that her work had forced the company to act—she was also ready to leave the environmental lab, where she felt marginalized. After giving birth, she joined 3M's medical-devices team. But, first, she decided to have one last blood sample tested for PFOS: her own. The results showed one of the lowest readings she'd seen in human blood. Immediately, she thought of the rats that had passed the chemical on to their pups.

Hansen told me that, for the next nineteen years, she avoided the subject of fluorochemicals with the same intensity with which she had once pursued it. She focussed on raising her kids and coaching a cross-country ski team; she worked a variety of jobs at 3M, none related to fluorochemicals. In 2002, when 3M announced that it would be replacing PFOS with another fluorochemical, PFBS, Hansen knew that it, too, would remain in the environment indefinitely. Still, she decided not to involve herself. She skipped over articles about the chemicals in scientific journals and newspapers, where they were starting to be linked to possible developmental, immune-system, and liver problems. (In 2006, after the E.P.A. accused 3M of violating the Toxic Substances Control Act, in part by repeatedly failing to disclose the harms of fluorochemicals promptly, the company agreed to pay a small penalty of $1.5 million, without admitting wrongdoing.)

During that time, forever chemicals gained a new scientific name—per- and polyfluoroalkyl substances, or PFAS, an acronym that is vexingly similar to the specific fluorochemical PFOS. A swath of a hundred and fifty square miles around 3M's headquarters was found to be polluted with PFAS; scientists discovered PFOS and PFBS in local fish, and various fluorochemicals in water that roughly a hundred and twenty-five thousand Minnesotans drank. Hansen's husband, Peter, told me that, when friends asked Hansen about PFAS, she would change the subject. Still, she repeatedly told him—and herself—that the chemicals were safe.

In the 2016 book "Secrecy at Work," two management theorists, Jana Costas and Christopher Grey, argue that there is nothing inherently wrong or harmful about keeping secrets. Trade secrets, for example, are protected by federal and state law, on the ground that they promote innovation and contribute to the economy. The authors draw on a large body of sociological research to illustrate the many ways that information can be concealed. An organization can compartmentalize a secret by slicing it into smaller components, preventing any one person from piecing together the whole. Managers who don't want to disclose sensitive information may employ "stone-faced silence." Secret-keepers can form a kind of tribe, dependent on one another's continued discretion; in this way, even the existence of a secret can be kept secret. Such techniques become pernicious, Costas and Grey write, when a company keeps a dark secret, a secret about wrongdoing.

Certain unpredictable events—a leak, a lawsuit, a news story—can start to unspool a secret. In the case of forever chemicals, the unspooling began on a cattle farm. In 1998, a West Virginia farmer told a lawyer, Robert Bilott, that wastewater from a DuPont site seemed to be poisoning his cows: they had started to foam at the mouth, their teeth grew black, and more than a hundred eventually fell over and died. Bilott sued and obtained tens of thousands of internal documents, which helped push forever chemicals into the public consciousness. The documents revealed that the farm's water contained PFOA, the fluorochemical that DuPont had bought from 3M, and that both companies had long understood it to be toxic. (The lawsuit, which ended in a settlement, was dramatized in the film "Dark Waters," starring Mark Ruffalo as Bilott.) Bilott later sued 3M over contamination in Minnesota, but the judge prohibited discussion of health repercussions; a jury ultimately decided in 3M's favor. Finally, in 2010, the Minnesota attorney general's office filed its own suit, alleging that 3M had harmed the environment and polluted drinking water. The company paid eight hundred and fifty million dollars in a settlement, without an admission of fault or liability. The A.G. also released thousands more internal 3M records to the public.

The A.G.'s records helped me report a series of stories for the Intercept about forever chemicals. Much of my reporting, which started in 2015, focussed on what 3M and DuPont knew, even as they continued to produce PFAS. But, as I reported on the coverup, I wondered what it meant for a sprawling multinational company to *know* that its products were dangerous. Who knew? How much, exactly, did they know? And how had the company kept its secret? For many years, no one inside 3M would agree to speak with me.

Then, in 2021, John Oliver did a segment on his comedy news show, "Last Week Tonight," about forever chemicals. The segment, which mentioned my reporting, said that they could cause cancer, immune-system issues, and other problems. "The world is basically soaked in the Devil's piss right now," Oliver said. "And not in a remotely hot way." One of Hansen's former professors sent her the segment, and Hansen watched it at her kitchen table—a moment that would eventually lead her to me.

"This actually made me sad as there are so many inaccuracies," Hansen wrote to her professor, in response. But, when the professor asked her what was incorrect, Hansen didn't know what to say. For the first time, she Googled the health effects of PFOS.

Hansen was deeply troubled by what she read. One paper, published in 2012 in the *Journal of the American Medical Association*, found that, in children, as PFOS levels rose so did the chance that vaccines were ineffective. Children with high levels of PFOS and other fluorochemicals were more likely to experience fevers, according to a 2016 study. Other research linked the chemicals to increased rates of infectious diseases, food allergies, and asthma in children. Dozens of scientific papers had found that, in adults, even very low levels of PFOS could interfere with hormones, fertility, liver and thyroid function, cholesterol levels, and fetal development. Even PFBS, the chemical that 3M chose as a replacement for PFOS, caused developmental and reproductive irregularities in animals, according to the Minnesota Department of Health.

Reading these studies, Hansen felt a paradoxical kind of relief: as bad as PFOS seemed to be, at least independent scientists were studying it. But she also felt enraged at the company, and at herself. For years, she had repeated the company's claim that PFOS was not harmful. "I'm not proud of that," she told me. She felt "dirty" for ever collecting a 3M paycheck. When she read the documents released by the Minnesota A.G., she was horrified by how much the company had known, and how little it had told her. She found records of studies that she had conducted, as well as the typed notes from her meeting with Newmark.

In October, 2022, after Hansen had been at 3M for twenty-six years, her job was eliminated, and she chose not to apply for a new one. Three months later, she wrote me an e-mail, offering to speak about what she had witnessed inside the company. "If you'd be interested in talking further, please let me know," she wrote. The next day, we had the first of dozens of conversations.

When Hansen first told me about her experiences, I felt conflicted. Her work seemed to have helped force 3M to stop making a number of toxic chemicals, but I kept thinking about the twenty years in which she had kept quiet. During my first visit to Hansen's home, in February, 2023, we sat in her kitchen, eating bread that her husband had just baked. She showed me pictures of her father and shared a color-coded time line of 3M's history with forever chemicals. On a bitterly cold walk in a local park, we tried to figure out if any of her colleagues, besides Newmark, had known that PFOS was in everyone's blood. She often sprinkled her stories with such Midwesternisms as "holy buckets!"

During my second trip, this past August, I asked her why, as a scientist who was trained to ask questions, she hadn't been more skeptical of claims that PFOS was harmless. In the awkward silence that followed, I looked out the window at some hummingbirds.

Hansen's superiors had given her the same explanation that they gave journalists, she finally said—that factory workers were fine, so people with lower levels would be, too. Her specialty was the detection of chemicals, not their harms. "You've got literally the medical director of 3M saying, 'We studied this, there are no effects,' " she told me. "I wasn't about to challenge that." Her income had helped to support a family of five. Perhaps, I wondered aloud, she hadn't really wanted to know whether her company was poisoning the public.

To my surprise, Hansen readily agreed. "It almost would have been too much to bear at the time," she told me. 3M had successfully compartmentalized its secret; Hansen had only seen one slice. (When I sent the company detailed questions about Hansen's account, a spokesperson responded without answering most of them or mentioning Hansen by name.)

Recently, I thought back on Taves and Guy, the academic scientists who, in the seventies, came so close to proving that 3M's chemicals were accumulating in humans. Taves is ninety-seven, but when I called him he told me that he still remembers clearly when company representatives visited his lab at the University of Rochester. "They wanted to know everything about what we were doing," he told me. But the exchange was not reciprocal. "I soon found out that they weren't going to tell me anything." 3M never confirmed to Taves or Guy, who was a postdoctoral student at the time, that its fluorochemicals were in human blood. "I'm sort of kicking myself for not having followed up on this more, but I didn't have any research money," Guy told me. He eventually became a dentist to support his wife and family. (He died this year, at eighty-one.) Taves, too, left the field, to become a psychiatrist, and the trail ended there.

Last year, while reading about the thousands of PFAS-related lawsuits that 3M was facing, I was intrigued to learn that one of them, filed by cities and towns with polluted water, had produced a new set of internal 3M documents. When I requested several from the plaintiff's legal team, I saw two names that I recognized. In a document from 1991, a 3M scientist talked about using a mass spectrometer—the same tool that Hansen would use years later—to devise a technique for measuring PFOS in biological fluid. The author was Jim Johnson—and he had sent the report to his boss, Dale Bacon.

This revelation made me gasp. Johnson had been Hansen's first boss and had instigated her research into PFOS. Bacon had questioned her findings and ultimately told her to stop her work. (In a sworn deposition, Bacon said that by the eighties he had heard, during a water-cooler chat with a colleague, that Taves and Guy had found PFOS in human blood.) What I couldn't understand was why Johnson would ask Hansen to investigate something that he had already studied himself—and then act surprised by the results.

Jim Johnson, who is now an eighty-one-year-old widower, lives with several dogs in a pale-yellow house in North Dakota. When I first called him, he said that he had begun researching PFOS in the seventies. "I did a lot of the very original work on it," he told me. He said that when he saw the chemical's structure he understood "within twenty minutes" that it would not break down in nature. Shortly thereafter, one of his experiments revealed that PFOS was binding to proteins in the body, causing the chemical to accumulate over time. He told me that he also looked for PFOS in an informal test of blood from the general population, around the late seventies, and was not surprised when he found it there.

Johnson initially cited "four hundred and eighty pounds of dog" as a reason that I shouldn't visit him, but he later relented. When I arrived, on a chilly day in November, we spent a few minutes standing outside his house, watching Snozzle, Sadie, and Junkyard press their slobbery snouts against his living-room window. Then we decamped to the nearest IHOP. Johnson, who was dressed in jeans and a flannel shirt, was so tall that he couldn't comfortably fit into a booth. We sat at a table and ordered two bottomless coffees.

In an experiment in the early eighties, Johnson fed a component of Scotchban to rats and found that PFOS accumulated in their livers, a result that suggested how the chemical would behave in humans. When I asked why that mattered to the company, he took a sip of coffee and said, "It meant they were screwed."

At the time, Johnson said, he didn't think PFOS caused significant health problems. Still, he told me, "it was obviously bad," because man-made compounds from household products didn't belong in the human body. He said that he argued against using fluorochemicals in toothpaste and diapers. Contractors working for 3M had shaved rabbits, he said, and smeared them with the company's fluorochemicals to see if PFOS showed up in their bodies. "They'd send me the livers and, yup, there it was," he told me. "I killed a lot of rabbits." But he considered his efforts largely futile. "These idiots were already putting it in food packaging," he said.

Johnson told me, with seeming pride, that one reason he didn't do more was that he was a "loyal soldier," committed to protecting 3M from liability. Some of his assignments had come directly from company lawyers, he added, and he couldn't discuss them with me. "I didn't even report it to my boss, or anybody," he said. "There are some things you take to your grave." At one point, he also told me that, if he were asked to testify in a PFOS-related lawsuit, he would probably be of little help. "I'm an old man, and so I think they would find that I got extremely forgetful all of a sudden," he said, and chuckled.

Out the windows of IHOP, I watched a light dusting of snow fall on the parking lot. In Johnson's telling, a tacit rule prevailed at 3M: not all questions needed to be asked, or answered. His realization that PFOS was in the general public's blood "wasn't something anyone cared to hear," he said. He wasn't, for instance, putting his research on posters and expecting a warm reception. Over the years, he tried to convince several executives to stop making PFOS altogether, he told me, but they had good reason not to. "These people were selling fluorochemicals," he said. He retired as the second-highest-ranked scientist in his division, but he claimed that important business decisions were out of his control. "It wasn't for me to jump up and start saying, 'This is bullshit!' " he said, and he was "not really too interested in getting my butt fired." And so his portion of 3M's secret stayed in a compartment, both known and not known.

Johnson said that he eventually tired of arguing with the few colleagues with whom he could speak openly about PFOS. "It was time," he said. So he hired an outside lab to look for the chemical in the blood of 3M workers, knowing that it would also test blood-bank samples, for comparison—the first domino in a chain that would ultimately take the compound off the market. Oddly, he compared the head of the lab to a vending machine. "He gave me what I paid for," Johnson said.

"I knew what would happen." Then Johnson tasked Hansen with something that he had long avoided: going beyond his initial experiments and meticulously documenting the chemical's ubiquity. While Hansen took the heat, he took early retirement.
Johnson described Hansen as though she were a vending machine, too. "She did what she was supposed to do with the tools I left her," he said.

I pointed out that Hansen had suffered professionally and personally, and that she now feels those experiences tainted her career. "I didn't say I was a nice guy," Johnson replied, and laughed. After four hours, we were nearing the bottom of our bottomless coffees.

Johnson has strayed from evidence-based science in recent years. He now believes, for instance, that the theory of evolution is wrong, and that COVID-19 vaccines cause "turbo-cancers." But his account of what happened at 3M closely matched Hansen's, and when I asked him about meetings and experiments described in court documents he remembered them clearly.

As a scientist at 3M, Kris Hansen found her company's chemicals in the blood of the general public. Her superiors did not tell her that they were toxic. Photograph by Haruka Sakaguchi

When I called Hansen about my conversation with Johnson, she grew angrier than I'd ever heard her. "He knew the whole time!" she said. Then she had to get off the phone for an appointment. "So glad I'm going to see my therapist," she added, and hung up.

I once thought of secrets as discrete, explosive truths that a heroic person could suddenly reveal. In the 1983 film "Silkwood," which is based on real events, Karen Silkwood, a worker at a plutonium plant, assembles a thick folder documenting her employer's shoddy safety practices; while driving to share them with a reporter, she dies in a mysterious one-car crash. In another adaptation of a true story, the 2015 film "Spotlight," a source delivers a box of critical documents to the Boston *Globe*, helping the paper to publish an investigation into child sexual abuse within the Catholic Church. Talking to Hansen and Johnson, though, I saw that the truth can come out piecemeal over many years, and that the same people who keep secrets can help divulge them. Some slices of 3M's secret are only now coming to light, and others may never come out.

Between 1951 and 2000, 3M produced at least a hundred million pounds of PFOS and chemicals that degrade into PFOS. This is roughly the weight of the Titanic. After the late seventies, when 3M scientists established that the chemical was toxic in animals and was accumulating in humans, it produced millions of pounds per year. Scientists are still struggling to grasp all the biological consequences. They have learned, just as Johnson did decades ago, that proteins in the body bind to PFOS. It enters our cells and organs, where even tiny amounts can cause stress and interfere with basic biological functions. It contributes to diseases that take many years to develop; at the time of a diagnosis, one's PFOS level may have fallen, making it difficult to establish causation with any certainty.

The other day, I called Brad Creacey, who became an Air Force firefighter in the seventies, at the age of eighteen. He told me that several times a year, for practice, he and his comrades put on rubber boots and heavy silver uniforms that looked like spacesuits. Then a "torch man," holding a stick tipped with a burning rag, ignited jet fuel that had been poured into an open-air pit. To extinguish the hundred-foot-tall flames, Creacey and his colleagues sprayed them with aqueous film-forming foam, or A.F.F.F. 3M manufactured it from several forever chemicals, including PFOS.

Creacey remembers that A.F.F.F. felt slick and sudsy, almost like soap, and dried out the skin on his hands until it cracked. To celebrate his last day on a military base in Germany, his friends dumped a ceremonial bucket on him. Only later, after working with firefighting foam at an airport in Monterey, California, did he start to wonder if a string of ailments—cysts on his liver, a nodule near his thyroid—were connected to the foam. He had high cholesterol, which diet and exercise were unable to change. Then he was diagnosed with thyroid cancer. "It makes me feel like I was a lab rat, like we were all disposable," Creacey told me. "I've lost faith in human beings."

It may be tempting to think of Creacey and his peers as unwitting research subjects; indeed, recent studies show that PFOS is associated with an increased risk of thyroid cancer and, in Air Force servicemen, an elevated risk of testicular cancer. But it is probably more accurate to say that we are all part of the experiment. Average levels of PFOS are falling, but nearly all people have at least one forever chemical in their blood, according to the Centers for Disease Control and Prevention. "When you have a contaminated site, you can clean it up," Elsie Sunderland, an environmental chemist at Harvard University, told me. "When you ubiquitously introduce a toxicant at a global scale, so that it's detectable in everyone . . . we're reducing public health on an incredibly large scale." Once everyone's blood is contaminated, there is no control group with which to compare, making it difficult to establish responsibility.

New health effects continue to be discovered. Researchers have found that exposure to PFAS during pregnancy can lead to developmental delays in children. Numerous recent studies have linked the chemicals to diabetes and obesity. This year, a study discovered thirteen forever chemicals, including PFOS, in weeks-old fetuses from terminated pregnancies, and linked the chemicals to biomarkers associated with liver problems. A team of N.Y.U. researchers estimated, in 2018, that the costs of just two forever chemicals, PFOA and PFOS—in terms of disease burden, disability, and health-care expenses—amounted to as much as sixty-two billion dollars in a single year. This exceeds the current market value of 3M.

Philippe Grandjean, a physician who helped discover that PFAS harm the immune system, believes that anyone exposed to these chemicals—essentially everyone—may have an elevated risk of cancer. Our immune systems often find and kill abnormal cells before they turn into tumors. "PFAS interfere with the immune system, and likely also this critical function," he told me. Grandjean, who served as an expert witness in the Minnesota A.G.'s case, has studied many environmental contaminants, including mercury. The impact of PFAS was so much more extreme, he said, that one of his colleagues initially thought it was the result of nuclear radiation.

In April, the E.P.A. took two historic steps to reduce exposure to PFAS. It said that PFOS and PFOA are "likely to cause cancer" and that no level of either chemical is considered safe; it deemed them hazardous substances under the Superfund law, increasing the government's power to force polluters to clean them up. The agency also set limits for six PFAS in drinking water. In a few years, when the E.P.A. begins enforcing the new regulations, local utilities will be required to test their water and remove any amount of PFOS or PFOA which exceeds four parts per trillion—the equivalent of one drop dissolved in several Olympic swimming pools. 3M has produced enough PFOS and chemicals that degrade into PFOS to exceed this level in all of the freshwater on earth. Meanwhile, many other PFAS continue to be used, and companies are still developing new ones. Thousands of the compounds have been produced; the Department of Defense still depends on many for use in explosives, semiconductors, cleaning fluids, and batteries. PFAS can be found in nonstick cookware, guitar strings, dental floss, makeup, hand sanitizer, brake fluid, ski wax, fishing lines, and countless other products.

In a statement, a 3M spokesman told me that the company "is proactively managing PFAS," and that 3M's approach to the chemicals has evolved along with "the science and technology of PFAS, societal and regulatory expectations, and our expectations of ourselves." He directed me to a fact sheet about their continued importance in society. "These substances are critical to multiple industries—including the cars we drive, planes we fly, computers and smart phones we use to stay connected, and more," the fact sheet read.

Recently, 3M settled the lawsuit filed by cities and towns with polluted water. It will pay up to twelve and a half billion dollars to cover the costs of filtering out PFAS, depending on how many water systems need the chemicals removed. The settlement, however, doesn't approach the scale of the problem. At least forty-five per cent of U.S. tap water is estimated to contain one or more forever chemicals, and one drinking-water expert told me that the cost of removing them all would likely reach a hundred billion dollars.

In 2022, 3M said that it would stop making PFAS, and would "work to discontinue the use of PFAS across its product portfolio," by the end of 2025—a pledge that it called "another example of how we are positioning 3M for continued sustainable growth." But it acknowledged that more than sixteen thousand of its products still contained PFAS. Direct sales of the chemicals were generating $1.3 billion annually. 3M's regulatory filings also allow for the possibility that a full phaseout won't happen—for example, if 3M fails to find substitutes. "We are continuing to make progress on our announcement to exit PFAS manufacturing," 3M's spokesperson told me. The company and its scientists have not admitted wrongdoing or faced criminal liability for producing forever chemicals or for concealing their harms.

Hansen often wonders what her father would say about 3M if he were still alive. A few years ago, he began to show signs of dementia, which worsened during the COVID-19 pandemic. Every time Hansen explained to him that a novel coronavirus was sickening people around the world, he asked how he might contribute—forgetting that the N95 mask he helped to create was already protecting millions of people from infection. When he died, in January, 2021, Hansen noticed some Coban wrap on his arm. It was shielding his delicate skin from tears, just as he had designed it to. "He invented that," Hansen told the hospice nurse, who smiled politely.

After she left 3M, Hansen began volunteering at a local nature preserve, where she works to clear paths and protect native plants. Last August, she took me there, and we walked to a creek where she often spends time. The water is home to three species of trout, she told me. It is also polluted by forever chemicals that 3M once dumped upstream.

For most of our hike, a thick wall of flowers—purple joe-pye weed and goldenrod—made it impossible to see the creek bank. Then we came to a wooden bench. I climbed on top of it and looked down on the creek. As I listened to the gurgling of water and the buzzing of insects, I thought I understood why Hansen liked to come here. It was too late to save the creek from pollution; 3M's chemicals could be there for thousands of years to come. Hansen just wanted to appreciate what was left, and to leave the place a little better than she'd found it. ♦

*ProPublica is a nonprofit newsroom that investigates abuses of power. Sign up to get stories like this one as soon as they are published.*

*Published in the print edition of the May 27, 2024, issue, with the headline "You Make Me Sick."*

Exhibit KH-3

OPINION    OPINION COLUMNISTS • Opinion, Opinion Columnist

# Opinion: We agree PFAS should not be used in fracking, and it is not

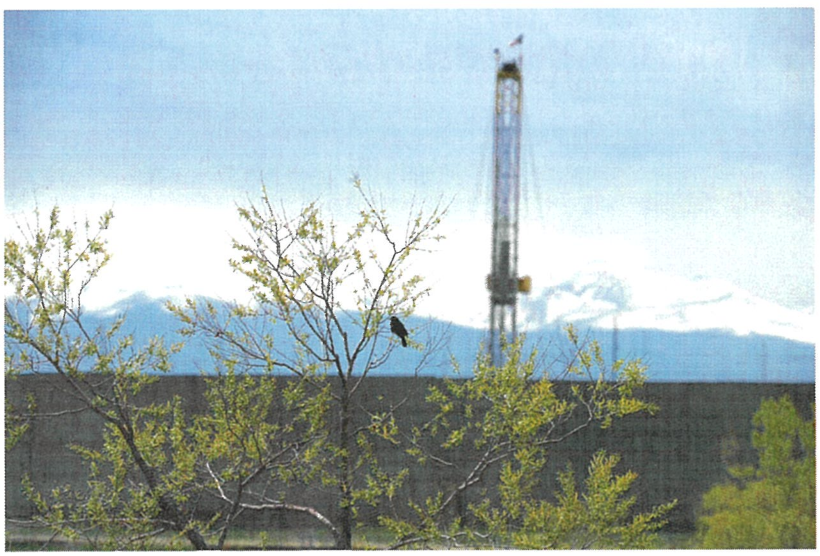


Photo by Helen H. Richardson/The Denver Post

The Ivey Pad site in Adams County is operated by Great Western Petroleum. The company calls it their very first "GREEN platinum facility." The site opened in November 2020. "GREEN" stands for Globally Reduced Emissions and Extraction Network.

By **LYNN GRANGER** | Guest Commentary and **DAN HALEY** | The Denver Post

PUBLISHED: March 2, 2022 at 9:36 a.m.

In response to a recent Denver Post editorial, Colorado's natural gas and oil industry would like to respond.

We couldn't agree more with the headline — "PFAS should not be used in hydraulic fracturing." Per- and polyfluoroalkyl (PFAS) substances should not be intentionally used in hydraulic fracturing fluid.

In recent weeks, an organization called Physicians for Social Responsibility published a new "analysis," titled "Fracking with 'Forever Chemicals' in Colorado." The report, paid for by the Sierra Club, insinuates citing records from a disclosure website that PFAS have been used in Colorado hydraulic fracturing operations, and without any evidence concluded that companies that fail to disclose trade secrets or intellectual property information might be hiding other uses of PFAS, which is simply untrue.

It is important to clarify the motivation of the report. The Sierra Club and Physicians for Social Responsibility are committed to stopping responsible oil and natural gas development in Colorado and across the United States. It's little surprise, then, that the final recommendation from the analysis is that lawmakers and regulators "Limit or ban drilling and fracking."

We could certainly respond point for point to why the report is agenda-driven and amounts to nothing more than exaggerated accusations. Instead, we will focus on the meaningful actions already taken as it relates to this important issue.

Colorado's natural gas and oil industry has been highly engaged in Colorado Oil and Gas Conservation Commission (COGCC) rulemakings over the past decade regarding hydraulic fracturing fluid chemical requirements, groundwater sampling, and related matters. Ours was the first state to undertake a hydraulic fracturing fluid disclosure rulemaking in 2011, ensuring transparency to the state regarding chemicals used in hydraulic fracturing fluid, which comprise less than one-half of one percent of the mixture's ingredients. In addition, during last year's mission change rulemaking before the COGCC, state regulators further refined the list of chemicals permitted in hydraulic fracturing fluid and engaged in an extensive process to add additional chemicals to the prohibited list (Rule 437).

The state also enjoys extensive groundwater protection rules that were further strengthened through the 2020 wellbore integrity and mission change rulemakings, which increased and improved groundwater sampling, surface water protections and soil testing (600 Series rules and 900 Series rules).

According to a related story in The Post, " 'The state Water Quality Control Division isn't aware of any impact to drinking water from PFAS potentially used in fracking,' spokeswoman Erin Garcia said. The division sampled 400 water systems in 2020 for PFAS and none of the water tested above the federal advisory level."

Specific to PFAS, the state and many industries have engaged in discussions about PFAS foam, which has occasionally been used to combat electrical and other fires. In recent years, our industry has specifically engaged in legislation that strengthened the state's oversight of PFAS (House Bill 20-1119, Senate Bill 20-218, House Bill 19-1279). All told, recent legislative work has prohibited the sale of PFAS foam, prohibited the use of foam for testing and training, improved containment requirements, and required registration for entities that may be storing or using PFAS foam. And our industry is committed to being a proactive partner as the state continues to explore ways to tackle this issue.

But when political agendas motivate science, a report like this is the result. We are disappointed that The Post played into the hands of organizations who use fearmongering and misinformation as a means to an end. That "end," in this case, is the prohibition of oil and gas development in Colorado and across the nation, at a time of historic inflation and emergent geopolitical unrest.

As for Colorado's natural gas and oil industry, we intend to continue producing among the safest and cleanest molecules in the world. Our state's regulatory framework is among the strongest in the nation – and, as a result, the world – and the women and men of our industry have no intention of backing away from our commitment to public health, safety, and stewardship of the environment and wildlife.

*Lynn Granger is executive director of API Colorado, a division of the American Petroleum Institute. Dan Haley is President and CEO of the Colorado Oil & Gas Association.*