

SOUTHERN ENVIRONMENTAL LAW CENTER

Telephone 919-967-1450

601 WEST ROSEMARY STREET, SUITE 220
CHAPEL HILL, NC 27516-2356

Facsimile 919-929-9421

September 27, 2018

VIA E-MAIL

Attn: Louise Hughes
North Carolina Department of Environmental Quality
1601 Mail Service Center
Raleigh, N.C. 27699-1601
Comments.SABReport@ncdenr.gov

Re: GenX Report

Dear Science Advisory Board:

On behalf of Cape Fear River Watch, North Carolina Conservation Network, North Carolina Coastal Federation, Sound Rivers, Haw River Assembly, Catawba Riverkeeper Foundation, the French Broad Riverkeeper, and the North Carolina Chapter of the Sierra Club, please accept these comments on the North Carolina Secretaries' Science Advisory Board's August 29, 2018 Draft Review of the North Carolina Drinking Water Provisional Health Goal for GenX.

I. The GenX health goal of 140 ppt cannot be used as the protective standard for those living around, and downstream of, Chemours' facility.

First, the SAB must be more explicit about what the GenX health goal should and should not be used for. The report states that the 140 ppt level "is not a boundary line between a 'safe' and 'dangerous' level of [GenX]," and that it is instead "the concentration of GenX in drinking water at which no adverse non-cancer health effects would be anticipated over an entire lifetime of exposure." According to the SAB's report, therefore, the 140 ppt health goal is insufficient to protect people who have been exposed to levels of GenX much higher than 140 ppt throughout their lifetime.

Communities around and downstream of Chemours' Fayetteville Works Facility (1) have had GenX in their drinking water for four decades at levels far higher than 140 ppt, (2) have had dozens of other perfluoroalkyl and polyfluoroalkyl substances (PFAS) in their drinking water at high levels, and (3) have been exposed to PFAS through their air, soil, fish, vegetables, and even honey. When DEQ began investigating the facility in June 2016, GenX levels at Chemours' outfall into the Cape Fear River reached levels of up to 39,000 ppt, and GenX levels in the finished drinking water from the Cape Fear Public Utility Authority's Sweeney Water Treatment Plant reached levels of up to 1,100 ppt.¹ Since then, DEQ has found GenX in private drinking

¹ June 19 to July 25, 2017 GenX Surface Water Sampling Results, included as Attachment 1.

water wells at levels as high as 4,000 ppt—28 times the state’s health goal of 140 ppt.² GenX and other PFAS have been released in high concentrations from the Fayetteville Works Facility into the Cape Fear River since 1980.³ Not only have communities been exposed to GenX at extremely high levels, they have lived with dozens of other PFAS in their air, water, and soil. From September to December of 2017, DEQ found at least 33 different PFAS in private drinking water wells, some at concentrations of 299 ppt and 209 ppt.⁴ As the SAB’s report states, PFAS has also been found in fish and sediment around the facility, and in garden crops in similarly PFAS-contaminated sites.

Yet DEQ and Chemours have both misused the 140 ppt health goal. In DEQ’s June 11, 2018 proposed order in *N.C. Dept. of Environmental Quality v. Chemours* in Bladen County Superior Court, DEQ suggests that Chemours should establish permanent water supplies only for households with wells contaminated “in exceedance of a health goal established by DHHS.”⁵ In Chemours’ plans for cleaning up its on-site contamination, the company states that its goal “is to ensure concentrations in the Cape Fear River do not exceed 140 ppt of [GenX] downstream of the river water intake.”⁶ But the communities that have been exposed to GenX and other PFAS in thousands of parts per trillion for decades cannot be protected by a health goal that (1) only considers exposure to one out of dozens, if not hundreds, of PFAS, and (2) does not account for prior exposure to extremely high levels of GenX.

The SAB should explicitly warn DEQ against using—and DEQ must not use—the GenX 140 ppt health goal as the level to protect communities that have already been exposed to Chemours’ highly toxic pollution for decades. Rather, a health goal that accounts for prior long-term exposure to high levels of multiple PFAS must apply to those communities.

II. PFAS must be regulated as a class.

The SAB should advise the Environmental Management Commission and DEQ that any regulation of PFAS must apply to the entire class of compounds. The SAB has taken nearly a full year to assess the health goal for GenX, which is only one compound within a family of over 3,000 PFAS on the global market.⁷ A regulatory process which addresses one PFAS at a time will not effectively protect the health of the public and the environment.

The duties of the SAB include: “advis[ing] the [Environmental Management Commission],” “recommend[ing] the necessity and/or urgency for controlling the releases” of PFAS, and “act[ing] as consultants regarding the DEQ’s determinations to regulate releases of contaminants.” The SAB should be explicit about the protective limits of the GenX health goal

² NC DEQ Presentation to the House Select Committee on North Carolina River Quality, slides 9-10, Apr. 26, 2018, included as Attachment 2.

³ “Notes from Chemours meeting with local, state officials,” *StarNews*, Jun. 15, 2017, included as Attachment 3.

⁴ NC DEQ, Expanded PFAS Analysis on DEQ Collected Private Wells Associated with Chemours-Fayetteville, included as Attachment 4.

⁵ Draft Proposed Order for Preliminary Injunctive Relief, *N.C. Dept. of Environmental Quality v. Chemours*, 17 CVS 580, 25 (N.C. Super. 2018), included as Attachment 5.

⁶ Chemours, “Focused Remedial Action Plan for PFAS in Groundwater,” 1, Mar. 28, 2018, included as Attachment 6.

⁷ KEMI, Swedish Chemicals Agency, Occurrence and use of highly fluorinated substances and alternatives 6 (2015), included as Attachment 7.

for impacted communities, and advise the Environmental Management Commission and DEQ on how to feasibly regulate the thousands of existing PFAS.

Thank you for considering these comments. Please contact us at ggisler@selcnc.org, jzhuang@selcnc.org, or 919-967-1450 if you have any questions regarding this letter.

Sincerely,



Geoffrey R. Gisler
Senior Attorney



Jean Zhuang
Associate Attorney

GRG/rgd
Cc (via email):
Kemp Burdette, CFRW

ATTACHMENT 48

HFPO-DA (GenX) Analysis June - July 2017 (Results in ppt)													
FRO Location	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		QA Comments ^{1,2,3}
	06/19/2017 results		06/26/2017 results		07/03/2017 results ppt		07/12/2017 results ppt		7/17/2017 results ppt		7/24/2017 results		
	Test America 98464	EPA RTP, NC	Test America 98722	EPA RTP, NC	Test America ⁴ 98957	EPA RTP, NC	Test America 99190	EPA RTP, NC	Test America 99305	EPA RTP, NC	Test America 99530	EPA RTP, NC	
Hoffer WTP Raw	N/A	N/A	N/A	N/A	13	4	<10	<10	<10	<10	<10	<10	EPA 7/03: Below Limit of Quantitation (LOQ) of 10 ppt TestAmerica 7/03: SURR REC 24%, IS Low TestAmerica 7/12: SURR REC 25%, IS Low EPA 7/12: Below Limit of Quantitation (LOQ) of 10 ppt EPA 7/17: Below Limit of Quantitation (LOQ) of 10 ppt EPA 7/24: Below LOQ
Chemours outfall 002	39000	21760	19000	15250	30000	21530	3300	2430	830	713	150	102	TestAmerica 6/19: 50X dilution, DUPs 41000 and 36000 [13% RPD], SURR RECs 45 and 48%, MS DNR, IS Low for DUP and MS EPA 6/19: 20X dilution TestAmerica 6/26: 50X dilution, DUPs 18000 and 21000 [15.4% RPD], MS DNR EPA 6/26: 20X dilution EPA 7/03: 20X dilution TestAmerica 7/03: 50X dilution, DUPs 31000 and 28000 [10.2% RPD], MS DNR, IS Low TestAmerica 7/12: 10X dilution EPA 7/12: 20X dilution EPA 7/17: 20X dilution TestAmerica 7/17: 2X dilution, DUPs 850 and 810 [5% RPD], MS 88%, MS SURR REC 107% TestAmerica 7/24: DUPs 150 and 152 [3% RPD], MS 105%, MS SURR REC 73% EPA 7/25: Avg. 2 reps
Bladen Bluffs Raw	580	501	36	31	240	168	310	77	70	54	51	30.4	EPA 6/19: 5X dilution TestAmerica 6/26: SURR REC 33%, IS Low TestAmerica 7/03: SURR REC 22%, IS Low TestAmerica 7/12: SURR REC 24%, IS Low EPA 7/24: Avg. 2 reps
Bladen Bluffs Raw Duplicate	590		33										
Bladen Bluffs Finished	790		76		190		95		76	59	35	34.2	TestAmerica 6/19: 2X dilution, SURR REC 14%, IS Low TestAmerica 7/03: SURR REC 34%, IS Low TestAmerica 7/12: SURR REC 36%, IS Low
Smithfield Foods Well Field	<10		<10		<10		<10		<10	<10	<10	<10	TestAmerica 6/19: SURR REC 9%, IS Low EPA 7/17: Below Limit of Quantitation (LOQ) of 10 ppt EPA 7/24: Below LOQ
Chemours Field Blank	<10		<10		<10		<10		<10		<10		
QC					QCA 1 <10		QCA 2 <10		QAA 4 <10				TestAmerica 7/03: HNO ₃ preserved; adj w/10% NH ₄ OH, SURR REC 17%, IS Low
QC					QCB 1 65		QCB 2 61		QAB 4 70				TestAmerica 7/03: HNO ₃ preserved; adj w/10% NH ₄ OH, SURR REC 25%, IS Low, Spike nominal value not yet known
QC					QCC 1 210		QCC 2 210		QAC 4 260				TestAmerica 7/03: HNO ₃ preserved; adj w/10% NH ₄ OH, SURR REC 29%, IS Low, Spike nominal value not yet known

WIRO Location	Week 1		Week 2		Week 3		Week 4		Week 5		Week 6		QA Comments ^{1,2,3}
	06/22/2017 results		06/29/2017 results		07/06/2017 results ppt		7/13/2017 results ppt		7/20/2017		7/27/2107		
	Test America 98623 98675	EPA RTP, NC	Test America 98886	EPA RTP, NC	Test America 99020	EPA RTP, NC	Test America 99263	EPA RTP, NC	Test America 99470	EPA RTP, NC	Test America 99695	EPA RTP, NC	
International Paper Raw	810	703	73	41	160	158	110	60	86	74	49	36.3	TestAmerica 6/22: DUPs 810 and 810 [0%RPD], MS 101% EPA 6/22: 5X dilution TestAmerica 6/29: SURR REC 20%, IS Low TestAmerica 7/06: SURR REC 35%, IS Low TestAmerica 7/27: SURR REC 14%, IS Low TestAmerica 7/13: SURR REC 23%, IS Low
International Paper Raw DUP						162							
International Paper Finished	690	523	140	111	110	80	31	17	38	34	32	22.2	TestAmerica 6/22: SURR REC 45%, IS Low EPA 6/22: 5X dilution TestAmerica 6/29: SURR REC 19%, IS Low TestAmerica 7/06: SURR REC 48%, IS Low
NW Brunswick WTP Finished	910	695	51	52	150	125	110	51	83	69	61	31.2	EPA 6/22: 5X dilution TestAmerica 6/29: SURR REC 24%, IS Low TestAmerica 7/13: SURR REC 36%, IS Low TestAmerica 7/27: SURR REC 47%, IS Low

Pender Co. 421 WTP Finished	340	269	160	112	81	68	100	75	120	100	76	65.2	TestAmerica 6/22: SURR REC 8%, IS Low EPA 6/22: 5X dilution TestAmerica 6/29: SURR REC 43%, IS Low TestAmerica 7/13: SURR REC 41%, IS Low
LCFWSA Raw	830	629	67	72	150	119	130	88	67	57	47	35.1	TestAmerica 6/22: IS Low EPA 6/22: 5X dilution TestAmerica 6/29: SURR REC 24%, IS Low TestAmerica 7/06: SURR REC 33%, IS Low TestAmerica 7/13: SURR REC 24%, IS Low; MS 114%, MS SURR REC 18%, IS Low TestAmerica 7/20: MS 107%, MS SURR REC 67% TestAmerica 7/27: SURR REC 28%, MS SURR REC 23%, IS Low, MS REC 105%
LCFWSA Raw DUP								89					
CFPUA Sweeney Finished	1100	726	110	100	97	87	110	81	120	95	63	69.5	EPA 6/22: 5X dilution TestAmerica 6/29: SURR REC 40%, IS Low TestAmerica 7/13: SURR REC 45%, IS Low
CFPUA – ASR Well	820	588	400	336	190	148	120	84	120	94	86	53.6	EPA 6/22: 5X dilution TestAmerica 6/29: SURR REC 25 %, MS 118% REC, IS Low EPA 6/29: 2X dilution TestAmerica 7/13: SURR REC 42%, IS Low
Wrightsville Beach Well No. 6									<10		<10		EPA 7/17: Below Limit of Quantitation (LOQ) of 10 ppt
Wrightsville Beach Well No. 11	26	27	24	28	28	24	29	<10	44	37	26	19.2	TestAmerica 6/22: DUPs 26 and 25 [3.9% RPD] TestAmerica 6/29: SURR REC 34%, IS Low TestAmerica 7/06: MS 109%, MS SURR REC 60% EPA 7/12: Below Limit of Quantitation (LOQ) of 10 ppt
International Paper Raw Site Blank	<10		N/A										
Wrightsville Beach Well No. 11 Blank	<10		N/A										
EPA Trip Spike High	N/A		270										TestAmerica 6/29: HNO ₃ preserved; adj w/10% NH ₄ OH, SURR REC 24%, IS Low, Spike nominal value 200 ppt, 135% REC
EPA Trip Spike Low	N/A		95										TestAmerica 6/29: HNO ₃ preserved; adj w/10% NH ₄ OH, SURR REC 23%, IS Low, Spike nominal value 70 ppt, 136% REC
EPA Trip Blank	N/A		<10										TestAmerica 6/29: HNO ₃ preserved; adj w/10% NH ₄ OH, SURR REC 9%, IS Low
Trip Blank 9	N/A		<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	
QC											QCA 5	<10	TestAmerica 7/27: nominal value not yet known
QC											QCB 5	76	TestAmerica 7/27: nominal value not yet known
QC											QCC 5	260	TestAmerica 7/27: nominal value not yet known

QA samples (Blanks, Duplicate & Spikes)

¹ The TestAmerica laboratory performs an isotope dilution methodology which employs internal standards which are stable isotopically labeled analogs of the target analytes added to the sample prior to extraction. Physical and chemical properties of each labeled compound are virtually the same as its unlabeled native analog, thus any losses of the target compound that may occur during sample preparation or determinative steps will be mirrored by a similar loss of the labeled standard. A recovery correction is then applied to sample results.

² Except where noted the associated MB, low-level LCS, mid-level LCS/LCSD and MS recoveries were in control for TestAmerica data. QC data not yet reported for EPA.

³ The internal standard/surrogate is added to samples prior to the extraction step.

⁴ The TestAmerica low-level LCS associated with this batch of samples exhibited a percent recovery above the QC control limits. This is an indicator that data may be biased high. This outage is due to a miss spike by the laboratory. The mid-level LCS was in control; therefore, corrective action was deemed unnecessary.



DEQ GenX Update
House Select Committee on River Water
Quality

April 26, 2018





Division of Water Resources

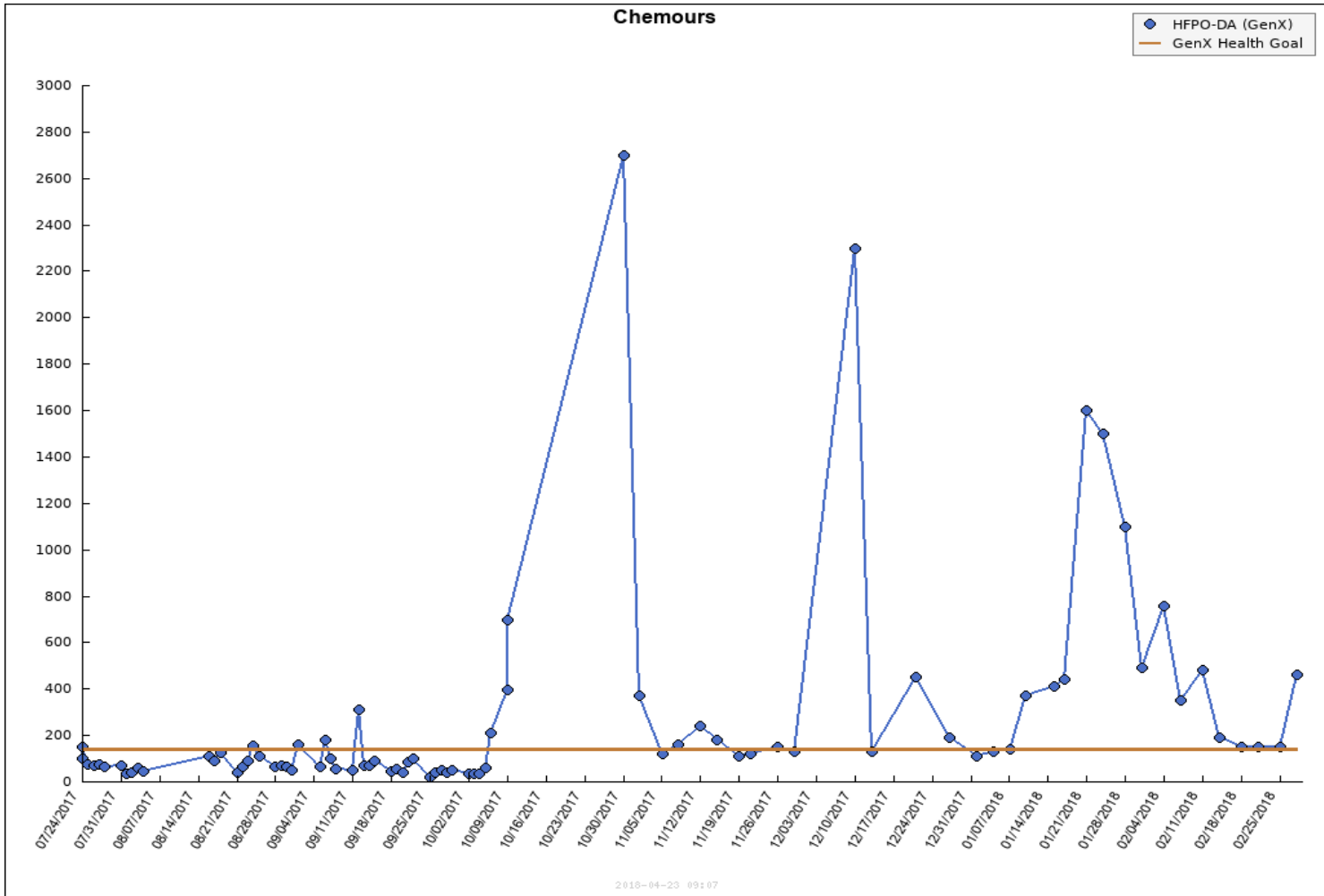


Current Sampling

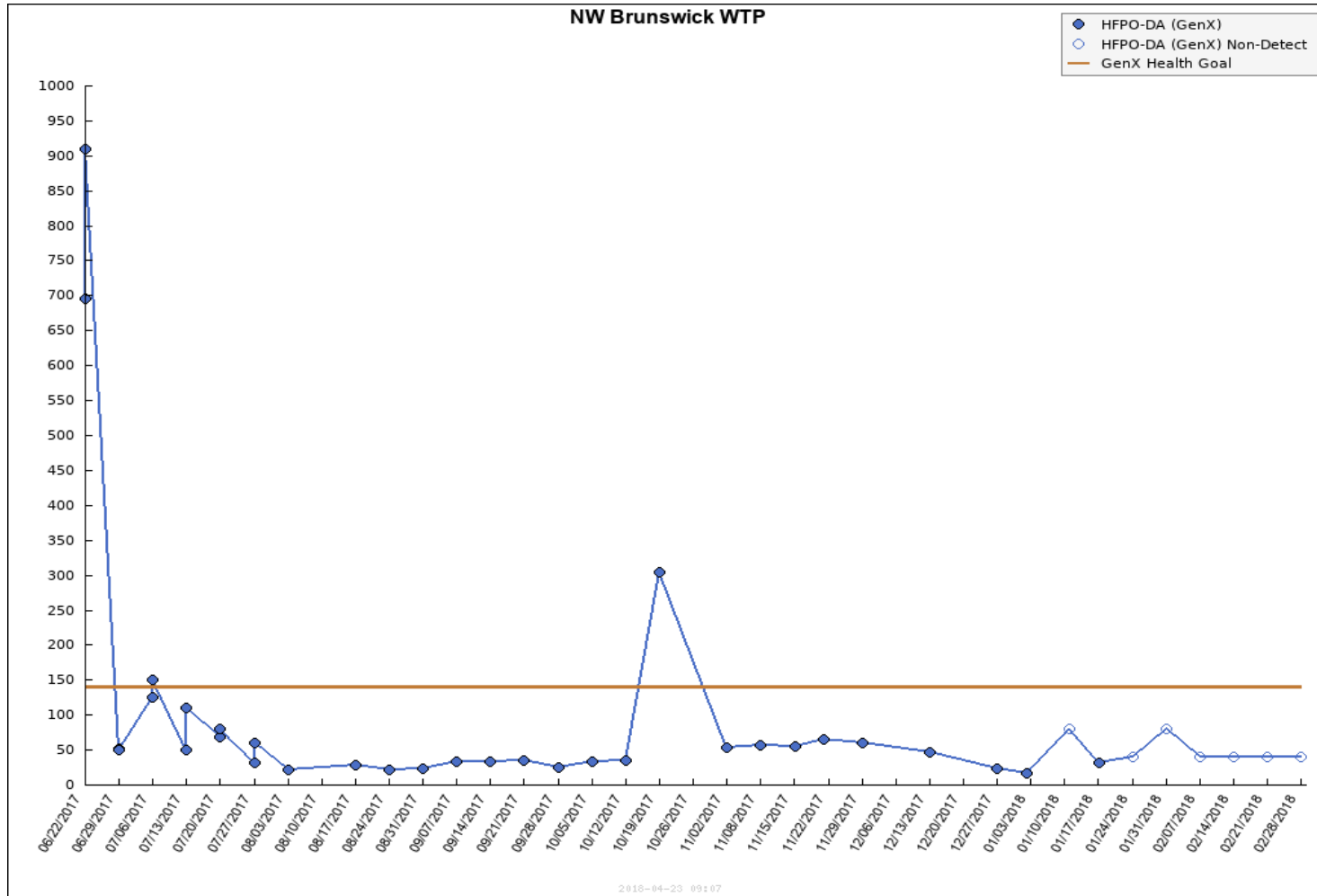
- Two composite samples weekly at Chemours wastewater outfall into the Cape Fear River: Monday - Thursday and Friday - Sunday
- Drinking water facilities downstream are sampled weekly:
 - Bladen Bluff
 - International Paper
 - NW Brunswick
 - Pender County
 - CFPU Sweeney
- Ambient monitoring for PFAS across North Carolina
 - Jordan Lake watershed monthly Jan – June 2018
 - Cape Fear Reservoirs May – October 2018



Data at Chemours Outfall 002 GenX (parts per trillion)



Data at Drinking Water Facilities GenX (parts per trillion)

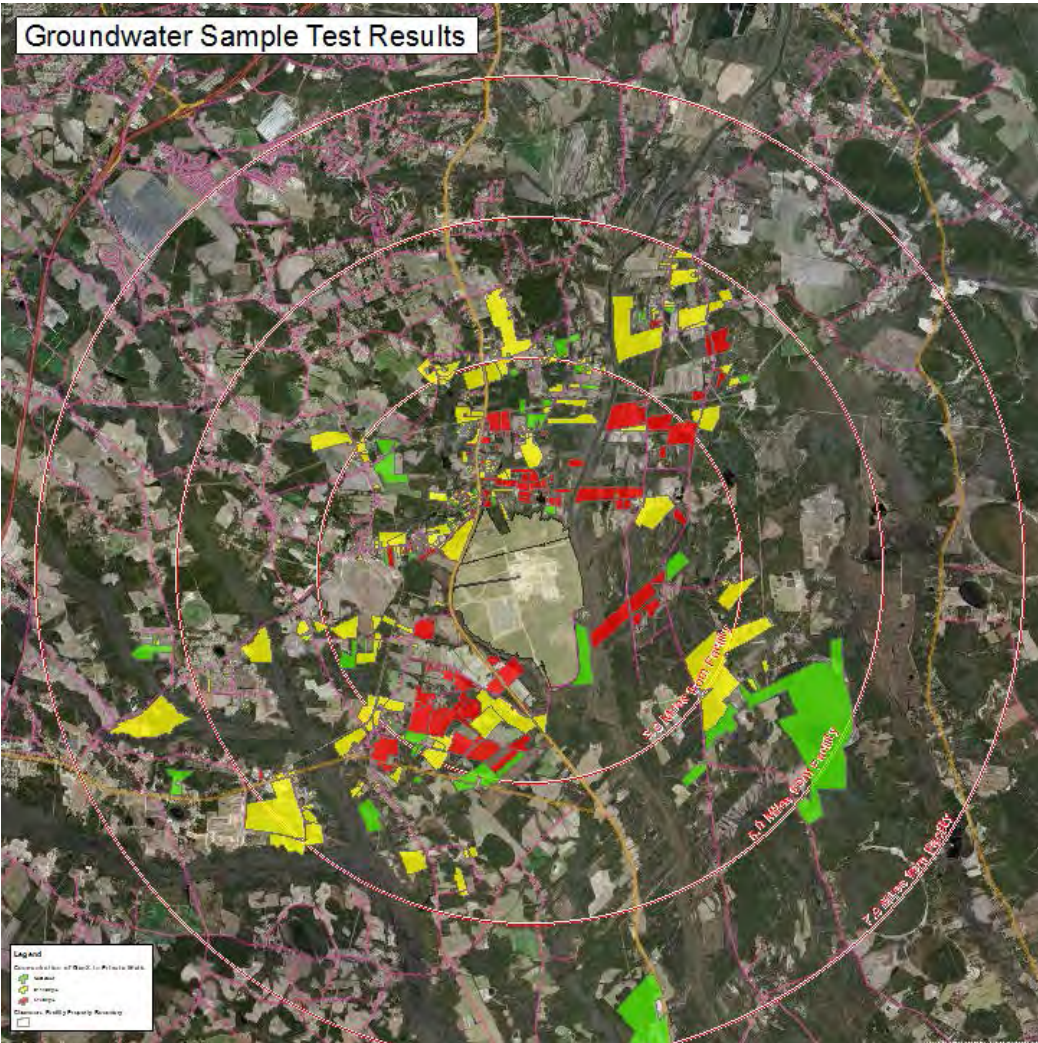




Division of Waste Management



Division of Waste Management



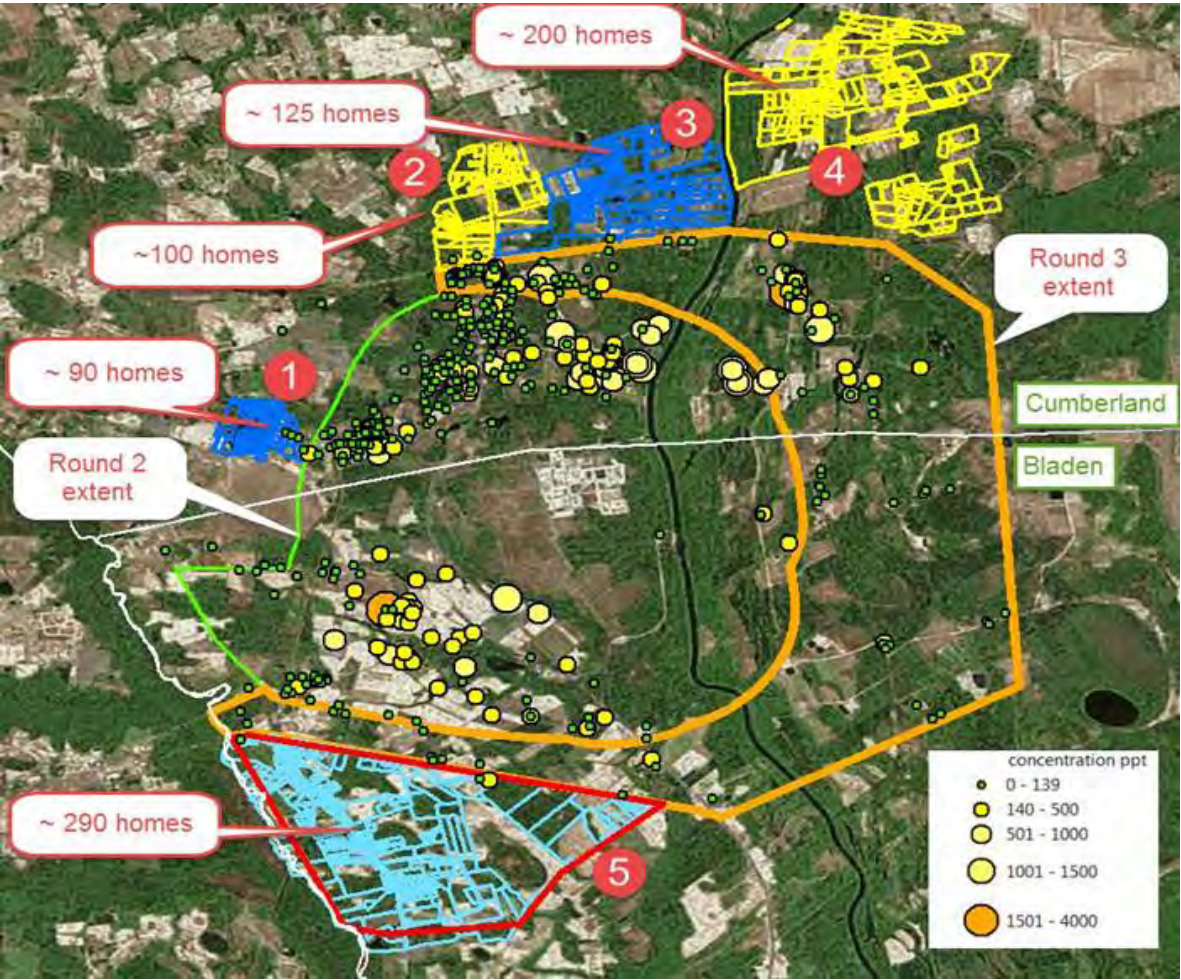
Well Sampling Results
in the Chemours area,
Approximate distances from
facility boundary:
Northeast – 5.5 miles
West – 1.8 miles
Southwest – 3.9 miles
East – 2.6 miles

GenX: NC health goal = 140 ng/l

Red = > 140 ng/l
Yellow = 0-140 ng/l
Green = Non detect



Division of Waste Management



Chemours “Phase 4” sampling plan

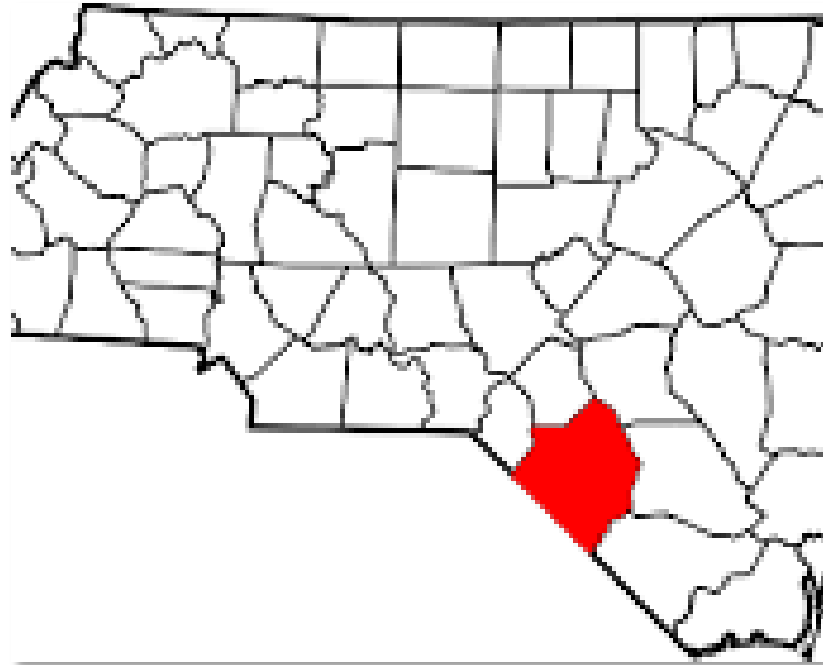
Starts with areas in red and yellow (2, 4 and 5)

287 residences have been sampled thus far in phase IV

Data is showing a lower percentage of wells above the health goal



Robeson County Private Well Testing



- Robeson County tested 35 drinking water wells. 33 were from residences and 2 were from county-run facilities.
- Sample dates: 1/29/18, 2/13/18 and 3/26/2018
- Results:
 - 1 residence well was reported at 232 ng/L GenX, exceeding the Provisional Health Goal of 140 ng/L.
 - 33 wells had GenX detections, 2 were ND
 - 28 wells had PFOS detections, 26 had PFOA detections, 5 wells were ND for both, and the highest combined detection was 33 ng/L
 - 0 wells exceeded the health goal for PFOS + PFOA (70 ng/L)
 - 3 wells were ND for all three PFAS

Division of Waste Management

Combined Phase I, II, III , IV (partial) Private Well PFAS Data, also Includes Robeson Co. and DEQ-collected Data

Private Well Water GenX Summary	Combined Well Data
Distance from Chemours' border	Up to 5.5 miles
Well Collection Dates	9/6/2017 – 3/26/2018
Number of Wells tested	837
Number of Exceedances of the GenX Provisional Health Goal	207
Number of Not-Detected ("ND") GenX Analyses	178
<small>a. The NC DHHS Provisional Drinking Water Health Goal for GenX is 140 ng/L (July 2017)</small>	
Number of GenX Detections Less than the Health Goal ^a	450
Maximum Detected GenX Concentration	4000 ng/L



Granular Activated Carbon Point of Use Filtration Systems



- Chemours has submitted to DEQ a proposal to install granular activated carbon filtration systems for residences with Gen X present in the well at or above 140 ppt
- DEQ has provided initial feedback to Chemours to include the requirement to install 5 additional filter systems for sampling.
- The final system was installed on April 20. Both DEQ and Chemours have sampled some of the five units. We are currently waiting for the results.
- Sampling data regarding the effectiveness of the systems will be shared online



Fish Tissue Testing

Marshwood Lake Testing by DEQ

- DEQ sampled Marshwood Lake on March 14:
 - 2 surface water sample locations
 - 2 composite sediment sample locations
 - 2 Largemouth Bass fillet tissue composites
 - 1 Redear Sunfish fillet tissue composite
- Catfish will be collected in the near future
- A drinking water well onsite at the lake was sampled
- A composite sediment sample was taken from Lock & Dam 3 in the Cape Fear River
- 2 surface water samples were collected at Camp Dixie Lake
- All samples collected will be analyzed using USEPA M537-modified for Full PFAS Suite at GEL Labs
- Surface water will also be tested for Total Organic Carbon, Dissolved Organic Carbon, pH and Total Particulates; Sediment will also be tested for Total Organic Carbon and %Lipids
- Partial data has been received and is under review



Additional Media Testing

- **DEQ continues to coordinate with DHHS and NCDA & CS regarding testing of other media (Garden Crops and Soil)**
- **Current areas of focus include evaluating if there are other sources of exposure to perfluorinated compounds around the Fayetteville Works Facility**
- **DEQ and DHHS continue to gather information from other states who have sampled food products for perfluorinated compounds**
- **DEQ has also been in discussions with different laboratories regarding their ability to test plant tissue for perfluorinated compounds**



Division of Air Quality



Emerging Compounds

DAQ's investigation involving GenX and other PFAS from Chemours

- **GenX emissions data**
 - Started with only estimates
 - Required stack tests
 - Method development
 - First of its kind measurements

Chemours 2016 emissions estimates as originally reported to DAQ	Chemours revised 2016 emissions estimates as of October 2017	Latest emissions estimates, including information from January 2018 stack test measurements
66.6 lb/yr	594 lb/yr	2758 lb/yr

Emerging Compounds

DAQ's investigation involving GenX and other PFAS from Chemours

- **GenX ambient air quality data**
 - **Methods?**
 - **Wet deposition data - first of its kind**



Department of Environmental Quality



January 28-29, 2018
Rainwater GenX ppt



79.4

ND

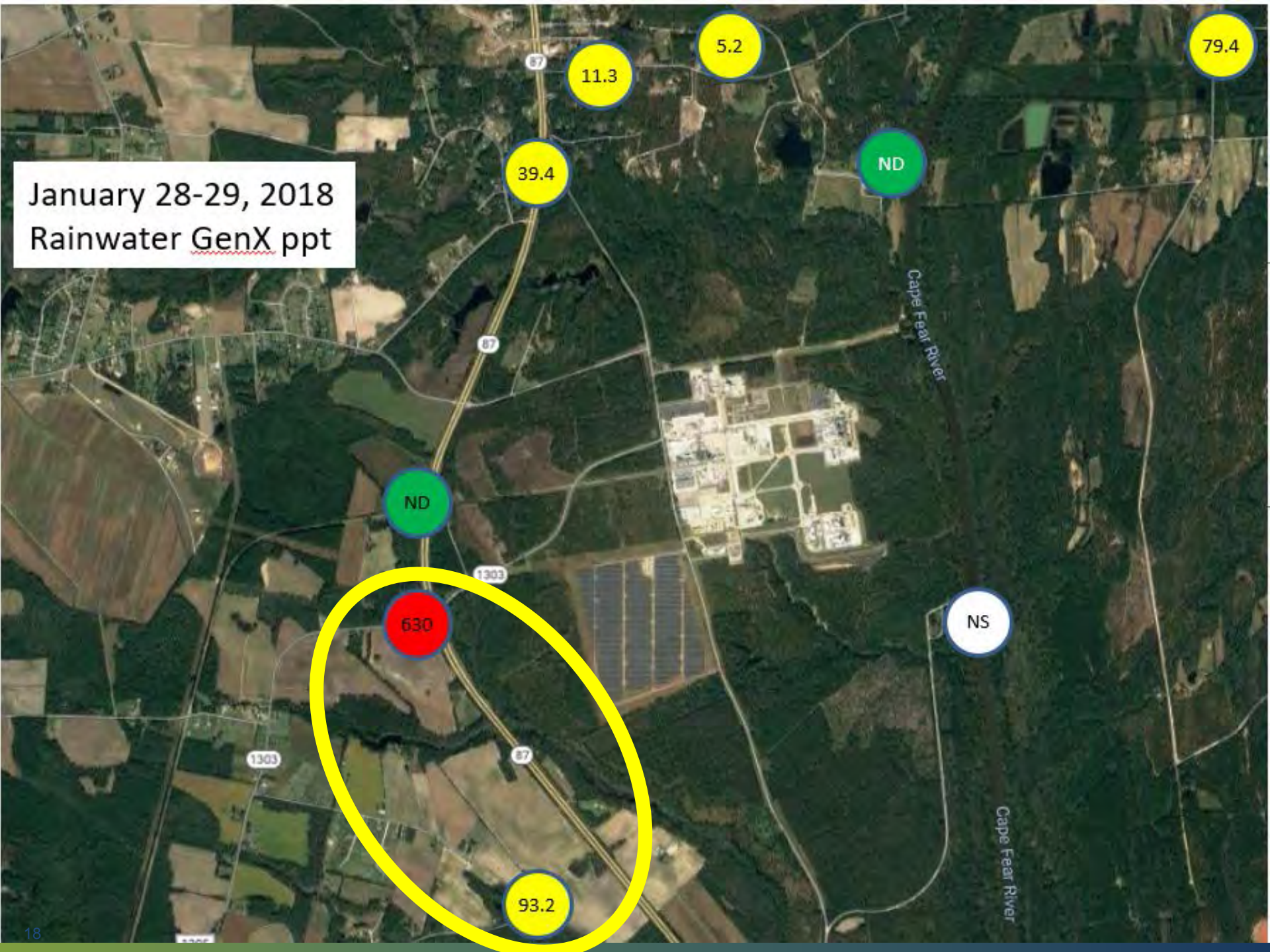
ND

630

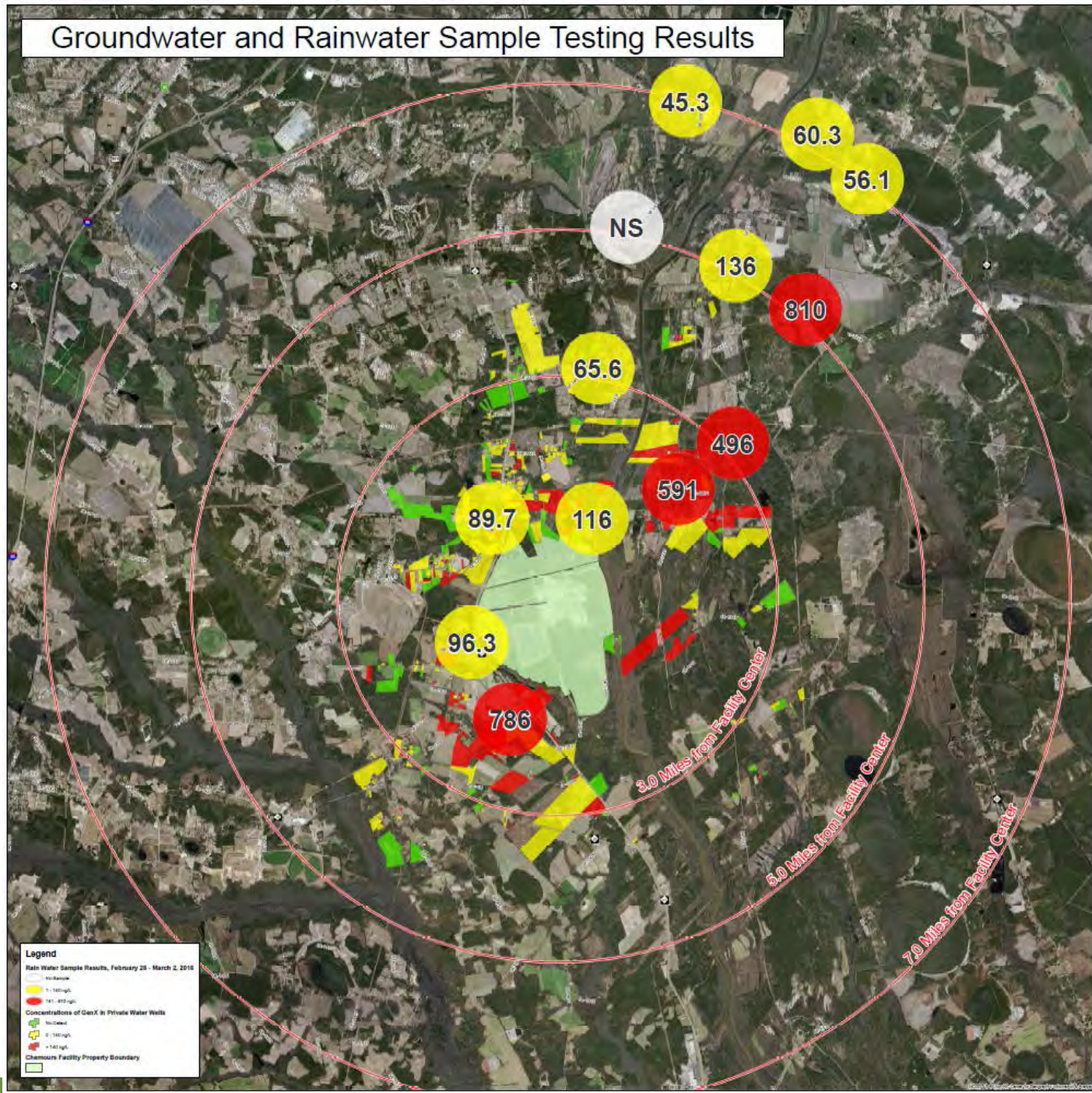
NS

93.2

January 28-29, 2018
Rainwater GenX ppt



Groundwater and Rainwater Sample Testing Results



Emerging Compounds

DAQ's investigation involving GenX and other PFAS from Chemours

- **Health impacts – what are the inhalation risks?**
 - **SAB**
- **Controls – what's technically feasible?**
 - **Carbon Adsorber trial approved**
 - **Thermal Oxidizer**

Emerging Compounds

DAQ's investigation involving GenX and other PFAS from Chemours

Summary:

- The measured air emissions of GenX compounds are significantly higher than previously understood and reported.
- The GenX compounds are deposited on the land by rainfall at distances of at least 7 miles from Chemours.
- The evidence of atmospheric deposition of GenX shows a geographic footprint that is similar to the detection of GenX in groundwater samples.



Emerging Compounds

GenX - Recent Actions

April 6, 2018:

- **60 day notice of intent to modify Chemours' air permit:**
 - **Requires demonstration that emissions of GenX compounds do not or will not cause or contribute to violations of groundwater rules.**

The science and data collected to date informed this action.



Emerging Compounds

GenX - Recent Actions

April 9, 2018:

- **Amended complaint and motion for preliminary injunctive relief.**
- **Addresses the air emissions contributions to the groundwater violations.**



Questions ?



NOTE FROM STARNEWS: Managing editor Sherry Jones is continuing to clean up the doc for typos and other oddities. Her email is Sherry.Jones@starnewsonline.com.

11:30 a.m. Thursday, June 15, 2017

County managers on the left side of the room


Elected and state officials in the middle

Chemours on the right side

Lawyers on the right side

Woody White, chairman of the New Hanover County Board of Commissioners, opening remarks: We want this to be somewhat informal, but meaningful and helpful.

Kathy O'Keefe, Chemours product sustainability director, introductory comments:

- Thanked officials for the opportunity "to have a very open and candid discussion. I understand it's been a challenging week, a very challenging week. There's been a lot of questions, a lot of concerns that have been raised and our goal today is to answer as many questions as we can"
 - "My commitment to you was to gather the experts from the Chemours company and bring those experts down here"
 - "One thing that I wanted to make sure you understand is we are very committed to the license to operate here so we are embracing our role and your expectation of us as a responsible manufacturer" ... employ 300 people at Fayetteville Plant
 - "Your concerns are our concern and we really want to be part of the solution and make sure we can provide as much information as possible to you.
 - "Our belief is that the GenX level in the drinking water coming from the Cape Fear River is safe and it does not pose any harm to human health. We have that belief; we're confident in that belief:
 - "We have extensive health and safety data for GenX. GenX is the replacement for ... PFOA. That PFOA substance we phased out of through the voluntary stewardship program with the EPA"
 - Submitted through an approval process through the US EPA TSCA program ... that's the normal process in the U.S. for getting a new chemical approved. We did extensive health and safety testing through that process, we submitted it to the EPA and
 - "We provided a lot of safety studies to the EPA; they asked for some more. They asked for seven more studies in that process. We conducted those studies and we provided them to the EPA years ago and there was no further action on them.
 - Consent order called for 99 percent control or capture of the material
 - "In fact we capture 100 percent of GenX so the likely question on your minds would be, 'If you capture 100 percent of GenX, how's GenX getting in the river' ... we're manufacturing GenX and it's governed through this consent order ... 100 percent compliance 100 percent of the time. At a different production area of the site we make polyvinyl ether"
-  "This is the emissions that are in the Cape Fear River, from this unregulated byproduct."
- "It's not about the regulatory piece when we're manufacturing; it's a different production unit on site where it's an unintended by product"

- "We had an unregulated chemical. There's no requirement to capture emissions of that chemical but we put abatement technology in place and we did that in November of 2013." Knappe team samples taken between June and December of 2013 and some additional samples in 2014... mean for the samples is 631 ppt.



"With that abatement technology that was put in place in November 2013, we have models that calculate the efficiency and how much is reduced of the emissions and that's about 80 percent reduction" ... 631 down to about 100 ppt ... "These are calculations. They are not actual samples that have been taken and we recognize it would be better to have actual samples that have been taken; I think that's what your expectation would be."

- "We're committed to (sampling) the activities are underway"
- "It's our expectation that we would show the levels of GenX in the Cape Fear River have been going down because of the abatement technology that's been put in place."
- Generating data, "We did see earlier this week that the NC DHHS did set an advisory level and that level was 70,909 ppt. What we're looking at here is to confidently say the water is safe. We have the data; the data has been reviewed and considered; the level has been set."
- "What we believe is that abatement technology that has been put in place will show there have been reductions in the Cape Fear River."



There's an exemption for R and D materials, there's an exemption for byproducts – in consent order – "It is a C3 dimer acid, it has the same structure, it has the same (CAS) number" – produced as part of the byproduct process

Woody White: Do you know if it was known in 2009 that the manufacturing process would create the chemical known as GenX?

Kathy O'Keefe: All of that is captured, there is no waste there, ... these are low levels that we're talking about, so a few years ago this would have been 'it's not there' because of the science around detection

Woody White: In 2009 when the EPA allowed that authorization, that was not an intended and foreseeable byproduct, is that right?



Kathy O'Keefe: The other part of the plant was not reviewed for that consent order'

Kathy O'Keefe: The consent order process wouldn't have had any data around other production units on site ... "unregulated wastes are not regulated under the TSCA new chemicals program"


Woody White: You said health studies, Dr. Knappe and other research that we've all read seems to cite an animal study, one study. Are there other studies you've done and could you identify those?

Kathy O'Keefe: In that consent order, they came back and they asked for another six studies ... the one study that they asked for was a chronic toxicity ... that is the definitive study for determining if a substance is a carcinogen or not. That study was conducted; the results were provided to the EPA. ... (Not identified as a human carcinogen)

Frank Williams, chairman of Brunswick County Board of Commissioners, asked if the decrease had occurred.

Mike Johnson, Chemours Fayetteville Works environmental manager: What we did is after the

study was published and the concerns were expressed here we had some internal processes that were run back in 2016 with NMR method and during the vinyl ethers process that Kathy was talking about. There's only one of the vinyl ethers that actually produces the GenX compound and it's actually made as an intermediate to that compound ... had 10 results that would show the peak during that process (ppm) ... you can do the math of flow times concentration and get a mass discharge, then I took those 10 numbers and if you count the time it takes to go to the wastewater treatment plant (down the Cape Fear River to the CFPWA intake) ... (it's) right around three days ... can determine what the flow was ... I took them ass that was discharged or created at ...

 Models showed an average discharge from the byproduct 'right at 96 ppt.' So if you compare the 96 ... " It comes out to be about 80 percent reduction" so the abatement we put in

Wilmington Mayor Bill Saffo: Has that been shared with DEQ or DHHS?


Mike Johnson: Yes

Bill Saffo: How about EPA

Mike Johnson: No because NC has primary for clean water in this state

Woody White: Considering according to Ms. O'Keefe's comments .. did you do it voluntarily?

Mike Johnson: Yes .. "We knew the GenX compound is a byproduct of the vinyl ethers process".

 ..." the manufacturing unit that makes GenX, there's no pipe that leads to the cape fear river so all waste and the water, which is a solid waste, is all containerized and sent off site for incineration. It's incinerated in Arkansas or at a site in ohio


"The realization that APFO none of it was going to the river and DuPont at the time proudly announced this until was built in such a ... no water discharges and very small air emissions.

"Then we transferred to genx, same statement none of that material can get to the Cape Fear River but we were aware the same molecule was coming out as a byproduct"

Woody White: What period of time before you realized it and began installing the abatement technology. My second question is the 96 ppt you cited ...?

Mike Johnson: It's well within the process itself because analytically our detection limit with NMR is 1 ppm. ... This is actually a process sample that's taken well up into the process of which there's many feeding into the wastewater treatment plant. The average flow on this is about 2k kg per hour and at 1

Woody White: And my first question about the time ... When did you install the technology and from that time backwards how long was GenX (being created as a byproduct)

 **Mike Johnson:** The discharge of the byproduct would have started with the installation of that process .. from 1980 up until 11/2013, this was a component in our wastewater discharge .

In November 2013, when this abatement was installed and started up, thereafter from then on you should have seen an 80 percent reduction in that amount.

We're talking about very, very small levels and if you went back a handful or over 10 years ago on -- all the various water pollutants -- at that time parts per million was pretty much the standard and as time went on, technology got better...

We're working with the Department of Environmental Quality right now, they're going to be sampling 10 locations here in the three county area, Pender County, New Hanover and Brunswick next week there are 10 samples taken

Bill Saffo: This process, this vinyl process that is creating this compound that has the same components of GenX, how long has it been going on?

Mike Johnson: Since 1980.

Bill Saffo: "Break it down so the average person can understand that. ... I'm trying to wrap my head around what does the thing look like? What's going in the river?"

Mike Johnson: "I certainly understand that. Our average flow going through our wastewater treatment plant is right at 1 million gallons per day". ... We pump water out of the Cape Fear River, it passes through heater, cools it and goes right back out..." Those two streams co-mingle, they come together so we have a regulated outfall on our water permit that's coming out of the water."

"You're looking at about 12 million gallons per day of water, of which if you look at how much of the GenX molecule is in there, that would be 100 million pounds per day and divide 2.2 by that so you end up with 20 parts per billion in our effluent, mix that with the river and that's where it's going to drive down to about 100 ppt" ... "it's not like there's a cup or a swimming pool"

Bill Saffo: Is it a pound, is it 10 pounds, is it 13 pounds?

Mike Johnson: "What's been on the news has been Flint Michigan, the discovery of lead up there. The limit on lead established under the safe drinking water act is 15,000 ppt. So 15,000 parts per trillion of lead is what's allowed." ... It would comply with the safe drinking water act. "By comparison, what's in the river, your intakes of this compound is 100 ppt. So compare 15,000 parts per trillion of lead versus 100 of this compound"

Frank Williams: "Not to get too picky, but was it a regular pool or an Olympic swimming pool?"

Mike Johnson: "It is very, very small. When you look at parts per trillion, you're looking at very, very small concentrations."

Kathy O'Keefe: What they found in the Flint water was between 30,000 and 50,000 parts per trillion, so here we're talking it was 631 ppt back in 2013, now we're ... that safe level

"There's a huge margin of safety between what was found in the river and the advisory level set by your DHHS."

Mike Brown, chairman of Cape Fear Public Utility Authority board: The limit on GenX is 70,000 parts per trillion... the GenX we are seeing in the river

Mike Johnson: There's a record keeping requirement and if the EPA comes knocking on Chemours' door they would present the data to them.

"All of these production units are regulated by our Title 5 air unit and air permits."

"We are regulated but for an unregulated compound, as the name would imply, there's no regulations requiring limits or monitoring, so this goes back to that."

"The only regulation or requirement we're talking about is that TOSCA consent order."

Mike Brown: They issued the consent order, they had some additional requirements for some additional testing ... y'all did that test and submitted it to EPA?

Kathy O'Keefe: "The study was a requirement, we conducted the study, we provided it to EPA." ... "There was no follow up on that. In the consent order if you read the language of the consent order, they made a statement that they had some concerns."

"Most substances going through the EPA today have some requirement on them... gloves, respirators, exposure levels for worker protection and then there's the emissions provision as well and the final requirement is a record keeping requirement."

"Chemours is not going to touch it. (The testing) The only thing we're doing is we're paying for it. The DEQ staff will work with the treatment staff to pull the samples. They're going to pull the incoming inlet water and then the finished water just to validate the levels are very very low."

Frank Williams: There's no GenX being released in the river from that part of the manufacturing process?

Answer: (Correct)



Mike Johnson: "Unfortunately, where it comes out of the process ultimately currently it's in our wastewater flow so as we do the GenX production unit we put all the waste into tankers, it's a small amount of water that's generated. If we tried to do the same thing on this one, it would be three tankers per day going out because it's just a lot of flow."

"It's difficult to burn water is what we're talking about here."

"I'm pretty confident that we've eliminated 80 percent of what was going in the river from 2013 to today."

"The final 20 percent we're currently looking at some possible changes in the process or changes to operation to see if we can reduce that further."

"We're trying to see if we could keep it out of the water."

Stephanie Smith, New Hanover County health board chairwoman

My first question ... is the rate of discharge -- and I don't know if that's the right term-- is it consistent if you go on a daily basis or are there time increments where that concentration is higher?

Mike Johnson: "The byproduct is produced only during one campaign and that campaign runs in summation about six months a year and it's not a continual six months ... which is called PPVE, just for clarification here, we like acronyms and PPVE is a continual process so the generation of this on a real time basis should be very, very consistent"

We're going to be sampling our effluent on our site that's going out, we're going to be using a 24 hour composite sampler to do that. ... pull flow and submit that to the lab ...

"It's consistent that it's being generated but when that process is not running, the level should be at or near zero because it's not being generated. As it turns out, if you look at the 2013 sampling ... every time they were sampling the PPVE campaign was running so all those represent when we were running, there was never a period when the unit was down."

"The numbers we're talking about here, the 96 ppt I mentioned, that's when the unit's running so on any given day when it's running it would be that, that should be six months a year, the other 6 months should be at or near zero."

Stephanie Smith: I know we've been focusing our discussions so far on water, but if you want to put in the air component.

Mike Johnson: "On average, what comes out of that unit is about 40 or 50 pounds per year as an air emission." ...

Stephanie Smith: The air emission is governed under the consent order, right?

Mike Johnson: Yes

Mike Johnson: The 99 percent control was for the whole corporation and the vast majority of that was at the West Virginia site we had ... 0 (emissions from manufacture) in the water and 50 pounds a year in the air so our numerator and denominator was very small,

Mike Brown: In addition to what we're going to call GenX ...

Kathy O'Keefe: "Everybody's got a different acronym for it"

Mike Brown: "There are six other in a layman's terms ways I understand it, variants of this GenX or original GenX compounds (in 2016 study)?"



Kathy O'Keefe: "Those other PFCs could come from other users or manufacturers of these PFCs. They could come from firefighting foam that was used at Fort Bragg" ... 1 of 7 definitely coming from Chemours ... "They're coming from somewhere, but I can't speak for other users or manufacturers. I don't know where."

Mike Brown: "You're saying those other six have been ruled out as coming from your process?"

Mike Johnson: "I would not say that. I'd have to look at those compounds." Going back to that study, ... there's a very interesting bar graph and what the study did, they went up to the water treatment system in ... they looked at those three sites and when you looked at the bar graph, you would see compounds detected up in Pittsboro, compounds detected in Fayetteville and compounds found in bladen bluffs.

"What stood out is the compound they call genx was found only at your bladen bluffs treatment a facility and that was not surprising because that's an intermediate we make" ... the GenX one and very admittedly the peak of that thing dwarfed all the others that were on that report.

George Brown, chairman of Pender County Board of Commissioners: Did you say the test would be performed on all three counties (Pender, Brunswick, New Hanover)?

Mike Johnson: total of 10 samples that will be taken; Smithfield Foods in Tar Heel ... them, Pender County, Brunswick ... "I said how many coolers do you need and (DEQ official) said 10"

Michael Regan, secretary of N.C. Department of Environmental Quality: "You indicated that with your modeling with the addition of the abatement technology (resulted in reductions). Is there any plan for you to show with DEQ or share with DEQ the proof of those assumptions?"

Mike Johnson: "Oh I'd be happy to."

Michael Regan: "Walk us through the level of difficulty of going from an 80 percent to a 100 percent reduction."

Mike Johnson: That's going to be difficult to answer ... "The actual initial abatement that was put in in 2013, it was the major one when you make the vinyl ether or product we were attempting to make, the actual feed, the intermediate that's in there is what we call GenX, the C3 dimer acid, and it also generates carbon dioxide"

"For years what was used was a water scrubber. .. a gas permeator was put in that allows the carbon dioxide to go through and leaves the dimer behind, it goes to the next distillation still, they scrub off the product, the dimer is left behind and it goes to our incineration process"

"Even as we speak, they are going to try, the belief is the 20 percent vast majority is coming out of a feed tank that goes to a reactor that makes our vinyl ether and there's a pressure control system in there" ... "They're going to try and see if it's even technically feasible to change the scheme of that venting and see if they can bottle up that tank and see if there is no venting. If that doesn't cause any process problems, and you don't know it until you try it, that would be an easy fix."

Also talk of a cold brine condenser

"There's different ways of this that are being considered and we're working diligently to try to do that."

Michael Regan: Any considerations of the time frame?

Mike Johnson: If you're talking about equipment, actual hardware, then you've got to spec it out, order ... "At the earliest would be our annual turnaround which occurs from September to October."

Michael Regan: "But the first if it is possible, if it's very easy, then you're talking about a very short window?"

Mike Johnson: "Oh yeah."

Michael Regan: "Could you give us an approximation?"

Mike Johnson: "I'd say within a month. Again, if it works. The best laid plans go amiss."

Woody White: First, you mentioned 12 million gallons a day, I think that's what you presently average that you withdraw from the Cape Fear River .. (new application includes a 26.5 million gallons per day request).

"I'm just trying to get a picture for what your intentions are as a company, depending on market conditions, increasing production of the substance?"

Mike Johnson: The 1 million gallons per day going through our wastewater treatment plant, that's our process waste, ... "1 million gallons per day, that's pretty steady 12 months of a year"

Woody White: So it's fair to say you do have plans to increase production or

Ellis McGaughey, Fayetteville Works Plant manager: "That water intake feeds three different companies, we're feeding Kurakay and we're feeding DuPont, we're an industrial park. ... "We own the permits so our tenants go through our permits."

Woody White: As it relates to what you said earlier about the fluctuation of 180 days, you answered a question and said 1980 ... the predecessor chemical compound that was withdrawn in the application renewal, the C8, you don't do that anymore.

"But since 1980 on the vinyl side, you've been creating GenX, is that correct?"

Mike Johnson: Yes

Woody White: When did y'all realize that you could use GenX to serve the same purposes as its predecessor, the C8?

Mike Johnson: When DuPont announced we were going to stop the use and the production of the APFO effluent, our research and development started trying to find a replacement that would work. I can't explain the process that would ...

Woody White, presenting 2010 manufacturing brochure that he hands to Mike Johnson, including information about GenX: "I just want to know, did DuPont and subsequently Chemours realize this was marketable and usable, patent it ..?"

Mike Johnson: In 1980, no? ...

Woody White: So how did you know it was being produced in 1980?

Mike Johnson: It was a byproduct in the vinyl ethers process and that process has not changed from 1980 to 2013 when we changed the abatement system so when we scrubbed out the carbon dioxide, we were scrubbing out the dimer acid.

"Take Ibuprofen and Advil. Ibuprofen is the molecule and Advil is the trademark it's sold under so you can think of the C3 dimer acid as ibuprofen and GenX as Advil.

Kathy O'Keefe: I can tell you that one thing the European database for registering chemicals does really well is you can go to a link to search dossiers, you can put in the CAS number I mentioned ... "If you want the complete tox study, dr gannon can certainly make those available"

Frank Williams: It's important to me to understand the reaction of the audience to something ... How you can help us address the public's response to this. In relation to that, obviously we've been talking about ppt but most people outside this (room don't know what ppt is)

"What's your perception of the average citizens take?"

Kathy O'Keefe: "I was surprised there was such a strong reaction but I understand it because it's an emotional issue. I'm a mother. I have two children. I have tons to worry about with my children. I don't want to worry about what's in their water, what's in their food."

"I think a lot of it is the unknown. There's this toxic chemical in our water. There's the first rule of toxicology which is the dose makes the poison. Just because something is present doesn't mean it's going to cause harm."

"When you cook Brussels sprouts, did you know you release formaldehyde?"

"The easiest thing to do is say these are the levels that we see, this is the safe level that has been established and I always use the term margin of safety but there's probably a better term to use. There's a safe distance between the (level) seen in the water and the level of safety that's been set by our agencies."

Frank Williams: "You reinforced my dislike for Brussels sprouts."

Mike Brown: "Is cycle (that produces GenX as byproduct) running right now?"

Mike Johnson: The current campaign is supposed to run three weeks (more)... "we want to get samples taken during that period, when the campaign is up and running"

"We're pulling a sample of our effluent three days per week so we're going to take a Monday, Tuesday, Wednesday sample" ... "If we can line up a discharge for us and their intake so when we do our Monday sample, the coordination is going to be they're sampling Thursday. ... We're going to have hopefully three weeks of data for you folks, that's going to be a once per week pulling samples from your site, we're going to have a three per week."

George Brown: "Do you plan on continuing GenX? Will it be a continuing thing with you all?"

Mike Johnson: "Producing it? Yeah. The production of it, yeah."

Woody White: "What about the discharge of it?"

Mike Johnson: "The discharge, the intent is if we're currently causing say 100 ppt in a public water system and if DHHS has come up with 71k is acceptable, then ... we're proactively trying to see if we can reduce that further"

Woody White: "Has your company considered once the samples are taken ceasing production until we know the answers to those two questions you just posed?"

Mike Johnson: "I would say we have not considered it." ... "We've got 2016 data that supports that our abatement system did reduce emissions by 80 percent. We have a safe level here. We've been down here and now we're actually lower and I've got 10 numbers."

"I'd use the term, maybe 'unjustified.' I understand you're under a huge amount of pressure from the public, but hopefully, as a result of this meeting if you can convey to them, this is safe. In 2013, it was here. It's six times lower in 2016 and in 2017, also."

Frank Williams: "People are responding to us emotionally and ... they're not even worried about themselves, they're worried about their children. ... They want to know something's being done differently a week ago more than anything else and action's being taken to eliminate as best we can the substance in the water."



"There's a Facebook group in Wilmington that went from 0 to 7,000 in four days. If there's something you guys can do that's a positive, proactive, voluntary step in that direction, that would go a long, long, long way."



Woody White: "EPA allows you to recapture 99 percent on the one side that's regulated and you capture 100 percent and on the other side you capture 80 percent, you said. It's the same substance based on your answers. ... That does not meet the common sense test. If the EPA and the federal government have said there's outstanding questions ... meanwhile just down the street you're producing that as a byproduct and you're OK with that, that does not make sense. That's hard to explain."

Mike Johnson: Let me confuse you further. The whole purpose of the consent order is when DuPont ... "At that time, DuPont didn't have the tox test completed and submitted per the premanufacturing order ... so the consent order allows DuPont to make in some amount ... until the final report was submitted to satisfy the PMN."

At that point and I think there's language in there, the consent order ... "It isn't, 'Oh from this point forward you're somehow limited,' it was to allow the commercialization of a product earlier than if you went the normal route so that was the whole purpose of the consent order."

Woody White: "If it does expire or sunset as you say, do you intend to take your reclamation role from 100 percent down?"

Mike Johnson: No

Kathy O'Keefe: The question is, 'it doesn't make sense, it's regulated in one place, it's not regulated in the other... there are a lot of unregulated wastes. We took action from a stewardship perspective because we understand this is something you don't want in your water. ... We are looking at that, as Mike said. We don't have a definitive plan. The closer you get to try to lock it up at 100 percent, that technology to put in place gets more and more difficult."

"We always want to drive, it's a sustainability principle for us, keep driving our environmental footprint down. It's important to your communities and it's a good business proposition, also."

"We also want to look to see if we can do any process aids that are non-fluorinated. In fact, we do have one that was introduced about two years ago and it's a non fluorinated processing aid"

George Brown: "That's the thing I'm having the most issue getting my hands around here because the regulated side, the discharge side, the permit with the EPA addresses that" .." I get everything you're saying, it's hard for me to explain to folks though how the EPA did not have a requirement on the byproduct side as much as the discharge side"



Kathy O'Keefe: "It's a separate regulatory agency. So you have different regulatory agencies that look at different substances for different purposes"

Kathy O'Keefe: "It was new in that it was the first time it was added to the TOSCA inventory for commercial substances. Before that it may have been a known chemical structure"

George Brown: It's like you can test one side but you can't test the other side." ... "Our position makes it a little different for us to try to explain that, it doesn't seem like common sense for most folks out there."

Bill Saffo: This process has been going on since 1980 so you didn't actually ...

Kathy O'Keefe: It was never used. It was produced unintentionally so under the requirements of TOSCA "It's made in the byproduct of the process. There's no commercial intent there so it doesn't get regulated until there's commercial intent."

Bill Saffo: "So the actual compound has been going into the river since 1980?"

Kathy O'Keefe: Yes

Bill Saffo: "It's not like this all of a sudden showed up? It's been going in the river since 1980?"

Mike Johnson: GenX became a commercial product. ... "Before that time, it was ibuprofen, it was the identical molecule that was unintentionally produced ... That product didn't go into the commercial, if that makes sense, it's after the different reaction that you come up with a whole new molecule."

Bill Saffo: "Because it's under different rules and it's unregulated, you can put this in the river?"

Kathy O'Keefe: "Permission to manufacture the chemical, the byproduct -- that's not regulated by any regulatory agency."

There's manufacturing something for commercial purposes, that's TOSCA, a waste emission to the river, that's (NPDES)

Sheila Hollman, DEQ: Could you all just clarify at what point the detection levels at ppt happen ... at what point did y'all know it was there?

Mike Johnson: That came about really through the PFOA analysis where that technique was developed to get down to the parts per trillion then they were using the same machine, the same analytical technique and tweaking it to (find GenX) ... It has been the last few years

Andrew Hartten, Chemours Remediation Principle: In 2012, when they were getting ready first using GenX in trials, to look for it analytically you have to have a known standard and Wellington Labs who's like a known leader they produced the first analytical standard in 2012, so it's been about five years.

Frank Williams: My comment is going back to the whole conversation... "The average citizen out there doesn't know about all the different regulatory agencies and all that. ..." "The average citizen doesn't know that or understand that."

What gives you confidence in those that this is safe?

Kathy O'Keefe: "I think it's been studied at least as much, if not more, than other chemicals that are out there."

The EPA was replacing the long chain PFC, the PFOA, so the bar was set very high to make sure they had a very good understanding of the risk assessment to understand the hazard, the exposure routes ...

Sean Gannon, Chemours Toxicology leader: I do agree with you that it was a tremendous amount of data. There are something along the lines of 25 to 30 studies.

Woody White: We sent you a written list of 18 questions ... did you bring written answers?

Kathy O'Keefe: "We didn't write up the answers; we were just expecting that we'd have a dialogue."

Mark Benton, deputy secretary for health services: "I've heard some references to some data that we put out, some have referred to it as a guidance or a standard ... It was not a regulatory communication, I just want to make sure that as we move on from this table, folks have a good understanding as we pull that together of what it was"

Zack Moore, N.C. state epidemiologist

The level that our preliminary calculations came up is the 71,000 level ... "It is a health screening level, it's not a regulatory level, it's not an enforceable level -- that's the level below which we don't expect health effects to occur."

"It can be updated frequently as more data become available"

Mike Brown: Is that based on your data or is it available on

Stephanie Smith: "With the results of this testing that's about to occur, is it possible the health screening level could change?"

Zack Moore: "These are based on toxicity data."

Mike Johnson: "If I could inject one thing, I thought DHHS did a really good job in their statement, the discussion has been how to communicate this to the public, to the more lay people ... they did it where it was this level is more than 100 times greater than what was measured in 2013. I think people can measure that better than ng/L because I imagine most of your citizens have no idea what that is."



Sheila Hollman: I want to make sure I understand the answer to the question about stopping the discharge to the river. As I understand GenX is part of outfall one and ultimately becomes part of outfall 2. Is it three tanker trucks per day that would be needed to hold outfall 1?

Mike Johnson: The smaller stream is the three tankers per day. ...

Mike Johnson: Three that's actually the process flow, you're up in the bowels of the process where it's first generated and it's headed down to the wastewater treatment plant. .. I think it's 19k gallons per day so you're looking at three tankers.

Woody White: Have you all been discussing that you're willing to inform us about any effort on your part to further educate any members of this community? ... What if any discussions has your company engaged in to try to assuage the hysteria this community's going through?

Kathy O'Keefe: "We want to have a conversation with you first" ... We haven't really had a lot of time to think about is there something ...

"I tend to think the community doesn't want to hear from the company. They want to hear from the regulatory agencies and the county. ... If I were somebody in the community, I'm not sure I would trust me coming in and saying everything is safe, ... but we're willing to partner with you as best we can."

Bill Saffo: Well, we'd like to see 100 percent capture.

Woody White: It's as simple as that. We want to see you turn the faucet off.

Kathy O'Keefe: Hopefully, this is the beginning of discussions.

ATTACHMENT 57

Expanded PFAS Analysis on DEQ-
Collected Private Wells Associated with
Chemours-Fayetteville

PFAS	2,3,3,3-Tetrafluoro-2-(1,1,2,2,3,3,3-heptafluoropropoxy)propanoic acid (PFPrOPrA, "GenX")	Perfluorooctane-sulfonate (PFOS)	Perfluoro- octanoic acid (PFOA)	Perfluoro- 2-methoxyacetic acid (PFMOAA)	Perfluoro- (3,5-dioxahexanoic) acid (PFO2HxA)	Perfluoro- 3-methoxypropanoic acid (PFMOPrA)	Perfluoro- butane-sulfonate (PFBS)	Perfluoro- butyric acid (PFBA)	Perfluoro- (3,5,7-trioxaoctanoic) acid (PFO3OA)	Perfluoro-4-methoxy- butanic acid (PFMOBA)	Perfluoro-pentane-sulfonate (PFPeS)	Perfluoro-pentanoic acid (PFPeA)		
CASN	13252-13-6	1763-23-1	335-67-1	674-13-5	39492-88-1	377-73-1	375-73-5	375-22-4	39492-89-2	863090-89-5	2706-91-4	2706-90-3		
Chemical Formula	C6HF11O3	C8HF17O3S	C8HF15O2	C3HF5O3	C4HF7O4	C4HF7O3	C4HF9O3S	C4HF7O2	C5HF9O5	C5HF9O3	C5HF11O3S	C5HF9O2		
Estimated Concentration *				X	X	X			X	X				
DEQ Location No.	Collection date	units												
2	9/19/2017	ng/L	20.8	ND	ND	ND	1.61	6.55	ND	ND	ND	ND	ND	
3	9/20/2017	ng/L	55.2	ND	ND	ND	5.70	18.3	ND	ND	ND	1.73	ND	ND
4A	9/18/2017	ng/L	243	0.760 J	3.42	0.368	108	199	41.5	6.69	16.6	43.1	ND	7.83
4B	9/18/2017	ng/L	273	0.781 J	3.59	0.350	120	214	46.9	7.05	15.9	45.2	ND	8.68
5	9/20/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	9/20/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8	9/21/2017	ng/L	343	0.974 J	ND	0.268	72.2	180	2.13	6.37	7.30	34.6	ND	7.11
9	9/15/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13	9/19/2017	ng/L	133	ND	ND	ND	38.0	66.1	ND	4.37	6.68	10.7	ND	6.05
14	9/15/2017	ng/L	176	ND	0.739 J	ND	53.2	83.2	0.700 J	4.8	ND	15.9	ND	6.41
15	9/15/2017	ng/L	6.43	ND	ND	ND	1.06	4.88	ND	ND	ND	0.455	ND	ND
15R	9/29/2017	ng/L	4.73	ND	ND	ND	0.929	4.14	ND	ND	ND	0.397	ND	ND
16	9/19/2017	ng/L	41.0	ND	ND	ND	3.09	18.8	ND	0.818 J	ND	1.16	ND	0.862 J
31	9/19/2017	ng/L	7.79	ND	ND	ND	0.333	5.75	ND	ND	ND	0.349	ND	ND
32	9/21/2017	ng/L	132	2.71	2.40	ND	57.5	161	4.18	7.82	14.6	18.2	ND	4.50
35	9/18/2017	ng/L	453	19.5	12.4	0.289	149	210	0.687 J	11.4	55.6	50.2	ND	6.70
38	9/19/2017	ng/L	1030	ND	5.03	0.642	209	299	2.93	20.2	60.6	67.7	1.83 J	14.4
39	9/20/2017	ng/L	643	ND	3.97	0.455	210	253	1.22 J	25.2	101	62.0	ND	13.1
42	9/18/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.584	ND	ND
71	11/7/2017	ng/L	1160	0.835 J	5.75	0.728	167	ND	2.22	14.7	38.8	45.4	ND	20.7
71-duplicate	11/7/2017	ng/L	1170	0.814 J	6.43	0.711	167	ND	2.09	15.3	39.0	46.9	ND	20.8
75 - pre-filter	12/20/2017	ng/L	845	1.02 J	14.5	0.405	148	294	1.51 J	13.7	26.4	61.0	1.86 U	16.2

BOLD = GenX concentration greater than or equal to the NC DHHS July 2017 GenX Provisional Drinking Water Health Goal of 140 ng/L GenX

The USEPA 2016 Drinking Water Health Advisory Level for PFOS, PFOA or (PFOS + PFOA) = 70 ng/L

PFAS = per- and poly-fluorinated alkyl substances

CASN = the Chemical Abstract Number

ND = Not Detected, sample reporting limits (RLs) in the range of approximately 1.6 - 4.6 ng/L

* "X" indicates the reported PFAS concentration is estimated and was quantified from the GenX calibration curve because an authentic calibration standard for this PFAS was not available at the time of the analysis

ng/L = nanograms per liter, or "parts-per-trillion"

U = PFAS not detected at the indicated sample-specific analyte reporting limit concentration

J = estimated concentration reported at less than the sample-specific analyte reporting limit concentration

Expanded PFAS Analysis on DEQ-
Collected Private Wells Associated with
Chemours-Fayetteville

PFAS	Fluorotelomer sulfonate 4:2 (4:2 FTS)	Perfluoro-hexanesulfonate (PFHxS)	Perfluoro-hexanoic acid (PFHxA)	Nafion Byproduct 1	Nafion Byproduct 2	Perfluoro-heptanesulfonate (PFHpS)	Perfluoro-heptanoic acid (PFHpA)	Fluorotelomer sulfonate 6:2 (6:2 FTS)	Perfluoro-octane-sulfonamide (PFOSA)	Perfluoro-nonane-sulfonate (PFNS)	Perfluoro-nonanoic acid (PFNA)
CASN	757124-72-4	355-46-4	307-24-4	29311-67-9	749836-20-2	375-92-8	375-85-9	27619-97-2	754-91-6	68259-12-1	375-95-1
Chemical Formula	C6H5F9O3S	C6HF13O3S	C6HF11O2	C7HF13SO5	C7H2F14SO5	C7HF15O3S	C7HF13O2	C8H5F13O3S	C8H2F17NO2S	C9HF19O3S	C9HF17O2
Estimated Concentration *				X	X						

DEQ Location No.	Collection date	units	Fluorotelomer sulfonate 4:2 (4:2 FTS)	Perfluoro-hexanesulfonate (PFHxS)	Perfluoro-hexanoic acid (PFHxA)	Nafion Byproduct 1	Nafion Byproduct 2	Perfluoro-heptanesulfonate (PFHpS)	Perfluoro-heptanoic acid (PFHpA)	Fluorotelomer sulfonate 6:2 (6:2 FTS)	Perfluoro-octane-sulfonamide (PFOSA)	Perfluoro-nonane-sulfonate (PFNS)	Perfluoro-nonanoic acid (PFNA)
2	9/19/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	9/20/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4A	9/18/2017	ng/L	ND	4.92	2.91	0.411	41.9	ND	1.73 J	ND	ND	ND	ND
4B	9/18/2017	ng/L	ND	5.74	3.16	0.482	46.4	ND	2.01	ND	ND	ND	ND
5	9/20/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	9/20/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8	9/21/2017	ng/L	ND	ND	1.89	ND	2.53	ND	ND	ND	ND	ND	ND
9	9/15/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
13	9/19/2017	ng/L	ND	ND	1.72 J	ND	9.14	ND	0.627 J	ND	ND	ND	ND
14	9/15/2017	ng/L	ND	0.652 J	2.05	ND	22.5	ND	0.958 J	6.70	ND	ND	ND
15	9/15/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	7.60	ND	ND	ND
15R	9/29/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
16	9/19/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
31	9/19/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
32	9/21/2017	ng/L	ND	0.812 J	1.49 J	0.405	69.3	ND	1.25 J	ND	ND	ND	ND
35	9/18/2017	ng/L	ND	ND	2.53	0.359	125	0.909 J	3.44	ND	ND	ND	ND
38	9/19/2017	ng/L	ND	4.74	5.50	1.40	36.8	ND	4.91	ND	ND	ND	ND
39	9/20/2017	ng/L	ND	1.24 J	3.84	0.915	60.6	ND	3.74	ND	ND	ND	ND
42	9/18/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
71	11/7/2017	ng/L	ND	1.77	6.84	1.52	43.5	ND	3.51	ND	ND	ND	ND
71 - duplicate	11/7/2017	ng/L	ND	1.94	7.11	1.47	46.1	ND	3.59	ND	ND	ND	ND
75 - pre-filter	12/20/2017	ng/L	3.72 U	0.819 J	4.73	ND	48.5	1.88 U	2.88	3.76 U	1.84 U	1.90 U	1.98 U

Expanded PFAS Analysis on DEQ-
Collected Private Wells Associated with
Chemours-Fayetteville

PFAS	Perfluoro- (3,5,7,9-tetraoxadecanoic acid (PFO4DA)	Perfluoro- decanoic acid (PFDA)	N-methylperfluoro- 1-octane-sulfon- amidoacetic acid (N-MeFOSAA)	Perfluoro- undecanoic acid (PFUdA)	N-ethylperfluoro- 1-octane-sulfon-amidoacetic acid (N-EtFOSAA)	Perfluoro- dodecanoic acid (PFDoA)	Perfluoro- tridecanoic acid (PFTrDA)	Perfluoro- tetradecanoic acid (PFTeDA)		
CASN	39108-34-4	39492-90-5	335-77-3	335-76-2	2355-31-9	2058-94-8	2991-50-6	307-55-1	72629-94-8	376-06-7
Chemical Formula	C10H5F17O3S	C10H7F11O6	C10HF21O3S	C10GF19O2	C11H6F17NO4S	C11HF21O2	C12H8F17NO4S	C12HF23O2	C13HF25O2	C14HF27O2
Estimated Concentration *	X									

DEQ Location No.	Collection date	units	Perfluoro- (3,5,7,9-tetraoxadecanoic acid (PFO4DA)	Perfluoro- decanoic acid (PFDA)	N-methylperfluoro- 1-octane-sulfon- amidoacetic acid (N-MeFOSAA)	Perfluoro- undecanoic acid (PFUdA)	N-ethylperfluoro- 1-octane-sulfon-amidoacetic acid (N-EtFOSAA)	Perfluoro- dodecanoic acid (PFDoA)	Perfluoro- tridecanoic acid (PFTrDA)	Perfluoro- tetradecanoic acid (PFTeDA)
2	9/19/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND
3	9/20/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND
4A	9/18/2017	ng/L	ND	4.98	ND	ND	ND	ND	ND	ND
4B	9/18/2017	ng/L	ND	4.34	ND	ND	ND	ND	ND	ND
5	9/20/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND
6	9/20/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND
8	9/21/2017	ng/L	ND	0.347	ND	ND	ND	1.30 J	ND	ND
9	9/15/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND
13	9/19/2017	ng/L	ND	0.741	ND	ND	ND	ND	ND	ND
14	9/15/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND
15	9/15/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND
15R	9/29/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND
16	9/19/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND
31	9/19/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND
32	9/21/2017	ng/L	ND	6.35	ND	ND	ND	ND	ND	ND
35	9/18/2017	ng/L	ND	49.5	ND	ND	ND	ND	ND	ND
38	9/19/2017	ng/L	ND	30.7	ND	ND	ND	ND	ND	ND
39	9/20/2017	ng/L	ND	35.0	ND	ND	ND	ND	ND	ND
42	9/18/2017	ng/L	ND	ND	ND	ND	ND	ND	ND	ND
71	11/7/2017	ng/L	ND	9.86	ND	ND	ND	ND	ND	ND
71-duplicate	11/7/2017	ng/L	ND	10.2	ND	ND	ND	ND	ND	ND
75 - pre-filter	12/20/2017	ng/L	3.80 U	12.8	1.92 U	1.98 U	3.95 U	1.98 U	3.95 U	1.98 U

Draft for Public Review

STATE OF NORTH CAROLINA
COUNTY OF BLADEN

IN THE GENERAL COURT OF JUSTICE
SUPERIOR COURT DIVISION
17 CVS 580

STATE OF NORTH CAROLINA, *ex rel.*,)
MICHAEL S. REGAN, SECRETARY,)
NORTH CAROLINA DEPARTMENT OF)
ENVIRONMENTAL QUALITY,)
)
Plaintiff,)
)
v.)
)
THE CHEMOURS COMPANY FC, LLC,)
)
Defendant.)
)
)

**DRAFT PROPOSED
ORDER FOR PRELIMINARY
INJUNCTIVE RELIEF**

THIS CAUSE was heard by the Honorable Douglas B. Sasser, Senior Resident Superior Court Judge, presiding by designation pursuant to Rule 2.1 of the General Rules of Practice, upon the application of Plaintiff, the State of North Carolina, by and through Michael S. Regan, Secretary of the North Carolina Department of Environmental Quality (“DEQ”), for entry of a Preliminary Injunction pursuant to N.C. Gen. Stat. § 143-215.6C to prevent and abate violations of the North Carolina’s water quality laws by Defendant The Chemours Company FC, LLC (“Chemours”).

After reviewing the submissions of the Parties and considering the arguments of counsel, this Court finds and concludes the following:

JURISDICTION AND VENUE

1. Plaintiff is the sovereign State of North Carolina. This action was brought on the relation of Michael S. Regan, Secretary of DEQ, the State agency established pursuant to N.C. Gen. Stat. § 143B-279.1 *et seq.*, and vested with the statutory authority to enforce the State’s

Draft for Public Review

environmental protection laws, including laws enacted to protect the water and air quality of the State. The Division of Water Resources (“DWR”), the Division of Waste Management (“DWM”), and the Division of Air Quality (“DAQ”) are divisions within DEQ and all actions taken by these Divisions are actions of the Plaintiff.

2. Defendant Chemours is a Delaware limited liability company registered and doing business in North Carolina. Chemours owns and operates its Fayetteville Works facility located at 22828 NC Highway 87 W, Fayetteville, Bladen County, North Carolina, which is the subject of this action.

3. This Court has jurisdiction over this action for injunctive relief for existing or threatened violations of various laws and rules governing the protection of water quality pursuant to N.C. Gen. Stat. § 143-215.6C and air quality pursuant to N.C. Gen. Stat. § 143-215.114C. Furthermore, jurisdiction for injunctive relief sought to compel enforcement of a statute or regulation rests in the Superior Court pursuant to N.C. Gen. Stat. § 7A-245(a)(2) and N.C. Gen. Stat. § 1-493.

4. Bladen County, North Carolina, is a proper venue for this action because a significant portion of the alleged violations or threatened violations that are the subject of this action for injunctive relief have occurred, are occurring, and may continue to occur at the Fayetteville Works facility. N.C. Gen. Stat. § 143-215.6C; N.C. Gen. Stat. § 143-215.114C.

FINDINGS OF FACT

5. The Facility. Chemours owns a chemical manufacturing facility called the Fayetteville Works facility (“Facility”) in Bladen County, North Carolina. Chemours has owned and operated the Facility since July of 2015. Prior to that time, the Facility was owned by

Draft for Public Review

Chemours' predecessor, E. I. DuPont de Nemours & Company, Inc. ("DuPont"). Chemours manufactures, among other products, Chemours Nafion® Membrane and Polymer Dispersions, HFPO Monomers and Vinyl Ether Monomers, as well as a Polymer Processing Aid known as "GenX."

6. "GenX" is the trade name for the chemical C3 Dimer Acid (also known as HFPO Dimer Acid), which has a Chemical Abstracts Registry or "CAS" number of 13252-13-6.¹ C3 Dimer Acid Fluoride (also known as HFPO Dimer Acid Fluoride), CAS No. 2062-98-8, and C3 Dimer Acid Ammonium Salt (also known as HFPO Dimer Acid Ammonium Salt), CAS No. 62037-80-3, convert to GenX in the presence of water. GenX, C3 Dimer Acid Fluoride, and C3 Dimer Acid Ammonium Salt are collectively referred to herein as "GenX Compounds." GenX Compounds fall within a family of chemicals known as per- and polyfluoroalkyl substances or "PFAS."

7. GenX was developed by DuPont as a substitute for Perfluorooctanoic acid or "PFOA," which DuPont ceased manufacturing pursuant to United States Environmental Protection Agency's ("EPA's") "PFOA Stewardship Program." EPA launched the PFOA Stewardship Program in 2006 because of concerns about the impact of PFOA and other long-chain PFAS on human health and the environment, including concerns about their persistence, presence in the environment and in the blood of the general U.S. population, long half-life in people, and developmental and other adverse effects in laboratory animals. The goal of the program was for companies to work towards eliminating PFOA from emissions and product content by 2015.

¹ CAS numbers are universally used to provide a unique identifier for chemical substances.

Draft for Public Review

8. On January 28, 2009, EPA and DuPont entered into a Consent Order governing the manufacture of GenX pursuant to the Toxic Substances Control Act (“TSCA”). That Consent Order states that “EPA has concerns that [GenX] will persist in the environment, could bioaccumulate, and be toxic . . . to people, wild animals, and birds.” The Consent Order also stated that EPA had “human health concerns” regarding GenX and recognized that “uncontrolled . . . disposal of [GenX] may present an unreasonable risk of injury to human health and the environment.” The Consent Order required DuPont to “recover and capture (destroy) or recycle [GenX] at an overall efficiency of 99% from all the effluent process streams and the air emissions (point source and fugitive).”

9. While there are no federal environmental regulatory standards for GenX, the North Carolina Department of Health and Human Services (“DHHS”) has established a provisional health goal for exposure to GenX in drinking water of 140 nanograms per liter (“ng/L,” also expressed as parts per trillion or “ppt”).

10. Wastewater Discharge Permit. The Facility discharges wastewater into the Cape Fear River pursuant to National Pollutant Discharge Elimination System Permit No. NC003573 (“NPDES Permit”). The most recent version of the NPDES Permit was issued by DWR on October 28, 2015, and partially suspended on November 30, 2017. The NPDES Permit authorizes the discharge of wastewater from the Facility through two outfalls: Outfall 001 and Outfall 002. Outfall 001 is an internal outfall from the Facility’s wastewater treatment plant. Outfall 002 discharges the Facility’s treated wastewater as well as non-contact cooling water and stormwater into the Cape Fear River. The partial suspension of the NPDES permit on November 30, 2017 suspended Chemours’ authorization to discharge process wastewater from its

Draft for Public Review

manufacturing areas.

11. The segment of the Cape Fear River into which the Facility's wastewater is discharged is classified by regulation as a WS-IV water—waters protected as a public source of drinking water—and is located upstream of various drinking water intakes serving utilities such as the Lower Cape Fear Water and Sewer Authority, Cape Fear Public Utility Authority, and Brunswick County.

12. Air Quality Permit. The Facility is also subject to Air Quality Permit No. 03735T43 (“Air Permit”), issued by DAQ. The Air Permit authorizes the operation of various emissions sources and pollution control devices at the Facility subject to certain conditions, including pollution control, monitoring, and reporting requirements.

13. Emissions from several manufacturing processes at the Facility are controlled by scrubbers called the “Division Waste Gas Scrubber” and the “Vinyl Ethers South Scrubber,” and vented to the atmosphere through the “Division Stack” and “Vinyl Ethers South Stack,” respectively. The processes controlled by these scrubbers include the Vinyl Ethers North Process, the RSU Process, the FPS Liquid Waste Stabilization Process, the MMF Process, the Hexafluoropropylene oxide (“HFPO”) Process, and the Vinyl Ethers South Process. Emissions from the Polymer Processing Aid (“PPA”) Process are controlled by a scrubber called the “PPA Scrubber,” and vented through the PPA Stack. PPA Process emissions are also controlled by the PPA Carbon Adsorber Unit, which was installed on or around May 25, 2018. The Air Permit also applies to other emissions sources at various locations throughout the Facility.

14. In addition to process emissions vented through stacks, the Facility releases fugitive emissions into the atmosphere as a result of outdoor and indoor equipment leaks. Chemours is

Draft for Public Review

required to minimize its fugitive emissions through implementation of a Leak Detection and Repair (“LDAR”) Program. Indoor fugitive emissions from the Vinyl Ethers North Process are also controlled by the Vinyl Ethers North Carbon Adsorber Unit, which was installed on or around May 25, 2018. Indoor fugitive emissions from the PPA Process are controlled by the PPA Carbon Adsorber Unit.

15. DEQ’s Investigation and Enforcement Action. Since June of 2017, DEQ, in consultation with DHHS and EPA, has been leading a State investigation into the presence of GenX and other PFAS in surface waters, groundwater, and public and private drinking water in the Cape Fear region.

16. Wastewater from Chemours’ manufacturing processes has contained GenX Compounds and other PFAS since the 1980s. While wastewater from Chemours’ PPA Process (which produces GenX as a commercial product) has been historically captured for offsite disposal, GenX Compounds and other PFAS have also been generated at the Facility in connection with other manufacturing processes and discharged to the wastewater treatment plant. GenX and other PFAS have also been captured in scrubber waste water, which was also discharged to the wastewater treatment plant. Because the Facility’s wastewater treatment plant is ineffective at removing PFAS, these compounds have been continuously discharged into the Cape Fear River for decades by Chemours and DuPont.

17. On June 19, 2017, a sample at Chemours’ Outfall 002 showed concentrations of GenX at 39,000 ng/L.

18. On June 19, 2017, DEQ also began collecting surface water samples from sites along the Cape Fear River. Analysis of samples of finished water from public utilities showed

Draft for Public Review

concentrations of GenX as high as 1,100 ng/L.

19. DuPont and Chemours failed to timely disclose to DWR in the NPDES permitting process any discharge of GenX Compounds or other PFAS into the Cape Fear River. DuPont and Chemours also failed to timely disclose to DEQ that C3 Dimer Acid Fluoride reacts with water to generate GenX and that any discharge or emissions of C3 Dimer Acid Fluoride is likely to result in the release of GenX into the environment.

20. None of the DuPont or Chemours NPDES permit applications referenced “GenX,” “GenX Compounds,” “C3 Dimer Acid,” “C3 Dimer Acid Fluoride,” “C3 Dimer Acid Ammonium Salt” or any chemical name, formula, or CAS number that would identify any GenX or other PFAS in the Facility’s discharge.

21. In fact, information provided by DuPont and Chemours led DWR staff to reasonably believe that GenX was not being discharged into the Cape Fear. On August 26, 2010, representatives of DuPont, including environmental manager Michael Johnson, met with DEQ staff regarding DuPont’s anticipated use of GenX technology at the Fayetteville Works as a replacement for PFOA. The information DuPont provided indicated that the GenX would be produced in a closed-loop system that would not result in the discharge of GenX into the Cape Fear River. DuPont and Chemours did not notify DWR of an actual ongoing discharge of GenX at this meeting or in any information subsequently provided to DWR prior to 2017.

22. Chemours’ discharge of GenX Compounds and other PFAS in its effluent was not disclosed and was not authorized by Chemours’ NPDES permit.

23. On September 7, 2017, DEQ filed a Complaint, Motion for Temporary Restraining Order, and Motion for Preliminary Injunctive relief in this Court, seeking various forms of

Draft for Public Review

injunctive relief relating to the PFAS contamination in surface water and groundwater.

24. On September 8, 2017, the Court entered a partial consent order requiring Chemours to take immediate measures to capture process wastewater containing GenX compounds as well as two additional PFAS called PFESA Byproduct 1, CAS No. 66796-30-3, and PFESA Byproduct 2, CAS No. 749836-20-2, for offsite disposal.

25. Despite Chemours' diversion of additional process wastewater for offsite disposal, DEQ continued to detect elevated levels of GenX at the Facility's outfall and in the Cape Fear River after issuance of the partial consent order. In addition, approximately one month after entry of the partial consent order, Chemours failed to report a spill of wastewater containing PFAS, which resulted in elevated levels of PFAS in the Cape Fear River and in downstream drinking water intakes. On November 13, 2017 DEQ issued Chemours an NOV for its violation of NPDES reporting requirements and 15A N.C.A.C. 2B .0216(3)(a).

26. On November 16, 2017, DWR sent a letter to Chemours partially suspending the NPDES Permit effective November 30, 2017. As a result of this action, Chemours is currently prohibited from discharging any process wastewater from its manufacturing areas.

27. DEQ's investigation and enforcement actions have also addressed GenX and PFAS contamination in groundwater. In August 2017, samples gathered from fourteen groundwater monitoring wells at the Facility showed GenX in thirteen of those wells at levels ranging from 519 ng/L to 61,300 ng/L. More recent data shows even higher concentrations of GenX in onsite groundwater. For example, Chemours' January 31, 2018 Additional Onsite Investigation Report showed GenX in onsite groundwater at concentrations as high as 640,000 ng/L. Five wells located adjacent to the Cape Fear River have GenX in concentrations greater than 11,800 ng/L. The report

Draft for Public Review

also showed that other PFAS were detected in onsite groundwater. For example, PFMOAA, CAS No. 674-13-5, was detected in concentrations of more than 8 million ng/L; “PFESA Byproduct 1,” CAS No. 29311-67-9 was detected in concentrations of more than 260,000 ng/L; and “PFESA Byproduct 2,” CAS No. 749836-20-2 was detected in concentrations of more than 76,000 ng/L in groundwater beneath the Facility.

28. A primary source of this contamination at the site has been a leaking terracotta pipe that, until November of 2017, was used to convey process wastewater from the Facility’s manufacturing areas to its wastewater treatment plant. In addition Chemours has represented that an unlined cooling water channel known as the “Nafion Ditch” is also a source of groundwater contamination. Chemours has discharged “neutralized waste nitric acid” into the Nafion Ditch since 1977. In the summer of 2017 Chemours tested this process waste stream and detected PFESA Byproduct 2, CAS # 749836-20-2. Water conveyed by the Nafion Ditch bypasses the Facility’s wastewater treatment plant and is discharged directly into the Cape Fear River.

29. Concentrations of PFAS beneath the Facility are contributing to contamination of groundwater (including offsite groundwater) and adjacent surface water bodies, including Willis Creek, the Georgia Branch, and the Cape Fear River. According to Chemours’ analysis, flow of onsite groundwater directly to the Cape Fear River is the most significant current source of contaminant loading in the River.

30. In addition to evaluating onsite groundwater contamination, from September 2017 through the present, DWM has overseen sampling of groundwater in offsite residential drinking water wells. To date, approximately 1,000 offsite wells have been tested. Approximately 225 wells have concentrations of GenX above the DHHS provisional health goal of 140 ng/L and

Draft for Public Review

approximately 538 wells have detectable concentrations of GenX at a level lower than 140 ng/L. Concentrations above 140 ng/L were detected in private drinking water wells out to approximately four (4) miles from the Facility.

31. On May 24, 2018, DWM sent Chemours a letter directing Chemours to develop a plan to connect residents whose well water has concentrations of GenX above the health goal set by DHHS to public water supplies.

32. On December 15, 2017, DWM ordered Chemours to “commence immediate Interim Measures to terminate and control the sources of contamination, and mitigate any hazards resulting from exposure to the pollutants.” When DWM found Chemours’ response to this directive inadequate, DWM issued a “Notice of Violation – Immediate Action Required,” on February 12, 2018 directing Chemours to “initiate immediate source control measures to control primary and secondary sources of PFAS contamination” or risk further enforcement action.

33. DWM has issued Notices of Violation pursuant to 15A N.C.A.C. 2L .0202 against Chemours for its unlawful contamination of groundwater with GenX Compounds and other PFAS, including: PFBS, CAS #375-73-5; PFDA, CAS #335-76-2; PFDoA, CAS #307-55-1; PFHpA, CAS #375-85-9; PFHxS, CAS #355-46-4; PFHxA, CAS #307-24-4; PFNA, CAS #375-95-1; PFTriA, CAS #72629-94-8; PFUnA, CAS #2058-94-8; PFPeA, CAS #2706-90-3; PFMOAA, CAS # 674-13-5; PFECA_F, CAS# 377-73-1; PFO2HxA, CAS # 39492-88-1; PFO3OA, CAS# 39492-89-2; PFO4DA, CAS# 39492-90-5; PFO5DA, CAS# 39492-91-6; PFESA Byproduct 1, CAS# 66796-30-3; and PFESA Byproduct 2, CAS # 749836-20-2.

34. In addition to sources of groundwater contamination such as leaks, spills, and infiltration of wastewater conveyances into groundwater, Chemours’ emissions of GenX

Draft for Public Review

Compounds and other PFAS into the atmosphere represent a significant source of contamination in private drinking water wells.

35. On September 20, 2017, DAQ sent a letter to Chemours requesting information regarding Chemours' emissions of GenX Compounds and other PFAS. Chemours submitted a revised assessment of those emissions on October 20, 2017, raising its estimates of emissions GenX Compounds from approximately 66.6 pounds to approximately 594 pounds.

36. Those revised estimates and subsequent stack testing showed that Chemours' air emissions of GenX Compounds far exceeded both the initially reported and revised emissions report, with the current estimate of 2016 emissions at approximately 2,241 pounds. This figure is approximately 33.6 times higher than the quantity of emissions of GenX Compounds reported to DAQ in June 2017 and approximately 3.7 times higher than in the quantity of emissions of GenX Compounds reported in October 2017. Current data, as reported by Chemours, indicates that Chemours emitted approximately 2,199 pounds of GenX Compounds in 2017 (referred to herein as "2017 Total Reported Emissions").

37. Beginning in January 2018, DAQ conducted rainwater sampling and air deposition modeling to determine the fate of GenX Compounds emissions from the Facility in the environment. DAQ's analysis included measurements of 810 ng/L of GenX in rainwater five miles to the northeast of the facility and 40 and 60 ng/L of GenX in rainwater seven miles to the northeast of the Facility. DAQ's analysis of Chemours' emissions, rainwater data, groundwater data, and meteorological data established that atmospheric deposition of Chemours' emissions is a primary source of groundwater contamination.

38. On April 6, 2018, DAQ issued a letter notifying Chemours of DAQ's intent to

Draft for Public Review

modify Chemours' air permit to prohibit the emission of GenX Compounds if Chemours failed to demonstrate that it can operate in a manner that will not result in its emissions causing or contributing to unlawful groundwater contamination. On April 10, 2018, DEQ filed an Amended Complaint, in part, to supplement its September 8, 2017 Complaint with new allegations and evidence relating to Chemours emissions of GenX Compounds and other PFAS into the atmosphere.

39. On April 27, 2018, DEQ received Chemours' response to its April 6, 2018 letter. On May 11, 2018, after reviewing this response and the accompanying attachments, DEQ sent Chemours a request for clarification and additional information. On May 18, 2018, Chemours responded to that letter.

40. DEQ's analysis of Chemours' submissions and all available evidence indicates that significant reductions of Chemours' emissions will be necessary in order to prevent Chemours from causing or contributing to violations of North Carolina's groundwater rules.

41. DEQ's analysis further indicates that the Chemours' commitment in its April 27, 2018 response to reduce GenX emissions by 72% by October 2018 and to reduce emissions further by April 30, 2020 is inadequate to address Chemours' ongoing contamination of groundwater.

42. DEQ has concluded that, at a minimum, a reduction in facility-wide emissions of GenX Compounds by at least 99% from 2017 Total Reported Emissions is necessary to prevent and abate Chemours' ongoing contamination of groundwater with GenX Compounds.

43. Chemours' submissions to DEQ demonstrate that the technology necessary to achieve these emissions reduction will also control process emissions of other PFAS at a control efficiency of 99.99%.

Draft for Public Review

44. While the technology necessary to achieve these goals is being implemented, DEQ has concluded that accelerated measures to reduce facility-wide emissions of GenX Compounds is necessary, and that, by August 31, 2018, Chemours must reduce emissions of these compounds facility-wide by at least 97% from 2017 Total Reported Emissions.

CONCLUSIONS OF LAW

45. To the extent that the findings of fact contain conclusions of law, or that the conclusions of law may be considered or include findings of fact, they should be so considered without regard to their given labels.

46. The Clean Water Act and North Carolina's NPDES Program. The Federal Clean Water Act prohibits any person from discharging pollutants from a point source into surface waters without first obtaining an appropriate permit. 33 U.S.C. § 1311. Individual states are authorized to assume responsibility for implementation of an NPDES Program upon statutory authorization and application to EPA. 33 U.S.C. § 1342(b). EPA approved North Carolina's NPDES program in 1975. North Carolina has authority to take action to enforce violations of 33 U.S.C. § 1311 of the Clean Water Act, which prohibits the unpermitted discharge of pollutants into surface waters. MOA § VI.A.2.a; N.C. Gen. Stat. § 143-215.1.

47. North Carolina's primary statute for implementing its NPDES permitting program is N.C. Gen. Stat. § 143-215.1, which requires a permit before any person can "make any outlet into waters of the state," or "[c]ause or permit any waste, directly or indirectly, to be discharged to or in any manner intermixed with the waters of the State in violation of the water quality standards . . . unless allowed as a condition of any permit."

48. Under North Carolina rules implementing the State's NPDES permitting process,

Draft for Public Review

the permit applicant has “the burden of providing sufficient evidence to reasonably ensure that the proposed system will comply with all applicable water quality standards.” 15A N.C.A.C. 2H .0112(c). These rules further provide “no permit may be issued when the imposition of conditions cannot reasonably ensure compliance with applicable water quality standards.” *Id.*

49. Part of the permit applicant’s burden in this regard is to disclose all relevant information, such as the presence of known constituents in a discharge that pose a potential risk to human health. The permit applicant is required to disclose “all known toxic components that can be reasonably expected to be in the discharge, including *but not limited to* those contained in a priority pollutant analysis.” 15A N.C.A.C. 2H .0105(j) (emphasis added).

50. While the North Carolina Administrative Code does not contain a definition of “toxic component,” North Carolina water quality regulations define “toxic substance” to include:

any substance or combination of substances (including disease-causing agents), which after discharge and upon exposure, ingestion, inhalation, or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, has the potential to cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions or suppression in reproduction or growth) or physical deformities in such organisms or their offspring.

15A N.C.A.C. 2B .0202(64). These disclosure obligations do not cease upon issuance of a permit. Rather, they are ongoing. Pursuant to NPDES Standard Permit Condition II.E.8, “Where the Permittee becomes aware that it failed to submit any relevant facts in a permit application . . . or in any report to the Director, it shall promptly submit such facts or information.” *See* 40 C.F.R. 122.41(1)(8).

51. While compliance with the express terms of an NPDES permit generally “shields” the permittee from liability for violations of 33 U.S.C. § 1311, the permit does not shield the

Draft for Public Review

permittee from liability where the pollutant being discharged was not within the “reasonable contemplation” of the permitting agency when it issued the permit due to nondisclosure by the permittee. 33 U.S.C. § 1342(k); *see also Piney Run Pres. Ass’n v. Cty. Comm’rs of Carroll Cty., MD*, 268 F.3d 255, 265 (4th Cir. 2001). Indeed, EPA’s guidance regarding the permit shield provides that a permit only “provides authorization and therefore a shield for . . . pollutants resulting from facility processes, waste streams and operations that have been *clearly identified* in the permit application process when discharged from specified outfalls.” *EPA, Revised Policy Statement on Scope of Discharge Authorization and Shield Associated with NPDES Permits*, available at <https://www3.epa.gov/npdes/pubs/owm0131.pdf> (emphasis added).

52. North Carolina’s Groundwater Standards. In addition to regulating surface waters, the Environmental Management Commission (“EMC”) has promulgated rules in 15A N.C.A.C. Subchapter 2L (the “groundwater rules”) that “establish a series of classifications and water quality standards applicable to the groundwaters of the State.” 15A N.C.A.C. 2L .0101(a). “Groundwaters” are defined in the groundwater rules as “those waters occurring in the subsurface under saturated conditions.” 15A N.C.A.C. 2L .0102(1). The groundwater rules “are applicable to all activities or actions, intentional or accidental, which contribute to the degradation of groundwater quality, regardless of any permit issued by a governmental agency authorizing such action or activity,” except in certain situations not applicable here. 15A N.C.A.C. 2L .0101(b).

53. The groundwater rules “are intended to maintain and preserve the quality of the groundwaters, prevent and abate pollution and contamination of the waters of the state, protect public health, and permit management of the groundwaters for their best usage by the citizens of North Carolina.” 15A N.C.A.C. 2L .0103(a). The policy section of the groundwater rules provides

Draft for Public Review

further that “[i]t is the policy of the Commission that the best usage of the groundwaters of the state is as a source of drinking water.” 15A N.C.A.C. 2L .0103(a). The policy section of the groundwater rules provides further that “[n]o person shall conduct or cause to be conducted, any activity which causes the concentration of any substance to exceed that specified in Rule .0202 of this Subchapter, except as authorized by the rules of this Subchapter.” 15A N.C.A.C. 2L .0103(d).

54. With certain exceptions not relevant here, “substances which are not naturally occurring and for which no standard is specified shall not be permitted in concentrations at or above the practical quantitation limit” in groundwaters. 15A N.C.A.C. 2L .0202(c). The “practical quantitation limit” or “PQL” is defined as “the lowest concentration of a given material that can be reliably achieved among laboratories within specified limits of precision and accuracy by a given analytical method during routine laboratory analysis.” 15A N.C.A.C. 2L .0102(15). “Any person conducting or controlling an activity that results in the discharge of a waste or hazardous substance or oil to the groundwaters of the State, or in proximity thereto, shall take action upon discovery to terminate and control the discharge, mitigate any hazards resulting from exposure to the pollutants and notify the Department.” 15A N.C.A.C. 2L .0106(b).

55. Pursuant to the groundwater rules, “[i]nitial response required to be conducted prior to or concurrent with the assessment required” as set forth above “shall include” among other things,

(2) abatement, containment, or control of the migration of contaminants; (3) removal, treatment, or control of any primary pollution source such as buried waste, waste stockpiles, or surficial accumulations of free products; (4) removal, treatment, or control of secondary pollution sources that would be potential continuing sources of pollutants to the groundwaters, such as contaminated soils and non-aqueous phase liquids.

Draft for Public Review

15A N.C.A.C. 2L .0106(f).

56. The Clean Air Act and North Carolina's Air Quality Laws. Title V of the Federal Clean Air Act, 42 U.S.C. § 7661 *et seq.* requires major sources of air pollutants to obtain and operate in compliance with an operating permit. A Title V operating permit generally incorporates all applicable state and federal air quality requirements into a single permit, including emissions standards, monitoring requirements, record keeping requirements, and reporting requirements.

57. North Carolina has received approval from EPA to operate a Title V program and the General Assembly has delegated authority to the EMC to promulgate rules for that purpose. N.C. Gen. Stat. §§ 143-215.107(a)(10), 143-215.3(c); 40 CFR Part 70, Appendix A (“Approval Status of State and Local Operating Permit Programs”).

58. The purposes of North Carolina's air quality program are set forth in N.C. Gen. Stat. § 143-215.105, which incorporates by reference the policy goals set forth in Article 21 of Chapter 143 of the North Carolina General Statutes (“Water and Air Resources”). As described in Article 21, the General Assembly intended for North Carolina's water quality and air quality programs to provide an integrated scheme for ensuring protection of public health and natural resources. The statute provides that “water and air resources of the State belong to the people, [and] the General Assembly affirms the State's ultimate responsibility for the preservation and development of these resources in the best interest of all its citizens and declares the prudent utilization of these resources to be essential to the general welfare.” N.C. Gen. Stat. § 143-211(a). The statute further requires that “[s]tandards of water and air purity shall,” among other things, “be designed to protect human health, to prevent injury to plant and animal life, to prevent damage to public and private property.” N.C. Gen. Stat. § 143-211(c). The EMC has delegated authority

Draft for Public Review

to the Director of the DAQ to terminate, modify or revoke any Title V permit if necessary to carry out these purposes. 15A N.C.A.C. 2Q .0519.

59. Standard for Injunctive Relief. Whenever DEQ has reasonable cause to believe that any person has violated or is threatening to violate any of the provisions of the State's water quality laws or administrative rules, DEQ is authorized to "request the Attorney General to institute a civil action in the name of the State upon the relation of [DEQ] for injunctive relief to restrain the violation or threatened violation." N.C. Gen. Stat. § 143-215.6C; *see also* N.C. Gen. Stat. § 143-215.114C (pertaining to injunctive relief to enforce air quality laws). That section further provides that "[u]pon a determination by the court that the alleged violation of the provisions of this Part or the regulations of the [EMC] has occurred or is threatened, the court shall grant the relief necessary to prevent or abate the violation or threatened violation." N.C. Gen. Stat. §§ 143-215.6C, 143-215.114C.

60. When the State brings an action to vindicate the public interest pursuant to a statute which provides for injunctive relief to abate violations of law, the usual test for issuance of injunctions need not be met. *See State ex rel. Morgan v. Dare To Be Great, Inc.*, 15 N.C. App. 275, 189 S.E.2d 802 (1972) (negating the general rule that there will be no equitable relief if there is an adequate remedy at law when the statutory scheme provided the State with injunctive relief under the circumstances presented). For example, the State is not required to show actual injury, such as irreparable harm, in order to obtain injunctive relief, including a preliminary injunction. *State ex rel. Edmisten v. Challenge, Inc.*, 54 N.C. App. 513, 521-22, 284 S.E.2d 333, 338-39 (1981) (explaining that irreparable harm need not be established by the State as long as the statutory conditions for issuance of a preliminary injunction exist). Rather, it must show only that the acts

Draft for Public Review

or practices complained of adversely affect the public interest. *See id.* An adverse effect on the public interest exists as a matter of law where the statutory conditions for issuance of injunctive relief are present, i.e., where a violation of the applicable statute or regulations exists or is threatened. *Id.* at 522, 284 S.E.2d at 339.

61. Violations. The Court concludes that Chemours has violated multiple North Carolina laws and regulations pertaining to the protection of North Carolina's water resources:

- a. *Unpermitted discharge of undisclosed pollutants.* Chemours violated N.C. Gen. Stat. § 143-215.1(a)(1) by “making an outlet” or engaging in the unpermitted discharge of GenX Compounds and other PFAS into waters of the State without disclosing the existence of these compounds in its discharge.
- b. *Failure to disclose.* Chemours violated 15A N.C.A.C. 2H .0105(j) and NPDES Permit Standard Condition II.E.8 by failing to fully disclose all known toxic components reasonably expected to be in its discharge.
- c. *Failure to operate and maintain.* Chemours violated NPDES Permit Standard Condition II.C.2 by failing to properly operate and maintain all facilities and systems of treatment and control at the Facility, including allowing the so-called “terracotta pipe” (which, prior to November 2017, conveyed process wastewater from Chemours’ manufacturing areas to its wastewater treatment plant) to leak process wastewater into groundwater beneath the Facility.
- d. *Unpermitted discharge into Nafion Ditch and bypass of wastewater*

Draft for Public Review

treatment plant. Chemours violated N.C. Gen. Stat. § 143-215.1(a)(1) by “making an outlet” into waters of the state or engaging in the unpermitted discharge of wastewater into the Nafion Ditch and bypassing the Facility’s wastewater treatment plant.

- e. *Failure to timely report October 6, 2017 Spill.* Chemours violated NPDES Permit Standard Condition II.E.9 by failing to timely report the release of GenX Compounds that occurred on October 6, 2017.
- f. *Violation of Fresh Surface Water Quality Standards for WS-IV Waters:* Chemours violated 15A N.C.A.C. 2B .0216(3)(a) by discharging untreated wastewater through Outfall 002 after its unreported spill of GenX Compounds on October 6, 2017.
- g. *Contamination of groundwater.* Chemours violated 15A N.C.A.C. 2L .0103 and 15A N.C.A.C. 2L .0202 by conducting an activity which has caused substances in groundwater to exceed concentrations allowed by 15A N.C.A.C. 2L .0202. Specifically Chemours has caused the following non-naturally occurring substances to be detected in concentrations above the practical quantitation limit: PFPrOPrA (GenX) CAS No. 13252-13-6; PFBS CAS No. 375-73-5; PFDA CAS No. 335-76-2; PFD_oA CAS No. 307-55-1; PFHpA CAS No. 375-85-9; PFH_xS CAS No. 355-46-4; PFH_xA CAS No. 307-24-4; PFNA CAS No. 375-95-1; PFTriA CAS No. 72629-94-8; PFUnA CAS No. 2058-94-8; PFPeA CAS No. 2706-90-3; PFMOAA CAS No. 674-13-5;

Draft for Public Review

PFECA_F CAS No. 377-73-1; PFO2HxA CAS No. 39492-88-1;
PFO3OA CAS No. 39492-89-2; PFO4DA CAS No. 39492-90-5;
PFO5DA CAS No. 39492-91-6; PFESA Byproduct 1 CAS No. 66796-
30-3, and PFESA Byproduct 2 CAS No. 749836-20-2.

- h. *Failure to terminate and control sources of groundwater contamination.* Chemours has violated 15A N.C.A.C. 2L .0106(f) by failing to timely identify and implement measures to terminate or control sources of groundwater contamination.

Based on the foregoing findings and conclusions, it is therefore ORDERED, JUDGED and DECREED that during the pendency of this action:

COMPLIANCE MEASURES – AIR EMISSIONS

62. Emissions Reductions: Chemours shall achieve the overall emissions reductions of GenX Compounds in accordance with the following schedule.

- a. By August 31, 2018, Chemours shall reduce facility-wide emissions of GenX Compounds by at least 97% from 2017 Total Reported Emissions.
- b. By December 31, 2019, Chemours shall reduce facility-wide emissions of GenX Compounds by at least 99% from Chemours' reported 2017 Total Reported Emissions.

Within ninety (90) days of each deadline set forth in this paragraph, Chemours shall submit to DAQ a demonstration of compliance with applicable emissions reductions.

63. Control of all PFAS: By December 31, 2019, Chemours shall control all PFAS

Draft for Public Review

emissions from the HFPO Process, the Vinyl Ethers North Process, the Vinyl Ethers South Process, the RSU Process, the TFE Process, the MMF Process, the Polymers Process, and the PPA Process at an efficiency of 99.99%. Within ninety (90) days of December 31, 2019, Chemours shall submit to DAQ a demonstration of compliance with this requirement.

64. Disclosure of PFAS emissions: Chemours shall have an ongoing duty to disclose (1) any previously undisclosed PFAS and emissions rates for those PFAS, and (2) any new process or production that may lead to the addition of any previously undisclosed PFAS in the Facility's emissions. For any such PFAS, Chemours shall provide DAQ with test methods and lab standards.

COMPLIANCE MEASURES – SURFACE WATER

65. No Discharge of Process Wastewater from Chemours Manufacturing Areas: Chemours shall not discharge process wastewater from Chemours' manufacturing areas unless or until issuance of an NPDES Permit expressly authorizing the discharge of such process wastewater and with such limits as DEQ deems necessary and appropriate to control the discharge of GenX Compounds and other PFAS.

66. Characterization of PFAS in process and non-process wastewater and stormwater at the Facility:

- a. *Test methods and lab standards:* By no later than twelve (12) months of issuance of this Order, Chemours shall provide DWR with test methods and lab standards for all PFAS in all process and non-process wastewater and stormwater at the Facility, including but not limited to all process and non-process wastewater and stormwater discharged through Outfall 002. Chemours shall follow the EPA's Protocol for

Draft for Public Review

Review and Validation of New Methods for Regulated Organic and Inorganic Analytes in Wastewater under EPA's Alternate Test Procedure Program, *see*

https://www.epa.gov/sites/production/files/2016-03/documents/chemical-new-method-protocol_feb-2016.pdf, and shall write each test procedure in the standard EPA format.

- b. *Sampling plan:* Within thirty (30) days of issuance of this Order, Chemours shall submit a sampling plan to DWR for approval. This sampling plan shall include proposed locations for the sampling to carry out the initial characterization of all PFAS described in subparagraph (c).
- c. *Initial characterization:* Within thirty (30) days of approval of the sampling plan, Chemours shall commence submission of quarterly reports to DEQ identifying PFAS constituents and initial concentrations at reporting levels agreed to by DEQ in all process and non-process wastewater and stormwater at the Facility, including but not limited to all process and non-process wastewater and stormwater discharged through Outfall 002. As part of this report, process and non-process wastewater and stormwater shall be characterized from each of Chemours' manufacturing areas as well as the manufacturing areas of its tenants, Kuraray and DuPont. Similar testing for PFAS constituents in the raw water intake shall be performed in conjunction with all other

Draft for Public Review

sampling in order to assess background concentrations. The final quarterly report shall be submitted, and initial characterization of all PFAS completed, no later than eighteen (18) months after approval of the sampling plan.

- d. *Sampling frequency:* For all PFAS for which test methods and lab standards have been developed, on at least a monthly basis, Chemours shall sample for each such PFAS at approved locations and report the results to DWR.
- e. *Ongoing duty to disclose:* Chemours shall have an ongoing duty to disclose (1) any previously undisclosed PFAS and concentrations of any previously undisclosed PFAS in all process and non-process wastewater and stormwater at the Facility, and (2) any new process or production that may lead to the addition of any previously undisclosed PFAS in process and non-process wastewater and stormwater at the Facility. For any such PFAS, Chemours shall provide DWR with test methods and lab standards as specified in subparagraph (a) above.

67. **Health Studies:** Within sixty (60) days of issuance of this Order, Chemours shall submit a plan and proposed schedule for review and approval by DEQ for conducting or facilitating the conducting of toxicity studies relating to both human health and aquatic life sufficient to aid in development of surface water and groundwater regulatory standards for all PFAS present in the process and non-process wastewater and stormwater at the Facility discharged at Outfall 002. The plan shall be developed in consultation with DEQ, and shall describe the specific steps to be taken

Draft for Public Review

and a time schedule for accomplishing these measures. Chemours shall implement the measures set forth in the plan.

68. Notice to and Coordination with Water Utilities: In the event of an upset or other condition at the Facility that has the potential to cause a discharge of GenX Compounds into the Cape Fear River through Outfall 002 at concentrations exceeding 140 ng/L, Chemours shall provide notice to downstream public water utilities within one (1) hour of knowledge of the condition. Chemours shall maintain a list of appropriate contacts of downstream public water utilities, which Chemours shall routinely update by requesting contact information from DEQ. Chemours shall also post a description of the condition including any estimated quantity of the release on a publicly available website within twenty-four (24) hours of knowledge of the condition.

COMPLIANCE MEASURES – GROUNDWATER

69. Permanent Replacement of Private Drinking Water Supplies: By no later than twelve (12) months after issuance of this Order, Chemours shall establish permanent replacement water supplies for each household with a water supply well contaminated by any PFAS in exceedance of a health goal established by DHHS or of a health advisory level established by the EPA (“affected households”). The replacement water supply shall be established by connection to a public water supply, except that (1) an affected household may elect to receive a filtration system approved by DEQ in lieu of a connection to public water supply, in which case Chemours shall install a filtration system, or (2) if DEQ determines that connection to a public water supply to a particular household would be cost-prohibitive or unsafe, DEQ may authorize provision of a permanent replacement water supply to that household through installation of a filtration system.

Draft for Public Review

For affected households Chemours shall be liable for any water bills from public utilities and for periodic required maintenance of the filtration systems. Chemours shall submit a plan for compliance with this provision, including a detailed schedule with milestones, no later than sixty (60) days after entry of this Order. This provision shall supplement any prior requirements regarding the provision of permanent replacement water supplies.

70. Re-Testing of Private Wells: Chemours shall conduct testing of private drinking water supply wells as follows:

- a. for wells with test results for GenX Compounds above 70 ng/L but less than 140 ng/L, Chemours shall re-test on a quarterly basis until sampling shows that results of less than 70 ng/L for eight consecutive sampling events;
- b. for wells with test results for GenX Compounds showing detectable concentrations of less than 70 ng/L, Chemours shall re-test on a semiannual basis until sampling shows that results of non-detect for four consecutive sampling events;
- c. for wells with test results showing no detectable concentrations of GenX Compounds, Chemours shall re-test on an annual basis until sampling shows no detectable concentrations of GenX Compounds for two consecutive sampling events.

Chemours shall provide to DEQ a list of residents within these sampling ranges, identified by both their address and sample ID. Chemours shall also provide to DEQ a list of wells (identified by

Draft for Public Review

address) targeted for testing that have not yet been tested and verifying its efforts to test these wells.

71. Geographic Extent of Private Well Testing: Chemours shall continue to sample drinking water wells for a distance of at least one quarter (1/4) mile beyond the nearest well with test results showing a detectable level of GenX Compounds.

72. Lining of Nafion Ditch and Sedimentation Ponds: Within fourteen (14) days of issuance of this Order, Chemours shall submit a plan for approval by DWM to permanently line the entire Nafion Ditch and all sedimentation ponds. Chemours shall complete permanent lining of the Nafion Ditch no later than August 31, 2018 in accordance with the plan approved by DWM, except for the approximately thirty (30) feet of Nafion Ditch in the area of the designated blast zone which shall be permanently lined no later than October 31, 2018. Chemours shall complete permanent lining of (1) the south sedimentation pond no later than November 1, 2018 and (2) the north sedimentation pond no later than December 1, 2018 in accordance with the plan approved by DWM.

73. Comprehensive Receptor Survey: Within 30 days of entry of this Order, Chemours shall submit to DWM a comprehensive receptor survey to include drinking water wells and surface waters within a ten (10) mile radius of the Facility.

74. Plan to Control Flow of Onsite Groundwater: Within sixty (60) days of entry of this Order, Chemours shall submit to DWM an engineering study analyzing methods by which onsite groundwater flow to receptors (including drinking water wells and surface waters) can be reduced or eliminated, and which do not involve discharge to the Cape Fear River. Chemours shall implement the approved plan in accordance with a schedule approved by DWM.

Draft for Public Review

75. On and Offsite Assessment: Within thirty (30) days of entry of this Order, Chemours shall submit a comprehensive plan to characterize the full extent of on and offsite groundwater contamination (i.e., concentrations above the PQL in groundwater for any PFAS). This plan shall also include characterization of the full extent PFAS contamination of soil, surface water, drinking water wells and ecological receptors. Chemours shall implement the approved plan in accordance with a schedule approved by DWM.

PUBLIC MEETINGS

76. Whenever Chemours proposes to make a material change to its facility operations, including but not limited to a change that results in the use, production, or release into the environment of a previously undisclosed PFAS, Chemours shall conduct at least one public meeting and prior to the meeting, notify DEQ when and where the meeting will occur. Any meeting shall be held prior to any permit applications for the change being submitted to DEQ.

DEQ CONTACTS

77. Any information or documents submitted pursuant to this Order shall be submitted to the appropriate division using the contact information listed below. The contact listed for DEQ shall be copied on all submissions to the appropriate division:

DWR:

Linda Culpepper
Interim Director, Division of Water Resources,
North Carolina Department of Environmental Quality
1611 Mail Service Center
Raleigh, NC 27699-1611

DWM:

Michael E. Scott

Draft for Public Review

Director, Division of Waste Management
North Carolina Department of Environmental Quality
1646 Mail Service Center
Raleigh, NC 27699-1641

DAQ:

Michael A. Abraczinskas
Director, Division of Air Quality
North Carolina Department of Environmental Quality
1641 Mail Service Center
Raleigh, NC 27699-1641

DEQ:

Sheila Holman
Assistant Secretary for the Environment,
North Carolina Department of Environmental Quality
1641 Mail Service Center
Raleigh, NC 27699-1641

COMPLIANCE AND ENFORCEMENT

78. Nothing in this Order limits Chemours' obligations to comply with the requirements of all applicable state and federal laws and regulations. This Order is not, and shall not be construed to be, a permit issued pursuant to any federal or state statute or regulation.

79. DEQ shall determine Chemours' compliance with the terms of this Order, and DEQ may request that the Court exercise its contempt authority pursuant to provisions of Article 2, Chapter 5A of North Carolina General Statutes to enforce this Order.

80. Nothing in this Order prevents DEQ from taking other legal or equitable action as it deems appropriate and necessary, or from requiring Chemours in the future to perform additional activities pursuant to applicable law. Nothing in this Order shall limit DEQ's power and authority to pursue enforcement against other entities liable for violations identified in this Order.

Draft for Public Review

EFFECTIVE DATE

81. This Order shall become effective on the date that it is entered.
82. This Order may be signed out-of-court, out-of-term, and out-of-county.

This the __ day of ____, 2018.

DRAFT FOR PUBLIC REVIEW
Superior Court Judge

DRAFT



The Chemours Company 704-560-6435
Corporate Remediation Group chemours.com
1007 Market Street, Room 13116A
Wilmington, DE 19899

March 28, 2018

Mr. Joe Ghiold, Project Manager
Facility Management Branch
Hazardous Waste Section
Division of Waste Management
NC Department of Environmental Quality
1646 Mail Service Center
Raleigh, NC 27699-1646

**Re: Focused Remedial Action Plan for PFAS in Groundwater
Chemours Fayetteville Works
Fayetteville, North Carolina
EPA ID No. NCD 047 368 642**

Dear Mr. Ghiold:

Enclosed, please find two hard copies of the *Focused Remedial Action Plan for PFAS in Groundwater* for The Chemours Company FC, LLC (Chemours) Fayetteville Works. The purpose of this RAP is to provide details for the design and implementation of near-term remedial actions at the site. In addition to this hard copy of the report, an electronic version (PDF) has been submitted to you via email.

We are submitting this Plan in accordance with the schedule Chemours submitted to NC DEQ on October 3, 2017. We recognize that we have not yet received NC DEQ's comments on earlier reports that Chemours has submitted but, as you requested have proceeded to prepare this report. We look forward to receiving your comments on this Plan and earlier reports, and look forward to working with you on the timely implementation of effective remedial actions at the site.

If you have any questions or need any additional information, please feel free to contact me at 704-560-6435.

Respectfully submitted,

A handwritten signature in black ink, appearing to read 'Kevin Garon', is written over a light blue horizontal line.

Kevin Garon
Project Director
Chemours Corporate Remediation Group

cc: Christel Compton – Chemours Fayetteville Works
File

Enclosures (as stated)

PARSONS

**FOCUSED REMEDIAL ACTION
PLAN FOR PFAS IN
GROUNDWATER**

**CHEMOURS FAYETTEVILLE WORKS
RCRA PERMIT NO. NCD047368642-R2-M3**

Prepared for:

The Chemours Company FC, LLC
Corporate Remediation Group
22828 NC Highway 87 W
Fayetteville, NC 28306-7332

Prepared by:

PARSONS
4701 Hedgemore Drive
Charlotte, NC 28209

March 2018

Chemours PN 504639
Parsons PN 450768

This page intentionally left blank

PROFESSIONAL SIGNATURES AND SEALS

Professional Engineer

Name	NC Engineer License number	Expiration date
Michael G. Robinson	034781	12/31/2018
Telephone number	FAX number	E-mail
(704) 558-4255		Michael.Robinson@parsons.com

DOCUMENT:

**FOCUSED REMEDIAL ACTION PLAN FOR PFAS IN GROUNDWATER
CHEMOURS FAYETTEVILLE WORKS
RCRA PERMIT NO. NCD047368642-R2-M3**

Seals, as applicable:



This page intentionally left blank

TABLE OF CONTENTS

1.0	INTRODUCTION	1
1.1	Site Background	1
1.2	Plant Site Operations.....	2
1.3	Regulatory History.....	2
1.4	Summary of Focused FS Report – PFAS	3
1.5	Work Plan Purpose	4
2.0	REMEDIAL ACTION OBJECTIVES	5
2.1	Near-Term Objectives	5
2.2	Long-Term Objectives	5
2.3	Ongoing Interim Measures	6
3.0	REMEDIAL ACTIONS, GOALS, AND CONCEPTUAL DESIGNS	9
3.1	Perched Zone Groundwater	9
3.1.1	Perched Zone Groundwater Remedial Action Goals.....	9
3.1.2	Perched Zone Groundwater Remedial Actions	9
3.1.3	Conceptual Design – Cooling Water Channel.....	10
3.1.4	Conceptual Design – Sedimentation Basin Liners	11
3.1.5	Conceptual Design – Temporary Groundwater Treatment System	11
3.1.6	Conceptual Design – Temporary Dewatering System.....	13
3.2	Surficial and Black Creek Aquifers	13
3.3	Former Outfall No. 002 Channel	14
4.0	PRE-REMEDIAL ACTION AND DESIGN ACTIVITIES	17
4.1	Perched Zone	17
4.1.1	Cooling Water Channel Lining	17
4.1.2	Sedimentation Basin Lining	17
4.1.3	Temporary Groundwater Treatment System Pre-Design	19
4.2	Surficial and Black Creek Aquifers	19
4.3	Former Outfall No. 002 Channel Pre-Design	19
4.3.1	Pre-Design (Flow and Geotechnical Studies)	19
4.3.2	Pre-Design (Process Development and Validation)	20
5.0	SCHEDULE	21
5.1	Perched Zone	21
5.1.1	Cooling Water Channel Lining	21

5.1.2	Sedimentation Basin Lining	21
5.1.3	Temporary Groundwater Treatment System.....	22
5.2	Surficial and Black Creek Aquifers.....	22
5.3	Former Outfall No. 002 Channel.....	23
6.0	REFERENCES.....	25

FIGURES

Figure 1	Site Location Map
Figure 2	Site Layout Map
Figure 3	Sedimentation Basins and Cooling Water Channel
Figure 4	Temporary Treatment System Process Flow Diagram
Figure 5	Old Outfall No. 2 - Treatment Options

ACRONYMS

Acronym	Definition / Description
APFO	Ammonium perfluorooctanoate
Chemours	The Chemours Company FC, LLC
CRG	Corporate Remediation Group
CMS	Corrective Measures Study
DHHS	NC Department of Health and Human Services
DuPont	E. I. du Pont de Nemours and Company
EQ	Equalization
FEP	Fluorinated ethylene propylene
FS	Feasibility Study
GAC	Granular activated carbon
GCL	Geosynthetic clay liner
gpm	Gallon(s) per minute
HDPE	High-density polyethylene
HFPO-DA	Hexafluoropropylene oxide dimer acid
IM	Interim measure
IMAC	Interim maximum allowable concentrations
NCDENR	North Carolina Department of Environmental and Natural Resources
NCDEQ	North Carolina Department of Environmental Quality
ng/L	Nanogram(s) per liter
NPDES	National Pollutant Discharge Elimination System
PFAS	Per- and Polyfluoroalkyl Substances
PHA/HAZOPS	Process hazard analysis (hazardous operations)
PPA	Polymer processing aid
ppt	Parts per trillion
PMDF	Polymer Manufacturing Development Facility
PVF	Polyvinyl Fluoride
PMDF	Polymer Manufacturing Development Facility
RAO	Remedial action objective
RAP	Remedial Action Plan
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
Site	Chemours Fayetteville Works Facility
SPLP	Synthetic Precipitation Leaching Procedure
TCLP	Toxicity Characteristic Leaching Procedure
WWTP	Wastewater treatment plant

This page intentionally left blank

1.0 INTRODUCTION

Parsons has prepared this Focused Remedial Action Plan (RAP) on behalf of The Chemours Company FC, LLC (Chemours) for per- and polyfluoroalkyl substances (PFAS) in groundwater at the Fayetteville Works facility (the Site). The Site is located near Duart Township in Bladen County, North Carolina, and was owned by E. I. du Pont de Nemours and Company (DuPont) until July 2015.

This RAP describes the activities required to implement the selected remedies for reducing PFAS in groundwater at the site and to prevent, to the extent feasible, the release of PFAS into the Cape Fear River. Chemours has already taken a number of initial steps to prevent the release of PFAS into the groundwater from the manufacturing process. Chemours will monitor the effectiveness of these remedial actions and may take further longer-term actions as appropriate. Potential remedial options for various areas of the Site were analyzed and presented in the Focused Feasibility Study (FS) Report – PFAS Remediation (Parsons 2018). The goal of these actions is to ensure concentrations in the Cape Fear River do not exceed 140 ppt of Hexafluoropropylene oxide dimer acid (HFPO-DA) downstream of the river water intake. It is believed that by addressing HFPO-DA, all PFAS constituents will also be addressed. Long-term monitoring will evaluate the overall effectiveness of these measures for reducing all constituents. If any constituents are not effectively addressed additional measures will be developed with respect to those constituents.

This plan is organized into six sections, including this Introduction, which presents site background, operational information, and purpose. Section 2.0 presents the remedial action objectives (RAOs). The preliminary remedial design parameters and goals are presented in Section 3.0. Activities required before the remediation can be conducted are described in Section 4.0, and the proposed schedule is outlined in Section 5.0. Finally, references cited in the text are presented in Section 6.0.

1.1 Site Background

The Site is located on NC Highway 87, 15 miles southeast of the City of Fayetteville, and south of the Bladen-Cumberland county line. The Site encompasses 2,177 acres of relatively flat undeveloped open land and woodland bounded on the east by the Cape Fear River, on the west by NC Highway 87, and on the north and south by farmland (Figure 1).

DuPont purchased the property in parcels from several families in 1970. The Site's first manufacturing area was constructed in the early 1970s. The Site currently manufactures plastic sheeting, fluorochemicals, and intermediates for plastics manufacturing. A former manufacturing area, which was sold in 1992, produced nylon strapping and elastomeric tape.

DuPont sold its Butacite® and SentryGlas® manufacturing units to Kuraray America Inc. in June 2014. On July 1, 2015, DuPont separated its specialty chemicals business into a new publicly-traded company named The Chemours Company FC, LLC. With this separation, Chemours became the owner of the entire 2,177 acres of the Fayetteville Works along with the fluoromonomers, Nafion™ membranes, and PPA¹ manufacturing units. The polyvinyl fluoride (PVF) resin manufacturing unit remains with DuPont.

¹ PPA – polymer processing aid

In addition to the manufacturing operations, Chemours operates two natural gas-fired boilers and a wastewater treatment plant (WWTP) for the treatment of process and sanitary wastewaters from Chemours, Kuraray, and DuPont. Hazardous wastes generated from the Chemours manufacturing processes and laboratories are currently managed at the permitted Hazardous Waste Container Storage Area, in four permitted hazardous waste tanks, and at the 90-day ignitable waste accumulation area prior to being shipped offsite for treatment, disposal, or recycling.

1.2 Plant Site Operations

Figure 1 depicts the location of the Chemours Fayetteville Works facility on an excerpt of the United States Geological Survey topographic map of the area. The site layout is depicted on Figure 2. The Site consists of five main manufacturing areas, one former manufacturing area, and two support areas, as summarized in the table below:

Area	Description
Main Manufacturing Areas	
Chemours Fluoromonomers and Nafion™ Membrane	Manufactures Nafion™ fluoropolymer membrane for electronic cells and various fluorochemicals used for Nafion™ membrane, Teflon® fluoropolymer, Viton® elastomers, and other fluorinated products.
Chemours Polymer Processing Aid (PPA)	Manufactures fluorochemicals that are used as a processing aid for off-site fluoropolymer manufacturing. This area formerly manufactured ammonium perfluorooctanoate (APFO). (Note: The last date of APFO production at the Site was April 28, 2013. Although APFO was manufactured in this area, it was never used in any of the other manufacturing facilities at the Site.)
Kuraray Butacite®	Manufactures Butacite® polyvinyl butyral sheeting and polyvinyl butyral resin for automotive and architectural safety glass.
Kuraray SentryGlas®	Manufactures SentryGlas® structural interlayer for automotive and architectural safety glass (previous location of now defunct Dymetrol® nylon strapping).
DuPont Company PVF	Manufactures PVF resin used to produce Tedlar® film.
Former Manufacturing Area	
Polymer Manufacturing Development Facility (PMDF)	Manufactured Teflon® fluorinated ethylene propylene (FEP) for electrical wiring insulation and other applications. (Note: this Teflon® unit did not use APFO in its process.) The PMDF unit was permanently shut down in June 2009; it no longer manufactures DuPont Teflon®.
Support Areas	
Power	Generates steam via natural gas and fuel oil-fired boilers for the facility's manufacturing areas as well as comfort heating for employees. Produces process water and demineralized water from raw river water.
Wastewater Treatment Plant	The WWTP treats process wastewater and sanitary wastewater prior to discharge to the Cape Fear River.

1.3 Regulatory History

The Fayetteville Works facility received its initial Resource Conservation and Recovery Act (RCRA) Permit (NCD047368642) to operate a hazardous waste container storage

area and tanks in February 1983, while under DuPont ownership. DuPont submitted an amended Part A application in 1991 to document upgrades to its fluorocarbon waste treatment and tank system. The RCRA Part B permit application submitted in August 1993 identified 71,750 gallons of container storage capacity at the container storage area. Stored waste included characteristic wastes (D001, D002, D003, D007, D009, and D029) and listed wastes (F002, F003, and F005).

In January 1998, the Site's RCRA Permit was reissued and was to remain in effect for 10 years. In June 2007, DuPont submitted an application for renewal of the Site's RCRA Permit. The North Carolina Department of Environment and Natural Resources (NCDENR; now the North Carolina Department of Environmental Quality [NCDEQ]) reissued the permit on September 28, 2012.

Since 1996, as required by Part V of the permit, several stages of investigation have been conducted at the Site under NCDENR/NCDEQ oversight to meet the conditions of the permit. The Phase III (Final) RFI² report was submitted in August 2014 (DuPont Corporate Remediation Group [CRG]). In addition, the Site voluntarily agreed to the NCDENR request to investigate potential APFO releases as part the ongoing RFI. The findings of the APFO investigation activities (conducted during the Phase II RFI) were included in Appendix A of the Phase II RFI Report (DuPont CRG 2006). The Corrective Measures Study (CMS) Work Plan was submitted on December 2, 2016 (Chemours CRG) and approved on February 8, 2017. As previously mentioned, a Focused FS Report for PFAS was submitted on February 28, 2018 (Parsons 2018).

1.4 Summary of Focused FS Report – PFAS

Based on the detailed analysis of alternatives presented in the February 28 FS Report, the following remedial options are proposed:

- Perched Zone: Pumping the Perched Zone and lining the ponds followed by use of a temporary dewatering system was selected as the best alternative for reducing both the volume of PFAS groundwater and reducing the transport of groundwater containing PFAS to the lower aquifers, thus meeting the remedial objectives in this zone.
 - Cooling Water Channel: Contaminated materials in the bottom of the ditch will be excavated, and the channel will be lined with a low-permeability liner. These actions will reduce the water entering the Perched Zone.
 - Sedimentation Basins: For the two surface impoundments used to collect sediment generated during the filtration and clarification of cooling water from the Cape Fear River used at the facility, Chemours will sequentially empty and line each basin with a high quality synthetic liner. The purpose of this work is to reduce the inflow of water into the Perched Zone. The design work and implementation for this project is discussed in this RAP.
 - Temporary Dewatering of the Perched Zone: A temporary dewatering system will be used to recover groundwater from the Perched Zone for treatment.
- Surficial and Black Creek Aquifers: Remediation of the Perched Zone will remove the source feeding the Surficial and Black Creek Aquifers. It is expected that this

² RFI – RCRA Facility Investigation

action will reduce or eliminate the need for active remediation of the lower aquifers. Following the Perched Zone remediation, groundwater and surface water monitoring will be conducted to evaluate the need for additional remedial activities.

- Old Outfall No. 002: The Focused FS proposed lining and/or piping the ditch as possible alternatives for meeting the remedial objectives related to this former outfall. However, at the time of the FS Report, additional data were required to evaluate these options. Additional data collected since the Focused FS supports implementation of an alternative remedy, as discussed later in this report.

1.5 Work Plan Purpose

The purpose of this RAP is to provide the design and implementation details for the near-term remedial actions at the Site. The RAP addresses PFAS releases to groundwater from historical and current operations. The goal of these actions is to ensure concentrations in the Cape Fear River do not exceed 140 parts per trillion (ppt) of HFPO-DA downstream of the river water intake.

This RAP presents RAOs and design criteria and describes the conceptual design and preliminary implementation plans for the remedial actions. It also summarizes the schedule for completing the design and performing the remedial actions.

2.0 REMEDIAL ACTION OBJECTIVES

As set forth in the Focused FS Report, Chemours will address PFAS releases to groundwater from historical and current operations in a manner that protects people and the environment. Remedial actions will comport to the extent reasonably feasible with state groundwater quality standards and their customary application or utilization at similar sites in North Carolina.

Toward that end, Chemours proposes to focus on a set of remedial actions and objectives that meet the following goals:

- Mitigates PFAS releases of significance to environmental media from primary and secondary sources on the property or current Site operations
- Protects Cape Fear River water quality consistent with established NCDEQ water quality standards and the North Carolina Department of Health and Human Services (DHHS) provisional health goal for drinking water
- Identifies and addresses off-site drinking water wells that exceed the DHHS provisional health goals

Near-term and long-term objectives and associated remedial actions are discussed further below.

2.1 Near-Term Objectives

The following objectives will address near-term goals:

- Expand the current quantitative assessment and understanding of the actual or potential significance of current and historical releases into environmental media (air, soil, groundwater, surface water) of HFPO-DA and other site-related PFAS.
- Continue to mitigate further releases of significance to environmental media, specifically:
 - Reduce air releases consistent with targets and schedules approved and agreed upon by NCDEQ.
 - Identify and address any significant remaining ongoing sources of process-impacted stormwater released to onsite groundwater or to surface water bodies.
- Identify and take specific actions to address discharge of onsite groundwater/surface water as necessary to ensure concentrations in the Cape Fear River do not exceed 140 ppt of HFPO-DA at any established downstream river water intake.

2.2 Long-Term Objectives

Chemours recognizes that additional long-term actions may be necessary to address on-site or off-site groundwater quality, in accordance with current or future state standards. Toward that end, Chemours proposes an adaptive management approach to guide further long-range actions, monitor progress, and determine if and where actions taken

2.3 Ongoing Interim Measures

In addition to the measures described in this RAP, the following Interim Measures (IMs) are currently underway:

- Temporary pumping of water from the Perched Zone. The sampling and analytical data have shown that the Perched Zone has the highest concentrations of HFPO-DA and other PFAS and is a source of groundwater contamination through infiltration to other zones.
 - After committing to do so by March 15, 2018, Chemours began to pump water from the Perched Zone on February 28, 2018, using wells NAF-03, NAF-12, and PZ-18.
 - Pumping began as soon as equipment could be procured and safely installed. Pumping began at PZ-18 on February 28, 2018, at NAF-12 on March 1, 2018, and at NAF-03 on March 6, 2018.
 - The pumped water is being containerized for off-site disposal until suitable treatment technology can be installed on-site.
 - Pumping from these wells is ongoing.
- For off-site residential impacts, Chemours is working with NCDEQ to implement the granulated activated carbon (GAC) pilot program for residential water and to adopt other feasible and effective measures to mitigate impacts to groundwater outside the plant watershed from air deposition. Chemours is installing point-of-exposure treatment with activated carbon systems, and connections to public water supplies where existing water mains already exist and tap connections alone are required.³
- Process Sewer System: Process wastewater from the Fluoropolymers/Nafion™ area was formerly conveyed via a terracotta sewer pipe to the site wastewater treatment plant. The wastewater pipe from that area runs down 3rd Street and then down C Avenue where it mixes with process water from Sentry Glass, Butacite®, and the power plant before ultimately discharging to the WWTP. This pipe is likely the source of elevated concentrations detected in well PZ-18. The terracotta sewer pipe from the Fluoropolymers/Nafion™ area was cut and capped in November 2017 and is therefore no longer a source of target PFAS to the Perched Zone. Additional sampling will be undertaken around the terracotta pipe to assess potential past releases.
- Removal of contaminated soils near the Cooling Water Channel for disposal: This work was initiated between February 26 and March 2, 2018, and stage 1 is complete as reported in the Status Report submitted to NCDEQ on Monday, March 19, 2018.
- Air emissions data collected from a comprehensive source testing program has provided information on the sources and quantities of air emissions of HFPO-DA and other PFAS from the Site. Chemours is focusing its abatement efforts on areas where it can achieve the greatest level of short-term abatement. This

³ Chemours has submitted a proposal to NCDEQ for installing granular activated carbon treatment systems at residences with drinking water wells exceeding 140 ppt. NCDEQ has asked that further pilot testing be conducted to confirm the systems can achieve the stated goals and plans for that testing are being finalized.

testing has required the development of sampling and testing standards and methods where none previously existed. The process continues because NCDEQ has asked Chemours to sample and test for additional compounds. In coordination with the NCDEQ Division of Air Quality, Chemours has been developing short-term and longer-term abatement options to reduce PFAS air emissions from the Site.

This page intentionally left blank

3.0 REMEDIAL ACTIONS, GOALS, AND CONCEPTUAL DESIGNS

The following subsections contain a brief description and preliminary design parameters for the various actions proposed in this RAP.

3.1 Perched Zone Groundwater

Based on evaluation of sources and transport of contaminants, the remaining major secondary source of PFAS to the Surficial and Black Creek Aquifers is groundwater flowing from the Perched Zone to these deeper aquifers. The Perched Zone water is relatively shallow and easily accessible, and remediation of this water should have a significant effect on reducing site groundwater concentrations.

To address the Perched Zone as a contributing source (until the final remedy is selected and installed), Chemours has begun pumping groundwater from the three highest concentration wells in the Perched Zone (NAF-12, NAF-03, and PZ-18). As previously mentioned, pumping was initiated at the three wells between February 28 and March 6, 2018. Pumping from these wells during daytime hours is ongoing. The pumped water is being containerized for off-site disposal until a suitable treatment technology can be installed on site.

3.1.1 Perched Zone Groundwater Remedial Action Goals

The goals for the Perched Zone groundwater remedial actions are to

1. Reduce infiltration of cooling water and stormwater into the Perched Zone and
2. Remove groundwater from the Perched Zone

The primary sources of water from within the Site into the Perched Zone are infiltration from the unlined Cooling Water Channel and infiltration from the unlined cooling water sedimentation basins. These are the major sources because there is cooling water in the basins and in the ditch continuously and stormwater from the Site is directed into the ditches. Figure 3 shows the location of the Cooling Water Channel and North and South Sedimentation Basins.

3.1.2 Perched Zone Groundwater Remedial Actions

Based on the results of the FS, the following remedial actions are proposed to address the Perched Zone:

1. Line the Cooling Water Channel and the two sedimentation basins. Lining the ditch and basins will reduce infiltration from these areas and thus significantly reduce the recharge of the Perched Zone. Reducing recharge to the Perched Zone will in turn reduce transport of mass to the lower aquifers.
2. Install temporary dewatering points to remove water from the Perched Zone for on-site treatment. The purpose of this action is to remove a significant portion of the existing groundwater from the Perched Zone and some of the PFAS mass in this groundwater. The flow rate of the dewatering system will be sized to efficiently dewater the Perched Zone while balancing treatment requirements.

Water from the Cape Fear River flows into the cooling water filtration system which removes the river's suspended sediment. The backwash water and suspended sediment from the cooling water filtration system are discharged into the Sedimentation Basins. No process water is discharged in the Sediment Basins. Water in the Cooling

Water Channel is once-through cooling water from refrigeration chillers and storm water. The Cooling Water Channel does not carry process water. Both of these water sources contain Cape Fear River sediment in the cooling water and site sediment in storm water runoff. Conceptual Design – Cooling Water Channel

3.1.3 Conceptual Design – Cooling Water Channel

Parsons and Chemours reviewed several lining materials and construction options for the various sections of the channel. Based on varying requirements for different portions of the channel (e.g., number and type of flows discharged into the channel, the need to remove sediment), different approaches will be employed across the channel. Based on these conditions, the following is proposed:

- The north and west portions of the channel will be lined with an appropriate liner system that may be exposed or covered with an earthen or rock material to protect the liner. Since little sediment accumulation is expected in these areas, there is no need to protect the liner from sediment removal activities.
- The east and south portions will be concrete-lined open channel.
 - Pre-cast concrete “U” sections will be used for open channel. These will provide good water flow and low-cost operation and maintenance. It will be relatively easy to remove sediment that accumulates in the channel.
 - A low-permeability liner system will be placed underneath concrete sections to further reduce infiltration.
 - Preliminary sizing indicates the channel will be approximately four to six feet wide and two feet deep. This will be verified during the design.
- The southeast corner and the section immediately downstream (west) of the corner will be piped.
 - A double walled (corrugated) high-density polyethylene (HDPE) pipe is proposed.
 - The pipe provides very good containment, and the smooth inner wall provides good hydraulic performance.

The system must be installed in sequence to accommodate the various components and production schedules. The proposed sequence of work is shown below:

1. Clean and inspect existing storm drain pipes in the northeast section (from north of Cooling Water Channel east to existing stormwater channels)
2. Clean Cooling Water Channel west channel and re-grade to handle cooling water flow to the south.
3. Install new culvert in gap between the north and west channels in northwest corner.
4. Re-grade the western portion of the north channel.
5. Install temporary dam at north end of east ditch (just south of cooling water pipes).
6. Install temporary flow diversions for stormwater inflow into east ditch, cooling water that enters at the southeast corner of the ditch, and stormwater into south channel.

7. Construct new Cooling Water Channel south channel, new Cooling Water Channel pipeline in the southwest, and new Cooling Water Channel east channel (except for the north 30 feet near the temporary dam where cooling water enters the ditch).
8. Install lining in north channel and west channel.
9. Construct the final section of the east channel (north 30 feet at dam) during plant shut down in October 2018.

3.1.4 Conceptual Design – Sedimentation Basin Liners

The preliminary design for the liner system consists of a synthetic membrane over GCL. The final design may change as the design proceeds, but the final system will provide similar resistance to infiltration. The ponds are traditionally operated on a five-year cycle. One pond is in service at a time and operates for about five years before accumulated sediment needs to be removed. When the sediment in one pond needs to be removed, water flow is directed into the second pond for the next five years. Therefore, the system must be designed to allow for future sediment removal. The following options are currently being considered (although other equivalent options may also be considered):

- Concrete liner system (e.g., Fabriform®) to protect the liner
- Replacing the synthetic membrane every five years when the pond is dredged.

The final decision will be based on engineering and operational concerns and cost. In addition to liner considerations, efforts will be made to improve the settling efficiency of the pond. The liner material will be selected during design. Liner materials that will be evaluated include XR-5 polyester, chlorosulfonated polyethylene (CSPE), HDPE, linear low-density polyethylene (LLDPE), polyvinyl chloride (PVC), polypropylene (PP), or ethylene propylene terpolymer (EPDM).

The following scope of work is proposed:

1. Dredge the South Sedimentation Basin. Settled river solids will be removed from the basin and dewatered. Supernatant will be placed in the North Sedimentation Basin.
2. Prepare the subgrade in the South Sedimentation Basin and install the liner system.
3. Return the South Sedimentation Basin to service and shut off the North Sedimentation Basin.
4. Dewater the North Sedimentation Basin and remove settled solids. Supernatant will be placed in the South Sedimentation Basin.
5. Prepare the subgrade in the North Sedimentation Basin and install the liner system.

3.1.5 Conceptual Design – Temporary Groundwater Treatment System

A temporary treatment system will be constructed to remove PFAS from groundwater recovered from the Perched Zone. The system will be sized to meet the requirements of the perched water dewatering system. The treatment system will consist of a minimum of two-stage carbon treatment.

The treatment system would preliminarily consist of the following unit processes:

- Equalization
- Chemical precipitation and settling
- Filtration
- PFAS adsorption
- Clear well
- Sludge holding and dewatering

A preliminary process flow diagram is presented as Figure 4. The unit treatment processes are described below.

Equalization (EQ). The EQ system will be designed to attenuate variations in dewatering extraction flow rates to allow a consistent flow rate to be achieved through the treatment system. The EQ system will preliminarily consist of sufficient volume to provide at least 24 hours of hydraulic retention time to accommodate potential interruptions in dewatering operations, plus associated equipment and instruments/controls including such elements as transfer pumps and level control.

Chemical Precipitation and Settling. Chemical precipitation will be implemented to remove iron to prevent fouling downstream in the PFAS adsorption process. The preliminary system will consist of the following steps:

- Aeration to oxidize soluble iron
- Chemical addition including pH adjustment and, if necessary, coagulant
- Flocculation (assisted with polymer addition)
- Settling

The chemical precipitation and settling process will consist of vessels configured to provide chambers for rapid mix, flocculation, settling, and the associated baffling to promote the desired flow patterns through the process. The settling chamber will include inclined plates (lamella-type) or tubes to enhance settling of precipitated solids. Associated equipment will include blowers and air diffusion media to promote oxidation of iron, chemical storage and metering (acid/caustic, coagulant if needed), polymer feed, instruments and controls (e.g., pH adjustment), transfer pumps, and sludge underflow pumps.

A modular treatment system that contains all precipitation and settling steps within a single modular unit will be considered, as will alternatives for utilizing configurable rental equipment (e.g., frac tanks).

Filtration. A filtration system preliminarily consisting of canister (bag) filters will remove suspended/fugitive solids in effluent from the chemical precipitation process to prevent them from accumulating in the PFAS adsorption process, which otherwise could potentially cause short-circuiting through the adsorption process. The recommended type of filter (e.g., sand/multimedia filter, canister filter) will be determined during the process development phase. The filtration system would be equipped with differential pressure monitoring to signal the need for bag filter replacement or trigger filter backwash depending on the type of filtration system installed.

PFAS Adsorption. PFAS removal will be accomplished using GAC adsorption. A minimum of two GAC adsorption units will be installed and operated in parallel. GAC

sizing and utilization rates will be determined based on column studies and the flow rate requirements of the dewatering system.

The carbon units would be operated in lead-lag fashion and monitored for breakthrough of the HPFO-DA at a selected maintenance concentration (action level) (e.g., 140 ppt) or one-half the state provisional health goal. Upon breakthrough, the lag unit would be switched to the lead position and the lead unit replaced with fresh GAC. To maximize GAC utilization and reduce inadvertent breakthrough of the lag unit, installation of more than two units operated in series may be considered. Final carbon adsorption system selection and sizing will depend on the design concentration of PFAS (specifically HFPO-DA) in the extracted dewatering volume and the final design flow rate to ensure an acceptable hydraulic loading rate can be maintained.

Clear Well. The system will preliminarily include a treated water clear well. The clear well will allow treated water to be held and returned to the head of the plant in the event the treated water does not meet discharge criteria.

Sludge Holding and Dewatering. The underflow solids from the chemical precipitation and settling process will be pumped to a sludge holding tank for further management and disposal. The sludge holding tank will consist of a vertical HDPE tank to promote gravity settling of the sludge solids to reduce the overall sludge volume. The decant from the settled sludge will be pumped back to the EQ tanks. The settled sludge will either be disposed of directly or, pending disposal requirements, undergo dewatering using a plate-and-frame filter press. The dewatering filtrate would be collected and pumped to the EQ tanks, and the dewatered solids would be disposed of off site. Specific disposal requirements will be determined during the design phase.

3.1.6 Conceptual Design – Temporary Dewatering System

The Site will be divided into a grid. Temporary vertical well points and headers will be installed in the grid to dewater the Perched Zone beneath the area. The grids will be sized to efficiently dewater the Perched Zone and may vary in size and layout based on the Perched Zone thickness in each area and obstructions such as buildings and underground utilities. Once an area is dewatered to the extent practical, the well points and treatment system will be removed and installed in another grid. The system will continue until most of the Perched Zone has been dewatered. Hydraulic head distribution will be evaluated to aid in determining the effectiveness of the remedial response actions.

3.2 Surficial and Black Creek Aquifers

As previously mentioned, the current condition of the Surficial and Black Creek Aquifers meets the RAOs as presented in Section 2.0. Removal of the source area located in the Perched Zone will further reduce the contribution of PFAS to surface water. Therefore, no action is required to meet short-term RAOs for these deeper aquifers. Groundwater monitoring is proposed to confirm this hypothesis.

Groundwater and surface water will be monitored long term at the Site as part of the final remedial response action. The purpose of the monitoring will be to measure site-wide groundwater hydraulic heads and surface water elevations and determine constituent of concern concentrations in groundwater and surface water to aid in confirming that the overall corrective action goals are being met. To accomplish this, water levels will be measured at select Site monitoring wells and surface water locations. Select wells and surface water locations also will be sampled for analysis of site-specific constituents of

concern. The concentration distribution of constituents of concern will then be evaluated to aid in determining whether the implemented response action is effective.

3.3 Former Outfall No. 002 Channel

During the FS, it was determined that lining the channel or installing a pipe and filling in the ditch would be an effective means to eliminate groundwater migrating into this ditch and ultimately into the Cape Fear River. However, additional data gathering has indicated that these options are likely impractical due to the physical nature of the ditch, the existing hydrogeological conditions, and the permitting that would be required. Therefore, Chemours plans to capture the water from this creek for treatment.

Figure 5 shows the results of surface water samples collected at various locations along the Old Outfall Channel. The highest concentrations were measured in the headwaters of the channel closest to the manufacturing area. One option is to capture groundwater just downstream of sample point D and pump the water to a new facility wastewater treatment plant designed to treat PFAS (Option A on Figure 5). Alternatively, the flow would be captured just west of Glenngerry Road (Option B on Figure 5). Data to determine which option best supports the ROAs is currently being gathered.

If Option B is selected, a treatment system will be constructed to remove PFAS from Former Outfall 002 water. Based on current estimates, the system will be sized for a flow rate of approximately 500 gallons per minute (gpm). The treatment system will likely consist of the same unit processes outlined for the temporary groundwater treatment system described in Section 3.1.5. However, due to the larger anticipated design flow rate and design life, how the processes are implemented (e.g., types of equipment, constructability, instrumentation and controls, electrical requirements) will differ significantly from the temporary treatment system. The following briefly describes the anticipated treatment process as conceptualized for Former Outfall 002 treatment.

The treatment system would preliminarily consist of the following unit processes:

- EQ
- Chemical precipitation and settling
- Filtration
- PFAS adsorption
- Clear well
- Sludge holding and dewatering

The anticipated treatment process for the Former Outfall 002 treatment system would be similar to that presented for the temporary groundwater treatment system in Figure 4.

The unit treatment processes are described below.

EQ. The EQ system will be designed to attenuate variations in influent flow rates and target constituent concentrations. Sizing for the EQ system for the Former Outfall 002 treatment system will preliminarily consider variations in measured flow rates and HFPO-DA concentrations in the stream flow to achieve a desired level of attenuation that will be determined during the design process. The EQ system will include the necessary tankage to provide the desired level of hydraulic retention plus associated equipment and instruments/controls including such elements as transfer pumps, level control, and interlocks with downstream processes.

Iron Precipitation / Clarification. Chemical precipitation will be implemented to remove iron, if necessary to prevent fouling downstream in the PFAS adsorption process. The preliminary system will consist of the following steps:

- Aeration to oxidize soluble iron
- Chemical addition including pH adjustment and, if necessary, coagulant
- Flocculation (assisted with polymer addition)
- Settling

Iron oxidation will take place in a dedicated tank fitted with an aeration diffusion grid supplied by rotary-type blowers. In the event no other metals are identified for removal, the flow will proceed to a lamella clarifier to facilitate removal of precipitated iron solids. Treated flow will proceed to filtration; settled solids will be transferred by an underflow sludge pump to a sludge holding tank.

Filtration. Treated flow from the lamella clarifier will undergo filtration to prevent suspended/fugitive solids from fouling the downstream PFAS adsorption process. The type of filter (e.g., pressurized versus gravity) and media will be evaluated during the design process. The filtration system would be equipped with differential pressure monitoring to trigger filter backwash.

PFAS Adsorption. PFAS removal will be accomplished using GAC adsorption. Based on related GAC adsorption studies and the estimated influent conditions presented above, approximately 200,000 pounds of GAC will be required per year. An appropriate design factor will be applied to estimate full-scale installed utilization.

It is anticipated skid-based contactor systems (e.g., Calgon Mod12) would be utilized. To maximize GAC utilization, installation and operation of two sets of dual contactor systems (e.g., 2 x 2) operated in series (i.e., effluent from first set proceeds through the second set) will be considered. The carbon units within each set would be operated in lead-lag fashion. GAC refresh criteria for each set of contactors will be developed during the construction and startup phase.

Clear Well. The system will preliminarily include a treated water clear well. The clear well will allow treated water to be held and returned to the head of the plant in the event the treated water does not meet discharge criteria.

Sludge Holding and Dewatering. It is anticipated the sludge solids will undergo thickening either in a gravity settler or by other means. The thickened solids will then be dewatered. The thickening and dewatering technologies and associated equipment (e.g., thickened sludge transfer pumps, polymer addition) will be evaluated during the design phase. Liquid removed during thickening and dewatering will be transferred back to the EQ system.

System Interlocks. In addition to local controls, interlocks will be instituted among various processes to prevent such factors as overflows and out-of-spec discharges, which would be determined based on real-time instrument readings. For example, influent pumps will automatically shut down if the level in the EQ system exceeds a high-level set point, and transfer pumps will automatically shut off if tank levels drop below low-level set points.

This page intentionally left blank

4.0 PRE-REMEDIAL ACTION AND DESIGN ACTIVITIES

This section describes the preparation activities to be conducted before the remedial actions, including but not limited to notifications and permitting, site mobilization, and subsurface utility clearance. All remedial activities will be conducted in compliance with applicable federal, state, and local permitting requirements. Not all permitting requirements have been identified, since some designs have not progressed sufficiently to identify all required permits.

4.1 Perched Zone

4.1.1 Cooling Water Channel Lining

Drawings of the existing conditions are being prepared. Surveying to confirm the location and elevations for key structures is underway. In addition, flow information from the various pipes entering the ditch has been gathered, and Chemours is preparing hydraulic calculations to support the system design. Based on currently available information, a land disturbance permit may be required from the local permitting authority. The table below outlines the tasks required to complete the liner system design.

Component	Tasks Required	Schedule
<ul style="list-style-type: none"> ▪ Cooling Water Channel - East ▪ Cooling Water Channel - South ▪ Pipeline in southeast corner ▪ Nafion™ North Drain Channel Lining ▪ Nafion™ West Drain Channel Lining ▪ Cooling Water by-pass ▪ Temporary Dam 	<ul style="list-style-type: none"> ▪ Flow calculations ▪ Channel size ▪ Manhole sizes / dimensions ▪ Pipe diameter and type ▪ 30% drawings ▪ Specs for long-lead items ▪ Final design 	<ul style="list-style-type: none"> ▪ Complete engineering analyses – March 31 ▪ Material specifications one week after analyses ▪ Order long-lead items mid-April ▪ 30% design drawings – April 15 ▪ Complete drawing package – May 15
Clean and video inspect Northeast pipes		2 weeks
Fabricate and delivery pre-cast channel sections, pipe, manholes, liner materials	Assume 8 weeks for delivery	Expected delivery mid-June

4.1.2 Sedimentation Basin Lining

Existing drawings and available geotechnical data are being gathered and reviewed to determine if a new survey or geotechnical sampling will be required to complete the design. Based on currently available information, a land disturbance permit will be required from the local permitting authority. The design must be completed in order to submit an application for this permit. A permit is also required for on-site disposal (land application) of the dredged material. The table below outlines the tasks required to complete the liner system design.

Component	Tasks Required	Schedule
Excavation and disposal of accumulated sediment in basins.	Assume on-site land application	Chemours is currently working to obtain the necessary state permit.

Component	Tasks Required	Schedule
Excavate to subgrade and excavate or fill for required basin side slopes.	<ul style="list-style-type: none"> ▪ Need influent flow rate and estimate of total suspended solids. ▪ Need design and as-built information on basins, including perimeter berm design. ▪ Need data on soil properties of soil below basins and in perimeter berms. ▪ Calculate necessary depth in basins from water surface to top of liner system. (based on hydraulic detention time and thickness of accumulated sediment in basins). ▪ Determine elevation of basin subgrade. ▪ Determine allowable side slope angle. (either match existing or perform stability calculations). 	<ul style="list-style-type: none"> ▪ Obtain as-built information from Chemours – by March 30 ▪ Obtain site geologic and geotechnical data from previous investigations – by March 30. ▪ If needed, use test pits or cone penetration tests to obtain site geotechnical data for design. ▪ Fieldwork complete – April 30 ▪ Geotechnical laboratory work complete – May 31. ▪ Complete hydraulic and size calculations – May 31.
Design effluent weirs and influent piping.	<ul style="list-style-type: none"> ▪ Flow calculations ▪ Develop details for weirs, diffusers, piping, valves and controls. 	<ul style="list-style-type: none"> ▪ Calculations complete– June 31. ▪ Final design – July 31.
Select liner type.	Consider permeability, reliability, design life, installed cost, installation schedule,	May 15.
Cost benefit for concrete cover to protect membrane versus replacing membrane every 5 years.	Compare cost of installing concrete system over membrane versus membrane replacement cost.	May 31.
<ul style="list-style-type: none"> ▪ 30% drawings – basin plan and cross-sections; liner system layers, effluent weirs. ▪ Specs for long-lead materials – liner system, fabricated weirs. ▪ 100% drawings – Subgrade grading plan, mechanical details, control details. ▪ Installation work plan. 	<ul style="list-style-type: none"> ▪ Prepare drawings ▪ Prepared specifications for material procurement. ▪ (Design documents based on use of sole-source contractor for design-build team approach). 	<ul style="list-style-type: none"> ▪ 30% design and material specs – May 31 ▪ Final design June 30

4.1.3 Temporary Groundwater Treatment System Pre-Design

The preliminary treatment system design will be supported through execution of focused bench-scale treatment testing to verify performance, determine optimum treatment conditions (e.g., chemical dosing, treatment pH) and assist with equipment sizing. Treatment testing would be performed on representative extracted dewatering volume samples. Treatment testing components are described below.

Chemical precipitation. Jar tests would be performed to determine the optimum treatment conditions for iron precipitation and settling. Variables would include (1) aeration requirements; (2) optimum pH; (3) potential improvements with chemical coagulant; and (4) polymer type and dose. Treated effluent would undergo filtration testing to ascertain suspended solid reductions at a range of filtration pore sizes. Settled sludge would undergo testing to determine (1) gravity settleability and (2) preliminary dewaterability as needed. Dewatered sludge would be analyzed for leaching potential (TCLP or SPLP⁴) if required for disposal consideration.

PFAS adsorption. PFAS adsorption testing would include the following studies:

- GAC adsorption isotherm study – to determine overall adsorptive capacity of GAC for target compounds within representative dewatering volume
- GAC adsorption column study – to estimate GAC utilization rates based on breakthrough of PFAS, which will be used for contactor sizing and estimation of GAC replenishment frequency

It is assumed a single type of GAC (e.g., Calgon Filtrasorb® 400 or 600) will be selected for evaluation, although testing could compare alternative GACs. The above-described treatment testing regimen assumes there are no target constituents other than iron and PFAS. In the event other target constituents are identified due to discharge regulations, additional testing would be proposed that specifically addresses those constituents and the influence on system design considered.

4.2 Surficial and Black Creek Aquifers

Perched Zone water, Surficial Aquifer groundwater, and Black Creek Aquifer groundwater will be monitored (i.e., gauged and sampled). Willis Creek, Georgia Branch, Cape Fear River, and potentially the Old 002-Outfall ditch will be monitored. No additional data collection is anticipated as part of this action. The final list of monitored constituents of concern will be specified in the Long-Term Groundwater and Surface Water Monitoring Plan for PFAS.

4.3 Former Outfall No. 002 Channel Pre-Design

4.3.1 Pre-Design (Flow and Geotechnical Studies)

Preliminary estimates of the flow in the channel have been used to develop an approximate flow rate of 500 gpm at Glengerry Road. However, additional flow studies are required to determine the flow rate in the upstream portion of the channel (Option A).

⁴ TCLP – Toxicity Characteristic Leaching Procedure; SPLP – Synthetic Precipitation Leaching Procedure

4.3.2 Pre-Design (Process Development and Validation)

The preliminary treatment system design will be supported through execution of focused bench-scale treatment testing to verify performance, determine optimum treatment conditions (e.g., chemical dosing, treatment pH) and assist with equipment sizing. Treatment testing would be performed on representative extracted dewatering volume samples. Treatment testing would encompass the following:

Iron Precipitation / Clarification. Treatment testing including jar tests and sludge studies similar to those described for the temporary groundwater treatment system would be performed. Dewatered sludge would be analyzed for leaching potential (TCLP or SPLP) if required for disposal consideration.

PFAS adsorption. PFAS adsorption testing including isotherm and column studies would be performed to evaluate adsorption performance of the selected GAC or alternative GAC types, while capturing potential competitive adsorption effects within the outfall water matrix.

The above-described treatment testing regimen assumes there are no target constituents other than iron and PFAS. In the event other target constituents are identified due to discharge regulations, additional testing would be proposed that specifically address those constituents and the influence on system design considered.

5.0 SCHEDULE

5.1 Perched Zone

5.1.1 Cooling Water Channel Lining

As previously mentioned, design of the Cooling Water Channel lining project is currently underway. Survey data have been collected. The approximate schedule for completing this portion of the project is outlined below. Weather, material acquisition, and other unforeseen items that are beyond the project team's control may impact the proposed schedule.

Component	Tasks Required	Schedule
Design	30% Design Complete Order Long Lead Materials Final Design (100%)	April 15, 2018 Mid-April, 2018 May 15, 2018
Perform construction, except North 30 feet with plant in operation.	Install temporary diversions before materials arrive	Start temporary construction – June, 2018 Construction Complete – August 31, 2018
Construct North 30-foot section	Plant shut-down required	October 2018 or next plant shut down (if sooner).

5.1.2 Sedimentation Basin Lining

As previously mentioned, preliminary design activities are currently underway for this task. The approximate schedule for completing this portion of the project is outlined below. Weather, material acquisition, and other unforeseen items that are beyond the project team's control may impact the proposed schedule. In addition, we have assumed that dewatering will not be required to install the liner. If dewatering is required, then the schedule will need to be delayed for the design and installation of a treatment system as described in the next subsection.

Activity	Duration (work days)	Start	Finish
30% Design		Ongoing	May 31, 2018
Final Design		Jun 1, 2018	Jun 30, 2018
Long-lead materials (liner, fabricated mechanical equipment)	40	Jul 1, 2018	Sep 1, 2018
Dredge South Basin	10	Sep 1, 2018	Sep 15, 2018
Prepare subgrade in South Basin	10	Sep 16, 2018	Sep 30, 2018
Install liner system and mechanical systems, return flow to South Basin.	20	Nov 1, 2018	Nov 30, 2018
Dredge North Basin	10	Dec 1, 2018	Dec 15, 2018
Prepare subgrade in North Basin	10	Dec 16, 2018	Dec 31, 2018
Install liner system and mechanical systems in North Basin	20	Jan 1*, 2019	Jan 31*, 2019
*Cannot perform earthwork or liner installation when temperature is below freezing. Completion may take longer when working through cold-weather seasons.			

5.1.3 Temporary Groundwater Treatment System

The design phase will consist of the following stages:

- Basis of Evaluation – a brief technical memorandum will be prepared to document agreed-to influent conditions, treatment requirements, and the design process.
- Pre-Design – process development (treatment testing) will be followed by conceptual design and budget-level capital cost estimation for selection and approval of treatment system configuration. Deliverables include Basis of Design report including preliminary process flow diagram, mass balance, and equipment layout.
- Detail Design – includes development of final system configuration and equipment sizing; process hazard analysis for hazardous operations (PHA/HAZOP); and preparation of equipment, line, valve, and instrument lists and equipment specifications or a general Performance Specification (if the entire system is to be awarded to a treatment system vendor).

The overall testing and design schedules is preliminarily laid out as follows, assuming PFAS and iron are the only target parameters for treatment:

Activity	Duration (weeks)	Start	Finish
Data Collection	4	April 1, 2018	April 31, 2018
Basis of Evaluation Memo	3	May 1, 2018	May 22, 2018
Pre-Design / Column Studies / Basis of Design Report	12	May 23, 2018	Aug 15, 2018
Detailed Design (30% Design / Final)	12	Aug 16, 2018	Nov 8, 2018
Bidding and Procurement	8	Nov 9, 2018	Jan 3, 2019
Mobilization / Construction Start	4	Jan 4, 2019	Feb 1, 2019

The schedule presented above is estimated based on the preliminary concept design and pre-design steps described herein. The estimated schedule includes one week of review for the Basis of Evaluation memorandum and two weeks of review for the Pre-Design and Detailed Design submittals. The schedule is subject to change as the design progresses and additional information is obtained (e.g., if additional treatment technologies are required to meet the remedial objectives). The schedule also assumes that a new National Pollutant Discharge Elimination System (NPDES) permit is not required and that treated water can be discharged to a separate internal outfall under the existing plant NPDES permit.

5.2 Surficial and Black Creek Aquifers

Perched Zone water, Surficial Aquifer groundwater, and Black Creek Aquifer groundwater will be monitored (i.e., gauged and sampled). Willis Creek, Georgia Branch, Cape Fear River, and potentially the Old 002-Outfall ditch will be monitored. The final list of monitored constituents of concern will be specified in the Long-Term Groundwater and Surface Water Monitoring Plan for PFAS, scheduled for submittal by September 30, 2018. Semi-annual monitoring with annual reporting will be proposed, with the first monitoring event scheduled for the first half of 2019.

5.3 Former Outfall No. 002 Channel

The design phase will consist of the following stages:

- Basis of Evaluation – a brief technical memorandum will be developed to document agreed-to influent conditions, treatment requirements, and the design process. This memorandum will also include an alternatives analysis to select the preferred remedial alternative.
- Pre-Design - process development (treatment testing) will be followed by conceptual design and budget-level capital cost estimation for selection and approval of treatment system configuration. Input would be requested from engineering trades, including a review of applicable codes. A summary of requirements for the detailed design would be prepared. Deliverables will include a Basis of Design report including preliminary process flow diagram, mass balance, and equipment layout.

The overall testing and pre-design schedules are preliminarily laid out as follows, assuming PFAS and iron are the only target parameters for treatment:

Activity	Duration (weeks)	Start	Finish
Data Collection	4	April 15, 2018	May 15, 2018
Basis of Evaluation Memo	4	May 16, 2018	Jun 15, 2018
Pre-Design / Column Studies / Basis of Design Report	20	Jun 15, 2018	October 31, 2018

The schedule as presented here is estimated based on the preliminary concept design and pre-design steps described herein. The schedule is subject to change as the design progresses and additional information is obtained (e.g., if additional treatment technologies are required to meet the remedial objectives). The schedule assumes that all permits (including NPDES) can be obtained within the timeframe noted above; delays in receiving permits may cause delays to the schedule.

This page intentionally left blank

6.0 REFERENCES

Chemours CRG, 2016. Corrective Measures Study Work Plan. December 2.

DuPont CRG, 2006. Phase II RFI Report.

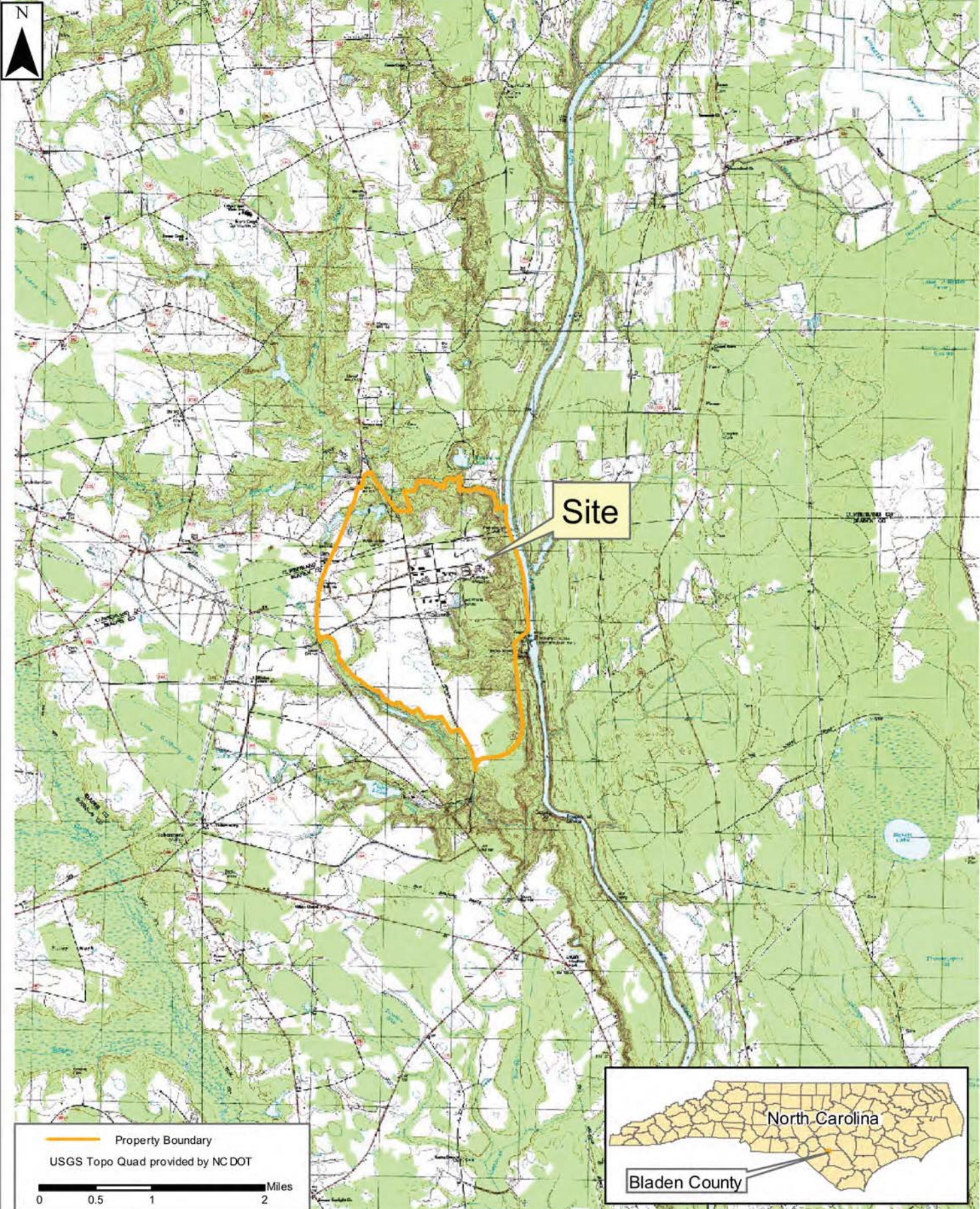
DuPont CRG, 2014. Phase III (Final) RCRA Facility Investigation Report. August.

Parsons, 2018. Focused Feasibility Study Report – PFAS Remediation, Chemours Fayetteville Works, RCRA Permit No. NCD047368642-Rs-M3. February.

This page intentionally left blank

FIGURES

This page intentionally left blank



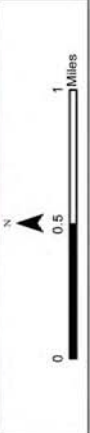
Property Boundary
 USGS Topo Quad provided by NC DOT
 0 0.5 1 2 Miles



PARSONS
 PE&I
 4701 Hedgemore Dr.
 Charlotte, NC 28209

Site Location Map
 Focused Remedial Action Plan-PFAS Remediation
 Chemours Fayetteville Works
 Fayetteville, North Carolina

Drawn: C. Oneal	Date: 1/29/2018	File Project Number: 449338.01050
Revision: 1	Figure Number: 1	
Name: Fay_Fig_1_Site_Loc		



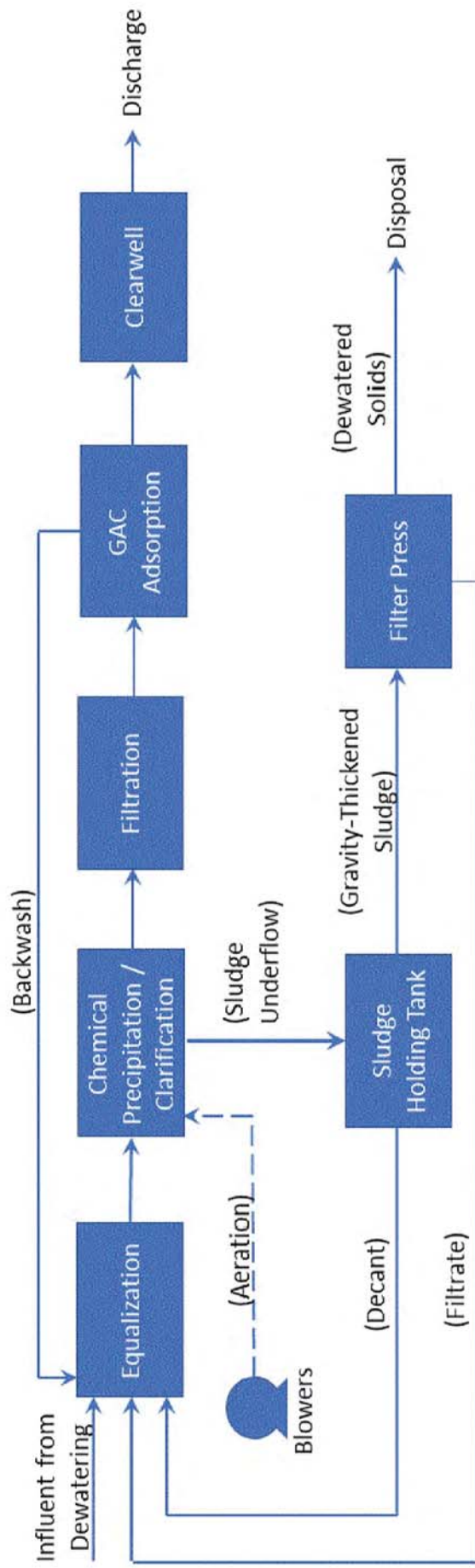
	Pavement/Curb
	Plant Border
	Drainage Channel
	River
	Site Structure
	SWMU

Aerial Photograph provided by DuPont, taken 12/2005

DRAWN:	C. Dreal	DATE:	3/19/2018	DUPONT NO.:	
REVISION:	1	FIGURE NO.:	2	PARSONS NO.:	449238.01050
Name: Fay_Site_Layout					

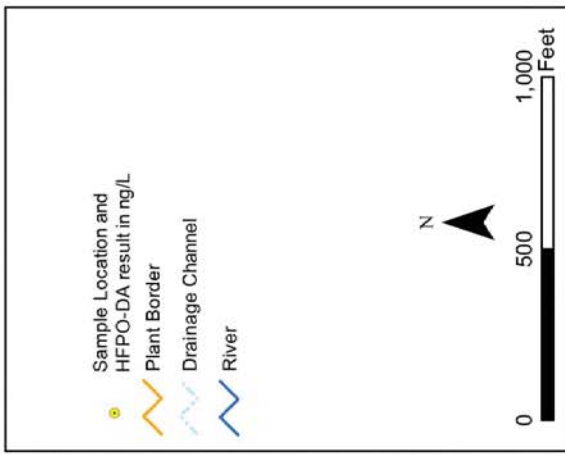
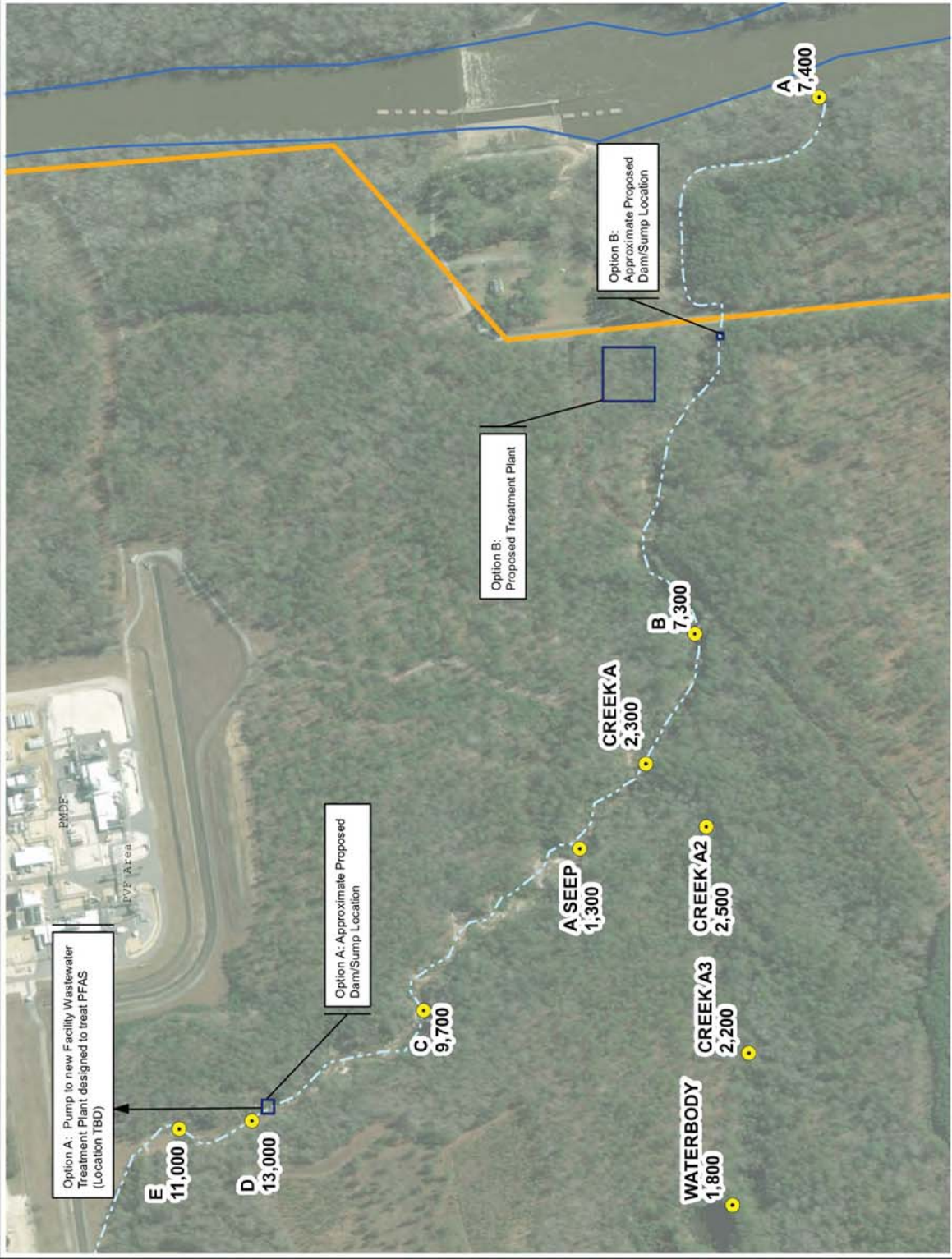
Site Layout Map
 Focused Remedial Action Plan-PFAS Remediation
 Chemours Fayetteville Works
 Fayetteville, North Carolina

PARSONS
 PE&E
 4701 Hedgemore Dr.
 Charlotte, NC 28209



TEMPORARY TREATMENT SYSTEM PROCESS FLOW DIAGRAM
 FOCUSED REMEDIAL ACTION PLAN – PFAS
 CHEMOURS FAYETTEVILLE WORKS
 FAYETTEVILLE, NORTH CAROLINA

CREATED:	M. ROBINSON	CLIENT PROJECT NO.:
DATE:	2018-03-20	PARSONS PROJECT NO.:
REVISION:		449338.01090
FILE NAME:		FIGURE NO.:
		4



Drawn: C. Overall	Date: 3/26/2018	File Project Number: 449338.01050
Revision: 1		
Name: Option_F4		Figure Number: 5

Old Outfall No. 2 - Treatment Options
 Focused Feasibility Study Report - PFAS
 Chemours Fayetteville Works
 Fayetteville, North Carolina

PARSONS
 PE&E
 4701 Heidemore Dr.
 Charlotte, NC 28209

Occurrence and use of highly fluorinated substances and alternatives

Report from a government assignment

REPORT 7/15



The Swedish Chemicals Agency is supervisory authority under the Government. We work in Sweden, the EU and internationally to develop legislation and other incentives to promote good health and improved environment. We monitor compliance of applicable rules on chemical products, pesticides and substances in articles and carry out inspections. We review and authorise pesticides before they can be used. Our environmental quality objective is A Non-toxic Environment.

© Swedish Chemicals Agency. Print: Arkitektkopia, Stockholm 2015.

ISSN 0284-1185. Article number: 361 164.

Order print from Arkitektkopia AB, Box 11093, SE-161 11 Bromma.

Order tel: +46 8 505 933 35, Order fax: +46 8 505 933 99, e-mail: kemi@cm.se.

Preface

The Swedish Chemicals Agency (KEMI) has been assigned by the Swedish Government to produce a national action plan for a toxic-free everyday environment: *Action plan for a toxic-free everyday environment 2011 – 2014 – protect the children better*. The action plan has been extended to 2020. Efforts are going on in several areas, both in Sweden, within the EU and internationally and often in cooperation with other authorities.

Reducing chemical risks in the everyday environment is one step towards attaining the Swedish Parliament's environment quality objective A Non-Toxic Environment, which is the objective that the Swedish Chemicals Agency is responsible for. Within the framework of the action plan, we compile knowledge in the Swedish Chemicals Agency's report and PM series elaborated by experienced colleagues, researchers or consultants. In this way, we present new and essential knowledge in publications which can be downloaded from the website www.kemikalieinspektionen.se.

One area of focus in the action plan is highly fluorinated substances. The Swedish Chemicals Agency has been assigned to produce a national programme of measures for highly fluorinated substances. As part of this task the Swedish Chemicals Agency has carried out a survey of the occurrence and use of highly fluorinated substances and alternative substances and materials. The survey is presented in this report.

The aim of the survey is to give a clearer picture of where highly fluorinated substances are currently used and what alternative substances, materials and technologies are available.

The survey was carried out by the Department for the Development of Legislation and Other Instruments. The head of unit Agneta Falk-Filipsson was responsible for the project and the project group comprised Stellan Fischer and Jenny Ivarsson (project leader). Johan Forsberg and Maria Delvin have also contributed to the report.

Content

Summary	6
Sammanfattning	8
1 Background	10
2 The assignment and its scope	11
3 Terminology, manufacture, function and abbreviations	12
3.1 Perfluorinated and polyfluorinated alkyl substances (PFAS).....	12
3.1.1 Non-polymers.....	13
3.1.2 Polymers	14
3.2 Manufacture and technical quality	15
3.2.1 Electrochemical fluorination, ECF	15
3.2.2 Telomerization.....	16
3.2.3 Technical quality	16
3.3 Properties and functions	16
3.4 Abbreviations and explanations	17
4 Legislation and voluntary agreements	18
4.1 The Stockholm Convention.....	18
4.2 EU regulations.....	19
4.3 Voluntary agreements	20
5 Survey methodology	20
5.1 Highly fluorinated substances and alternatives on the market	21
5.1.1 The work process.....	21
5.1.1.1 Regulatory databases	23
5.1.1.2 Scientific literature.....	24
5.1.1.3 Company information	24
5.2 Uncertainty in gathered information	25
5.2.1 Substance identification	25
5.2.2 Assessment of end use.....	26
5.2.3 The limits of notification requirements	26
5.2.4 Confidential company information.....	26
5.2.5 Import of articles.....	26
6 Occurrence and use of highly fluorinated substances	27
6.1 General overview	27
6.1.1 Types of PFAS	27
6.1.2 Description of PFA usage.	30
6.1.3 Number of PFAS on the global market	31
6.1.4 Volumes in the EU	32
6.2 Identification of areas of application.....	33
6.2.1 Textiles and leather.....	33
6.2.2 Paper- and food-packaging.....	34
6.2.3 Fire-fighting foam	35

6.2.4	Cosmetic products	38
6.2.5	Household products	40
6.2.5.1	Impregnating agents for textiles	40
6.2.5.2	Paint, printing ink and lacquer	40
6.2.5.3	Cleaning agents and polish	42
6.2.5.4	Non-stick products	42
6.2.5.5	Ski Wax	42
6.2.6	Metal (hard- and decorative-chrome plating)	43
6.2.7	Hydraulic systems in the aviation industry	45
6.2.8	Photographic & Electronic equipment and components	46
6.2.8.1	Electronic equipment and components	46
6.2.8.2	Photographic surface layers	46
6.2.8.3	Photoresistors and anti-reflective coatings for semiconductors	47
6.2.8.4	Market information Photographic & Electronic equipment and components	47
6.2.9	Synthesis chemicals (intermediaries)	48
6.2.10	Other uses	50
6.2.10.1	Medical devices	50
6.2.10.2	Building materials	50
6.2.10.3	Oil- and mining-production	50
6.2.10.4	Plant protection agents	51
7	Market trends	52
7.1	Market history	52
7.2	Conformational changes in PFAS chains	53
7.3	Patent information	54
7.4	The Swedish Products Register	55
7.4.1	Changes over time	56
7.4.2	PFAS in active chemical products	56
7.4.3	In expired chemical products (0-100 kg marketed each year in Sweden)	58
7.5	The European chemicals data base IUCLID	59
8	Alternative substances, materials and technologies	61
8.1.1	Fluorine-free substances	61
8.1.2	Non-chemical technologies	62
8.1.3	Alternatives for specific areas of application	62
8.1.3.1	Textiles and leather	62
8.1.3.2	Paper- and food-packaging	63
8.1.3.3	Fire-fighting foam	63
8.1.3.4	Surface coating of metal (hard- and decorative-chrome plating)	64
8.1.3.5	Hydraulic systems in the aviation industry	64
8.1.3.6	Photographic & Electronic equipment and components	65
9	Discussion and Conclusions	66
10	Bibliography	70
Appendix 1: Abbreviations and explanations		76
Appendix 2: Highly fluorinated substances found on the world market....		78

Summary

Highly fluorinated substances (per- and polyfluorinated alkyl substances, PFAS) are used in many different articles and chemical products due to their attractive properties. They are repellent to water, grease, and dirt, temperature resistant and film-forming. However, other less desirable properties are their extreme persistence in the environment, and that several of them accumulate in living organisms and can be toxic.

The knowledge of the presence and use of highly fluorinated substances is limited and this report is a survey of how these substances are used. The report will be used in future work to prevent additional health and environmental problems with PFAS.

The survey was conducted at the Swedish Chemicals Agency in (the spring) 2015. It is based on information from databases available to the agency (e.g. the Swedish products register and EU databases). Searches were also made in scientific publications and reports as well as lists of industrial chemicals from various countries (mainly from North America and Asia). In addition, information has been obtained from the industry and searches have been made in patent databases. Although all known uses of PFAS are considered in the report, the focus is on those assessed to be most relevant for Sweden. Alternatives to PFAS, alternative materials and methods are also included in the survey.

The highly fluorinated substances have been compiled and grouped and, when possible, related to different uses.

The results of this survey demonstrate that there are probably more than 3,000 commercial highly fluorinated substances in circulation on the global market. The largest group is polymers. Many of the substances have technical qualities with more or less unspecified formulations. We see that the industry has replaced longer carbon chain lengths with shorter ones, mainly six perfluorinated carbons. Information from various patents suggests a strong increase of proposed uses of existing substances in new technical areas. Further, it indicates that the development of new highly fluorinated substances is more moderate.

The survey shows that these substances already today are widely used, from more well-known areas, such as fire-fighting foam, textiles and food packaging to less investigated areas, such as cosmetics, dental restorative materials and dirt-repellent coating for smartphones.

Identified alternatives to PFAS are fluorine-free substances, different materials and alternative techniques. Alternatives could be identified primarily for textiles and fire-fighting foam. Generally, it has been difficult to find alternatives that will match the desired properties of the highly fluorinated substances. This lack of alternatives demonstrates that there is a need for technical development.

Due to significant lack of available information this survey cannot give a complete picture. For example, information on quantities could only be obtained for a few substances. Furthermore, our sources could only give information on uses for about half of the identified substances. This is not surprising, since many of the highly fluorinated substances are entering the EU and Sweden through imports of articles, and for those there are virtually no control.

Another reason for the lack of information is that many highly fluorinated substances are very effective and therefore used in low concentrations to achieve the desired effect. Within REACH there are register requirements for the manufacturers or importers of substances from 100 tonne/year. At low volumes, which can be the case for most PFAS, information

requirements are very low. For quantities below 100 tonne/year (1 tonne/year from June 2018) manufacturers and importers are not required to submit any information at all. In Sweden manufacturers and importers are obliged to register chemical products in the Swedish products register. However, there are in many cases no requirements to notify substances that are added in concentrations below 5 percent, which often is the case for highly fluorinated substances in chemical products.

The results of the survey show that there is a need for increased reporting demands from the industry in Sweden as well as the rest of the EU. Furthermore, we see that there is a need to follow the development of both the known and the less known uses.

Sammanfattning

Högfluorerade ämnen (per-och polyfluorerade alkylsubstanser, PFAS) används i många olika varor och kemiska produkter på grund av sina eftertraktade tekniska egenskaper. De är fett-, smuts- och vattenavvisande, temperaturtåliga och filmbildande. Andra, mindre eftersträvningsvärda egenskaper är dock att de är extremt svårnedbrytbara i miljön, samt att flera av dem ansamlas i levande varelser och kan vara giftiga.

Kunskapen om högfluorerade ämnens förekomst och användning är begränsad och denna rapport är en kartläggning av hur ämnena används. Rapporten ska användas i det kommande arbetet med att förhindra ytterligare hälso- och miljöproblem med PFAS.

Kartläggningen genomfördes på Kemikalieinspektionen under våren 2015. Den är baserad på information från databaser som myndigheten har tillgång till (t.ex. det svenska produktregistret och EUs databaser). Sökningar har även gjorts i vetenskapliga artiklar och rapporter samt listor över industrikemikalier från olika länder (främst från Nordamerika och Asien). Dessutom har information inhämtats från industrin och patentdatabaser. Alla kända användningar av PFAS har vägts in i rapporten. Fokus ligger dock på användningar som bedöms som mest relevanta för Sverige. Rapporten redovisar även alternativ till PFAS samt alternativa material och metoder.

De högfluorerade ämnena har sammanställts och grupperats och, i de fall det varit möjligt, kopplats till olika användningsområden.

Resultatet av kartläggningen visar att fler än 3000 kommersiella högfluorerade ämnen troligtvis finns i omlopp på världsmarknaden. Största gruppen utgörs av polymerer. Många av ämnena är tekniska kvaliteter med mer eller mindre ospecificerade sammansättningar. Vi ser att industrin gått över till ämnen baserade på kortare kolkedjor, främst sex perfluorerade kol. Information från olika patent antyder en stark ökning av föreslagna användningar av befintliga ämnen inom nya teknikområden. Vidare verkar utveckling av nya högfluorerade ämnen uppvisa en mera måttlig utvecklingstakt.

Kartläggningen visar att dessa ämnen redan idag har en bred användning, från mer kända såsom brandskum, textil och livsmedelsförpackningar till mindre undersökta som kosmetika, tandlagningsmaterial och smutsavvisande ytbehandling för smartphones.

Identifierade alternativ till högfluorerade ämnen består av fluorfria ämnen, andra materialval samt alternativa tekniker. Det är främst för textil och brandskum som alternativ har hittats. Generellt har det varit svårt att hitta alternativ som mäter sig med de högfluorerade ämnens eftertraktade egenskaper. Denna brist på alternativ visar på ett behov av teknisk utveckling.

Betydande brist i tillgänglig information gör att denna kartläggning inte ger en heltäckande bild. Exempelvis har information om mängder enbart varit möjlig att få fram för ett fåtal ämnen. Vidare saknas information om användning i våra källor för hälften av de identifierade ämnena. Detta är inte förvånande, då många av de högfluorerade ämnena kommer in i EU och Sverige genom import av varor, och för dessa saknas i stort sett kontroll.

En annan anledning till avsaknad av information är att många högfluorerade ämnen är mycket potenta och därför endast behöver användas i låga koncentrationer. Inom Reach finns krav att registrera ett ämne som tillverkas eller importeras i mängder om minst 100 ton per tillverkare/importör och år i EU. Vid de låga volymer som det kan handla om för PFAS är krav på information mycket låga. För mängder under 100 ton/år (1 ton/år fr.o.m. juni 2018) behöver tillverkare och importörer inte registrera någon information alls. Även det svenska produktregistret har liknande begränsningar i registreringsplikten. Här finns i många fall inget krav på

att anmäla tillsatämnen som används i halter lägre än 5 procent, något som ofta är fallet för högfluorerade ämnen i kemiska produkter.

Resultaten från kartläggningen visar att det finns behov av ökade inrapporteringskrav från industrin i så väl Sverige som resten av EU. Vidare ser vi att det finns behov av att bevaka utvecklingen för såväl de mer kända som de mindre uppmärksammade användningarna.

1 Background

Highly fluorinated substances (perfluorinated and polyfluorinated alkyl substances, PFAS) are used in many different chemical products and articles because of their desirable properties and as a result they find their way into the environment. The substances have extremely poor environmental biodegradability (persistent, P) and many of them accumulate in living organisms (bioaccumulating, B) and are toxic (T). There is a lack of overall knowledge of highly fluorinated substances and to prevent further pre-existing health and environmental problems from building up and persisting for a long time, it is important to map out the occurrence and use of these substances.

We know that the use of highly fluorinated substances in fire-fighting foam is particularly problematic as it involves direct release into the environment. There are also other possible sources of the highly fluorinated substances that are found in humans and in the environment. Highly fluorinated substances can cause very long term problems in the environment by contaminating groundwater and subsequently drinking water. It is suspected that drinking water with high levels of these substances can increase the risk of adverse health effects, affecting for example the thyroid gland, the liver, fat metabolism and the immune system.

In the government directive M2015/375/Ke, *Action plan for a toxin-free everyday environment*, the Swedish Chemicals Agency has been instructed to develop a programme of measures for dealing with highly fluorinated substances. In implementing this task we have carried out a survey of how highly fluorinated substances are used and what alternative substances and materials are commercially available. The survey will be used as a basis for other projects within the programme of measures for highly fluorinated substances.

There is only limited knowledge of the occurrence of PFAS in Sweden and the EU. One reason is that many PFAS are very potent and are therefore used at low concentrations to achieve the desired effect. These low concentrations can be below the level at which REACH requires information to be registered and therefore do not permit hazard and risk assessments. For quantities below 100 tonne/year¹ manufacturers and importers are not required to register any information at all.

There are various phases in the life cycle of highly fluorinated substances (Figure 1) when release can occur, with exposure of humans and the environment. The first is the manufacture of the substance itself, after which there are various processing stages in which the substance may be used (such as process chemicals in the production and formulation of chemical products, for example, fire-fighting foam). This survey focuses on final stage uses, i.e., the final use of a chemical prior to its entering the waste management stage, as this is deemed to be the most relevant to Sweden. However, use as a starting material in chemical synthesis (polymer production) is described in section 6.2.9. The waste management stage is an important part of the life cycle. Bearing in mind that all highly fluorinated substances (directly or indirectly) are very persistent and in some cases also bioaccumulating and toxic, waste from various applications may be highly relevant with regard to exposure. Incineration at high temperatures (at least 1100°C) generally breaks down PFAS to carbon dioxide and hydrogen fluoride (Sandblom 2014, UNEP 2012). However, it is not known what is produced at lower temperatures.

¹ This will be reduced to 1 tonne/year from the start of June 2018.

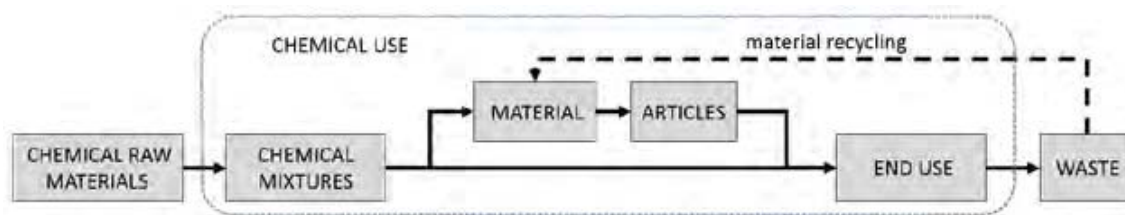


Figure 1: Life cycle of chemicals in the community.

2 The assignment and its scope

The survey looks at highly fluorinated substances, the definition of which, as used in this study, was derived from the conventionally accepted definition of perfluorinated and polyfluorinated alkyl substances, PFAS (OECD 2013). Added to these are those perfluorinated substances which, though lacking functional groups, are regarded as extremely persistent and have similar areas of application (cosmetics raw materials, emulsifiers, solvents, refrigerants).

The survey includes known highly fluorinated substances on the world market as well as known alternatives. This is based on information from the literature and from those databases to which the Swedish Chemicals Agency has access.

This survey includes both short- and long-chain PFAS. Using this definition there are a very large number of highly fluorinated substances on the world market. A large group of these (>1000) includes only short fragments of perfluorinated carbon, principally the CF_3 -group (see Figure 2). Compounds with CF_3 -groups are broken down to perfluoroacetic acid, which is much less persistent than other PFAS (Benskin 2015), and can also be formed naturally in the environment. The CF_3 -group has been assessed to be of less relevance and has therefore not been included in this survey.

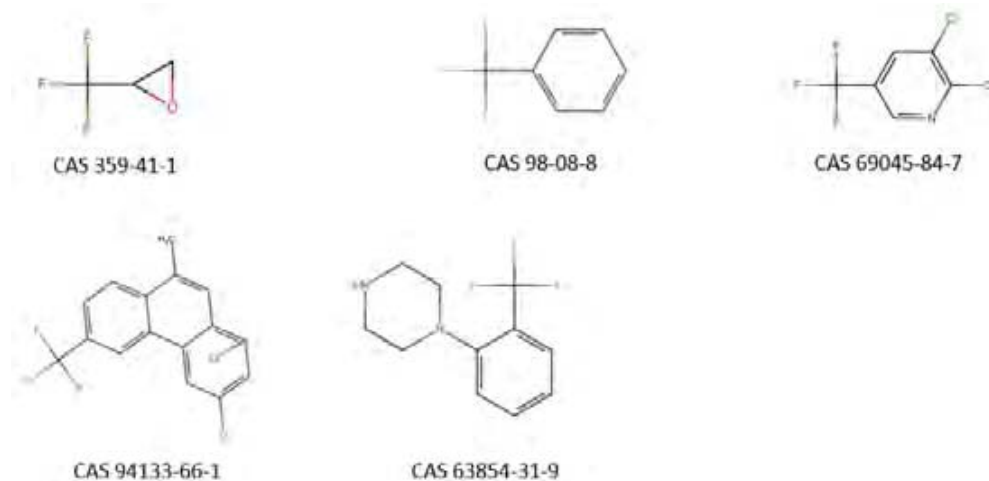


Figure 2: Examples of substances that only have " CF_3 " and are therefore not included in the survey.

A group of PFAS with short perfluoro chains which by contrast have been included in the survey is perfluoro ethers, in which several short perfluoro chains are linked to each other via oxygen bridges (so-called ether bridges, see Figure 3). If there are several oxygen bridges in the same chain, the substance is termed a perfluoropolyether. These have been included in the

survey as it is suspected that they have similar properties, including persistence, to PFAS with longer carbon chains (Gomis et al. 2015).

Perfluoro alkylether (e.g, 2 C3s):	$F_3C-CF_2-CF_2-O-CF_2-CF_2-CF_3$
Perfluoro alkylpolyether (>2 perfluoro chains):	$F_3C-CF_2-CF_2-O-CF_2-CF_2-O-CF_2-CF_3$
Examples of relevant perfluoro alkyl chains: (if $n > ca. 20$, the molecule is regarded as a polymer)	$-[CF_2-CF_2-CF_2-O]_n-$ $-[CF_2(CF_3)-CF_2-O]_n-$ $-[CF_2-CF_2-O]_n-$ $-[CF_2-O]_n-$

Figure 3: Other types of perfluoro ethers that are described in the survey.

The survey focuses on chemical products and articles in Sweden in which PFAS can be found. As it can be assumed that there are similar uses in other EU countries and non-EU countries, information from other countries is to a certain extent included in the assignment. As PFAS can be incorporated into polymers used in the production of articles imported from other countries outside the EU, PFAS marketed in other parts of the world are included in this survey.

Uses considered in this report are primarily end uses but the use of PFAS as starting materials in polymer production is also described. However, the waste produced by this end use is not included in the survey.

To the extent that information was available on how much PFAS are used, quantities have been recorded (however, the information is only available for a few substances and applications).

There are several studies which have analysed PFAS in various chemical products and articles in different markets. A number of these are mentioned in this survey. However, only a few substances have been analysed (mainly those for which chemical reference substances are available).

The survey includes no exposure calculations or risk assessments. This also applies to the various alternatives mentioned in the report.

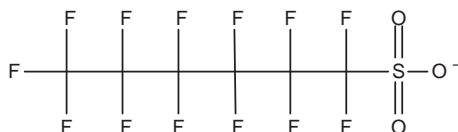
3 Terminology, manufacture, function and abbreviations

3.1 Perfluorinated and polyfluorinated alkyl substances (PFAS)

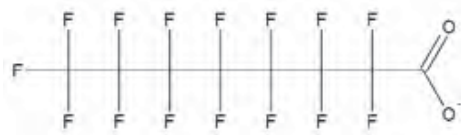
Highly fluorinated substances belong to an extensive group of substances which can be divided into several sub-groups, some of which were reported in OECD (2013). To begin with, polymers and non-polymers are normally separated and these can then be divided into the sub-groups listed below.

3.1.1 Non-polymers

- Fully or partially fluorinated carbon chains that are usually² bound to a functional group³ (n = number of perfluorinated carbons, CX=PFAS with X perfluorinated carbons)
 - Perfluoroalkyl sulfonic acids (PFSA)*: e.g., PFHxS and PFOS
 - long chain $n \geq 6$, PFHxS (C6) and longer.
 - short chain $n < 6$, e.g., PFBS (C4).



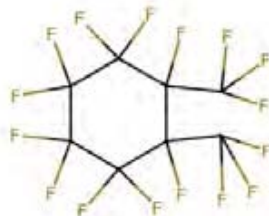
- Perfluoroalkyl carboxylic acids (PFCA)*: e.g., PFOA
 - long chain $n \geq 7$, PFOA (C7) and longer.
 - short chain $n < 7$, e.g., PFBA (C3), PFHxA (C5).



- Precursors to PFSA and PFCA*: such as fluorotelomers, e.g., 6:2 FTOH and 8:2 FTS. Fluorotelomers consist of a carbon chain that is not fully fluorinated and a functional group (6:2 indicates that 6 carbons are perfluorinated, 2 are non-fluorinated). These can be broken down to PFCA in the environment.



- Branched and/or cyclic perfluorocarbon chains*: e.g., Decafluoro-5,6-bis(trifluoromethyl)cyclohexane.

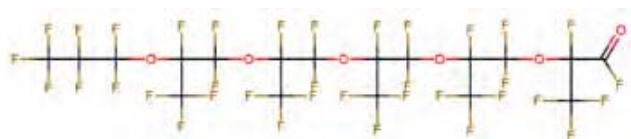


- Perfluoro ethers*: ethers can have one or more oxygen bridges (Figure 3). Those with the most bridges are so long that they can be defined as polymers.

² Fluoro waxes consist solely of a perfluorinated carbon chain and are included in this survey.

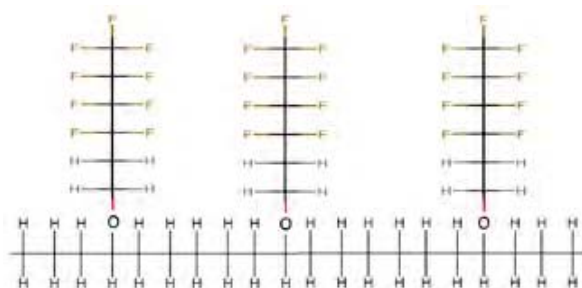
³ By functional group we mean a group of atoms which has a major effect on the molecule's properties. Examples of functional groups are an -OH bound to a hydrocarbon chain (this gives an alcohol) and the carboxyl group -COOH which gives a carboxylic acid.

The limit for applying the term polymer is uncertain but it could be greater than 20 (Posner 2015). In the literature, ethers with more than one oxygen bridge are termed perfluoropolyethers, PFPE (Buck et al. 2011). It is mainly the low molecular weight polyethers that have been recorded in this survey. Polyethers have two or more perfluorinated methyl-, ethyl- and/or propyl chains, linked together by oxygen bridges (see Figure 3), e.g., 3,6,9,12,15-Pentaoxaoctadecanoyl fluoride, 2,4,4,5,7,7,8,10,10,11,13,13,14,16,16,17,17,18,18,18-eicosafluoro-2,5,8,11,14-pentakis(trifluoromethyl)- (CAS no. 13252-15-8).



3.1.2 Polymers

- *Side-chain fluorinated polymers:* Polymers with fluorinated side chains. Side-chain fluorinated polymers comprising polyfluorinated (and possibly perfluorinated) side chains. These can be broken down to PFCA.



- *Fluoropolymers:* Polymers with a fluorinated backbone (the backbone consists solely of carbon atoms to which fluorine is bound).



Examples of common fluoropolymers are:

- Polytetrafluoroethylene (PTFE) which is used in Teflon®.
- Polyvinylidene fluoride (PVDF) which is used in electronics, for example, loud speakers.
- Fluorinated ethylene propylene (FEP) which is mainly used in cables, for example, in computers.
- Perfluoroalkoxyl polymer (PFA) which is used, for example, in cable insulation that requires unusual thermal, chemical, etc., properties.

Fluoropolymers are not produced from PFCA nor from their precursors. However, variants of different PFCA are used as process chemicals in

manufacture and the finished product may contain residues of these substances.

3.2 Manufacture and technical quality

As stated earlier in section 3.1 the highly fluorinated substances group is complex and includes several different substance groups. To obtain a better understanding of this, this section describes the underlying chemistry on which these substances are based as well as the two main manufacturing processes.

The highly fluorinated substances are based on two structural components:

- 1) a hydrophobic (water repellent) tail which consists of a perfluorinated part and
- 2) a hydrophilic (water soluble) component.

In some cases there is also a "spacer" group which links these together (Figure 4). These three components together create a substance with many beneficial functions. The water-soluble component can be made up of a wide range of different groups (which means that the highly fluorinated group has a lot of development potential): a) anionic, such as carboxylates, sulfonates and phosphates, b) cationic, such as quaternary ammonium, c) non-ionic, such as acrylamide oligomers and polyethylene glycols, and d) amphoteric, such as betaines and sulfobetaines (Buck et al. 2012).

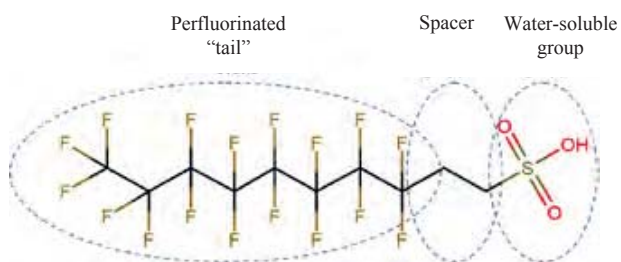


Figure 4: Schematic diagram of the formation of fluorosurfactants.

Highly fluorinated substances are mainly produced via two different processes: electrochemical fluorination, ECF and telomerization (Buck et al. 2011). The highly fluorinated substances formed can then undergo further reactions to produce polymers and various derivatives.

3.2.1 Electrochemical fluorination, ECF

Electrochemical fluorination, ECF is a method which major manufacturers in the west are increasingly moving away from (Buck et al. 2011). The method involves dissolving, in liquid hydrogen fluoride (HF), the organic chemical raw material (for example, octane sulfonyl fluoride, C₈H₁₇SO₂F) that is to be fluorinated and passing an electrical current through the solution (electrolysis). This causes all the hydrogen atoms (H) to be replaced by fluorine atoms (F). The process is very powerful and results in a mixture of linear and branched perfluorinated isomers with different carbon chain lengths. The relationship between the amounts of linear and branched perfluorinated carbon chains that are formed during ECF varies, depending on how well the process is controlled, but roughly 70-80 percent is linear and 20-30 percent branched. ECF with C₈H₁₇SO₂F yields various perfluorinated substances which in turn can react further; for example perfluorooctane sulfonyl fluoride (POSF,

$C_8F_{17}SO_2F$) which is the starting material for manufacturing PFOS. The major fluorochemical manufacturers (DuPont, 3M and BASF) previously used ECF to produce perfluorinated alkane sulfonyl derivatives and products from these, principally those based on six and eight (though also ten) perfluorinated carbon atoms. PFOA has also historically been manufactured using this process. Nowadays ECF is not used to the same extent and is based on perfluorobutane, therefore C4 rather than C8 (Buck et al. 2011). It is not clear how extensively the ECF process is used nowadays; there is information on its use in at least three facilities in the EU (ECHA 2015).

3.2.2 Telomerization

Telomerization is now the most commonly used process for manufacturing highly fluorinated substances (Wang et al. 2014). The first step involves the reaction of a perfluoroalkyl iodide ($C_mF_{2m+1}I$, PFAI, most commonly PFEI), termed a telogen, with a tetrafluoroethylene iodide ($CF_2=CF_2$, TFE), termed a taxogen. The telogen and the taxogen react to form a mixture of perfluoroalkyl iodides with longer perfluorinated chains, $C_mF_{2m+1}(CF_2CF_2)_nI$ (termed Telomer A). The product mixture is often allowed to react further in a second step by adding ethylene to form $C_mF_{2m+1}(CF_2CF_2)_nCH_2CH_2I$ (termed Telomer B). Telomer A and Telomer B then serve as intermediates that are used to manufacture more building blocks which then react further to produce a large group of fluorotelomer based surfactants and polymers (Buck et al. 2011). When a linear telogen and taxogen react, the product is exclusively linear. If a telogen that is branched and/or has an odd number of carbon atoms is reacted with a taxogen, the product is branched, with or without an odd number of carbon atoms. However, it is uncertain how marketable such branched variants are.

3.2.3 Technical quality

The technical quality depends on the manufacturing process for the highly fluorinated substances. In the manufacture of C6 (substances with six perfluorinated carbons), C8 (substances with eight perfluorinated carbons) are produced as by-products. The intermediate C6 product contains around 20 percent C8 which to a large extent is removed before the end product is brought onto the market. According to industry residual content is less than 0.01% of C8 in the C6 end product (European Commission 2014). However, there are studies which show that C6 products have large contents of both C8 and longer carbon chains. In some cases the content of C8 can be more or less higher than that of C6 despite the fact that it is marketed as "C6" (SUPFES 2015). C4 (substances with four perfluorinated carbons) content has also been found in C6 products, though in smaller quantities. Similarly other lengths of carbon chains have been found in C8 products. A previous study from the Swedish Chemicals Agency (2006) shows that telomers are produced and marketed commercially as mixtures of different chain lengths of perfluorinated carbons.

3.3 Properties and functions

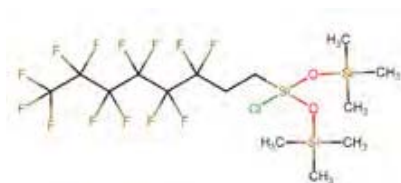
Highly fluorinated substances have been produced and used since the 1950s because of their special properties. The substances have high thermal stability, are fire resistant and have film-forming properties. They are repellent towards water, dirt and grease and are also electrically stable. They are used in many different applications, ranging from industrial use to consumer household use. As PFAS are very potent substances low concentrations will usually achieve the desired effect.

Moreover, the more or less fully fluorinated single carbon chains with a single functional group (similar to PFOS, PFOA) have PFAS chains incorporated as part of the larger molecule. One aim is to combine the properties of PFAS with other properties that will allow the substance to be used in new technical concepts. Examples of such structures are:



2-Propenoic acid, 2-[[[(2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,11)-eicosaflluoroundecyl)sulfonyl]methylamino]ethyl ester

(CAS no. 66008-68-2)



Trisiloxane, 3-chloro-1,1,1,5,5,5-hexamethyl-3-(3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl)-

(CAS no. 94237-06-6)



1-Hexanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,6-tridecafluoro-N-[2-(phosphonoxy)ethyl]-

(CAS no. 67969-65-7)



1-Octanesulfonamide, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-(phenylmethyl)-

(CAS no. 50598-29-3)

3.4 Abbreviations and explanations

See Appendix 1

4 Legislation and voluntary agreements

Only a few highly fluorinated substances are currently governed by regulations, mainly PFOS (perfluorooctane sulfonate).

4.1 The Stockholm Convention

PFOS and around a hundred substances that can be broken down to PFOS were nominated by Sweden in 2005 for a global phasing out by listing them under the Stockholm Convention on Persistent Organic Pollutants, POPs. In a decision by the parties to the Convention⁴ in 2009 PFOS and PFOS-related substances were included in the Stockholm Convention's Annex B for global regulation of production, use and also waste management. However, in the regulations there are 20 permitted uses that are regularly reviewed. In 2015 a conference of the parties to the Convention carried out the first overhaul of these exemptions for PFOS use which are valid until 26 August 2015. This resulted in half the twelve time-restricted exemptions being cancelled for all parties. This means that for the following areas the global use of PFOS will cease no later than 2015: carpets, leather articles, textiles and fillers, paper and packaging material, and rubber and plastics.

Only two of the 179 parties have registered a need for the remaining time-restricted exemptions. These are: photomasks for semiconductors and liquid crystals for the manufacture of monitors, decorative chrome plating and hard chrome plating in closed-loop systems, electronic components for certain colour printers/photocopiers, insect bait for controlling red imported fire ants and termites, and chemical enhanced oil recovery.

With regard to the eight exemptions that are not time-restricted the conference of the parties decided only on continuing registration and follow up. Each party can decide for itself whether to cancel its registration of the use of PFOS in: photographic film, etchants for semiconductors and ceramic filters, hydraulic oils for the aviation industry, certain medical equipment, mist suppressants for hard chrome plating in closed-loop systems, fire-fighting foam and insect bait for controlling two species of ants. The overhaul carried out at the conference of the parties in 2015 showed that there are alternatives for fire-fighting foams, etc.

The regulation of PFOS under the Stockholm Convention has been implemented in the EU by the so-called POPs regulation⁵. In the EU some of the globally permitted (not time-restricted) uses have been withdrawn but some remain, including those for photographic film, hydraulic oils for the aviation industry, and mist suppressants for hard chrome plating in closed-loop systems. However, according to a study carried out in 2015 (European Commission 2015a) the only application for which there is still a need in the EU is in hard chrome plating.

The EU intends in 2015 to nominate the substance PFOA (perfluorooctanoic acid) for global phasing out by listing it under the Stockholm Convention (European Council 2015).

⁴ The Stockholm Convention involves parties from 179 countries.

⁵ Regulation (EC) No 850/2004 of the European Parliament and of the Council of 29 April 2004 on persistent organic pollutants and amending Directive 79/117/EEC.

4.2 EU regulations

REACH⁶ is the most important regulatory framework for chemicals in the EU. At present the regulation does not impose any restriction on PFAS but a process is underway to restrict the use of PFOA through a supplement to Annex XVII of the REACH ordinance. If the proposed restriction is accepted a ban will be imposed on the manufacture and the release onto the EU market of PFOA and substances that can be broken down into PFOA, as well as the use of any of these in manufacturing processes or articles.

Many perfluorinated long-chain carboxylic acids are already regulated or about to be regulated under the REACH system in the EU. Sweden is actively involved in this work, for example, the Swedish Chemicals Agency has submitted proposals for harmonized classification of PFNA (perfluorononanoic acid) and PFDA (perfluorodecanoic acid), for which we, together with Germany, have submitted (for PFNA) and will submit (for PFDA) proposals for addition to the REACH candidate list. PFNA is therefore expected to appear on the candidate list at the end of 2015 and PFDA during 2016. We are also examining the possibility of placing PFHxS (perfluorohexane sulfonate) on the candidate list. PFHxS is a shorter version of PFOS.

The REACH candidate list currently includes PFOA, the ammonium salt of PFOA and four perfluorinated carboxylic acids with longer carbon chains (Table 1). If a substance appears on the candidate list this does not mean that its use is restricted. However it is subject to an information provision requirement in accordance with Article 33 of REACH. This stipulates that a manufacturer, importer or distributor of a product containing more than 0.1 weight percent of substances on the candidate list is required to provide information on these substances. Substances on the candidate list may in the long term become the subject of the REACH authorization process.

Table 1: PFAS on the candidate list spring 2015.

Substance	CAS no.
Perfluorooctanoic acid (PFOA)	335-67-1
Ammonium pentadecafluorooctanoate (APFO)	3825-26-1
Heneicosfluoroundecanoic acid (PFUnDA)	2058-94-8*
Heptacosfluorotetradecanoic acid (PFTeDA)	376-06-7*
Pentacosfluorotridecanoic acid (PFTrDA)	72629-94-8*
Tricosfluorododecanoic acid (PFDoDA)	307-55-1*

* Perfluoro carboxylates for which there is a lack of information on areas of use.

The substance is not registered under ECHA.

In the current situation only PFOS and PFOA (and some of their related substances) have harmonized classification and they are classified as, amongst other things, reproductively toxic, carcinogenic and harmful to the thyroid.

PFOS comes under the Water Framework Directive⁷, which means it is a priority substance with environmental quality standards that are used to establish chemical status. If

⁶ Regulation (EC) No. 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH).

⁷ Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for Community action in the field of water policy, Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy.

environmental quality standards are exceeded then good chemical status in surface water bodies is not achieved and measures must be taken. PFOS is also subject to EU regulations governing the export and import of hazardous chemicals⁸. The regulations do not impose any restrictions on the use of the substance but do contain certain requirements for information concerning export and import.

PFAS are also governed by an EU regulation concerning plastic material intended to come into contact with food⁹. The regulation includes a list of substances that can be used (the so-called Union list). The list also states the manner in which the substances may be used. PFOA is one example of the PFAS that are included.

In addition there are a number of regulatory frameworks which ban substances according to their classification, for example, the regulatory framework for medical devices which regulates the use of CMR substances. This means that PFAS can be regulated indirectly, depending on classification.

The regulation of cosmetic products has been dealt with in the Swedish Chemical Agency's report "Bättre EU-regler för en giftfri miljö" (Improved EU-rules for a non-toxic environment) (Swedish Chemicals Agency 2012). The report states that cosmetics regulations are aimed at protecting consumers from health risks associated with the use of cosmetics, but the regulations do not deal with environmental aspects, nor with health risks mediated through the environment (for example, drinking water). The cosmetics regulations state that such risks should be dealt with through the REACH regulation.

4.3 Voluntary agreements

At the start of 2006 the 2010/2015 PFOA Stewardship Program (US EPA 2015) was launched. This is a voluntary agreement between industry and the US Environmental Protection Agency aimed at reducing and eliminating industrial emissions and PFOA content in products. The agreement also covers substances that can be broken down to PFOA as well as related substances with longer carbon chains. Through an incremental reduction of emissions and content, there will be a complete phasing out of these substances by the end of 2015. DuPont, 3M, Solvay and BASF are amongst the companies taking part. There has been a significant reduction of PFOA and the companies have also reported that there will be no problem in entirely phasing out PFOA within the specified time scale. At the same time as industry has implemented these changes, an increase has been observed in the use of highly fluorinated substances with shorter carbon chains (principally with six perfluorinated carbons but also with four carbons).

5 Survey methodology

The survey was developed from a preliminary study carried out by the Swedish Chemicals Agency in spring 2014 and comprises two parts, one of which concerns the occurrence and use of highly fluorinated substances which are described in section 6, and the other of which concerns the occurrence and use of alternative substances, materials and technologies which can be found in section 8.

⁸ Regulation (EU) No. 649/2012 of the European Parliament and of the Council concerning the export and import of hazardous chemicals.

⁹ The European Commission's Regulation (EC) No. 10/2011 on plastic materials and articles intended to come into contact with food.

5.1 Highly fluorinated substances and alternatives on the market

The work of this survey is based on information from databases that the agency has access to (e.g., the Swedish Products Register and the ECHAS database of registered substances). An important limitation for these sources is the fact that the material may be confidential. This means it is not always possible to communicate all data in detail. In addition, there is a lack of information on substances that are distributed in smaller volumes: in the Products Register less than 100 kg per product and year and under REACH (IUCLID) less than 100 tonne per company and year. In many cases there is no requirement to declare substances to the Products Register which are added at concentrations below 5%¹⁰, which is often the case with PFAS in chemical products.

Searches have also included scientific articles and various reports on, and lists of, industrial chemicals from other countries (mainly North America and Asia). Information from industry has also been examined.

All known uses have been recorded but the focus has been on those that are most relevant to Sweden. Information on substances has been compiled, grouped and, where possible, linked to different areas of application.

Substances manufactured in Asia and North America have been included, mainly because they can enter the EU and Sweden via articles, with importers expected to have difficulties in obtaining information on any PFAS content.

5.1.1 The work process

A screening of available information was carried out to gain an awareness of the great variety of highly fluorinated substances on the Swedish market. The work began with an initial inventory of known substances on the world market (Figure 5). Information on which articles and chemical products PFAS end up in is often not found in open source literature. As the majority of those substances that are found lack all types of function descriptions, these have been deduced instead from other information such as chemical structure, chemical and physical properties, and structural analogy with known substances. Possible areas of application have been assumed from technical function, thus giving an indication of occurrence in consumer products (incl. synthetic chemicals).

¹⁰ Only for substances with a high hazard classification (CMR) and/or with a CSR that according to REACH needs to be declared at lower concentrations.

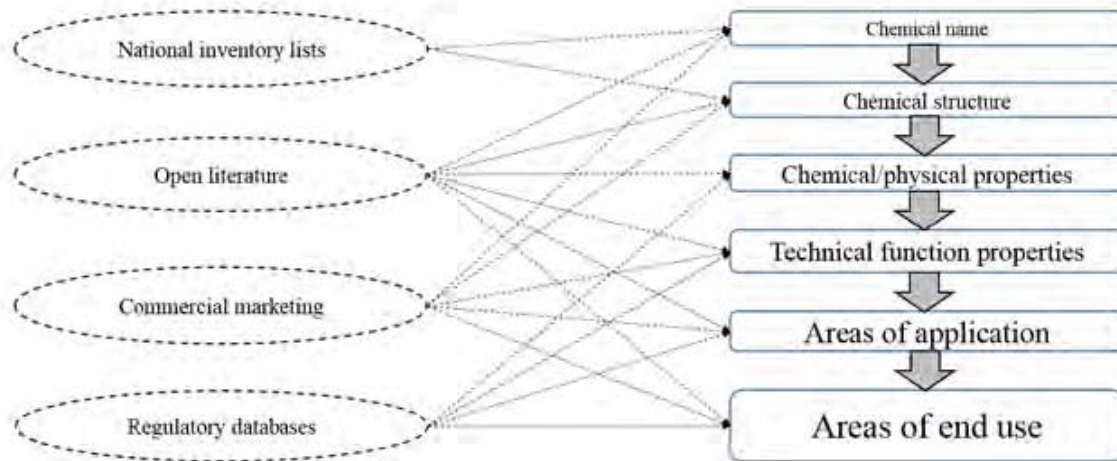


Figure 5: The work procedure for identifying highly fluorinated substances (grey arrows) together with the main types of information sources.

Official national lists of industrial chemicals¹¹ ("Inventory lists") have been an important source of information for the international survey. However, behind the lists there is a substantial amount of hidden data because regulations usually give suppliers of newly developed substances the right to withhold the exact identity of these substances from publication in order to protect the company from competitors. Therefore we also attempted to discover additional substances on the international market by looking through the marketing material of various companies.

Searches have also been made of various regulatory databases, such as the Products Register (covering Swedish chemicals management), the IUCLID database (substances registered under REACH) and CosIng (the EU's cosmetics database).

Information on alternatives (substances and materials) to highly fluorinated substances is based on various reports and documentation from industry. Available information on substances/substance groups, technologies and materials has been recorded for various areas of application.

¹¹ Sweden, the EU, the USA, Canada, China, Japan, South Korea, New Zealand and the Philippines (downloadable from the internet).

5.1.1.1 Regulatory databases

The Products Register

The Swedish Products Register covers a substantial part of Swedish management of chemical products. Use data has been stored since 1992 and covers Swedish products that are marketed in Sweden at more than 100 kg per year. However, information on composition for substances without hazard classification only needs to be recorded if the content in the product is above 5 percent. Most highly fluorinated substances lack hazard classification and, if they are used at low concentrations, are not recorded in the Product Register. The search for use information has been carried out for both commercially active products and expired products. Unlike other chemical registers the Swedish Products Register also includes polymers. The register only covers the use of PFAS in chemical mixtures. However, indications of usage as raw material for articles can be recorded indirectly if the articles were manufactured in Sweden (via sector and function codes in the Products Register). For “commercially active” products on the Swedish market the last year for which data can be searched on the register was 2013.

The IUCLID database

IUCLID is a regulatory database¹² which contains information on industrial chemicals that are registered under REACH. It contains substances that are classified as hazardous or have been brought onto the EU market in a quantity of at least 100 tonne per company per year (the limit will be reduced to 1 tonne in 2018). In the first instance the non-confidential information has been covered by the survey.

National inventory lists

National authority inventory lists (“regulatory inventory lists”)¹³ have been used to identify which chemicals are found in various markets throughout the world. These mainly cover industrial chemicals. The information available on these lists is chemical names and various identity numbers (usually CAS number). This is often enough to identify which are highly fluorinated substances. Searches have been carried out of inventory lists from the EU (EINECS, as well as substances pre-registered under REACH), the USA (TSCA), Canada (DSL), China (IECSC), Japan (ENCS), Korea (KECI), the Philippines (PICCS) and New Zealand (NZIoC).

The EU's Classification and Labelling Inventory database

The hazard classification of chemicals is stored on a publicly searchable database called “C&L Inventory”¹⁴. This contains around 130,000 substances. Highly fluorinated substances that have only been identified in this database have not been included with those that are “available on the market” but have been dealt with separately. The reason is that it also contains substances that are still undergoing research and development.

The EU's cosmetics database

On its database CosIng the European Directorate General for Health and Food Safety records information on substances that may be found in cosmetics (CosIng 2015). The database is available on the internet. It lists, amongst other things, the so-called INCI name which will appear in the list of contents printed on the cosmetic products. The database also contains more detailed information on the chemical identity and function(s) of the substances.

¹² <http://ECHA.europa.eu/information-on-chemicals/registered-substances>

¹³ http://www.cirs-REACH.com/Inventory/Global_Chemical_Inventories.html

¹⁴ Included here are both harmonized classification and the company's own classification.
<http://ECHA.europa.eu/information-on-chemicals/cl-inventory-database>

Patent information

Searchable patent information includes detailed descriptions of chemicals and their intended use. However, a patent does not constitute proof that a proposed use will be commercialized. Nevertheless it does contain valuable technical information that can clarify the scanty information obtained from other sources. A patent usually consists of a very comprehensive body of text. Each patent should therefore always include a brief summary. This survey uses the database of the United States Patent and Trademark Office, USPTO¹⁵. This was chosen because it represents a large and strategic market (in which patents are sought from all over the world). In addition, the database has a flexible search engine. The search functions "date search" and "indexed text search" were used.

As patents can be searched back in time (>1760s) it has been possible in patent searches to determine the trends over time in perfluoro technology. By carrying out retrospective searches it is possible to determine when a chemical first turned up in a patent and in how many patents certain words appeared over a particular time period. The text fragment "perfluoro" is often used in the English language technical literature in which the use of highly fluorinated substances is mentioned. The fragment "perfluoro" was therefore chosen for searching patent databases. Text searches were carried out on two levels: in the abstract text and in whole body of the text. If "perfluoro" was found in the summary it was assumed that the patent focused on the development of perfluoro technology; for example, the development of new substances, polymers or materials. If instead "perfluoro" was found in the full body of text it was assumed that the patent concerned the use of existing perfluorinated substances on the market in new areas of application. Whole text searches also included summary texts. However, this overlap was assessed to be negligible as it was estimated that it did not exceed 4 percent of cases. This search strategy should only be regarded as a preliminary screening of trends. One restriction in the choice of a name fragment is that in principle it should also include substances with only one perfluorinated carbon (which have been excluded from the survey). However, test searches of the database showed that such substances did not occur very often. For a more reliable assessment one also needs to analyse and categorize each individual patent.

5.1.1.2 Scientific literature

Inventories have also been made of use descriptions in scientific articles, regulatory reports and industry documentation. Posner et al. (2013) have compiled data to obtain an overview of which PFAS are found in various applications and have surveyed usage in the Nordic countries. In many studies the focus has been on PFOS and PFOA but Posner et al. (2013) have taken a broad view in an attempt to include all PFAS on the Nordic market. The work with the Stockholm Convention includes reports which describe different uses, such as UNEP/POPS/POPRC.9/INF/11/Rev.1 (2013) and the European Commission (2015a). Another example is OECD's and UNEP's global perfluorinated and polyfluorinated chemical group which in 2013 produced a synthesis paper on highly fluorinated substances (OECD 2013).

5.1.1.3 Company information

The marketing material of chemical companies has been used as a complementary source of information on chemical usage. A number of publicly searchable databases have been used,

¹⁵ <http://patft.uspto.gov/netahtml/PTO/index.html>

including LockChem¹⁶, ChemNet¹⁷, ChemicalBook¹⁸, Made-in-china¹⁹ and AgenaChemical²⁰.

Different branches of the chemical industry in the EU have compiled lists of substances in the various sectors. This survey employs an inventory of chemicals that were used in printing inks for printing on food packaging (EuPIA 2013).

To some degree the age of a substance on the global market can be estimated from the date when the substance assigned to an international identity number (CAS no.). This can be sought from the registry management organization Chemical Abstract Service²¹. This survey instead applied a simplified method based on the fact that the length of the CAS number increases with the time of registration. This relationship is shown to be linear from around the year 2000. A simple equation was then used to calculate the registration years during the period 2000 to 2014²². However, the registry date can in individual cases sometimes be misleading. For example, deviations can arise when old substances are re-registered and where the manufacturer has delayed for several years before obtaining a CAS number (e.g., to avoid publicity). The method works best when screening a large number of substances.

5.2 Uncertainty in gathered information

5.2.1 Substance identification

Most information databases which contain chemically related use information can normally be searched using the substance's CAS number. In many cases companies communicate substance information without attaching the CAS number. This applies to marketing, safety data sheets and registration with various authorities. As a result an unknown number of PFAS have not been picked up in this survey. A rough estimate has therefore been made in this survey of how many PFAS on the world market missing CAS numbers. This has been carried out using information on substances registered with the European Chemicals Agency's (ECHA's) IUCLID register and with the EU's cosmetics database, CosIng. Both registers are based on legislation which requires the reporting of all contained components. The chemicals reported here are given an unambiguous chemical identification. It is expected that the CAS number will be included if it is available. It is therefore possible to make a rough estimate of the number of "hidden" substances from the number of registered PFAS which have no CAS number.

Many PFAS are not pure substances but isomer mixtures. In practice they are mixtures of similar PFAS. Normally the length of the perfluorinated chain varies and/or the chain is to a greater or lesser degree branched. The chemical name does not always indicate whether a PFAS is an isomer mixture. Also, it usually does not indicate the dominating chain length. Overall, isomer mixtures create significant uncertainty with regard to what substance is being used.

¹⁶ <http://www.lookchem.com>

¹⁷ <http://www.chemnet.com>

¹⁸ <http://www.chemicalbook.com>

¹⁹ <http://www.made-in-china.com>

²⁰ <http://www.angenechemical.com>

²¹ <http://www.cas.org>

²² CASno (without hyphen) = 262133 * registration date (Excel's data format) + 9E+09. When applied to the period 2000-2014, gives a precision of R²=0.9994.

5.2.2 Assessment of end use

For PFAS where the CAS number is available it has been possible to carry out database searches of different markets. However, there was only a very sparse amount of available information on how the substances were used. Possible areas of application can nevertheless be deduced on the basis of chemical structure and similarity with other PFAS with known uses. Yet there can be large variations in uncertainty. The large number of identified substances has not permitted any more detailed analysis of the end uses of PFAS.

5.2.3 The limits of notification requirements

It is because PFAS have such high potency that information in various regulatory substance- and product-registers on how they are used is conspicuous by its absence. High technical effectiveness means that only very low concentrations need to be added, whereas in many cases requirement for registration depends on content or quantity. Only industrial semi-manufactures and concentrates are recorded, while end-user products fall outside the regulatory framework.

5.2.4 Confidential company information

Another difficulty with PFAS is that they are relatively new on the international market. The more recently a substance has appeared on the market the more concerned the manufacturer is over information on its molecular structure and usage becoming known to competitors. In many cases manufacturers regard the content of fluoro ingredients as trade secrets and therefore do not always apply for patents for their products. However, they may consider releasing information in special cases where a confidentiality agreement is involved.

5.2.5 Import of articles

Many PFAS uses involve the manufacture and treatment of solid materials. A major part of the materials and articles consumed in the EU are manufactured outside the EU. As a whole this leads to a great deal of uncertainty over the occurrence of PFAS in imported articles (e.g., textiles). The reason is that the EU's chemicals legislation is not totally appropriate for imported articles. Naturally, the fact that importers of articles do not normally have focus/expertise in the field of chemicals means even greater uncertainty.

6 Occurrence and use of highly fluorinated substances

Summary of the Occurrence and use of highly fluorinated substances

- There are more than 3000 commercial PFAS on the world market.
- A substantial proportion of them do not have a CAS number.
- The largest group is polymers (mostly acrylate based).
- Isomer mixtures make up more than 14 percent of PFAS (C8-14 and C4-8 are the most common).
- Information on quantities is seldom available.
- Use in the EU currently involves mainly chains with six perfluorinated carbons.
- PFAS have many different areas of application.
- As the substances are highly effective, only low concentrations are needed in products.
- There is no usage information available for half of all PFAS.
- Less well-known areas of application include cosmetics, dental restorative material, medical equipment and dirt-repellent agents for building materials, smart phones and solar cells.

6.1 General overview

The main limitation in uncovering information on end uses of PFAS is the fact that it is often not generally available. In addition a difficulty generally encountered by purchasers of PFAS-based products is the fact that the product name is often retained even if the chemical composition is changed over time (Swedish Chemicals Agency 2014). For example, some fire-fighting foams and impregnating agents have been replaced by more short-chain PFAS alternatives but have kept the same product names. This creates difficulties for purchasers who want to know what substances a product contains.

Because of the known environmental risks associated with long-chain PFAS, industry in the west has largely switched to more short-chain variants for various applications (Posner et al. 2013). These include:

- 6:2 fluorotelomers, which replace their long-chain equivalents.
- Perfluorobutane sulfonyl fluoride (PBSF)-based PFAS, which replace perfluorooctane sulfonyl fluoride (POSF) for surface treatment and coating.
- Perfluoropolyethers (PFPE), which are alternative process chemicals for fluoropolymer production.

6.1.1 Types of PFAS

PFAS on the international market are found in a large number of fluoroorganic groups (Table 2). One large group comprises different types of PFAS-containing polymers. The most common polymer type is (meth)acrylate-based. A second major group comprises fluorosurfactants, principally various sulfonamide derivatives. Other major PFAS groups include phosphates,

alkanes, esters, sulfonic acids (surfactants), carboxylic acids, silicones/siloxanes, (meth)acryl monomers, iodides, sulfonamides, thiols, etc.

All identified PFAS are listed in Appendix 2 with CAS number, EC number, name, chemical grouping and perfluoro chain length.

Table 2: Chemical grouping of PFAS found on the global market and the number of different substances in each group.

Fluoro group	Number of substances
fluorinated (meth)acrylate polymers	234
N-alkyl perfluoroalkyl sulfonamides	226
poly/perfluorinated polymers	173
poly/perfluorinated phosphoorganics	143
polytetrafluoroethylene (PTFE)	137
poly/perfluorinated alkanes/alkenes	120
poly/perfluorinated sulfonic/sulfinic acids	93
poly/perfluorinated carboxylic acids	93
other poly/perfluorinated organics	90
poly/perfluorinated ethers	80
poly/perfluorinated esters	69
poly/perfluorinated alkanoyl/sulfonyl chloride or fluorides	68
poly/perfluorinated iodides	64
poly/perfluorinated (meth)acrylates	58
poly/perfluorinated alcohols	56
poly/perfluorinated sulfonamides	52
poly/perfluorinated siloxanes/silicones/silanes/silicates	50
poly/perfluorinated thiols	45
poly/perfluorinated copolymers	35
fluorinated urethanes polymers	33
poly/perfluorinated amines	34
polyfluoro siloxane and silicone polymers	29
poly/perfluorinated ammonium organics	21
poly/perfluorinated naphthalenes	16
poly/perfluorinated oxiranes	14
poly/perfluorinated ethoxylates	8
fluorinated oxetane polymers	8
poly/perfluorinated iodides	4
poly/perfluorinated urethanes	3
perfluoroalkyl sulfonamides	2
polyvinylidene fluoride (PVDF)	2
Total number	2060

From the chemical name, 296 (14%) could be identified as isomer mixtures. They are usually mixtures of different lengths of perfluoro chains. Ranges of up to 1-24 carbons (C1-24) are found. The most common isomer mixtures are in the ranges C8-14 and C4-8 (Table 3). The broadest ranges are C1-24, C1-20 and C4-23 (Table 4).

Table 3: The distribution of various isomer mixtures amongst PFAS on the global market - The ten most common isomer mixtures on the global market.

Perfluoro chain length	Number of PFAS
C8-14	60
C4-8	54
C8-20	26
C6-12	25
C4-14	16
C6-20	9
C4-20	9
C8-16	8
C4-10	5
C6-14	5

Table 4: The distribution of various isomer mixtures amongst PFAS on the global market - The ten broadest chain length ranges for PFAS.

Perfluoro chain length	Size of chain length range
C1-24	23
C1-20	19
C4-23	19
C4-20	16
C6-22	16
C2-18	16
C7-22	15
C3-18	15
C6-20	14
C4-18	14

500-600 PFAS were found in the EU's Classification and Labelling Inventory database which were not found in any of the other databases that were searched. This could be because they are still in the research and development phase and are therefore more representative of newly developed PFAS. However, this assignment does not involve a closer analysis of what these substances are.

6.1.2 Description of PFA usage.

Information on how the substances are used could be found or deduced for around half the substances (Figure 6). The information discovered was usually brief. One fifth of the substances had associated information on "surface active substance" functions. Surface active substances have relatively broad areas of application. More detailed information was found for one third of all substances. These were, in decreasing order:

- Synthetic chemicals
- Electronics products
- Printing products
- Cosmetic products
- Textiles/leather impregnation
- Pharmaceuticals/plant protection/biocides
- Paint/Adhesive raw materials
- Paper impregnation
- Foam-based fire-fighting agents

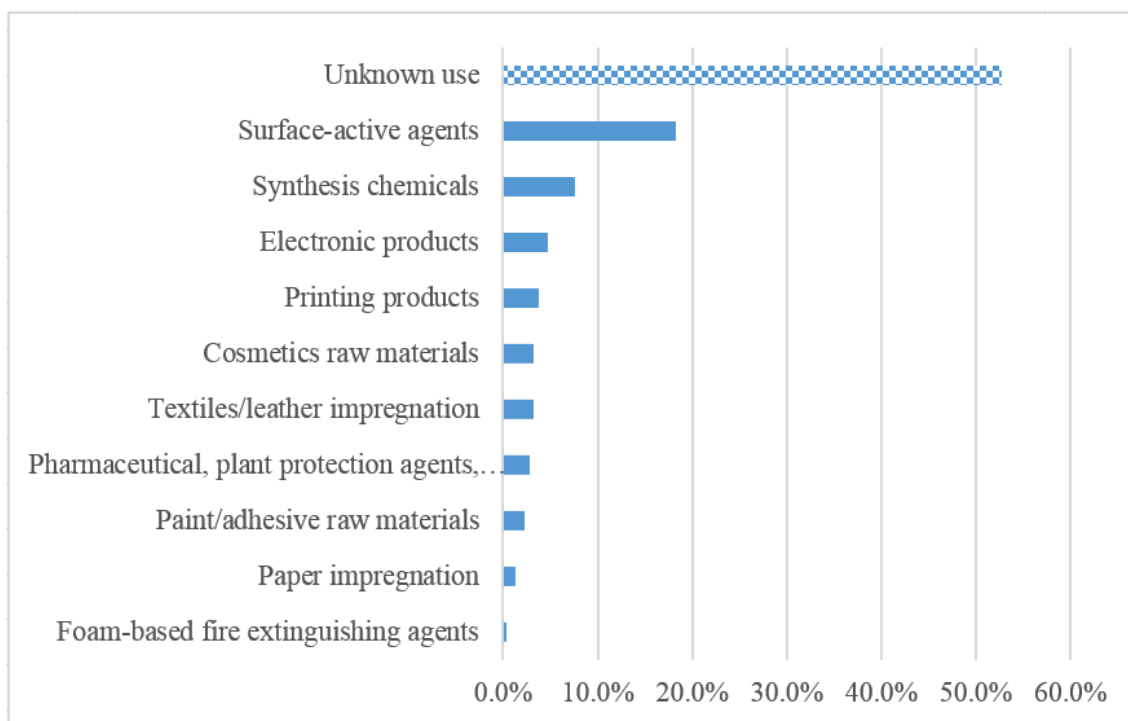


Figure 6: Uses (and non-uses) of PFAS identified on the global market (identified in spring 2015).

Many PFSA groups have several areas of application. Figure 7 shows the most commonly occurring associations. The number of PFAS identified for the different substance- and usage-groups is also included. The associations in the figure show a complex structure which suggests that the majority of PFAS groups probably have a broad usage potential in the community. However, only possible associations are presented. If quantitative data is found to be available it should be possible to determine which associations are dominant.

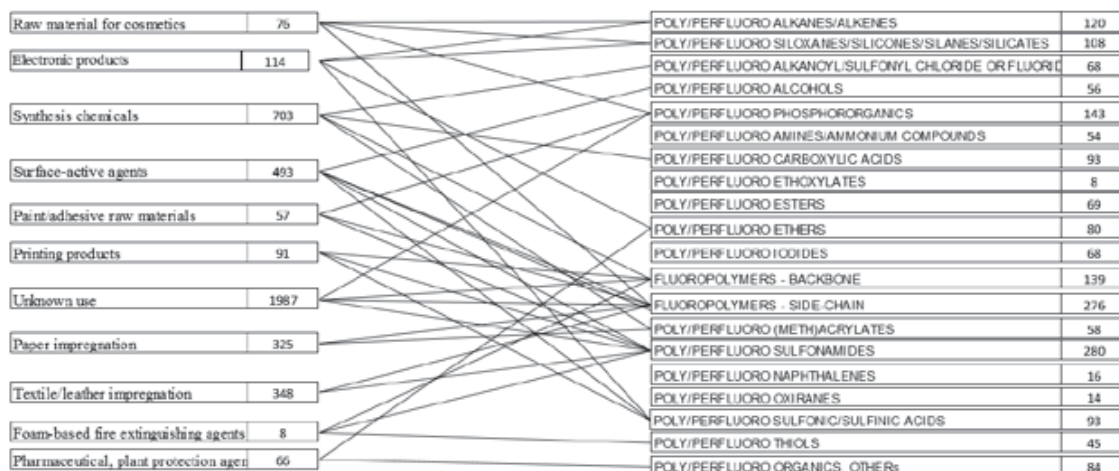


Figure 7: The number of PFAS found on the global market and their distribution between different areas of application. The figures give the number of substances per usage group (left) and chemical group (right).

6.1.3 Number of PFAS on the global market

The survey was able to identify 2060 highly fluorinated substances that are found or have been found on the global market. It is mainly substances with CAS numbers that have been identifiable. To obtain an idea of the total number of PFAS on the market an estimate is therefore needed of the number of PFAS without CAS numbers. This has been derived from two regulatory databases on which substances without CAS numbers must also be registered. These were the EU's IUCLID database (which is administered by the European Chemicals Agency, ECHA) and the EU's cosmetics database (CosIng). A total of 134 PFAS were found on these registers (Table 5). 49-53% of these substances had no CAS number. Assuming that this is true for all PFAS on the market, there will be an additional 2000 unidentified PFAS. This gives a total of around 4000 PFAS.

Table 5: Number of registered PFAS without a CAS number.

Database	Total number of PFAS	PFAS without a CAS no.
IUCLID (industrial chemicals)	58	31 (53%)
CosIng (cosmetics chemicals)	76	37 (49%)
Average value	134	68 (51%)

Examples of substances which may still not have been fully brought onto the market are the 500-600 unique PFAS found in the EU's Classification and Labelling Inventory database (all with CAS numbers). The database also includes chemicals that are in research and development. This could be the reason why these are not found in other databases.

Given the overall uncertainty in calculation and assumptions one might reasonably estimate that there are probably at least 3000 PFAS currently on the global market.

6.1.4 Volumes in the EU

It is not easy to obtain information on the quantities of highly fluorinated substances that are imported, manufactured and used in Sweden and the EU. It is assumed that the import of articles accounts for a substantial proportion. These are poorly monitored. Another reason for the scarcity of information is the fact that companies often regard fluorine content as confidential, something which came to light in the Swedish Chemical Agency's survey of fire-fighting foams carried out in spring 2014 (Swedish Chemicals Agency 2014). The most closely observed substances are and have been PFOS and PFOA. It is therefore not surprising that the information we have obtained mainly concerns these substances (and to some extent substances that can be broken down to PFOS or PFOA).

Within the framework of the Stockholm Convention and the POPs regulation there are lists of uses in the EU of PFOS and substances that can be broken down into PFOS (ESWI 2011, European Commission 2015a). The best available information has been compiled in Table 6 below.

The quantities recorded below do not give the full picture; it is most definite an underestimate with respect to the number of different highly fluorinated substances on the market.

Table 6: Estimated PFOS use in industry in the EU and Sweden. Source European Commission (ESWI 2011, European Commission 2015a) and Glas (2013).

Sector	PFOS use in the EU (kg/year)	PFOS use in Sweden (kg/year)
Hard chrome plating industry	6500	180
Photographic industry	562	0
Semiconductor industry	9.3	0
Hydraulic fluids for the aviation industry	600-730	6-10

The restriction proposal for PFOA (ECHA 2015) gives an estimate of the quantities of PFOA and PFOA-related substances that are imported into or manufactured in the EU (Table 7). The estimate is based on REACH registrations, information from the European Commission and consultation with industry. PFOA and its salts are not registered under REACH but it is estimated that 40 tonne PFOA (and its salts) are imported annually by the EU. Certain PFOA-related substances are registered under REACH and on the basis of this information it is assumed that 100-1000 tonne per year are manufactured in the EU. However, it is likely that not all PFOA-related substances are registered yet, which means it is probable that more than 1000 tonne are involved. According to industry 100-1000 tonne PFOA-related substances are imported each year (which are not registered under REACH). Only a limited number of companies participated in the consultation with industry, therefore it is highly likely that larger quantities are involved. In addition, it is assumed that substantial quantities of substances that can be broken down to PFOA enter the EU via import of articles, but it is difficult to obtain information on this (Table 7). ECHA (2015) regards textiles as a particularly important area of use and estimates that 1000-10,000 tonne of PFOA-related substances enter the EU in the form of imported textiles. There is a lack of information on other articles.

Table 7: Import of PFOA and PFOA-related substances into the EU.

Import into the EU	(tonne/year)
PFOA (and its salts) as substances	20
PFOA (and its salts) as mixtures	10
Import of PFOA (and its salts) in articles	10
PFOA-related substances	100-1000
PFOA-related substances in textiles	1000-10,000

6.2 Identification of areas of application

The various uses identified for highly fluorinated substances are recorded in this section. This is based on official databases which contain information from manufacturers and importers about what substances they use in their production. We have had access to the Swedish Products Register and the EU's IUCLID database and cosmetics database (CosIng), as well as various national inventory lists of industrial chemicals. These databases show that there are a large number of PFAS on the global market. As well as databases we have also included scientific literature, other reports, and company information.

6.2.1 Textiles and leather

Various highly fluorinated substances are used extensively by the textile industry in a range of textile-related articles such as outer garments, umbrellas, bags, sails, tents, parasols, car seat covers, leather articles, shoes, carpets, etc. They are used to repel water, oil and dirt (stains). PFAS contribute circa 2-3 percent of fibre weight in textiles and around 15 percent in synthetic carpets. There are mainly two different polymer groups that are used:

- 1) High molecular weight polytetrafluoroethylene (PTFE), which belongs to the PFAS group of fluoropolymers. This is used in highly porous fabrics (such as Gore-Tex®). A 10 micrometre thick membrane of PTFE is laminated onto a conventional textile material to impart mechanical strength. This thin film has 1.4 billion pores per cm². The pores are much smaller than raindrops (2-3 µm compared with 100 µm) but much larger than water vapour molecules (0.0004 µm). The materials are thus permeable to water vapour but not to water in liquid form (rain) and are therefore popular in outdoor clothing and camping equipment.
- 2) Side-chain fluorinated polymers such as, for example, PASF²³- or fluorotelomer-based acrylate polymers are used as surface treatments (finish) to improve surfaces and to make them water-, grease- and dirt-repellent. The method is used, for example, in textiles, carpets and leather.

These polymers can contain residues of, or are broken down to, fluorotelomers (such as 8:2 FTOH and 6:2 FTOH) or perfluorinated carboxylic acids (such as PFOA and PFHxA) (Posner 2015).

With so-called all-weather clothing it is normal for different parts of the garment to consist of different types of polymers. A porous PTFE membrane is often used to allow the garment to "breathe". Moreover, the outer later can consist of nylon or polyester that has been treated with side-chain fluorinated polymers. The occurrence of highly fluorinated substances in

²³ Perfluoralkyl sulfonyl fluoride

textiles has been analysed in many studies (particularly all-weather garments but also carpets). In many cases high levels of polyfluorinated substances can be detected but this has varied between tests (Kotthoff et al. 2015, Greenpeace 2014a, Greenpeace 2014b, Liu et al. 2014, Liu et al. 2013, Greenpeace 2012, Herzke et al. 2012, STF 2006). The fluorotelomer alcohols observed in clothing are from the side-chain fluorinated polymer and not from the PTFE membrane. (Buck et al. 2011).

Protective clothing for various applications (for example, flame retardant clothing) can either be surface treated with a side-chain fluorinated polymer or produced from fluoropolymers such as woven porous PTFE or similar materials. A German study from 2012 looked at various perfluorinated substances in workwear for medics, pilots and firemen which protect against cold, rain and fire (Zangl et al. 2012). The concentrations varied but it was possible to detect, for example, PFHxA, PFOA, PFNA and PFDA in a number of analysed garments.

With PFAS used in textiles and leather, the trend in the west seems to be towards shorter chain lengths. Instead of side chains consisting of fluorotelomers with 6-14 perfluorinated carbons or POSF²⁴-based derivatives, shorter equivalents with side chains are now being used. In the 2000s 3M developed a number of surface treatment products that were side-chain fluorinated polymers based on derivatives of PBSF (perfluorobutane sulfonyl fluoride), i.e., in which four perfluorinated carbons were used. Examples of product names are Scotchguard PM-3622 (CAS number 949581-65-1), PM-490 (CAS number 940891-99-6) and PM-930 (CAS number 923298-12-8). There are also examples of fluorotelomers that are used as alternatives, primarily those based on six perfluorinated carbons. These contain copolymers from 6:2 fluorotelomers and polyfluorinated siloxanes. The company Miteni has launched polyfluoroalkyl alcohols (5:1 and 3:1 FTOH, CAS numbers 423-46-1 and 375-01-9) that can be used as building blocks for side-chain fluorinated polymers. Solvay uses PFPE as an alternative to side-chain fluorinated polymers (Wang et al. 2013).

In China, for example, PHxSF (perfluorohexane sulfonyl fluoride), is produced as an alternative to PFOS. There are also indications that there is some production in the EU, in Italy (Miteni 2015). PHxSF can be broken down to PFHxS (perfluorohexane sulfonate) which is a shorter version of PFOS.

Information from inventoried databases concerning textiles shows that, amongst polymers and polymer raw materials, it is mainly polyfluorinated/perfluorinated (meth)acryl polymers (C2-20) that are used. Other polymers include fluorinated urethanes (C4-18). Other raw materials include various polyfluorinated/perfluorinated substances. These are alkyl sulfonamide derivatives (C4-9), alkyl ammonium compounds (C4-7), alkyl alcohols (C3-14), and a smaller number of alkyl sulfonic acids/sulfinic acids (C8), alkyl thiols (C8-20), alkyl sulfonamides (C8), alkyl esters (C8-14), alkanes/alkenes (C6) and alkanoyl/sulfonyl chlorides or fluorides (C8).

6.2.2 Paper- and food-packaging

Fluorochemicals are used in the paper industry to manufacture grease- and water-repellent paper. They are used in food packaging (plates, popcorn bags and pizza cartons) and in other paper packaging (cartons, containers and masking paper). A content of 1-1.5 weight percent in the end product is normal (UNEP/POPS/POPRC.9/INF/11 2013).

There is a range of different brands from various suppliers on the international market that are listed in UNEP/POPS/POPRC.9/INF/11 (2013) and Posner et al. (2013). It is mainly side-

²⁴Perfluorooctane sulfonyl fluoride (starting material in PFOS-manufacture)

chain fluorinated polymers and polyfluoroalkyl phosphonic acids (PAPs/diPAPs) that are used (Wang et al. 2013). Nowadays these are mainly based on 6:2 fluorotelomers, unlike previously when fluorotelomers with longer chains were used. Acrylate polymers and other polymers with a fluorinated side chain are also commonly found because they are effective repellents of oil, grease and water. Several examples of 6:2 fluorotelomers used for this purpose are registered in the USA, some being from DuPont. Perfluoropolyesters (PFPE) from Solvay are also used as alternatives. Usage in the EU and Sweden is unclear but according to researchers it is relatively easy to determine whether a paper has been treated with highly fluorinated substances (Trier 2015). Oil and water both form round drops with PFAS, whereas oil drops, but not water drops, are levelled out with, for example, silicone. In many cases there is a lack of information on PFAS in paper- and food-packaging as this is regarded as confidential business information. Analyses of Danish microwave popcorn bags show contents of diPAPs and S-diPAPs (Trier et al. 2011). An American study (Liu et al. 2013) was able to measure the content of FTOH in nearly 90% of food packaging examined. The highest levels found were of 6:2 FTOH (12 mg/kg) and the median level for total FTOH was 0.4 mg/kg.

Information from the Swedish Products Register, the IUCLID database and various inventory lists shows that on the global paper industry market there are a large number of polymers/polymer raw materials, mainly polyfluorinated/perfluorinated (meth)acryl polymers and monomers. Other major substance groups are poly/perfluorinated alkyl thiols (C4-20), poly/perfluorinated alkyl sulfonamide derivatives (C4-9), and poly/perfluorinated alkyl phosphorus compounds (C8). There are a smaller number in the substance groups alkyl esters (C6-14), alkyl silicones/siloxanes (C6) and alkyl sulfonic/sulfinic acids (C8).

6.2.3 Fire-fighting foam

The occurrence of PFAS in fire-fighting foam has been described in previous publications from the Swedish Chemicals Agency (Swedish Chemicals Agency 2013, 2015a, 2015b). There are various types of fire-fighting foam that are used with different types of fire. So-called Class A foams are for fires in fibrous materials such as in building whereas Class B foams are used for fires involving liquids. It is in Class B foams where highly fluorinated substances are used (Swedish Chemicals Agency 2015b). They are mainly used because of their effectiveness in creating a thin film of water between the foam and the burning fuel. The film increases the ability of the foam to spread rapidly over the liquid surface and at the same time inhibits evaporation and heat radiation. These fire-fighting foams are used in petroleum fires; for example, at airports and oil refineries, so-called Class B fires. There are also examples of fluorinated fire-fighting foams being used at fire-fighting training centres, though in a diluted form (Swedish Chemicals Agency 2015a).

Fluorine-based fire-fighting foams can be divided into the following categories:

- Fluoroprotein foam (FP). Common outside Sweden and used, for example, for fire protection in petroleum industries and on board ships.
- Film forming foam (AFFF, Aqueous Film Forming Foam). Developed in the 1960s and used for petroleum fires in, for example, aviation and the marine sector.
- Film forming fluoroprotein foam (FFFP). Also used in aviation. Fluorinated substances are also used here as foam stabilizers (Wang et al. 2013).
- Alcohol-resistant fluoropolymer detergent liquids (alcohol-resistant aqueous film forming foam, AR-AFFF). This is a universal foam in which the fluorinated substance is used as a foam stabilizer.

- Alcohol-resistant film forming fluoroprotein foam (AR-FFFP). This is a universal foam developed in the 1970s.

The survey of fire-fighting foams carried out by the Swedish Chemicals Agency together with the Swedish Civil Contingencies Agency in spring 2014 (Swedish Chemicals Agency 2015a) shows that there are two manufacturers of fire-fighting foam in Sweden: Fomtec in Helsingborg and Kempartner in Vadstena. They produce film forming foams, both with and without fluorosurfactants. With regard to suppliers, the Swedish market for fire-fighting foam is dominated by Dafo, Presto and Kidde. Dafo has part ownership in Fomtec and distributes Fomtec's products to airports, oil terminals, and fire and rescue services. Presto purchases a large portion of its products from Dr Sthamer in Germany, ABC Fire Protection in England and also from smaller European manufacturers. ABC Fire Protection specializes in portable fire extinguishers. Kidde buys in most of its fire-fighting foam from Angus in England and supplies industries, coast guard operations, and fire and rescue services in Sweden.

According to the Swedish Chemicals Agency (2014) there were no direct imports from manufacturers outside the EU or USA by those players who participated in the study. The fire-fighting foam used was produced in the EU and USA. However, this may not apply to other parts of the EU market. On the basis of information obtained in the various interviews we carried out in the course of the survey, it would seem that fire-fighting foam has nowadays become restricted and is only used to a small extent. This applies to both training and real fires. However, the situation appears to vary between municipalities. One player who was interviewed said that their use of foam was increasing as the area of application for fire-fighting foam had been expanded to include fires in buildings.

Even though manufacturers believe that their products comply with Swedish legislation and do not contain any PFOS, the survey of fire-fighting foam shows there is a lack of knowledge about other PFAS. Fire-fighting foam available on the Swedish market may contain an amount of various components but the information on fluorosurfactants is often regarded as confidential. There is therefore a significant lack of information on constituent highly fluorinated substances. Producers regard constituent components as confidential business information and therefore do not seek to patent their products. However, they may consider releasing information in special cases where a confidentiality agreement is involved. Another problem can be that purchasers and users are unable to find out whether a product has changed its chemical content.

According to the Swedish Chemicals Agency's PM from 2013, which identified fire-fighting foam as a possible polluter of drinking water (Swedish Chemicals Agency 2013), fire-fighting foam is produced as a concentrate (1-6% fluorosurfactants) and mixed with water. This agrees with information in the Swedish Products Register. A search for products with perfluorinated and polyfluorinated substances shows that there are a number of highly fluorinated substances with fire extinguishing function. However, the information in the Products Register is deficient as in most cases companies are not required to record lower levels of PFAS. The information in the Products Register is therefore incomplete (see section 7.4).

Nowadays PFOS and substances that can be broken down to PFOS are regulated globally under the Stockholm Convention (read further in section 4.1). However, only in the EU is there a ban on their use in fire-fighting foam. Globally PFOS is permitted in fire-fighting foam. Production and use still take place in China (even of PFHxS - six perfluorinated carbons) for fire-fighting foam. In 2002 the only manufacturer in the west, 3M, ceased producing PFOS-based AFFF and then developed an agent based on a fluorinated ketone in gaseous form (CAS number 756-13-8, UNEP/POPS/ POPRC.8/INF/17 2012). Today most

AFFF are based on fluorotelomers with six perfluorinated carbons. There is also a company in China that has developed an AFFF product based on PFBS derivatives (four perfluorinated carbons). It is not clear whether it is distributed nowadays (Fire fighting foam coalition 2015, Wang et al. 2013).

The Stockholm Convention has ordered a study of which fluorine-based fire-fighting foams (in the AFFF group) are currently in use and has written about C6-fluorotelomers (for example 6:2 FTS) and dodecafluoro-2-methylpentan-3-one which is manufactured by 3M (UNEP/POPS/POPRC.8/INF/17/ Rev.1 2012). Nine different fluorinated fire-fighting foams are named in the analysis but the chief fluorinated component (6:2 FTS and dodecafluoro-2-methylpentan-3-one) is given for only two of these. For the other seven there is a reference to confidential business information. It also writes that AFFF can be used in all different types of fire extinguishing equipment (e.g., sprinklers, portable fire extinguishers, fire services equipment).

According to Posner et al. (2013) the alternatives that are most commonly used are C8-C20- γ - ω -perfluorotelomer thiols with acrylamide (CAS number 70969-47-0). The aim is to use pure 6:2 fluorotelomers (betaines and amine oxides). However, it has proved difficult and expensive to get rid of longer chain molecules (e.g., C8) that can be broken down to PFOA. The petroleum sector has declared that it uses PASF (perfluoralkyl sulfonic acids) and FTS (fluorotelomer sulfonates). It has also been reported in a publication from the Swedish Chemicals Agency (2013) that the new generation of fire-fighting foams are to a large extent based on 6:2 FTS.

Swedavia, which owns ten Swedish airports, including Arlanda and Landvetter, had previously used fluorine-based fire-fighting foams but in June 2011 switched to a fluorine-free alternative (see section 8.1.3.3).

The Swedish Armed Forces began phasing out the use of perfluorinated substances in fire-fighting foam in Sweden in 2011 [according to Berglind et al. (2013)]. Nowadays the Swedish Armed Forces use a fluorotelomer-based fire-fighting foam, i.e. the substance that is broken down to perfluorinated substances. (Swedish Chemicals Agency 2015a).

PFOS can still be found in old portable fire extinguishers and in the equipment of fire and rescue services (Berglind et al. 2013). Concentrates of fire-fighting foam can be found in the inventories of fire services and on ships.

In autumn 2014, under commission from the Swedish Chemicals Agency and the Swedish Civil Contingencies Agency, Örebro University analysed ten different fire-fighting foams that were on the Swedish market (Swedish Chemicals Agency 2015b). Selection for analysis was based on the Agencies' previous survey of fire-fighting foams (Swedish Chemicals Agency 2015a) and on what was considered to be common on the Swedish market. In the analyses the researchers searched specifically for certain known PFAS but the products were also screened, revealing other fluorinated substances. One problem in the analysis was the fact that some samples from users were contaminated. Samples from unbroken packaging (with less risk of contamination) were also included in the study. The results showed that it was in Class B foams where fluoro-organic substances were to be found. The main substance groups contained in these foams were 6:2 fluorotelomer-based (6:2 FTSAS²⁵ and 6:2 FTAB, CAS number 34455-29-3²⁶) which can be broken down to the perfluorinated substances PFHxA

²⁵ Fluorotelomermercaptoalkylamido sulfonate.

²⁶ Fluorotelomer sulfonamide alkylbetaine, 1-Propanaminium, N-(carboxymethyl)-N,N-dimethyl-3-[[[(3,3,4,4,5,5,6,6,7,7,8,8,+ C339458-tridecafluorooctyl)sulfonyl]amino]-, inner salt.

and PFPeA). All products from unbroken (non-contaminated) packaging contained 6:2 FTS, PFHpA, PFHxA and shorter carboxylic acids. PFOA and PFNA could also be detected, though at low concentrations. The analysis report concludes that C8 was probably not used in the products studied. Whether low concentrations of PFOA and PFNA are detected depends in all likelihood on the technical quality of the C6-fluorochemicals (also certain amounts of C8 are formed in the production of C6).

Information from inventoried databases, etc., on fire-fighting foam is limited. Only six PFAS are mentioned. Besides those mentioned above there are also the following:

- Polymers (the Swedish Products Register, precise identity confidential).
- Polyperfluorinated alkyl thiols (the Swedish Products Register, precise identity confidential).

6.2.4 Cosmetic products

There has recently been an expansion in the use of highly fluorinated substances in various cosmetic and hygiene products (Fujii et al. 2013). This specifically concerns polyfluoroalkyl phosphonic acids (PAPs/diPAPs). These are used in sun creams, body lotions and other cosmetic products to make the products oil- and water-repellent. A Japanese study (Fujii et al. 2013) analysed various products that contained PAPs or other fluorine-based compounds (for example, polyfluoroalkyl silylated mica) according to the international cosmetics database INCI (International Nomenclature of Cosmetic Ingredients). Various cosmetic products for the face and nails were analysed, as were sun creams from various manufacturers. The results show that besides PAPs the products also contained perfluorinated carboxylic acids, PFCA (in the form of PFOA and shorter carbon chains such as PFHxA and PFHpA). 87 percent of cosmetics samples (13 of 15) and 89 percent of sun creams (8 of 9) contained PFCA. The highest concentration of analysed PFCA found was 5.9 µg/g in a foundation cream in powder form and 19 µg/g in a sun cream. The levels were generally higher in the sun creams. Also analysed were products which, according to INCI, did not contain any fluorine-based substances (such as PAPs) but which came from the same manufacturer. These contained no detectable PFCA which, according to the study, indicates that PAPs are an important source of PFCA in consumer products. However, this was a small study and more analyses would need to be performed before any reliable conclusions could be drawn.

CosIng is the European Commission's public database with information on substances that may be found in cosmetic products (see section 5.1.1.1). As well as chemical identity, there is also information on the substances' technical functions. 76 PFAS were found in the database. These represent many different chemical groups (see Table 8).

Table 8: Substance groups that can be found in cosmetics (CosIng 2015).

fluorinated (meth)acrylate polymers
poly/perfluorinated naphthalenes
poly/perfluorinated alkanes/alkenes
other poly/perfluoro organics
poly/perfluorinated alcohols
poly/perfluorinated siloxanes/silicones/silanes/silicates
poly/perfluorinated polymers

poly/perfluorinated copolymers
poly/perfluorinated sulfonamides
polytetrafluoroethylene (PTFE)
poly/perfluorinated phosphoorganics
poly/perfluoro ethers
poly/perfluoro esters
polyfluoroalkyl phosphoric acid esters (...PAPs)
poly/perfluorinated sulfonic/sulfinic acids
poly/perfluorinated (meth)acrylates

The public part of the database contains no information on concentrations and quantities so it is not possible to determine how commonly occurring these are in cosmetics on the Swedish market.

Table 9 shows the technical functions of various PFAS in cosmetic products. These cover a broad range of uses, such as anticaking agents, emulsifiers, antistatics, stabilizers, surfactants, film formers, viscosity regulators and solvents. The list shows that many of the substances have been used for a variety of different functions. Many of them are indicated for use on the skin and hair.

Table 9: Functions found (incl. combinations) for PFAS in cosmetic product (CosIng 2015).

Adsorbent, anticaking, emulsion stabilizing, skin conditioning
Adsorbent, anticaking, skin conditioning, binding, emulsion stabilizing
Anticaking
Antistatic, hair conditioning, skin conditioning
Binding
Binding, emollient
Bulking
Cleansing, surfactant
Cosmetic chemical
Detangling, skin conditioning, solvent
Emollient
Emollient, skin conditioning
Emulsifying
Emulsifying, skin conditioning
Emulsifying, surfactant
Emulsion stabilizing, solvent, surfactant
Emulsion stabilizing, skin conditioning
Film forming
Film forming, opacifying
Film forming, skin conditioning
Film forming, viscosity controlling
Hair conditioning
Hair conditioning, skin conditioning

Hair conditioning, skin conditioning, solvent
Hair conditioning, skin conditioning, surfactant
Skin conditioning
Solvent
Solvent, skin conditioning
Solvent, viscosity controlling
Surfactant
Surfactant, viscosity controlling

6.2.5 Household products

PFAS are used in various household products. Often only low concentrations are needed to achieve the desired function in various cleaning agents (window polish, floor polish, waxes and car care products). Other examples of household products in which PFAS can be used are paints, printing inks, lacquer and cooking vessels (non-stick frying pans coated with PTFE).

6.2.5.1 Impregnating agents for textiles

There are a number of studies which show the content of various highly fluorinated substances in impregnating agents for textiles (Ye et al. 2014, Kotthoff et al. 2015, Liu 2014, Herzke et al. 2012, Fielder et al. 2010, Schulze and Norin 2007). These examine both fluorotelomers (FTOH and FTS) and perfluorinated substances, primarily carboxylic acids with various chain lengths. It is mainly fluorotelomer alcohols, FTOH, that are found in high concentrations. In the Swedish study by Schulze and Norin (2007) 3 out of 13 analysed products had concentrations of 1000-9000 mg FTOH (C4-C10)/L impregnating agent. The median values for 10:2 FTOH, 8:2 FTOH and 6:2 FTOH in the German study by Kothoff et al. (2015) were 71 mg/kg, 146 mg/kg and 19 mg/kg, respectively.

There was no available information on textile treatment in the databases searched as this is too detailed a function to be found listed there.

6.2.5.2 Paint, printing ink and lacquer

Highly fluorinated substances such as PFOA can be used in paints and printing to improve wetting, smoothness and flow. The highly fluorinated substance is used to reduce surface tension in paints so that the surface on which the paint is applied is wetted. Compared with other wetting agents, such as silicones, PFAS are more effective in reducing surface tension which ultimately improves paint adhesion. It is primarily in water-based paints where these properties are required and PFAS can be present at concentrations of about 1 percent. However, this figure is unreliable; in most cases there may be much lower concentrations, around 0.05 percent (ECHA 2015). Yet there does not appear to be any significant use of highly fluorinated substances [at least not in Denmark and Finland according to Posner et al. (2013)]. Suppliers in the paint industry are of the opinion that surface-active fluorinated substances are generally significantly more expensive than alternative surface-active substances. They are therefore used only if such a low surface tension is required that this cannot be achieved with a fluorine-free alternative (UNEP/POPS/POPRC.9/INF/11 2013).

Adding fluorinated surface active substances to inkjets improves the working of modern printers as well as enhancing picture quality with different media. The surface active fluorinated substance improves surface wetting during the printing process (UNEP/POPS/POPRC.8/INF/17 2012).

As for other areas of application, there are indications that, where paint and lacquer are concerned, industry has switched to highly fluorinated substances with shorter perfluorinated chain lengths (ECHA 2015). Highly fluorinated substances that can be found today are:

- Short-chain fluorotelomer-based surface-active substances (for example, Capstone®).
- C4-compounds based on PFBS (particularly where the surface treatment of electronic products is concerned).
- Fluorinated polyethers (for example, PolyFox®).

A number of polymers and polymer raw materials appear in inventoried databases of paints and adhesives. These include perfluorinated and polyfluorinated (meth)acryl polymers, PTFE, and fluorinated urethane, as well as several complex compounded side-chain fluorinated polymers (copolymers) which have not been categorized. Other raw materials include various polyfluorinated/perfluorinated substances. These are alkylsulfonamide derivatives (C4-9), silicones/siloxanes (C2-14), alkylammonium compounds (C4-7), and a smaller number of alkyl thiols (C4-20), alkyl sulfonamides (C4-8), phosphorus compounds (C6), iodides (C11), alcohols (C8-14), meth(acrylates) (C6).

For printing inks there are on the global market a smaller number of polymers/polymer raw materials, principally PTFE, poly/perfluorinated (meth)acryl polymers (C4-16) and fluorinated urethanes (C8). Other raw materials include various poly/perfluorinated alkyl sulfonamide derivatives (C4-8), polyfluorinated silicones/siloxanes (C6-14), poly/perfluorinated alkyl sulfonamides (C4-8), poly/perfluorinated alkyl alcohols (C8-14).

An inventory carried out by the EU branch organization for printing inks, published in 2013, found 37 highly fluorinated substances that were used within that sector [out of a total of 5452 substances according to EuPIA (2013)]. These were divided into four different technical printing ink functions: "monomer or other precursors", "plastics additives", "polymer resins" and "printing ink additives" (Table 10). Most PFAS belong to the group sulfonic acids and sulfonamide derivatives. These were all categorized as "printing ink additives" and have between four and nine perfluorinated carbon chains. PFAS were also found in binders in the form of perfluoropolyethers, perfluoro(meth)acrylate and perfluoroalkyl alcohols. Other PFAS are PTFE and a polyfluorinated siloxane polymer.

Table 10: PFAS in printing inks in the EU (EuPIA 2013).

Chemical group	Number of PFAS	Function	Perfluorinated chain length
N-alkyl perfluoroalkyl sulfonamides	16	Printing ink additives	C4-9
poly/perfluorinated sulfonic acids	8	Printing ink additives	C4-8
polytetrafluoroethylene (PTFE)	4	Printing ink additives	C4
poly/perfluorinated polymers	1	Printing ink additives	
poly/perfluorinated ethers	1	Monomer or other precursor	C3
poly/perfluorinated copolymers	1	Printing ink additives	
poly/perfluorinated carboxylic acids	1	Printing ink additives	C7
poly/perfluorinated carboxylic acids	1	Plastics additives	C7
poly/perfluorinated alcohols	1	Polymer resins	C8-14
poly/perfluorinated (meth)acrylates	1	Polymer resins	C6
poly/perfluorinated (meth)acrylates	1	Monomer or other precursor	C1-6
polyfluoro siloxane and silicone polymers	1	Printing ink additives	C8
fluorinated (meth)acrylate polymers	1	Printing ink additives	C6

6.2.5.3 Cleaning agents and polish

With regard to floor polish most manufacturers believe that fluorinated substances are necessary to give the product the desired properties (wetting, flowing and levelling evenly over the floor). Concentrations of 100-200 ppm have been found in the products (Posner et al. 2013).

A German study (Kotthoff et al. 2015) analysed nine different cleaning agents. The results showed low or no content of perfluorinated carboxylic acids whereas levels of fluorotelomer alcohols were high (median 10:2 FTOH 23 mg/kg, 8:2 63 mg/kg, 6:2 38 mg/kg). In an American study (Liu et al. 2014) of around fifty different consumer products in ten different categories, products for the treatment of floors and stone/wood had the highest levels of 6:2 FTOH (the highest level was 331 mg/kg) and 8:2 FTOH (the highest level was 92 mg/kg).

There was no available information on cleaning agents and polish in the databases searched as this is too detailed a function to be found listed there.

6.2.5.4 Non-stick products

So-called non-stick frying pans are treated with fluoropolymer (usually PTFE) to prevent food from sticking to the pan. PTFE-treated non-stick products cope with temperatures up to 290°C. Coatings are made up of one to three layers. These are sintered at²⁷ between circa 200°C and circa 430°C (Termoflon coating 2015). A previous method involved the frying pan being hard blasted to give a rough surface to which PTFE could adhere. However, the method gave a surface that was prone to being removed when scraped with a metal implement. Nowadays PTFE with various degrees of "slipperiness" are used. The surface is still roughened initially and a sticky variant of PTFE is sprayed on as the base layer, followed by a middle layer of less sticky PTFE. Finally a layer of normal PTFE is applied (often mixed with ceramic material) for a more durable surface. These products have various trade names, for example, Teflon[®] which was launched by DuPont in 1944; another example is Dyneon[™] PTFE from 3M.

A Norwegian study (Herzke et al. 2012) analysed samples from six non-stick frying pans, three of which contained PFOS and PFHxS, though not at concentrations which exceeded the currently permitted PFOS level (threshold limit 0.1 weight %). PFOA was found in one of the samples (436 µg/kg) which also had the highest total PFAS concentration (739 µg/kg).

There was no available information on non-stick agents in the databases searched as this is too detailed a function to be found listed there.

6.2.5.5 Ski Wax

It has been shown that the use of PFAS in ski wax is a source of exposure for professional users of ski wax (mainly via air). Studies in Sweden and Norway have shown elevated levels of PFOA and PFNA in blood samples (Nilsson et al. 2010). Another study produced similar results (Freberg et al. 2010). Analysis has also been carried out of fluorotelomers in air samples in association with the use of ski wax, and this showed high levels of fluorotelomer alcohols, FTOH (Nilsson et al. 2013).

It is not certain what levels are present in the products themselves but ski waxes may contain mixtures of many different perfluoro-n-alkanes (C12-C24, C7 or C8) (Posner et al. 2013). Analyses of short-chain PFAS in the Nordic countries showed the presence of 6:2 FTOH in

²⁷ Sintering is a process in which particles are joined together at high temperatures to form larger objects.

all analysed ski waxes, though at low levels, 0.2-0.7 mg/kg (Blom and Hanssen 2015). A study of 13 different ski waxes (Kotthoff et al. 2015) showed the presence of various perfluorinated substances, principally perfluorinated carboxylic acids (C4-C14 PFCA in the form of PFBA, PFHxA, PFOA, PFNA and PFDA). PFOA (max. concentration 658 µg/kg, median 3.2 µg/kg) was found in 90% of the samples, along with PFHxA (max. concentration 183 µg/kg, median 1.4 µg/kg). PFOS could also be detected in all samples, though at lower concentrations.

There is a lack of market information on PFAS in ski wax. However, likely product choices can be obtained from information in patent documents (USEPO 2015). International patent information indicates that the first generation of PFAS in ski wax consisted of perfluorinated carbon chains (perfluoroparaffins, C1-21). It is proposed that these include both straight and branched chains (US patent 5202041, 1993, USEPO 2015). More complex perfluoro molecules appear in later patents, such as:

- Perfluoroalkyl polyether diols (US patent 6,465,398, 2002, USEPO 2015).
- Tetrafluoroethylene-perfluoro (propylvinyl ether) copolymer (US patent 6,465,398, 2002, USEPO 2015).
- Organofunctionalized silicone polymer, which contains at least one straight or branched, saturated or unsaturated perfluoro chain (C1-10), e.g., trifluoropropylmethyl/dimethyl siloxane (US patent 7,745,560, 2010, USEPO 2015).
- Polychlorotrifluoroethylenes (PCTFE) (US patent 7,655,606, 2010, USEPO 2015).

6.2.6 Metal (hard- and decorative-chrome plating)

Fluorine-based surfactants are used as wetting agents in hard chrome plating processes²⁸ because they effectively reduce surface tension. During chrome plating hydrogen gas and oxygen gas are released from the chromium bath, drawing chromium vapour with them into the surrounding air.

The use of PFOS in non-decorative hard chrome plating is authorized under the Stockholm Convention²⁹. PFOS-related substances reduce surface tension in the chromium (VI) bath and form a barrier over the bath, thereby inhibiting the release of chromium vapour (the Swedish Chemicals Agency 2004). Other wetting agents are broken down more or less rapidly under the conditions prevailing in the chromium bath (which are strongly corrosive and oxidizing). Chromium (VI) is carcinogenic and therefore its emission is regulated in order to protect workers from exposure in the work environment.

Examples of areas in which hard chrome plated metal is used are wheel bearings and couplings for the rail industry, hydraulic cylinders and moulds for the plastics and rubber industries. Before 2010 circa 200 kg PFOS was used each year by the hard chrome plating industry in Sweden. Now usage is circa 180 kg/year. According to information (Glas 2013) there are seven hard chrome plating facilities in Sweden, three of which use PFOS. Non-decorative hard chrome plating accounts for 95 percent of the market. Because of internationalization of the machine industry over recent decades, a number of companies have disappeared from the sector.

²⁸ The term "hard" refers to the process for applying a 0.2 mm or thicker layer of a specific type of metal directly onto a substrate.

²⁹ This is assuming that it takes place in a closed system, which is a misleading term as 10-20% of the PFOS added is discharged in the waste water.

The PFOS-related substance that is used most in hard chrome plating is tetraethylammonium heptadecafluorooctane sulfonate (with trade names such as Fluortenside-248 and SurTec 960) which is found as 5-10 percent solutions.

In more recent years substitutes for PFOS seem to have appeared globally in the form of various polyfluorinated surfactants. For example, in the EU salts of 6:2 FTS (6:2 FTSA) are used which have been shown to be effective in certain tests but at present there are no alternatives that can match PFOS in creating low surface tension (European Commission 2015a). Therefore 3-10 times the amount of a polyfluorinated alternative is required to replace PFOS. Derivatives of PFBS (N(Et)₄-PFBS, CAS number 25628-08-4) have also been registered in the EU for use in metal chrome plating, with a production volume of 1-10 tonne per year.

However, in some cases fluorotelomers have been shown to impart sufficiently good properties and are now used by two medium-sized hard chrome plating companies in Sweden. These companies believe that the cost is lower than with PFOS. Fluorotelomers were introduced into the Swedish hard chrome plating industry in 2009 by one dealer after which, in the same year, two companies carried out a test run with a substance and in 2011 they completely replaced PFOS with this substance. In addition, a smaller chrome plating firm is planning to introduce fluorotelomers. It is estimated that circa 8 kg fluorotelomers are now used in hard chrome plating in Sweden.

There are also alternative technologies which involve PTFE-coated spheres situated above the chrome bath.

In China two different products are used in place of PFOS. These are:

- Potassium 1,1,2,2-tetrafluoro-2-(perfluorohexyloxy)ethane sulfonate with the trade name F-53 and CAS number 754925-54-7.
- Potassium 2-(6-chloro-1,1,2,2,3,3,4,4,5,5,6,6-dodecafluorohexyloxy)-1,1,2,2-tetrafluoroethane sulfonate with the trade name F-53B and the CAS number 73606-19-6.

Approximately 20-30 tonne F-53 and F-53B were used in China in 2009. These are substances that can be broken down to PFHxS. Some of these substances can only be broken down in boiling water, which makes it an awkward process.

Decorative chrome plating is a different process from hard chrome plating which is described above. The chrome layer is much thinner (0.05-0.5 μm) than with hard chrome plating (0.2 mm or thicker). PFOS was also once used in decorative chrome plating but new technology, which uses chromium (III) instead of chromium (VI), results in less intensive processes and non-hazardous aerosols. There is therefore not the same need for highly fluorinated substances (European Commission 2015a).

Decorative chrome plating is carried out for aesthetic reasons, preventing the metal from becoming tarnished and discoloured. It is used for car and motorcycle components, kitchen appliances, smartphones, etc.

Inventoried databases for metal chrome plating show that there is available information on the global market for a small number of substances (23) that can be used in metalwork. The use mainly concerns metal surface coating ("electroplating"), but in some cases it involves instead the use of lubricants in metal working. The substances found are recorded in Table 11.

Table 11: PFAS which can be used in metalwork. Chemical group with the largest number of substances recorded at the top (others in decreasing order).

Chemical group	Perfluorinated chain length
poly/perfluorinated alcohols	C8-14
poly/perfluorinated amines	C5-12
poly/perfluorinated (meth)acrylates	C6
poly/perfluorinated phosphoorganics	C4-6
poly/perfluorinated sulfonic/sulfinic acids	C8
poly/perfluorinated sulfonamides	C6-8
poly/perfluorinated sulfonyl chloride	C6
n-alkyl perfluoroalkyl sulfonamides	C4
fluorinated (meth)acrylate polymers	C7-8
other poly/perfluorinated organics	C4-5

6.2.7 Hydraulic systems in the aviation industry

The manufacture of phosphate ester-based hydraulic fluids for the aviation industry involves the use of PFOS or PFOS-related substances as additives, with a PFOS level of around 0.1 percent. According to manufacturers they prevent fire, corrosion and evaporation. Before 2013 10 tonnes hydraulic fluids and 6 kg PFOS were used each year in Sweden. The equivalent figure for the EU was 600 kg PFOS/year. However, according to information from a supplier this use of PFOS has been phased out in Sweden and has been replaced by the use of other highly fluorinated substances. The total global market for highly fluorinated substances in hydraulic fluids for aircraft is estimated at circa 2 tonne per year (European Commission 2015a). The equivalent figure for the EU is circa 730 kg per year. Because of confidential business information it is difficult to find out which specific PFAS these products contain.

Inventoried databases only contain information on the use of hydraulic oils associated with three different PFAS. They are all cyclohexane-based poly/perfluorinated sulfonic acids (C7-8).

6.2.8 *Photographic & Electronic equipment and components*

6.2.8.1 *Electronic equipment and components*

Fluoropolymers are used in electronics because they are water-repellent and do not conduct electricity. They are used, for example, in printed circuit boards, PVDF films in loud speakers, transducers and similar products.

According to manufacturers the potassium salt of PFBS (CAS number 29420-49-3) is used as a flame retardant in polycarbonate resins (OECD 2013).

PFOS-related substances can be used in the manufacture of printers, scanners, digital cameras, mobile telephones, radar systems, etc. Use in colour printers and colour copiers is permitted in large parts of the world, but not in the EU. The PFOS-related substances are used as process chemicals and the end product is free from PFOS. They are used in many parts of the electronics industry and are added in various processes that are necessary both for electrical and electronic components and that involve both open and closed systems.

Highly fluorinated substances can be a component in dirt-repellent coatings which safeguard the transparency of glass surfaces on, for example, smartphones and solar cells (ACS 2009, US patent 8864897, Oct. 2014, USEPO 2015). These can consist of fluorosilanes with a perfluorinated dirt-repellent tail (see Figure 4). The tail can consist of C1-20 perfluoro chains or polyethers (molecular weight > 1000, at least 20Å³⁰ thick). Besides their dirt repellent properties fluoro substances are colourless and do not interfere with the optical properties that are necessary for the functioning of an underlying antireflex coating (US patent No. 6,277,485, USEPO 2015). (Meth)acrylates with straight (C1-9) or cyclic (C3-7) perfluorocarbon chains are also mentioned in patents for this type of use (US patent 8231973 from 2012, USEPO 2015).

6.2.8.2 *Photographic surface layers*

PFOS-related substances have been used in the photographic industry for the manufacture of film, film paper and photographic plates. It is mainly light-sensitive imaging materials (such as high speed film) that benefit from the properties of highly fluorinated substances (European Commission 2015a). It has also been reported that PFOA and PFOA-related substances (for example 8:2 FTOH) are used in the EU both professionally and by consumers. These fluorinated substances repel dirt and also function as friction control agents to reduce static electricity and surface tension. There are reports that 0.1-0.8 µg/cm² of PFOS-related substances were used previously and that small amounts of PFOS are still used in x-ray film for photo images for industrial and medical technology equipment. According to information from industry (ECHA 2015) less than 0.1 tonne PFOA and 0.1 tonne PFOA-related substances are used in the EU per year for photographic applications. However, this figure could be an underestimate. The use of photographic film globally and in Sweden is showing a downward trend in line with the development of digital technologies. In 2013 only a few gramme PFOS were imported into Sweden in film. Other conceivable highly fluorinated substances that have been identified in reports within the international work with the Stockholm Convention (UNEP/POPS/POPRC.9/ INF/11/Rev.1 2013) are substances with three or four perfluorinated carbons (C3 and C4) and telomer-based products with varying perfluorinated carbon chain length.

This use is too detailed to be found in inventoried databases.

³⁰ 1Å = 1x10⁻⁷mm.

6.2.8.3 Photoresistors and anti-reflective coatings for semiconductors

PFOS has been used as a surfactant to reduce surface tension and reflectivity in etching solutions, which is important for precise photolithographs in the semiconductor industry (photomasks). Small amounts of PFOS are required in a couple of critical photolithographic uses in the manufacture of semiconductor chips. (UNEP/POPS/POPRC.9/INF/11/Rev.1 2013). Before the year 2000 ca 500 kg PFOS were used for this application in the EU. Ten years later this figure was 10 kg. However, it is not clear which other highly fluorinated substances are used. Industry has stated that nowadays there are no alternatives for these critical applications. It is thought that PFBS, PFPE (perfluoropolyethers) or telomers can be used for non-critical applications (for example, developing agents).

This use is too detailed to be found in inventoried databases.

6.2.8.4 Market information Photographic & Electronic equipment and components

Market information on use in electronic equipment can be found in those databases that have been searched. In total 114 PFAS are associated with electronic equipment. Table 12 shows those fluorosurfactants that may possibly be associated with electronic products. The substances found have been listed in order of decreasing number on the global market.

Table 12: PFAS with possible associations with electronic products. Chemical group with the largest number of substances recorded at the top (others in decreasing order).

Chemical group	Perfluorinated chain length
poly/perfluorinated sulfonic/sulfinic acids	(C4-10)
poly/perfluorinated alkanes/alkenes	(C1-8)
other poly/perfluorinated organics	(C4-8)
poly/perfluorinated esters	(C1-8)
poly/perfluorinated carboxylic acids	(C5-8)
n-alkyl perfluoroalkyl sulfonamides	(C4-9)
poly/perfluorinated ethers	(C1-8)
poly/perfluorinated amines	(C4-18)
poly/perfluorinated siloxanes/silicones/silanes/silicates	(C4-8)
poly/perfluorinated phosphoorganics	(C4-9)
fluorinated (meth)acrylate polymers	(C4-8)
polytetrafluoroethylene (PTFE)	
poly/perfluorinated copolymers	(C8)
poly/perfluorinated thiols	(C6-8)
poly/perfluorinated iodides	(C4-20)
poly/perfluorinated polymers	
poly/perfluorinated ammonium organics	(C4-7)
poly/perfluorinated alcohols	(C3-8)
poly/perfluorinated (meth)acrylates	(C6-8)
poly/perfluorinated sulfonamides	(C8)

6.2.9 Synthesis chemicals (intermediaries)

All manufacturers used to use sodium- or ammonium perfluorooctanoate (NaPFO or APFO, i.e. salts of PFOA) to a significant extent as process chemicals in the production of fluoropolymers (polymers with a fluorinated backbone, for an explanation see section 3.1). Surface-active fluorinated substances are used as emulsifiers and contribute to the substance's ability, from the aqueous phase, to react with substances from the hydrophobic phase to form a polymer. According to Prevedouros et al. (2006) only a few tenths of a percent of the highly fluorinated substance is required, relative to the amount of polymer produced. The process chemical (the surface-active fluorinated substance) is destroyed when the water-containing the fluoropolymer emulsion is dried at high temperatures. At low hardening temperatures residues of the process chemical can be found in the finished polymer product. One example of a fluoropolymer is polytetrafluoroethylene (PTFE) which is used in Teflon®; other examples are polyvinylidene fluoride (PVDF), fluorinated ethylene propylene (FEP) and perfluoroalkoxyl polymer (PFA). The largest manufacturers in North America, Japan and Europe have joined the American EPA's so-called Stewardship Program and have thereby undertaken to phase out PFOA and its salts from production by the end of 2015. This means that the use of PFOA for the production of fluoropolymers in the EU will decrease. By contrast it is highly likely that companies which have not joined the Stewardship Program (major manufacturers in China and Russia) will continue to use PFOA.

The current total demand for fluoropolymers in the EU is estimated at 53,000 tonne per year [20 percent of the global market according to ECHA (2015)]. In terms of volume PTFE is the most important fluoropolymer as it makes up circa 60 percent of the global fluoropolymer market. Demand in the EU for PTFE produced via emulsion (therefore using fluorochemicals as process chemicals) is estimated at 21,000 tonne per year. Assuming that supply in the EU reflects the global market, this means that 70 percent have joined the Stewardship Program and that other manufacturers are still using PFOA and their salts in their production. Therefore 6500 tonne per year (30 percent) of the PTFE used in the EU may contain residues of PFOA.

Studies reported in the PFOA restriction proposal (ECHA 2015) show that when PFOA is used as a process chemical the end product (the fluoropolymer) may contain relatively high levels of PFOA. But the level of PFOA can vary significantly, between 0.001-0.005 percent in dry material and 0.1-0.5 percent in dispersed material. This means that (based on 6500 tonne PTFE) that around 3-16 tonne PFOA per year enter the EU via imports of PTFE mixtures.

Even if several companies in the west have stopped using PFOA in their production, in recent years they have developed other fluorine-based alternatives, often producers develop their own. Use of these as process chemicals (corresponding to the way in which PFOA is used) can mean that there are residues remaining in the end product. In many cases various perfluoropolyesters (PFPE) are used as process chemicals instead of PFOA. For example, the global chemical companies 3M, DuPont, Solvay and Asahi have developed various substances which belong to the group PFPE.

GenX or D3 Dimer salt ($\text{CF}_3\text{CF}_2\text{CF}_2\text{OCF}(\text{CF}_3)\text{COO}^- \text{NH}_4^+$, CAS number 62037-80-3) from DuPont is registered under REACH for a production of 10-100 tonne/year in the EU. Other examples of fluorine-based process chemicals that are registered in the EU are ADONA from 3M ($\text{CF}_3\text{OCF}_2\text{CF}_2\text{CF}_2\text{OCHFCF}_2\text{COO}^- \text{NH}_4^+$, CAS number 958445-44-8) (Wang et al. 2013, ECHA 2015) and EEA-NH4 (ammonium difluoro [1,1,2,2-tetrafluoro-2-(pentafluoroethoxy)ethoxy]acetate, CAS number 908020-52-0) (ECHA 2015).

According to industry (ECHA 2015) highly fluorinated substances with shorter carbon chains function in a similar way to PFOA, though higher concentrations are required to achieve the

same effect. Chinese manufacturers can use 6:2 fluorotelomer carboxylic acids (6:2 FTCA, C₆F₁₃CH₂COOH, CAS number 53826-12-3) as an alternative to PFOA. There are also examples of Chinese companies (Chenguang 2015) which use PFPE-related substances as alternative process chemicals. As a rule, larger amounts of these substances are required, compared with PFOA (ECHA 2015).

On the basis of the above information it can be assumed that 14,500 tonne PTFE/year (21,000 x 70%) on the EU market may contain residues of fluorine-based process chemicals (with shorter carbon chain lengths than PFOA). If the same calculations as above are used (0.001-0.5% fluorine content, depending on type of material) this should mean that totally 7-36 tonne highly fluorinated substances with shorter perfluorinated carbon chains (primarily PFPE) enter the EU each year via the import of PTFE mixtures. However, it is important to remember that this is a rough estimate. For example, larger amounts of PFPE are required than PFOA in manufacturing. This should mean higher levels in the finished PTFE mixture.

Information from inventoried databases concerning use in synthesis shows that one third of the PFAS found on the world market can wholly or partly be used as raw materials for synthesis. These can be divided into two groups: polymer raw materials and raw materials for fluorosurfactants. The chemical groups recorded in Table 13 could be identified (arranged in order of decreasing number).

Table 13: PFAS that can be used as raw materials for the synthesis of polymers and fluorosurfactants. Chemical group with the largest number of substances recorded at the top (others in decreasing order).

Polymer raw materials Chemical group	Perfluorinated chain length
poly/perfluorinated (meth)acrylate polymers	
poly/perfluorinated urethane (meth)acrylate polymer	(C3-22)
polytetrafluoroethylene polymer (PTFE)	-
poly/perfluorinated oxetane polymers	-
Fluorosurfactant raw materials (only those most commonly occurring are included)	
poly/perfluorinated carboxylic acids	(C2-20)
poly/perfluorinated iodides	(C3-26)
poly/perfluorinated alcohols	(C3-22)
poly/perfluorinated alkanoyl/sulfonyl chlorides or fluorides	(C1-12)
poly/perfluorinated sulfonamide derivatives	(C4-9)
poly/perfluorinated esters	(C1-11)
poly/perfluorinated phosphorus compounds	(C4-12)
poly/perfluorinated (meth)acrylates	(C4-9)
poly/perfluorinated oxiranes	(C2-17)
poly/perfluorinated sulfonamides	(C5-8)
poly/perfluorinated sulfonic/sulfinic acids	(C4-8)
poly/perfluorinated ethers	(C1-4)
poly/perfluorinated alkanes/alkenes	(C1-17)
poly/perfluorinated thiols	(C6-11)
poly/perfluorinated siloxanes/silicones	(C6)

6.2.10 Other uses

6.2.10.1 Medical devices

Fluorochemicals are used in medical devices and equipment. Textiles, for example surgical drapes and gowns are treated with side-chain fluorinated polymers to improve the surfaces and to enhance water-, oil- and dirt-resistance. The inert properties of fluoropolymers make them suitable material for implants and other medical materials. Also highly fluorinated substances are used in the manufacture of x-ray film that is still needed for photoimaging with medical equipment (OECD 2013). Old video endoscopes in hospitals have a CCD colour filter which contains small amounts of PFOS. New CCD filters are PFOS-free. There are other medical devices in which PFBS has replaced PFOS. Some manufacturing in the EU uses PFOA as a process chemical. This could, for example, be the manufacture of mechanical heart valves, artery tubes and equipment for implanting these (European Commission 2015b).

A Japanese patent for the manufacture of contact lenses from 2012 names a large number of PFAS as raw materials. These belong to the group (meth)acrylate polymers (C1-4) and carboxylic acid esters (C1-20) (US patent 8,288,496, USEPO 2015). The text of the patent refers to other patents in which PFAS are proposed as raw materials.

A Nordic study (Blom and Hanssen 2015) analysed, amongst other things, two different types of dental floss. The results show a content of various fluorotelomers (6:2 and 8:2 FTOH, average concentration 0.4 mg/kg and 2.5 mg/kg, respectively) and low levels of PFOA.

Linear/branched alcohols, ethers and esters with alkyl chains which are terminated with perfluoro chains (C1-6) (US patent 8,962,708, USEPO 2015) are mentioned in a German patent document from February 2015 dealing with the composition of UV-hardened dental restorative materials.

Another German patent document from 2013 dealing with the composition of UV-hardened dental restorative materials also mentions longer perfluorinated alkyl chains (C1-9 and C2-6) (US patent 8,466,210, USEPO 2015).

This use in medical equipment is too detailed to be found in inventoried databases.

6.2.10.2 Building materials

Fluoropolymers, such as PTFE and PVDF, can be used as surface treatments in various building materials (for example, tiles and glass material) to impart fire- or weather-resistant properties.

There are reports that some fluorochemicals are used in various building and construction products that have contact with lightweight concrete. Examples of these substances are thiols, C₈-C₂₀- γ - ω -perfluorotelomer thiols with acrylamide (CAS number 70969-47-0). This is found in Australia but it is not known whether this use also occurs in the EU and in the Nordic countries (Posner et al. 2013). The construction material in question here is often recovered, crushed and used as a filling material at landfill sites.

This use in building materials is too detailed a function to be found in inventoried databases.

6.2.10.3 Oil- and mining-production

Highly fluorinated substances (formerly PFOS) are used in the oil and mining industries to enhance oil or gas recovery, as an aviation fuel, as a hydrocarbon solvent, as a petrol evaporation inhibitor, and to increase the amount of metal recovery from ore in copper and

gold mines (UNEP/POPS/POPRC.9/INF/11/Rev.1 2013). According to OECD (2006) 3M was intending to develop PFBS as alternatives to PFOS. Other perfluorinated substances for this use are (according to US patents) perfluoralkyl-substituted amines, amino acids and thioether acids. At present there is not much information on their uses.

This use in oil and mining production is too detailed a function to be found in inventoried databases.

6.2.10.4 Plant protection agents

International studies (UNEP/POPS/POPRC.9/INF/11 2013) have reported that highly fluorinated substances can be used in plant protection agents both as active ingredients (the pesticide) and as additives (adjuvants). PFAS can have various functions as additives: dispersants, to facilitate the spreading of plant protection agents on insects and plant leaves and to increase uptake by insects and plants. As PFAS is an effective additives it is only required in relatively low concentrations (0.1 percent). There are patents for these substances and they have been marketed. Posner et al. (2013) claim that no studies have been carried out to determine what they are and that there is a lack of information on manufacturers. It is also unclear whether and to what extent they are used on the Nordic and European markets (Posner et al. 2013). In Sweden, however, all plant protection agents have comprehensive information on composition, manufacturers of the substances contained and co-formulants.

The PFOS-related substance sulfuramid (or sulfluramid) (EtFOSA) is both a surfactant and a plant protection agent and is used in tropical environments against termites, cockroaches and other insects. PFOS-related agents are not used on the European market. The EU and the American EPA ceased registration of sulfuramid in 2008. On the other hand, the substance is used in Brazil and China. It is estimated that 10 percent of the substance is broken down to PFOS.

Moreover there are also plant protection agents which contain one or more fluorine atoms, usually as substance groups with $-CF_3$.

The use of plant protection agents is too detailed a function to be included in inventoried databases.

7 Market trends

Summary of Market trends

- Less than 2 percent are registered under REACH (should increase to <20 percent by 2018) and less than 4 percent in the Swedish Products Register.
- The Swedish chemical industry has carried out an extensive replacement of highly fluorinated substances (at least over the last 20 years).
- Historical development towards shorter chains.
- Many perfluorinated chains can be branched.
- Patent data indicates moderate development of new highly fluorinated substances, with a strong increase in the use of existing PFAS in new areas.

The occurrence of chemicals on the Swedish market is strongly integrated with the international market. This applies in particular to trade in imported articles and trade in small quantities of chemical products where the possibilities for control are limited. Therefore it is thought that even information on the use of articles manufactured in other parts of the world, such as the USA and China, can also be found in Sweden. Information from foreign sources has been assessed to be relevant and has therefore been included in this survey.

Of all the PFAS that can probably be found on the global market, 58 (<2%) were registered under REACH in 2015. Chemicals in the lowest quantity category (1-100 tonne per company per year) will be registered under REACH in 2018. Information on pre-registrations³¹ indicates that a good 500 more PFAS (a further 18%) will be registered.

Information on chemical-specific market trends is usually not officially available and is mainly produced for various industrial players. Some rough estimates can be made from the official information. In this study information has been gathered from scientific articles, an official patent database, and from confidential chemical registers in Sweden (the Products Register) and of the European Chemicals Agency (ECHA).

7.1 Market history

One way of understanding the history is to analyse at what point in time a manufacturer registered a CAS number. It has been possible to estimate the year of registration from and including the year 2000 (estimated from the length of the CAS number, see section 5.1.1.3). The majority of identified PFAS were registered before the year 2000 (87%). A clear downward trend can be observed for the remainder (13%). Fewer and fewer new PFAS are being registered. The figure was nearly zero in 2014 (Figure 8).

³¹ The reduced list from 2010.

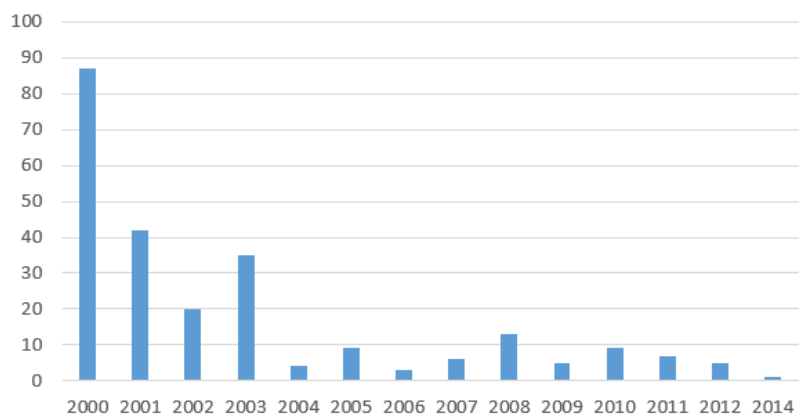


Figure 8: Number of CAS-registered PFAS per year.

7.2 Conformational changes in PFAS chains

Simpler perfluorinated chains in PFAS molecules have over time been replaced by more complex molecules (see Figure 9). This is in part because regulations and restrictions have been introduced as substances with simple perfluorinated chains have shown, and are suspected to have, PBT properties.

One adjustment that can be observed is a shortening of the perfluorinated carbon chain. Another tendency has been for the structures to become more complex, such as:

- Branched molecules.
- Cyclic molecules.
- With oxygen bridges in perfluorinated chains [”polyether”-bridges, Buck et al. (2012)].
- Fluorine atoms on one or more carbons in perfluorocarbon compounds have been replaced by other halogens or hydrogen atoms.

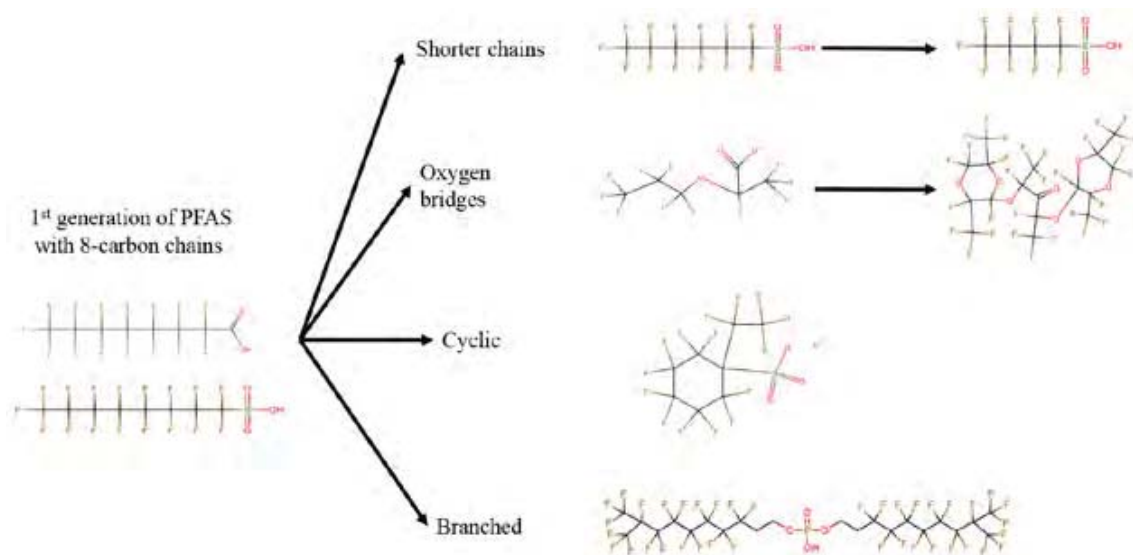


Figure 9: Changes in the conformation of perfluorinated chains (...-CF₂-...) in marketed PFAS.

An American study (Liu et al. 2013) analysed perfluorinated carboxylic acids (PFCA) in various products between 2007 and 2011. Treated carpets, floor waxes, sealants and paper- and food-packaging are examples of products included in the study. Different time trends could be observed. There was generally a reduction in PFCA content, particularly for carpets, textile care products and treated healthcare clothing. On the other hand, it was observed that recorded concentrations of PFBA had increased in 19 of 35 examined products, with floor waxes showing a significant increase. Perfluorinated sulfonic acids (PFSA) were also analysed in 14 different products over a period of time. Among the products analysed, various products used to treat carpets had the highest concentrations. It was observed that the concentration of PFSA in a carpet shampoo increased between 2008 and 2011. There are indications that the short-chain perfluorinated sulfonic acid PFBS has been developed by 3M as an alternative to PFOS (Wang et al. 2013). The results are in agreement with information from industry (Holt 2011) and elsewhere that short-chain PFAS are becoming more common in various areas of application. However, it is uncertain how effective C4 chemistry is compared with C6. According to experts (Posner 2015) C8 substances (such as PFOS, PFOA, 8:2 FTOH) confer the ultimate properties and to some degree C6 substances (6:2 FTOH etc.) can confer similar properties but are not as powerful as C8s. There is less certainty about the effectiveness of fluorinated substances based on four perfluorinated carbons (C4).

7.3 Patent information

The text fragment “perfluoro” is normally used in patents where highly fluorinated organic substances are mentioned. A patent usually comprises a very comprehensive body of text and must therefore always have a summary. A search for the fragment was carried out partly in the patent's summary and partly in the entire patent text. If it was found in the summary text it was assumed that the patent concerned a further development of perfluoro chemistry itself whereas if it was found in the full text it was assumed that the patent concerned the exploitation of existing perfluoro chemistry in more or less new areas of application (see section 5.1.1.1).

A total of 73,642 different patents contained “perfluoro” in their full text. In barely 4 percent of these, “perfluoro” was also mentioned in the summary.

The first patent in which “perfluoro” was found in the patent text was from the period 1950-1955 (Figure 10A). The curve subsequently shows a clear increase throughout the entire period studied (up to 1 Jan 2015). In the year 2000 3M announced that, for environmental reasons, it was ending its manufacture of PFOS (Swedish Chemicals Agency 2004). This could possibly explain the temporary brake in the number of patents during the period 2000-2010. However, the subsequent strong growth in patents during the most recent period (2010-2015) indicates optimism prior to a continuation in the use of perfluoro technology.

Our searches in patent summaries (the “abstract” text, Figure 10B) during the same period also show this in the form of a substantial increase in the occurrence of the text fragment “perfluoro”. However, the difference was that the increase came to a halt in the 1990s, after which the trend was one of slight reduction.

In summary, the patent information indicates that the development of new perfluorinated substances appears to be proceeding at a moderate rate, whereas the use of existing perfluorinated substances is probably still developing strongly.

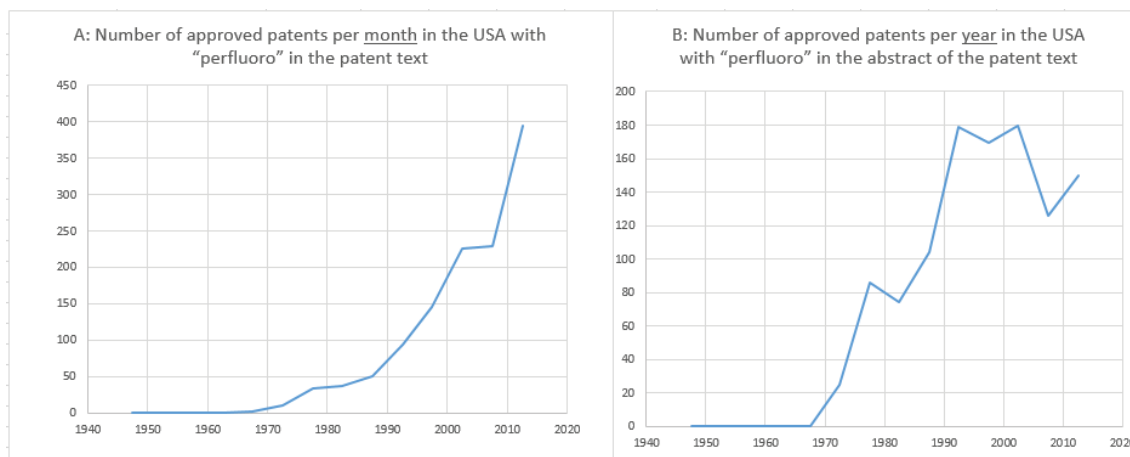


Figure 10: Trends over time in the number of patents in which the word “perfluoro” is mentioned in the full patent text (A), and in the text's summary (B) (searched in the patent database USPTO April 2015).

7.4 The Swedish Products Register

There are a total of 232 PFAS in the Swedish Products Register which is administered by the Swedish Chemicals Agency. A good half (53%) of these are products on the Swedish market (active products). Those PFAS that are no longer registered as active products (expired products) in Sweden can, despite this, still be found on the Swedish market, mainly for the following reasons:

1. They may be in products at concentrations that are below the limit at which substances must be reported. The limit is 5 weight percent for substances that are not classified as hazardous (which is the case for most PFAS).
2. They can be found in products sold in Sweden but are below the quantity limit at which registration with the Product Register is required (100 kg product/year per company).
3. They can be found in durable articles that have not yet reached the waste management stage.
4. They can arrive in Sweden via imported articles (e.g., in impregnated textiles). The substances may be used in countries from which Sweden imports consumer articles. Even those PFAS that are regulated in the EU (through the candidate list) may arrive in Sweden via articles imported from countries outside the EU.

The precise identity of substances on the Products Register is sometimes confidential and it may require the company's permission before a substance's identity can be published. Therefore only the chemical group to which they belong is given below. The range of lengths of perfluorinated carbon chains is also given.

7.4.1 Changes over time

The historical information in the Swedish Products Register allows analysis of trends over time. This shows that many PFAS, new to the Swedish market, were registered up to the start of the 2000s (the oldest registration date is from 1992, Figure 12). Around 2002 there was a temporary net reduction in the number of PFAS in active products. After this period the turnover of PFAS in the register balanced itself out at about zero (newly registered \approx deregistered).

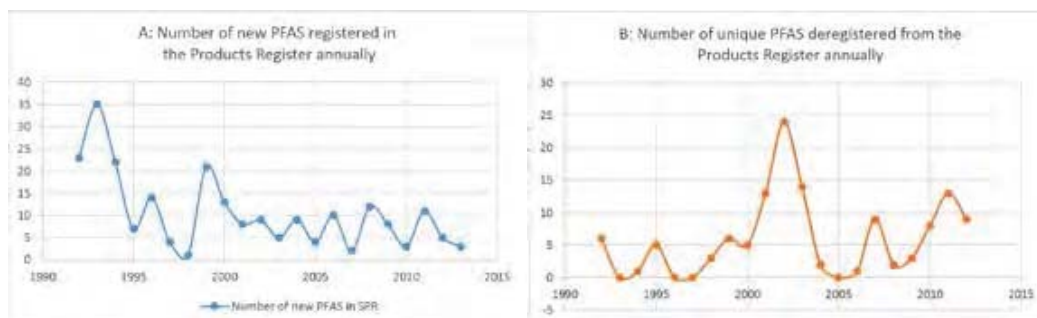


Figure 11: Annual increase (A) or decrease (B) in unique PFAS in the Product Register 1992-2013.

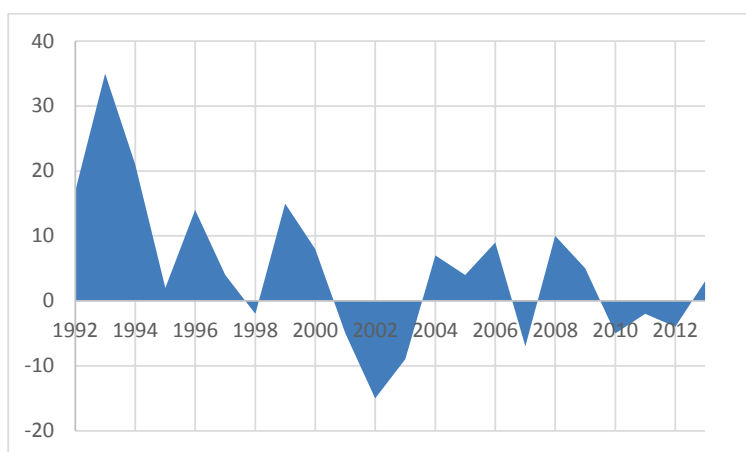


Figure 12: Net change in the number of unique PFAS in active products registered in the Products Register. Calculated as the number of new unique PFAS that are added through new registration (Figure 11a) minus the number of unique PFAS that disappear through deregistration (Figure 11b).

7.4.2 PFAS in active chemical products

There are 124 PFAS registered in active products. The most frequently encountered type of highly fluorinated substances in the Products Register is polymers. The most common fluoropolymer group is acrylate-based. Fluoropolymers are often combined in a complex manner with various types of monomers. This makes categorization of polymer type more difficult.

Many of the PFAS found in the Products Register are used or have been used in a number of product groups. Those PFAS that are present in products on the Swedish market (2013) are listed below in Table 14.

- **Impregnating substances for textiles and leather:** (meth)acrylate polymers (C4-20), urethane polymers (C8-14), other polymers (C2), N-alkyl sulfonamides (C4-8), alkyl alcohols (C3).
- **Paints, Adhesives, (including raw materials):** (meth)acrylate polymers (C4-20), PTFE polymers, silicone/siloxane polymers (C8-14), N-alkyl sulfonamides (C4-8), sulfonamides (C4-8), silicones/siloxanes (C6), alkyl phosphates (C6), alkyl alcohols (C8-14), etc.
- **Substances in Polish:** PTFE polymers, (meth)acrylate polymers (C6-20), other polymers (C6), alkyl phosphorus compounds (C6-12), alkyl phosphates (C6-12), N-alkyl sulfonamides (C8), alkyl ethers (C<5), silicones/siloxanes (C6), alkanes (C5) etc.
- **Metal surface treatment and surface coating substances:** alkyl sulfonic acids/amides (C6-8), PTFE, alkyl phosphates (C6-12), alkyl alcohols (C8-14), alkyl ethers (C<5), alkyl sulfonyl chlorides (C6), alkanes/alkenes (C6).
- **Printing ink substances:** (meth)acrylate polymers (C4-16), silicone polymers (C8-14), alkyl sulfonamides (C4-8), alkyl sulfonic/sulfinic acids (C4-8), silicones/siloxanes (C6), N-alkyl sulfonamides (C4-8), PTFE-polymers, alkyl alcohols (C8-14).
- **Raw materials for electronics:** alkyl sulfonic acids (C8), ethers (C<5), PTFE, alkanes (C5-7), alkyl alcohols (C3), N-alkyl sulfonamides (C4), alkyl amines (C5-18).
- **Fire-fighting foam substances:** alkyl sulfonamides (C6-20), alkyl thiols, N-alkyl sulfonamides (C6), polymers³².
- **Raw materials for optics:** ethers (C<5), esters, alkanes.
- **Biocide substances (insecticides/herbicides):** esters, phosphorus compounds.
- **Hydraulic oil substances:** alkyl sulfonic acids (C7).

³² The identity of the substances may be confidential.

Table 14: Number of PFAS in active product in the Swedish Products Register (2013, source: Swedish Products Register, SPR, 2015).

Number of PFAS	Fluoro group	Number of years in SPR (average value)
23	N-alkyl perfluoroalkyl sulfonamides	10
22	fluorinated (meth)acrylate polymers	6
15	poly/perfluorinated sulfonic/sulfinic acids	9
8	poly/perfluorinated copolymers	7
7	poly/perfluorinated carboxylic acids	5
7	poly/perfluorinated polymers	6
6	poly/perfluorinated alkanes/alkenes	9
5	poly/perfluorinated ethers	12
4	poly/perfluorinated amines	4
4	poly/perfluorinated (meth)acrylates	9
4	fluorinated urethanes polymers	9
3	poly/perfluorinated esters	10
3	poly/perfluorinated thiols	9
3	polytetrafluoroethylene (PTFE)	11
3	poly/perfluorinated ammonium organics	9
2	poly/perfluorinated phosphoorganics	8
2	poly/perfluorinated sulfonamides	6
1	poly/perfluorinated iodides	3
1	poly/perfluorinated siloxanes/silicones/silanes/silicates	2
1	poly/perfluorinated alcohols	10

7.4.3 In expired chemical products (0-100 kg marketed each year in Sweden)

103 of the PFAS named in the Products Register were only found in expired products (do not fulfil the extended requirements for registration). However, the usage patterns for these are still relevant, particularly from an international perspective. These have therefore been compiled and used as surrogate data for those PFAS for which usage information is otherwise lacking. As these uses may be relevant we have listed them below and in Table 15.

- **Impregnating substances for textiles and leather:** (meth)acrylate polymers (C2-18), N-alkyl sulfonamides (C5-9), other polymers, e.g. urethane-based (C4-18), (meth)acrylates (C6-12), alkyl ammonium compounds (C4-7), alkyl sulfonic/sulfinic acids (C8), alkanes/alkenes (C6), alkyl thiols (C8-20), alkyl esters (C8-14).
- **Paint raw material substances:** N-alkyl sulfonamides (C4-9), alkyl ammonium compounds (C4-7), siloxanes/silicones (C4-6), siloxanes/silicones (C2-6), (meth)acrylate polymers (C4-8), fluorinated alkyl iodides (C11).
- **Impregnating substances for paper:** (meth)acrylate polymers (C4-20), (meth)acrylates (C6), alkyl thiols (C4-20), N-alkyl sulfonamides (C8-16), alkyl sulfonamides (C8-16), alkyl phosphates (C8), alkyl esters (C8-14).

- **Metal surface treatment-/surface coating-substances:** (meth)acrylate polymers (C10-20), other polymers (C8), (meth)acrylates (C6) and alkyl sulfonic acids (C6-12), alkyl sulfonamides (C8).
- **Substances in Polish:** (meth)acrylate polymers (C4-14), alkyl sulfonic/sulfinic acids (C8-10), alkyl sulfonamides (C6).

Table 15: Number of PFAS in expired product in the Swedish Products Register (1992-2012, source: Swedish Products Register, SPR, 2015).

Number of PFAS	Fluoro group	Number of years in SPR (average value)
26	fluorinated (meth)acrylate polymers	9
14	polytetrafluoroethylene (PTFE)	15
11	poly/perfluorinated polymers	11
7	N-alkyl perfluoroalkyl sulfonamides (...FASAs)	15
6	poly/perfluorinated alkanes/alkenes	9
5	poly/perfluorinated sulfonic/sulfinic acids	18
4	poly/perfluorinated sulfonamides	4
4	poly/perfluorinated siloxanes/silicones/silanes/silicates	11
4	poly/perfluorinated phosphororganics	12
4	fluorinated urethanes polymers	15
3	poly/perfluorinated ethers	10
3	poly/perfluorinated esters	11
3	polyfluoro siloxane and silicone polymers	14
3	other poly/perfluorinated organics	8
2	poly/perfluorinated alcohols	16
1	poly/perfluorinated alkanoyl/sulfonyl chlorides or fluorides	2
1	poly/perfluorinated copolymers	18
1	poly/perfluorinated thiols	14
1	poly/perfluorinated amines	22

7.5 The European chemicals data base IUCLID

58 PFAS can be found in the IUCLID database (see Table 16). Of these, 14 are said to be used only as raw materials for synthesis, mainly polymers. Information on the use of the majority of these substances is confidential and in most cases very brief.

There are 551 PFAS in the list of substances which industry may consider registering in the future ("pre-registration", REACH pre-registration database 2008). There is no use information to be found here. Unlike the Swedish Products Register, in which the largest group is polymers, the largest group in IUCLID is N-alkyl perfluoroalkyl sulfonamides (see Table 16). The difference is that there is no requirement for polymers to be registered under REACH (with certain exceptions), but they should be registered with the Products Register.

Table 16: Registered and pre-registered substances under REACH – number in poly/perfluoro groups.

Fluoro group	Registered	Pre-registered
N-alkyl perfluoroalkyl sulfonamides	3	139
poly/perfluorinated phosphororganics	2	67
poly/perfluorinated sulfonic/sulfinic acids	2	45
poly/perfluorinated carboxylic acids		44
poly/perfluorinated alkanoyl/sulfonyl chlorides or fluorides	3	27
poly/perfluorinated alcohols	2	23
poly/perfluorinated amines	1	23
poly/perfluorinated (meth)acrylates	2	22
poly/perfluorinated esters	1	21
poly/perfluorinated sulfonamides		18
other poly/perfluorinated organics	15	17
poly/perfluorinated ethers	10	17
poly/perfluorinated alkanes/alkenes	7	17
poly/perfluorinated iodides	3	17
poly/perfluorinated siloxanes/silicones/silanes/silicates	2	15
poly/perfluorinated oxiranes		10
poly/perfluorinated thiols	2	9
poly/perfluorinated copolymers		6
poly/perfluorinated ethoxylates		5
poly/perfluorinated urethanes		5
polytetrafluoroethylene (PTFE)		2
poly/perfluorinated polymers	3	1
poly/perfluorinated naphthalenes		1
Total number	58	551

8 Alternative substances, materials and technologies

Summary of Alternative substances, materials and technologies

- The alternatives may be fluorine-free substances, or they may be other materials or technologies.
- Alternatives are primarily found for textiles and fire-fighting foams.
- It is difficult to find alternatives that have the same desirable properties as PFAS.

The alternatives to highly fluorinated substances can be fluorine-free substances which offer similar properties. Entirely different technologies may also be used which do not have the same requirement for chemicals (for example in textiles and fire-fighting foams). As previously described in this report (see section 3.3), highly fluorinated substances have a number of desirable functions. Their unique properties make them to a large degree “irreplaceable” in many applications (Buck et al. 2012). This is probably one reason why very little information can be found on alternatives.

8.1.1 Fluorine-free substances

According to the trade association FluoroCouncil (Holt 2011) fluorine-free alternatives are available for certain applications but they are not always as effective. It can be difficult to find a fluorine-free alternative when it comes to achieving a very low surface tension or where durable water- or grease-repellent properties are required. Table 17 below presents fluorine-free alternatives that are used in various areas of application. In section 8.1.3 we look at identified alternatives for specific areas of application.

Table 17: Fluorine-free alternatives (UNEP/POPS/POPRC.9/INF/11/Rev.1 2013, OECD 2013, MST 2005).

Group	Uses
Propylated aromatics (naphthalenes/biphenyls)	Water-repellent agents for rust prevention systems, marine paints, surface treatments, etc.
Fatty alcohol polyglycol ether sulfonates	Levelling and wetting agents
Sulfosuccinates	Levelling and wetting agents Wetting agents and dispersants in paints and the surface treatment industry
Surface-active hydrocarbons	Photographic industry
Siloxane and silicone polymers	Impregnation of textiles, leather and carpets or surface treatment Wetting agents in the paint and ink industries Cleaning agents, polish and car wax Anti-foaming agents
Stearamidomethyl pyridine chloride	Impregnation of all-weather textiles, leather and carpets
Polypropylene glycol ether, amines, sulfates	Levelling and wetting agents Decorative chrome plating, etc.

8.1.2 Non-chemical technologies

For some applications alternative technologies can be introduced and replace highly fluorinated substances without any need for other chemicals. In the area of plant protection agents this can, for example, involve biological, physiological or natural control methods for dealing with pests. Another example is foam blankets and other barriers which can be used instead of PFAS as mist suppressants for surface treatment of metals (OECD 2013).

8.1.3 Alternatives for specific areas of application

This section describes alternatives to PFAS in specific areas of application. However, an alternative described for one particular use could possibly have other uses. Most information on conceivable alternatives has been found for textiles and fire-fighting foam, but even here the information is scanty. For other uses, for example decorative chrome plating, there is no longer the same need for highly fluorinated substances.

8.1.3.1 Textiles and leather

With regard to water-repellent properties there are a number of substances that can be used instead of highly fluorinated substances. It is more difficult to find alternatives for grease- and dirt-repellent agents. Those substances most discussed as water-repellent alternatives to fluorine are:

- Silicone-based agents, for example, high molecular weight polydimethylsiloxanes (PDMS). Silicones (or polymerized siloxanes or polysiloxanes) is the general name for inorganic polymers based on chains of oxygen and silicon. Hydrocarbon compounds are bound to these chains. They are resistant to the action of chemicals, are not water soluble and do not conduct electricity.
In the manufacture of PDMS can be found various cyclic and linear siloxanes such as cyclic octamethylcyclotetrasiloxane (D4, CAS number 556-67-2), decamethylcyclopentasiloxane (D5, CAS number 541-02-6) and dodecamethylcyclohexasiloxane (D6, CAS number 540-97-6). Fluorinated siloxanes (fluoroalkyl siloxanes) are also found in this group.
- Mixtures of silicones and stearamidomethyl pyridine chloride, sometimes together with carbamide (urea) and melamine resins.
- Waxes and paraffins, which usually consist of modified melamine-based resins.
- Particular structures, so-called dendrimers, that were developed to imitate the ability of the lotus blossom to repel water. These structures often occur in nanosize (1 to 100 nm) and generally comprise hydrophobic, modified, highly branched polymers, including polyurethane.
According to industry dendrimers confer superhydrophobic properties, which means large contact angles (larger than 150°), that can be used in coatings for textiles, leather, etc. The literature contains a large variety of dendrimers for which a range of different areas of application are described; some of these are fluorinated and some are cationic.

One conceivable alternative non-chemical technology is tightly woven fabrics. Another is the so-called reverse osmosis membrane. The membrane comprises extremely thin films made of polymer materials and is constructed in such a manner that it is highly impermeable to water in liquid form but permeable to water vapour (breathable fabric). An alternative to PTFE is a composite of a hydrophobic polyester and a hydrophilic polymer which forms a microstructure that allows the fabric to "breathe". The reverse osmosis membrane lets the user

feel dry but does not stop the outside of the garment becoming wet. There are commercially available alternatives to PTFE for this application on the international market (Posner 2015).

One example of an international initiative to find fluorine-free alternatives is Huntsman Textile Effects (global supplier of dyes and other chemicals for the textile industry) which started a collaboration with DuPont to develop a new product with water-repellent properties. According to the companies this is the sector's first water-repellent treatment that consists totally of renewable material, 63 percent of which is obtained from plant-based, non-GMO raw materials (Ecotextile News 2015).

In Sweden researchers and industry are working in collaboration in the FORMAS-funded project SUPFES (2015) to find an alternative that can replace harmful fluorinated chemicals in textile. The aim of the research is to assess the risks associated with various chemicals and to ensure that the alternatives do have the desired functions.

8.1.3.2 Paper- and food-packaging

Use of grease-resistant paper started before the introduction of PFOS technology and there are technologies that do not require fluorochemicals. At least one manufacturer has developed a fluorine-free alternative, the Norwegian firm Nordic Paper. It uses a high density paper which prevents the passage of grease through it.

8.1.3.3 Fire-fighting foam

Fire-fighting foam is, as described in section 6.2.3, divided into different classes according to what fire they are intended for: class A foam for fibrous materials and class B foam (in which PFAS are found) for fires involving liquids. According to the Swedish Civil Contingencies Agency various alternative solutions should replace the majority of all uses of foams for fire extinguishing as these can involve negative effects for both humans and the environment (Swedish Civil Contingencies Agency 2015).

Nowadays Class A foam or water is used as the extinguishing agent for fires in buildings. If water is used at high pressure (200-300 Bar) it creates a mist of many small water droplets which has an effective extinguishing effect. It both cools smoke gases and reduces oxygen levels. To prevent any re-ignition and protect neighbouring buildings an agent is added which comprises inorganic salts (such as ammonium, phosphates, sulfates and chlorides). According to studies these salts reduce the size of water droplets by a factor of at least four, thereby making the mist more effective. Additives also have a cooling effect.

As stated by the Swedish Civil Contingencies Agency it is important for the incident commander at a fire to assess whether or not to try to extinguish the fire. Extinguishing can cause major environmental damage and it may be better to allow the fire to burn in a controlled manner.

For example, petroleum fires are tackled by using Class B foam to "put a lid on" the fire. Most foam products for Class B fires contain highly fluorinated substance and according to the Swedish Civil Contingencies Agency fire-fighting foam products need to be developed. One possible approach is to develop mist fire-suppression systems with additives, even for liquid fires. Another way is to develop an entirely new technology, such as expanded glass (Pyrobubbles), which is currently being studied.

There are various fluorine-free Class B foams on the Swedish market. An example is protein-based or detergent-based fire-fighting foam (Swedish Chemicals Agency 2015a). In 2011 the new fire-fighting foam Moussol-FF 3/6 was introduced at Swedavia's airports (Arlanda,

Landvetter, etc.). It is used in both training and emergency call outs. According to Swedavia the product is broken down to carbon dioxide and water in the environment. It is also effective in the sort of fire suppression required at airports where high safety standards have to be maintained (Fridlund 2014).

According to manufacturers and some users, fluorine-free fire-fighting foams do not have as good an extinguishing effect as foams with fluorosurfactants (Fomtec 2015). Compared with fluorine-based fire-fighting foams (AFFF foams) around twice as much water and foam concentrate are required when extinguishing liquid fires. According to some analyses fluorine-free fire-fighting foams may give less protection against re-ignition which means that the fire may flare up without warning (Fomtec 2015). There are operations whose standards are such that current fluorine-free fire-fighting foams are not acceptable alternatives. One example is the Swedish Armed Forces which, in the event of a fire, allows 90 seconds to reach the location and a maximum of 90 seconds to cool down the cockpit (Borgh 2014). According to the Swedish Armed Forces it is difficult to find fluorine-free alternatives which meet these safety requirements. However, fluorine-free detergent foam is used in training.

The fire-fighting foams manufacturer Solberg distributes fire-fighting foams in a number of countries in the EU, but not in Sweden (Swedish Chemicals Agency 2015a). The company has developed a fluorine-free foam concentrate, RE-HEALING™, which is a mixture of hydrocarbon surfactant, water, solvent, sugar, preservative and a corrosion inhibitor. This is produced for use at concentrations of 1, 3 or 6 percent to control Class B fires. According to the manufacturer the presence of complex carbohydrates gives the foam a much greater capacity to absorb heat than fluorine-based foams (Solberg 2015).

Various fluorine-free alternatives have also been recorded in several reports in the Stockholm Convention. The fire-fighting foams mentioned are silicone- and hydrocarbon-based surfactants, synthetic detergent foams and protein-based foams. However, these fluorine-free fire-fighting foams are often used in combination with fluorosurfactants (UNEP/POPS/POPRC.8/INF/17/Rev.1 2012).

8.1.3.4 Surface coating of metal (hard- and decorative-chrome plating)

There are fluorine-free alternatives (aminoethanol, CAS number 141-43-5 and alkyl sulfonates which are marketed under the name TIB Suract CR-H) but they do not appear to be as effective and currently have only a small market share. One problem is that fluorine-free alternatives are broken down in a chrome bath and therefore need to be constantly replenished.

There are also alternative technologies such as foam blankets and other barriers that can be used to inhibit misting. Combined with increased ventilation these alternative technologies reduce mist formation so much that there should be no need to use PFOS and PFAS to reduce mist formation. A closed system or increased ventilation combined with extraction of chromium (VI) have been proposed as alternative solutions where chromium (III) technology not yet functions (European Commission 2015a).

8.1.3.5 Hydraulic systems in the aviation industry

There are some hydraulic fluids which do not contain fluorochemicals. However, according to reports produced within the framework of the work with the Stockholm Convention (UNEP/POPS/POPRC.9/INF/11 2013), they can damage metal components in hydraulic systems. The degree of acidity needs to be constantly monitored as this determines the lifetime of the fluid. It is said that the search for alternatives has been going on for 30 years

but because of confidential business information it is difficult to discover whether fluorinated compounds are involved and, if so, exactly what they are.

8.1.3.6 Photographic & Electronic equipment and components

According to reports from the work with the Stockholm Convention (UNEP/POPS/POPRC.9/INF/11 2013) alternatives are being developed in this area.

Because of the development of digital technologies the use of photographic film has decreased markedly. Those alternatives identified under the Stockholm Convention (UNEP/POPS/POPRC.9/INF/11/Rev.1 2013) are:

- Hydrocarbon-based surface-active substances
- Silicone chemicals

9 Discussion and Conclusions

Summary of Discussion and Conclusions

- There is a wide range of substances as well as substantial development of new substances and areas of application.
- A significant lack of available information means that this survey does not give a complete picture.
- The Swedish Chemicals Agency therefore intends to look at an expanded requirement for reporting to the Swedish Products Register. We also intend to examine how this can be managed at an EU level.
- Existing knowledge indicates to us that the use of PFAS in fire-fighting foam is what most urgently needs to be addressed and we are therefore reviewing the regulations and other measures relating to fire-fighting foam.
- The survey has identified many lesser known uses, such as cosmetics, dental restorative materials and smudge-repellent surface treatment for smartphones. The Swedish Chemicals Agency intends to monitor developments in these areas.
- The pattern of usage shows that the flow of used PFAS into the waste management stage is substantial which means it should be ensured that waste management is properly implemented.
- The lack of alternatives to PFAS shows a need for technological development. Alternatives have mainly been found for fire-fighting foams and textiles.

The range of different PFAS available on the world market was much greater than expected. This meant that a deeper analysis of the use of various substances was not possible. Instead of focusing only on a limited number of substances with more or less known applications, the focus was extended to obtain an overview of the previously unknown diversity of substances on the market.

This assignment is aimed at end uses, i.e. the end use of PFAS in articles and chemical products. The survey shows that highly fluorinated substances have a very extensive range of uses and can be used in many different applications. Some areas of application are already well known, for example textiles and fire-fighting foams. Other areas are less well known. Amongst the "new" areas mentioned are:

- cosmetics additives,
- dental restorative material and
- use in electronics (e.g., coolants and dirt-repellent agents for smartphones and solar cells).

The technological potential of these highly fluorinated substances has probably not yet been fully exploited on the international market. It is therefore likely that they will appear in new areas of application in the future. Surveys of how highly fluorinated substances are used can therefore quickly become out of date.

It is evident from current knowledge and from concentrations measured in the environment that the most problematic use is in fire-fighting foam. The Swedish Chemicals Agency is therefore examining the need for regulation and other measures and will present proposals to the government in spring 2016. We will also continue to monitor how PFAS are used in other areas and, where necessary to add to and analyse this information. Some areas of application

are in part the responsibility of other authorities and therefore our existing collaboration with other relevant authorities (the Swedish Environmental Protection Agency, the National Food Agency, the Geological Survey of Sweden, the Swedish Geotechnical Institute, the Swedish Agency for Marine and Water Management and the Swedish Civil Contingencies Agency) is important.

There are a large number of PFAS on the world market (>3000). There is only a limited amount of information on total quantities and the extent of usage in various areas of application. This does not come as a surprise as many highly fluorinated substances enter the EU and Sweden through the import of articles (for example, textiles) and for the most part these are not monitored. Less than 2 percent of the 3000 highly fluorinated substances are registered under Reach. Forecasts of future registrations (the latest round of registrations will be completed in 2018) indicate that a substantial proportion of all PFAS will still be unregistered (>80 percent). Even though the Swedish Products Register includes more PFAS, it covers at most 4 percent of internationally available PFAS. An important reason for the low representation of PFAS in the EU and Swedish registers is that these substances are very potent which means that they are normally used at low concentrations. This can mean that they do not need to be registered under REACH or in the Swedish Products Register. Additive substances at below 5 percent do not normally need to be recorded in the Swedish Products Register³³; this is usually well above the effective concentration for a highly fluorinated substance. The low level of usage means that the majority of PFAS on the market have an annual tonnage in the EU which is below the registration threshold under REACH (>1 tonne per company per year, from and including June 2018). The Swedish Chemicals Agency intends to examine the possibility of an expanded requirement for reporting to the Products Register for the group PFAS. An expanded requirement should make it easier to find information on which highly fluorinated substances are used in Sweden. The Swedish Chemicals Agency will work further to get an EU strategy in place for PFAS which will take into account problems with low volumes of use.

There are almost endless possibilities for designing polymers that contain perfluorinated chains and this is therefore difficult to monitor and regulate. Over time the first generations of PFAS with 7-8 perfluorinated carbon chains have been complemented with more complex PFAS molecules. Moreover, it has been observed that straight chain PFAS can also to a greater or lesser degree be contaminated with branched variants. PFAS with mostly branched chains are also available on the world market. A large number of PFAS in polymer form have been identified in this report, above all in material surface treatment. It is expected that many of these are broken down to other PFAS over time.

There is a relatively large group of perfluorinated substances which lack functional groups³⁴. In many cases these are probably end products and are used in many sectors of the community. They can include, for example, solvents, emulsion stabilizers in cosmetics, freons and coolants for electronics. It is expected that, like other perfluorinated substances, substances in this group are extremely persistent. The lack of a functional group will probably affect their surface-active properties.

³³ The threshold for reporting to the Swedish Products Register is 100 kg per product per year. Those highly fluorinated substances that are not classified as hazardous only need to be reported to the Register if the concentration is more than 5 percent.

³⁴ Circa 58 are found on the market. By functional group we mean a group of atoms which has a major effect on the molecule's properties. Examples of functional groups are an -OH bound to a hydrocarbon chain (this gives an alcohol) and the carboxyl group -COOH which gives a carboxylic acid.

Another identified group is PFAS with extra-long perfluorinated carbon chains (C>15). As well as being very persistent, their hazard characteristics are to a greater or lesser degree unknown.

The identity of a PFAS is often difficult to determine. Many contain isomer mixtures. Sometimes this is indicated in the name of the substance as this includes the range of perfluorinated chain lengths (around 14 percent of the substances found). There are ranges of up to 1-24 carbons (C1-24). The reason for giving intervals could be that fewer raw materials and/or imprecise synthesis methods are used. The large ranges create difficulties in work to regulate the use of PFAS, etc., as REACH legislation mainly deals with individual substances.

Our calculations indicate that at present less than 5 percent³⁵ of the identified substances are covered by some form of EU regulation. The REACH candidate list includes six long-chain carboxylic acids and the POPs regulation governs PFOS and substances that can be broken down to PFOS. If PFOA and substances that can be broken down to PFOA are restricted in the EU³⁶ and expected perfluorinated substances appear on the candidate list, there will be a further 3 percent. This means that less than 8 percent of the highly fluorinated substances are regulated or are about to be regulated within the EU.

An analysis of trends over time for how PFAS are introduced onto the market shows a complex picture. From their international identity numbers (CAS number) it appears that most PFAS that are available on the market were allocated their identity number before the year 2000. The number of PFAS with new identity numbers has fallen to nearly zero over the period 2000-2014. There could be a number of reasons for this. It could be that there is now almost no production of new PFAS. However, statistics for international patents indicate a steady influx of new patents for the development of new PFAS technologies (i.e., the development of new PFAS or the modification of existing PFAS). Another explanation could be that, once a substance group becomes associated with undesirable environmental properties, it is more likely that manufacturers will decide not to request CAS numbers for its substances. If companies decided against CAS numbers this might be due to a desire, at least in the first instance, to maintain a low profile with regard to competing manufacturers. It would appear from, amongst other things, statistics based on regulatory registers for industrial chemicals and cosmetics additives in the EU, that a substantial portion of existing PFAS (about half) are not marketed with CAS numbers.

The fact that many PFAS lack CAS numbers causes problems of identification, as the naming of substances in this group is very variable. It is often difficult to identify and categorize substances such as PFAS from the name only.

This survey has confirmed that industry (leastways in North America, Europe and Japan³⁷) has switched from highly fluorinated substances with carbon chains containing at least seven or eight perfluorinated carbons (for example PFOS, PFOA and 8:2 FTOH) to shorter carbon chains (mainly based on six perfluorinated carbons, such as 6:2 FTOH) and perfluoro ethers, such as perfluoropolyethers, PFPE). A switch to shorter carbon chains probably means increased volumes of PFAS on the market, as higher concentrations of substances with shorter carbon chains are required to achieve the same effect as produced by substances with longer carbon chains. If PFOS and PFOA (and substances that can be broken down to these), whose

³⁵ Based on a total of 3000 substances, which is assumed to be an underestimate.

³⁶ The REACH restriction proposal that is under discussion. By PFOA here we mean PFOA, its ammonium salt and identified telomers that can be broken down to PFOA.

³⁷ As a result of regulations and the voluntary American Stewardship Program the majority of large manufacturers in North America, Europe and Japan have switched to substances with shorter chain lengths.

volumes of use are recorded in this report (see section 6.1.4), are replaced by other highly fluorinated substances, this will presumably mean higher volumes.

The lack of information on how and where PFAS are used makes it difficult to assess how the market is developing. Certain trends can be deduced from patent databases. Patent information indicates a strong growth in recent times in patents for using existing PFAS in more or less new areas of application (see section 7.3). However, patent proposals for new and modified PFAS show a more uniform development (circa 150 PFAS patents per year).

In the Swedish Products Register it is possible to see changes in chemicals management in Sweden (≥ 1992). This is most apparent for industrial intermediates (concentrates), primarily in the surface treatment of textiles. This register information shows a clear reduction in usage. The reasons are probably both regulatory and structural (e.g., the closure of the Swedish textile industry). However, the Products Register only includes chemical products (such as fire-fighting foam and impregnating agents) and not articles (such as textiles and paper packaging); PFAS-treated articles enter the Swedish market through imports. Fewer register entries for PFAS in the Products Register therefore does not indicate that the amount of PFAS on the Swedish market is decreasing.

As described in section 6 there are many examples of studies that have analysed PFAS in various chemical products and articles. As generally only a few PFAS are analysed there is a risk that the results do not give a complete picture. To obtain a fuller picture one needs more comprehensive analyses of screening character or analyses of the total content of organic fluorine.

This assignment focuses on end uses, i.e., the end use of PFAS in articles and chemical products where the next stage in the chain of use is waste management. Because of the wide-ranging use of these extremely persistent substances, we perceive that the management of material waste produced is important. Incineration at high temperatures (at least 1100°C) generally breaks down PFAS to carbon dioxide and hydrogen fluoride. However, within the scope of this survey we have come no closer to determining the best manner in which to handle the waste.

This survey shows that there is substantial development potential for alternatives to highly fluorinated substances. For some applications there are neither fluorine-free alternatives nor alternative methods. This is probably due to the unique properties of highly fluorinated substances which are therefore regarded as irreplaceable in many applications. One question that can be asked is whether these properties are really required for all applications. For example, use in textiles could be limited to clothing for occupational and protective purposes.

10 Bibliography

ACS (2009). *Toward making smart phone touch-screens more glare and smudge resistant*. Wed Aug 19 16:42:03 EDT 2009.

<http://www.acs.org/content/acs/en/pressroom/newsreleases/2009/august/toward-making-smart-phone-touch-screens-more-glare-and-smudge-resistant.html> (2015-06-09)

Benskin (2015). *Personal communication with Jonathan Benskin*, researcher at ACES, Stockholm University. May 2015.

Berglind, R., Helldén, J., Johansson, N., Liljedahl, B., Sjöström, J. (2013). *Perfluorerade ämnen i jord, grundvatten och ytvatten*. (Perfluorinated substances in soil, ground water and surface water). Report FOI-R--3705—SE, The Swedish Armed Forces.

(<http://www.forsvarsmakten.se/siteassets/4-om-myndigheten/dokumentfiler/rapporter/foi-rapport-3705-perfluorerade-amnen-i-jord.pdf>)

Blom, C and Hanssen, L. (2015). *Analysis of per- and polyfluorinated substances in articles*. Nordic Working Papers. Norden. NA2015:911. ISSN 2311-0562.

Borgh, F., 2014. *Personal communication with Folke Borgh*, Försvarsmakten (the Swedish Armed Forces). 2014-05-12.

Buck R.C, Murphy P. M., Pabon M. (2012). *Polyfluorinated Chemicals and Transformation Products*. p. 7. In Handbook of Environmental Chemistry. Springer förlag. ISBN 978-3-642-21871-2.

Buck, R.C., Franklin, J., Berger, U., Conder, J.M., Cousins, I.T., de Voogt, P., Jensen, A.A., Kannan, K., Mabury, S.A., van Leeuwen, S.P., 2011. Perfluoroalkyl and polyfluoroalkyl substances in the environment: terminology, classification, and origins. *Integr Environ Assess Manag* **7**, 513-541.

Chenguang (2015). <http://www.chenguang-chemi.com/> (2015-05-21).

CosIng (2015). The European Commission database CosIng with information on cosmetic substances and ingredients contained in the "Cosmetics Regulation" (EC) No 1223/2009 of the European Parliament and of the Council and "Cosmetics Directive" 76/768/EEC (Cosmetics Directive). Search January-March 2015.

<http://ec.europa.eu/consumers/cosmetics/cosing/index.cfm?fuseaction=search.advance>

Echa (2015). *ANNEX XV Restriction Report, Proposal For A Restriction, Perfluorooctanoic acid (PFOA), PFOA salts and PFOA-related substances*. The German and Norwegian competent authorities. Version Number: 1.0. Date: 17 October 2014.

Ecotextile News (2015). *DWR textile finish is renewably sourced*.

<https://www.ecotextile.com/2015042921444/dyes-chemicals-news/dwr-textile-finish-is-renewably-sourced.html> (2015-05-18)

ESWI (2011). *Study on waste related issues of newly listed POPs and candidate POPs*. ESWI consortium: Bipro, Umweltbundesamt and Enviroplan for the European Commission.

- European Commission (2014). *Meeting with representatives of ARCHROMA*, 17 September 2014 – 11.30 – 13.30 h (BREY 12/ST01). Brussels, 17/09/2014.
- European Commission (2015a). *13th Meeting Of The Competent Authorities Under Regulation EC No 850/2004 (POPs)*. European Commission, DG Environment, Brussels, 27.03.2015. POP CA/2015/03.
- European Commission (2015b). *Meeting with representatives of W.L. Gore and Associates*, 23 January 2015, 10.00-10.45 h (BREY 8/138). Brussels, 26/01/2015.
- EuPIA (2013). EuPIA. A sector of CEPE aisbl. inventory list – version December 2013. <http://www.eupia.org/index.php?id=29>.
- The European Council (2015). *Proposal for a Council Decision on the submission, on behalf of the European Union, of a proposal for the listing of additional chemicals in Annex A to the Stockholm Convention on Persistent Organic Pollutants*. 7365/15 ENV 179 ENT 43 ONU 34 CHIMIE 13- COM (2015) 133 final. Brussels 23 March 2015.
- Fiedler, S., Pfister, G., Schramm, K.-W. (2010). Poly- and perfluorinated compounds in household consumer products. *Toxicological & Environmental Chemistry* **92**, 1801-1811.
- Fire Fighting Foam Coalition (2015). <http://www.ffc.org/images/AFFFfactsheet14.pdf>
- Fomtec (2015). *Personal communication with Jan-Erik Jönsson, Dafo Fomtec AB. The viewpoint of a supplier of fire fighting foam on the development and use of fire fighting foam*. Network meeting on highly fluorinated substances 23 April, 10.00-16.00, at Stockholm University, Stockholm. 23/04/2015.
- Freberg, I.B., Haug, L.S., Olsen, R., Hanne, L.D., Hersson, M., Thomsen, C., et al., 2010. Occupational exposure to airborne perfluorinated compounds during professional ski waxing. *Environ Sci Technol*. 2010;44:7723-8.
- Fridlund, M., 2014. *Personal communication with Malin Fridlund*, Swedavia. 15/05/2014.
- Fujii, Y., Harada, K.H., Koizumi, A. (2013). Occurrence of perfluorinated carboxylic acids (PFCAs) in personal care products and compounding agents. *Chemosphere* **93**, 538-544.
- Glas, L. G., Hawerman, L., Östman, A. (2013). *Uses of PFOS in Sweden 2012/13 in the areas exempted from the ban*. October 10, 2013, revised 131121. Kemiinformation, For the Swedish Chemical Agency.
- Gomis, M. I., Wang, Z., Scheringer, M., Cousins, I. T. (2015). Modeling assessment of the physicochemical properties and environmental fate of emerging and novel per- and polyfluoroalkyl substances. *Sci Total Environ*. 2015 Feb 1;505:981-991. doi: 10.1016/j.scitotenv.2014.10.062. Epub 2014 Nov 8.
- Greenpeace (2012). *Chemistry for any weather. Greenpeace tests outdoor clothes for perfluorinated toxins*. Publisher Greenpeace e. V., Große Elbstraße 39, 22767 Hamburg.

Greenpeace (2014a). *Hazardous chemicals in branded luxury textile products on sale during 2013*. Greenpeace Research Laboratories Technical Report 01/2014, February 2014.

Greenpeace (2014b). *A little story about the monsters in your closet*. Published January 2014 by Greenpeace East Asia.

Herzke, D., Olsson, E., Posner, S. (2012). Perfluoroalkyl and polyfluoroalkyl substances (PFASs) in consumer products in Norway - A pilot study. *Chemosphere* **88**, 980-987.

Holt, R. (2011). *Alternatives to long-chain PFCs*. OECD Webinar on alternatives to long chain PFCs. (<http://www.oecd.org/env/ehs/risk-management/47651662.pdf>).

Kotthoff, M., Müller, J., Jüriling, H., Schlummer, M., Fiedler, D. (2015). Per- and Polyfluorinated Substances in Consumer Products. *Environ Sci Pollut Res*.

Liu, X., Guo, Z., Edgar E., Folk, IV., Roache, N. (2014). Determination of fluorotelomer alcohols in selected consumer products and preliminary investigation of their fate in the indoor environment. *Chemosphere* **129** (2015) 81–86

Liu, X., Guo, Z., Krebs, K., Pope, R., Roache, N. (2013). Concentrations and trends of perfluorinated chemicals in potential indoor sources from 2007 through 2011 in the US. *Chemosphere* **98** (2014) 51-57

Miteni (2015). Miteni, the fluorine specialist.
<http://www.miteni.com/Products/perfluorinatedde.html> (2015-05-28).

MST (2005). *More environmentally friendly alternatives to PFOS-compounds and PFOA*. Miljøprojekt. Danish EPA (Miljøstyrelsen). Environmental Project No. 1013 2005.

Nilsson, H., Kärrman, A., Rotander, A., van Bavel, B., Lindström, G., Westberg, H., 2013. Biotransformation of fluorotelomer compound to perfluorocarboxylates in humans. *Environment International*. 2013;**51**(0):8-12.

Nilsson, H., Kärrman, A., Westberg, H., Rotander, A., Lindström, G., 2010. A time trend study of significantly elevated perfluorocarboxylate levels in humans after using fluorinated ski wax. *Environ Sci Technol*. 2010;**44**:2150-5.

OECD (2006). *Results of the 2006 OECD Survey on Production and Use of PFOS, PFAS, PFOA, PFCA, Their Related Substances and Products/Mixtures Containing These Substances*. ENV/JM/MONO(2006)36.

OECD (2013). OECD/UNEP Global PFC Group. *Synthesis paper on per- and polyfluorinated chemicals (PFCs)*. Environment, Health and Safety, Environment Directorate, OECD. Paris 2013.

Posner (2015). *Personal communication with Stefan Posner*, Expert, Swerea IVF. May-June 2015.

Posner, S., Roos, S., (Swerea IVF), Brunn Poulsen, P., (FORCE Technology), Jörundsdóttir, H., Gunnlaugsdóttir, H., (Mátis ohf/Icelandic Food and Biotech R&D), Trier, X., (Technical

University of Denmark, DTU), Jensen, A. A., (Nordic Institute of Product Sustainability, Environmental Chemistry and Toxicology, NIPSECT), Katsogiannis, A. A., Herzke, D., (Norwegian Institute for Air Research, NILU), Bonefeld-Jørgensen, E. C., (University of Aarhus), Jönsson, C., (Swerea IVF), Alsing Pedersen, G., (DTU), Ghisari, M., (University of Århus), Jensen, S., (Matis) (2013). *Per- and polyfluorinated substances in the Nordic Countries, Use, occurrence and toxicology. TemaNord 2013:542.* (<http://www.norden.org/sv/publikationer/publikationer/2013-542>)

Prevedouros, K., Cousins, I.T., Buck, R.C., Korzeniowski, S.H. (2006). Sources, fate and transport of perfluorocarboxylates. *Environ. Sci. Technol.* **40**, 32-44.

Reach-förregistreringsdatabas (REACH pre-registration database) (2008). http://echa.europa.eu/information-on-chemicals/pre-registered-substances_

Sandblom, O. (2014). *Waste Incineration as a Possible Source of Perfluoroalkyl Acids to the Environment – Method Development and Screening.* Master's Thesis 2014:4. Department of Applied Environmental Science, ITM, Stockholm University.

Schulze P-E, Norin H. (2007). *Fluorerade miljögifter i Impregneringsmedel.* (Fluorinated pollutants in Impregnating agents) – Report Number: 7971, Swedish Society for Nature Conservation.

Solberg (2015). *RE-HEALING™ FOAM CONCENTRATE.* Solberg Company <http://www.solbergfoam.com/Foam-Concentrates/RE-HEALING-Foam.aspx>

STF (2006). *Kartlegging av perfluoroalkylstoffer (PFAS) i utvalgte tekstiler.* (Survey of perfluoroalkyl substances (PFAS) in selected textiles.) TA-2173/2006. ISBN 82-7655-285-4. SFT, Oslo, April 2006.

SUPFES (2015). <http://www.supfes.eu/>

Swedish Chemicals Agency (2004). *PFOS-relaterade ämnen, Strategi för utfasning.* (PFOS-related substances, Strategy for phasing out.) Rapport 3/04. The Swedish Chemicals Agency 2004. (http://www.kemi.se/Documents/Publikationer/Trycksaker/Rapporter/Rapport3_04.pdf)

Swedish Chemicals Agency (2006). *Perfluorinated substances and their uses in Sweden.* Report 7/06. The Swedish Chemicals Agency 2006. (http://www.kemi.se/Documents/Publikationer/Trycksaker/Rapporter/Report7_06.pdf)

Swedish Chemicals Agency (2012). *Bättre EU-regler för en giftfri miljö– rapport från ett regeringsuppdrag.* (Better EU regulations for a toxin-free environment - report from government commission.) Rapport 1/12. The Swedish Chemicals Agency 2012. (http://www.kemi.se/Documents/Publikationer/Trycksaker/Rapporter/Rapport1_12.pdf)

Swedish Chemicals Agency (2013). *Brandskum som möjlig förorenare av dricksvattentäkter.* (Fire-fighting foam as a possible polluter of drinking water sources.) PM 5/13. Ett samarbetsprojekt mellan Livsmedelsverket och Kemikalieinspektionen. (A collaborative project between The National Food Administration and The Swedish Chemicals Agency.) 2013. (<http://www.kemi.se/Documents/Publikationer/Trycksaker/PM/PM5-13.pdf>)

Swedish Chemicals Agency (2015a). *Survey of fire-fighting foam*. PM 5/15. The Swedish Chemicals Agency 2015.
(<http://www.kemi.se/Documents/Publikationer/Trycksaker/PM/PM5-15-Survey-of-fire-fighting-foam.pdf>)

The Swedish Chemicals Agency (2015b). *Chemical Analysis Of Selected Firefighting Foams On The Swedish Market 2014*. Anna Kärrman, PhD. Örebro University. PM 6/15. The Swedish Chemicals Agency. 05/05/2015.

Swedish Civil Contingencies Agency (2015). *Personal communication with Bo Andersson*, Expert intervention at fires, Swedish Civil Contingencies Agency. 20/05/2015.

Termoflon coating (2015). <http://www.termoflon.com/> (2015-05-21)

Trier, X. (2015). *Personal communication with Xenia Trier*, Ph.D., Chemist at National Food Institute, DTU, Denmark. 13/04/2015.

Trier, X., Granby, K., Christensen, J. (2011). Polyfluorinated surfactants (PFS) in paper and board coatings for food packaging. *Environ Sci Pollut Res* (2011) **18**:1108–1120. DOI 10.1007/s11356-010-0439-3

UNEP/POPS/POPRC.8/10 (2012). *Assessment of alternatives to perfluorooctane sulfonic acid in open applications*. Stockholm Convention on Persistent Organic Pollutants.
(<http://chm.pops.int/Convention/POPsReviewCommittee/LatestMeeting/POPRC8/MeetingDocuments/tabid/2801/Default.aspx>)

UNEP/POPS/POPRC.8/INF/17 (2012). *Technical paper on the identification and assessment of alternatives to the use of perfluorooctane sulfonic acid in open applications*. Stockholm Convention on Persistent Organic Pollutants.
(<http://chm.pops.int/Convention/POPsReviewCommittee/POPRCMeetings/POPRC8/POPRC7WorkingDocuments/tabid/2801/Default.aspx>)

UNEP/POPS/POPRC.8/INF/17/Rev.1 (2012). *Technical paper on the identification and assessment of alternatives to the use of perfluorooctane sulfonic acid, its salts, perfluorooctane sulfonyl fluoride and their related chemicals in open applications*. Stockholm Convention on Persistent Organic Pollutants.
(<http://chm.pops.int/Convention/POPsReviewCommittee/POPRCMeetings/POPRC8/POPRC7WorkingDocuments/tabid/2801/Default.aspx>)

UNEP/POPS/POPRC.9/INF/11 (2013). *Revised draft guidance on alternatives to perfluorooctane sulfonic acid, its salts, perfluorooctane sulfonyl fluoride and their related chemicals*. Stockholm Convention on Persistent Organic Pollutants.
(<http://chm.pops.int/Convention/POPsReviewCommittee/LatestMeeting/POPRC9/POPRC9Documents/tabid/3281/Default.aspx>)

UNEP/POPS/POPRC.9/INF/11/Rev.1 (2013). *Guidance on alternatives to perfluorooctane sulfonic acid, its salts, perfluorooctane sulfonyl fluoride and their related chemicals*. Stockholm Convention on Persistent Organic Pollutants.
(<http://chm.pops.int/Convention/POPsReviewCommittee/LatestMeeting/POPRC9/POPRC9Documents/tabid/3281/Default.aspx>)

UNEP (2012). *Guidance on best available techniques and best environmental practices for the use of perfluorooctane sulfonic acid (PFOS) and related chemicals listed under the Stockholm Convention on Persistent Organic Pollutants*. Draft July 2012.

US EPA (2015). *2010/2015 PFOA Stewardship Program*.
<http://www.epa.gov/opptintr/pfoa/pubs/stewardship/>

USEPO (2015). US-patent database. United States Patent and Trademark Office. (Search carried out January-June 2015). <http://patft.uspto.gov/netahtml/PTO/index.html>.

Wang, Z., Cousins, I., Scheringer, M., Hungerbühler, K. (2013). Fluorinated alternatives to long-chain perfluoroalkyl carboxylic acids (PFCAs), perfluoroalkane sulfonic acids (PFSA) and their potential precursors. *Environment International* **60** (2013) 242–248.

Wang, Z., Cousins, I.T., Scheringer, M., Buck, R.C., Hungerbühler, K. (2014). Global Emission Inventories for C4-C14 Perfluoroalkyl Carboxylic Acid (PFCA) Homologues from 1951 to 2030, Part I: Production and Emission from Quantifiable Sources. *Environment International* **70**, 62-75.

Yamanaka et al. (2005). United States Patent. Patent NO.: US 6,878,440 B1 Date of Patent: Apr. 12, 2005.

Ye, F., Zushi, Y., Masunaga, S. (2014). Survey of perfluoroalkyl acids (PFAAs) and their precursors present in Japanese consumer products. *Chemosphere* **127** (2015) 262-268

Zangl, S., Blepp, M., Marquardt, M., Moch, K., Wirth, O., Homburg, B., Temme, C. (2012). *Nationale Umsetzung des Stockholmer Übereinkommens zu persistenten organischen Schadstoffen (POPs) - PBDE und PFOS in Erzeugnissen und im Recyclingkreislauf Report No. [National Implementation of the Stockholm Convention on Persistent Organic Pollutants (POPs) - PBDE and PFOS in Products and in the Recycling Loop Report No.] UBA-FB 001661*, Project No. FKZ 371063415,
http://www.bmub.bund.de/fileadmin/Daten_BMU/Pool/Forschungsdatenbank/3710_63_415_stockholm_bf.pdf.

Appendix 1: Abbreviations and explanations

Highly fluorinated substances	Includes both fully and partially fluorinated carbon chains.
PFAS	Perfluorinated and polyfluorinated alkyl substances (PFAS)
Perfluorinated substances	Fully fluorinated organic substances, i.e., consisting of a carbon chain in which each hydrogen atom has been replaced by a fluorine atom. They are extremely persistent.
Polyfluorinated substances	Partially fluorinated organic substances, i.e., the carbon chain still contains some hydrogen atoms. They are not as stable as perfluorinated substances but can be broken down to perfluorinated substances.
Telomer	Partially fluorinated substances: part of the carbon chain is fully fluorinated, another part is a hydrocarbon. Can be broken down to perfluorinated substances.
End use	The final use of a chemical before it enters the waste management stage of the usage chain.
Precursors (to a perfluorinated substance, X)	Other highly fluorinated substances that can be converted to substance X.
Electrochemical fluorination, ECF	Manufacturing process for highly fluorinated substances
Telomerization	Manufacturing process for highly fluorinated substances
Telogen	Perfluorinated molecule which reacts with a taxogen in the first step in telomerization
Taxogen	Unsaturated molecule which reacts with a telogen in the first step in telomerization
Emulsion polymerization	Polymerization which normally begins with an emulsion that contains water, monomer and surface-active substance
PASF	Perfluoroalkyl sulfonyl fluoride which is a raw material in the production of perfluoroalkyl sulfonic acids (PFSA)
PFCA	Perfluoroalkyl carboxylic acids
PFBA	Perfluorobutanoic acid
PFPeA	Perfluoropentanoic acid
PFH _x A	Perfluorohexanoic acid
PFHpA	Perfluoroheptanoic acid
PFOA	Perfluorooctanoic acid
PFOA-related substances	All substances that can be broken down to PFOA
APFO	Ammonium pentadecafluorooctanoate (ammonium salt of PFOA)
PFNA	Perfluorononanoic acid
PFDA	Perfluorodecanoic acid
PFUnDA	Perfluoroundecanoic acid (Heneicosafleuroundecanoic acid)
PFDoDA	Perfluorododecanoic acid (Tricosafleurododecanoic acid)
PFT _r DA	Perfluorotridecanoic acid (Pentacosafleurotridecanoic acid)
PFT _e DA	Perfluorotetradecanoic acid (Heptacosafleurotetradecanoic acid)
PFSA	Perfluoroalkyl sulfonic acids
PFBS	Perfluorobutane sulfonate
PBSF	Perfluorobutane sulfonyl fluoride
PFH _x S	Perfluorohexane sulfonate
PH _x SF	Perfluorohexane sulfonyl fluoride
PFOS	Perfluorooctane sulfonate

POSF	Perfluorooctane sulfonyl fluoride (starting material in PFOS manufacture)
PFOS-related substances	All substances that can be broken down to PFOS
FEP	Fluorinated ethylene propylene (fluoropolymer)
FTA	Fluorotelomer acrylates: intermediates in polymer production. Can be broken down to PFCA.
FTOH	Fluorotelomer alcohols: components in commercial products that can be broken down to PFCA
FTS	Fluorotelomer sulfonates: precursors to 6:2 FTS are used as alternatives to PFOS in fire-fighting foam. Can be broken down to PFCA.
PFA	Perfluoroalkoxyl polymer (fluoropolymer)
PFPE	Perfluoropolyethers
PTFE	Polytetrafluoroethylene (fluoropolymer)
PVDF	Polyvinylidene fluoride (fluoropolymer)
PAPs	Polyfluoroalkyl phosphate esters
diPAPs	Polyfluoroalkyl phosphate diesters
S-diPAPs	Sulfur-based polyfluoroalkyl phosphate diesters
CX	PFAS with X number of perfluorinated carbons (at least two fluorine atoms bonded to one carbon atom), e.g., 6:2 FTOH = C6, PFBS = C4.
CX-Y	Range of lengths for perfluorinated carbon chains, e.g., C4-8
CMR	Carcinogenic, mutagenic, reprotoxic (CMR) substances
CSR	The chemical safety report (CSR) records the chemical safety assessment and is a part of the REACH registration process in which the registrant demonstrates that risks from exposure to a substance are controlled.

Appendix 2: Highly fluorinated substances found on the world market 2014-2015

Sid 78

CAS number	EC number	Name	Poly(p)fluoro group	Perfluoro chain length Min.	Perfluoro chain length Max.
921296-12-8	-	-	poly(perfluoromethyl)ethers	4	4
940891-99-2	-	-	poly(perfluoromethyl)ethers	4	4
949881-65-1	-	-	poly(perfluoromethyl)ethers	4	4
207574-77-4	3-40-8	1-(1-hydroxyethyl)-2-(2-hydroxyethyl)ethane-1,2-dithiolane	poly(perfluoromethyl)ethers	6	6
76888-49-2	110-37-3	alpha-(1-hydroxyethyl)-2-(2-hydroxyethyl)ethane-1,2-dithiolane	poly(perfluoromethyl)ethers	4	4
110-37-3	110-37-3	alpha-(1-hydroxyethyl)-2-(2-hydroxyethyl)ethane-1,2-dithiolane	poly(perfluoromethyl)ethers	4	4
110-38-4	110-38-4	alpha-(1-hydroxyethyl)-2-(2-hydroxyethyl)ethane-1,2-dithiolane	fluorinated (meth)acrylate polymers	1	99
110-36-2	110-36-2	alpha-(1-hydroxyethyl)-2-(2-hydroxyethyl)ethane-1,2-dithiolane	poly(perfluoromethyl)ethers	1	99
114-97-4	114-97-4	1-fluoro-5-[12-(2-methyl-1-oxo-2-propenyl)oxy]hexyl diethanolamine	poly(perfluoromethyl)ethers	1	99
114-98-5	114-98-5	1-fluoro-5-[12-(2-methyl-1-oxo-2-propenyl)oxy]hexyl diethanolamine	poly(perfluoromethyl)ethers	1	99
691358-66-4	691358-66-4	1-(9H-fluorene-2-yl)-2,3,4,4,5,5,6,6,7,7,8,8,8,8-tetrafluoro-1,2-dithiolane	OTHER poly(perfluoromethyl)ethers	4	6
401535-1	401535-1	1,1,1,3,3-pentafluoroethane	poly(perfluoromethyl)ethers	2	2
442339-9	442339-9	1,1,2,2,3,3-hexafluoroethane	poly(perfluoromethyl)ethers	1	3
28501-21-5	28501-21-5	1,1,1,3,3,3-hexafluoro-2-fluoroisopropane	poly(perfluoromethyl)ethers	1	3
10562-77-9	10562-77-9	1,1,1,3,3,3-hexafluoro-2-fluoroisopropane	fluorinated (meth)acrylate polymers	3	3
21334-16-4	21334-16-4	1,2,3-propanetriol carbonate, 2-hydroxy-, 1,2-bis(2-oxoethyl)oxy-	poly(perfluoromethyl)ethers	5	5
125304-20-3	125304-20-3	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	8	10
68934-01-8	68934-01-8	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	8	10
119178-92-1	119178-92-1	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	8	10
54009-74-4	54009-74-4	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	9	9
6815-70-8	6815-70-8	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	9	9
94206-43-3	94206-43-3	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	14	14
94206-48-3	94206-48-3	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	14	14
63295-29-4	63295-29-4	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	15	15
94206-42-9	94206-42-9	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	15	15
94206-44-9	94206-44-9	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	16	16
94206-49-4	94206-49-4	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	16	16
94206-53-0	94206-53-0	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	17	17
10516-14-4	10516-14-4	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	6	6
94206-50-7	94206-50-7	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	12	12
94206-47-2	94206-47-2	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	12	12
63295-28-3	63295-28-3	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	13	13
94206-51-8	94206-51-8	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	13	13
94158-70-6	94158-70-6	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	10	10
94206-46-1	94206-46-1	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	10	10
63295-27-2	63295-27-2	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	11	11
94159-84-9	94159-84-9	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	11	11
94206-45-0	94206-45-0	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	8	8
170004-70-3	170004-70-3	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	8	8
67824-44-4	67824-44-4	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	9	9
63295-18-1	63295-18-1	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	9	9
63295-20-5	63295-20-5	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	9	9
54009-73-3	54009-73-3	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	8	8
106796-59-2	106796-59-2	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	2	4
57101-59-4	57101-59-4	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	9	9
21574-38-4	21574-38-4	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	7	7
73919-29-2	73919-29-2	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	8	8
96210-37-6	96210-37-6	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	8	8
90184-06-2	90184-06-2	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	poly(perfluoromethyl)ethers	4	4
119275-54-6	119275-54-6	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	fluorinated (meth)acrylate polymers	10	10
384-04-3	384-04-3	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	OTHER poly(perfluoromethyl)ethers	8	8
64486-83-3	64486-83-3	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	OTHER poly(perfluoromethyl)ethers	8	8
80979-54-3	80979-54-3	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	OTHER poly(perfluoromethyl)ethers	8	8
94159-88-3	94159-88-3	1,2,4,5-hexametastereoisomer of 1,4-dimethyl-2,3,4,5-tetrafluoro-2,3-dithiolane	OTHER poly(perfluoromethyl)ethers	8	8

6784-489	H-tetrasulfamide, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-N2-propyl-		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	6	6
6859-154	H-tetrasulfamide, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-N-ethyl-		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	6	6
67919-024	H-tetrasulfamide, N,N'-bis[2-(dimethylamino)ethyl]-, ethandiol	N-ethyl-N,N'-bis[2-(2,2,3,3,4,4,5,5,6,6,6,6-tetrafluoroethyl)amino]ethane-1,2-diol	poly(perfluorotetrafluoro)sulfonamides (- FASAs)	6	6
6898-282	H-tetrasulfamide, N1,4-dimethylamino-propyl-1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	6	6
7372-335	H-tetrasulfamide, N1,4-dimethylamino-propyl-1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, monosulfate		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	6	6
6897-619	H-tetrasulfamide, N1,4-dimethylamino-propyl-1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, monosulfate		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	6	6
7372-344	H-tetrasulfamide, N1,4-dimethylamino-propyl-1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, disulfate		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	6	6
3026-568	H-tetrasulfamide, N1,4-dimethylamino-propyl-1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	6	6
17894-718	H-tetrasulfamide, N1,4-dimethylamino-propyl-1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, potassium salt		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	6	6
3445-023	H-tetrasulfamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-N2-hydroxyethyl-		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	6	6
67969-665	H-tetrasulfamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-N2-hydroxypropyl-		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	7	7
68239-758	H-tetrasulfamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-N2-(2-hydroxyethyl)propyl-		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	7	7
355-464	H-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-		poly(perfluorotetrafluoro)sulfonic sulfonic acids	6	6
6859-082	H-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, ammonium salt		poly(perfluorotetrafluoro)sulfonic sulfonic acids	6	6
7023-160	H-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, compd. with 2,2'-iminobis[ethanol] (1:1)		poly(perfluorotetrafluoro)sulfonic sulfonic acids	6	6
85120-779	H-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, lithium salt		poly(perfluorotetrafluoro)sulfonic sulfonic acids	6	6
3071-994	H-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, potassium salt		poly(perfluorotetrafluoro)sulfonic sulfonic acids	6	6
8238-125	H-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, sodium salt		poly(perfluorotetrafluoro)sulfonic sulfonic acids	6	6
5591-234	H-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-		poly(perfluorotetrafluoro)sulfonic sulfonic acids	6	6
27619-884	H-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-		poly(perfluorotetrafluoro)sulfonic sulfonic acids	6	6
423-502	H-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-		poly(perfluorotetrafluoro)sulfonic sulfonic acids	6	6
423-461	H-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-(1:1)H2Perfluoroethane-1,4'		poly(perfluorotetrafluoro)sulfonic sulfonic acids	5	5
2043-472	H-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-		poly(perfluorotetrafluoro)sulfonic sulfonic acids	4	4
34839-444	H-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-, nitrate		poly(perfluorotetrafluoro)sulfonic sulfonic acids	6	6
755-259	H-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-		poly(perfluorotetrafluoro)sulfonic sulfonic acids	6	6
19430-934	H-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-		poly(perfluorotetrafluoro)sulfonic sulfonic acids	4	4
6858-855	H-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-, polymer with ethane and tetrahydrofuran		poly(perfluorotetrafluoro)sulfonic sulfonic acids	2	4
3247-355	H-tetrasulfonic acid, 1,4,2,2',3,3',4,4',4'-bis[2-(dimethylamino)ethyl]-		poly(perfluorotetrafluoro)sulfonic sulfonic acids	3	3
6859-121	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, ammonium salt		poly(perfluorotetrafluoro)sulfonic sulfonic acids	9	9
17202-414	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, ammonium salt		poly(perfluorotetrafluoro)sulfonic sulfonic acids	9	9
29189-394	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, potassium salt		poly(perfluorotetrafluoro)sulfonic sulfonic acids	9	9
98789-572	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, sodium salt		poly(perfluorotetrafluoro)sulfonic sulfonic acids	9	9
27607-610	N-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-		poly(perfluorotetrafluoro)sulfonic sulfonic acids	7	7
6859-063	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-		poly(perfluorotetrafluoro)sulfonic sulfonic acids	9	9
376-181	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, Shanghai Sunway Pharmaceutical Technology Co. Ltd.		poly(perfluorotetrafluoro)sulfonic sulfonic acids	8	8
37013-722	N-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-, dibutyltin phosphate		poly(perfluorotetrafluoro)sulfonic sulfonic acids	7	7
6859-394	N-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-, dibutyltin phosphate, diammonium salt		poly(perfluorotetrafluoro)sulfonic sulfonic acids	7	7
376-227	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-		poly(perfluorotetrafluoro)sulfonic sulfonic acids	9	9
4241-452	N-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-		poly(perfluorotetrafluoro)sulfonic sulfonic acids	7	7
22007-103	N-tetrasulfonic acid, reaction product with its ester of reduced polybut, oxidized tetrahydrofuran		poly(perfluorotetrafluoro)sulfonic sulfonic acids	16	16
6104-674	N-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-, 1,1,1,1,2,2,2,2-tetrafluoroethane		poly(perfluorotetrafluoro)sulfonic sulfonic acids	16	16
94200-552	N-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-, 1,1,1,1,2,2,2,2-tetrafluoroethane		poly(perfluorotetrafluoro)sulfonic sulfonic acids	6	6
9387-484	N-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-, 1,1,1,1,2,2,2,2-tetrafluoroethane		poly(perfluorotetrafluoro)sulfonic sulfonic acids	16	16
9387-544	N-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-, 1,1,1,1,2,2,2,2-tetrafluoroethane		poly(perfluorotetrafluoro)sulfonic sulfonic acids	16	16
9376-239	N-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-, 1,1,1,1,2,2,2,2-tetrafluoroethane		poly(perfluorotetrafluoro)sulfonic sulfonic acids	16	16
94291-764	N-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-, 1,1,1,1,2,2,2,2-tetrafluoroethane		poly(perfluorotetrafluoro)sulfonic sulfonic acids	16	16
94291-594	N-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-, 1,1,1,1,2,2,2,2-tetrafluoroethane		poly(perfluorotetrafluoro)sulfonic sulfonic acids	17	17
9387-433	N-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-, 1,1,1,1,2,2,2,2-tetrafluoroethane		poly(perfluorotetrafluoro)sulfonic sulfonic acids	17	17
9376-193	N-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-, 1,1,1,1,2,2,2,2-tetrafluoroethane		poly(perfluorotetrafluoro)sulfonic sulfonic acids	17	17
9376-284	N-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-, 1,1,1,1,2,2,2,2-tetrafluoroethane		poly(perfluorotetrafluoro)sulfonic sulfonic acids	17	17
9376-319	N-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-, 1,1,1,1,2,2,2,2-tetrafluoroethane		poly(perfluorotetrafluoro)sulfonic sulfonic acids	17	17
307-299	N-tetrasulfonic acid, 3,3',4,4',5,5',6,6'-octafluoro-, 1,1,1,1,2,2,2,2-tetrafluoroethane		poly(perfluorotetrafluoro)sulfonic sulfonic acids	7	7
6855-679	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, sodium salt		poly(perfluorotetrafluoro)sulfonic sulfonic acids	8	8
784-914	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, compd. with N,N'-diethylmethanamine (1:1)		poly(perfluorotetrafluoro)sulfonic sulfonic acids	8	8
78752-824	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, compd. with N,N'-diethylmethanamine (1:1)		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	8	8
2448-094	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, N,N'-bis[2-(2,2,3,3,4,4,5,5,6,6,6,6-tetrafluoroethyl)amino]ethane-1,2-diol		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	8	8
4516-151	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, N,N'-bis[2-(2,2,3,3,4,4,5,5,6,6,6,6-tetrafluoroethyl)amino]ethane-1,2-diol		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	8	8
68239-734	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, N,N'-bis[2-(2,2,3,3,4,4,5,5,6,6,6,6-tetrafluoroethyl)amino]ethane-1,2-diol		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	8	8
5098-293	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, N,N'-bis[2-(2,2,3,3,4,4,5,5,6,6,6,6-tetrafluoroethyl)amino]ethane-1,2-diol		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	8	8
4030-613	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, N,N'-bis[2-(2,2,3,3,4,4,5,5,6,6,6,6-tetrafluoroethyl)amino]ethane-1,2-diol		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	8	8
64264-444	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, N,N'-bis[2-(2,2,3,3,4,4,5,5,6,6,6,6-tetrafluoroethyl)amino]ethane-1,2-diol		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	8	8
432-869	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, N,N'-bis[2-(2,2,3,3,4,4,5,5,6,6,6,6-tetrafluoroethyl)amino]ethane-1,2-diol		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	8	8
31866-324	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, N,N'-bis[2-(2,2,3,3,4,4,5,5,6,6,6,6-tetrafluoroethyl)amino]ethane-1,2-diol		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	8	8
34814-454	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, N,N'-bis[2-(2,2,3,3,4,4,5,5,6,6,6,6-tetrafluoroethyl)amino]ethane-1,2-diol		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	8	8
13794-559	N-tetrasulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6-tetrafluoro-, N,N'-bis[2-(2,2,3,3,4,4,5,5,6,6,6,6-tetrafluoroethyl)amino]ethane-1,2-diol		N-alkyl perfluorotetrafluoro sulfonamides (- FASAs)	8	8

68539-09-46	269-512-1	1-Propansulfone acid, 1,1,2,2,3,3,4,4,5,5,5-undecafluoro-, ammonium salt		poly(perfluorinated sulfone)sulfonic acids	5	5
7025-17-1	375-25-1	1-Pentansulfonic acid, 1,1,2,2,3,3,4,4,5,5,5-undecafluoro-, compd. with 2,2'-imino[ethanol](1:1)		poly(perfluorinated sulfone)sulfonic acids	5	5
355-806-1	306-93-4	1-Pentamethyl fluoride, 1,1,2,2,3,3,4,4,5,5,5-undecafluoro-		poly(perfluorinated alkanoyl sulfonylethyl chloride or trifluorides)	5	5
355-806-2	306-93-5	1-Pentamethyl fluoride, 1,1,2,2,3,3,4,4,5,5,5-undecafluoro-		poly(perfluorinated alkanoyl sulfonylethyl chloride or trifluorides)	5	5
376-87-4	306-93-4	1-Pentamethyl fluoride, 1,1,2,2,3,3,4,4,5,5,5-undecafluoro-		poly(perfluorinated alkanoyl sulfonylethyl chloride or trifluorides)	5	5
1547-26-4	1543-08-4	1-Pentene, 2,3,3,4,4,5,5-hexafluoro-		poly(perfluorinated alkanes)alkenes	4	4
338-83-3	206-20-2	1-Pentene, 4,5-epoxy-, 1,1,2,2,3,3,4,4,5,5,5-undecafluoro-		OTHER poly(perfluorinated organics)	5	5
223-557-20-4		1-Propanamine, 3-(bis(2-hydroxyethyl)amino)-, reaction products with Et esters of oxidized poly(ether sulfone)sulfonates		poly(perfluorinated ammonium)organics	3	3
70933-26-0	175-691-3	1-Propanamine, 2-(bis(2-hydroxyethyl)amino)-N,N,N-trimethyl-, iodide		poly(perfluorinated polyamides)	8	8
6810-62-1		1-Propanamine, 2-(bis(2-hydroxyethyl)amino)-N,N,N-trimethyl-, iodide		poly(perfluorinated polyamides)	6	20
6818-36-5		1-Propanamine, 3-(carboxymethyl)bis(2-hydroxyethyl)amino)-N,N,N-trimethyl-, iodide, ammonium salt		poly(perfluorinated polyamides)	8	8
38850-52-1		1-Propanamine, 3-(carboxymethyl)bis(2-hydroxyethyl)amino)-N,N,N-trimethyl-, iodide		poly(perfluorinated polyamides)	8	8
43837-77-5		1-Propanamine, 3-(4-(4,4,5,5,6,6,7,7,8,8,9,9,10,10,10,10-tetradecafluoro-2-hydroxyethyl)amino)-N,N,N-trimethyl-, iodide		poly(perfluorinated polyamides)	8	8
9413-01-2		1-Propanamine, 3-(bis(2-hydroxyethyl)amino)-N,N,N-trimethyl-, iodide		poly(perfluorinated polyamides)	8	8
68298-11-3		1-Propanamine, 3-(bis(2-hydroxyethyl)amino)-N,N,N-trimethyl-, iodide		poly(perfluorinated polyamides)	8	8
71149-44-7		1-Propanamine, 3-(bis(2-hydroxyethyl)amino)-N,N,N-trimethyl-, iodide		poly(perfluorinated polyamides)	8	8
38066-74-1		1-Propanamine, 3-(bis(2-hydroxyethyl)amino)-N,N,N-trimethyl-, iodide		poly(perfluorinated polyamides)	8	8
8565-67-4		1-Propanamine, 3-(bis(2-hydroxyethyl)amino)-N,N,N-trimethyl-, iodide		poly(perfluorinated polyamides)	8	8
1652-63-7	116-716-3	1-Propanamine, 3-(bis(2-hydroxyethyl)amino)-N,N,N-trimethyl-, iodide		poly(perfluorinated polyamides)	8	8
6810-75-8		1-Propanamine, 3-(bis(2-hydroxyethyl)amino)-N,N,N-trimethyl-, iodide, ammonium salt		poly(perfluorinated polyamides)	8	8
70225-26-2		1-Propanamine, 3-(bis(2-hydroxyethyl)amino)-N,N,N-trimethyl-, iodide		poly(perfluorinated polyamides)	8	8
59493-70-8		1-Propanamine, 3-(bis(2-hydroxyethyl)amino)-N,N,N-trimethyl-, iodide		poly(perfluorinated polyamides)	8	8
59493-72-4	497-460-8	1-Propanamine, 3-(bis(2-hydroxyethyl)amino)-N,N,N-trimethyl-, iodide		poly(perfluorinated polyamides)	9	9
107715-61-3		1-Propanamine, 3-(bis(2-hydroxyethyl)amino)-N,N,N-trimethyl-, iodide		poly(perfluorinated polyamides)	4	20
11931-05-1		1-Propanamine, N-(2-carboxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides)	8	8
93776-14-8		1-Propanamine, N-(2-carboxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides)	8	8
93776-15-9		1-Propanamine, N-(2-carboxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides)	8	8
93777-12-9		1-Propanamine, N-(2-carboxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides)	11	11
73353-25-0		1-Propanamine, N-(2-carboxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides)	9	9
30186-66-0		1-Propanamine, N-(2-carboxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides)	7	7
3158-52-1		1-Propanamine, N-(2-carboxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides)	7	7
11933-08-5		1-Propanamine, N-(2-carboxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides)	9	9
93776-12-6		1-Propanamine, N-(2-carboxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides)	12	12
61798-69-1		1-Propanamine, N-(2-carboxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides)	6	6
93776-15-9		1-Propanamine, N-(2-carboxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides)	13	13
66008-22-8		1-Propanamine, N-(2-carboxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	6	6
81198-38-7		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	6	6
38850-53-6		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	8	8
77958-18-0		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	8	8
34455-21-5		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	8	8
75946-16-1		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	8	8
130114-31-7		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides)	6	6
90178-20-8		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides)	7	7
70674-24-1		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides)	9	9
34455-29-7	512-666-8	1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	6	6
66008-71-7		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	6	6
109669-38-3		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	8	8
93951-33-8		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	1	7
53517-08-9		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides)	7	7
94088-80-9		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides)	6	6
60991-206-9		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides)	9	9
53518-06-6		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	4	4
67939-95-1		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	4	4
70225-22-8		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	4	4
68555-81-7		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	7	7
67844-58-1		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	7	7
70225-20-6		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	7	7
52166-82-2		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	6	6
68957-58-4		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	6	6
70248-52-1		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	6	6
68957-55-1		1-Propanamine, N-(2-hydroxyethyl)-N,N-dimethyl-, iodide		poly(perfluorinated polyamides) (FASAs)	5	5

68957-57-3	1-Propylamine, N,N,N-trimethyl-3-[[[undecylhexoxy]sulfonyl]lamino], iodide		N-alkyl perfluoropoly sulfonamides (-FASAs)	5	5
70225-24-0	1-Propylamine, N,N,N-trimethyl-3-[[[undecylhexoxy]sulfonyl]lamino], sulfate (2:1)		N-alkyl perfluoropoly sulfonamides (-FASAs)	5	5
93894-22-5	1-Propanamine, N,N-dimethyl-3-[[[tridecylhexafluoroxy]sulfonyl]lamino], N-ethyl-, iodide		polyperfluorinated iodides	8	8
93894-66-6	1-Propanamine, N,N-dimethyl-3-[[[tridecylhexafluoroxy]sulfonyl]lamino], N-ethyl-, iodide		polyperfluorinated iodides	8	8
93762-11-9	1-Propansulfonamide, 1,1,2,2,3,3-hexafluoro-N-(2-hydroxyethyl)-N-ethyl-, iodide		N-alkyl perfluoropoly sulfonamides (-FASAs)	4	4
93762-12-0	1-Propansulfonamide, 1,1,2,2,3,3-hexafluoro-N-(2-hydroxyethyl)-2-(trifluoromethyl)-		N-alkyl perfluoropoly sulfonamides (-FASAs)	4	4
93762-09-5	1-Propansulfonamide, 1,1,2,2,3,3-hexafluoro-N-(2-hydroxyethyl)-2-(trifluoromethyl)-		polyperfluorinated sulfonic sulfonic acids	2	2
93762-10-4	1-Propansulfonamide, 1,1,2,2,3,3-hexafluoro-N-(2-hydroxyethyl)-2-(trifluoromethyl)-		polyperfluorinated sulfonic sulfonic acids	4	4
93762-08-1	1-Propansulfonamide, 1,1,2,2,3,3-hexafluoro-N-(2-hydroxyethyl)-2-(trifluoromethyl)-, potassium salt		polyperfluorinated sulfonic sulfonic acids	4	4
448023-58-2	1-Propansulfonamide, 2-hydroxy-3-[[[2-hydroxyethyl]bis[2-(trifluoromethyl)ethyl]amino]ethyl]-, ammonium salt		N-alkyl perfluoropoly sulfonamides (-FASAs)	4	4
448023-58-3	1-Propansulfonamide, 2-hydroxy-3-[[[2-hydroxyethyl]bis[2-(trifluoromethyl)ethyl]amino]ethyl]-, ammonium salt		N-alkyl perfluoropoly sulfonamides (-FASAs)	4	4
448023-58-4	1-Propansulfonamide, 2-hydroxy-3-[[[2-hydroxyethyl]bis[2-(trifluoromethyl)ethyl]amino]ethyl]-, ammonium salt		polyperfluorinated TOL.S	4	4
72785-08-1	1-Propansulfonamide, 3-[[[4-dimethylamino]propyl]bis[2-(trifluoromethyl)ethyl]amino]-		polyperfluorinated sulfonic sulfonic acids	8	8
94133-09-1	1-Propansulfonamide, 3-[[[4-dimethylamino]propyl]bis[2-(trifluoromethyl)ethyl]amino]-, monosodium salt		polyperfluorinated sulfonic sulfonic acids	8	8
38859-60-1	1-Propansulfonamide, 3-[[[4-dimethylamino]propyl]bis[2-(trifluoromethyl)ethyl]amino]-, monosodium salt		polyperfluorinated sulfonic sulfonic acids	6	6
73172-32-4	1-Propansulfonamide, 3-[[[4-dimethylamino]propyl]bis[2-(trifluoromethyl)ethyl]amino]-2-hydroxy-, monosodium salt		polyperfluorinated sulfonic sulfonic acids	6	6
85665-65-2	1-Propansulfonamide, 3-[[[4-dimethylamino]propyl]bis[2-(trifluoromethyl)ethyl]amino]-2-hydroxy-, monosodium salt		polyperfluorinated sulfonic sulfonic acids	8	8
89885-41-0	1-Propansulfonamide, 3-[[[4-dimethylamino]propyl]bis[2-(trifluoromethyl)ethyl]amino]-2-hydroxy-, sodium salt		OTHER polyperfluorinated ORGANICS	7	7
75932-81-4	1-Propansulfonamide, 3-[[[4-dimethylamino]propyl]bis[2-(trifluoromethyl)ethyl]amino]-2-hydroxy-, sodium salt		polyperfluorinated sulfonic sulfonic acids	8	8
70983-61-8	1-Propanol, 2,2,3,3-tetrafluoro-2-[[1,1,2,2,3,3-hexafluoro-2-[[1,1,2,2,3,3-hexafluoroethyl]oxy]propoxy]-, polymer with 1,1,2,2,3,3-hexafluoroethyl]oxy]propane and 1,1,2,2,3,3-hexafluoroethyl]oxy]propane and 1,1,2,2,3,3-hexafluoroethyl]oxy]propane		polyperfluorinated TOL.S	2	3
25212-05-9	1-Propene-2-ol, 3,3,3-trifluoro-, acetate, polymers		polyperfluorinated TOL.S	6	20
116-15-4	1-Propene, 1,1,2,2,3,3-hexafluoro-, oxidized, polymer		polyperfluorinated POLYMERS	3	3
108144-05-4	1-Propene, 1,1,2,2,3,3-hexafluoro-, oxidized, polymer		polyperfluorated ALKANES/ALKENES		
63654-41-1	1-Propene, 1,1,2,2,3,3-hexafluoro-, polymer with 1,1,2,2,3,3-hexafluoroethyl]oxy]propane and 1,1,2,2,3,3-hexafluoroethyl]oxy]propane		polyperfluorated POLYMERS		1
87845-84-7	1-Propene, 1,1,2,2,3,3-hexafluoro-, polymer with 1,1,2,2,3,3-hexafluoroethyl]oxy]propane and 1,1,2,2,3,3-hexafluoroethyl]oxy]propane		polyperfluorated POLYMERS		
25190-89-0	1-Propene, 1,1,2,2,3,3-hexafluoro-, polymer with 1,1,2,2,3,3-hexafluoroethyl]oxy]propane and 1,1,2,2,3,3-hexafluoroethyl]oxy]propane		polyperfluorated POLYMERS		
68182-34-3	1-Propene, 1,1,2,2,3,3-hexafluoro-, polymer with 1,1,2,2,3,3-hexafluoroethyl]oxy]propane and 1,1,2,2,3,3-hexafluoroethyl]oxy]propane		polyperfluorated POLYMERS		
57570-64-4	1-Propene, 1,1,2,2,3,3-hexafluoro-, polymer with 1,1,2,2,3,3-hexafluoroethyl]oxy]propane and 1,1,2,2,3,3-hexafluoroethyl]oxy]propane		polyperfluorated POLYMERS		
149935-20-3	1-Propene, 1,1,2,2,3,3-hexafluoro-, polymer with 1,1,2,2,3,3-hexafluoroethyl]oxy]propane and 1,1,2,2,3,3-hexafluoroethyl]oxy]propane		polyperfluorated POLYMERS		
60918-85-6	1-Propene, 1,1,2,2,3,3-hexafluoro-, polymer with 1,1,2,2,3,3-hexafluoroethyl]oxy]propane and 1,1,2,2,3,3-hexafluoroethyl]oxy]propane		polyperfluorated POLYMERS		
64155-70-0	1-Propene, 1,1,2,2,3,3-hexafluoro-, polymer with 1,1,2,2,3,3-hexafluoroethyl]oxy]propane and 1,1,2,2,3,3-hexafluoroethyl]oxy]propane		polyperfluorated POLYMERS		
95325-75-0	1-Propene, 1,1,2,2,3,3-hexafluoro-, polymer with 1,1,2,2,3,3-hexafluoroethyl]oxy]propane and 1,1,2,2,3,3-hexafluoroethyl]oxy]propane		polyperfluorated POLYMERS		
35560-16-8	1-Propene, 1,1,2,2,3,3-hexafluoro-, polymer with 1,1,2,2,3,3-hexafluoroethyl]oxy]propane and 1,1,2,2,3,3-hexafluoroethyl]oxy]propane		polyperfluorated POLYMERS		
74409-71-1	1-Propene, 1,1,2,2,3,3-hexafluoro-, polymer with 1,1,2,2,3,3-hexafluoroethyl]oxy]propane and 1,1,2,2,3,3-hexafluoroethyl]oxy]propane		polyperfluorated POLYMERS		
74409-69-3	1-Propene, 1,1,2,2,3,3-hexafluoro-, polymer with 1,1,2,2,3,3-hexafluoroethyl]oxy]propane and 1,1,2,2,3,3-hexafluoroethyl]oxy]propane		polyperfluorated POLYMERS		
183706-63-9	1-Propene, 1,1,2,2,3,3-hexafluoro-, polymer with 1,1,2,2,3,3-hexafluoroethyl]oxy]propane and 1,1,2,2,3,3-hexafluoroethyl]oxy]propane		polyperfluorated POLYMERS		
74409-70-0	1-Propene, 1,1,2,2,3,3-hexafluoro-, polymer with 1,1,2,2,3,3-hexafluoroethyl]oxy]propane and 1,1,2,2,3,3-hexafluoroethyl]oxy]propane		polyperfluorated POLYMERS		
6391-86-6	1-Propene, polymer with 1,1,1,2,2,3,3-hexafluoro-2-[[trifluoroethyl]oxy]propane and tetrafluoroethane		polyperfluorated POLYMERS		
60918-86-7	1-Propene, polymer with 1,1,1,2,2,3,3-hexafluoro-2-[[trifluoroethyl]oxy]propane and tetrafluoroethane		polyperfluorated POLYMERS		
27029-05-6	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
68758-57-4	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
9329-97-5	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
57878-07-4	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
93857-46-6	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
57877-99-3	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
93776-22-8	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
57878-00-9	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
93898-42-5	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
94208-57-4	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
93857-51-3	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
93857-56-8	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
94231-56-8	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
93776-21-4	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
94159-77-0	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
92971-84-6	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
93776-18-2	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
80909-29-1	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
94159-78-1	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
65702-24-1	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
706-209-5	1-Propene, polymer with tetrafluoroethane		polyperfluorated POLYMERS		
161075-53-0	2-(4-chlorophenylamino)-2-(dimethylamino)ethyl propanoate		polyperfluorated CARBOXYLIC ACIDS	3	12
117841-18-5	2-(4-chlorophenylamino)-2-(dimethylamino)ethyl propanoate		polyperfluorated AMINES	4	4

94804-04-0	2-(15-thioxo-1,4-dithiabenzene-6,6',7,7',8,8',9,10,10',11,11'-dioxathio-3,3',4',4'-tetramethyl...)	poly(perfluorinated siloxanes)silicones/silanes/silicates	6	6
918-105-7	(methoxyethyl)carbamate	OTHER poly(perfluorinated)ORGANICS	6	6
441-600-2	2,2,3,3,4,4,5,5,6,6-hexafluoro-4-ethoxybutane-2-amine	OTHER poly(perfluorinated)ORGANICS	3	5
80133-82-8	1,4-bis(2-hydroxyethyl)benzene	poly(perfluorinated)ALKANES/ALKENES	5	5
147076-07-1	2,2-bis[4-(4-aminophenoxy)phenyl]propane	poly(perfluorinated)ALKANES/ALKENES	7	10
18570-88-6	1,3-bis(2-hydroxyethyl)benzene	poly(perfluorinated)ALKANES/ALKENES	11	11
9378-07-9	2,2-bis[4-(4-aminophenoxy)phenyl]propane	poly(perfluorinated)ALKANES/ALKENES	1	8
9378-07-9	2,2-bis[4-(4-aminophenoxy)phenyl]propane	poly(perfluorinated)ALKANES/ALKENES	9	9
9378-07-9	2,2-bis[4-(4-aminophenoxy)phenyl]propane	poly(perfluorinated)ALKANES/ALKENES	12	12
9378-07-9	2,2-bis[4-(4-aminophenoxy)phenyl]propane	poly(perfluorinated)ALKANES/ALKENES	13	13
88987-13-1	2,2-bis[4-(4-aminophenoxy)phenyl]propane	poly(perfluorinated)ALKANES/ALKENES	8	9
25383-98-1	2,2-bis[4-(4-aminophenoxy)phenyl]propane	poly(perfluorinated)ALKANES/ALKENES	7	7
25383-98-1	2,2-bis[4-(4-aminophenoxy)phenyl]propane	poly(perfluorinated)ALKANES/ALKENES	10	10
25383-98-1	2,2-bis[4-(4-aminophenoxy)phenyl]propane	poly(perfluorinated)ALKANES/ALKENES	12	12
146915-43-7	2,2-bis[4-(4-aminophenoxy)phenyl]propane	poly(perfluorinated)ALKANES/ALKENES	8	8
99908-28-8	2,2-bis[4-(4-aminophenoxy)phenyl]propane	poly(perfluorinated)ALKANES/ALKENES	8	8
110570-00-6	2,2-bis[4-(4-aminophenoxy)phenyl]propane	poly(perfluorinated)ALKANES/ALKENES	8	8
116585-66-6	2,2-bis[4-(4-aminophenoxy)phenyl]propane	poly(perfluorinated)ALKANES/ALKENES	6	17
81969-74-1	2,2-bis[4-(4-aminophenoxy)phenyl]propane	poly(perfluorinated)ALKANES/ALKENES	4	4
94158-20-0	2,2-bis[4-(4-aminophenoxy)phenyl]propane	poly(perfluorinated)ALKANES/ALKENES	4	4
360-89-4	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	6	6
1516-64-9	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	4	4
869-86-1	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	4	4
360-88-3	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	1	1
20972-44-5	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	1	1
15286-16-3	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	1	1
15251-12-5	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	1	1
15286-22-1	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	1	1
221455-71-6	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	8	20
221455-71-6	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	8	20
221455-71-6	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	8	20
169797-36-8	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	2	2
68037-22-9	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	4	20
86130-60-3	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	8	8
182706-82-9	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	8	8
54949-04-3	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	1	20
182706-82-9	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	1	20
51433-70-5	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	8	8
72843-29-5	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	8	8
97259-81-9	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	8	8
149868-74-6	2-butane, 1,1,2,2,4,4,4-tetrafluoro-	poly(perfluorinated)ALKANES/ALKENES	8	8
22386-53-6	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	8	14
160709-33-1	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	8	8
335-35-3	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	3	4
68155-54-4	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	5	9
336-47-3	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	3	5
801-26-3	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	3	8
26570-69-4	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	3	8
51801-21-5	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	3	3
247037-61-6	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	6	20
154865-63-6	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	8	8
68685-58-3	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	8	8
142033-27-0	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	8	14
332076-33-2	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	8	14
332076-33-2	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	8	14
332076-33-2	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	8	14
156592-18-1	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	12	12
9378-07-9	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	12	12
9378-07-9	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	12	12
94159-29-2	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	13	13
94159-29-2	2-ethyl-2-hydroxyacetone	fluorinated urethane polymers	13	13

36978-04-1	2-Propenoic acid, butyl ester, polymer with acrylamide, 2-(methylperfluorocetyl)alkyl(aminomethyl) acrylate and styrene chloride			Fluorinated (meth)acrylate polymers	4	8
102568-17-4	2-Propenoic acid, butyl ester, reaction product with poly(oxo-1,2-ethanediyl), alpha-methyl-, omega-hydroxy-, and N-ethyl-N-(2-hydroxyethyl)perfluorooctane sulfonamide			Fluorinated (meth)acrylate polymers	8	8
68237-96-3	2-Propenoic acid, butyl ester, tetramer with (hexafluoroisobutyl)aminoethyl 2-propenoate, 4-(methyl(oxoethoxy)butyl)aminoethyl 2-propenoate, alpha-(2-methyl-1-oxo-2-propenyl)-4-butenediol, alpha			Fluorinated (meth)acrylate polymers	4	8
182700-81-8	2-Propenoic acid, C(120-alkyl) ester, polymer with alpha-fluoro-omega-12-(1-oxo-2-propenyl)oxyethyl poly(difluoromethyl) ether			Fluorinated (meth)acrylate polymers	4	8
182700-84-1	2-Propenoic acid, C(120-alkyl) ester, polymer with alpha-fluoro-omega-12-(1-oxo-2-propenyl)oxyethyl poly(difluoromethyl) ether and poly(ethylene propylene glycol) monosulfate			Fluorinated (meth)acrylate polymers	1	20
16036-06-4	2-Propenoic acid, C(16-18-alkyl) ester, polymer with 3,3,4,4,5,5,6,6,7,7,8,8,9,10,10-hexadecafluoro-1-ethoxyacrylate			Fluorinated (meth)acrylate polymers	8	8
33089-59-4	2-Propenoic acid, decyl ester, polymer with tetrahydrofuranthiophene, N-hydroxyethyl-2-propenoamide and gamma-omega-perfluoro-C(10-14-alkyl) acrylates			Fluorinated (meth)acrylate polymers	10	14
144831-01-4	2-Propenoic acid, decyl ester, polymer with Br-(1-oxo-2-propenyl)perfluorooctane and gamma-omega-perfluoro-C(14-alkyl) acrylate			Fluorinated (meth)acrylate polymers	8	14
68329-61-4	2-Propenoic acid, decyl ester, polymer with 2-[[[hexafluoroisobutyl]aminoethyl]aminoethyl]aminoethyl 2-propenoate, 2-methyl[[[hexafluoroisobutyl]aminoethyl]aminoethyl]aminoethyl 2-propenoate, 2-methyl[[[perfluorooctyl]aminoethyl]aminoethyl]aminoethyl 2-propenoate, 2-methyl[[[perfluorooctyl]aminoethyl]aminoethyl]aminoethyl 2-propenoate, 2-methyl[[[perfluorooctyl]aminoethyl]aminoethyl]aminoethyl 2-propenoate			Fluorinated (meth)acrylate polymers	4	8
68929-15-9	2-Propenoic acid, decyl ester, polymer with 2-[[[hexafluoroisobutyl]aminoethyl]aminoethyl]aminoethyl 2-propenoate, 2-methyl[[[hexafluoroisobutyl]aminoethyl]aminoethyl]aminoethyl 2-propenoate, 2-methyl[[[perfluorooctyl]aminoethyl]aminoethyl]aminoethyl 2-propenoate, 2-methyl[[[perfluorooctyl]aminoethyl]aminoethyl]aminoethyl 2-propenoate, 2-methyl[[[perfluorooctyl]aminoethyl]aminoethyl]aminoethyl 2-propenoate			Fluorinated (meth)acrylate polymers	4	8
68238-00-2	2-Propenoic acid, ethyl ester, polymer with 4-[[[heptafluoroisobutyl]aminoethyl]aminoethyl]aminoethyl 2-propenoate, 4-(methyl(oxoethoxy)butyl)aminoethyl 2-propenoate, alpha-(2-methyl-1-oxo-2-propenyl)-4-butenediol			Fluorinated (meth)acrylate polymers	4	8
152521-13-6	2-Propenoic acid, hexadecyl ester, polymer with alpha-fluoro-omega-12-(1-oxo-2-propenyl)oxyethyl poly(difluoromethyl) ether and octadecyl 2-propenoate			Fluorinated (meth)acrylate polymers	6	22
65065-69-8	2-Propenoic acid, methyl ester, polymer with alpha-fluoro-omega-12-(1-oxo-2-propenyl)oxyethyl poly(difluoromethyl) ether			Fluorinated (meth)acrylate polymers	6	22
578089-15-5	2-Propenoic acid, mixed isomer with dipentyl ether and 3-(1,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10-hexadecafluoro-1-ethoxy)acrylate			polyperfluorinated (METH)ACRYLATES	8	8
3-303-3	2-Propenoic acid, octyl ester, polymer with hexadecyl 2-methyl-2-propenoate and 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10-hexadecafluoro-1-ethoxyacrylate			Fluorinated (meth)acrylate polymers	6	6
931819-33-5	2-Propenoic acid, octyl ester, polymer with gamma-omega-perfluoro-C(22-alkyl) acrylate and poly(ethylene glycol) methacrylate			Fluorinated (meth)acrylate polymers	6	22
93182-59-7	2-Propenoic acid, octyl ester, polymer with gamma-omega-perfluoro-C(22-alkyl) acrylate			Fluorinated (meth)acrylate polymers	6	22
85881-64-7	2-Propenoic acid, octyl ester, polymer with gamma-omega-perfluoro-C(22-alkyl) acrylate and poly(ethylene glycol) methacrylate			Fluorinated (meth)acrylate polymers	6	22
68541-80-9	2-Propenoic acid, polymer with 2-ethyl[[[heptafluoroisobutyl]aminoethyl]aminoethyl]aminoethyl 2-propenoate and octadecyl 2-propenoate			Fluorinated (meth)acrylate polymers	8	8
1264108-29-8	2-Propenoic acid, polymer with butyl 2-propenoate and 2,5-dimethylamino-2-propenoate			Fluorinated (meth)acrylate polymers	8	14
524729-93-9	2-Propenoic acid, polymer with butyl 2-propenoate and 2,5-dimethylamino-2-propenoate			Fluorinated (meth)acrylate polymers	8	14
350672-20-7	2-Propenoic acid, polymer with butyl 2-propenoate and 2,5-dimethylamino-2-propenoate			Fluorinated (meth)acrylate polymers	6	6
503297-86-7	2-Propenoic acid, polymer with butyl 2-propenoate and 2,5-dimethylamino-2-propenoate			Fluorinated (meth)acrylate polymers	8	16
61756-62-0	2-Propenoic acid, polymer with butyl 2-propenoate and 2,5-dimethylamino-2-propenoate			Fluorinated (meth)acrylate polymers	4	4
801-250-5	2-Propenoic acid, polymer with butyl 2-propenoate and 2,5-dimethylamino-2-propenoate			Fluorinated (meth)acrylate polymers	9	15
47970-03-6	2-Propenoic acid, 3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetrafluoroethyl ester, polymer with 2-methyl-2-propenoate and 2-methyl(oxoethyl)acrylate			Fluorinated (meth)acrylate polymers	6	6
113150-11-1	2-Propenoic acid, 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-tetrafluoroethyl ester, polymer with 2-methyl-2-propenoate and 2,2,2-trifluoroethyl 2-propenoate			Fluorinated (meth)acrylate polymers	8	8
831241-91-9	2-Propenoic acid, 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-tetrafluoroethyl ester, polymer with ethyl(oxoethyl)acrylate and 2,2,2-trifluoroethyl 2-propenoate			polyperfluorinated POLYIMERS	8	8
790697-02-0	2-Propenoic acid, 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-tetrafluoroethyl ester, polymer with ethyl(oxoethyl)acrylate and 2,2,2-trifluoroethyl 2-propenoate			polyperfluorinated POLYIMERS	8	8
93776-04-3	2-Tridecanol, 1,1'-bis[2-(2-ethyl-2-hydroxyethyl)aminoethyl]aminoethyl 2-propenoate, 2-methyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate			polyperfluorinated ALKOHOLS	10	10
93776-04-3	2-Tridecanol, 1,1'-bis[2-(2-ethyl-2-hydroxyethyl)aminoethyl]aminoethyl 2-propenoate, 2-methyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate			polyperfluorinated ALKOHOLS	11	11
94159-80-5	2-Tridecanol, 1,1'-bis[2-(2-ethyl-2-hydroxyethyl)aminoethyl]aminoethyl 2-propenoate, 2-methyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate			polyperfluorinated ALKOHOLS	10	10
94159-83-8	2-Tridecanol, 1,1'-bis[2-(2-ethyl-2-hydroxyethyl)aminoethyl]aminoethyl 2-propenoate, 2-methyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate			polyperfluorinated ALKOHOLS	11	11
94159-86-1	2-Tridecanol, 1,1'-bis[2-(2-ethyl-2-hydroxyethyl)aminoethyl]aminoethyl 2-propenoate, 2-methyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate			polyperfluorinated ALKOHOLS	8	8
93776-02-4	2-Tridecanol, 1,1'-bis[2-(2-ethyl-2-hydroxyethyl)aminoethyl]aminoethyl 2-propenoate, 2-methyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate			polyperfluorinated ALKOHOLS	9	8
93776-02-4	2-Tridecanol, 1,1'-bis[2-(2-ethyl-2-hydroxyethyl)aminoethyl]aminoethyl 2-propenoate, 2-methyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate			polyperfluorinated ALKOHOLS	8	8
94159-81-6	2-Tridecanol, 1,1'-bis[2-(2-ethyl-2-hydroxyethyl)aminoethyl]aminoethyl 2-propenoate, 2-methyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate			polyperfluorinated ALKOHOLS	8	8
73533-26-1	2-Tridecanol, 1,1'-bis[2-(2-ethyl-2-hydroxyethyl)aminoethyl]aminoethyl 2-propenoate, 2-methyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate			polyperfluorinated ALKOHOLS	9	8
94158-41-9	2-Tridecanol, 1,1'-bis[2-(2-ethyl-2-hydroxyethyl)aminoethyl]aminoethyl 2-propenoate, 2-methyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate			polyperfluorinated ALKOHOLS	8	8
94158-62-0	2-Tridecanol, 1,1'-bis[2-(2-ethyl-2-hydroxyethyl)aminoethyl]aminoethyl 2-propenoate, 2-methyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate			polyperfluorinated ALKOHOLS	9	8
94159-91-8	2-Tridecanol, 1,1'-bis[2-(2-ethyl-2-hydroxyethyl)aminoethyl]aminoethyl 2-propenoate, 2-methyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate			polyperfluorinated ALKOHOLS	8	8
94159-92-9	2-Tridecanol, 1,1'-bis[2-(2-ethyl-2-hydroxyethyl)aminoethyl]aminoethyl 2-propenoate, 2-methyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate			polyperfluorinated ALKOHOLS	9	9
407-810-7	2-Tridecanol, 1,1'-bis[2-(2-ethyl-2-hydroxyethyl)aminoethyl]aminoethyl 2-propenoate, 2-methyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate, 2-ethyl-2-propenoate			perfluorinated sulfonamides (FASAs)	4	8
477259-20-9	3-(Trimethylsilyloxy)propyl 2-methyl-2-propenoate polymer with 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,12-trichloroethyl 2-propenoate, 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-trifluoroethyl 2-propenoate			polyperfluorinated POLYIMERS	8	10
701099-41-3	3-(4,4,5,5,6,6,6,6-tetrafluorobutyl)ethyl 2-methyl-2-propenoate			polyperfluorinated (METH)ACRYLATES	4	4
202026-92-6	3-(4,4,5,5,6,6,6,6-tetrafluorobutyl)ethyl 2-methyl-2-propenoate			OTHER polyperfluorinated ORGANICS	6	6
1352-15-8	3-(4,4,5,5,6,6,6,6-tetrafluorobutyl)ethyl 2-methyl-2-propenoate			OTHER polyperfluorinated ORGANICS	3	3
26738-51-2	3-(4,4,5,5,6,6,6,6-tetrafluorobutyl)ethyl 2-methyl-2-propenoate			OTHER polyperfluorinated ORGANICS	3	3
34761-47-2	3-(4,4,5,5,6,6,6,6-tetrafluorobutyl)ethyl 2-methyl-2-propenoate			OTHER polyperfluorinated ORGANICS	3	3
96388-56-1	3-(4,4,5,5,6,6,6,6-tetrafluorobutyl)ethyl 2-methyl-2-propenoate			OTHER polyperfluorinated ORGANICS	2	3
104267-24-5	3-(4,4,5,5,6,6,6,6-tetrafluorobutyl)ethyl 2-methyl-2-propenoate			OTHER polyperfluorinated ORGANICS	14	14
160336-10-7	3-(4,4,5,5,6,6,6,6-tetrafluorobutyl)ethyl 2-methyl-2-propenoate			OTHER polyperfluorinated ORGANICS	8	8
348137-34-8	3-(4,4,5,5,6,6,6,6-tetrafluorobutyl)ethyl 2-methyl-2-propenoate			OTHER polyperfluorinated ORGANICS	9	15
54012-87-2	3-(4,4,5,5,6,6,6,6-tetrafluorobutyl)ethyl 2-methyl-2-propenoate			OTHER polyperfluorinated ORGANICS	2	2
813-45-5	3-(4,4,5,5,6,6,6,6-tetrafluorobutyl)ethyl 2-methyl-2-propenoate			OTHER polyperfluorinated ORGANICS	3	3
95845-44-8	3-(4,4,5,5,6,6,6,6-tetrafluorobutyl)ethyl 2-methyl-2-propenoate			OTHER polyperfluorinated ORGANICS	5	5
6189-00-0	3-(4,4,5,5,6,6,6,6-tetrafluorobutyl)ethyl 2-methyl-2-propenoate			OTHER polyperfluorinated ORGANICS	7	7
6884-92-0	3-(4,4,5,5,6,6,6,6-tetrafluorobutyl)ethyl 2-methyl-2-propenoate			OTHER polyperfluorinated ORGANICS	6	6

684-32-2	3-Pentanoic acid, 1,1,2,2,4,4,5,5,5-tetrafluoro-	OTHER poly(perfluorinated) ORGANICS	4	4
756-134-7	3-Pentanoic acid, 1,1,2,2,4,4,5,5,5-tetrafluoro-4-(trifluoromethyl)-	OTHER poly(perfluorinated) ORGANICS	5	5
813-44-4	3-Pentanoic acid, 1,1,2,4,4,5,5,5-tetrafluoro-2-(bis(trifluoromethyl)-	OTHER poly(perfluorinated) ORGANICS	6	6
61097-066	3-Pentanoic acid, 1,1,2,4,4,5,5,5-tetrafluoro-2-(bis(trifluoromethyl)-4-(thiomethyl)-2-propyl-	poly(perfluorinated) ETHERS	3	5
80994-479	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) METHACRYLATES	6	6
28579-85-1	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) ETHERS	4	4
101896-23-4	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	7	7
101896-23-4	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) PHOSPHORORGANICS	9	9
90811-88-7	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	20
291-441-3	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	8
291-441-29	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	8
90811-88-7	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	8
71608-58-7	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) SULFONIC ACIDS	1	3
83464-71-2	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	7	8
478-182	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	4	4
101283-70-7	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	6	6
107102-25-7	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	6	6
1266450-09-0	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	6	6
1345817-52-8	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	6	6
125708-41-4	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	4	4
220237-52-5	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	10	10
185303-00-4	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	12	12
451-310-6	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	8
283164-62-5	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	1	3
70776-26-0	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	6	6
68805-70-9	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	2	4
71608-37-2	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	20
71608-38-3	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	20
71608-39-4	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	20
71608-40-7	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	20
72823-70-2	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	20
8561-41-2	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	20
91770-94-4	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	20
90822-43-8	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	20
391895-07-1	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	20
6826-07-6	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	20
37451-53-4	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	14
91745-16-3	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	14
118102-37-7	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	14
118102-37-8	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	14
37634-33-9	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	14
185303-70-0	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	14
68155-04-4	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	9	10
210423-23-2	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	4	20
97659-47-7	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	14
68390-33-0	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	14
68390-32-9	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	10	12
68188-12-5	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	14	20
90622-21-2	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	4	20
89945-01-4	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	6	18
20622-29-1	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	8	14
206099-80-5	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	7	19
206099-81-4	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	6	12
1-87-6	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	6	12
16094-74-1	4-(trans-4-ethylcyclohexyl)-2-thioxoacetic acid, tetra(nonafluorophenyl) ester	poly(perfluorinated) POLYIMIDES	10	12
		OTHER poly(perfluorinated) ORGANICS	8	8

480-310-4	ammonium 2,2,4-trifluoro-4-(1,2,2,3,3,3-hexafluoro-3-trifluoromethylpropoxy)propionate Ammonium perfluorobiphenyl ethylphosphates is the ammonium salt of a complex mixture of esters of perfluorobiphenyl and phosphoric acid	poly(perfluorinated ETHERS)	1	3
	Ammonium salt of imine and bis(3,3',4,4',5,5',6,6',7,8,8'-trifluoroethyl acyl) and poly (substituted alkyl) phosphate	poly(perfluorinated PHOSPHORORGANICS)	6	6
7919-199	8-benzyloxy-1-methyl-2-(2-methyl-2-propylthio)ethyl methacrylate	poly(perfluorinated PHOSPHORORGANICS)	6	6
175449-31-7	1,4-bis(2-ethylhexafluoroethyl)butane	fluorinated methacrylate polymers	2	10
26638-70-8	2,4-difluoro-2-(trifluoromethyl)ethyl methacrylate	poly(perfluorinated POLYIMIDES)	8	8
09037-75-4	Benzene, 1,2-dichloro-; polymers with hydrogen Me esters of reduced polyacid oxidized tetrafluoromethylene	poly(perfluorinated POLYIMIDES)	8	8
68972-99-2	Benzene, pentafluoro-2-(trifluoromethyl)ethyl methacrylate	Poly(perfluorinated POLYIMIDES)	8	8
52026-59-2	Benzenesulfonamide, N-(2,4,4,5,5-pentafluoro-2-(perfluoromethyl)ethyl)-2,4,4,5,5-pentafluoro-2-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated AMMONIUM ORGANICS)	8	8
9319-973	Benzenesulfonamide, N-(2,4,4,5,5-pentafluoro-2-(perfluoromethyl)ethyl)-2,4,4,5,5-pentafluoro-2-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated ETHERS)	1	6
6903-2449	Benzenesulfonamide, N-(2,4,4,5,5-pentafluoro-2-(perfluoromethyl)ethyl)-2,4,4,5,5-pentafluoro-2-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated ETHERS)	1	7
41674-67-1	Benzenesulfonic acid, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated ETHERS)	8	8
51032-47-4	Benzenesulfonic acid, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated SILFONAMIDES)	8	8
68299-19-4	Benzenesulfonic acid, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated SILFONAMIDES)	4	4
68299-20-8	Benzenesulfonic acid, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated SILFONAMIDES)	6	6
68299-21-2	Benzenesulfonic acid, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated SILFONAMIDES)	5	5
59258-17-3	Benzenesulfonic acid, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated ETHERS)	8	8
5903-844-1	Benzenesulfonic acid, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated ETHERS)	5	5
94022-99-2	Benzenesulfonic acid, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated ESTERS)	1	5
85284-15-2	Benzenesulfonic acid, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated ESTERS)	1	4
94022-94-1	Benzenesulfonic acid, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated ESTERS)	3	4
85284-17-2	Benzenesulfonic acid, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated ESTERS)	1	3
70278-64-4	Benzenesulfonic acid, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated ESTERS)	1	5
52584-45-9	Benzenesulfonic acid, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated ESTERS)	1	7
68299-29-6	Benzenesulfonic acid, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated SILFONAMIDES)	7	7
90218-21-6	Benzenesulfon chloride, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated ALKANOL SULFONYL CHLORIDE or FLUORIDES)	7	7
90218-20-5	Benzenesulfon chloride, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated ALKANOL SULFONYL CHLORIDE or FLUORIDES)	8	8
2426-16-5	Benzenesulfon chloride, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated ALKANOL SULFONYL CHLORIDE or FLUORIDES)	7	7
25444-35-3	Benzenesulfon chloride, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated ALKANOL SULFONYL CHLORIDE or FLUORIDES)	7	7
49258-15-1	Benzenesulfon chloride, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated ETHERS)	7	7
5903-825-2	Benzenesulfon chloride, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated ETHERS)	5	8
51847-19-4	Benzenesulfon chloride, 4-(1,1,1,2,2,2-hexafluoroethyl)-2-(2,2,2-trifluoroethyl)-5-(perfluoromethyl)ethyl methacrylate	poly(perfluorinated ETHERS)	8	8
57819-85-2	Benzoic acid, 2,3,4,5-tetrafluoro-6-(2-(2,2,2-trifluoroethyl)ethyl)hexanoic acid	poly(perfluorinated SILFONIC SULFONIC ACIDS)	8	8
68268-54-7	Benzoic acid, 2,3,4,5-tetrafluoro-6-(2-(2,2,2-trifluoroethyl)ethyl)hexanoic acid	poly(perfluorinated SILFONIC SULFONIC ACIDS)	4	4
6851-40-5	Benzoic acid, 2,3,4,5-tetrafluoro-6-(2-(2,2,2-trifluoroethyl)ethyl)hexanoic acid	poly(perfluorinated SILFONIC SULFONIC ACIDS)	7	7
68815-72-5	Benzoic acid, 2,3,4,5-tetrafluoro-6-(2-(2,2,2-trifluoroethyl)ethyl)hexanoic acid	poly(perfluorinated SILFONIC SULFONIC ACIDS)	6	6
68511-62-5	Benzoic acid, 2,3,4,5-tetrafluoro-6-(2-(2,2,2-trifluoroethyl)ethyl)hexanoic acid	poly(perfluorinated SILFONIC SULFONIC ACIDS)	11	11
29211-192-6	Benzoic acid, 2,3,4,5-tetrafluoro-6-(2-(2,2,2-trifluoroethyl)ethyl)hexanoic acid	poly(perfluorinated SILFONIC SULFONIC ACIDS)	6	6
460207-51-0	Benzoic acid, 4-(1,1-dimethyl)ethyl-, ethyl ester, polymer with ethene, 4-(etheno)loxy-1,1-bis(2,2,2-trifluoro-1-(trifluoromethyl)ethyl)hexanoic acid, 4-(1,1-dimethyl)ethyl-, ethyl ester, polymer with ethene, 4-(etheno)loxy-1,1-bis(2,2,2-trifluoro-1-(trifluoromethyl)ethyl)hexanoic acid	poly(perfluorinated POLYIMIDES)	6	6
503454-47-5	Benzoic acid, 4-(1,1-dimethyl)ethyl-, ethyl ester, polymer with ethene, 4-(etheno)loxy-1,1-bis(2,2,2-trifluoro-1-(trifluoromethyl)ethyl)hexanoic acid, 4-(1,1-dimethyl)ethyl-, ethyl ester, polymer with ethene, 4-(etheno)loxy-1,1-bis(2,2,2-trifluoro-1-(trifluoromethyl)ethyl)hexanoic acid	poly(perfluorinated POLYIMIDES)	6	6
500359-40-3	Benzoic acid, 4-(1,1-dimethyl)ethyl-, ethyl ester, polymer with ethene, 4-(etheno)loxy-1,1-bis(2,2,2-trifluoro-1-(trifluoromethyl)ethyl)hexanoic acid, 4-(1,1-dimethyl)ethyl-, ethyl ester, polymer with ethene, 4-(etheno)loxy-1,1-bis(2,2,2-trifluoro-1-(trifluoromethyl)ethyl)hexanoic acid	poly(perfluorinated POLYIMIDES)	6	6
1202745-43-4	Benzoic acid, 4-(1,1-dimethyl)ethyl-, ethyl ester, polymer with ethene, 4-(etheno)loxy-1,1-bis(2,2,2-trifluoro-1-(trifluoromethyl)ethyl)hexanoic acid, 4-(1,1-dimethyl)ethyl-, ethyl ester, polymer with ethene, 4-(etheno)loxy-1,1-bis(2,2,2-trifluoro-1-(trifluoromethyl)ethyl)hexanoic acid	poly(perfluorinated POLYIMIDES)	6	6
120510-15-4	Benzoic acid, 4-(1,1-dimethyl)ethyl-, ethyl ester, polymer with ethene, 4-(etheno)loxy-1,1-bis(2,2,2-trifluoro-1-(trifluoromethyl)ethyl)hexanoic acid, 4-(1,1-dimethyl)ethyl-, ethyl ester, polymer with ethene, 4-(etheno)loxy-1,1-bis(2,2,2-trifluoro-1-(trifluoromethyl)ethyl)hexanoic acid	poly(perfluorinated POLYIMIDES)	6	6
5853-65-9	Benzoic acid, 4-(1,1-dimethyl)ethyl-, ethyl ester, polymer with ethene, 4-(etheno)loxy-1,1-bis(2,2,2-trifluoro-1-(trifluoromethyl)ethyl)hexanoic acid, 4-(1,1-dimethyl)ethyl-, ethyl ester, polymer with ethene, 4-(etheno)loxy-1,1-bis(2,2,2-trifluoro-1-(trifluoromethyl)ethyl)hexanoic acid	poly(perfluorinated POLYIMIDES)	8	8
15432-82-8	Benzoic acid, ethyl ester, polymer with propenoic acid, 2,2-dimethyl-, ethyl ester, 1-butanol-1-(etheno)loxy-, 1-propene, 2-methyl-, and ethene, tetrahydro-	poly(perfluorinated POLYIMIDES)	8	8
115340-82-4	Benzoic acid, ethyl ester, polymer with propenoic acid, 2,2-dimethyl-, ethyl ester, 1-butanol-1-(etheno)loxy-, 1-propene, 2-methyl-, and ethene, tetrahydro-	OTHER poly(perfluorinated ORGANICS)	8	14
98319-29-5	Benzoic acid, ethyl ester, polymer with propenoic acid, 2,2-dimethyl-, ethyl ester, 1-butanol-1-(etheno)loxy-, 1-propene, 2-methyl-, and ethene, tetrahydro-	OTHER poly(perfluorinated ORGANICS)	8	14
70850-11-2	Benzoic acid, ethyl ester, polymer with propenoic acid, 2,2-dimethyl-, ethyl ester, 1-butanol-1-(etheno)loxy-, 1-propene, 2-methyl-, and ethene, tetrahydro-	poly(perfluorinated POLYIMIDES)	8	8
71608-43-0	Benzoic acid, ethyl ester, polymer with propenoic acid, 2,2-dimethyl-, ethyl ester, 1-butanol-1-(etheno)loxy-, 1-propene, 2-methyl-, and ethene, tetrahydro-	poly(perfluorinated POLYIMIDES)	8	20
32887-76-4	Bis(2,2,3,4,4,5,5,6,6,7,8,8,8-octadecafluorooctanoic acid) hydrogen phosphate	poly(perfluorinated CARBOXYLIC ACIDS)	6	6
57877-95-9	Bis(2,2,3,4,4,5,5,6,6,7,8,8,8-octadecafluorooctanoic acid) hydrogen phosphate	poly(perfluorinated PHOSPHORORGANICS)	6	6
7010-483-3	Bis(2,2,3,4,4,5,5,6,6,7,8,8,8-octadecafluorooctanoic acid) hydrogen phosphate	poly(perfluorinated PHOSPHORORGANICS)	4	4
52299-25-9	Bis(2,2,3,4,4,5,5,6,6,7,8,8,8-octadecafluorooctanoic acid) hydrogen phosphate	Fluorinated oxetane polymers	2	2
864910-70-3	Bis(2,2,3,4,4,5,5,6,6,7,8,8,8-octadecafluorooctanoic acid) hydrogen phosphate	Fluorinated oxetane polymers	2	2
53270-06-9	Bis(2,2,3,4,4,5,5,6,6,7,8,8,8-octadecafluorooctanoic acid) hydrogen phosphate	Fluorinated oxetane polymers	2	2
53270-07-2	Bis(2,2,3,4,4,5,5,6,6,7,8,8,8-octadecafluorooctanoic acid) hydrogen phosphate	Fluorinated oxetane polymers	2	2
513501-46-5	Bis(2,2,3,4,4,5,5,6,6,7,8,8,8-octadecafluorooctanoic acid) hydrogen phosphate	Fluorinated oxetane polymers	2	2
452880-67-0	Bis(2,2,3,4,4,5,5,6,6,7,8,8,8-octadecafluorooctanoic acid) hydrogen phosphate	Fluorinated oxetane polymers	2	2
102889-65-1	Bis(2,2,3,4,4,5,5,6,6,7,8,8,8-octadecafluorooctanoic acid) hydrogen phosphate	Fluorinated oxetane polymers	2	2
375-02-2	Bis(2,2,3,4,4,5,5,6,6,7,8,8,8-octadecafluorooctanoic acid) hydrogen phosphate	Fluorinated oxetane polymers	2	2
662-50-4	Bis(2,2,3,4,4,5,5,6,6,7,8,8,8-octadecafluorooctanoic acid) hydrogen phosphate	Fluorinated oxetane polymers	2	2
346-10-1	Bis(2,2,3,4,4,5,5,6,6,7,8,8,8-octadecafluorooctanoic acid) hydrogen phosphate	Fluorinated oxetane polymers	2	2
432-39-2	Bis(2,2,3,4,4,5,5,6,6,7,8,8,8-octadecafluorooctanoic acid) hydrogen phosphate	Fluorinated oxetane polymers	2	2
297-02-8	Bis(2,2,3,4,4,5,5,6,6,7,8,8,8-octadecafluorooctanoic acid) hydrogen phosphate	Fluorinated oxetane polymers	2	2

16702-07-6	Branine, 1,1,2,2,3,3,4,4-tetrafluoro-4-methoxy-	OTHER poly(perfluorinated)ORGANICS		4	4
185045-68-5	Branine, 1,1,2,2,3,3,4,4-tetrafluoro-4-methoxy, mix. with (1D)-1,2-dichloroethane and 2-difluoroethoxy)methyl-1,1,2,2,3,3,4,4-tetrafluoroethane	poly(perfluorinated)ETHERS		1	4
704-984	Branine, 1,1,2,2,3,3,4,4-tetrafluoro-4-iodo-	poly(perfluorinated)ETHERS		3	3
375-5149	Branine, 1,1,2,2,3,3,4,4-tetrafluoro-4-iodo-	poly(perfluorinated)ETHERS		4	4
40721-8042	Branine, 1,1,2,2,3,3,4,4-tetrafluoro-2-(trifluoromethyl)-	poly(perfluorinated)ETHERS		4	4
594-91-2	Branine, 1,1,2,2,3,3,4,4-tetrafluoro-2-(trifluoromethyl)-	poly(perfluorinated)ALKANES/ALKENES		5	5
2901-01-1	Branine, 1,1,2,2,3,3,4,4-tetrafluoro-2-(trifluoromethyl)-	poly(perfluorinated)ETHERS		4	4
334-06-1	Branine, 1,1,2,2,3,3,4,4-tetrafluoro-2-(trifluoromethyl)-	poly(perfluorinated)ALKANES/ALKENES		6	6
377-3664	Branine, 1,1,2,2,3,3,4,4-tetrafluoro-2-(trifluoromethyl)-	OTHER poly(perfluorinated)ORGANICS		4	4
375-504	Branine, 1,1,2,2,3,3,4,4-tetrafluoro-4-iodo-	poly(perfluorinated)ETHERS		4	4
54752-172	Branine, 1,1,2,2,3,3,4,4-tetrafluoro-1,2,3,4-tetrafluoroethoxypropyl-, (R,S)	poly(perfluorinated)ETHERS		4	4
54208-46-1	Branine, 1,1,2,2,3,3,4,4-tetrafluoro-1,2,3,4-tetrafluoroethoxypropyl-	OTHER poly(perfluorinated)ORGANICS		4	4
355-2448	Branine, 1,4-dichloro-1,1,2,2,3,3,4,4-tetrafluoro-	poly(perfluorinated)ETHERS		4	4
16702-05-4	Branine, 1-ethoxy-1,1,2,2,3,3,4,4-tetrafluoro-	OTHER poly(perfluorinated)ORGANICS		4	4
335-20-4	Branine, 2,3-dichloro-1,1,2,2,3,3,4,4-tetrafluoro-	OTHER poly(perfluorinated)ALKANES/ALKENES		4	4
335-2529	Branine, decafluoro-	OTHER poly(perfluorinated)ALKANES/ALKENES		2	4
28084-80-7	Branine, trichloroethoxyethoxy-	poly(perfluorinated)ETHERS		4	4
30353-3324	Branine, acid, (carboxymethyl)bis-, 1,4-bis(2,3,4,5,6,6-tetrafluoroethoxy)ethane, lithium salt	poly(perfluorinated)ETHERS		6	12
94166-88-3	Branine, acid, sulfite, 1,4-bis(2,3,4,5,6,6-tetrafluoroethoxy)ethane, sodium salt	poly(perfluorinated)ETHERS		6	12
63867-1749	Branine, acid, sulfite, 1,4-bis(2,3,4,5,6,6-tetrafluoroethoxy)ethane, sodium salt	poly(perfluorinated)ETHERS		8	8
98151-22-5	Branine, acid, sulfite, 1,4-bis(2,3,4,5,6,6-tetrafluoroethoxy)ethane, sodium salt	poly(perfluorinated)ETHERS		5	5
54950-05-9	Branine, acid, sulfite, 1,4-bis(2,3,4,5,6,6-tetrafluoroethoxy)ethane, sodium salt	poly(perfluorinated)ETHERS		6	6
72905-91-0	Branine, acid, sulfite, 1,4-bis(2,3,4,5,6,6-tetrafluoroethoxy)ethane, sodium salt	poly(perfluorinated)ETHERS		4	6
90584-45-4	Branine, (sodium) dithiophosphate, bis-	poly(perfluorinated)ALKANES/ALKENES/SULFONYL CHLORIDE or FLUORIDES		4	4
60178-45-3	Branine, acid, 2,2,3,3,4,4-tetrafluoro-4-[[trifluoroethoxy]oxy], methyl ester, hemiperfluoro-, hydrolyzed	poly(perfluorinated)ALKANES/ALKENES		6	20
68187-25-7	Branine, acid, 4-[[[2-(dimethylamino)propyl]amino]-4-oxo-, 2-oxo-3-[[[gamma-(omega-perfluoro-C6-20-alkyl)thio]ethyl]amino]-2-oxo-3-[[[gamma-(omega-perfluoro-C6-20-alkyl)thio]ethyl]amino]butanoate	poly(perfluorinated)POLYIMIDES		6	20
375-22-2	Branine, acid, heptafluoro-	poly(perfluorinated)POLYIMIDES		3	3
17165-55-8	Branine, acid, heptafluoro-, 2-propoxy ester	poly(perfluorinated)CARBOXYLIC ACIDS		4	4
336-59-4	Branine, acid, heptafluoro-, n-butyl diolide	poly(perfluorinated)ESTERS		4	4
336-28-5	Branine, acid, heptafluoro-, ethyl ester	poly(perfluorinated)ESTERS		4	4
336-27-5	Branine, acid, heptafluoro-, ethyl ester	poly(perfluorinated)ESTERS		4	4
336-24-1	Branine, acid, heptafluoro-, methyl ester	poly(perfluorinated)ESTERS		4	4
3794-64-7	Branine, acid, heptafluoro-, ethyl F-1 salt	poly(perfluorinated)CARBOXYLIC ACIDS		4	4
218-34-4	Branine, acid, heptafluoro-, sodium salt	poly(perfluorinated)CARBOXYLIC ACIDS		4	4
21897-45-9	Branine, acid, 2,2,3,3,4,4-tetrafluoro-4-[[trifluoroethoxy]oxy], sodium salt, polymer with 1,1,2,2,3,3,4,4-tetrafluoro-4-[[trifluoroethoxy]oxy]propane and tetrafluoroethane	Poly(etherthioether) (PETE)		4	4
89461-13-2	Branine, (carboxy)oxy-, polymer with chloroethane and ethoxyethoxyethylacetate	Poly(etherthioether) (PETE)		4	4
11079-46-9	Branine, acrylates	poly(perfluorinated)POLYIMIDES		4	4
21118-00-2	Branine, bis[2-methyl-2-(2-phenylpropanoate)-6-oxo-1,4-dioxane]diacrylate, polymer	poly(perfluorinated)ALKANES/ALKENES		4	4
50937-96-7	Branine, bis[2-methyl-2-(2-phenylpropanoate)-6-oxo-1,4-dioxane]diacrylate, copolymer with 2,2,2,2-tetrafluoroethyl acrylate and methacrylate	poly(perfluorinated)ALKANES/ALKENES		6	12
172616-04-5	Branine, bis[2-methyl-2-(2-phenylpropanoate)-6-oxo-1,4-dioxane]diacrylate, copolymer with 2,2,2,2-tetrafluoroethyl acrylate and methacrylate	fluorinated (methacrylate) polymers		8	8
141807-32-1	C-1 Perfluorinated surfactant	OTHER poly(perfluorinated)ORGANICS		4	4
21055-48-9	C-6-14 Perfluorinated surfactant	OTHER poly(perfluorinated)ORGANICS		6	6
6881-83-1	Carbamic acid, (4-methyl-1,2-phenyleneoxy)-bis(2-ethyl)bis[perfluorooctyl]bis[perfluorooctyl]diethylamine polymer	fluorinated (methacrylate) polymers		8	8
67846-66-6	Carbamic acid, [2-(4-iodophenyl)ethyl]bis[2-(4-iodophenyl)ethyl]diethylamine polymer	fluorinated (methacrylate) polymers		8	8
9570-51-7	Carbamic acid, [2-(4-iodophenyl)ethyl]bis[2-(4-iodophenyl)ethyl]diethylamine polymer	poly(perfluorinated)URETHANES		6	9
82109-07-3	Carbamic acid, [2-(4-iodophenyl)ethyl]bis[2-(4-iodophenyl)ethyl]diethylamine polymer	poly(perfluorinated)URETHANES		6	6
53122-42-2	Carbamic acid, [4-methyl-3-[[[2-(2-phenylpropanoate)-6-oxo-1,4-dioxane]diacrylate]oxy]butyl]diethylamine polymer	poly(perfluorinated)POLYIMIDES		9	9
72779-44-5	Carbamic acid, [4-methyl-3-[[[2-(2-phenylpropanoate)-6-oxo-1,4-dioxane]diacrylate]oxy]butyl]diethylamine polymer	poly(perfluorinated)POLYIMIDES		10	10
72779-05-6	Carbamic acid, [4-methyl-3-[[[2-(2-phenylpropanoate)-6-oxo-1,4-dioxane]diacrylate]oxy]butyl]diethylamine polymer	poly(perfluorinated)POLYIMIDES		7	7
93841-74-2	Carbamic acid, [5-[[[2-[[[bis(2-phenylpropanoate)-6-oxo-1,4-dioxane]diacrylate]oxy]butyl]diethylamine polymer]]-9-oxoacetyl] ester	Nealkyl perfluorinated sulfonamides (FASAs)		8	8
94113-84-5	Carbamic acid, [5-[[[2-[[[bis(2-phenylpropanoate)-6-oxo-1,4-dioxane]diacrylate]oxy]butyl]diethylamine polymer]]-9-oxoacetyl] ester (Z)	Nealkyl perfluorinated sulfonamides (FASAs)		8	8
72968-38-4	Carboxylic acids, C7-13, perfluoro-, ammonium salts	poly(perfluorinated)CARBOXYLIC ACIDS		7	13
16076-26-8	Chloroethoxybis[2-(2-phenylpropanoate)-6-oxo-1,4-dioxane]diacrylate copolymer	poly(perfluorinated)POLYIMIDES		2	2
172074-63-4	Chloroethoxybis[2-(2-phenylpropanoate)-6-oxo-1,4-dioxane]diacrylate copolymer	poly(perfluorinated)POLYIMIDES		2	2
71608-45-2	Chromium, 4-4-bis(4-gamma-omega-perfluoro-C8-20-alkyl)perfluorooctyl ether bisoxalate, chloro bisoxalate complex	poly(perfluorinated)POLYIMIDES		8	20
71608-44-1	Chromium, 4-4-bis(4-gamma-omega-perfluoro-C8-20-alkyl)perfluorooctyl ether bisoxalate, ethyl bisoxalate complex	poly(perfluorinated)POLYIMIDES		8	20
71608-46-3	Chromium, ethoxy bis[4-gamma-omega-perfluoro-C8-20-alkyl]perfluorooctyl ether bisoxalate, 3-chloroxydicarbonyl complex	poly(perfluorinated)POLYIMIDES		8	20
6881-96-3	Chromium, diacetylacetonate, [N-ethyl-N-(2-phenylpropanoate)-6-oxo-1,4-dioxane]diacrylate copolymer	Nealkyl perfluorinated sulfonamides (FASAs)		8	8
6890-97-0	Chromium, diacetylacetonate, [N-ethyl-N-(2-phenylpropanoate)-6-oxo-1,4-dioxane]diacrylate copolymer	Nealkyl perfluorinated sulfonamides (FASAs)		4	4
6881-97-4	Chromium, diacetylacetonate, [N-ethyl-N-(2-phenylpropanoate)-6-oxo-1,4-dioxane]diacrylate copolymer	Nealkyl perfluorinated sulfonamides (FASAs)		7	7
6881-98-5	Chromium, diacetylacetonate, [N-ethyl-N-(2-phenylpropanoate)-6-oxo-1,4-dioxane]diacrylate copolymer	Nealkyl perfluorinated sulfonamides (FASAs)		6	6

68891-89-6	Chromium, di(n-butylamino)ethoxy[2,2-bis(4-(4-aminophenoxy)phenoxy)acetate] (CAS#)	Nealkyl perfluoropolyether sulfonamides (C-FASAs)	5	5
97298-47-0	Chromium, hexachloro[2,2-bis(4-(4-aminophenoxy)phenoxy)acetate] (CAS#)	Nealkyl perfluoropolyether sulfonamides (C-FASAs)	8	8
72669-27-3	Chromium, hexachloro[2,2-bis(4-(4-aminophenoxy)phenoxy)acetate] (CAS#)	Nealkyl perfluoropolyether sulfonamides (C-FASAs)	7	11
3769-70-4	Cis-PeFluoro-4-methyl-2-pentene	polyperfluorinated ALKANES/ALKENES	5	5
162567-74-0	Complex mixture of phosphoric acid esters and perfluoropolyether (isopropyl ether)	polyperfluorinated PHOSPHORIC ACIDS	3	3
143336-91-8	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	polyperfluorinated POLYIMIDES	3	3
151402-74-3	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	polyperfluorinated POLYIMIDES	3	3
51271-19-5	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	8	8
310732-38-4	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	4	4
510733-10-5	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	4	14
510733-10-5	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	4	14
503287-56-7	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	4	14
511271-18-4	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	6	14
503296-97-7	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	6	14
51271-19-5	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	4	14
310732-38-4	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	4	14
510733-10-5	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	4	14
503296-97-7	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	4	14
202875-75-0	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	4	14
503296-97-7	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	4	14
510732-38-4	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	6	14
147026-01-5	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	2	2
93811-23-5	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	4	4
29763-63-9	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	7	7
29763-63-9	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	6	6
13221-71-1	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	6	6
1983-98-8	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	6	6
28677-00-1	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	4	4
204475-2	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	4	4
378-17-6	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	4	4
6977-11-0	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	3	10
8488-44-0	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	8	8
306-98-2	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	8	8
335-27-2	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	8	8
374-77-6	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	9	9
2637-06-3	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	8	8
355-06-2	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	6	6
308-24-7	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	5	5
374-60-7	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	7	7
84238-52-8	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	4	6
6838-63-2	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	11	18
28388-06-3	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	6	6
17042-59-8	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	6	6
335-24-0	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	8	8
67584-02-3	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	8	8
3107-18-4	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	6	6
68156-06-9	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	6	6
68138-24-3	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	7	7
68156-00-3	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	6	8
355-03-1	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	6	6
336-19-6	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	4	4
355-25-2	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	6	6
15290-77-4	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	5	5
376-77-2	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	5	5
1805-22-2	Caprolactide, 2-bis(4-(4-aminophenoxy)phenoxy)acetate (CAS#)	Fluorinated (meth)acrylate polymers	7	7

21615-47-2	244-79-6	Hexamethacrylate, ammonium salt	poly(perfluorinated CARBOXYLIC ACIDS)	6	6
2923-26-4		Hexamethacrylate, sodium salt	poly(perfluorinated CARBOXYLIC ACIDS)	6	6
64018-24-7		Hexamethyl chloride, 3,3,4,4,5,5,6,6-octachloro-	poly(perfluorinated ALKANOL SULFONYL CHLORIDE or FLUORIDES)	6	6
1422-98-6		Hexamethyl chloride, 3,5,6,6-tetrachloro-2,2,4,4,5,5,6,6-octachloro-	poly(perfluorinated ALKANOL SULFONYL CHLORIDE or FLUORIDES)	5	5
353-334-2	306-82-4	Hexamethyl ether, 2,2,3,3,4,4,5,5,6,6-octachloro-5-(trifluoromethyl)-	poly(perfluorinated ALKANOL SULFONYL CHLORIDE or FLUORIDES)	5	5
18017-31-7		Hydrofluoric acid, reaction products with bis(trimethylsilyl) ether, fluoroacetyl by-products	OTHER poly(perfluorinated ORGANICS)	6	6
90411-87-3		Hydrofluoric acid, reaction products with tetramethyl ether, fluoroacetyl by-products	OTHER poly(perfluorinated ORGANICS)	1	99
90411-88-4		Hydrofluoric acid, reaction products with tetraethyl ether, fluoroacetyl by-products	OTHER poly(perfluorinated ORGANICS)	1	99
110053-43-5		Imidacarbonyl diamide, N,N'-2-mercaptoacetyl-, reaction products with 3-alkene-1,2-epoxidation and alpha-thioacetamide-2-hydroxyethyl(methylthiomethyl)	poly(perfluorinated POLYMERS)	4	4
194899-48-4		Iodolium bis[4-(1-ethoxyethyl)phenyl]-, salt with 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-octachloro-3-hydroxybutane-2-thione sulfonic acid (1:1)	poly(perfluorinated SULFONIC SULFONIC ACIDS)	8	8
21740-80-8		Iodolium bis[4-(1-ethoxyethyl)phenyl]-, salt with 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-octachloro-3-hydroxybutane-2-thione sulfonic acid (1:1)	poly(perfluorinated SULFONIC SULFONIC ACIDS)	8	8
160738-49-2		Isohexafluoroacetone (5:10)	poly(perfluorinated IODIDES)	5	14
25884-89-3		Isohexafluoroacetone (5:10)	poly(perfluorinated IODIDES)	4	4
93894-56-5		Isononyl perfluorooctyl ether Diether Difluoroacetone in a mixture of esters formed by the reaction of Diisobutyl Acid and Ceric Acid with bis(isobutanol and perfluorooctyl ethyl alcohol)	poly(perfluorinated ESTERS)	8	8
93894-57-6		Isononyl perfluorooctyl ether Diether Difluoroacetone in a mixture of esters formed by the reaction of Diisobutyl Acid and Ceric Acid with bis(isobutanol and perfluorooctyl ethyl alcohol)	poly(perfluorinated ESTERS)	8	8
93894-58-7		Isononyl perfluorooctyl ether Diether Difluoroacetone in a mixture of esters formed by the reaction of Diisobutyl Acid and Ceric Acid with bis(isobutanol and perfluorooctyl ethyl alcohol)	poly(perfluorinated ESTERS)	8	8
93894-59-8		Isononyl perfluorooctyl ether Diether Difluoroacetone in a mixture of esters formed by the reaction of Diisobutyl Acid and Ceric Acid with bis(isobutanol and perfluorooctyl ethyl alcohol)	poly(perfluorinated ESTERS)	8	8
93894-60-9		Isononyl perfluorooctyl ether Diether Difluoroacetone in a mixture of esters formed by the reaction of Diisobutyl Acid and Ceric Acid with bis(isobutanol and perfluorooctyl ethyl alcohol)	poly(perfluorinated ESTERS)	8	8
93894-61-0		Isononyl perfluorooctyl ether Diether Difluoroacetone in a mixture of esters formed by the reaction of Diisobutyl Acid and Ceric Acid with bis(isobutanol and perfluorooctyl ethyl alcohol)	poly(perfluorinated ESTERS)	8	8
93894-62-1		Isononyl perfluorooctyl ether Diether Difluoroacetone in a mixture of esters formed by the reaction of Diisobutyl Acid and Ceric Acid with bis(isobutanol and perfluorooctyl ethyl alcohol)	poly(perfluorinated ESTERS)	8	8
93894-63-2		Isononyl perfluorooctyl ether Diether Difluoroacetone in a mixture of esters formed by the reaction of Diisobutyl Acid and Ceric Acid with bis(isobutanol and perfluorooctyl ethyl alcohol)	poly(perfluorinated ESTERS)	8	8
93894-64-3		Isononyl perfluorooctyl ether Diether Difluoroacetone in a mixture of esters formed by the reaction of Diisobutyl Acid and Ceric Acid with bis(isobutanol and perfluorooctyl ethyl alcohol)	poly(perfluorinated ESTERS)	8	8
93894-65-4		Isononyl perfluorooctyl ether Diether Difluoroacetone in a mixture of esters formed by the reaction of Diisobutyl Acid and Ceric Acid with bis(isobutanol and perfluorooctyl ethyl alcohol)	poly(perfluorinated ESTERS)	8	8
93894-66-5		Isononyl perfluorooctyl ether Diether Difluoroacetone in a mixture of esters formed by the reaction of Diisobutyl Acid and Ceric Acid with bis(isobutanol and perfluorooctyl ethyl alcohol)	poly(perfluorinated ESTERS)	8	8
93894-67-6		Isononyl perfluorooctyl ether Diether Difluoroacetone in a mixture of esters formed by the reaction of Diisobutyl Acid and Ceric Acid with bis(isobutanol and perfluorooctyl ethyl alcohol)	poly(perfluorinated ESTERS)	8	8
93894-68-7		Isononyl perfluorooctyl ether Diether Difluoroacetone in a mixture of esters formed by the reaction of Diisobutyl Acid and Ceric Acid with bis(isobutanol and perfluorooctyl ethyl alcohol)	poly(perfluorinated ESTERS)	8	8
93894-69-8		Isononyl perfluorooctyl ether Diether Difluoroacetone in a mixture of esters formed by the reaction of Diisobutyl Acid and Ceric Acid with bis(isobutanol and perfluorooctyl ethyl alcohol)	poly(perfluorinated ESTERS)	8	8
172018-29-0		Isononyl perfluorooctyl ether Diether Difluoroacetone in a mixture of esters formed by the reaction of Diisobutyl Acid and Ceric Acid with bis(isobutanol and perfluorooctyl ethyl alcohol)	poly(perfluorinated ESTERS)	2	2
79023-95-0		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	8	8
16062-15-3		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	8	8
349660-50-0		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	8	8
19190-61-5	700-677-9	Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	1	24
95845-54-4	700-37-4	Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	2	4
160498-33-9		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	2	4
55716-11-5		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	10	18
382-285-2	306-84-1	Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	2	2
1609-71-1		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	1	1
25828-08-4	700-536-1	Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	7	7
16062-26-6		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	4	4
1220100-43-2	700-37-4	Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	7	11
82019-83-9		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	3	3
116109-9		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	4	14
160336-21-0		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	3	3
154800-34-4		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	3	3
12981-09-4		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	4	14
306-92-3		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	4	14
191911-87-6		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	11	11
19107-86-9		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	14	14
306-95-4		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	14	14
191911-88-5		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	14	14
19107-87-0		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	14	14
2342-07-6		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	14	14
2796-08-9		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	14	14
118945-65-9		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	14	14
118945-64-4		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	14	14
118945-63-5		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	14	14
51294-16-7		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	11	11
118945-64-4		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	14	14
306-94-2	206-192-4	Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	10	10
313-72-4	206-193-9	Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	8	8
31896-34-0		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	8	8
1-483		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	8	8
1-511		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	8	8
1-509		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	8	8
1-510		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	8	8
1-512		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	8	8
33291-24-7		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	4	4
558-97-7		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	9	9
2045-52-4		Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	7	7
3850-34-4	253-394-3	Gamma. acid, N-(heptafluorooctyl)acetyl-, diacid salt	poly(perfluorinated SULFONAMIDES)	6	6

7126-31-3	Nonane, 9-(ethoxyoxy)-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8-hexadecalithone-	poly(perfluorinated CARBOXYLIC ACIDS)	9	9
375-96-2	Nonane, octadecalithone-	poly(perfluorinated ALKANES/ALKENES)	9	9
4149-60-4	Nonanoic acid, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,9,9-tetradecafluoro-, ammonium salt (1:1)	poly(perfluorinated CARBOXYLIC ACIDS)	8	8
309-944-5	Nonanoic acid, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,9,9-tetradecafluoro-	poly(perfluorinated CARBOXYLIC ACIDS)	8	8
1888-86-1	Nonanoic acid, 2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,9,9-tetrafluoro-, ammonium salt	poly(perfluorinated CARBOXYLIC ACIDS)	8	8
754-87-0	Nonanoic acid, 2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,9,9-tetrafluoro-	poly(perfluorinated CARBOXYLIC ACIDS)	8	8
5321-25-7	Nonanoic acid, 3,5,7,9-tetrafluoro-2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,9,9-tetrafluoro-	poly(perfluorinated CARBOXYLIC ACIDS)	8	8
375-95-1	Nonanoic acid, heptadecafluoro-	poly(perfluorinated CARBOXYLIC ACIDS)	8	8
3077-52-2	Nonanoic acid, heptadecafluoro-, ethyl ester	poly(perfluorinated ESTERS)	8	8
5247-23-1	Nonanoyl chloride, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,9,9-tetrafluoro-	poly(perfluorinated ALKANOLSULFONYL CHLORIDE or FLUORIDES)	8	8
423-946-2	Nonanoyl chloride, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,9,9-tetrafluoro-	poly(perfluorinated ALKANOLSULFONYL CHLORIDE or FLUORIDES)	8	8
84029-252-1	Nonane, 1-[1-(4-hydroxybutyl)oxy]heptadecafluoro-	poly(perfluorinated ETHERS)	8	8
84029-56-1	Nonane, 1-[1-(5-pentylmethoxy)heptadecafluoro-	poly(perfluorinated ETHERS)	8	8
84029-58-3	Nonane, 1-[1-(6-hexamethoxy)heptadecafluoro-	poly(perfluorinated ETHERS)	8	8
60138-93-0	Nonane, 1-[1-(7-heptamethoxy)heptadecafluoro-	poly(perfluorinated ETHERS)	8	8
84029-60-7	Nonane, heptadecafluoro-1-(2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,9,9-tetrafluoroethoxy)oxy-	poly(perfluorinated ETHERS)	7	7
29089-35-6	Oxalidic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,12,12,13,13,13,13,14,14,15,15,16,16,17,17,18,18-pentacosantalithone-18-tetradecadecanoic acid	poly(perfluorinated ETHERS)	18	18
6150-94-0	Oxalidic acid, pentacosantalithone-	poly(perfluorinated ETHERS)	18	18
16517-112-2	Oxalidic acid, pentacosantalithone-	poly(perfluorinated CARBOXYLIC ACIDS)	18	18
423-54-1	Oxamide, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-pentadecafluoro-	OTHER poly(perfluorinated)ORGANICS	7	7
85938-56-3	Oxamide, N-(3-aminopropyl)-2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-pentadecafluoro-	OTHER poly(perfluorinated)ORGANICS	7	7
41358-63-3	Oxamide, N-(3-bis(2-hydroxyethyl)amino)propyl-2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-pentadecafluoro-	OTHER poly(perfluorinated)ORGANICS	7	7
335-65-2	Oxane, 1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-	poly(perfluorinated ALKANES/ALKENES)	8	8
307-65-1	Oxane, 1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-8-tetradecanoic acid	poly(perfluorinated ETHERS)	8	8
80793-175-2	Oxane, 1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-8-tetradecanoic acid	poly(perfluorinated ALKANES/ALKENES)	8	8
20433-57-4	Oxane, 1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-8-tetradecanoic acid	poly(perfluorinated ETHERS)	8	8
3021-63-4	Oxane, 1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-2,7-bis(trifluoromethyl)-	poly(perfluorinated ALKANES/ALKENES)	10	10
423-55-5	Oxane, 1-thione-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-	OTHER poly(perfluorinated)ORGANICS	8	8
307-33-5	Oxane, 1-thione-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-	OTHER poly(perfluorinated)ORGANICS	8	8
21086-25-6	Oxane, 8-(1,1-dimethylbutyl)-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-	OTHER poly(perfluorinated)ORGANICS	6	6
85711-89-1	Oxane, ethylheptadecafluoro-	poly(perfluorinated ALKANES/ALKENES)	8	8
307-34-4	Oxane, octadecafluoro-	poly(perfluorinated ALKANES/ALKENES)	8	8
447-12-1	Oxanemirle, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-pentadecafluoro-	OTHER poly(perfluorinated)ORGANICS	7	7
15899-31-7	Oxanoic acid, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-7-(trifluoromethyl)-	poly(perfluorinated CARBOXYLIC ACIDS)	8	8
68015-86-1	Oxanoic acid, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-7-(trifluoromethyl)-, ammonium salt	poly(perfluorinated CARBOXYLIC ACIDS)	8	8
3328-12-3	Oxanoic acid, 2,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-	poly(perfluorinated CARBOXYLIC ACIDS)	8	8
3828-57-9	Oxanoic acid, 7-(chlorodifluoromethyl)-2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-, ammonium salt	poly(perfluorinated CARBOXYLIC ACIDS)	6	6
16557-94-1	Oxanoic acid, 7-(chlorodifluoromethyl)-2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-, ammonium salt	poly(perfluorinated CARBOXYLIC ACIDS)	3	8
223-320-4	Oxanoic acid, pentadecafluoro-	poly(perfluorinated CARBOXYLIC ACIDS)	7	7
206-397-9	Oxanoic acid, pentadecafluoro-, ammonium salt	poly(perfluorinated CARBOXYLIC ACIDS)	7	7
332-26-1	Oxanoic acid, pentadecafluoro-, amide	poly(perfluorinated CARBOXYLIC ACIDS)	7	7
33296-48-9	Oxanoic acid, pentadecafluoro-, bromide	poly(perfluorinated CARBOXYLIC ACIDS)	7	7
90489-55-6	Oxanoic acid, pentadecafluoro-, bromide, ammonium salt	poly(perfluorinated CARBOXYLIC ACIDS)	7	7
90489-56-1	Oxanoic acid, pentadecafluoro-, bromide, ammonium salt	poly(perfluorinated CARBOXYLIC ACIDS)	7	7
68141-25-2	Oxanoic acid, pentadecafluoro-, sodium salt	poly(perfluorinated CARBOXYLIC ACIDS)	7	7
3108-24-2	Oxanoic acid, pentadecafluoro-, ethyl ester	poly(perfluorinated CARBOXYLIC ACIDS)	7	7
45283-51-6	Oxanoic acid, pentadecafluoro-, tert (1)	poly(perfluorinated CARBOXYLIC ACIDS)	7	7
376-27-2	Oxanoic acid, pentadecafluoro-, methyl ester	poly(perfluorinated CARBOXYLIC ACIDS)	7	7
90489-57-2	Oxanoic acid, pentadecafluoro-, mixed ester with 2,2'-[1,4-bis(methylphenoxy)methyl]oxirane and 2,2'-[1,4-bis(methylphenoxy)methyl]oxirane	poly(perfluorinated CARBOXYLIC ACIDS)	7	7
2345-60-3	Oxanoic acid, pentadecafluoro-, potassium salt	poly(perfluorinated CARBOXYLIC ACIDS)	7	7
333-93-1	Oxanoic acid, pentadecafluoro-, silver (1) salt	poly(perfluorinated CARBOXYLIC ACIDS)	7	7
333-95-2	Oxanoic acid, pentadecafluoro-, sodium salt	poly(perfluorinated CARBOXYLIC ACIDS)	7	7
335-64-4	Oxanoic chloride, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-pentadecafluoro-	poly(perfluorinated ALKANOLSULFONYL CHLORIDE or FLUORIDES)	7	7
64018-25-3	Oxanoic chloride, 3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-	poly(perfluorinated ALKANOLSULFONYL CHLORIDE or FLUORIDES)	6	6
335-66-2	Oxanoic fluoride, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-	poly(perfluorinated ALKANOLSULFONYL CHLORIDE or FLUORIDES)	7	7
15702-62-3	Oxapane, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-	poly(perfluorinated ALKANOLSULFONYL CHLORIDE or FLUORIDES)	8	8
388-41-0	Oxapane, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-	poly(perfluorinated ETHERS)	6	6
1387-1	Oxapane, 3-(methyl[3-(3,4,4,5,5,6,6,6,6-tetrafluorophenoxy)propyl]ethyl)-	poly(perfluorinated ETHERS)	4	4
475678-78-5	Oxapane, 3-(methyl[3-(3,4,4,5,5,6,6,6,6-tetrafluorophenoxy)propyl]ethyl)-	poly(perfluorinated ETHERS)	4	4
38665-52-2	Oxirane, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-	poly(perfluorinated OXIRANES)	6	6
38665-54-7	Oxirane, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-10,10,11,11,12,12,13,13,13,13,14,14,15,15,15,15-tetraoxadecahydroxy-	poly(perfluorinated OXIRANES)	10	10
94158-66-4	Oxirane, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-10,10,11,11,12,12,13,13,13,13,14,14,15,15,15,15-tetraoxadecahydroxy-	poly(perfluorinated OXIRANES)	12	12
94158-67-5	Oxirane, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-10,10,11,11,12,12,13,13,13,13,14,14,15,15,15,15-tetraoxadecahydroxy-	poly(perfluorinated OXIRANES)	14	14
94158-68-6	Oxirane, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-10,10,11,11,12,12,13,13,13,13,14,14,15,15,15,15-tetraoxadecahydroxy-	poly(perfluorinated OXIRANES)	16	16
38565-531-2	Oxirane, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,8,8-tetradecafluoro-	poly(perfluorinated OXIRANES)	8	8

182700-79-4	perfluoro-C8-14-alk- and -N,N,2-tet(6-isocyanatohexyl)imidazole carbonic diamide	OTHER poly(perfluorinated)ORGANICS	8	14
25067-11-2	Perfluoropolyether polypropylene copolymer	poly(perfluorinated) POLYMERS	1	89
106427-63-6	Perfluorobenzene sulfonic acid	poly(perfluorinated) SULFONIC/SULFONIC ACIDS	6	6
41997-13-1	Perfluorobenzene sulfonamide	poly(perfluorinated) SULFONAMIDES	6	6
	PURE LITHIUM DIALLYL DIOXIDE POLYOL GRAPHANEDATE			
141074-63-7	Perfluoropolyether carboxylic acid	poly(perfluorinated) CARBOXYLIC ACIDS	2	11
113114-93-5	Perfluoropolyether carboxylic acid	poly(perfluorinated) CARBOXYLIC ACIDS	15	15
8608-42-1	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	5	18
28348-49-6	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	5	5
306-91-2	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	14	14
19182-40-0	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	8	8
142623-70-9	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	10	10
52299-27-1	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	8	8
40143-79-1	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	12	12
64412-69-4	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	6	6
93082-53-4	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	6	12
40143-77-9	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	6	6
40143-78-0	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	8	8
40143-76-8	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	6	6
631813-12-2	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	8	8
71463-79-0	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	8	8
71463-80-1	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	8	8
71463-79-1	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	7	7
71463-81-5	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	7	7
68412-68-0	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	6	12
90481-10-0	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	6	12
33230-90-6	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
642-238-6	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
412-860-7	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
74099-44-3	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	8	16
92332-25-7	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	8	14
1224029-82-6	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	6	6
92332-26-4	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	6	6
1189025-96-1	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	8	14
71336-38-2	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	8	8
564-11-4	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	2	5
359-71-7	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	1	5
412-660-2	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
105566-63-1	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
65306-84-6	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
65306-85-0	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
65306-75-4	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
71550-16-8	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
71278-43-8	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
71230-79-0	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
71230-80-3	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
71538-15-7	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
71530-17-9	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
65306-76-9	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
245331-40-2	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
65306-76-9	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
71002-40-9	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
65306-83-3	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
65306-89-0	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
161278-39-1	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
65306-85-4	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
71002-40-9	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
131324-06-6	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
79070-11-1	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4
65306-75-3	Perfluoropolyether diamine	OTHER poly(perfluorinated)AMINES	4	4

59006-66-5	Polythiophene (C2-S) methacrylate			Fluorinated (meth)acrylate polymers	2	5
95243-53-1	Polythiophene (C2-S) methacrylate			Fluorinated (meth)acrylate polymers	2	5
512179-88-5	Polymer of N-methyl methacrylate, 1,4-hydroxy-5,6,12-trioxadecahydroxy methacrylate and 2-perfluorooctyl[1,1,1,1,3,3,3,3]octyl methacrylate, which has addition compound of octane-1-thiol on one terminal			Fluorinated (meth)acrylate polymers	4	14
15510	Polymer of N-methyl methacrylate, 1,4-hydroxy-5,6,12-trioxadecahydroxy methacrylate, octadecyl methacrylate, N-hydroxyethyl acrylamide, vinylidene chloride and dimethylaminoethyl methacrylate			poly(perfluorinated COPOLYMERS)	4	8
160336-17-4	Poly(methyl acrylate-2-(2-methylacrylate)acrylate)			Fluorinated (meth)acrylate polymers	4	8
	poly(ethylene glycol-co-2-(2-methylacrylate)acrylate)			poly(perfluorinated ETHERS)	3	3
	poly(ethylene glycol-co-2-(2-methylacrylate)acrylate)			poly(perfluorinated ETHERS)	3	3
60164-51-4	poly(ethylene glycol-co-2-(2-methylacrylate)acrylate)			poly(perfluorinated ETHERS)	3	3
65330-82-7	poly(ethylene glycol-co-2-(2-methylacrylate)acrylate)			poly(perfluorinated ETHERS)	3	3
	poly(ethylene glycol-co-2-(2-methylacrylate)acrylate)			poly(perfluorinated ETHERS)	2	2
	poly(ethylene glycol-co-2-(2-methylacrylate)acrylate)			poly(perfluorinated ETHERS)	1	99
	poly(ethylene glycol-co-2-(2-methylacrylate)acrylate)			poly(perfluorinated ETHERS)	4	4
	poly(ethylene glycol-co-2-(2-methylacrylate)acrylate)			poly(perfluorinated ETHERS)	4	4
19065-64-2	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ALKOHOLS)	5	10
78628-58-1	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	2	6
16005-97-5	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	6	8
90381-63-8	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	8	8
68187-42-8	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	4	10
71608-63-4	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	6	20
106372-30-9	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	3	3
1623-66-5	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	3	3
74899-88-5	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)		
35397-13-8	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)		
29897-71-6	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)		
26555-06-5	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)		
165178-32-5	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)		
354-92-7	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)		
10372-98-2	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	4	4
28253-86-6	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	1	3
374-51-6	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	3	3
44591-18-1	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	5	5
44591-18-1	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	4	4
252846-11-0	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	4	4
16627-66-2	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	5	5
3330-14-1	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	1	3
16441-11-2	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	3	3
85720-81-4	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	3	3
29683-887-4	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	4	4
1542-18-3	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	4	4
16702-06-7	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	1	4
163702-06-5	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	3	3
29619-30-6	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	2	2
226899-30-9	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	6	6
22975-01-4	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	6	6
238420-80-9	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	8	12
238420-80-3	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	8	12
17784-43-4	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	3	4
69004-19-2	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	1	2
71333-66-1	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	6	6
149339-57-1	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	1	3
91905-14-4	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	2	3
62037-80-2	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	2	3
13252-34-2	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	2	3
2166-337-3	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	1	3
67118-57-2	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	1	3
2665-79-9	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	1	3
4089-61-4	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	1	3
231826-5	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	6	18
176509-84-4	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	1	99
70892-42-1	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	6	6
433333-62-1	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	6	6
476304-39-9	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	8	8
69688-23-1	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	2	2
1378703-30-3	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	1	3
69887-46-3	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	1	3
63653-44-5	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	1	3
70788-53-3	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	1	3
69887-47-1	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	1	3
69116-67-0	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	1	3
36075-57-5	Potassium salt of perfluorooctanoic acid (C8-F10) N-ethylhexan-1-amine			poly(perfluorinated ETHERS)	7	8

30675-56-1	Propionic acid, 3-hydroxy-2-(4-hydroxyphenyl)-2-methyl-, polymer with 2-(4-hydroxyphenyl)-1,3-propanediol and NX-2-4066-(6-oxo-2-oxo-1,2,3,4-tetrahydro-2H-pyridin-2-ylidene)carbamate, diamide, reaction products with N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8-heptafluorooct-2-yl	poly(perfluorinated POLYIMERS)	7	8
32839-65-2	Propionic acid, 3-hydroxy-2-(4-hydroxyphenyl)-2-methyl-, polymers with 1,4-cyclohexanedimethanol, 5-isocyanato-1-(5-cyanatomethyl)-1,3,3-trimethylcyclohexane and reduced Me esters of reduced poly(methyl tetrafluoroethylene, copoly, with triethylamine	poly(perfluorinated POLYIMERS)		
32839-65-2	Propionic acid, 3-hydroxy-2-(4-hydroxyphenyl)-2-methyl-, polymers with 1,4-cyclohexanedimethanol, 5-isocyanato-1-(5-cyanatomethyl)-1,3,3-trimethylcyclohexane and reduced Me esters of reduced poly(methyl tetrafluoroethylene, copoly, with triethylamine	poly(perfluorinated POLYIMERS)		
2679-08-6	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane and tetrafluoroethane	Poly(tetrafluoroethylene) (PTFE)	4	4
425-38-1	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	4	4
1822-78-4	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	1	3
2062-98-2	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	12	12
2927-83-5	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	1	1
4089-57-9	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	2	5
241-148-23-2	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	5	5
25711-77-1	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	1	4
4089-58-4	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	2	3
27639-98-1	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	3	3
112820-37-5	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	4	4
8176-57-0	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	4	4
69888-53-4	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	8	14
29335-14-2	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	8	8
61798-68-3	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	8	8
9279-34-5	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	8	14
145877-62-1	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	8	14
127133-57-2	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	8	14
15325-45-2	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	8	14
9181-09-3	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	8	14
85831-40-9	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	8	14
115535-26-9	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated ALKANOLYL SULFONYL CHLORIDE or FLUORIDES	5	11
68127-59-1	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)		
7016-355-2	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	3	7
9384-133-2	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	2	2
422-270-2	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	4	3
4252-40-0	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	3	3
9084-92-3	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	4	5
4733-296-7	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	2	4
161075-00-2	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)		
1190931-27-1	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	3	3
1190931-41-29	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	3	3
6822-239-6	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	6	6
1190931-39-2	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	3	3
1644-10-6	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	8	8
182700-200-9	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	6	6
510732-30-6	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	6	12
507225-08-3	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	3	8
512179-62-3	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	8	8
509866-57-1	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	6	18
104753-34-5	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)		
70815-20-2	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)		
83948-65-1	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	8	8
38436-16-2	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	4	4
73699-36-6	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	6	6
152992-46-6	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	4	4
83938-83-9	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	6	6
85837-17-6	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	6	6
9437-08-8	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	6	6
103481-41-8	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	6	6
375-63-3	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	4	4
78560-45-9	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	6	6
78640-44-4	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	8	8
14643-08-1	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	8	8
102590-98-7	Propionic acid, ethyl ester, polymer with 1,1-difluoroethane	poly(perfluorinated POLYIMERS)	4	4

148884-79-1	Sulfonamides, C4-6-alkane, perfluoro, N-(hydroxyethyl)-N-methyl, reaction products with 1,6-dioxacyanohydroxane, homopolymer and ethylene glycol	Fluorinated urethanes polymers	4	8
306973-67-7	Sulfonamides, C4-6-alkane, perfluoro, N-(hydroxyethyl)-N-methyl, reaction products with 1,2-ethylenedioxyethane and 2,4,6-trimethylaminium salts	poly(perfluorinated sulfonamides)	4	8
91081-49-1	Sulfonamides, C4-6-alkane, perfluoro, N-(hydroxyethyl)-N-methyl, reaction products with quaternary ammonium salts	poly(perfluorinated sulfonamides)	4	8
306969-27-8	Sulfonamides, C4-6-alkane, perfluoro, N,N'-[1,6-hexanedithio]bis(2-oxo-3,5-oxazolidinethione)bis(N,N'-methyl-)	OTHER poly(perfluorinated organics)	4	8
129622-29-6	Sulfonamides, C4-6-alkane, perfluoro, N-(2-dimethylamino)propyl, reaction products with acrylic acid (FSA)	Fluorinated methacrylate polymers	4	8
306973-44-4	Sulfonamides, C4-6-alkane, perfluoro, N-(2-dimethylamino)propyl, reaction products with acrylic acid (FSA)	Fluorinated methacrylate polymers	4	8
179005-07-3	Sulfonamides, C4-6-alkane, perfluoro, N-(3-dimethylsilyloxy)propyl, reaction products with acrylic acid (FSA)	Nealkyl perfluorinated sulfonamides (FASA)	4	8
179005-06-2	Sulfonamides, C4-6-alkane, perfluoro, N-(3-dimethylsilyloxy)propyl, reaction products with acrylic acid (FSA)	Nealkyl perfluorinated sulfonamides (FASA)	4	8
178315-22-3	Sulfonamides, C4-6-alkane, perfluoro, N-ethyl-N-(hydroxyethyl), reaction products with 1,1-dimethyl-3-oxo-2-oxazolidinethione	Fluorinated urethanes polymers	4	8
68608-14-0	Sulfonamides, C4-6-alkane, perfluoro, N-ethyl-N-(hydroxyethyl), reaction products with 1,1-dimethyl-3-oxo-2-oxazolidinethione	Fluorinated urethanes polymers	4	8
68608-13-9	Sulfonamides, C4-6-alkane, perfluoro, N-ethyl-N-(hydroxyethyl), reaction products with 1,1-dimethyl-3-oxo-2-oxazolidinethione	Fluorinated urethanes polymers	4	8
160901-25-7	Sulfonamides, C4-6-alkane, perfluoro, N-ethyl-N-(hydroxyethyl), reaction products with 2-ethyl-1-hexanol and poly(methyl methacrylate) (PMMA)	Fluorinated urethanes polymers	4	8
306973-51-3	Sulfonamides, C4-6-alkane, perfluoro, N-ethyl-N-(hydroxyethyl), reaction products with 2-ethyl-1-hexanol and poly(methyl methacrylate) (PMMA)	Fluorinated urethanes polymers	4	8
160901-26-8	Sulfonamides, C4-6-alkane, perfluoro, N-ethyl-N-(hydroxyethyl), reaction products with 2-ethyl-1-hexanol and poly(methyl methacrylate) (PMMA)	Fluorinated urethanes polymers	4	8
222716-67-8	Sulfonamides, C4-6-alkane, perfluoro, N-ethyl-N-(hydroxyethyl), reaction products with poly(Bis(acryloyl) and poly(silylone-polypropylene glycol) mono- <i>tert</i> ether	poly(perfluorinated sulfonamides)	4	8
129181-21-4	Sulfonamides, C4-6-alkane, perfluoro, N-methyl-N-(2-oxo-3,5-oxazolidinethione)	poly(perfluorinated sulfonamides)	4	8
306974-19-6	Sulfonamides, C4-6-alkane, perfluoro, N-methyl-N-(2-oxo-3,5-oxazolidinethione)	poly(perfluorinated sulfonamides)	4	8
98999-57-6	Sulfonamides, C7-8-alkane, perfluoro, N-methyl-N-(2-[1-(2-oxo-2-propenyl)oxy]ethyl), polymers with 2-ethylhexyl acrylate, glycidyl methacrylate and N,N'-dimethyl-2-[2-methyl-1-(2-oxo-2-propenyl)oxy]ethanamine hydrochloride	Fluorinated methacrylate polymers	7	8
180832-29-0	Sulfonic acids, C6-12-alkane, perfluoro	poly(perfluorinated sulfonic sulfonic acids)	6	12
93772-72-6	Sulfonic acids, C6-12-alkane, perfluoro	poly(perfluorinated sulfonic sulfonic acids)	6	12
68391-69-3	Sulfonic acids, C6-12-alkane, perfluoro, potassium salts	poly(perfluorinated sulfonic sulfonic acids)	6	12
306974-45-8	Sulfonic acids, C6-12-alkane, perfluoro, compds. with poly(ethylene-polypropylene glycol) bis(2-amino)propyl ether	poly(perfluorinated sulfonic sulfonic acids)	6	12
297175-71-4	Sulfonic acids, C8-20-alkane, gamma-omega-perfluoro, compds. with triethylamine	poly(perfluorinated sulfonic sulfonic acids)	6	12
144317-44-2	Sulfonic triphenyl, salt with 1,1,2,2,3,3,4,4-tetrafluoro-1-butanesulfonic acid (11)	poly(perfluorinated sulfonic sulfonic acids)	4	4
91770-70-0	Sulfonyl fluorides, C1-6-alkane, omega-(6-hydroxy)perfluoro	poly(perfluorinated alkanoyl sulfonyl chloride or fluorides)	1	5
68516-17-6	Sulfonic acid, mono-, gamma-omega-perfluoro-C(2-20)alkyl esters, ammonium salts	poly(perfluorinated esters)	6	12
84338-62-0	Sulfonic acid, mono-, gamma-omega-perfluoro-C(12-20)alkyl esters, ammonium salts	poly(perfluorinated esters)	8	12
101840-1259	Sulfonic acid, mono-, gamma-omega-perfluoro-C(14-20)alkyl esters, ammonium salts	poly(perfluorinated esters)	8	14
85995-90-0	Sulfonic acid, mono-, gamma-omega-perfluoro-C(14-20)alkyl esters, ammonium salts	poly(perfluorinated esters)	8	14
39623-55-7	TEA-C8-18 perfluorinated ethyl phosphate in the triethanolamine salt of a complex mixture of esters of phosphoric acid and a perfluorinated ethyl alcohol containing 8 to 18 carbons in the alkyl chain	poly(perfluorinated phosphoorganics)	8	18
307-66-4	TEA-C8-18 perfluorinated ethyl phosphate in the triethanolamine salt of a complex mixture of esters of phosphoric acid and a perfluorinated ethyl alcohol containing 8 to 18 carbons in the alkyl chain	poly(perfluorinated phosphoorganics)	8	18
30646-31-2	Tetradecane, 1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,13,13,14,14,14,14-tetrafluoro-14-iodo-	poly(perfluorinated iodides)	24	24
13331-77-8	Tetradecane, 1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,13,13,14,14,14,14-tetrafluoro-14-iodo-	poly(perfluorinated iodides)	14	14
376-06-2	Tetradecane, 1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,13,13,14,14-tetrafluoro-14-iodo-	poly(perfluorinated iodides)	12	12
18021-69-1	Tetradecane, 1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,13,13,14,14-tetrafluoro-14-iodo-2-(4-fluoromethyl)-	poly(perfluorinated iodides)	6	6
94994-26-5	Tetradecane, 1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,13,13,14,14-tetrafluoro-14-iodo-2-(4-fluoromethyl)-	poly(perfluorinated alkanes/alkenes)	6	6
3248-63-3	Tetradecane, trichloroethane-	poly(perfluorinated iodides)	15	15
307-62-0	Tetradecane, trichloroethane-	poly(perfluorinated alkanes/alkenes)	14	14
5102-53-4	Tetradecanoic acid, tetra- <i>ortho</i> -, dihydroxide	poly(perfluorinated alkanes/alkenes)	12	12
68052-68-6	Tetradecanoic acid, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,13,13,14,14-tetrafluoro-14-(2-fluoromethyl)-, compd. with ethanamine (1:1)	poly(perfluorinated carboxylic acids)	15	15
161075-06-2	Tetradecanoic acid, bis-(2-fluoroethyl)-	poly(perfluorinated carboxylic acids)	14	14
18021-69-1	Tetradecanoic acid, bis-(2-fluoroethyl)-	poly(perfluorinated carboxylic acids)	14	14
94994-26-5	Tetradecanoic acid, bis-(2-fluoroethyl)-	poly(perfluorinated carboxylic acids)	15	15
68052-62-7	Tetradecanoyl chloride, 2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,13,13,14,14-tetrafluoro-14-(2-fluoromethyl)-	poly(perfluorinated alkanoyl sulfonyl chloride or fluorides)	15	15
162491-38-2	Tetrahydroethane, homopolymer, telomers with pentafluorocyclohexane, reaction products with ethylene, hydroxyethyl, reaction products with 2,3-epoxypropyl- <i>tert</i> -, octadecan-1- <i>ol</i> -, octadecan-1- <i>yl</i> - and 1,3,5-tris(6-oxocyclohexyl)benzene	poly(perfluorinated alkanes/alkenes)	4	4
5101-54-3	Tetrahydroethane, oxidized, oligomers, reduced, methyl esters, reaction products with 3-amino)propyltriethylsilane	poly(perfluorinated polymers)	4	4
161075-06-2	Tetrahydroethane, oxidized, oligomers, reduced, methyl esters, reaction products with ethylamine	poly(perfluorinated polymers)	4	4
162492-14-0	Tetrahydroethane, oxidized, oligomers, reduced, methyl esters, reduced, reaction products with ethylene oxide and methacrylate acrylate	poly(perfluorinated copolyesters)	4	4
172714-62-3	Tetrahydroethane, formaldehyde copolymer	poly(perfluorinated copolyesters)	4	4
54675-89-7	Tetrahydroethane, propylene- <i>ortho</i> -ethylene fluoride polymer	poly(perfluorinated copolyesters)	4	4
32609-65-7	Tetramethylammoniumperfluorooctanoate	poly(perfluorinated carboxylic acids)	8	8
126917-82-4	Thianthrene, 3,4-bis(phosphino), homopolymer, 2-[1-(dihydro(1,2,2-trifluoroethyl)oxy)ethyl]-2,2,2-trifluoroethyl ether, acid- <i>ortho</i> -fluorobenzene, polymer-doped	poly(perfluorinated polymers)	4	20
97553-95-2	Thioanisic acid, gamma-omega-perfluoro-C(20-28)alkyl esters	poly(perfluorinated thiols)	6	6
26650-09-0	Thioanisic acid, 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,13,13,14,14-tetrafluoro-14-iodo-2-(4-fluoromethyl)-	poly(perfluorinated thiols)	8	8
68140-21-6	Thiols, C10-20, gamma-omega-perfluoro	poly(perfluorinated thiols)	10	20
68140-18-1	Thiols, C10-20, gamma-omega-perfluoro	poly(perfluorinated thiols)	10	20
68140-19-2	Thiols, C10-20, gamma-omega-perfluoro	poly(perfluorinated thiols)	10	20
151886-20-5	Thiols, C10-20, gamma-omega-perfluoro, telomers with acrylamide and acyclic acid, sulfonic salts	poly(perfluorinated polymers)	4	20
1079712-88-5	Thiols, C10-20, gamma-omega-perfluoro, reaction products with acrylamide and acyclic acid, sulfonic salts	Fluorinated methacrylate polymers	2	18
113889-67-1	Thiols, C6-12, gamma-omega-perfluoro, reaction products with methylated formaldehyde 1,3,5-triazines-2,4,6-triazine polymer (MCS)	poly(perfluorated polymers)	6	12
68140-20-5	Thiols, C6-12, gamma-omega-perfluoro	poly(perfluorated thiols)	6	12
70669-477-0	Thiophene, <i>ortho</i> -fluoroalkyl-, 1,1-diolefin	Fluorinated methacrylate polymers	4	4
42960-64-0	Triam-4-(1-thioethoxy)perfluoro-2-pentene	poly(perfluorinated sulfonic sulfonic acids)	6	6
3709-71-5	Triam-4-(1-thioethoxy)perfluoro-2-pentene	poly(perfluorinated alkanes/alkenes)	6	6
959462-54-5	TR-Ruck waxes	poly(perfluorinated alkanes/alkenes)	6	6

376-04-5	Tridecane, 1,1,2,2,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,13,13-heptafluoro-13-iodo-		poly(perfluorinated iodides)	13	13
376-04-7	Tridecane, octafluoro-		poly(perfluorinated alkanes/alkenes)	13	13
729-99-44	Tridecanoic acid, perfluoro-		poly(perfluorinated carboxylic acids)	13	13
43-520-4	Tridecyltrimethylsilane		poly(perfluorinated siloxanes/silicones/silanes/silicates)	1	3
13833-62-9	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	6	6
9437-07-7	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	8	8
16392-85-5	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	6	6
9437-06-6	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	2	2
114-96-3	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	5	5
424-18-0	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	11	11
307-504	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	9	9
65710-56-7	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	7	7
200112-75-0	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	11	11
9431-58-0	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	10	10
307-49-3	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	8	8
1765-48-2	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	9	9
5081-02-7	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	11	11
307-71-1	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	10	10
53281-37-1	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	8	8
3498-33-9	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	11	11
252-108-4	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	8	8
280-373-6	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	11	11
8310-58-4	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	5	5
2658-94-2	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	2	2
218-165-4	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	4	4
28497-93-0	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	8	8
17274-60-0	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	7	7
72974-65-6	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	3	3
25720-58-5	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	10	10
25101-38-6	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	8	8
32802-00-7	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	11	11
10721-31-8	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	5	5
107412-05-5	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	2	2
3107-33-2	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	4	4
96331-69-1	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	8	8
104075-56-7	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	7	7
152286-25-4	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	3	3
218286-10-1	Tridecyltrimethylsilyl ether		poly(perfluorinated siloxanes/silicones/silanes/silicates)	10	10



Box 2, SE-172 13 Sundbyberg
+46 8 519 41 100

Visitors' and delivery address
Esplanaden 3A, Sundbyberg

kemi@kemi.se
www.kemikalieinspektionen.se