Department
for Environment
Food & Rural Affairs

UK PFAS Workshop

Day 1 – April 27th 2021

Agenda

Morning

What is the concern?

- The diversity of PFAS
- PFAS levels in the environment
- What do we know about the public health risks
- NGO and industry perspectives

Afternoon

What do we know about UK sources?

- Assessing the potential PFAS legacy
- Water industry chemical investigations
- EA evaluations of REACH-registered PFAS used in UK

The diversity of PFAS

Presented by: **Ian Cousins** (Department of Environmental Science, Stockholm University)

The Diversity of PFAS

Ian T. Cousins

Department of Environmental Science,

Stockholm University, Sweden

UK Environmental Agency, 27th April 2021

Definitions of PFAS

- **Buck et al. (2011)** – first class definition
  - **PFAS** = "the **highly fluorinated aliphatic substances** that contain **1 or more C atoms** on which all the H substituents … have been replaced by F atoms, in such a manner that they contain the perfluoroalkyl moiety **C_nF_{2n+1}–" (has to contain at least -CF_3)**
- **Interstate Technology and Regulatory Council (ITRC)**
  - Same definition as Buck et al. (2011), but n ≥ 2 (i.e. must contain at least CF_3CF_2–)
- **OECD:** list of 4730
  - "…contain a perfluoroalkyl moiety with three or more carbons (i.e. –C_nF_{2n}–, n ≥ 3) or a perfluoroalkylether moiety with two or more carbons (i.e. –$C_nF_{2n}OC_mF_{2m}$–, n and m ≥1)."
- **OECD:** broader definition planned (unpublished)
  - "…the fluorinated substances that contain at least one fully fluorinated methyl or methylene carbon atom…" i.e. substances are PFAS that have **at least one -CF_2- or -CF_3** moiety in their structure

So how many PFAS are there? It depends on how you count…

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- Swedish Chemicals Agency (KEMI): 2060
- OECD: 4730
- US EPA dashboard: 6330 (consolidated list)
- CAS number searches (ChemSpider (http://www.chemspider.com/))
  - -CF_2- alone: 20 772 063 (**4 430 726 commercially available**, 16 341 337 not commercially available)
  - -CF_2CF_2-: 4 667 078 (**266 086 commercially available**, 4 400 992 not commercially available)
  - -$CF_2CF_2CF_2$-: 1 188 469 (**31 393 commercially available**, 1 157 076 not commercially available)
- Only 1 400 with identified uses…

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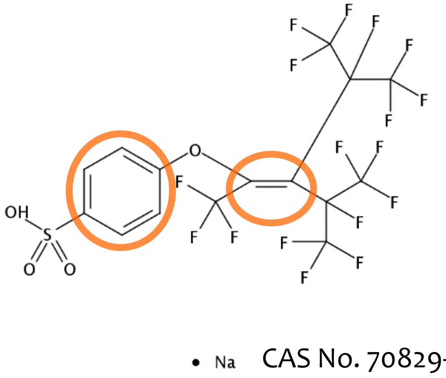
Cite this: DOI: 10.1039/d0em00291g

An overview of the uses of per- and polyfluoroalkyl substances (PFAS)†

Juliane Glüge,*[a] Martin Scheringer,[a] Ian T. Cousins,[b] Jamie C. DeWitt,[c] Gretta Goldenman,[d] Dorte Herzke,[ef] Rainer Lohmann,[g] Carla A. Ng,[h] Xenia Trier[i] and Zhanyun Wang[j]

OECD 2018 Report – Expanding universe

- In 2018, OECD published an updated PFAS List
  - → 4730 CAS numbers identified
  - → **Many not covered by Buck et al. definition**



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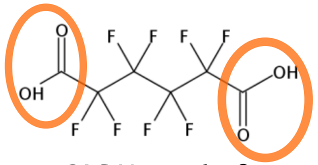


CAS No. 336-08-3

OECD
Organisation for Economic Co-operation and Development

ENV/JM/MONO(2018)7

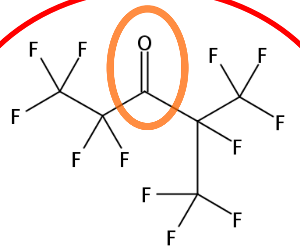
Unclassified English - Or. English
4 May 2018

ENVIRONMENT DIRECTORATE
JOINT MEETING OF THE CHEMICALS COMMITTEE AND THE WORKING PARTY ON CHEMICALS, PESTICIDES AND BIOTECHNOLOGY

TOWARD A NEW COMPREHENSIVE GLOBAL DATABASE OF PER- AND POLYFLUOROALKYL SUBSTANCES (PFASs):

SUMMARY REPORT ON UPDATING THE OECD 2007 LIST OF PER- AND POLYFLUOROALKYL SUBSTANCES (PFASs)

Series on Risk Management
No. 39



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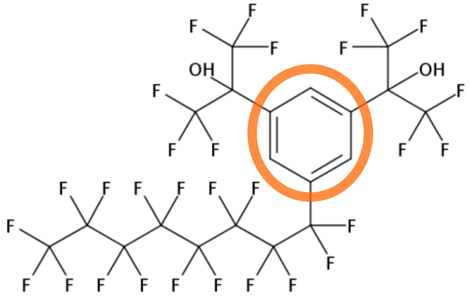

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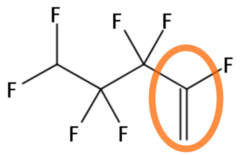

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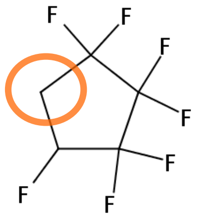

CAS No. 15290-77-4

PFAS according to broader OECD definition (unpublished)

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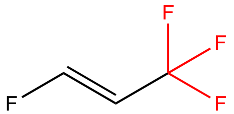
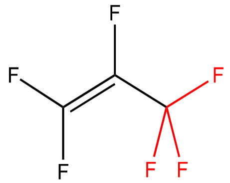
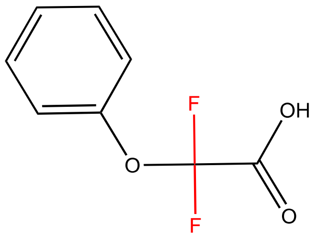


HFO-1234ze, CAS No. 29118-24-9



HFP, CAS No. 116-15-4



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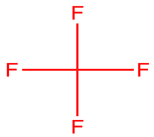

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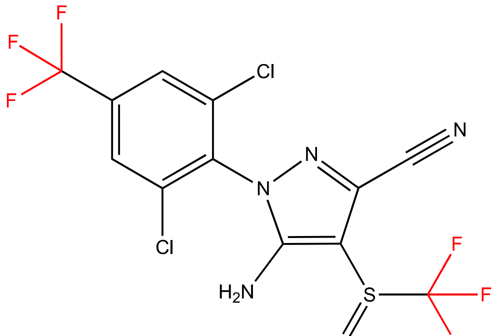
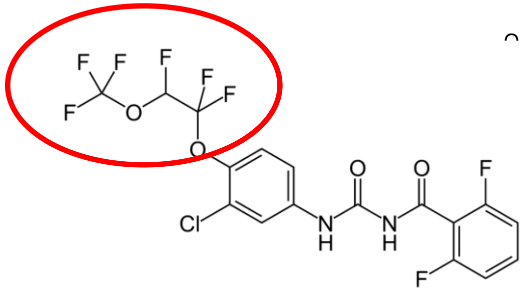


Fipronil, CAS No. 120068-37-3



Novaluron, CAS No. 116714-46-6

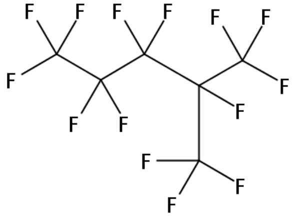
Is the definition too broad for regulatory purposes?

Diversity of PFAS

- Many thousands of **structurally diverse PFAS** in use in society
  - polymers & non-polymers; neutral, anionic, cationic & zwitterionic; solids, liquids & gases; reactive & inert; soluble & insoluble; volatile & involatile; mobile & immobile; bioaccumulative & non-bioaccumulative; highly toxic and relatively non-toxic
- We don’t know properties, toxicities etc. for most of them

Volatile neutral PFAS

- **Perfluoroalkanes (PFCs), perfluoroethers** and **perfluoroalkylamines**



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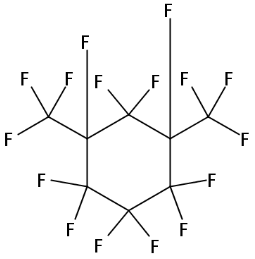

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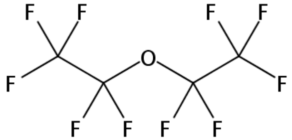

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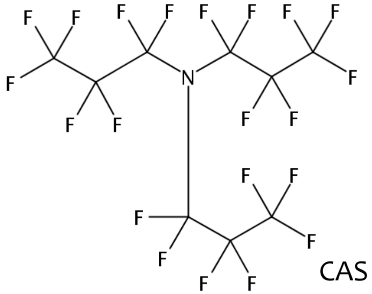

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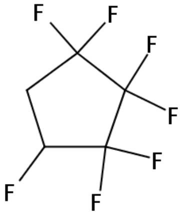
- **Certain hydrofluoro-carbons (HFCs), -ethers (HFEs)** and **-olefins (HFOs)**



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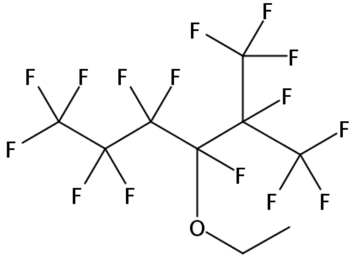

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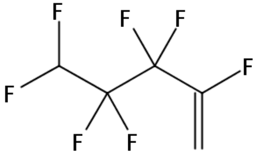


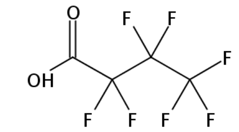
CAS No. 1547-26-8

- **PFCs, HFCs, HFEs and HFOs have own common nomenclature systems using letters and numbers, e.g. HFC-134a:** https://bit.ly/2M1Hp7l

Involatile anionic PFAS

- **Per- and polyfluoroalkyl acids (PFAAs)**

Per- and polyfluoroalkylether acids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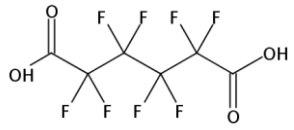
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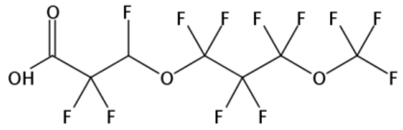
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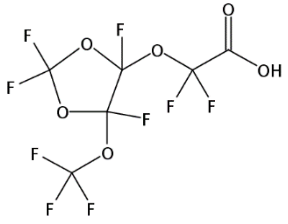
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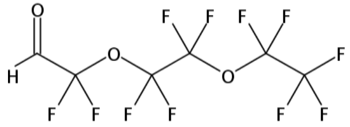
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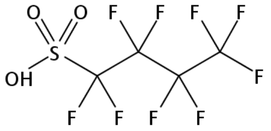
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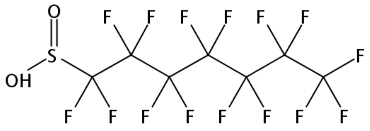
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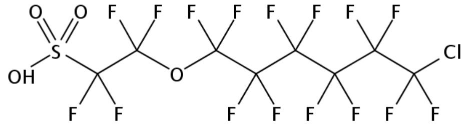
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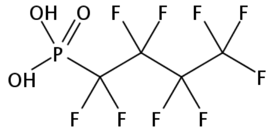
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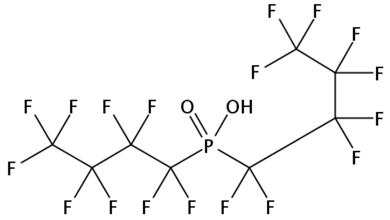

CAS No. 52299-25-9

All P and M and some B and T

Short-chain and long-chain PFAAs

Fluorinated polymers

- Fluoropolymers (e.g. PTFE) (F in the backbone)
  - high molecular weight, stable, inert, insoluble, involatile, immobile, do not cross biological membranes, low leachables

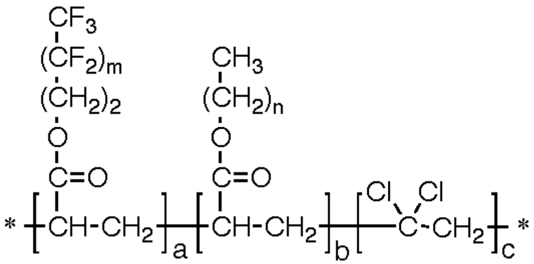
Integrated Environmental Assessment and Management — Volume 14, Number 3—pp. 316–334
316 Received: 26 September 2017 | Returned for Revision: 16 January 2018 | Accepted: 30 January 2018

Critical Review

A Critical Review of the Application of Polymer of Low Concern and Regulatory Criteria to Fluoropolymers

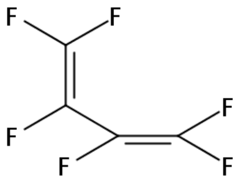
Barbara J Henry,† Joseph P Carlin,† Jon A Hammerschmidt,† Robert C Buck,‡ L William Buxton,‡ Heidelore Fiedler,§ Jennifer Seed,|| and Oscar Hernandez#*

- Side-chain fluorinated polymers (as used in Goretex) (non-fluorinated co-polymer backbone with fluorinated side chains)
  - Leachable PFAS, stable?



And many more

- Perfluoroalkenes (perfluoroolefins) and derivatives – a complex family with many unknowns



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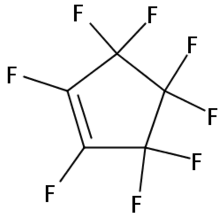

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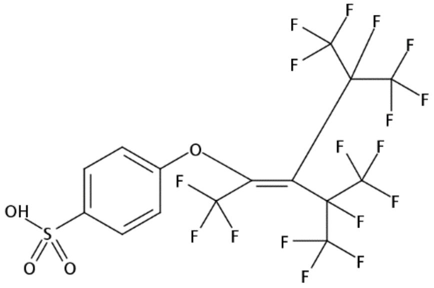

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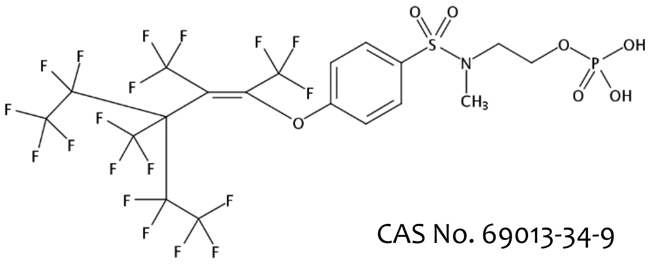

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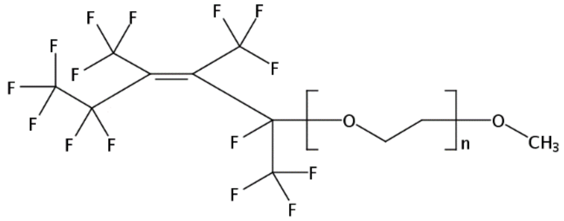

CAS No. 68877-51-0

- No common terminology available

The PFAS Universe: ITRC

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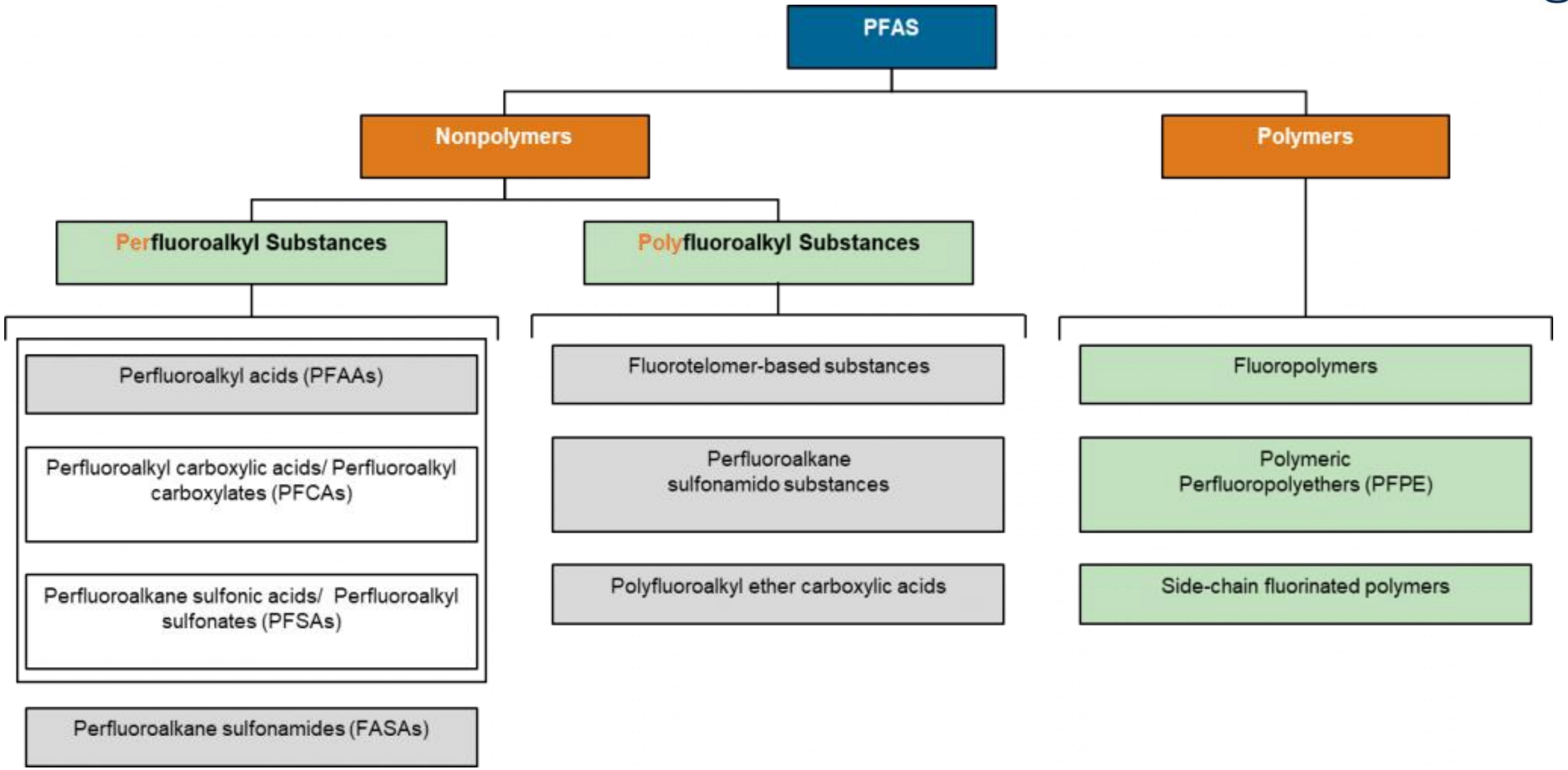
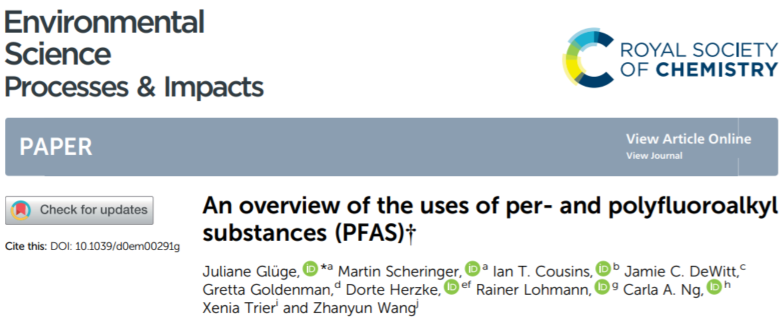


Interstate Technology & Regulatory Council (ITRC) (https://pfas-1.itrcweb.org/)

Uses of PFAS?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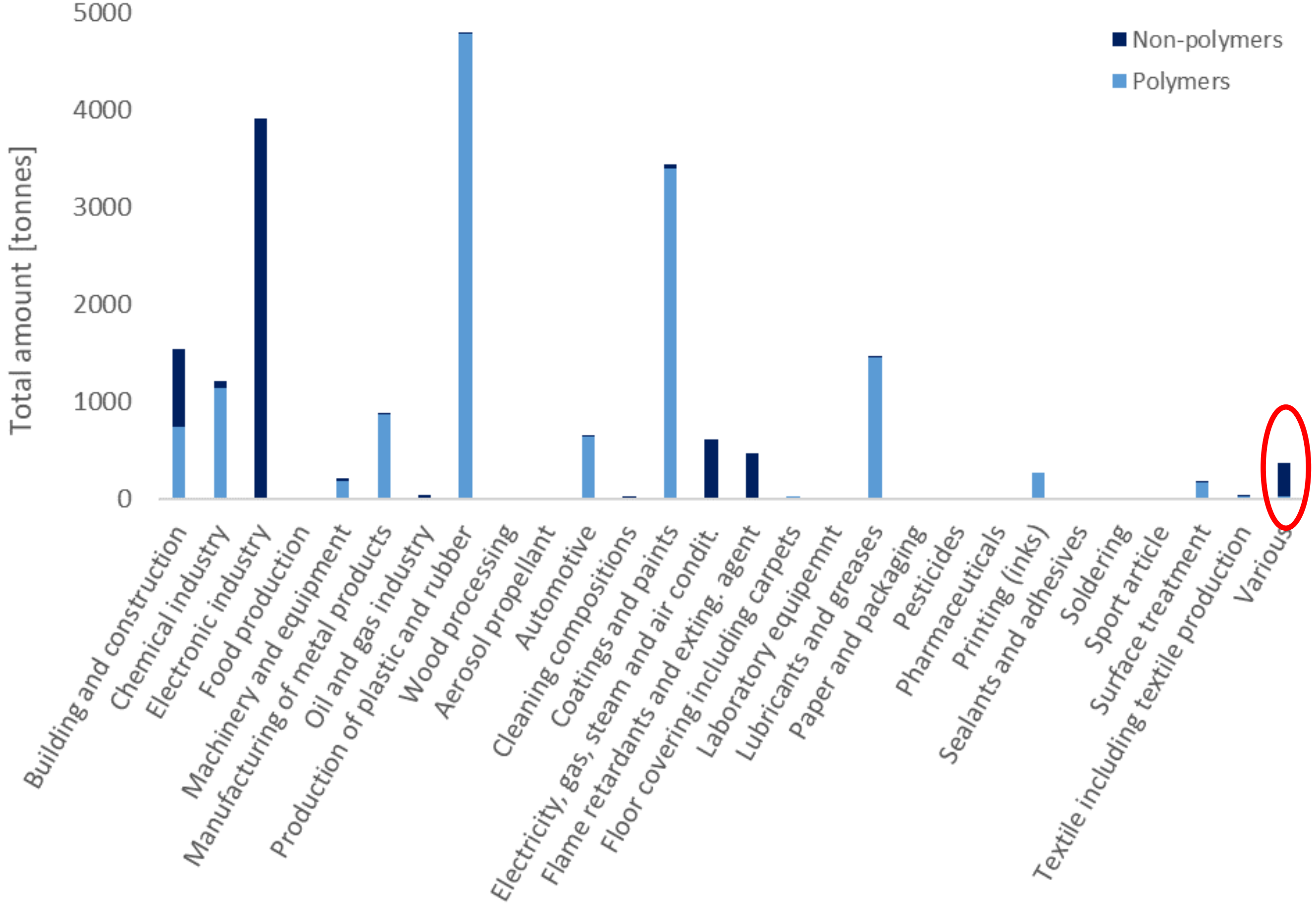


More than 200 uses identified for more than 1400 PFAS

- Less well known uses:
- ammunition,
- climbing ropes,
- guitar strings,
- artificial turf,
- soil remediation

Conclusions

- How many PFAS depends on how you count
  - hundreds to millions
- Need a regulatory definition of PFAS that is less broad than the OECD "chemistry" definition
- They are hugely diverse and the only common property is the high persistence
- We need methods to characterize and group them for regulation
  - in-depth chemical-by-chemical assessment implausible

Stockholm University

Thank you for your attention!

Acknowledgements

- The work behind this presentation has been performed by the scientists collaborating in the OECD/UNEP PFC Group and the Global PFAS Science Panel (GPSP).
- GPSP thanks the Tides Foundation for supporting our cooperation.

GLOBAL PFAS SCIENCE PANEL

PFAS levels in the water environment

Presented by: **Emma Pemberton** (Environment Agency)

PFAS levels in the water environment

Emma Pemberton

Advisor, Chief Scientist Group

Environment Agency

Evidence Synthesis

Environment Agency

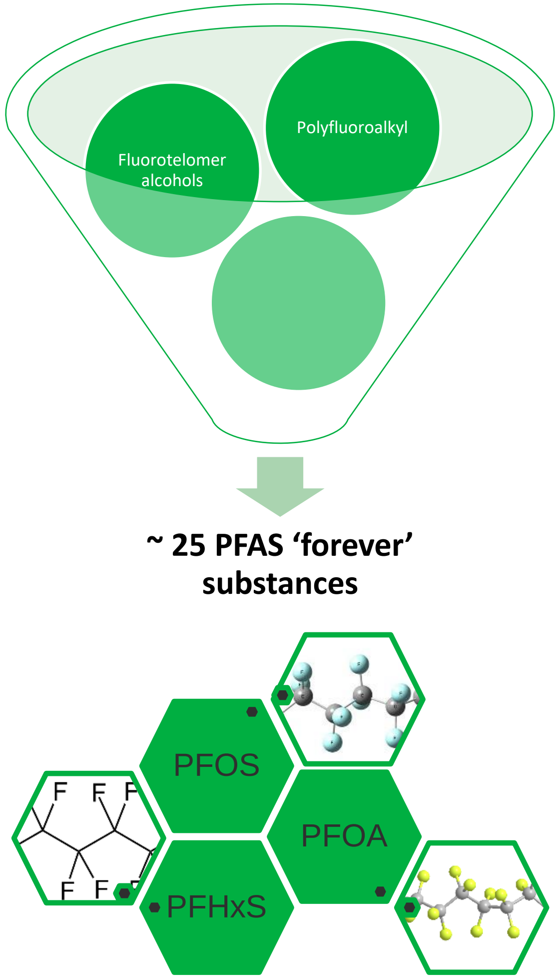
Scope

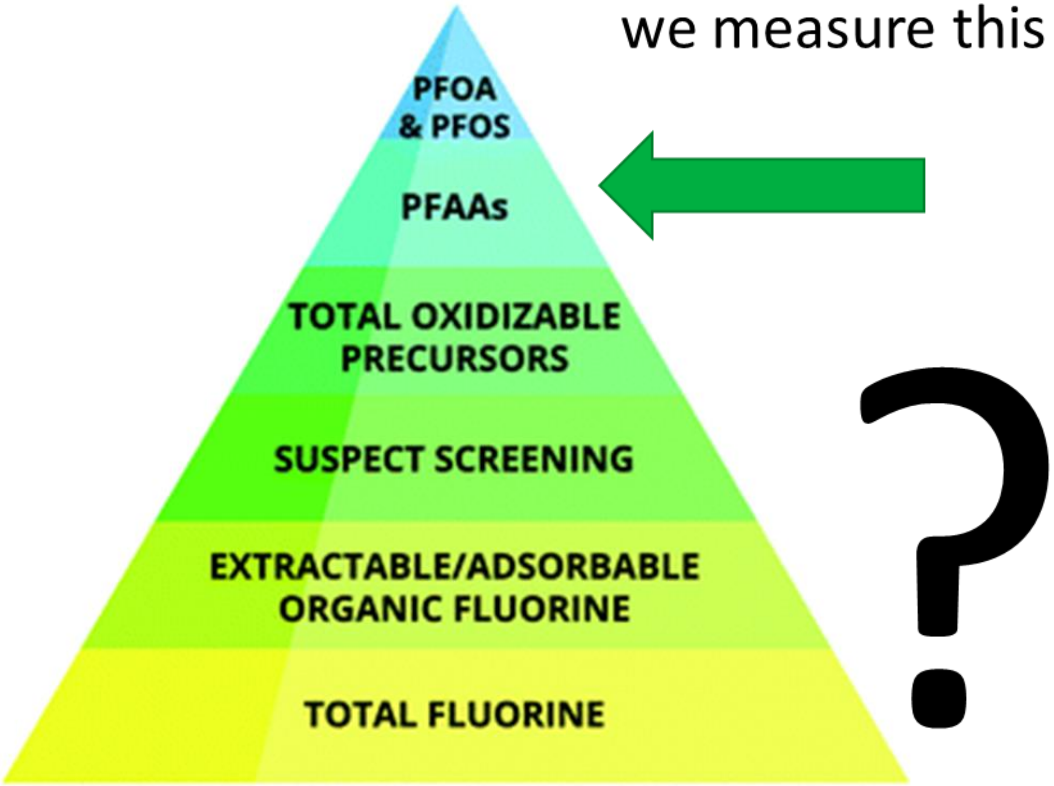
- scale of monitoring
- which PFAS ?
- PFAS levels in English rivers, groundwater, estuaries and coastal waters
- Environmental monitoring, 2021 onwards

What we're not going to cover – assigning sources and causes at specific locations

The challenge ….

1000s PFAS and precursor substances





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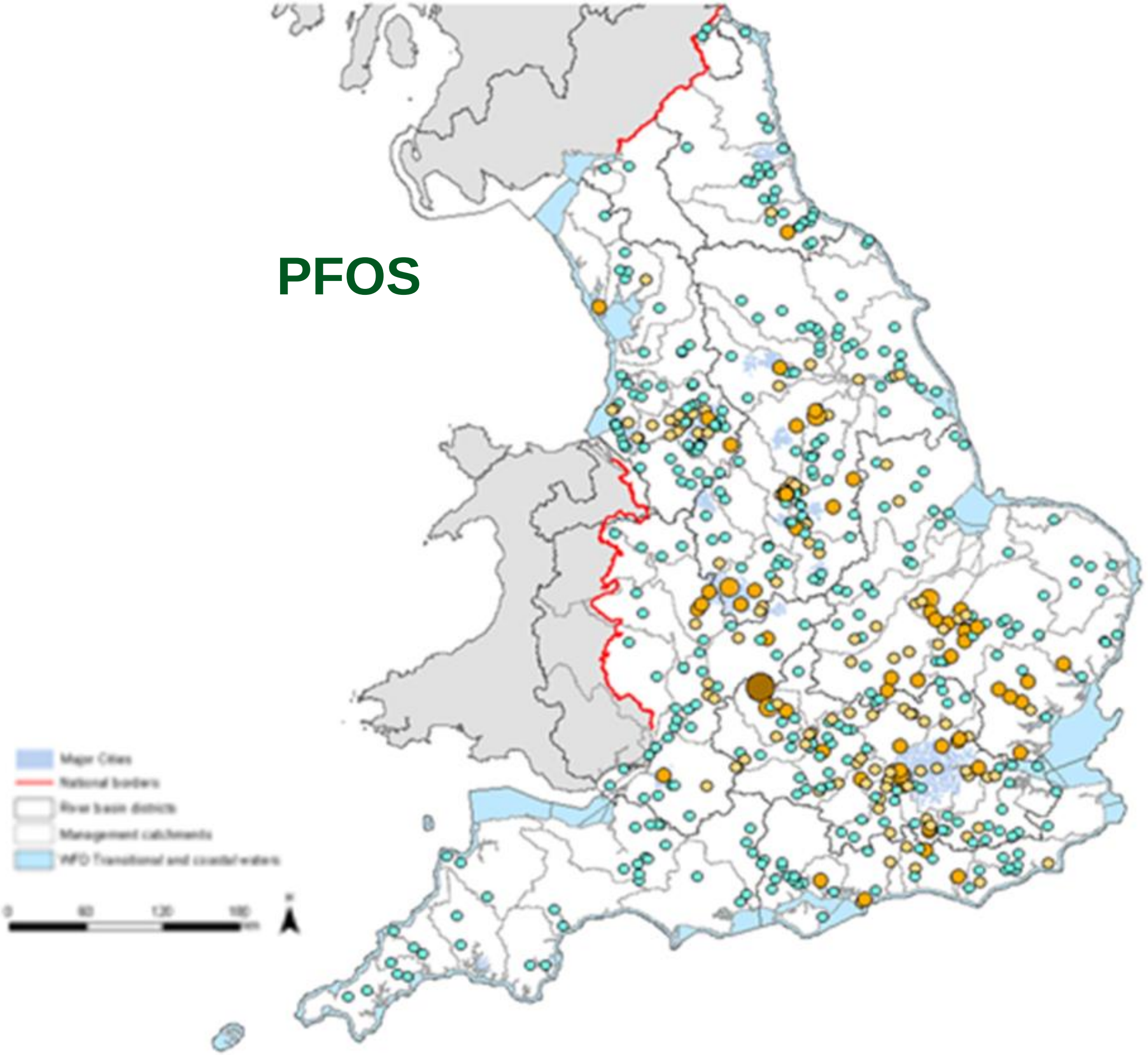
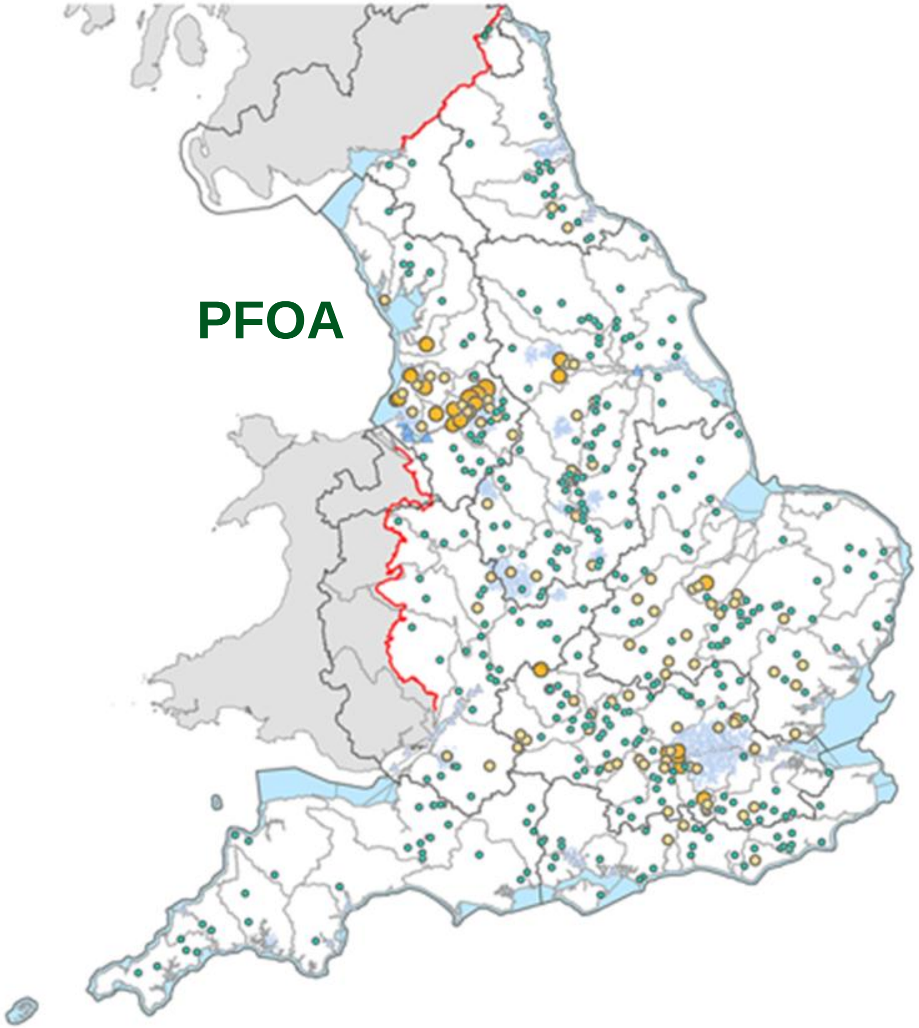
PFOS & PFOA in surface waters





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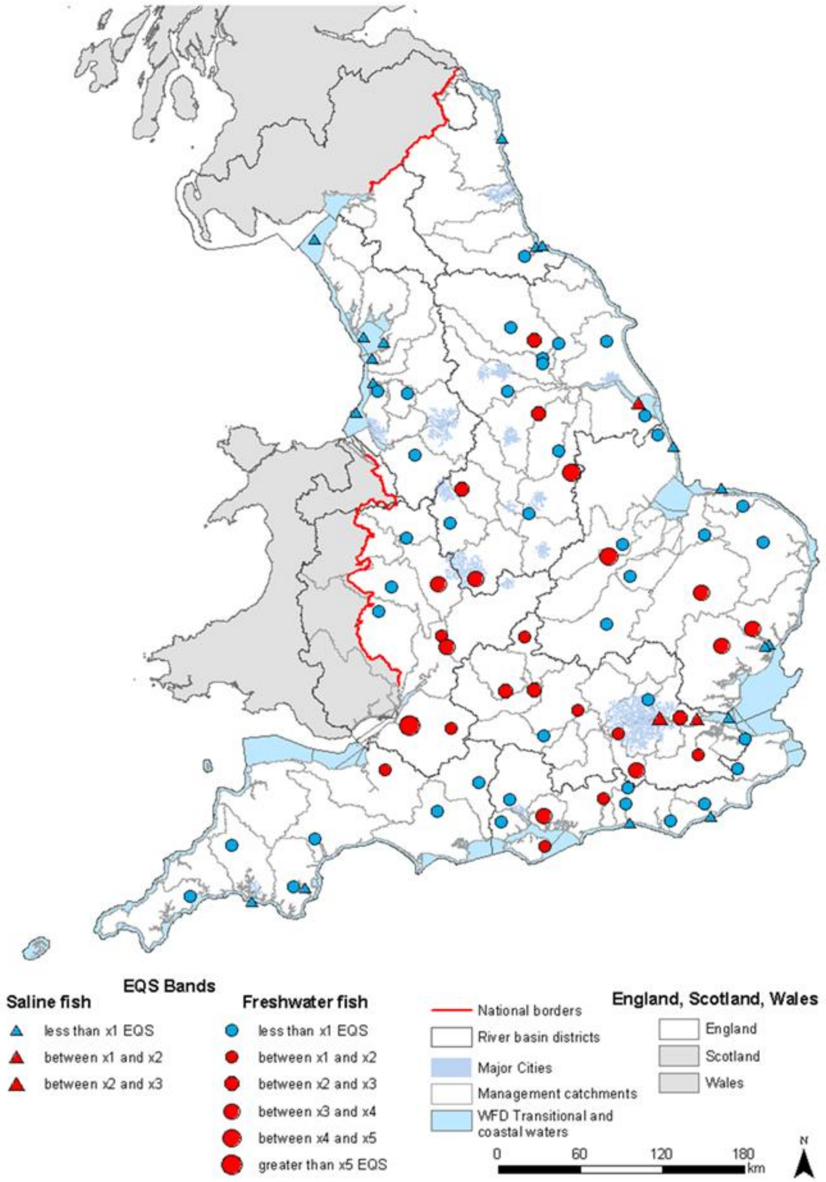
PFOS concentrations in fish

- biota EQS 9.1µg/kg wet weight (Priority Substances Directive (2013/39/EU))
- fresh water sites (78) – roach, brown trout & chubb
- Sampling since 2016 in FW
- ~25 % sites above EQS

- PFOA also analysed for in fish but not found above LOD in any samples (1µg/kg)



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Other PFAS monitoring in UK








Environment Agency

Which PFAS do we analyse for ?

2014 → 2019 → 2021 →

PFCAs

PFBA (C4)
PFPA (C5)
PFHxA (C6)
PFHpA (C7)
} short chain

PFOA (C8)
PFNA (C9)
PFDA (C10)
PFUnA (C11)
PFDoA (C12)
PFTeDA (C14)
} long chain

PFSAs

PFBS (C4)
PFPeS (C5)
} short chain

PFHxS (C6)
PFOS (C8)
} long chain

> 40 PFAS inc PFAAs, FTOHs, Gen-X,

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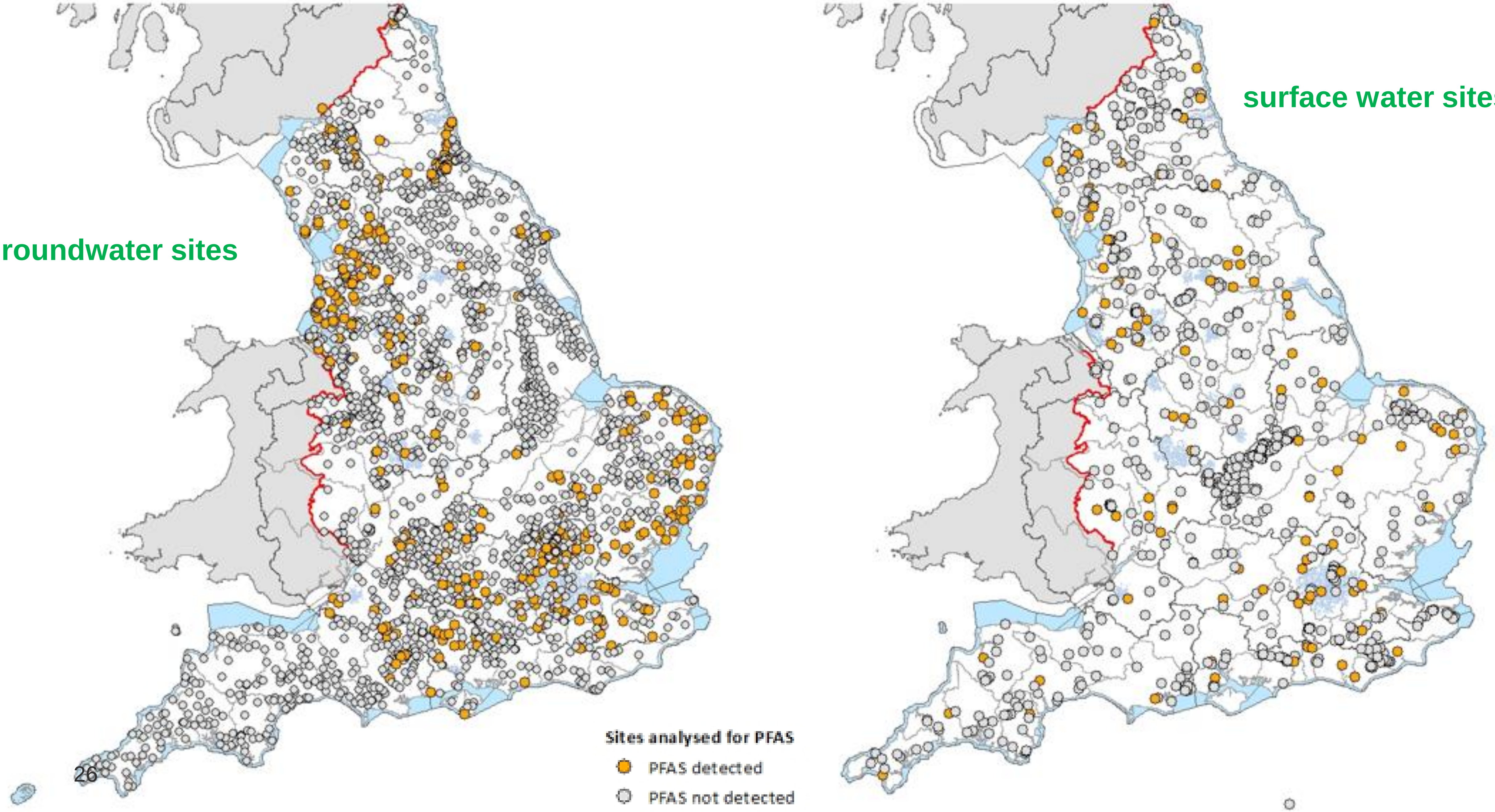
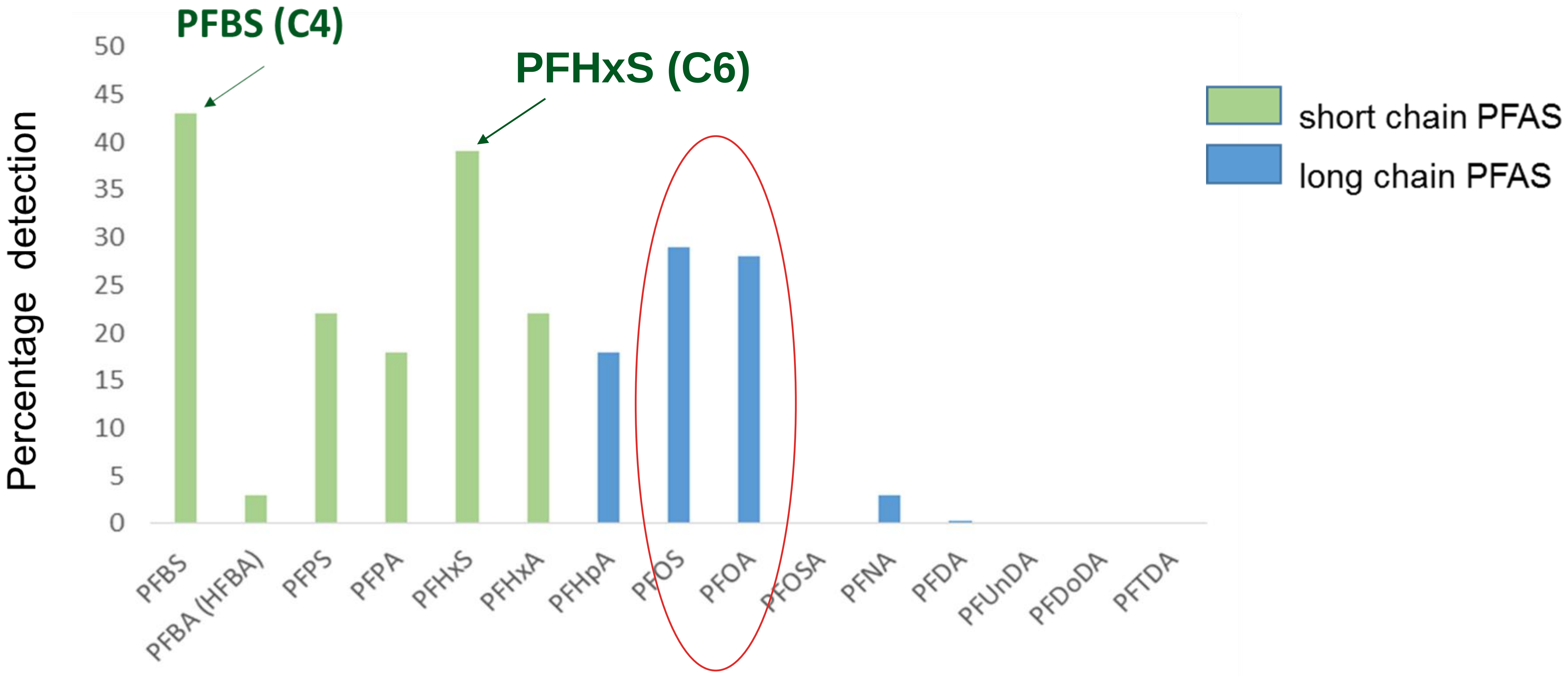
groundwater sites

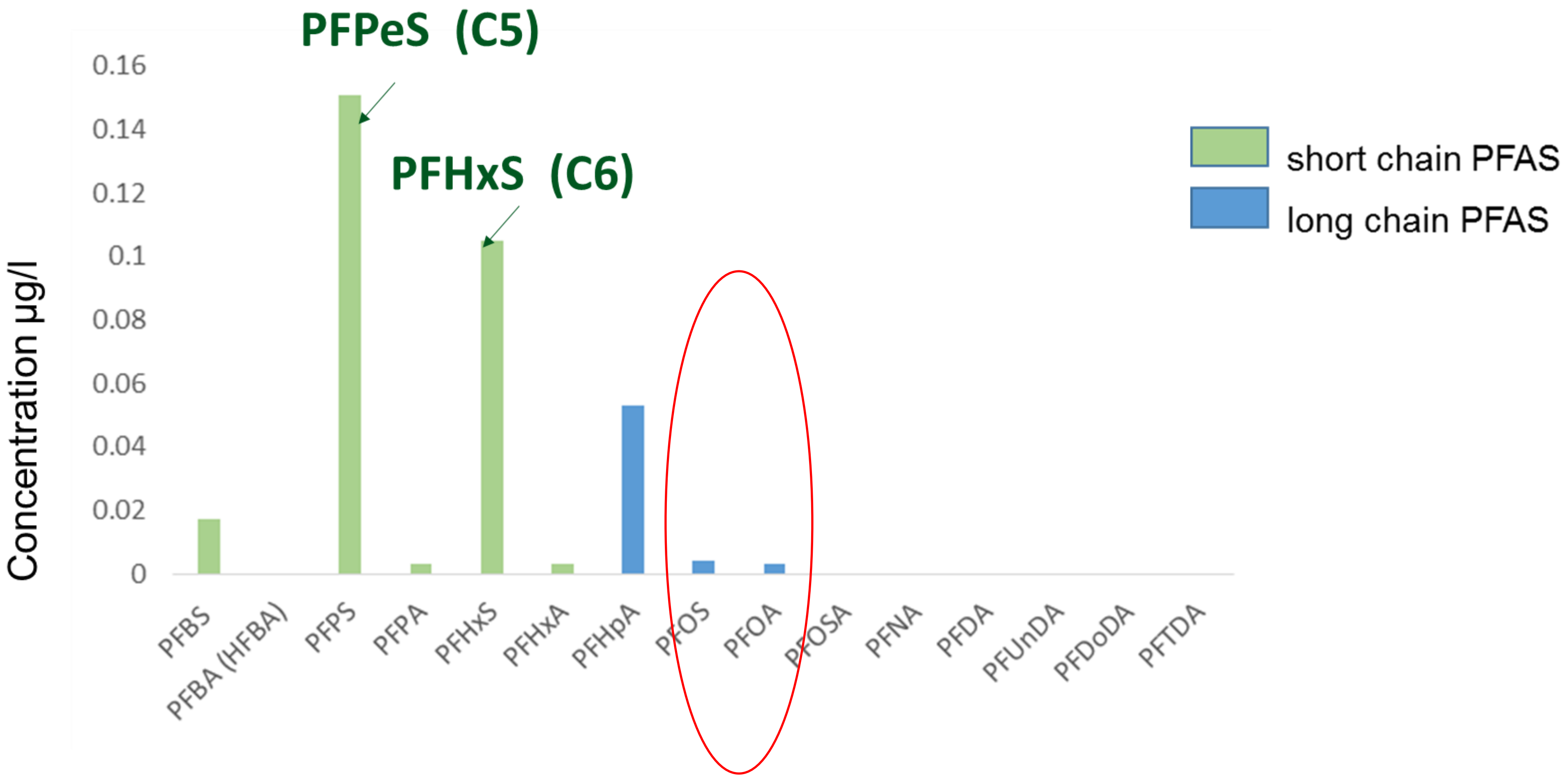
surface water sites



PFAS in groundwater



PFAS in groundwater



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Environmental monitoring for 2021 and beyond

Surveillance

- GW – 1000 samples, ~ 40 PFAS
- river surveillance network – 100 SW sites
- fish/otters

Source Investigation

- UKWIR Chemical Investigation Programme (CIP 3)
- landfill leachate
- targeted groundwater sampling @ higher risk sites

Analytical method development – TOP vs TOF

Environment Agency

PFAS: What do we know so far about public health risks?

Presented by: **Tony Fletcher** (PHE)

Public Health England

Protecting and improving the nation's health

PFAS: What do we know so far about the public health risks?

Tony Fletcher, PHE

April 27 2021

Outline

- Guidance values for PFAS in water & population exposure
- Guidance values for PFAS body burdens & population exposure
- Sources of epidemiological evidence on human health effects
- Adverse health outcomes associated with PFAS

Drinking water guidelines

- DWI Guidance values for PFOA and PFOS currently (wholesomeness) 0.1 µg/L (DWI 2021)[1]
- Comparable to US EPA guideline values of 0.07 µg/L
- (Although individual states have range of limits from 0.07 down to 0.008 µg/L)[3]
- In December 2020 DWI[2] concluded: "that it is unlikely that levels of any individual PFAS in drinking water will exceed 0.1 µg/L (100 ng/l). This conclusion is supported by the model that has been developed. The model indicates that if a drinking water standard of 0.1 µg/L were to be adopted for any individual PFAS, the majority of PFASs would not be anticipated to exceed that standard."

1) Guidance on the Water Supply (Water Quality) Regulations 20161 specific to PFOS (perfluorooctane sulphonate) and PFOA (perfluorooctanoic acid) concentrations in drinking water. DWI Jan 2021
2) Poly and Perfluorinated Alkyl Substances in Drinking Water. DWI 15 December 2020, (DWI 70/2/327)
3) Recent US State and Federal Drinking Water Guidelines for Per- and Poly-fluoroalkyl Substances
G Post, Environmental Toxicology and Chemistry 40: 550–563 (2021)

PFAS Population exposure

- Population monitoring relies mainly on monitoring serum levels
- Long chain PFAS have long half-lives so average serum levels quite stable
- Most epidemiological studies of long chain PFAS also relies on serum levels for exposure assessment
- There are limited data on population serum levels in UK. One small (30) study[1] of UK women

	GM µg/L
PFOS	3.1
PFOA	2.4
PFHxS	0.9
PFNA	0.5

1) Heffernan et al 2018. International Journal of Hygiene and Environmental Health, 221, 1068–1075

Reviews of PFAS Health effects

- **EFSA** reviews of 2018 and 2020: Reviewed Multiple PFAS
- Currently under review by COT
- PHE health guidance will be updated in light of COT conclusions
- EFSA derived Benchmark Guidance Values for Serum Concentration based on epidemiological data
- several outcomes in 2018, and only immune system effects in 2020
- Reduced Birth weight, Liver enzymes, Increased Cholesterol, Immune effects

1) EFSA CONTAM Panel (2020). Scientific Opinion on the risk to human health related to the presence of perfluoroalkyl substances in food. EFSA Journal 2020;18(9):6223, 391

2) EFSA CONTAM Panel (2018). Scientific Opinion on the risk to human health related to the presence of perfluorooctane sulfonic acid and perfluorooctanoic acid in food. EFSA Journal 2018;16(12):5194

PFAS Population exposure and EFSA Benchmarks

- Benchmark values proposed for PFOA and PFOS in 2018
- Benchmark values proposed for sum of long chain PFAS in 2020

	Heffernan 2018 GM µg/L	EFSA GVs
PFOS	3.1	21 to 26
PFOA	2.4	9.1 to 9.4
PFHxS	0.9	
PFNA	0.5	
sum	7	12.6 (2020)

PFAS Population exposure and EFSA Benchmarks

- Benchmark values proposed for PFOA and PFOS in 2018
- Benchmark values proposed for sum of long chain PFAS in 2020
- Compare to NHANES data to show variation in population serum (n= ~2000 per round)

	Heffernan 2018	EFSA	US (NHANES) data		
	GM µg/L	GVs	Median	P75	P90
PFOS	3.1	21 to 26	4.3	7.5	11.5
PFOA	2.4	9.1 to 9.4	1.4	2.1	3.0
PFHxS	0.9		1.1	1.9	3.0
PFNA	0.5		0.4	0.7	1.0
sum	7	12.6 (2020)	7	12	19

https://www.cdc.gov/exposurereport/pfas_early_release.html

Sources of evidence on health effects

- Animal data

- Epidemiology:

General population studies using serum PFAS (serum levels <10 µg/L)
Locally exposed communities (serum levels ~ 50-200)
Occupational groups (serum levels 1000+)
One study of cancer patients (serum levels 100,000+)

General population studies

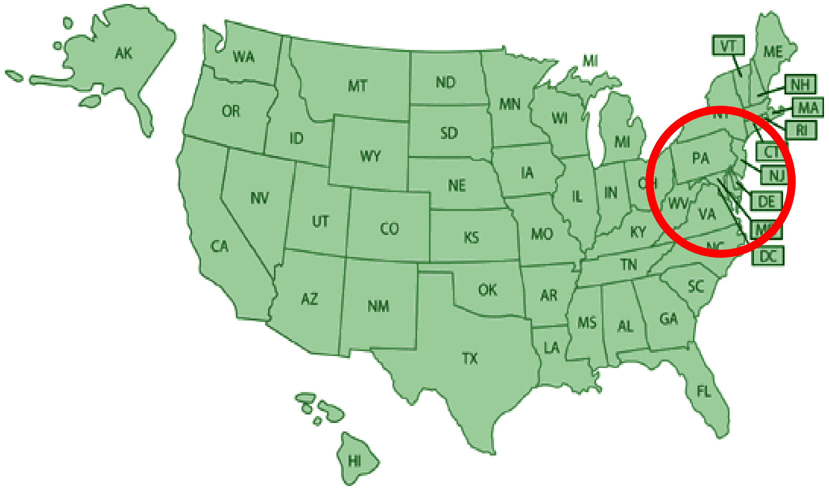
Designs

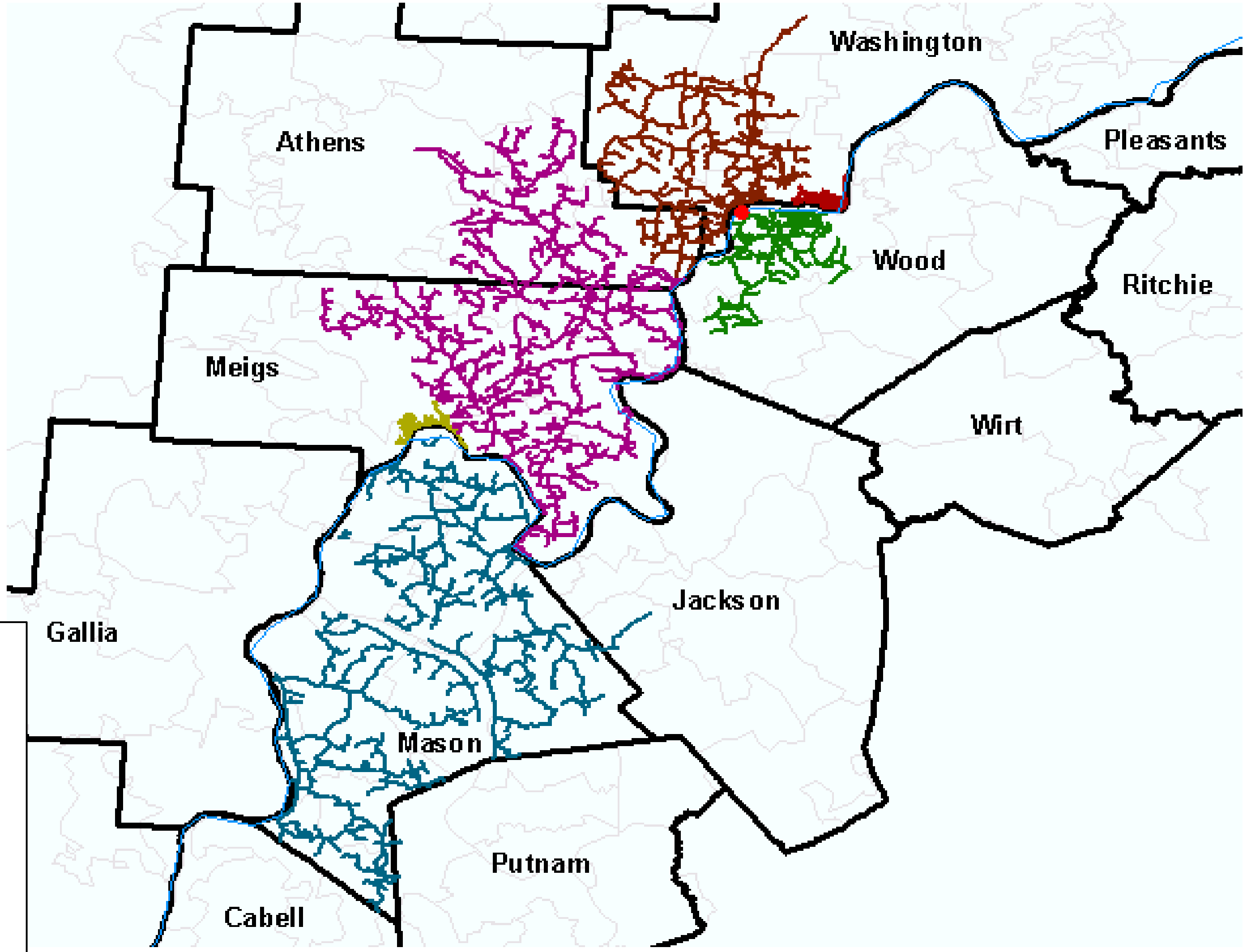
- Mainly cross sectional based serum concentrations
- Advantage – stable PFAS levels reflect internal body burdens well
- Disadvantage – PFAS levels reflect intake also reflect kidney and gut health which impact on excretion
- Longitudinal studies such as cohorts studies generally more reliable

Exposed communities

- Some large populations have been exposed.
- “C8 studies” in West Virginia, OHIO. Emissions from Teflon Manufacture; PFOA pollution of drinking water. Approx 69,000
- Ronneby, Sweden. Firefighting foam at airfield; mainly PFOS & PFHxS pollution of drinking water. Approx 30,000
- Veneto, Italy. PFAS production, Multiple PFAS pollution of drinking water; PFOA highest. Approx 100,000
- These populations provide possibilities to study disease in cohort studies.

C8 study area





Water District	PFOA (serum) µg/L (median)
Little Hocking	224
Lubeck	67
Belpre	35
Tuppers Plains	37
Pomeroy	12
Mason	12

C8 Study cohort analyses

69,000 people interviewed 2005-6, blood samples taken

40,000 adults re-interviewed 2008-9

Disease incidence in cohort analysed in relation to modelled serum PFOA

Adjusted relative risks indicated increased exposure-response for 6 disease categories:

- Raised Cholesterol
- Kidney cancer
- Testicular cancer
- Pregnancy Induced hypertension
- Ulcerative colitis
- Thyroid disease

C8 findings: in light of subsequent studies

• Raised Cholesterol	Yes
• Kidney cancer	One case control study positive
• Testicular cancer	No more data
• PIH	Not confirmed
• Ulcerative colitis	Not confirmed
• Thyroid disease	Not confirmed

Kyle Steenland, Tony Fletcher, Cheryl R. Stein, Scott M. Bartell, Lyndsey Darrow, Maria-Jose Lopez-Espinosa, P. Barry Ryan, David A. Savitz. Review: Evolution of evidence on PFOA and health following the assessments of the C8 Science Panel. Environment International 145 (2020)

Other potential adverse outcomes related to PFAS

- Decreased antibody response to vaccines, multiple studies
- Altered liver function

- Infections in children
- Chronic kidney disease, elevated uric acid, hyperuricemia
- Adverse developmental outcomes, decrease in birth weight
- Shortened duration of lactation in mothers
- Decreased male fertility
- Delayed puberty

Conclusions

- Population exposures via drinking water generally below DWI guidance
- Population body burden for long chain PFAS generally below EFSA benchmarks guidance
- Relative potency of different PFAS uncertain
- Strongest evidence of effects are immune suppression & increased cholesterol
- Not clear if either of these associated with severe disease
- Suggestive evidence of numerous other outcomes
- Needs more validation, particularly from studies in populations with clear contrasts in exposure

Disclaimer

The opinions and conclusions presented in this overview are those of the author and do not necessarily reflect PHE policy.

Contact:

Tony.Fletcher@phe.gov.uk

What do we know so far about the public health risks associated with exposure through food?

Presented by: **Claire Potter, David Mortimer** & **Timothy Chandler** (FSA)

Food Standards Agency
food.gov.uk

Toxicity of PFASs

- The most consistent and sensitive endpoint for PFASs following repeated exposures in laboratory animals was increased relative and absolute liver weight
- There have been observed effects in animal studies for reproduction and development, the immune system and neural development.
- There is no evidence for a direct genotoxic mode of action for PFOS and PFOA.
- PFOS and PFOA are tumour promoters in rodents. There is limited information for other PFASs
- In humans there appears to be evidence to support associations between PFASs and: reduced antibody response to vaccination; increased serum levels of cholesterol; increased serum levels of ALT.
- Studies on human cancer incidence or mortality provided limited evidence that exposure to PFASs are related.
- Evidence for associations of PFASs and other human health end points was insufficient
- The TWI of 4.4 ng/kg bw per week was calculated based on epidemiological studies of reduced antibody response to vaccination.

Exposure of PFAS via the food chain

- The main contributing food groups to the overall exposure to PFOS, PFOA, PFHxS and PFNA for all population groups were fish meat, fruit and fruit products and eggs and egg products.

- EFSA had calculated UK specific exposures for the sum of the four PFASs. These were multiplied by 7 to give ng/kg b.w. per week (Table 1). The CONTAM Panel concluded that the calculated LB exposure is likely to be more realistic than the UB exposure

Table 1. Mean and 95th percentile(a) chronic exposures to the 4 PFASs (ng/kg b.w. per week) for total population.

Survey	Age	Number of subjects	LB Mean exposure	UB Mean exposure	LB 95th Exposure	UB 95th Exposure
NDNS years 1-3	Toddlers	185	17	450	45	850
NDNS years 1-3	Other children	651	9.7	330	27	640
NDNS years 1-3	Adolescents	666	3.2	150	10	350
NDNS years 1-3	Adults	1266	4.3	97	13	200
NDNS years 1-3	Elderly	166	5.5	100	14	210
NDNS years 1-3	Very elderly	139	5.6	110	15	220
DNSIYC 2011	Infants	1369	61	590	110	870
DNSIYC 2011	Toddlers	1314	29	460	74	770

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The COT’s current (not final) conclusions on PFASs

- The Committee had reservations about the TWI (of 4.4 ng/kg bw per week) which had been established, due to the uncertainties and the caveats involved.

- The calculation of the TWI is critically dependent on the value taken for the half-life, about which there is appreciable uncertainty

- Health endpoint and critical study selection.

- Most population groups exceed the TWI based on the UK exposure data calculated by EFSA.

- The Committee had asked for further information to be provided in the next draft statement (July 2021).

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Risk management approach

1. New chemical risk identified
2. Analytical method developed for food
3. Levels measured in food and total diet samples
4. Dietary exposure estimated
5. Assessment of risk to consumers
6. Risk characterized
7. Mitigation measures implemented

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Perfluorinated alkyl substances (PFAS)

PFOS and PFOA identified as emerging risk, early 2000s

First UK PFOS/PFOA TDS commissioned late 2004

First Fluoros Symposium – pre - Dioxin 2005, Toronto

Buncefield oil depot explosion December 2005

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December 2005 - Buncefield Oil Depot, Hemel Hempstead, UK - one of the largest fires in peacetime Europe

40 million litres of PFOS-based foam applied

Up to 26 Ml of contaminated fire water held in storage

PFOS concentration ca. 1.2 mg/l

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Newspaper headlines in 2006

Toxic legacy poses a giant problem

‘Officials are most concerned about a toxic substance called PFOS or perfluorooctane sulphonate …’

Guardian, 07/02/2006

Poisonous legacy of Buncefield fire

‘Ministers were set to ban PFOS, a lethal chemical. They secretly backtracked after Buncefield left our water tables contaminated’

Independent, 05/05/2006

Agency anger over Buncefield toxic waste

Guardian, 25/07/2006

Risk management starts here …

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2006 TDS – compounds measured
(15 – limited to reference standard availability)

Chemical compound	Abbrev.	Number above LOD
Perfluorooctane sulphonate	PFOS	4
Perfluorooctanoic acid	PFOA	1
Perfluorooctanesulphonylamide	PFOSA	1
Perfluorobutane sulphonate	PFBS	2
Perfluorohexane sulphonate	PFHxS	1
Perfluoropentanoic acid	PFPeA	0
Perfluorohexanoic acid	PFHxA	1
Perfluoroheptanoic acid	PFHpA	0
Perfluorononanoic acid	PFNA	1
Perfluorodecanoic acid	PFDeA	1
Perfluoroundecanoic acid	PFUnA	1
Perfluorododecanoic acid	PFDoA	1
Perfluorotetradecanoic acid	PFTdA	1
Perfluorohexadecanoic acid	PFHdA	0
Perfluorooctadecanoic acid	PFOdA	0

Food Groups in which PFOS/PFOA
- detected (µg/kg)

Food group	PFOS	PFOA
Eggs	1 ± 0.2	<1 ± <0.2
Sugars & preserves	1 ± 0.2	<1 ± <0.2
Potatoes	10 ± 2	1 ± 0.2
Canned vegetables	2 ± 0.4	<5 ± <1

- undetected (LOD in µg/kg)

Food group	PFOS	PFOA	Food group	PFOS	PFOA
Bread	<20	<5	Green veg.	<3	<1
Cereals	<10	<5	Other veg.	<3	<10
Meat	<10	<2	Fresh fruit	<2	<5
Offal	<20	<2	Fruit products	<1	<5
Meat products	<10	<2	Beverages	<0.5	<0.5
Poultry	<10	<2	Milk	<0.5	<0.5
Fish	<5	<3	Dairy products	<5	<5
Oils and fats	<0.5	<1	Nuts	<2	<5

COT opinion Autumn 2006

COT noted many non-detects, high uncertainty

No immediate toxicological concerns

- But more toxicological and analytical data needed

PFOS

- based on lowest NOAEL of 0.03mg/kg for decreased serum T3 in monkey

PTDI 0.1 µg/kg

(around the estimated *upper bound* exposure)

PFOA

- based on NOAEL of 0.3mg/kg for a number of endpoints:

PTDI 3 µg/kg

(about an order of magnitude above the estimated *upper bound* exposure)

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UK Food survey 2007-9

- Testing of around 200 individual food samples
- PFOS detections much more frequent
- Highest levels found in fish and offal (nothing in potatoes!)
- PFOA rarely found (except in crab)
- Total PFAS dominated by PFOS

 - *Dietary exposure estimates for PFOS lowered significantly;*

 there continue to be no health concerns

CONCLUSION

- Risk management measures not necessary
- Further investigation low priority

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EFSA opinion February 2008

PFOS

TDI set at 0.15 µg/kg BW (applying uncertainty factor of 200 to NOAEL) (c.f. COT PTDI 0.1 µg/kg BW)

Estimated dietary exposure 0.06 µg/kg in adults (*upper bound*)

BUT EFSA noted non-food sources of PFOS may be significant to body burden as may precursors of PFOS in the body

PFOA

TDI set at 1.5 µg/kg BW (based on BMDL 10 for liver effects in mice / rats, UF 200) (c.f. COT 3.0 µg/kg BW)

Estimated dietary exposure 0.002 µg/kg in adults (*upper bound*)

Adverse effects unlikely but uncertainties about developmental effects

EFSA highlighted the need for:
- better analytical methods
- more occurrence data
- more toxicological data
- biomonitoring

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Follow-up to EFSA Opinion

- Call for data (Commission Recommendation 2010/161)
- UK data from previous survey submitted
- EFSA report on occurrence and dietary exposure, May 2012
- 7,500 samples, 54,000 results, 27 analytes

- PFOS exposure <10% of TDI; PFOA <1% of TDI
- 2011-12 UK TDS (presented at Dioxin 2013) concurred

- November 2013, EC Expert WG on POPs concluded PFAS low priority for further work – ***no risk management measures necessary***

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New EFSA opinions

Fresh opinion originally split in two – PFOS/PFOA and other PFAS

December 2018 – PFOS/PFOA opinion published:

	Old TDI	New TWI	Reduction
PFOS	150 ng/kg BW	13 ng/kg BW	80x
PFOA	1,500 ng/kg BW	6 ng/kg BW	1,750x

January 2020 – first draft PFAS published for consultation

- Proposed TWI 8.0 ng/kg BW for ∑4 PFAS

September 2020 – final version published

- **TWI set at 4.4 ng/kg BW for ∑4 PFAS**

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Implications for risk management

- Average consumer above ‘safe’ level of exposure
- Risk mitigation necessary, but
  - What do the adverse health effects mean?
    - Notably to different consumer groups
  - Limits? In what foods; is analysis good enough?
  - What would we regulate (linear PFOS/PFOA or 9-18 isomers – do we have reference standards)?
  - Consumption advice? Don’t eat fish … what about benefits, what about other POPs?
  - Contribution from other pathways?

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Food Contact Materials

<u>National legislation</u>

- The Materials and Articles in Contact with Food Regulations (UK nation*) (as amended**). Refer to Legislation.gov.uk and food.gov.uk for further information.

*separate domestic regulations exist for England, Wales, Northern Ireland and Scotland

**The amending Regulations (includes several EU Exit/non-EU provisions)

- Consolidated versions will be available in due course.
- It is important to refer to the domestic regulations when looking to place onto the market in any UK nation.

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Food Contact Materials

Retained EU legislation

- Retained EU **‘Framework’ Regulation 1935/2004** sets out the main requirements for materials and articles in contact with food.
- Under Article 3, food contact materials must be manufactured according to Good Manufacturing Practice (GMP) (Retained Regulation 2023/2006) so that they do not transfer substances at levels that could:
  - Endanger human health;
  - Unacceptably change the composition of the food; or
  - Bring about a deterioration in the organoleptic characteristics (for example, taste).

Food Contact Materials

PFAS

- Some evidence that UK food packaging industry has moved away from the use of fluorinated compounds in many paper and board products.
- Now predominantly used in specialist packaging which have certain technical requirements such as moisture or grease resistance.
- Manufacturers retain option to use PFAS for this technical function but need to ensure they are safe in expected use.
- There are strict specific migratory limits (SMLs) for specific PFAS that have been authorised for use in food contact plastics (under retained EU Regulation 10/2011 on plastic food contact materials). If appropriate, a read-across to these SMLs can sometimes be useful when considering some non-plastic materials.

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NGO perspective

Presented by: **Anna Watson** & **Julie Schneider** (ChemTrust)

Link to presentation:

https://chemtrust.org/wp-content/uploads/PFAS_Defraworkshop_April2021.pdf

Manufacturer perspective

Presented by: **Martyn Shenton** & **Edyta Lam** (AGCCE)

AGCCE's UK Fluoropolymer Manufacture

AGC

Dr Martyn Shenton and Dr Edyta Lam

DEFRA workshop, 27th April 2021

Your Dreams, Our Challenge

AGC Chemicals Europe, Ltd : Wholly owned by AGC Inc. of Japan

AGC
Your Dreams, Our Challenge

- **Established in 2007**

  UK and NL offices merged & became "AGC Chemicals Europe" (AGCCE)

- **Head Office in Thornton Cleveleys, Lancashire**

  ICI, previous owner of this UK production site, established a joint venture with AGC in 1981

  In 1999, AGC became the sole owner of this joint venture plus the PTFE businesses in the US and the UK

- **Approx. 200 employees**

- **Production:**

  Fluon® PTFE/ETFE Fluoropolymers

- **Sales & Marketing:**

  - Fluon® PTFE/ETFE/PFA Fluoropolymers
  - AFLAS® Fluoroelastomers
  - Fluorochemicals (Coatings, Films, etc.)
  - Other Speciality Chemicals

Head Office (UK)

Commercial Centre (NL)

What are Fluoropolymers?

AGC
Your Dreams, Our Challenge

- Fluoropolymers are polymers with fluorine atoms directly attached to their carbon backbone.
- They are virtually chemically inert, non-wetting, non-stick, and highly resistant to temperature, fire & weather.
- They ensure safety, reliability and performance in numerous technologies, industrial processes & everyday applications and help contribute to the achievement of UN SDGs and the EU Green Deal.

How are Fluoropolymers Different to Other PFAS

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Your Dreams, Our Challenge

- Per- and polyfluoroalkyl substances (PFAS) are a huge and diverse group of chemical compounds.
- Despite their chemical structure fluoropolymers are different to other PFAS and have specific toxicological and environmental profiles.
- Fluoropolymers are high molecular weight polymers and have unique physicochemical properties that constitute a distinct class within PFAS.
- Fluoropolymers that meet the OECD polymer of low concern criteria are non-toxic, bio-compatible, non-soluble and immobile molecules and they are deemed as such to have insignificant environmental and human health impacts.

What is PTFE and why is it used?

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Your Dreams, Our Challenge

- **Poly(tetrafluoroethylene) (PTFE)** is a polymer comprised of tetrafluoroethylene (C2F4).
- PTFE provides excellent performance for properties over a wide temperature range including:
  - **chemical resistance**
  - **thermal resistance**
  - **non-stick properties**
  - **electrical properties**
  - **weather resistence**

https://www.agcce.com/fluon-ptfe/

- Its superior combination of properties allows PTFE to be used in many applications where other polymers cannot.
- Placed on the market as **granular powder, fine powder, micropowder** and **aqueous dispersions**.

Typical property	Units	Value
Melting point	°C	327
Service temperature	°C	-260 → +260
Specific gravity		2.1 – 2.2
Coefficient of friction		0.02 – 0.1

What is ETFE and why is it used?

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Your Dreams, Our Challenge

- **Ethylene-Tetrafluoroethylene (ETFE)** is a copolymer comprised of tetrafluoroethylene (C2F4) and ethylene (C2H4).
- ETFE provides excellent all around performance in all properties of fluoropolymers such as **tear resistance, chemical resistance, thermal resistance, weatherability, non-stick properties and electrical properties.**

https://www.agcce.com/fluon-etfe-resins/

- Its **superior processability** allows ETFE to be used in applications where other fluoropolymers, like PTFE, cannot.
- Placed on the market as **beads, pellets, powders** or **film.**

Typical property	Units	Value
Melting point	°C	260
TFE : E ratio		50:50
Service temperature	°C	-40 → +175
Tensile strength	MPa	50
Elongation at break	%	400

Key Market Sectors: Fluoropolymers

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Transport Industry

- Automotive
- Aerospace
- Marine

Chemicals

- Linings
- Coatings
- Seals
- Moulded Parts
- Inner Tubes for Metal Pipe Systems

Electronics

- Cables
- Wires
- Coatings

Household Applications

- Plumbers Tape
- Non-Stick Coatings
- Kitchen Appliances

Architecture

- Walls & Roofing Structures
- Sports Stadia & Entertainment Venues

Offshore & Industrial

- Seals
- Pump Covers
- Yarn
- Packings
- O-Rings
- Gaskets
- Additives for Compounds

Irreplaceable Societal Value

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ONE-OF-A-KIND POLYMERS

Fluoropolymers are **unique chemical substances** used across **numerous technologies, industrial processes and everyday applications** from the aviation industry to transportation, medical devices and energy production and technical apparel.

With a **unique set of properties,** they are durable, chemically inert and mechanically strong. Fluorpolymers help to **keep us safe** and **enable innovation**.

WHY DO WE USE FLUOROPOLYMERS?

- Ensure **safety, reliability** and **performance** across a variety of sectors
- **Low-risk** polymer for human health & environment
- Help drive **EU industry competitiveness and innovation**
- Critical to numerous technologies **enabling the Green Deal**, reducing waste and emissions
- **Few**, if any, **viable alternatives**

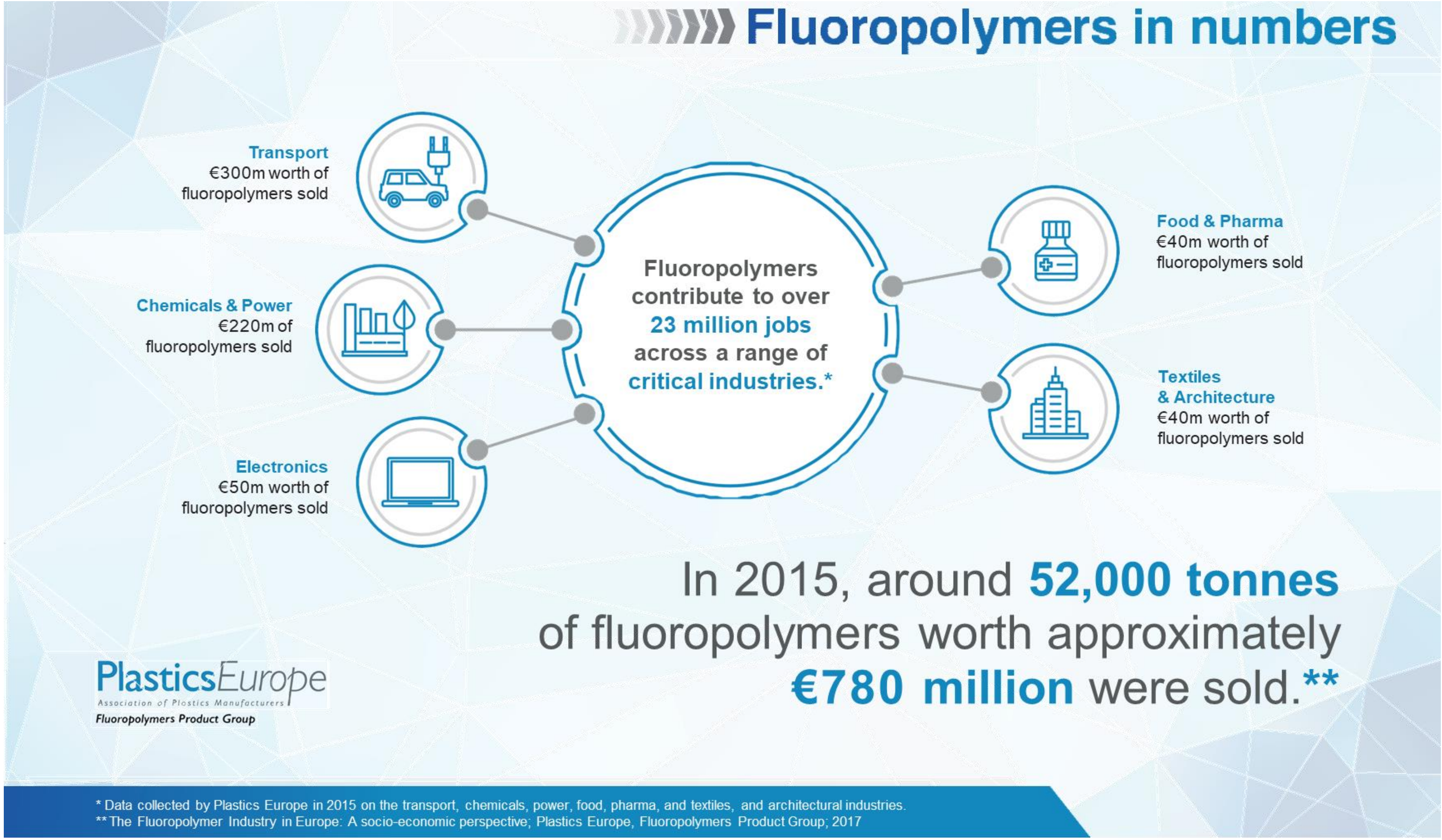
USES OF FLUOROPOLYMERS

- Promoting **sustainable and smart mobility** through **electric vehicles**.
- Extending the lifespan of medical equipment and devices, **reducing the need for replacements, risk of failure and cross infections**.
- Enabling a **data driven economy** though the manufacturing of microprocessors and **semi-conductors**.
- Facilitating the **Renovation Wave** and the **construction of energy efficient buildings**.
- Driving **innovation** and **helping decarbonise the aviation industry**.
- Assisting the **chemicals industry** in **preventing corrosion in harsh environments**.
- Ensuring **food and pharmaceuticals** remain **fresh and uncontaminated**.
- Protecting **workers** in **professional protective and high-performance clothing**.

PlasticsEurope
Association of Plastics Manufacturers
Fluoropolymers Product Group

Irreplaceable Societal Value

AGC
Your Dreams, Our Challenge



PlasticsEurope
Association of Plastics Manufacturers
Fluoropolymers Product Group

Product Range from AGC Chemicals Europe

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Fluon® PTFE

Resins
Compounds
Micropowders
Dispersions

Main Applications:

- Seals, Washers, Tape
- Semi-Finished Parts
- Thermoplastic Blends
- Dry Lubricants
- Cookware Coating
- Glasscloth Fabric Coating

Fluon® ETFE

Resins
Compounds
Powders

Main Applications:

- Wire & Cable Insulation
- Moulded Parts
- Packings
- Corrosion-Resistant Linings
- Fuel Hose & Coolant Hose
- Film

Fluon® PFA

Resins
Compounds
Powders

Main Applications:

- Wire & Cable Insulation
- Moulded Parts
- Packings
- Corrosion-Proof Coatings
- Film

AFLAS®

Fluoroelastomers

Main Applications:

- O-Rings
- Cables
- Packings
- Seals
- Pump Covers

Fluon® ETFE FILM

Main Applications:

- Architectural Film
- Release Film

F-CLEAN™

Main Applications:

- Greenhouse Film

Polyols

for Polyurethanes

Main Applications:

- Heat & Noise Insulation
- Coatings
- Adhesives
- Sealants
- Elastomers

Product Range from AGC Chemicals Europe

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Fine Chemicals

Main Applications:

- Pharmaceuticals
- Agrochemicals

Fine Silica

Main Applications:

- Chromatography
- Cosmetics

AsahiGuard®

Main Applications:

- Waterproof
- Stain-Repellent
- Coating for:
  - Paper
  - Food Packaging
  - Textiles & Apparel
  - Automotive Parts
  - Synthetic & Natural Leather

LUMIFLON™
FEVE Resin

Main Applications:

- UV/Corrosion-Resistant
- Coating for:
  - Bridges
  - Buildings
  - Ships
  - Aeroplanes
  - Windmills

Solvents

Main Applications:

- Precision Cleaning (Metals, Plastics)
- Drying Agent (After Cleansing with Alcohol / Hydrocarbons)
- De-Watering (After Aqueous Cleaning)

AMOLEA™ 1224yd

Main Applications:

- Air Conditioning
- Refrigeration

FORBLUE™ FLEMION

Ion Exchange Membranes

Main Applications:

- Desalination
- Chemical Separation
- Electrodialysis

Bio-based Epichlorohydrin

Main Applications:

- Epoxy Resins & Reactive Diluents
- Cationic Reagent
- Paper Chemicals
- Water Treatment Chemicals
- Surfactant

Summary / key messages

AGC
Your Dreams, Our Challenge

- Fluoropolymers – unique combination of properties including:
  Durability, inertness, mechanical strength, thermal stability, chemical stability, electrical properties, resistance to degradation.
- Fluoropolymers are high molecular weight polymers and have unique physicochemical properties that constitute a distinct class within PFAS.
- Fluoropolymers that meet the OECD polymer of low concern criteria are non-toxic, bio-compatible, non-soluble and immobile molecules and they are deemed as such to have insignificant environmental and human health impacts.

For further information on fluoropolymers is also available at the PLEUR FPG website:
https://fluoropolymers.plasticseurope.org/

PlasticsEurope
Association of Plastics Manufacturers
Fluoropolymers Product Group

Follow FPG on LinkedIn: Fluoropolymers Product Group: Overview | LinkedIn

Assessing the potential PFAS legacy

Presented by: **Angela Haslam** (Environment Agency) & **Jane Thrasher** (Jacobs)

Assessing the potential PFAS legacy

Angela Haslam, Environment Agency

Jane Thrasher, Jacobs

April 2021

PFAS sources - site prioritisation

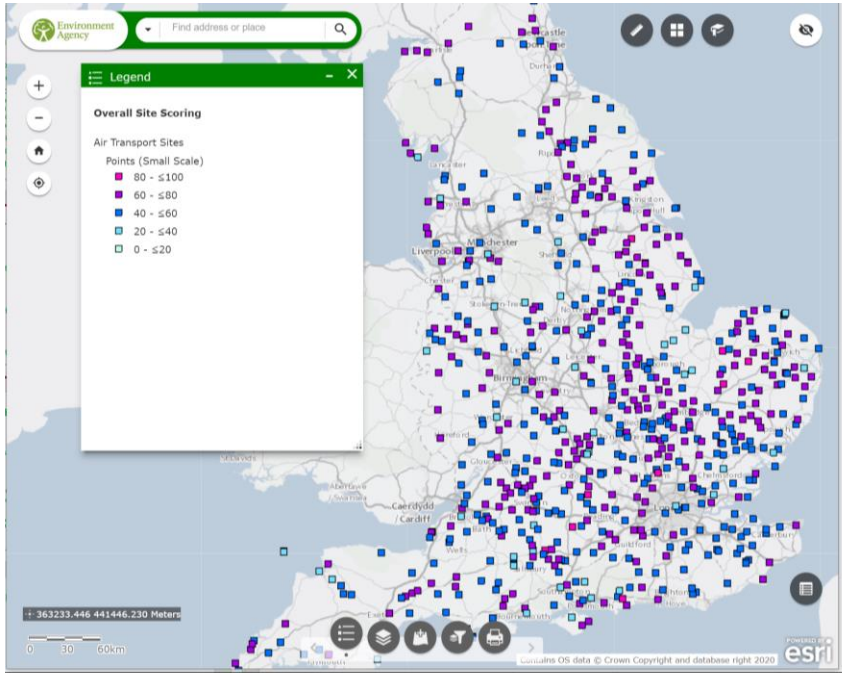
- The diversity of uses for PFAS, and number of different PFAS used is huge
- We can reduce environmental inputs by enforcing current restrictions on use and developing risk management options for substances in current use.
- But what about the legacy from past use ?
- It is not practical to try to tackle everything
- Project initiated by Environment Agency to identify higher risk potential source sites
- To prioritise effort on the sites that can make the most difference

Identification of source site types

- Step 1 – long list of PFAS users
- Step 2 – short list of key site types
- Criteria for selection of site types
  - Numerous sites widespread across England
  - Known ‘use’ of PFAS (although not necessarily at every site)
  - Plausible pathways for loss to the environment (esp. controlled waters)
  - Representative of different types of PFAS use
- Fire stations, air transport sites (including military), military bases
- Chrome plating, carpet manufacturing, leather and textiles, paper
- Landfill, waste water treatment works
- Preparation of short site profiles for key site types

Example: Airfields and Airports

- Sources
  - Fire training areas
  - Fire suppressant systems
  - Hangar protection
  - Fuel installations
  - Hydraulic fluids
  - Accident sites
  - Mechanic shops
  - Other past uses e.g. foam salutes, runway foaming



- Pathways
  - Direct loss to ground, leaky drains, discharge via interceptors
- Sites have been mapped and ranked based on environmental setting and existing water quality data

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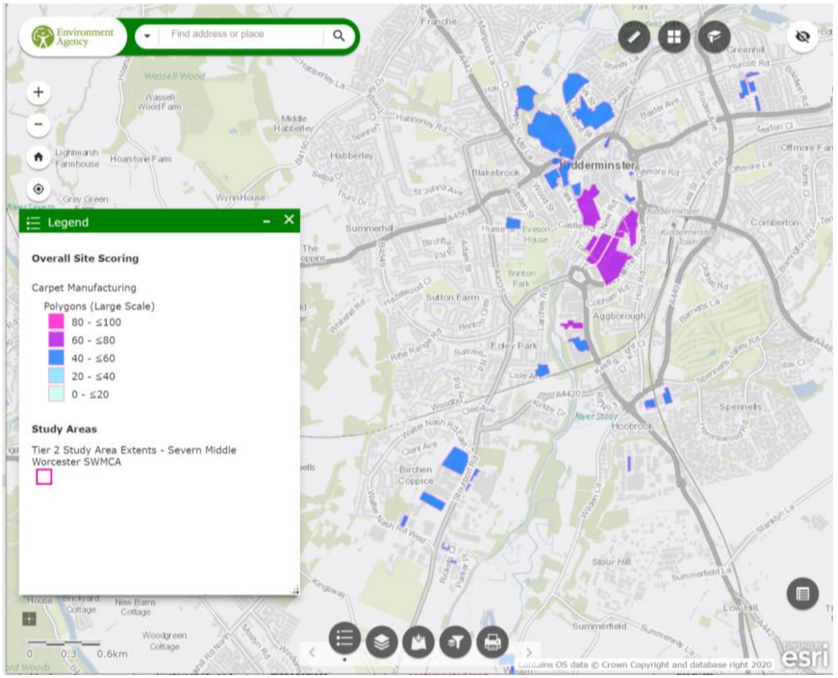
Example: Carpet Manufacture

- Sources
  - Anti stain treatment – can be applied as part of manufacturing process, or post production
- Pathways
  - Process water, spray areas, dye-bath
  - Loss from concentrate storage
  - Wastewater; leaky drains
  - Storm water run off and loss to ground
  - Decommissioning and demolition of redundant plant



- Questions
  - How much has PFAS been used by UK manufacturers ?
  - PFOS was widely used prior to 2004, but how much was this replaced by other PFAS ?

Example: Landfills

- Numerous studies around the world have found PFAS ubiquitous in landfill leachates

- Sources
  - – Disposal of consumer products
  - – Industrial waste containing PFAS
- Pathways
  - – Leachate dilute and disperse to groundwater
  - – Collected leachate discharge to sewer
  - – Leachate discharge to surface water
- Features
  - – Continuing source of PFAS which have been withdrawn from production and use
  - – Planned Defra project to analyse leachate in open & closed landfills in 2021 (delayed from last year)

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What PFAS should we be looking for ?

- PFOS and PFOA replaced with a range of equally persistent PFAS
- Manufacturers are often not clear about what is in replacement formulations
- Ongoing evolution of replacement formulations esp. e.g. AFFF
- C8 formulations replaced with C6 – PFHxS, PFHxA and 6:2 FTS
- Many replacements are based on Fluorotelomers
  - fluorotelomer sulphonates are persistent in the environment
  - commonly considered precursors because they break down to PFCAs, however they can be many times more abundant than PFCAs in environmental media
  - 5:3 FTCA widely reported in landfill leachate
- PFAS forensics are developing, can help identify source sites
- PFOS and PFOA often only a fraction of the total PFAS

What Next

- Continued research to identify and prioritise high risk sites
- Site specific investigation at selected high risk sites to confirm site characterization
- Ensure the most relevant PFAS chemicals are being considered in the approach including analysis
- Development of indicative soil guidelines for certain PFAS to explore and characterise risks
- Engage contaminated land community about the approach

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For further information

Please contact

- Jane Thrasher jane.thrasher@jacobs.com
- Angela Haslam angela.haslam@environment-agency.gov.uk

Water industry chemical investigations - current findings & planned work

Presented by: **Mark Craig** (Severn Trent) & **Howard Brett** (Thames Water)

CIP2 - 2015 to 2020

- >600 sewage works sampled for a range of hazardous substances + some emerging substances of concern
  - 20 final effluent samples taken over 12 months
  - 36 samples from upstream and downstream river – taken over 24 months
  - Upstream sampling was only possible at 527 sites
- 2 PFAS substances included in the programme

Substance	EQS ng/l	LOD (effluent) ng/l	LOD River ng/l
PFOS	0.65	0.65	0.09
PFOA		0.65	0.09

- Low receiving watercourse dilution was a criteria for selection, so CIP2 sites are not entirely representative in terms of environmental impact.
  - C.7000 sewage works in the UK, of which about 1300 have receiving watercourse dilution of <10:1
  - Severn Trent serve a total population equivalent of 10.5m – 50% by sewage works with dry weather dilution <2:1

Key findings

Location	Substance	Mean ng/l	SD ng/l	10%ile ng/l	95%ile ng/l
Upstream	PFOS	4.7	6.3	1.1	15.9
Effluent	PFOS	5.3	4.4	2.5	14.7
Downstream	PFOS	5.2	6	1.8	16.4
Upstream	PFOA	3.7	4	1.3	11.2
Effluent	PFOA	5.3	2.6	3.5	10.7
Downstream	PFOA	4	2.8	2.1	9.5

- On average PFOS concentrations downstream of sewage works are 19% higher than upstream
- For PFOA the average increase is 35%

- However, upstream concentrations of PFOS are, on average, already 7* higher than the EQS
- PFOA is, on average, 6* higher than the PFOS EQS

- At 175 of 527 sewage works, downstream PFOS river concentration was lower than upstream.
- For PFOA, the figure was 130 sites

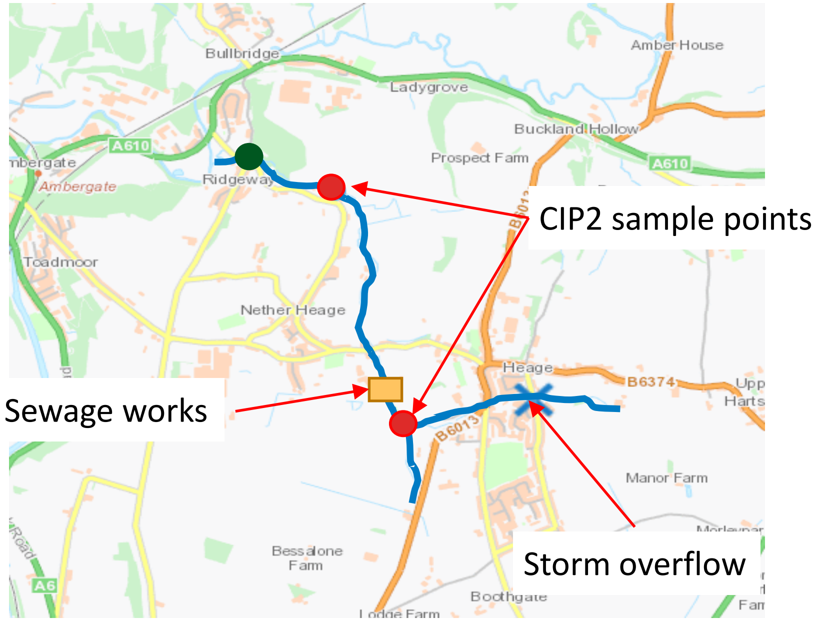
CIP3 – Sewer & river catchment investigations

- All companies have proposed at least 1 site for more intensive sewer and river sampling
- Objective is to further understanding of the potential sources of PFOS and PFOA
- Sites selection based on results from CIP2 (e.g. high levels in effluent, unexpected high levels in upstream river, no obvious sources etc)

Severn Trent site is Heage STW – small works in rural Derbyshire.

Serves 2750 people
No permitted trade effluent (one small trading estate)
only sewage works discharging into the river
Dry weather dilution 3:1
one storm overflow u/s of the upstream sample point

Location	Mean ng/l		95%ile ng/l	
	PFOS	PFOA	**PFOS**	PFOA
Upstream	**11.2**	3.1	**20.3**	6.4
Effluent	**5.7**	4	**8.6**	5.7
Downstream	**6.4**	3.5	**14.8**	5.7



CIP3 – Other investigations (1)

Treated sewage sludge

- 20 samples of treated sludge being taken at 10 sites
- Range of different sludge treatment processes covered
- Range of PFAS's covered – analysis to LOD of 0.001mg/kg

Perfluorooctane sulphonate (PFOS)
Perfluorooctanoic acid (PFOA)
Perfluorononanoic acid (PFNA)
Perfluorodecanoic acid (PFDA)
Perfluoroundecanoic acid (PFUnDA)
Perfluorododecanoic acid (PFDoDA)
Perfluorotetradecanoic acid
Perfluorotridecanoic acid
Perfluorobutane sulphonate (PFBS)
Perfluorohexanoic acid (PFHXA)
Perfluorohexanesulfonic acid (PFHxS)
Perfluorooctanesulfonamide (PFOSA)

Substances of emerging interest

- 30 sites across the country
- 18-20 samples taken over 12 months
- Effluent, upstream + downstream river (effluent only for TRaC discharges)
- Includes the following perfluorinated substances

Perfluorobutane sulfonic acid (PFBS)
Perfluoropentanoic acid (PFPeA)
Perfluoroheptanoic acid (PFHpA)
Carboxymethyldimethyl-3-[[(3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl)sulfonyl]amino]propylammonium hydroxide
3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctanesulfonic acid
Ammonium 2,3,3,3-tetrafluoro-2-(heptafluoropropoxy)propanoate (GEN-X)
Perfluorohexanoic acid (PFHXA)
Perfluorohexanesulfonic acid (PFHxS)

CIP3 – Other investigations (2)

Groundwater discharges

- 40 sites across the country
- Mix of fully quantitative analysis and GC-MS + LC-MS scans

Trend monitoring

- Running from mid 2020 to 2025
- 50 sites across the country covered
- Influent and effluent sampling covers PFOS and PFOA
- 6-12 samples PA
- To assess effectiveness of source control measures

TRaC discharges monitoring

- Sites serving >25,000PE discharging into these estuaries/coastal waters
- Effluent analysis includes PFOS

Thames
Severn
Tees
Humber
Mersey
Southampton Water

Mechanisms of removal

- Lab scale investigation into fate of various substances covered by CIP2 trials.
- Aim to find out if there is any biological degradation or just transfer from effluent to biosolids.
- ***Are we removing the problem or just transferring it somewhere else?***

Effectiveness of new treatment processes

- Some of the tech trialled in CIP2 is now in use at full scale (mainly on phosphate removal).
- Aim is to verify the percentage removal data from the CIP2 F&P trials on plant operating at full scale.

Environment Agency evaluations of REACH-registered PFAS used in the UK

Presented by: **Simon Hoy** (Environment Agency)

Environment Agency Evaluations of REACH-registered PFAS used in the UK

Simon Hoy
Chemicals Assessment Unit (CAU)

Environment Agency

Background

- Industrial uses of PFAS are regulated under REACH[1] (and other Regulations)
- Increasing interest prompted investigation by CAU in 2019 of PFAS registered under EU REACH by UK companies
- Initial list refined to 12 PFAS not subject to regulatory action or voluntary withdrawal - but still being imported, manufactured or used in UK at >1 tonne/year
- Two main Registrants and production sites in the UK: AGC Chemicals Europe, Ltd and F2 Chemicals Ltd - both in Lancashire

[1] Registration, Evaluation, Authorisation & restriction of Chemicals (REACH)

Purpose

- To conduct detailed scientific reviews during 2020/21 of published environmental data[2] on these 12 registered PFAS
- Also ‘F-53B’ - not REACH-registered but a potential substitute for PFOS detected at very low levels in UK surface water monitoring (and also since in otters)
- Not formal REACH Substance Evaluations but could form the basis of future assessments and also help quantify environmental standards/ exposure limits
- Evaluations consider physico-chemical properties, environmental fate and behaviour, exposure and (eco)toxicity information to identify information gaps, potential hazards and risks

[2] Main source of information was the ECHA public dissemination site: https://echa.europa.eu/information-on-chemicals - but also REACH Registration Dossiers and information from the public domain/literature searches

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AGC Chemicals Europe Ltd - what do they produce?

- Produces a number of grades of PTFE and ETFE[3]
- Products have a diverse range of specialist uses, such as in food contact materials and electrical cabling
- The site has two main product streams; PTFE - with a capacity up to 4000 tonnes per year and ETFE - with a capacity up to 2000 tonnes per year
- The substances evaluated are used as either processing aids or monomers in polymer production
- Working closely with AGCCE to further improve understanding of substances properties and their respective emissions

[3] polytetrafluoroethylene and ethylene tetrafluoroethylene fluoropolymers

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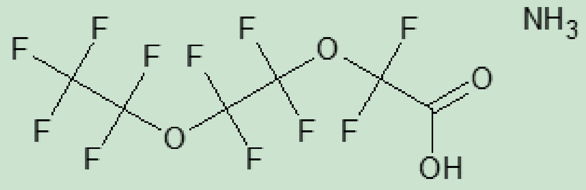
F2 Chemicals Ltd - what do they produce?

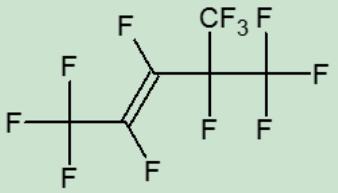
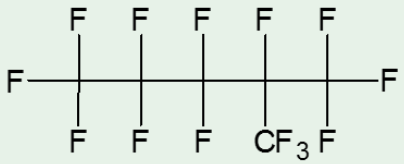
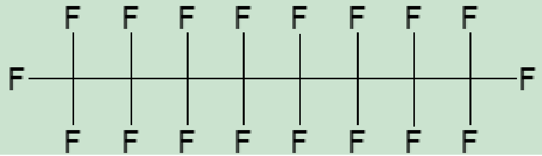
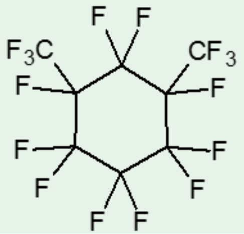
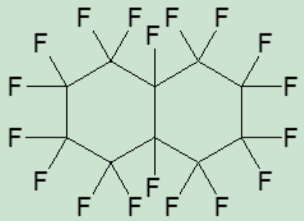
- Produces a range of liquid and gaseous perfluorocarbons (perfluoroalkanes and a perfluoroalkene) within the PFAS family
- Products also have a diverse range of specialist uses, such as in medical applications and the semiconductor industry
- F2 mainly produces saturated perfluoroalkanes which are generally considered chemically inert when compared to their hydrocarbon analogues due to the strength of the C-F bond
- However, several perfluoroalkanes have long residence times in the atmosphere and are known 'greenhouses gases' with a global warming potential (GWP) many thousands times greater than carbon dioxide.

Which PFAS are we evaluating? AGCCE

Substance	Registered tonnage[4] and main uses	Structure
CAS 908020-52-0 **Ammonium difluoro[1,1,2,2-tetrafluoro-2-(pentafluoroethoxy)ethoxy] acetate** **Perfluoro(2-ethoxy-2-fluoroethoxy)acetic acid ammonium salt [EEA-NH_4 or SAA-1000]**	10 to 100 tonnes/year polymerisation/processing aid	
Polyfluorinated polymerisation media	10 to 100 tonnes/year polymerisation/processing and mixing aid	_
Polyfluorinated monomer	100 to 1000 tonnes/year (but known to be much lower in UK at AGCCE) co-monomer in polymerisation process and surface treatment	_
Polyfluorinated monomer	100 to 1000 tonnes/year (but known to be much lower in UK at AGCCE) co-monomer in polymerisation process	_

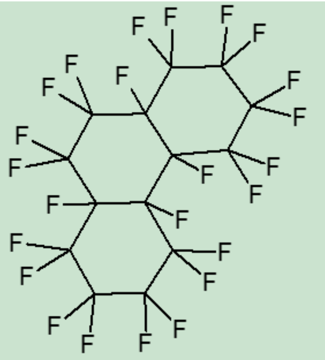
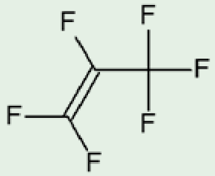
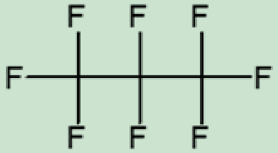
[4] EU REACH registered tonnage in 2020 - UK tonnages may differ and are often lower

Which PFAS are we evaluating? F2

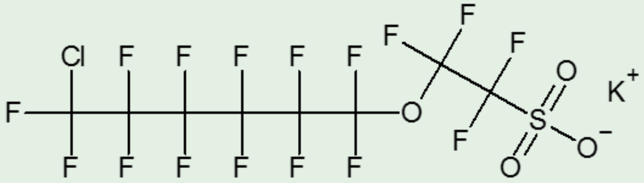
Substance	Registered tonnage[5] and main uses	Structure
CAS 3709-71-5 **(E)-1,1,1,2,3,4,5,5,5-Nonafluoro-4-(trifluoromethyl)pent-2-ene 5** **Perfluoro (4-methyl-2-pentene)[PFMP]**	100 to 1000 tonnes/year F2 registration is as an isolated intermediate in production processes (closed systems)	
CAS 355-04-4 **1,1,1,2,2,3,3,4,5,5,5-Undecafluoro-4-(trifluoromethyl)pentane** **Perfluoroisohexane [PFiHx]**	100 to 1000 tonnes/year Manufacturing processes, coolant in electronics industries, rigid foam blowing, tracer/taggant	
CAS 307-34-6 **Perfluorooctane [PFO]**	1 to 10 tonnes/year Chemical production processes, medical, tracer/taggant	
CAS 335-27-3 **1,1,2,2,3,3,4,5,5,6-Decafluoro-4,6-bis(trifluoromethyl) cyclohexane** **Perfluoro-1,3-dimethylcyclohexane [PFDMC]**	1 to 10 tonnes/year Chemical production processes, coolant in electronics industries, resin curant	
CAS 306-94-5 **Perflunafene** **Perfluorodecalin [PFD]**	1 to 10 tonnes/year Manufacturing processes, medical applications	

[5] Based on previous/current EU REACH Registrations and listings on F2 Chemicals Ltd website in 2020 (UK tonnages may differ)

Which PFAS are we evaluating? F2 - continued

Substances	Registered tonnage and main uses	Structure
CAS 306-91-2 **Perfluoroperhydrophen anthrene** **Perfluorophenanthrene [PFPh]**	Confidential - but low tonnage Manufacturing processes, coolant in electronics industries, medical and research applications	
CAS 116-15-4 **Hexafluoropropene [HFP]**	10 000 to 100 000 tonnes/year Raw material, processing aid and intermediate in polymerisation processes	
CAS 76-19-7 **Octafluoropropane** **Perfluoropropane [PFP]**	100 to 1000 tonnes/year Multiple uses, inc. processing and cleaning fluid, coolant, solvent, use in semiconductor manufacture	

F-53B (un-registered - not used by AGCCE or F2)

CAS 73606-19-6 **6:2 chlorinated polyfluorinated ether sulfonate** **6:2 Cl-PFESA [F-53B]**	No info but < REACH registration requirement limit of 1 tonne/year Potential PFOS replacement as mist suppressant in metal plating industry, amongst other possible uses	

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Preliminary findings - registered substances (1)

First the good news 👍:

- Based on currently available data few (eco)toxicity hazards were identified - and most of the fully saturated perfluorocarbons appear to be relatively inert and unreactive
- Emissions are generally low at both sites - as are environmental risks, where determined so far
- Wastes are sent for high temperature incineration
- Residual levels in manufactured products are low
- Both companies have cooperated with these informal Evaluations

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Preliminary findings - registered substances (2)

- A number of information gaps or areas requiring clarification in most dossiers
- All of the substances (or their transformation products) are persistent (P/vP)
- One or two of the registered substances with more reactive functional side/end groups are potentially classifiable (T)
- Bioaccumulation (B/vB), particularly in non-aquatic species, is also an area of uncertainty for some of the substances
- Still some releases to local rivers and air (particularly the more volatile PFCs)
- Room for improvement in identifying, quantifying and understanding emissions
- Scope for further regulation of volatile PFCs under F-gas Regulations?
- Uncertainty regarding downstream uses of some substances and products - and their full 'life-cycle'
- Potential for further targeted monitoring of the local environment and biota

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Preliminary findings - F-53B

- Unregistered in EU/GB - so only public domain data available and therefore a number of information gaps and issues requiring clarification
- Appears to be persistent (P/vP), bioaccumulative (B/vB) and toxic (T) in both wildlife and mammalian studies, including indications of endocrine disruption (ED) activity
- UK surface water levels are very low but also found in otters again at low levels but confirms bioaccumulation concern

- Never registered so how is it getting in to UK environment? Previous uses; potential continued low level use (<1 tonne/year); imported articles; transformation from something else; long range transport ???
- A possible replacement for PFOS, e.g. for use as mist-suppressant in chrome plating? Need to avoid ‘regrettable substitution’...
- Potential for further targeted monitoring of environment, including biota

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Next steps for our Evaluations...

- Four representative draft Reports and Overview paper going for comment to HSAC[6] in May
- Refinement and finalisation of all Reports (with assistance from Registrants) with a view to potential publication by end of 2021
- Consideration of individual substance and site-specific risk management - alongside wider PFAS RMOA
- Scope for formal regulatory consideration under GB REACH (e.g. Dossier or Substance Evaluation) - to be determined with HSE
- International collaboration?
- Evaluate additional PFAS of interest (e.g. a couple of other unregistered substances identified from otter biomonitoring)

[6] Hazardous Substances Advisory Committee

Acknowledgements and thanks (so far)

- All colleagues in the Chemicals Assessment Unit who have contributed to drafting the Reports
- HSE and PHE who have offered assistance with mammalian toxicology input
- Various internal and external advisors
- AGC Chemicals Europe Ltd and F2 Chemicals Ltd

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- and thank you for listening...

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