



# PFAS basics

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## 1. What are PFAS

Per- and polyfluoroalkyl substances (PFAS) are a large group of chemicals that have been used since the 1950s. The chemical structure of PFAS gives them useful properties, such as thermal stability and the ability to repel water and oil, that makes them valuable in a wide variety of industrial and consumer applications. They have been used in the manufacture of non-stick cookware, fabric, furniture and carpet stain protection applications, food packaging and in some types of firefighting foam (Table 1.1).

This group of chemicals was formerly known as *perfluorinated compounds*, or *PFCs*, but the name has been changed to avoid confusion with another group of chemicals that are relevant to climate change, which are also known as PFCs.

The best-known examples of PFAS are:

- perfluorooctane sulfonate, also known as PFOS; and
- perfluorooctanoic acid, also known as PFOA.

Perfluorohexane sulfonate (PFHxS) is another chemical of the PFAS group and is present in some firefighting foams.

In terms of the chemical structure PFAS consist of a fully (per) or partly (poly) fluorinated carbon chain connected to different functional groups. Based on the length of the fluorinated carbon chain, short and long chain PFASs can be distinguished<sup>1</sup>. Long chains refers to:

- perfluorocarboxylic acids (PFCAs) with carbon chain lengths C8 and higher, including perfluorooctanoic acid (PFOA);
- perfluoroalkane sulfonic acids (PFSA) with carbon chain lengths C6 and higher, including perfluorohexane sulfonic acid (PFHxS) and perfluorooctane sulfonate (PFOS); and

precursors of these substances that may be produced or present in products.

The length of the fluorinated carbon chain can result in different physicochemical properties that influence behaviour in the environment and in organisms, and its bioaccumulation and (eco) toxicity. There has historical perception that long-chain PFAS were of greater concern than shorter chain PFAS, however this perception has been challenged by recent research<sup>2</sup>.

PFAS are not manufactured in Australia but have been used here for many years in a wide range of manufacturing processes. PFOS and related compounds are imported into Australia mainly for use as mist suppressants in the metal plating industry, hydraulic fluid in the aviation industry and surfactants in the photography industry. PFOS and PFOA firefighting foams were used extensively worldwide from 1970s by both civilian and military authorities due to their effectiveness in extinguishing liquid fuel fires.

Prior to the regulation of PFAS, there were no controls associated with the waste disposal activities from manufacturing plants using these chemicals which can result in solid, liquid or airborne emission

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<sup>1</sup> For more detailed information see OECD (2013), OECD/UNEP Global PFC Group, Synthesis paper on per- and polyfluorinated chemicals (PFCs), Environment, Health and Safety, Environment Directorate, OECD.

<sup>2</sup> Brendel, S et al. (2018), Short-chain perfluoroalkyl acids: environmental concerns and a regulatory strategy under REACH. Environ Sci Eur. 2018; 30(1): 9. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5834591/>

of PFAS. Pollution is also present at many facilities where firefighting foams containing PFAS have been heavily used.

PFOS and PFOA may be present in a range of imported consumer products, although many countries have phased out, or are in the process of phasing out the use of PFOS and PFOA. Some countries, including Poland, India, China and Russia are still manufacturing PFAS.

**Table 1.1: List of historical applications of PFAS<sup>3</sup>**

Industry branch	PFAS application
Aviation, aerospace & defense	additive in aviation hydraulic fluid; insulators; solder sleeves
Biocides	active ingredient in plant growth regulators or ant baits, enhancers in pesticide formulation
Construction products	additives in paints and coatings; coating architectural materials
Electronics	flame retardants
Firefighting	film formers in AFFF and FFFP; protective clothing
Household products	wetting agent in floor polishes
Metal plating	wetting agent, mist suppressing agent
Oil production	surfactants in oil well stimulation
Polymerization	emulsion polymerization processing aids
Automotive	lubricants and low friction bearings and seals
cable and wiring	coating for weathering, flame and soil resistance
Electronics	insulators, solder sleeves
Energy	film to aid weatherability solar collectors
Food processing	fabrication materials
Household products	nonstick coating
Medical articles	grafts and implants; coatings for surgical drapes and gowns
Paper and packaging	oil and grease repellent
Semiconductors	working fluids in mechanical vacuum pumps
Textiles, leather and apparel	oil and water-repellent stain release; raw materials for highly porous fabrics

## 2. What is the concern?

During the manufacturing process of some PFAS, and the use of PFAS products, PFOA and PFOS have been released to the air, water and soil throughout the world. Unlike many other organic chemicals PFOS and PFOA do not bind strongly to soil and organic materials. This means that they are readily

<sup>3</sup> Source: OECD (2013), OECD/UNEP Global PFC Group, Synthesis paper on per- and polyfluorinated chemicals (PFCs), Environment, Health and Safety, Environment Directorate, OECD.

transported in solution in surface and groundwaters. Consequently, a plume of contamination in groundwater may be up to 100 times as extensive as plumes for other contaminants.<sup>4</sup>

"While there have been many studies into the health effects of PFAS it is uncertain whether PFAS are harmful to human health. In the few areas in which there is evidence for a possibly causal association of PFAS with an effect on human health the association is either uncertain or apparently weak."

The PFAS Health Study: Systematic Literature Review<sup>6</sup>.

PFAS have been detected in isolated parts of the world indicating that they are very long lived in the environment with half-lives of 2 to 4 years for PFOA, 5 to 6 years for PFOS and 8 to 9 years for PFHxS.<sup>1</sup> They may be transported over large distances by rivers and ocean currents and through airborne dispersion. Studies have indicated that PFAS bioaccumulate in freshwater and marine ecosystems.<sup>5</sup>

For most people, the potential exposure pathway for PFAS is through ingestion<sup>6</sup>, such as:

- Drinking contaminated water
- Eating food contaminated with PFAS, such as fish or shellfish
- Eating food packaged in materials containing PFAS (e.g. greaseproof packaging such as popcorn bags, pizza boxes)
- Hand to mouth transfer in babies and toddlers from stain resistant materials containing PFAS.

Exposure to PFOS and PFOA from inhalation and dermal routes during showering and bathing has been assessed as negligible<sup>7</sup>. Skin absorption studies have also suggested that under typical conditions, skin is resistant to PFOS and PFOA transport<sup>8</sup>.

The biological half-life in human serum varies with the type of PFAS, with estimates of 3.8 years for PFOA, 5.4 years for PFOS and 8.5 years for PFHxS<sup>9</sup>.

A recent review<sup>6</sup> examined published research to February 2017 on the health effects of exposure to PFAS chemicals on the human body. The research included people that had a higher than usual exposure of PFAS, such as manufacturing workers, firefighters and people exposed through contaminated water supplies.

The reported health effects<sup>10</sup> were:

- increased levels of cholesterol in the blood;
- increased levels of uric acid in the blood;

<sup>4</sup> <https://www.ienvi.com.au/pfas-frequently-asked-questions/>

<sup>5</sup> e.g. Ahrens (2011) Polyfluoroalkyl compounds in the aquatic environment: a review of their occurrence and fate J. Environ. Monit., 13, 20–31

<sup>6</sup> National Center for Environmental Health Agency for Toxic Substances and Disease Registry, An Overview of Perfluoroalkyl and Polyfluoroalkyl Substances and Interim Guidance for Clinicians Responding to Patient Exposure Concerns Interim Guidance Revised on 5/07/2018

<sup>7</sup> Health Canada (2016) Draft guidelines for public consultation: Perfluorooctanoic acid (PFOA) in Drinking Water. Health Canada (2016) Draft guidelines for public consultation: Perfluorooctane Sulfonate (PFOS) in Drinking Water.

<sup>8</sup> Franko, J., Meade, B.J., Frasch, H.F., Barbero, A.M. and Anderson, S.E. (2012). Dermal penetration potential of perfluorooctanoic acid (PFOA) in human and mouse skin. J. Toxicol. Environ. Health A., 75(1): 50–62.

<sup>9</sup> Kirk M, Smurthwaite K, Bräunig J, Trevenar S, D'Este C, Lucas R, Lal A, Korda R, Clements A, Mueller J, Armstrong B. The PFAS Health Study: Systematic Literature Review. Canberra: The Australian National University. 2018.

<sup>10</sup> Summary of the PFAS Expert Health Panel – Report to the Minister, March 2018

- reduced kidney function, although it is possible that poor kidney function caused by something else causes increase in PFAS levels in blood;
- alterations in some indicators of immune response;
- altered levels of thyroid hormones and sex hormones;
- later age for starting menstruation in girls, and earlier menopause; and
- lower birth weight in babies.

However, the differences in the reported health effects between people who have the highest exposure to PFAS and those who have had low exposure were small. The level of health effects reported in people with the highest exposure was generally still within the normal ranges for the whole population. The panel found inadequate evidence that PFAS caused other health effects.

Following on from the PFAS health review, the Government has commissioned the ANU to conduct an Epidemiological Study, to include the towns of Katherine (Northern Territory), Oakey (Queensland) and Williamtown (New South Wales). The study will include a cross-sectional health survey and blood serum study to provide a better understanding of possible health effects to the Australian population. The final report for this study is expected to be complete by mid-2021.

Many jurisdictions have opted to take a conservative approach to the regulation of PFAS on the assumption that future studies may yield evidence for a causal link between exposure and adverse health effects. This approach is a precautionary response to allay fears in the community that are stoked by media reports such as those in which PFAS chemicals have been described as “the new asbestos”.<sup>11</sup>

### 3. The Stockholm Convention

Australia is a signatory to the Stockholm Convention on Persistent Organic Pollutants. The Convention seeks to limit the use and production of persistent organic pollutants, a class of compounds which include PFAS such as PFOS, with the objective of protecting human health. PFOS, its salts, and perfluorooctane sulfonyl fluoride (PFOSF) were listed for restriction under the Convention in 2009. Perfluorooctanoic acid (PFOA), its salts, and PFOA-related compounds were nominated for listing on the Convention in 2015. Perfluorohexane sulfonic acid (PFHxS), its salts, and PFHxS-related compounds were nominated for listing in 2017.

At the current time, Australia has not ratified the 2009 changes to the Convention which would require a ban on the production and use of PFOS except for specified acceptable purposes and specific exemptions but has undertaken a regulatory impact analysis of the changes.

Ratification of the PFOS and PFOA listings or future listings of PFHxS or other PFAS in the Convention, would mean Australia accepting and implementing international standards for the management of these chemicals. One complication for the regulators is that there are many specific and useful applications of these compounds for which there is no suitable alternative.

All Australian governments (Commonwealth, state and territory), are parties to the National PFAS Position Statement, which includes the following on PFAS:

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<sup>11</sup> <https://www.abc.net.au/4corners/contamination/9032140>

**Australian governments agree the following objectives:**

- *Ongoing sale or use of products (i.e. chemical based formulations) and articles (i.e. objects that contain chemicals) that contain long-chain PFAS, for any industrial or commercial application, should be phased out, in line with the Stockholm Convention.*
  - *Where a product or article is suspected of containing PFAS, information should be gathered to ascertain if it contains long-chain PFAS and it should then be managed accordingly.*
- *Transitioning away from the use of chemicals that cause irreversible or long-term contamination of Australia's environment should be the ultimate goal for all users of PFAS in Australia.*
  - *Where short-chain PFAS are used in aqueous film forming foam (AFFF), they should only be used in emergency situations and in accordance with all relevant regulations. Any releases should be fully contained and wastes managed in accordance with the PFAS National Environmental Management Plan (NEMP).*
  - *Until effective and economically feasible non-PFAS alternatives are developed, the ongoing sale and use of products and articles containing short-chain PFAS may be necessary for uses for which no suitable and less hazardous alternatives are available.*
  - *Replacement chemicals should be degradable in the natural environment and not be bio-accumulative.*
- *Importers, sellers and users of chemicals should inform themselves about the presence of PFAS in products and articles, due to their potential negative environmental, health and socioeconomic impacts.*
  - *Entities that currently sell or use long- or short-chain PFAS are encouraged to develop a strategy that outlines their current uses, and how and when they will transition away from these chemicals.*

## 4. Guideline Values in Queensland

The three types of guideline values that are relevant to Water and Sewage Service Providers in Queensland are the those for health, biosolid application to soils and ecological water quality.

The limits in drinking water in Australia, which apply to Queensland water supplies, have been set out in the Australian Drinking Water Guidelines<sup>12</sup>. The Guidelines were updated in August 2018 to include specific health-based guidance values for PFAS in drinking water. These guidance values are the same as that published by the Australian Government Department of Health<sup>13</sup>. Similarly, the guidelines for recreational waters have been recently updated to reflect a revised exposure calculation methodology from the tolerable daily intake values, which remain unchanged.

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12 NHMRC, NRMCC, (2011) Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy. National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia, Canberra. Version 3.5 Updated August 2018

13 Australian Government Department of Health, (2017). Health based guidance values for PFAS for use in site investigations in Australia. <https://www1.health.gov.au/internet/main/publishing.nsf/Content/ohp-pfas-hbgv.htm>

**Table 3.1: Health based guidance values for PFAS**

Description	PFOS/PFHxS	PFOA	Source
Tolerable daily intake	0.02 µg/kg body weight/day	0.16 µg/kg body weight/day	FSANZ <sup>14</sup>
Drinking water	0.07 µg/L	0.56 µg/L	Australian Government Department of Health <sup>10</sup> and Australian Drinking Water Guidelines <sup>9</sup>
Recreational water	2 µg/L	10 µg/L	NHMRC <sup>15</sup>

For biosolids and their reuse, there is a separate set of rules that appears in the recently updated Queensland Department of Environment and Science End of Waste Code<sup>16</sup>. This is the only regulatory standard for biosolids in Australia to date and the methodology is still being developed. As of January 2020, the application of biosolids to agricultural land is subject to the following PFAS-specific trigger values (Table 3.2), which apply after the application of biosolids to land. These limits are in addition to other maximum allowable soil contaminant concentrations for contaminants specified in the code. Sampling of the biosolids must be undertaken for each 120 tonnes of biosolids applied, in addition to post application sampling to assess against the trigger values. The total oxidisable precursor assay (TOPA) analysis is to be used to determine the PFAS concentrations in the soil prior to application of biosolids.

**Table 3.2: Trigger values for PFAS in soil after the application to land**

Contaminant	Trigger value
PFOS	0.001 mg/kg
PFOS + PFHxS	0.002 mg/kg
PFHxS	0.003 mg/kg
PFOA	0.004 mg/kg
PFBA, PFPeA, PFHxA	0.001 mg/kg
Sum C <sub>9</sub> -C <sub>14</sub> Perfluoroalkyl carboxylic acids	0.01 mg/kg
Perfluoroalkyl sulfonamides	0.001 mg/kg
N:2 Fluorotelomer Sulfonic acids	0.004 mg/kg

At the time of this revision, the PFAS NEMP 2.0<sup>17</sup> which recommends ecological water quality guidelines, had not been endorsed by the Queensland government although it has been adopted by most other jurisdictions<sup>18</sup>. However, the PFAS NEMP 2.0 provides some additional guidelines,

14 <http://www.foodstandards.gov.au/consumer/chemicals/Pages/Perfluorinated-compounds.aspx>

15 NHMRC (2019) Guidance on Per and Polyfluoroalkyl (PFAS) in Recreational Water. National Health and Medical Research Council, Canberra. Updated August 2019

16 Queensland Government Department of Environment and Science, (2020). End of Waste Code Biosolids (ENEW07359617) <https://environment.des.qld.gov.au/assets/documents/regulation/wr-eowc-approved-biosolids.pdf>

17 PFAS National Environmental Management Plan Version 2.0, Heads of EPA Australia and New Zealand 2020.

18 <https://www.environment.gov.au/protection/publications/pfas-nemp-2>

including: human health investigation levels for soil; ecological guideline values for soil; biota guideline values; and ecological water quality guideline values developed by Australian and New Zealand water regulators that are likely to be adopted by local regulators. The ecological water quality guideline values developed by water regulators are provided in (Table 3.3).

**Table 3.3: PFAS NEMP 2.0 Ecological water quality guideline values**

Exposure scenario	PFOS	PFOA	Exposure scenario
Freshwater	0.00023 µg/L	19 µg/L	99% species protection-high conservation value systems
	0.13 µg/L	220 µg/L	95% species protection-slightly to moderately disturbed systems
	2 µg/L	632 µg/L	90% species protection -highly disturbed systems
	31 µg/L	1,824 µg/L	80% species protection -highly disturbed systems
Interim marine	0.00023 µg/L	19 µg/L	99% species protection-high conservation value systems
	0.13 µg/L	220 µg/L	95% species protection-slightly to moderately disturbed systems
	2 µg/L	632 µg/L	90% species protection -highly disturbed systems
	31 µg/L	1,824 µg/L	80% species protection -highly disturbed systems

The PFAS NEMP 2.0 notes that “the 99% species protection level for PFOS is close to the level of detection”, and indeed that detection limit is not possible for most NATA Accredited laboratories that conduct PFOS analysis at the time of writing.

## 5. Where are PFAS found?

There are several sites in Queensland that have been investigated for PFAS contamination due to their association (current or historical) with aviation, defence or fire and emergency services. PFAS is a major constituent of aqueous film forming foams (AFFF) used in firefighting that have been in use in Australia since the 1950s. The need for training of personnel in firefighting techniques has resulted in repeated use of the foams which in turn has resulted in contamination of some sites. These sites include areas where bores used for drinking water supply have been found to contain detectable levels of PFAS<sup>19</sup>.

In Australia PFAS are ubiquitous at low concentrations in wastewater influent, effluent, in biosolids<sup>20</sup> and in the leachate from landfill sites<sup>21</sup>. The source of the PFAS is enigmatic but is most likely to be from multiple commercial and industrial products containing PFAS, PFAS-contaminated trade waste

<sup>19</sup> <https://www.qld.gov.au/environment/pollution/management/disasters/investigation-pfas/sites>

<sup>20</sup> Gallen, C. et al. (2018). A mass estimate of perfluoroalkyl substance (PFAS) release from Australian wastewater treatment plants. *Chemosphere* 208 975-983.

<sup>21</sup> Gallen, C. et al. (2017) Australia-wide assessment of perfluoroalkyl substances (PFASs) in landfill leachates. *Journal of Hazardous Materials* 331, 132–141.



(liquid and solid), and from residential wastewater contaminated through normal household cleaning and washing.

Elsewhere, PFAS have been analysed for and detected at many locations including in dust from children's bedrooms in Finland<sup>22</sup>. PFOS were detected in more than half of the 63 samples analysed, with a median concentration of 0.95 ng/g. PFOA were detected in greater than 70% of the samples with a median concentration of 5.26 ng/g.

A number of background soil studies from around the world<sup>23</sup> yielded concentrations that ranged from 0.01-123.6 ng/g PFOA (maximum value from a sample from China) and 0.003-162 ng/g PFOS (maximum value from a sample from Norway).

Wastewater treatment processes only provide partial removal of some water soluble PFAS. It is also recognised that wastewater treatment breaks down PFAS precursor chemicals to produce PFOA. Thus, wastewater treatment processes can appear to increase the total amount of PFAS in effluent compared with an influent stream.

## 6. Detection and Quantification

The PFAS NEMP 2.0 provides a concise description of the standard methods of analysis for PFAS<sup>14</sup>. The table has been reproduced below (Table 5.1). In addition to the widely adopted Standard methods, the US EPA has released a new validated testing method for PFAS in drinking water, called EPA Method 533. The new Method 533 focuses on PFAS with carbon chain lengths of 4 to 12 ("short chain" PFAS) and complements EPA Method 537.1 (refer Table 5.1) which is widely used in Australian testing laboratories. In addition, the US EPA has issued SW-846 Method 8327, a validated method for analysis of PFAS in non-potable groundwater, surface water and wastewater. It is currently reviewing comments from public consultation to revise the method for publication in the SW-846 (Test Methods for Evaluation of Solid Waste) compendium in 2020.

In summary, for analysis of PFAS:

- It is recommended that total PFAS can be estimated using a combination of the appropriate US EPA method (for liquid or solid samples) with either a TOFA/TOF (total organic fluorine assay) or TOPA (total oxidisable precursor assay) analysis.
- TOFA detects the total mass of organic fluorine containing compounds (including PFAS) in a sample while TOPA detects only PFAS with perfluorinated carbon chain lengths from C4 to C14.
- TOFA has a significantly higher limit of reporting compared to that usually available with TOPA, because of the limitation of the analytical technique for TOFA
- TOFA can be used to check the degree to which TOPA analysis accounts for potential precursors, noting that any PFAS with a carbon chain length shorter than C4 and longer than C14 would be missed by either TOPA or standard LC-MS/MS analysis (using a Standard method).

Caution must be applied in the interpretation of results for the following reasons:

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<sup>22</sup> Winkens, K. et al. (2018) Environment International 119: 493–502.

<sup>23</sup> Brusseau, M. L. et al. (2020) Science of the Total Environment 740: 140017.



- The usual commercially available PFAS analysis only targets the specific analytes (for example the thirteen PFAS chemicals listed in Table 5.1 for US EPA Method 537) and therefore may underestimate the presence of total PFAS chemicals in the environment.
- In addition to PFAS, TOPA also detects the perfluorinated or polyfluorinated compounds that are sometimes termed “precursors” because they can bio-transform to form simpler perfluoroalkyl acids such as PFOA.
- The way the environment oxidizes precursors into potentially harmful forms may be over-estimated by the TOPA processes in the laboratory.

The PFAS NEMP 2.0 provides the following advice for sampling for PFAS, which is particularly concerning:

*"Attention should be given to the range of products that can cause PFAS contamination of samples, including new clothing, footwear, PPE and treated fabrics stain and water resistant products, sunscreen, moisturisers, cosmetics, fast food wrappers, Teflon®, sampling containers with Teflon®-lined lids, foil, glazed ceramics, stickers and labels, inks, sticky notes, waterproof papers, drilling fluids, decontamination solutions and reusable freezer blocks. These should not be worn or used during any stage of sampling (at site, during transport etc.) where sample contamination could affect analytical results."*

Many of these items are commonplace in the field sampler's kit and everyday life. This highlights the importance of good sampling protocols including duplicate samples and trip blanks to assess the extent to which contamination from external sources might be present.



**Table 5.1: PFAS standard methods of analysis**

Methods of PFAS analysis	Method Analytes	Sample type	How can the method be used?	Limitations	References
US EPA <b>Method 537.1</b> Determination of selected perfluorinated alkyl acids in drinking water by solid phase extraction and LC-MS/MS	PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA, PFTrA, PFTeA, PFBS, PFOS, PFTA, PFTrDA, NMeFOSAA, NEtFOSAA, HFPO-DA, 11Cl-PF3OUdS, 9Cl-PF3ONS, ADONA	Drinking water, ground and surface water	To analyse for specific analytes	Only detects specific PFAS Does not require results to be corrected for Internal Standard recovery Limited internal standards Further details in the reference	Shoemaker and Tettenhorst (2018) <sup>24</sup>
US EPA <b>Method EPA821-R-11-007</b> Draft Procedure for Analysis of Perfluorinated Carboxylic Acids and Sulfonic Acids in Sewage Sludge and Biosolids by HPLC/MS/MS December 2011	PFBA, PFPA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnA, PFDoA, PFTriDA, PFTeDA, PFBS, PFHxS, PFHpS, PFOS, PFOSA, NMeFOSA, NEtFOSA, NMeFOSE, NEtFOSE	Sewage sludge and biosolids	To analyse for specific analytes	Only detects specific PFAS Further details in the reference	US EPA Method EPA821-R-11-007
Total Oxidisable Precursor Assay ( <b>TOPA</b> )	Total PFAS chains (C4-C14)	Water samples and extracts including soil, biota, AFFF products and wastes	Can be used in conjunction with a US EPA method to estimate the total PFAS in a sample, and in some circumstances, the approximate end point PFAS. Can help inform risk assessments.	Cannot be used to target exact PFAS precursors, as it is a semiquantitative method. Allows for some inferences as to precursor chain length	Houtz and Sedlak (2012) <sup>25</sup>
Total Organic Fluorine Assay ( <b>TOF</b> ) as combustion ion chromatography (the most common available)	Total fluoride in organic and inorganic forms	Water samples and extracts including soil, biota, AFFF products and wastes	Can be used in conjunction with a US EPA method to understand the total presence of organic fluorine in a sample and compare this to the organic fluorine equivalent detected by the US EPA method.	Cannot be used to target exact PFAS precursor compounds	Laboratory reported methods only

24 Shoemaker, J.A. and Tettenhorst, D.R., (2018). Determination of selected perfluorinated alkyl acids in drinking water by solid-phase extraction and liquid chromatography/ tandem mass spectrometry (LC/MS/MS). EPA/600/R-18/352 Version 1.0. United States Government, Washington DC. Available at [https://cfpub.epa.gov/si/si\\_public\\_file\\_download.cfm?p\\_download\\_id=537290&Lab=NERL](https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=537290&Lab=NERL).

25 Houtz, E.F. and Sedlak, D.L., (2012). Oxidative conversion as a means of detecting precursors to perfluoroalkyl acids in urban runoff. Environmental science & technology, 46(17), pp.9342-9349.



## **7. What does it mean for the water and sewerage industry?**

As an industry we can expect to see greater regulation and ongoing attention to PFAS as an “emerging contaminant” that has now well and truly arrived.

The attention will come despite the current lack of a recognised substantial risk to human health. The underlying “precautionary principle” for this approach is outlined in Section 3 of the PFAS NEMP 2.0 published by the heads of EPA of Australia and New Zealand.

We can expect that as analytical methods improve, there will be an increased ability and potentially requirements to characterise greater numbers of PFAS compounds, along with greater expectations for lower detection limits.

Attention may shift to newer, presently unrecognised compounds that are not regulated, but have been potentially used to replace PFAS compounds in manufacturing processes.