

# Methodology | The Map of Forever Pollution

## The Forever Pollution Project

### Disclaimer

The purpose of the “Map of Forever Pollution” is to provide data about sites known to be contaminated or likely to be contaminated with per- and polyfluoroalkyl substances (PFAS) in Europe.

Our primary goal is to inform the public and to provide data to impacted community members, researchers and regulators, and to contribute to building knowledge on PFAS contamination for the public interest. Potentially contaminated sites could therefore be prioritised by governments to conduct sampling campaigns and tailor action plans to protect the public.

This map reflects information gathered to the best of our knowledge and journalistic resources. Due to the lack of widespread environmental testing for PFAS, the true extent of contamination is significantly underrepresented.

The number of sites identified in each country or area reflects the amount of testing conducted by the authorities or scientists, as well as the extent of PFAS contamination.

Some known contamination sites, although identified with monitoring data, have no identified source of pollution. Some countries or areas appear to have many contamination sites due to comprehensive monitoring efforts to identify and address contamination. Conversely, countries or areas that have few known sources of contamination have likely done less testing and thus are unaware of other contamination sites in their area. Some sites may have incomplete or missing data due to a lack of publicly available information.

Consequently, some of the presumptive sites on the map are not contaminated with PFAS, and other sites that are contaminated are not included in the map.

If you reference information from the map, please credit the Forever Pollution Project and include the website address of this mapping project. Our map will not be systematically updated beyond 1st March 2023. If you would like to correct inaccurate, incorrect or outdated information or to provide additional data, please contact Stéphane Horel at [horel\[@\]lemonde.fr](mailto:horel[@]lemonde.fr).

### **Acknowledgements**

Our research methodology was based on the [peer-reviewed methodology](#)<sup>1</sup> developed by the [PFAS Project Lab](#) (Boston, USA) and colleagues for the “[PFAS Sites and Community Resources Map](#)”<sup>2</sup> (a joint effort of the PFAS-REACH research team that includes Northeastern, Silent Spring Institute, Michigan State University, Testing for Pease, Massachusetts Breast Cancer Coalition, and Slingshot), as well as on advice and feedback from the following scientists: Alissa Cordner (Whitman College, Walla Walla, USA), Derrick Salvatore (Massachusetts Department of Environmental Protection, USA), Phil Brown and Kimberly K. Garrett (Northeastern University, Boston, USA), Ian Cousins (Stockholm University, Sweden), Gretta Goldenman (Global PFAS Science Panel, Brussels), Martin Scheringer (ETH Zürich, Switzerland).

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<sup>1</sup> Salvatore, D. *et al.* (2022). Presumptive Contamination: A New Approach to PFAS Contamination Based on Likely Sources. *Environmental Science & Technology Letters*, 9(11), 983-990, <https://doi.org/10.1021/acs.estlett.2c00502>.

<sup>2</sup> PFAS Project Lab, <https://experience.arcgis.com/experience/12412ab41b3141598e0bb48523a7c940/>

## 1. Geographic scope of the research

PFAS contamination sites were researched in the 27 Member States of the European Union (EU)<sup>3</sup>, in the United Kingdom (UK), and countries of the European Economic Area (EEA) and the European Free Trade Association (EFTA): Norway, Iceland, Liechtenstein, Switzerland. The Eurostat Country codes were used to identify the countries.<sup>4</sup>

## 2. PFAS contamination sites

The Map of Forever Pollution includes three categories of sites which are clearly distinguished:

- "known contamination sites"
- "presumed contamination sites"
- "known PFAS users".

This categorisation is largely based on the peer-reviewed methodology of the PFAS project Lab map<sup>5</sup>.

### 2.1 Known contamination sites

Known PFAS contamination sites are:

- Sites where PFAS have been detected with water and/or solids testing
- PFAS chemical production facilities even if no publicly available testing data exist, as it is assumed that they are, and they were, emitting PFAS.<sup>6</sup>

A colour code on the map distinguishes their levels of contamination.

#### 2.1.1 Sites where PFAS have been detected

Known contamination sites and hotspots are locations where environmental monitoring was performed by authorities or scientists, and where PFAS were detected.

#### 2.1.2 Current and legacy PFAS chemical production facilities or "producers"

Current and legacy PFAS producers are industrial facilities currently manufacturing PFAS, and industrial facilities which have manufactured PFAS such as PFOS, PFOA or Teflon-like products in the past.

PFAS producers are companies which:

- synthesise PFAS to sell them as 'ingredients' to PFAS users (= strictly producers)

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<sup>3</sup> Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden.

<sup>4</sup> Eurostat, "Glossary:Country codes", [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Country\\_codes](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Country_codes)

<sup>5</sup> Salvatore D. *et al.* (2022).

<sup>6</sup> Wang Z. *et al.* "Global emission inventories for C4–C14 perfluoroalkyl carboxylic acid (PFCA) homologues from 1951 to 2030, Part I: production and emissions from quantifiable sources." *Environment international* 70 (2014): 62-75, <https://doi.org/10.1016/j.envint.2014.04.013>.

Wang Z. *et al.* "Global emission inventories for C4–C14 perfluoroalkyl carboxylic acid (PFCA) homologues from 1951 to 2030, part II: The remaining pieces of the puzzle." *Environment international* 69 (2014): 166-176, <https://doi.org/10.1016/j.envint.2014.04.006>.

- synthesise PFAS and use them to manufacture their own fluoropolymers (which include: PTFE, PVDF, side-chain fluorinated polymers, perfluoropolyethers, fluoroelastomers) (= both producers and users)

## 2.2 Presumptive contamination sites

Presumed sites of PFAS contamination are sites where testing has not confirmed the presence of PFAS, but which can be presumed to be contaminated on the basis of scientific investigations and expert advice.<sup>7</sup>

This approach posits that, “in the absence of high-quality data to the contrary, PFAS contamination is probable near facilities known to produce, use, and/or release PFAS, and to protect public health, the existence of PFAS in these locations should be presumed until high-quality testing data is available”.

Several States in the U.S.<sup>8</sup>, the EU Commission, and the French environmental authorities<sup>9</sup> have used a similar approach to identify sampling targets for PFAS contamination based on facility type. In October 2022, the EU Commission listed nine industrial activities “where PFAS are likely used (textiles, leather, carpets, paper, paints and varnishes, cleaning products, metal treatments, car washes, plastic/resins/rubber)”<sup>10</sup> based on codes from the European Nomenclature of Economic Activities (NACE).<sup>11</sup> In France, the BRGM (Bureau de Recherches Géologiques et Minières) has listed 117 NAF codes corresponding to industrial activities correlated to PFAS use.<sup>12</sup>

Based on the methodology developed by Salvatore et al. (2022), PFAS contamination can be presumed around three types of facilities:

- fluorinated aqueous film-forming foam (AFFF) discharge and storage sites
- certain industrial facilities
- sites related to PFAS-containing waste.

A detailed methodology for locating EU sites based on these three categories is below.

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<sup>7</sup> Salvatore, D. *et al.* (2022).

<sup>8</sup> Salvatore, D. *et al.* (2022).

<sup>9</sup> DREAL Auvergne-Rhône-Alpes, “Substances perfluorées (PFAS)”, 23 December 2022, <https://www.auvergne-rhone-alpes.developpement-durable.gouv.fr/substances-perfluorees-pfas-a21871.html>

<sup>10</sup> Commission Staff Working Document. Impact Assessment Report accompanying the document Proposal for a Directive of the European Parliament and of the Council amending Directive 2000/60/EC establishing a framework for Community action in the field of water policy, Directive 2006/118/EC on the protection of groundwater against pollution and deterioration and Directive 2008/105/EC on environmental quality standards in the field of water policy {COM(2022) 540 final} - {SEC(2022) 540 final} - {SWD(2022) 543 final}, 26 October 2022. [https://environment.ec.europa.eu/system/files/2022-10/Staff%20Working%20Document%20-%20Impact%20Assessment%20Report%20accompanying%20the%20Proposal\\_0.pdf](https://environment.ec.europa.eu/system/files/2022-10/Staff%20Working%20Document%20-%20Impact%20Assessment%20Report%20accompanying%20the%20Proposal_0.pdf)

<sup>11</sup> DG Competition, List of NACE codes

[https://ec.europa.eu/competition/mergers/cases/index/nace\\_all.html](https://ec.europa.eu/competition/mergers/cases/index/nace_all.html)

Nace Codes, Complete list of all NACE Code, <https://nacev2.com/en>

<sup>12</sup> InfoTerre, BRGM - Base de données des corrélations Activités-Polluants, BD ActiPoll <https://ssp-infoterre.brgm.fr/fr/bd-activipoll/recherche#tab-2>

### 2.2.1 Fluorinated aqueous film-forming foam (AFFF) discharge sites

Fluorinated aqueous film-forming foam (AFFF) has been used extensively for fire training and extinguishing fuel-based fires.

Therefore, PFAS contamination is expected wherever AFFF has been discharged and stored, including<sup>13</sup>:

- military sites (military bases, military air bases and airports, military training camps, NATO bases, and formerly used defence sites)
- commercial civilian airports
- firefighting training sites (including fire stations)
- fire suppression locations (aeroplane and railroad crash sites, oil and gas extraction sites, petroleum refineries, bulk storage facilities, chemical manufacturing plants)

Within the EU, AFFF containing PFOS were banned in 2006 with a complete phase-out in 2011<sup>14</sup>, but replacement AFFFs still contained PFAS. Starting in 2020, the use of AFFF containing more than 25 ppb of PFOA or its salts as well as those containing more than 1000 ppb of one or a combination of PFOA related substances were also restricted.<sup>15</sup> A proposal for a EU-wide restriction of PFAS in firefighting foams was submitted by the European Chemicals Agency (ECHA) in February 2022.<sup>16</sup>

### 2.2.2 Industrial facilities

Salvatore et al. (2022) used the North American Industry Classification System (NAICS)<sup>17</sup> in order to identify industrial activities that are presumed PFAS users and contamination sources and establish a “suspect” list.<sup>18</sup> They developed a single set of 38 NAICS codes that are likely sources of PFAS contamination.

### 2.2.3 Sites related to PFAS-containing waste

PFAS can be present in wastewater and solid waste, resulting in contaminated effluent and sludge from wastewater treatment plants (WWTPs), and landfill leachate or incinerator ash.<sup>19</sup>

The following sites are included in the Presumptive contamination sites:

- WWTPs
- landfills for non-hazardous and hazardous waste
- incinerators.

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<sup>13</sup> Salvatore, D. *et al.* (2022).

<sup>14</sup> Swedish Chemicals Agency (2015). Survey of Fire Fighting Foam.

<https://www.kemi.se/en/publications/pms/2015/pm-5-15-survey-of-fire-fighting-foam>

<sup>15</sup> Commission Regulation (EU) 2017/1000 of 13 June 2017 amending Annex XVII to Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) as regards perfluorooctanoic acid (PFOA), its salts and PFOA-related substances.

<sup>16</sup> European Chemicals Agency, Proposal to ban ‘forever chemicals’ in firefighting foams throughout the EU, 22 February 2022,

<https://echa.europa.eu/fr/-/proposal-to-ban-forever-chemicals-in-firefighting-foams-throughout-the-eu>

<sup>17</sup> North American Industry Classification System, <https://www.census.gov/naics/>

<sup>18</sup> PFAS Lab Project NAICS Codes,

[https://docs.google.com/spreadsheets/d/10GbwbH4W\\_UFVgno-fqTdE5NHKRrLqPlgK\\_6\\_sD\\_Tbc/edit#gid=2112574405](https://docs.google.com/spreadsheets/d/10GbwbH4W_UFVgno-fqTdE5NHKRrLqPlgK_6_sD_Tbc/edit#gid=2112574405) 3

<sup>19</sup> Salvatore, D. *et al.* (2022).

### 2.3 Known PFAS users

The category "Known PFAS Users" is not defined in the Salvatore et al. (2022) peer-reviewed methodology, and was created for the needs of the European map. "Known PFAS Users" are locations for which there is evidence of PFAS use, but no testing data, and which can be considered likely to be contamination sources.

For example, companies which buy fluoropolymers such as PTFE, ECTFE or FEP in the form of pellets to manufacture their own branded PTFE-containing products or thermoplastics items can be considered neither as PFAS producers nor as presumptive contamination sites. They were therefore categorised as "Known PFAS Users". Similarly, AFFF manufacturers use PFAS to manufacture firefighting foams, but they are not included in the list of presumptive contamination sites in correlation to industrial activity. They were also categorised as "Known PFAS Users".

### 2.4 Types of sites as shown on the map

We sorted the types of sites under six categories which will appear as such in the map tooltips:

- Industrial site
- Waste management site
- Airport
- Military site
- Sampling location
- Firefighting incident / training
- Other

## 3. PFAS Reference Lists

The OECD list of 4,729 PFAS<sup>20</sup> and the US EPA Master List of 9,252 PFAS Substances<sup>21</sup> were used as reference lists of *existing PFAS*.

The list of PFAS established by the EU research programme Human Biomonitoring for the EU (HBM4EU)<sup>22</sup> was used as a primary reference list of *PFAS under surveillance*. The following criteria were used by HBM4EU to select the substances: "availability of substance identity and literature, building blocks or alternative processing aid in polymer manufacturing, use as food contact material, alternatives to long-chain PFAS and degradation products / intermediates." In addition, substances were divided in five categories (A to E) to "categorise possibly relevant substances that contribute to the overall PFAS burden in humans".<sup>23</sup>

→ See Annex 1

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<sup>20</sup> US EPA. "PFAS: Listed in OECD Global Database", <https://comptox.epa.gov/dashboard/chemical-lists/PFASOECD>

<sup>21</sup> US EPA. "PFAS Master List of PFAS Substances", <https://comptox.epa.gov/dashboard/chemical-lists/pfasmaster>

<sup>22</sup> HBM4EU, "About HBM4EU", <https://www.hbm4eu.eu/about-us/about-hbm4eu/>

<sup>23</sup> HBM4EU, "Prioritised substance group: Perfluorinated substances (PFAS)", [https://www.hbm4eu.eu/wp-content/uploads/2019/03/HBM4EU\\_D4.9\\_Scoping\\_Documents\\_HBM4EU\\_priority\\_substances\\_v1.0-PFAS.pdf](https://www.hbm4eu.eu/wp-content/uploads/2019/03/HBM4EU_D4.9_Scoping_Documents_HBM4EU_priority_substances_v1.0-PFAS.pdf)

## 4. Contamination values

### 4.1 Units

The values shown on the Map of Forever Pollution are in nanograms per kilogram (ng/kg) for concentrations in solids (soil, sediment, biota...) and nanograms per litre (ng/L) for concentrations in water. The scale and the colour-code below the map is in ng/kg, but applies to all concentrations (for PFAS concentrations in water, ng/kg are equivalent to ng per litre (ng/L)).

### 4.2 Limit values

In the EU, the 2020 Drinking Water Directive<sup>24</sup> sets a limit value of:

- 500 ng/L for the totality of all per- and polyfluoroalkyl substances ('PFAS Total')<sup>25</sup>
- 100 ng/L for "the sum of per- and polyfluoroalkyl substances considered a concern as regards water intended for human consumption listed in point 3 of Part B of Annex III" ('Sum of PFAS'), i.e. 20 PFAS compounds.

However, even levels below these limit values are considered by experts to be potentially concerning for public health. Grandjean and Clapp (2015) suggest a limit value of 1 ng/L for the sum of PFOA and PFOS based on immunotoxicity effects<sup>26</sup>.

In June 2022, the US Environmental Protection Agency (US EPA) announced drinking water "Health Advisory Levels" for four PFAS, including 0.004 ng/L for PFOA and 0.02 ng/L for PFOS.<sup>27</sup> Those values are 1,000 times lower than the previous 2016 advisory levels. The new level for PFOA is 125,000 times lower than the EU limit value for the total amount of PFAS in one sample. Maximum contaminant levels (MCLs), which are regulatory rather than advisory, are planned to be released in early 2023 in draft form for public comment.

The Map of Forever Pollution includes all testing data above the detection limit of 10ng/L, and above the limits of detection and/or limit of quantification for datasets with higher limits.

A colour code distinguishes the levels of contamination.

PFAS level (ng/L)

> 100,000

> 1,000–100,000

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<sup>24</sup> Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption (recast) (Text with EEA relevance)

<https://eur-lex.europa.eu/eli/dir/2020/2184/oj>

<sup>25</sup> "Substances that contain a perfluoroalkyl moiety with three or more carbons (i.e.  $-C_nF_{2n-}$ ,  $n \geq 3$ ) or a perfluoroalkylether moiety with two or more carbons (i.e.  $-C_nF_{2n}OC_mF_{2m-}$ ,  $n$  and  $m \geq 1$ )", as defined by Directive (EU) 2020/2184. "Technical guidelines regarding methods of analysis for monitoring of per- and polyfluoroalkyl substances under the parameters 'PFAS Total' and 'Sum of PFAS', including detection limits, parametric values and frequency of sampling" are yet to be established by the European Commission by 12 January 2024.

<https://eur-lex.europa.eu/eli/dir/2020/2184/oj>

<sup>26</sup> Grandjean, P., & Clapp, R. (2015). Perfluorinated alkyl substances: emerging insights into health risks. *New solutions: a journal of environmental and occupational health policy*, 25(2), 147-163.

<https://doi.org/10.1177/1048291115590506>.

<sup>27</sup> US Environmental Protection Agency, Drinking Water Health Advisories (HAs),

<https://www.epa.gov/sdwa/drinking-water-health-advisories-has>

> 10–1,000

0 - 10

Sites are colour-coded by the highest total PFAS concentration found at each site, with higher concentrations represented by darker shades.

0–10 nanograms per litre (ng/L) is a low level of contamination, though research suggests that there can still be long-term negative health outcomes when these levels are in drinking water.

10–1,000 ng/L is a high level of concern, though more readily able to be remediated than higher concentrations.

Any concentration >1,000 ng/L is a level that indicates ongoing and sustained contamination, often found at military bases, airports, and chemical production facilities<sup>28</sup>.

### 4.3 “Hotspot”

There is no consistent definition of a "hotspot" to describe sites of toxic chemical or air contamination in general. The goal for having a hotspot category is to identify areas where contamination is of concern in terms of drinking water remediation and potential health impacts.

We define a PFAS hotspot as any location where total PFAS (or PFOS + PFOA) have been measured in any media over 100 ng/L. This cutoff is supported by the majority of experts we have consulted.

A hotspot site such as a PFAS manufacturing facility could be surrounded by multiple locations with high values. This does not make each of the sampling locations a separate hotspot. The hotspot as such is the manufacturing facility as the epicentre of the contamination. We did not have the resources and time needed to refine the data down to the "epicentres". However, we did calculate “clusters” containing all locations with sampling values that were 1) less than 1 km away from each other and 2) no further than 4 km away from the highest value in the cluster. We describe this cluster identification in more detail below. Readers should zoom into areas of interest to identify possible clusters of hotspots linked to likely sources

### 4.4 PFAS of interest

The Map shows contamination levels for PFOS, PFOA, PFNA, PFBS, PFHxA and PFHxS. We chose these because PFOS and PFOA are both restricted through the EU persistent organic pollutant (POP) regulation, and PFNA, PFBS, PFHxA and PFHxS are listed as Substances of Very High Concern (SVHC) by the European Chemical Agency (ECHA).<sup>29</sup> Additionally, in 2020, the European Food Safety Authority (EFSA) reevaluated the tolerable weekly intake for PFOA, PFOS, PFNA and PFHxS based on concerns raised by decreased response of the immune system to vaccination.<sup>30</sup>

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<sup>28</sup> Salvatore, D. *et al.* (2022).

<sup>29</sup> European Chemical Agency, Candidate List of substances of very high concern for Authorisation, <https://echa.europa.eu/candidate-list-table>

<sup>30</sup> 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, 391pp <https://doi.org/10.2903/j.efsa.2020.6223>



*List of PFAS of interest:*

<b>Acronym</b>	<b>Substance</b>	<b>CAS number</b>
PFOS	Perfluorooctanesulfonic acid	1763-23-1
PFOA	Perfluorooctanoic acid	335-67-1
PFNA	Perfluorononanoic acid	375-95-1
PFBS	Perfluorobutanesulfonic acid	375-73-5
PFHxA	Perfluorohexanoic acid	307-24-4
PFHxS	Perfluorohexanesulfonic acid	355-46-4

#### **4.5 Multiple sampling on one site**

For sites with multiple sampling (multiple values on various dates and multiple matrices), we would ideally have selected the highest ever levels detected within the three years available. The rationale is that PFAS migrate and reach groundwater through routes that are still not well understood. One spot with a low value could be very high the year after. Besides, environmental remediation does not remove entirely all PFAS.

This was unfortunately not possible for practical reasons. In many locations, multiple sampling was not carried out within the same year for all PFAS, making it impossible to indicate the correct value for the total sum of PFAS. We have chosen to use the most recent testing data available, and within recent testing have selected the highest value if multiple values exist.

When sampling was performed in several matrices, we favoured values in drinking water, then groundwater, then surface water, then soil.

## 5. Research methodology

### 5.1 Known contamination sites

#### 5.1.1 Sites where PFAS have been detected

##### 5.1.1.1 Research

PFAS monitoring datasets were proactively collected from national and local authorities, regulatory agencies, national and regional databases (with data collected by 136 organisations in total), research institutes, universities, scientific research teams, and freedom of information requests across Europe.

Precisely 100 datasets were collected, harmonised and used in total.

#### – Scientific studies

We contacted scientists participating in the European research projects PROMISCES<sup>31</sup>, Perforce3<sup>32</sup>, NORMAN network<sup>33</sup>, Zero PM<sup>34</sup> to ask them for dataset sources, namely Martin Scheringer (ETH Zürich), Ian Cousins (Stockholm University) and Hans Peter Arp (Norwegian Geotechnical Institute).

Luc Miaz (Stockholm University) provided data from a database of published background PFAS concentrations in surface water across Europe used by Muir, D. and Miaz, L.C. (2021).<sup>35</sup>

To find relevant studies in the scientific literature, we performed a search in PubMed. The scientists were contacted to share their full datasets with geolocations in a spreadsheet format when those were not available as supplementary information.

We also relied on material produced by EU-funded research programme HBM4EU, such as the Activity Report “Setting up a network of experts for developing a guidance document on how to deal with human biomonitoring in PFAS hotspots”.<sup>36</sup>

In total, our database includes data from **20 scientific studies (see Annex 2)**.

#### – Testing conducted by the authorities

- **European Commission Working group on Ground Water Watch List (GWWL)**

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<sup>31</sup> CORDIS, PROMISCES (Preventing Recalcitrant Organic Mobile Industrial chemicals for Circular Economy in the Soil-sediment-water system <https://cordis.europa.eu/project/id/101036449>)

<sup>32</sup> Perforce3 (PER and polyfluorinated alkyl substances (PFASs) towards the Future Of Research and its Communication in Europe 3) <https://perforce3-itn.eu/esr-projects/supervisors/>

<sup>33</sup> NORMAN (Network of reference laboratories, research centres and related organisations for monitoring of emerging environmental substances), <https://www.norman-network.net/>

<sup>34</sup> Zero PM (Zero Pollution of Persistent, Mobile Substances), <https://zeropm.eu/who-is-zeropm/>

<sup>35</sup> Muir, Derek, and Miaz, Luc T. (2021). “Spatial and Temporal Trends of Perfluoroalkyl Substances in Global Ocean and Coastal Waters.” *Environmental Science & Technology* 55 (14): 9527–37. <https://doi.org/10.1021/acs.est.0c08035>.

<sup>36</sup> HBM4EU, "Setting up a network of experts for developing a guidance document on how to deal with human biomonitoring in PFAS hotspots", Activity Report, WP 5 Science to Policy - PFAS CGL. <https://www.hbm4eu.eu/?mdocs-file=12001>

In 2017, the EU Commission launched a pilot study on PFAS to develop a Ground Water Watch List (GWWL).<sup>37</sup> 11 datasets from either nationwide representative, or specific contaminated sites monitoring for 27 PFAS were transmitted by 19 Member States and associated countries. PFAS were detected in the groundwater of all 11 countries.<sup>38</sup> Our freedom of information request filed on 13 May 2022 to obtain the de-anonymized dataset on the basis on the Aarhus convention, which guarantees access to information in Environmental Matters,<sup>39</sup> was denied on 9 September 2022 on the basis that the EU Commission “contracted out the collection and analysis of data to an external contractor” and therefore “does not hold any documents that would correspond to the description given in your application.”<sup>40</sup>

- **Data about 15 textile facilities emitting PFAS**

In 2018, the European Commission’s Joint Research Centre collected emission data from over a hundred textile facilities across Europe.<sup>41</sup> We filed a freedom of information request and obtained PFAS emission data for the 15 facilities declaring PFAS discharges.

- **French Agency for Food, Environmental and Occupational Health & Safety (Anses) Drinking water campaign 2009**

In 2009, the French Agency for Food, Environmental and Occupational Health & Safety (Anses) conducted a monitoring campaign of PFAS in drinking water<sup>42</sup>. The locations were not made public. We obtained the full dataset with de-anonymised locations through a freedom of information request.

- **Scotland Scottish Environment Protection Agency (SEPA)**

We obtained PFAS data in Scotland surface water for the year 2018 through a freedom of information request to the Scottish Environment Protection Agency (SEPA).

- **German data**

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<sup>37</sup> CIRCABC, WG Groundwater, <https://circabc.europa.eu/ui/group/9ab5926d-bed4-4322-9aa7-9964bbe8312d/library/b1a3fb16-0308-479a-8b6d-0c056b6890e4>

<sup>38</sup> Belgium, Switzerland, Czech Republic, France, Italy, Netherlands, Austria, Germany, Sweden, Finland, United Kingdom.

<sup>39</sup> Regulation (EC) No 1367/2006 of the European Parliament and of the Council of 6 September 2006 on the application of the provisions of the Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters to Community institutions and bodies,

<https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32006R1367&from=FR>

<sup>40</sup> European Commission, Decision of the European Commission pursuant to article 4 of the implementing rules to Regulation (EC) no 1049/20011, GESTDEM 2022/2810, Brussels, 9 September 2022, C(2022) 6599 final.

<sup>41</sup> European Commission, Joint Research Centre, Workshop on data assessment for the review of the Best Available Techniques (BAT) Reference document for the textiles industry (txt) Seville, 1 – 2 october 2019, Background document, Ares(2019)4610103.

<sup>42</sup> Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail (ANSES), Campagne nationale d'occurrence des composés alkyls perfluorés dans les eaux destinées à la consommation humaine, May 2011, <https://www.anses.fr/fr/content/campagne-nationale-d%E2%80%99occurrence-des-compos%C3%A9s-alkyls-perfluor%C3%A9s-dans-les-eaux-destin%C3%A9es-%C3%A0-la>

Data were collected from the sumPFAS-Project<sup>43</sup> at the Fraunhofer Institute in cooperation with the Environmental agency UBA, database of the Helmholtz-Zentrum hereon<sup>44</sup>, as well as from parliamentary inquiries in 8 states, and from press requests about contamination cases and monitoring results of PFAS to all 16 states at the national level.

#### 5.1.1.2 Quantitative overview of the data

In total, our database includes data from at least 72 monitoring campaigns conducted by the authorities.

The Map tooltips show concentrations for:

1. each PFAS of interest if available ( PFOS, PFOA, PFNA, PFBS, PFHxA, PFHxS),
2. the PFOS+PFOA sum,
3. the sum of all measured PFAS.

We recalculated the sums in each dataset. The sum of all measured PFAS is often higher than the sum of the six PFAS of interest, because it takes into account all other PFAS. The values for all other measured PFAS indicated in the column “details” can be found in the Expert Dataset. The compounds' names were not standardised.

A number of sites do not have a concentration value, but have nevertheless been included as known contaminated sites. These are mainly sites in Germany where the authorities have confirmed contamination but refused to share sampling values. This explains why the figures below do not add up exactly.

In total we have found **19,986 locations with PFAS concentrations above 10 ng/kg:**

Concentration (ng/kg)	Sites
10 - 100	8,111
> 100	11,640
100 - 1,000	4,002
1,000 - 10,000	5,700
> 10,000	1,938

These numbers are not so meaningful as some places have many sampling points really close to each other. We made clusters containing all spots that are less than 1 km away from each other, as long as they are not more than 4 km away from the highest value in the cluster. We can then categorise each cluster as its highest concentration and we have:

**6,589** clusters with PFAS values above 10 ng/kg:

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<sup>43</sup> Fraunhofer Institute and Umweltbundesamt. SumPFAS. Neuen per- und polyfluorierten Stoffen auf der Spur, <https://sumpfas.ime.fraunhofer.de/>

<sup>44</sup> Helmholtz-Zentrum, hereon, [https://hcdc.hereon.de/campaign\\_db/#/download](https://hcdc.hereon.de/campaign_db/#/download)

Concentration (ng/kg)	Clusters
10 - 100	4,192
> 100	2,232
100 - 1,000	1,171
1,000 - 10,000	773
> 10,000	288

### 5.1.2 Current and legacy PFAS chemical production facilities or “producers”

The starting point of our research to locate PFAS producing facilities in Europe was the list established by Goldenman et al. (2019) shown below.<sup>45</sup>We used various sources and research strategies to verify, identify and confirm these locations.

**Table 10: List of manufacturers of fluorochemicals and/or fluoropolymers**

Country	Company and site of plant	What is being produced
Belgium	3M (Zwijndorf)	Fluorochemicals
France	Arkema (Pierre-Bénite)	Fluoropolymers (PVDF)
	Solvay Solexis (Tavaux)	Fluoropolymers (PVDF)
Germany	Daikin Chemical France S.A.S. <sup>1</sup>	Fluorochemicals
	Dyneon (Gendorf)	Fluorochemicals, fluoropolymers (PTFE, FEP, PFA, THV)
	BASF (Ludwigshafen)	n.a.
Italy	Solvay Solexis (Spinetta-Argeno)	Fluoropolymers ) – PTFE, MFA
	Heroflon S.p.A. (Collebeato)	Fluoropolymers (PTFE compounds and micropowders)
	Miteni (Trissino) <sup>2</sup>	Fluorinated intermediates; performance fluorinated products
Netherlands	Chemours (Dordrecht)	Fluoropolymers (PTFE, FEP)
	Daikin Chemical Netherlands (Oss) – Pre-compounding of fluoroelastomers	Fluorochemicals
United Kingdom	AGC (Blackpool)	Fluoropolymers – PTFE, PFA

Source: 1) Daikin Europe, manufacturing of fluoroelastomer base polymer and polymer processing aids.

2) Miteni files bankruptcy in October 2018.

#### – ECHA list of PFAS registrants

Upon request, the European Chemicals Agency (Echa) provided the list of PFAS registrants in the EU, to which we added Trifluoroacetic Acid (TFA, CAS n° 76-05-1), as it is not

<sup>45</sup> Goldenman G. *et al.* The cost of inaction. A socioeconomic analysis of environmental and health impacts linked to exposure to PFAS, Nordic Council of Ministers, 2019, <http://norden.diva-portal.org/smash/record.jsf?pid=diva2%3A1295959&dswid=5271>

included in OECD's list of PFAS used as a reference by ECHA. However, registrants are not necessarily producers; they could be users or suppliers.

We therefore performed a manual search with each address indicated in ECHA's list in Google Maps to exclude both suppliers and office buildings with no manufacturing capacity.

#### – Trade association member companies

We used the list of member companies for the three main trade association and their sector groups:

- Cefic (European Chemical Industry Council)
  - FluoroProducts and PFAS for Europe (FPP4EU)<sup>46</sup>
    - 3M
    - AGC
    - Arkema
    - BASF
    - Bayer
    - Chemours
    - Daikin
    - DuPont
    - ExxonMobil
    - Gujarat Fluorochemicals (GFL)
    - Merck
    - Synthomer/former OMNOVA Solutions
    - W.L. Gore & Associates
  - European FluoroCarbons Technical Committee (EFCTC)<sup>47</sup>
    - Koura
    - Arkema
    - Chemours
    - Honeywell fluorine products
    - Daikin chemical Europe
- Plastics Europe Fluoropolymers Products Group (FPG)<sup>48</sup>
  - 3M
  - AGC
  - Arkema
  - Chemours
  - Daikin
  - DuPont
  - Gujarat Fluorochemicals (GFL)
  - W.L. Gore & Associates
  - Honeywell
  - Solvay

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<sup>46</sup> FPP4EU, Who were are, <https://www.fpp4eu.eu/about-us/who-we-are/>

<sup>47</sup> EFCTC, About, <https://www.fluorocarbons.org/about/>

<sup>48</sup> Plastics Europe, Fluoropolymers Products Group, <https://fluoropolymers.plasticseurope.org/>

- American Chemistry Council (ACC)
  - °Alliance for Telomer Chemistry Stewardship (ATCS)<sup>49</sup>
    - AGC
    - Daikin America
    - Dynax Corporation
    - Johnson Controls
  - ° Performance Fluoropolymer Partnership (PFP)<sup>50</sup>
    - AGC
    - The Chemours Company
    - Daikin
    - Gujarat Fluorochemicals
    - Honeywell
    - ExxonMobil
    - MilliporeSigma
    - Shamrock Technologies
    - Sherwin-Williams
    - W.L. Gore & Associates

#### – Fluoropolymer and fluoroelastomer trade names

We assembled a list of fluoroplastics and PFAS types, trade names and manufacturers of fluoropolymers and fluoroelastomers, based on the companies' product portfolios, annual reports and scientific articles. The list was used to identify the locations of the facilities manufacturing them.

#### – Litigation and internal corporate documents

To identify possibly shut down manufacturing facilities with legacy PFAS contamination, we looked into litigation and internal corporate documents collected by the PFAS collection of the Chemical Industry Documents archive at the University of California, San Francisco<sup>51</sup>, and by the Toxic Docs project at Columbia University<sup>52</sup> with the following keywords: "Germany", "Europe", "Fluorochemical + plant + Europe", "fluor", "perfluor". This method did not identify any additional PFAS manufacturing facilities that were unknown to us.

#### – Corporate material

We used the company's websites, annual reports, sustainable development reports, Forms 10-k to the US Securities and Exchange Commission, product safety data sheets, and certificates of registration.

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<sup>49</sup> American Chemistry Council, Alliance for Telomer Chemistry Stewardship (ATCS)  
<https://www.americanchemistry.com/industry-groups/alliance-for-telomer-chemistry-stewardship-atcs>

<sup>50</sup> American Chemistry Council, Performance Fluoropolymer Partnership (PFP),  
<https://www.americanchemistry.com/industry-groups/performance-fluoropolymer-partnership-pfp>

<sup>51</sup> UCSF, PFAS collection,  
<https://www.industrydocuments.ucsf.edu/chemical/collections/pfas-collection/>

<sup>52</sup> Toxic Docs, <https://www.toxicdocs.org/>

### – Google Maps

Google Maps<sup>53</sup> was extensively used both to locate and identify PFAS manufacturing facilities.

### – Freedom of information material

We used documents obtained from freedom of information requests filed to the EU Commission and to the European Chemicals Agency (Echa) in June and July 2022.

The Swiss company Archroma was conclusively identified as a PFAS producer in Gendorf, Germany, in this way.

*“We’re writing to you on behalf of Archroma, producer of speciality chemicals and notably the only\* European producer of C6 fluorinated telomer products, a sub-category of PFAS. Archroma’s production facility is located in Germany (Gendorf, Bavaria).”*<sup>54</sup>

\*their emphasis

### – Confirmation emails from companies

Around 25 PFAS manufacturing facilities in Europe were identified by our research. Emails were sent to each company between October and December 2022. Only 3 did not reply (Archroma, Fluorsid, Mexichem/Koura). Confirmations, negations and clarifications led us to exclude several locations.

The final list of PFAS manufacturing facilities in Europe includes **20 locations** (17 active as of February 2023, 3 inactive). The company’s emails are right-to-reply evidence. The Grupa Azoty facility in Tarnów stopped manufacturing PFAS but is still active as a chemical plant and may manufacture PFAS-based products.

Name	Location	Country	Active as of 2023
Dyneon / 3M	Gendorf	DE	X
Solvay	Bad Wimpfen	DE	X
Archroma	Gendorf	DE	X
Gore	Gendorf	DE	X
Daikin refrigerants	Frankfurt am Main	DE	X
Lanxess	Leverkusen	DE	X
Arkema	Pierre-Bénite	FR	X
Daikin	Pierre-Bénite	FR	X
Solvay	Tavaux	FR	X

<sup>53</sup> Google Maps, <https://www.google.com/maps/>

<sup>54</sup> Email from Kreab on behalf of Archroma to EU Commission Directorate General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW), “Archroma Letter/ C6 transported intermediates under PFOA POP regulation & C9-C14 REACH restriction”, 3 June 2022.Ref. Ares(2022)5578121.



Solvay	Salindres	FR	X
Chemours	Villers Saint-Paul	FR	X
Miteni	Trissino	IT	
Solvay	Spinetta-Marengo	IT	X
AGC	Thornton-Cleveleys	UK	X
F2	Preston	UK	X
Mexichem/Koura	Runcorn	UK	X
3M	Zwijndrecht	BE	X
Chemours	Dordrecht	NL	X
Grupa Azoty	Tarnów	PL	
Arkema	Zaramillo	ES	

## 5.2 Presumptive contamination sites

### 5.2.1 Fluorinated aqueous film-forming foam (AFFF) discharge sites

#### – Military sites

Military sites include: military bases, military air bases and airports, military training camps, NATO bases, formerly used defence sites, military training grounds, military depots, military schools and military airfields such as the ones used by the U.S. Air Force in Europe.

There is no database of military sites in Europe. Due to the war in Ukraine, the defence authorities we contacted were not prone to cooperation and transparency.

According to ECHA, there are 239 military airbases in the EEA,<sup>55</sup> however this is an underestimate.

Using a great variety of open-intelligence (OSINT) sources<sup>56</sup>, we identified and included:

- 321 military air bases and airports (and former), NATO air bases and army aviation schools
- 84 naval bases (and former)
- 69 land military bases, including ammunition storage facilities and storage facilities
- 81 training sites (and former)
- 13 NATO sites

For a total of **642 military sites**.

<sup>55</sup> European Chemicals Agency (ECHA). Registry of restriction intentions until outcome. “Annex XV Restriction report. Proposal for a restriction. Substance name(s): per- and polyfluoroalkyl substances (PFAS) in firefighting foams”, 14 January 2022, <https://echa.europa.eu/fr/registry-of-restriction-intentions/-/dislist/details/0b0236e1856e8ce6> [https://echa.europa.eu/documents/10162/0/rest\\_pfas\\_ff\\_axvreport\\_en.pdf/5ee6f85d-8339-cf1c-34c8-cfcb2861bde7?t=1645608390512](https://echa.europa.eu/documents/10162/0/rest_pfas_ff_axvreport_en.pdf/5ee6f85d-8339-cf1c-34c8-cfcb2861bde7?t=1645608390512)

<sup>56</sup> Websites of the Ministries of Defense, Websites of the Armed Forces, Websites of airports, ForgottenAirfields, Foursquare, Wikimapia, Wikipedia, documents by the German Landtage and Bundestag, Websites of NATO, Metar-Taf.com, Military History Fandom, Dutch Aviation Society, GlobalSecurity.org.

### – Commercial civilian airports

We used the OurAirports online database<sup>57</sup> and selected large and medium airports, as well as 102 closed airports with an asphalted runway (we eliminated grass and turf runway using a list of runway types for all airports provided by OurAirports).

Following expert advice from ECHA, we excluded small airports and heliports, many of which are linked to hospitals or private establishments such as luxury resorts. PFAS contamination from the use of firefighting foams can only be caused by fire incidents or firefighting training. While AFFF use in firefighting training is a frequent occurrence, fire incidents in such sites are a rare occurrence and play a more minor role as sources of contamination.

Our final list includes **978 airports**.

### – Firefighting training sites (including fire stations)

There is no comprehensive database of firefighting training sites in Europe. However we included 1,096 fire training locations listed by the authorities in Flanders (Belgium), Sweden and Norway, and a few serendipitous findings.

### – Firefighting foam incidents

We included two datasets listing firefighting foam incidents in Sweden (10,774)<sup>58</sup> and Flanders (279)<sup>59</sup>, respectively.

### – Municipal fire brigades

According to ECHA, “there are over 50,000 public fire brigades in the EU, excluding those covering airports and private brigades covering industrial risks”.<sup>60</sup> There is no EU database of such sites.

### – Fire suppression locations (aeroplane and railroad crash sites, oil and gas extraction sites, petroleum refineries, bulk storage facilities, chemical manufacturing plants)

As there is no comprehensive database of fire suppression locations in Europe, we haven't included them as such. Petroleum refineries, bulk storage facilities and chemical manufacturing plants are included in the “Industrial facilities” category below.

## 5.2.2 Industrial facilities

### – Nomenclature of economic activities

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<sup>57</sup> Our airports, <https://ourairports.com/data>

<sup>58</sup> Rosenqvist, L. “Utvärdering av påverkan på grundvatten från platser där släckskum hanterats”, Sveriges geologiska undersökning, SGU, 2021, <https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1604725&dswid=-7034>

<sup>59</sup> Databank Ondergrond Vlaanderen. “Inventaris brandweer(oefen)terreinen en incidenten (PFAS)”. <https://www.dov.vlaanderen.be/geonetwerk/srv/eng/catalog.search#/metadata/97e28171-1171-41dc-ae71-6ae1e5d28568>

<sup>60</sup> European Chemicals Agency (ECHA). Registry of restriction intentions until outcome. “Annex XV Restriction report. Proposal for a restriction. Substance name(s): per- and polyfluoroalkyl substances (PFAS) in firefighting foams”, 14 January 2022, <https://echa.europa.eu/fr/registry-of-restriction-intentions/-/dislist/details/0b0236e1856e8ce6> [https://echa.europa.eu/documents/10162/0/rest\\_pfas\\_fff\\_axvreport\\_en.pdf/5ee6f85d-8339-cf1c-34c8-cfcb2861bde7?t=1645608390512](https://echa.europa.eu/documents/10162/0/rest_pfas_fff_axvreport_en.pdf/5ee6f85d-8339-cf1c-34c8-cfcb2861bde7?t=1645608390512)

Salvatore et al. (2022) used the North American Industry Classification System (NAICS)<sup>61</sup> in order to identify industrial activities that other academic studies and regulatory processes had identified as PFAS users and contamination sources.<sup>62</sup> They developed a single set of 38 NAICS codes that are likely sources of PFAS contamination and geolocated them using a federal database.

In the EU, the European Nomenclature of Economic Activities (NACE)<sup>63</sup> is an equivalent classification system. However, there is no EU database geolocating industrial activities.

To keep as close to the Salvatore et al. (2022) methodology as possible, despite such shortcomings, we first cross-matched the set of 38 US NAICS codes with the European NACE codes, using Glüge et al. (2020) on PFAS uses<sup>64</sup> and Goldenman et al. (2019)<sup>65</sup> as confirming documentation, and produced an equivalent list of 29 industrial activities that can be considered presumptive contamination sources in Europe.

The 29 NACE codes were then combined with data from the European Pollutant Release and Transfer Register (E-PRTR).<sup>66</sup> The matching of the respective industrial activity descriptions resulted in an overlap, and 18 industrial sectors declaring emission in the E-PRTR were ultimately categorised as presumptive contamination sites with a precise location. → **See Annex 3 for details.**

#### – Paper Mills

Paper mills are identified as presumptive contamination sites under NACE codes C17.1 and C17.2 (Manufacture of pulp, paper and paperboard; and Manufacture of articles of paper and paperboard, respectively).

To identify and locate paper mills, we scraped the member companies of CEPI, the European trade association representing 18 national trade associations for the pulp and paper industry<sup>67</sup>. GPS coordinates of each location were obtained by geocoding postal addresses using the Google Maps API. Whenever the addresses lacked a street number or related to a post box, the locations were checked and corrected manually.

**1,121 paper mills** were identified in total.

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<sup>61</sup> North American Industry Classification System, <https://www.census.gov/naics/>

<sup>62</sup> PFAS Lab Project NAICS Codes, [https://docs.google.com/spreadsheets/d/10GbwsH4W\\_UFVgno-fqTdE5NHKRrLqPIgK\\_6\\_sD\\_Tbc/edit#gid=2112574405](https://docs.google.com/spreadsheets/d/10GbwsH4W_UFVgno-fqTdE5NHKRrLqPIgK_6_sD_Tbc/edit#gid=2112574405) 3

<sup>63</sup> DG Competition, List of NACE codes [https://ec.europa.eu/competition/mergers/cases/index/nace\\_all.html](https://ec.europa.eu/competition/mergers/cases/index/nace_all.html)

Nace Codes, Complete list of all NACE Code, <https://nacev2.com/en>

<sup>64</sup> Glüge, J. et al. (2020). An overview of the uses of per- and polyfluoroalkyl substances (PFAS). *Environmental Science: Processes & Impacts*, 22(12), 2345-2373. <https://pubs.rsc.org/en/content/articlelanding/2020/em/d0em00291g>

<sup>65</sup> Goldenman G. et al. (2019).

<sup>66</sup> European environment Agency, Industrial Reporting under the Industrial Emissions Directive 2010/75/EU and European Pollutant Release and Transfer Register Regulation (EC) No 166/2006, <https://www.eea.europa.eu/data-and-maps/data/industrial-reporting-under-the-industrial-6>

<sup>67</sup> CEPI, Our Members. <https://www.cepi.org/about-cepi/organisation/>

## – Total

In total, **2,915** industrial sites were identified:

Industrial activity	Sites
Manufacture of pulp, paper and paperboard	1,120
Treatment and coating of metals	680
Manufacture of articles of paper and paperboard	302
Manufacture of plastics in primary forms	221
Manufacture of refined petroleum products	213
Manufacture of other fabricated metal products n.e.c.	132
Finishing of textiles	126
Manufacture of other organic basic chemicals	45
nan	45
Manufacture of rubber and plastic products	16
Tanning and dressing of leather; dressing and dyeing of fur	11
Treatment and disposal of hazardous waste	1
<b>Total</b>	<b>2,9152</b>

### 5.2.3 Sites related to PFAS-containing waste

#### – Wastewater treatment plants (WWTPs)

Goldenman et al. (2019) states that “conventional wastewater treatment is not effective in removing PFAS from waste streams. Thus municipal wastewater treatment plants (WWTP) are major point sources for PFAS contamination of the aquatic environment. The release of PFAS to the biosphere through WWTPs can be a result of both industrial activities and their domestic usage.”<sup>68</sup>

The European dataset “Urban Waste Water Treatment Directive, Agglomerations”, which contains agglomerations reported by countries with generated load  $\geq 2000$  p.e. (or even smaller)<sup>69</sup> includes 25,738 WWTPs. Salvatore et al. (2022)<sup>70</sup> filtered “to include only “major”

<sup>68</sup> Goldenman G. *et al.* (2019).

<sup>69</sup> European Environment Agency, Urban Waste Water Treatment Directive, Agglomerations reported under UWWTD data call 2019 - PUBLIC VERSION, Jan. 2022  
<https://sdi.eea.europa.eu/catalogue/srv/eng/catalog.search#/metadata/7c26ff2c-d1b1-4533-95e6-29b34d29fe0e>

<sup>70</sup> Salvatore, D. *et al.* (2022).

WWTPs, which have a design flow of  $\geq 1$  million gallons per day or an industrial pretreatment program.” We filtered the dataset to include 2,620 WWTPs, which treat the equivalent quantity of water, i.e. a minimum 3,700 cubic metres per day.

#### – Landfills for non-hazardous and hazardous waste and incinerators

Both landfills for non-hazardous and hazardous waste and incinerators are included in the industrial facilities under NACE codes E38.2.1 and E38.2.2 (Treatment and disposal of non-hazardous waste; and Treatment and disposal of hazardous waste respectively).

→ Under the umbrella name of “waste management sites”, both categories represented 4,787 locations.

#### 5.2.4 Data deduplication

The merging of presumptive datasets generated duplicated locations. For example, the same facility could be found in both the “Paper mills” and in the E-PRTR datasets. To reduce the number of duplicates, we performed a rough deduplication process between the E-PRTR dataset and the Paper mills and Wastewater treatment plants (WWTP) datasets. We chose to be conservative, and preferred to still have some duplicates left in the dataset rather than to delete possibly meaningful locations.

We considered two locations to be duplicates in the following cases:

- The locations were less than 50m apart.
- The locations were less than 400m apart and their sector was matching (typically, E-PRTR locations classified in the “Sewage” sector and locations in the WWTP dataset, and the equivalent for paper mills)
- The locations were less than 10 km apart and their names are almost similar. Those may correspond to imprecise coordinates in the E-PRTR dataset. These specific cases were all checked manually.

In total, we removed 804 duplicates, and always deleted the line in the E-PRTR dataset where the coordinates were less precise.

#### 5.2.5 Total

We located a total of **21,429 presumptive contamination** sites, including:

- 642 military sites
- 978 airports
- 12,127 fire training or fire incident locations
- 4,787 Waste management site (including WWTPs, landfills...)
- 2,912 industrial sites

See Eurostat statistics per sector below for comparison.

*Number of installations working in the sectors that may use or emit PFAS for the EEA. Figures in brackets represent businesses with more than 250 employees (Goldenman et al. 2019).*

Sector	Activity	Total
Waste water treatment plant	T1 (primary treatment)	7,279
	T2 (secondary treatment)	24,316
	T3 (tertiary treatment)	19,716
	Of which T3N (T3 + nitrogen removal)	11,502
	Of which T3P (T3 + phosphorus removal)	10,436
Drinking water treatment	Large	Thousands
	Small	Ten thousands
	Very small	Hundred thousands
Aviation	Main passenger airports	318
	Medium passenger airports	137
	Small airports	no data
	Military airbases	239
Other fire control	Fire stations	84,099
	Site emergency services	no data
Waste	Hazardous waste landfill	365
	Non-hazardous waste landfill	3,801
	Large incineration (as energy from waste)	808
Manufacturing industry	PFAS manufacturers <sup>a</sup>	12–20
	Textiles	61,685 (262)
	Leather	37,120 (159)
	Carpet	no data
	Paper	19,477 (488)
	Paints and varnishes	4,027 (104)
	Cleaning products	(178)
	Cosmetics and personal care	no data
	Electronics	no data
	Photography films	no data
	Metal treatments	151,455 (163)
	Car washes	79,000
	Mining	no data
Plastic, resins, rubbers	(340)	

### 5.3 Known PFAS users

In addition to all sources used to identify PFAS manufacturing facilities, we also relied on various other sources to identify PFAS downstream users.

#### – List of potential PFAS producers and users provided by Ian Cousins

Ian Cousins (Stockholm university) shared a research spreadsheet listing 108 potential producers and users in the world, including 25 in Europe. This list was the starting point to create a “Known PFAS users” category.

### – “The List by INDITEX”

The fashion group Inditex (Zara, Pull&Bear...) has developed a document named “The List by INDITEX”<sup>71</sup> which classifies a dozen commercially available chemical families used for textile and leather manufacturing processes (such as dyestuffs or water & oils repellents), according to their level of compliance with Inditex’s own “product health standard” and “manufacturing restricted substance list”. Products including fluorocarbons are tagged with #7. We looked up fluorocarbon-containing products and included their manufacturers in our “PFAS know users” category.

### – Manufacturers of aqueous film-forming foams (AFFF)

We identified and located 23 type B (AFFF) firefighting foam manufacturing facilities using lists and information from the ECHA restriction report on firefighting foams<sup>72</sup>, KEMI 2015<sup>73</sup>, and IPEN 2018.<sup>74</sup>

### – Google Maps

We entered the keyword “PTFE” in Google Maps and identified dozens of PTFE (Teflon) downstream users in Europe.

### – Serendipitous findings

Luck is part of research. Some locations were found by chance. For example, we were able to identify a few PFAS users while hovering over industrial zones and chemical parks in Google maps.

The "Known PFAS Users" include **231 locations**.

## 6. Sharing of data

Our dataset can be downloaded from Le Monde’s website: [lemde.fr/PFASmap](https://lemde.fr/PFASmap).

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<sup>71</sup> The List by INDITEX, IV Edition, [https://solutions.cht.com/cht/medien.nsf/gfx/med\\_MJOS-BMBEB4\\_3972BB/\\$file/The-List-by-INDITEX-Edition-IV.pdf](https://solutions.cht.com/cht/medien.nsf/gfx/med_MJOS-BMBEB4_3972BB/$file/The-List-by-INDITEX-Edition-IV.pdf)

<sup>72</sup> European Chemicals Agency (ECHA). Registry of restriction intentions until outcome. “ Annex XV Restriction report. Proposal for a restriction. Substance name(s): per- and polyfluoroalkyl substances (PFAS) in firefighting foams”, 14 January 2022, <https://echa.europa.eu/fr/registry-of-restriction-intentions/-/dislist/details/0b0236e1856e8ce6> [https://echa.europa.eu/documents/10162/0/rest\\_pfas\\_ff\\_axvreport\\_en.pdf/5ee6f85d-8339-cf1c-34c8-cfcb2861bde7?t=1645608390512](https://echa.europa.eu/documents/10162/0/rest_pfas_ff_axvreport_en.pdf/5ee6f85d-8339-cf1c-34c8-cfcb2861bde7?t=1645608390512)

<sup>73</sup> Swedish Chemicals Agency (KEMI). PM 5/15: Survey of fire-fighting foam, 2015, <https://www.kemi.se/en/publications/pms/2015/pm-5-15-survey-of-fire-fighting-foam>

<sup>74</sup> International Pollutants Elimination Network (IPEN), fluorine-free firefighting foams (3f) viable alternatives to fluorinated aqueous film-forming foams (AFFF), September 2018, [https://ipen.org/sites/default/files/documents/IPEN\\_F3\\_Position\\_Paper\\_POPRC-14\\_12September2018d.pdf](https://ipen.org/sites/default/files/documents/IPEN_F3_Position_Paper_POPRC-14_12September2018d.pdf)

## **Annex 1 | HBM4EU PFAS Reference List**



HBM4EU PFAS Reference List						
Category	Abbrev./Acronym	Surname	Type	Systematic name	CAS No.	Regulation
A	PFOA			Perfluorooctanoic acid (linear and branched isomers)	335-67-1	REACH Annex XVII restriction (Regulation (EU) 2017/1000), SVHC Candidate List (PBT, Repr.), CLH (Carc. 2, Repr. 1B, STOT RE 1, Acute Tox. 4, Eye Dam. 1), proposed for inclusion in the Stockholm Convention, Norman 2011, sufficient EU HBM data available
A	PFOS			Perfluorooctane sulphonate, Heptadecafluorooctane-1-	1763-23-1	REACH Annex XVII restriction, CLH (Carc. 2, Repr. 1B, Lact., STOT RE 1, Acute Tox. 4, Aquatic Chron. 2), PIC regulation, POP Regulation (EG) No. 757/2010, Stockholm Convention, environmental legislation (Seveso, Directive 2012/18/EU; Regulation 649/2012 concerning export and import of hazardous chemicals), sufficient EU HBM data available
A	PFNA			perfluoro-n-nonanoic acid	375-95-1	Restriction proposal, CLH (Carc. 2, Lact., STOT RE 1, Repr. 1B, Acute Tox. 4, Eye Dam. 1), SVHC Candidate List (Repr., PBT), PACT list (CMR, PBT), Annex III Directive 2008/98/EC on waste, Norman 2011, EU HBM data available
A	PFDA			perfluoro-n-decanoic acid	335-76-2	Restriction proposal, SVHC Candidate list (PBT, Repr.), PACT list (PBT), Norman 2011, EU HBM data available
A	PFU(n)DA			perfluoro-n-undecanoic acid	2058-94-8	Restriction proposal, SVHC Candidate List (vPvB), self classification (Acute tox. 4, Skin irrit. 2, Eye irrit. 2, STOT SE 3), Norman 2011, EU HBM data available
A	PFDODA			Perfluorodecanoic Acid	307-55-1	Restriction proposal, SVHC Candidate List (vPvB), self classification (Skin irrit. 2, Eye irrit. 2, STOT SE 3, Metal corr. 1, Skin corr. 1B, Eye dam. 1), Norman 2011, EU HBM data available
A	PFTTrDA			perfluoro-n-tridecanoic acid	72629-94-8	Restriction proposal, SVHC Candidate List (vPvB), self classification (Skin corr. 1B), EU HBM data available
A	PFTeDA			perfluoro-n-tetradecanoic acid	0376-06-07	SVHC Candidate List (vPvB), Restriction proposal, Norman 2011, EU HBM data available
A	PFHxS			perfluoro-1-hexanesulfonate (linear and branched isom)	355-46-4	PACT list, proposed for inclusion in the Stockholm Convention, Norman 2015, EU HBM data available, longest half-life in humans (8.5-30 years)
A	FOSA, PFOSA			Perfluorooctylsulfonamide; Perfluorooctanesulfonic acid	754-91-6	PFOS-related substance; POP Regulation (EG) No. 757/2010, OSH legislation (Council Directive 98/24/EC on protection of health and safety of workers), environmental legislation (Seveso, Directive 2012/18/EU), self classification (Acute tox. 3, Skin irrit. 2, Eye irrit. 2, STOT SE 3), Norman 2011, some (but not sufficient) EU HBM data available (e.g. Haug et al., 2009), other non-EU HBM data (e.g. Jin et al., 2016)
A	n-MeFOSA			N-methylperfluoro-1 octanesulphonamide 1,1,2,2,3,3,4	31506-32-8	PFOS-related substance; POP Regulation (EG) No. 757/2010, PIC Regulation, Norman 2011, some (but not sufficient) EU HBM data available (e.g. Bartolomé et al., 2017), other non-EU HBM data (e.g. Jin et al., 2016; Yeung and Mabury, 2016)
A	N-Et-FOSAA, Et-PFOSA-AcOH, Et-FOSAA			N-Ethyl-perfluorooctanesulfonamido acetic acid; N-ethyl	2991-50-6	PFOS-related substance, transformation product, POP Regulation (EG) No. 757/2010, its salts may be marketed under different trade names, may be marker of food or consumer exposures, Norman 2015, limited EU HBM data available (ELFE study – serum samples), other non-EU HBM data (e.g. Kato et al., 2014)
A	N-EtFOSA, SULFLURAMID			N-ethylperfluoro-1-octanesulphonamide or N-Ethyl-1,1,	4151-50-2	PFOS-related substance, POP Regulation (EG) No. 757/2010, PIC Regulation, environmental legislation (Seveso, Directive 2012/18/EU), self classification (Acute tox. 4), Norman 2011, investigated in human samples but not detected (Jin et al., 2016, Miyake et al., 2007, Yeung and Mabury, 2016), detected in indoor dust and air samples (Gebbinck et al., 2015)
A	N-EtFOSE			N-ethyl-perfluorooctane sulphonamidoethanol; N-Ethyl-	1691-99-2	PFOS-related substance; POP Regulation (EU) No. 850/2004 idgF, PIC Regulation, Norman 2011, detected in indoor dust and air samples (Gebbinck et al., 2015), quickly and extensively metabolised to PFOSA with an elimination half-life of 16-20 h, metabolites of N-EtFOSE were found in human samples (Thayer and Houlihan, 2002), HBM data scarcely available
A	N-MeFOSE			N-methyl perfluorooctanesulfonamidoethanol or 1,1,2,2	24448-09-07	PFOS-related substance, POP Regulation (EU) No. 850/2004 idgF, PIC Regulation, detected in indoor dust and air samples (Gebbinck et al., 2015), no HBM data available at current knowledge
A	8:2 diPAP			polyfluoroalkyl phosphoric acid diesters, Bis(3,3,4,4,5,5	678-41-1	PFOA-related substance, REACH Annex XVII restriction (Regulation (EU) 2017/1000), Norman 2015, Priority HBM List California, limited EU HBM data available (Yeung et al., 2013a, 2013b); other non-EU HBM data (e.g. Lee and Mabury, 2011; Yeung and Mabury, 2016)
A	6:2/8:2 diPAP			6:2/8:2 polyfluoroalkyl phosphoric acid diesters	943913-15-3	PFOA-related substance, REACH Annex XVII restriction (Regulation (EU) 2017/1000), Priority HBM List California, no HBM data available at current knowledge
A	8:2 monoPAP			8:2 polyfluoroalkyl phosphoric acid monoester	57678-03-02	PFOA-related substance, REACH Annex XVII restriction (Regulation (EU) 2017/1000), no HBM data available at current knowledge
B	TFA			Trifluoroacetic acid	76-05-1	Substance is used in formulation and re-packaging, at industrial sites and in manufacturing, recent HBM exposure data from Chinak
B	ADONA			Ammonium 4,8-dioxa-3H-perfluorononanoate (ammoni	958445-44-8	Alternative to APFO, possible PPAR $\alpha$ antagonist, use in food contact material, according to EFSA no risk under specific conditions of use (EFSA, 2011 b), CoRAP (suspected PBT/vPvB, exposure of environment, wide dispersive use), highlighted by ECHA, limited EU HBM data available (e.g. Fromme et al., 2017)
B	PFBA			perfluoro-n-butanoic acid	375-22-4	REACH RMOA, Annex III (suspected P), OSH legislation (Council Directive 98/24/EC on protection of health and safety of workers), self classification (Skin corr. 1A, Eye dam. 1, STOT SE 3, Metal corr. 1), Norman 2015, highlighted by ECHA, levels rising in environment and human tissues (Scheringer et al., 2014), some (but not sufficient) EU HBM data available in plasma, serum, breast milk
B	PFPeA			perfluoro-n-pentanoic acid	2706-90-3	REACH Annex III (suspected P, skin irritant), OSH legislation (Council Directive 98/24/EC on protection of health and safety of workers), self classification (Skin corr. 1B, Metal corr. 1, Eye dam. 1), Norman 2015, highlighted by ECHA, some (but not sufficient) EU HBM data available in plasma, serum, urine
B	PFHxA			perfluoro-n-hexanoic acid	307-24-4	RMOA, REACH Annex III (suspected P, C), PACT list (PBT), OSH legislation (Council Directive 98/24/EC on protection of health and safety of workers), self classification (Skin corr. 1B, Metal corr. 1, Eye dam. 1, Acute tox. 4), Norman 2011, highlighted by ECHA, in Spain higher levels were found in liver samples (68-141 ng/g) (Perez et al., 2012), some (but not sufficient) EU HBM data available in plasma, serum, whole blood, breast milk, urine, liver

HBM4EU PFAS Reference List						
Category	Abbrev./Acronym	Surname	Type	Systematic name	CAS No.	Regulation
B	PFHpA			Perfluoro-n-heptanoic acid	375-85-9	REACH Annex III (suspected B, P, C, acute tox via oral route, toxic), OSH legislation (Council Directive 98/24/EC on protection of health and safety of workers), self classification (Acute tox. 4, Skin corr. 1B, Metal corr. 1, Eye dam. 1), Norman 2011, highlighted by ECHA, some (but not sufficient) EU HBM data available in serum, plasma, whole blood, urine, breast milk
B	PFBS			perfluoro-1-butanefulfonate	375-73-5	RMOA, PACT list, REACH Annex III (suspected P, R), OSH legislation (Council Directive 98/24/EC on protection of health and safety of workers, Council Directive 94/33/EC on the protection of young people at work), self classification (Acute Tox. 4, Skin corr. 1B, Metal corr. 1, Eye dam. 1), highlighted by ECHA, ground water contaminant, some (but not sufficient) EU HBM data available in serum, whole blood, breast milk
B	PFHpS			perfluoro-heptanesulfonate	60270-55-5	REACH Annex III (suspected B, P, C, R, toxic, acute tox via oral route), self classification (Acute tox. 3, Eye irrit. 2, STOT SE 3), EU HBM data available
B	PFDS			perfluoro-1-decanesulfonate	335-77-3	REACH Annex III (suspected B, P, C, R, acute tox via oral route), some (but not sufficient) EU HBM data available in plasma, serum, breast milk, urine
B	N-Me-PFOSA-AcOH, Me-FOSAA			N-Methyl-perfluorooctane sulfonamido acetic acid	2355-31-9	transformation product, may be marker of food or consumer exposures, limited EU HBM data available (ELFE study – serum samples), other non-EU HBM data (e.g. Kato et al., 2014)
B	6:2 FTSA, H4PFOS, THPFOS			3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctanesulphonic acid	27619-97-2	REACH Annex III (suspected P, B, C, skin irritant), OSH legislation (Council Directive 98/24/EC on protection of health and safety of workers, Council Directive 94/33/EC on the protection of young people at work), Annex III Directive 2008/98/EC on waste, self classification (Skin corr. 1B, Eye dam. 1, Acute tox. 4, STOT RE 2), other non-EU HBM data (Yeung and Mabury, 2016)
B	8:2 FTSA			3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-heptadecafluorodecanoic acid	39108-34-4	REACH Annex III (suspected P, C, skin irritant), Priority HBM List California, other (non-EU) HBM data (Yeung and Mabury, 2016 – levels in all human blood samples below LOQ)
B	PFODA			Perfluorostearic acid; Perfluorooctadecanoic acid	16517-11-6	REACH Annex III (suspected C, P), priority HBM List California, limited EU HBM data available (Gebbink et al., 2015)
B	PFHxDA			Perfluoropalmitic acid, Perfluoro-n-hexadecanoic acid	67905-19-5	REACH Annex III (suspected P, B, C), Priority HBM List California, no HBM data available at current knowledge
C	4:2 FTSA			4:2 fluorotelomer sulfonic acid, 3,3,4,4,5,5,6,6,6-Nonafluorobutylsulfonic acid	757124-72-4	Priority HBM List California, no EU HBM data available at current knowledge, other non-EU HBM data (Yeung and Mabury, 2016 – levels in all human blood samples below LOQ)
C	5:3 FTCA 7:3 FTCA			Fluorotelomer carboxylic acids 5:3 Fluorotelomer carboxylic acid 7:3 Fluorotelomer carboxylic acid	-	Fluorotelomer metabolites, Priority HBM List California, detected in blood samples of ski way technicians (Nilsson et al., 2013), HBM data scarcely available
C	6:2 FTUCA 8:2 FTUCA 10:2 FTUCA			Fluorotelomer unsaturated carboxylic acids 6:2 Fluorotelomer unsaturated carboxylic acid 8:2 Fluorotelomer unsaturated carboxylic acid 10:2 Fluorotelomer unsaturated carboxylic acid	70887-88-6 70887-84-2 70887-94-4	Fluorotelomer metabolites, Priority HBM List California, detected in blood samples of ski way technicians (Nilsson et al., 2013), HBM data scarcely available
C	PFECA			Perfluoroether carboxylic acids for example: Ammonium 2,3,3,3-tetrafluoro-2-(heptafluoropropoxy)acetate	62037-80-3	CoRAP (suspected PBT/vPvB, exposure of environment), OSH legislation (Council Directive 98/24/EC on protection of health and safety of workers, Council Directive 94/33/EC on the protection of young people at work), Annex III Directive 2008/98/EC on waste, self classification (Acute tox. 4, Skin corr. 1C, Eye dam. 1, STOT SE 3, Skin corr. 1B), Norman 2015, highlighted by ECHA, no HBM data available at current knowledge
C	PFECA			perfluoro-1,1-ethylene glycol, terminated with chloroheptafluorobutylperfluoro[2-ethoxyethoxy]acetic acid], ammonium salt	908020-52-0	CoRAP (suspected PBT/vPvB, exposure of environment), resistant, not easily to metabolise, maybe bioaccumulative, expected increase in production and use, partially used in food contact materials, restriction on use according EFSA, no safety concern under the respective conditions identified (EFSA, 2011) no HBM data available at current knowledge
C	6:2 FTMAC			Fluorotelomer methacrylates e.g. 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate	2144-53-8	CoRAP (potential endocrine disrupter, suspected PBT/vPvB, other hazard based concern, exposure of environment, wide dispersive use), PACT list, OSH legislation (Council Directive 98/24/EC on protection of health and safety of workers), self classification (STOT RE 2, STOT SE 3, Skin irrit. 2, Eye irrit. 2), fully registered substance 100-1.000 tonnes, suspected endocrine disrupter, used for polymer production, in human blood probably only metabolites detectable (FTOH, FTCA, FTUCAs), no HBM data available at current knowledge
C	6:2 FTAC 8:2 FTAC 10:2 FTAC			Fluorotelomer acrylates e.g. 6:2 Fluorotelomer acrylate (8:2 Fluorotelomer acrylate 10:2 Fluorotelomer acrylate)	17527-29-6 27905-45-9 17741-60-5	CAS# 17527-29-6: CoRAP (potential endocrine disrupter, suspected PBT/vPvB, other hazard based concern, exposure of environment, wide dispersive use), PACT list; CAS# 27905-45-9 and CAS# 17741-60-5: REACH Annex III (suspected P, C, respiratory sensitiser, skin irritant, skin sensitiser); FTAC is a PFOA-related compound; used for polymer production, Priority HBM List California, in human blood probably only metabolites detectable, no HBM data available at current knowledge
C	PFHxDA			Perfluoropalmitic acid, Perfluoro-n-hexadecanoic acid	67905-19-5	REACH Annex III (suspected P, B, C), Priority HBM List California, no HBM data available at current knowledge
C	C4/C4 PFPIA			Bis(nonafluorobutyl)phosphinic acid	52299-25-9	CoRAP (suspected PBT/vPvB, other hazard based concern, exposure of environment), no HBM data available at current knowledge
C	8:2 FTOH			8:2 fluorotelomer alcohol	678-39-7	CLH proposal (Repr 1B), OSH legislation (Council Directive 98/24/EC on protection of health and safety of workers), self classification (Skin irrit. 2, Eye irrit. 2, STOT SE 3), Norman 2011, no HBM data available at current knowledge
C	C6/C6 PFPIA			Bis(perfluorohexyl)phosphinic acid	40143-77-9	Limited HBM data available (Human sera, single and pooled donor sample 2009, US : <1 - 50.2 ng/L and <1 - 201.4 ng/L (median) Lee & Mabury (2011)
C	C6/C8 PFPIA			Bis(perfluorohexyloctyl)phosphinic acid	610800-34-5	Priority HBM List California, Limited HBM data available (Human sera, single and pooled donor sample 2009, US : <1 - 60.9 ng/L and <1 - 283.4 ng/L (median) Lee & Mabury (2011)

HBM4EU PFAS Reference List						
Category	Abbrev./Acronym	Surname	Type	Systematic name	CAS No.	Regulation
C	C8/C8 PFPIA			Bis(perfluorooctyl)phosphinic acid	40143-79-1	Limited HBM data available (Human sera , single and pooled donor sample 2009, US : <1 - 22.2 ng/Land <1 - 50.7 ng/L (median) Lee & Mabury (2011)
C	HFPO			hexafluoropropylene oxide	220182-27-4	Highlighted by ECHA, no HBM data available at current knowledge
	PFCHS			Cyclic PFSA e.g Cyclohexanesulfonic acid undecafluoro-, potassium salt Cyclohexanesulfonic acid, nonafluorobis(trifluoromethyl)perfluoro-4-ethylcyclohexane sulfonate	3107-18-4 68156-01-4 335-24-0	CAS# 3107-18-4, CAS# 68156-01-4, CAS# 335-24-0: REACH Annex III (suspected C, P) ; no HBM data available at current knowledge
	6:2/8:2 diPAP			6:2/8:2 polyfluoroalkyl phosphoric acid diesters	943913-15-3	PFOA-related substance, REACH Annex XVII restriction (Regulation (EU) 2017/1000), Priority HBM List California, no HBM data available at current knowledge
	8:2 monoPAP			8:2 polyfluoroalkyl phosphoric acid monoester	57678-03-02	PFOA-related substance, REACH Annex XVII restriction (Regulation (EU) 2017/1000), no HBM data available at current knowledge
	PFOPA			Perfluorooctylphosphonic acid, 2-(Perfluorohexyl)ethyl]	252237-40-4	Sodium salt REACH registration (ECHA, 2017) High environmental exposure, Priority HBM List California, limited HBM data available, not detected in US human sera in Lee & Mabury (2011)
	Perfluorinated Siloxane			Trimethoxy(1H,1H,2H,2H-heptafluorodecyl)silane	83048-65-1	OSH legislation (Council Directive 98/24/EC on protection of health and safety of workers, Council Directive 94/33/EC on the protection of young people at work), Annex III Directive 2008/98/EC on waste, self classification (Skin irrit. 2, Eye irrit. 2, Skin corr. 1B), no HBM data available at current knowledge
	FL16.119			N-(2-methylcyclohexyl)-2,3,4,5,6-pentafluorobenzamide	1003050-32-5	more information on use and use levels needed EFSA (CEF panel, 2017) Other health hazard, no HBM data available at current knowledge
	6:2 FTCA 8:2 FTCA 10:2 FTCA			Fluorotelomer carboxylic acids: 6:2 Fluorotelomer carboxylic acid, 8:2 Fluorotelomer carboxylic acid 10:2 Fluorotelomer carboxylic acid	53826-12-3 27854-31-5 53826-13-4	Fluorotelomer metabolites, Priority HBM List California, no HBM data available at current knowledge
	PFECA			Perfluoro-1,2-propylene glycol and perfluoro-1,1-ethyle Perfluoro[(2-ethoxy-ethoxy)acetic acid], ammonium salt	329238-24-6	resistant, not easily to metabolise, maybe bioaccumulative, expected increase in production and use, partially used in food contact materials, restriction on use according EFSA, no safety concern under defined conditions (EFSA, 2010) no HBM data available at current knowledge
	FBSA			Perfluorobutane sulfonamide	30334-69-1	Alternative to PFOS, transformation product, recently detected in biota (fish) (Cu et al., 2016)
	MeFBSE			N-Methyl perfluorobutane-sulfonamidoethanol	34454-97-2	REACH, registered substance, Intermediate; Surfactants; Repellents for porous hard surfaces; Tile grout additive, Registered 12 – 100 t/y
	6:2 PAP			6:2 polyfluoroalkyl phosphoric acid monoesters	57678-01-0	Priority HBM List California, no HBM data available at current knowledge
	6:2 diPAP			6:2 polyfluoroalkyl phosphoric acid diesters	57677-95-9	Priority HBM List California, no HBM data available at current knowledge
	PFHxPA			Perfluorohexylphosphonic acid	40143-76-8	high environmental exposure, Priority HBM List California, not detected in US human sera in Lee & Mabury (2011) limited HBM data available
	PFDDPA			Perfluorodecylphosphonic acid	52299-26-0	Priority HBM List California, not detected in US human sera in Lee & Mabury (2011) limited HBM data available
	C8/C10 PFPIA			Bis(perfluorooctyldecyl)phosphinic acid	500776-81-8	no HBM data available at current knowledge
	Denum SH			Poly[oxy(1,1,2,2,3,3-hexafluoro-1,3-propanediyl)],a-(2-	120895-92-3	no HBM data available at current knowledge
	Krytox			Krytox-H	60164-51-4	no HBM data available at current knowledge
	Fomblin Z-DIAC,			Fomblin Z-DIAC, bis(pentafluorophenyl) ester	97462-40-1	no HBM data available at current knowledge
	-			C3; C15-C20 PFCA	-	no HBM data available at current knowledge
	-			C3, C15-C20 PFSA	-	no HBM data available at current knowledge
	TFEE-5			Polyfluoro-5,8,11,14-tetrakis(polyfluoroalkyl)-polyoxaalkane	-	CoRap, suspected PBT
	PTFE	Teflon	Polymer	Polytetrafluoroethylene	9002-84-0	More research on polymers
	PVDF			1,1 Difluoroethene	24937-79-9	Building blocks: CAS# 9002-84-0: REACH Annex III (suspected CMR); CAS# 24937-79-9: REACH Annex III (suspected P, M, hazardous to aquatic environment); CAS# 24981-14-4: - CAS# 116-14-3: PACT list (CMR); CAS# 116-15-4: CLH (Press. Gas, Acute Tox. 4, STOT SE 3), CoRAP (suspected CMR, high (aggregated) tonnage); production of toxic products if overheated; production of ultrafine particles by degradation; lung inflammation (PTFE), toxic monomers (PTFE); no HBM data available at current knowledge
	PVF			Polyvinyl fluorine	24981-14-4	
	TFE			Tetrafluoroethylene	116-14-3	
	HFP			Hexafluoropropylene	116-15-4	

## Annex 2 | 20 scientific studies used in the known contamination sites

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## **Annex 3 | Nomenclature of economic activities**

NAICS code US	Title	Sources	Quantity	NACE code EU	Activity	Definition
313320	Fabric Coating Mills	bcdefghik	380	C13.96	Manufacture of other technical and industrial textiles	<a href="https://nacev2.cor">https://nacev2.cor</a>
325510	Paint and Coating Manufacturing	abcdefghik	2100	C20.3	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	<a href="https://nacev2.cor">https://nacev2.cor</a>
322220	Paper Bag and Coated and Treated Paper Manufacturing	bcdefghi	0	C17.1	Manufacture of pulp, paper and paperboard	<a href="https://nacev2.cor">https://nacev2.cor</a>
313210	Broadwoven Fabric Mills	bcdefhk	484	C13.2.0	Weaving of textiles	<a href="https://nacev2.cor">https://nacev2.cor</a>
322121	Paper (except Newsprint) Mills	bcdefhk	610	C17.1	Manufacture of pulp	<a href="https://nacev2.cor">https://nacev2.cor</a>
	Idem			C17.2	Manufacture of paper and paperboard	<a href="https://nacev2.cor">https://nacev2.cor</a>
332813	Electroplating, Plating, Polishing, Anodizing, and Coloring	bcdefhi	5642	C25.6.1	Treatment and coating of metals	<a href="https://nacev2.cor">https://nacev2.cor</a>
324110	Petroleum Refineries	abcdehk	594	C19.2.0	Manufacture of refined petroleum products	<a href="https://nacev2.cor">https://nacev2.cor</a>
325612	Polish and Other Sanitation Good Manufacturing	abdefhk	673	C20.4.1	Manufacture of soap and detergents, cleaning and polishing preparations	<a href="https://nacev2.cor">https://nacev2.cor</a>
334413	Semiconductor and Related Device Manufacturing	bcdefi	1552	C26.1.1	Manufacture of electronic components	<a href="https://nacev2.cor">https://nacev2.cor</a>
326113	Unlaminated Plastics Film and Sheet (except Packaging) Manufacturing	bdefhi	597	C22	Manufacture of rubber and plastic products	<a href="https://nacev2.cor">https://nacev2.cor</a>
332812	Metal Coating, Engraving (except Jewelry and Silverware), and Allied Services to Manufacturers	bcefgi	3587	C25.6.1	Treatment and coating of metals	<a href="https://nacev2.cor">https://nacev2.cor</a>
333318	Other Commercial and Service Industry Machinery Manufacturing	bdefgh	0	C26.7.0	Manufacture of optical instruments and photographic equipment	<a href="https://nacev2.cor">https://nacev2.cor</a>
	Idem			C28.2.3	Manufacture of office machinery and equipment (except computers and peripheral equipment)	<a href="https://nacev2.cor">https://nacev2.cor</a>
334419	Other Electronic Component Manufacturing	bcdefg	1663	C26.1.1	Manufacture of electronic components	<a href="https://nacev2.cor">https://nacev2.cor</a>
	Idem			C26.1.2	Manufacture of loaded electronic board	<a href="https://nacev2.cor">https://nacev2.cor</a>
562212	Solid Waste Landfill	cdefjk	4765	E38.2.1	Treatment and disposal of non-hazardous waste	<a href="https://nacev2.cor">https://nacev2.cor</a>
325199	All Other Basic Organic Chemical Manufacturing	abdefi	1847	C20.1.4	Manufacture of other organic basic chemicals	<a href="https://nacev2.cor">https://nacev2.cor</a>
323111	Commercial Printing (except Screen and Books)	bcdhk	4226	C18.1.2	Other printing	<a href="https://nacev2.cor">https://nacev2.cor</a>
	Idem			C18.1.3	Pre-press and pre-media services	<a href="https://nacev2.cor">https://nacev2.cor</a>
313110	Fiber, Yarn, and Thread Mills	bcefn	0	C13.1.0	Preparation and spinning of textile fibres	<a href="https://nacev2.cor">https://nacev2.cor</a>
314110	Carpet and Rug Mills	bdhik	189	C13.9.3	Manufacture of carpets and rugs	<a href="https://nacev2.cor">https://nacev2.cor</a>
316110	Leather and Hide Tanning and Finishing	bdefg	276	C15.1.1	Tanning and dressing of leather; dressing and dyeing of fur	<a href="https://nacev2.cor">https://nacev2.cor</a>
325211	Plastics Material and Resin Manufacturing	bdgik	2141	C20.1.6	Manufacture of plastics in primary forms	<a href="https://nacev2.cor">https://nacev2.cor</a>
	Idem			C22	Manufacture of rubber and plastic products	<a href="https://nacev2.cor">https://nacev2.cor</a>
	Idem			C22.29	Manufacture of other plastic products	<a href="https://nacev2.cor">https://nacev2.cor</a>
324191	Petroleum Lubricating Oil and Grease Manufacturing	abcdh	919	C19.2.0	Manufacture of refined petroleum products	<a href="https://nacev2.cor">https://nacev2.cor</a>
325998	All Other Miscellaneous Chemical Product and Preparation Manufacturing	aefgk	2598	C20.5.9	Manufacture of other chemical products n.e.c.	<a href="https://nacev2.cor">https://nacev2.cor</a>
562211	Hazardous Waste Treatment and Disposal	acefj	1357	E38.2.2	Treatment and disposal of hazardous waste	<a href="https://nacev2.cor">https://nacev2.cor</a>
562213	Solid Waste Combustors and Incinerators	acefj	407	E38.2.1	Treatment and disposal of non-hazardous waste	<a href="https://nacev2.cor">https://nacev2.cor</a>
313310	Textile and Fabric Finishing Mills	bcdh	0	C13.3.0	Finishing of textiles	<a href="https://nacev2.cor">https://nacev2.cor</a>
322219	Other Paperboard Container Manufacturing	bcdh	0	C17.2.1	Manufacture of corrugated paper and paperboard and of containers of paper and paperboard	<a href="https://nacev2.cor">https://nacev2.cor</a>
323120	Support Activities for Printing	bcdh	0	C18.1.2	Other printing	<a href="https://nacev2.cor">https://nacev2.cor</a>
313220	Narrow Fabric Mills and Schiffli Machine Embroidery	cefk	0	C13.9.6	Manufacture of other technical and industrial textiles	<a href="https://nacev2.cor">https://nacev2.cor</a>
313230	Nonwoven Fabric Mills	bchk	239	C13.9.5	Manufacture of non-wovens and articles made from non-wovens, except apparel	<a href="https://nacev2.cor">https://nacev2.cor</a>
322130	Paperboard Mills	cefk	258	C17.1	Manufacture of pulp	<a href="https://nacev2.cor">https://nacev2.cor</a>
	idem			C17.2	Manufacture of paper and paperboard	<a href="https://nacev2.cor">https://nacev2.cor</a>
332999	All Other Miscellaneous Fabricated Metal Product Manufacturing	bdgh	4799	C25.9.9	Manufacture of other fabricated metal products n.e.c.	<a href="https://nacev2.cor">https://nacev2.cor</a>
424690	Other Chemical and Allied Products Merchant Wholesalers	bdhj	1698	G46.7.5	Wholesale of chemical products	<a href="https://nacev2.cor">https://nacev2.cor</a>
314910	Textile Bag and Canvas Mills	befi	0	C13.2.0	Weaving of textiles	<a href="https://nacev2.cor">https://nacev2.cor</a>
326112	Plastics Packaging Film and Sheet (including Laminated) Manufacturing	defi	350	C22	Manufacture of rubber and plastic products	<a href="https://nacev2.cor">https://nacev2.cor</a>
335999	All Other Miscellaneous Electrical Equipment and Component Manufacturing	befg	877	C27.9.0	Manufacture of other electrical equipment	<a href="https://nacev2.cor">https://nacev2.cor</a>
562112	Hazardous Waste Collection	cefj	2561	E38.1.2	Collection of hazardous waste	<a href="https://nacev2.cor">https://nacev2.cor</a>
562219	Other Nonhazardous Waste Treatment and Disposal	cefj	744	E38.2.1	Treatment and disposal of non-hazardous waste	<a href="https://nacev2.cor">https://nacev2.cor</a>
325611	Soap and Other Detergent Manufacturing	abeh	1012	C20.4.1	Manufacture of soap and detergents, cleaning and polishing preparations	<a href="https://nacev2.cor">https://nacev2.cor</a>

Sources: a: Facilities that reported PFAS to the TRI; b: [Eastern Research Group 2019](#), c: [Hu et al. 2016](#), d: [Schulz et al. 2021](#), e: [ASDWA 2020](#), f: [Kansas Department of Health and Environment 2019](#), g: [Massachusetts Science Advisory Board 2021](#), h: [Minnesota Pollution Control Agency 2020](#), i: [Utah Department of Environmental Quality 2020](#), j: [Environmental Protection Agency 2019](#), k: [Environmental Protection Agency 2021](#)

List of activities labels in E-PRTR Water and Air	Corresponding NACE Category	NACE Code EU
Chemical installations for the production on an industrial scale of basic organic chemicals: Basic plastic materials (polymers, synthetic fibres and cellulose-based fibres)	Manufacture of plastics in primary forms	C20.1.6
Chemical installations for the production on an industrial scale of basic organic chemicals: Dyes and pigments	Finishing of textiles	C13.30
Chemical installations for the production on an industrial scale of basic organic chemicals: Halogenic hydrocarbons	Manufacture of other organic basic chemicals	C20.1.4
Chemical installations for the production on an industrial scale of basic organic chemicals: Surface-active agents and surfactants	Manufacture of other organic basic chemicals	C20.1.4
Chemical installations for the production on an industrial scale of basic organic chemicals: Synthetic rubbers	Manufacture of rubber and plastic products	C22
Independently operated industrial waste-water treatment plants which serve one or more activities covered in annex 1 of Regulation 166/2006	?	?
Industrial plants for the production of paper and board and other primary wood products (such as chipboard, fibreboard and plywood)	Manufacture of articles of paper and paperboard	C17.2
Industrial plants for the production of pulp from timber or similar fibrous materials	Manufacture of pulp, paper and paperboard	C17.1
Installation for the production of non-ferrous crude metals from ore, concentrates or secondary raw materials by metallurgical, chemical or electrolytic processes	Manufacture of other fabricated metal products n.e.c.	C25.9.9
Installations for surface treatment of metals and plastic materials using an electrolytic or chemical process	Treatment and coating of metals	C25.6.1
Installations for the disposal of non-hazardous waste	Treatment and disposal of non-hazardous waste	E38.2.1
Installations for the incineration of non-hazardous waste in the scope of Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste	Treatment and disposal of non-hazardous waste	E38.2.1
Installations for the processing of ferrous metals, Application of protective fused metal coats	Treatment and coating of metals	C25.6.1
Installations for the recovery or disposal of hazardous waste	Treatment and disposal of hazardous waste	E38.2.2
Mineral oil and gas refineries	Manufacture of refined petroleum products	C19.2.0
Plants for the pre-treatment (operations such as washing, bleaching, mercerisation) or dyeing of fibres or textiles	Finishing of textiles	C13.30
Plants for the tanning of hides and skins	Tanning and dressing of leather; dressing and dyeing	C15.1.1
Urban waste-water treatment plants	Sewerage	E37.00
E-PRTR <a href="https://industry.eea.europa.eu/#/home">https://industry.eea.europa.eu/#/home</a>		



<b>NACE code EU</b>	<b>Activity</b>	<b>Definition</b>
C13.1.0	Preparation and spinning of textile fibres	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C13.2.0	Weaving of textiles	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C13.3.0	Finishing of textiles	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C13.9.3	Manufacture of carpets and rugs	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C13.9.5	Manufacture of non-wovens and articles made from non-wovens, except apparel	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C13.9.6	Manufacture of other technical and industrial textiles	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C15.1.1	Tanning and dressing of leather; dressing and dyeing of fur	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C17.1	Manufacture of pulp, paper and paperboard	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C17.2	Manufacture of articles of paper and paperboard	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C18.1.2	Other printing	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C18.1.3	Pre-press and pre-media services	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C19.2.0	Manufacture of refined petroleum products	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C20.1.4	Manufacture of other organic basic chemicals	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C20.1.6	Manufacture of plastics in primary forms	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C20.3	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C20.4.1	Manufacture of soap and detergents, cleaning and polishing preparations	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C20.5.9	Manufacture of other chemical products n.e.c.	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C22	Manufacture of rubber and plastic products	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C25.9.9	Manufacture of other fabricated metal products n.e.c.	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C25.6.1	Treatment and coating of metals	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C26.1.1	Manufacture of electronic components	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C26.1.2	Manufacture of loaded electronic board	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C26.7.0	Manufacture of optical instruments and photographic equipment	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C27.9.0	Manufacture of other electrical equipment	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
C28.2.3	Manufacture of office machinery and equipment (except computers and peripheral equipment)	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
E38.1.2	Collection of hazardous waste	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
E38.2.1	Treatment and disposal of non-hazardous waste	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
E38.2.2	Treatment and disposal of hazardous waste	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>
G46.7.5	Wholesale of chemical products	<a href="https://nacev2.com/en/activity">https://nacev2.com/en/activity</a>