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Alliance for Telomer Chemistry Stewardship's Response to the Public Consultation on Restriction Proposal on all PFAS

Part I – General Information Requests

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Introduction

The Alliance for Telomer Chemistry Stewardship (ATCS) represents some of the leading producers of **C6 short-chain fluorotelomer-based chemistry, including C6 side-chain fluorinated polymers (C6 SFPs) and C6 fluorosurfactants**. We welcome the opportunity to submit our opinion to the public consultation on all poly- and perfluoroalkyl substances (PFAS).

In the present document, which is focused on C6 fluorotelomer chemistry, ATCS would like to share its concerns with respect to the restriction proposal, including the scope, the legal basis, as well as the hazard and exposure assessments.

The main concerns are the following:

- Overall, substances that are already restricted, banned or have been assessed as part of parallel restriction processes should not be part of the risk assessment of this restriction proposal. This includes C6 fluorotelomers, which are already subject to the restriction proposal on undecafluorohexanoic acid (PFHxA), its salts and related substances – hereinafter, PFHxA restriction proposal.
- There is no scientific basis to refer to the potential irreversible adverse effects on the environment and on human health over time, especially not for PFHxA. Such vague assumptions do not constitute a demonstration of unacceptable risk as required by REACH, nor a sufficient basis to justify the use of the precautionary principle.
- Persistence is not an intrinsic hazard, as it does not in itself imply an adverse effect, and it should, therefore, not be used to justify the restriction of substances without having to prove unacceptable risk. Also, there are biodegradable PFASs that should not be subject to the restriction.
- Contrary to the assumption made in the Restriction Dossier, C6 is not used in consumer applications, especially due to the reduced use of C6 that will derive from the implementation of the PFHxA restriction proposal.
- ATCS members welcome the development of emission minimisation techniques and have been implementing them as part of their commitment to sustainable production. In addition, it should be underlined that remediation technologies to remediate water and soil contamination are currently available.
- Current analytical methods do not ensure product compliance and enforceability of the proposed thresholds. We believe that the availability of harmonised analytical methods is a prerequisite to any regulatory action, and that careful consideration would be necessary to optimize which of these method(s) are the best for each of the substances at stake.

In our other contribution, we address the Specific Information Requests, more specifically questions 1, 2, 3, 5, 6, 7, 8 and 10.

General Information Requests

1. Scope

Firstly, the ATCS would like to underline that C6 fluorotelomers are already subject to the PFHxA restriction proposal, its salts and related substances, which is under consideration by the European Commission, and the restriction proposal on PFAS in firefighting foams, which is under evaluation by the European Chemicals Agency (ECHA). Therefore, there is an overlap between the three restriction proposals in terms of chemistry intentionally used.

With regards to firefighting foams, we understand that the intention of the Dossier Submitters was to exclude the use from the scope of the restriction proposal, as it is subject to parallel regulatory action. However, we would like to note that such exclusion is not appropriately reflected in the proposed legal text and should, therefore, be included under paragraph 4.

Concerning other C6 fluorotelomer uses, we recommend that they are solely addressed under the PFHxA restriction proposal in order to avoid a duplication of regulation and ensure more consistent enforcement. While this could be done through the provision included under paragraph 9, it is not clearly indicated neither in the Restriction Dossier nor in the Background Documents.

Moreover, we would like to note that OECD Per- and Polyfluoroalkyl Substances (PFAS) project, produced with the financial assistance of the European Union, stated in its latest report (2021) that the proposed PFAS definition should be used solely for structural identification and classification not for regulation:

> The decision to broaden the definition compared to Buck et al. is not connected to decisions on how PFASs should be grouped in regulatory and voluntary actions.[1]

Furthermore, we would like to stress that the proposed definition of PFAS encompasses substances that vary widely in their physical and chemical properties, many of which are already restricted or banned.[2] These compounds should not be considered as part of the

[1] OECD, the Environment Directorate, Chemicals and Biotechnology Committee, *Reconciling Terminology of the Universe of Per- and Polyfluoroalkyl Substances: Recommendations and Practical Guidance*, July 9, 2021, ENV/CBC/MONO(2021)25, No.61, Paris.

[2] The first non-polymer, long-chain perfluoroalkyl substance to be restricted was perfluorooctane sulfonate, PFOS (Annex I, Part A. Regulation (EU) 2019/1021 of the European Parliament and the Council), followed by perfluorooctanoic acid, PFOA (Commission Regulation (EU) 2017/1000). Additionally, long-chain (C9-C14) perfluorocarboxylic acids, and perfluorohexane sulfonate (PFHxS) have been restricted under REACH after having been identified as Substances of Very High Concern (SVHCs).

risk assessment, as this is a misleading approach and can eventually lead to exaggerated risk considerations.

1.1. The restriction proposal uses a definition of PFAS substances that overestimates the number of PFAS in commerce

The list of 4730 PFAS chemicals was published in a 2018 OECD Report titled "Toward A New Comprehensive Global Database of Per- and Polyfluoroalkyl Substances (PFASs): Summary Report on Updating the OECD 2007 List of Per- and Polyfluoroalkyl Substances (PFASs)." Thereafter, the Report was cited by many to highlight and raise concern regarding the large, diverse, and expanding world of PFAS Chemicals in commerce and/or on the market.

In the 2018 OECD Report, the authors acknowledged they were trying to do a bottom up compilation of PFAS compounds from various global regulatory lists. The goal was to try to reflect what compounds were in commerce. As concluded by the authors, this aim was not successful. Nevertheless, the 4730 compounds still ended up being perpetuated as "4730 items in commerce". The 4730 compounds is a compilation from lists and has no bearing whatsoever on what compounds are actually in commerce today.

In addition, more recent analyses indicate that the OECD list vastly overestimates the number of PFAS compounds that are actually in commerce today. For example, in the US, the TSCA Inventory (one of the lists from which the OECD list was derived) includes approximately 1200 chemicals that the US Environmental Protection Agency (US EPA) identifies as PFAS substances[3]. However, a recent update of the TSCA Inventory revealed that only about 600 of the substances on the Inventory have been in commerce since 2006. Further analysis shows that, because of the phase-out of long-chain compounds in 2015, the actual number of PFAS substances in US commerce is substantially lower than 600.

In 2020, industry (the members of the Performance Fluoropolymer Partnership) assessed the list of 4730 to identify substances that are in or related to products in commerce today. The group published a manuscript in 2021, whereby these global manufacturers identify items in commerce today and classify them in the categories set forth in the original publication that established the nomenclature and terminology for

[3] United States Environmental Protection Agency (EPA), *EPA's Per- and Polyfluoroalkyl Substances (PFAS) Action Plan*, February 2019, EPA 823R18004, https://www.epa.gov/sites/production/files/2019-02/documents/pfas_action_plan_021319_508compliant_1.pdf (accessed Jan. 3, 2022).

per- and poly-fluoroalkyl substances[4] and in the categories presented in the 2018 OECD Report. This is a 'bona-fide bottom-up' current compilation of compounds in commerce that also includes intermediates, degradation products, etc. This industry group showed that the active list in commerce for the 3 major global manufacturers was <300 compounds, not thousands of compounds, which is more in line with the recent US EPA values noted above.[5]

2. Legal basis

Under Article 68 of the REACH Regulation, in order to be restricted, substances have to pose an unacceptable risk to human health or the environment. Instead of relying on the established criteria for the identification of PBT (persistent, bioaccumulative, toxic) and vPvB (very persistent, very bioaccumulative) substances, laid down in REACH Annex XIII, **the restriction proposal relies on the persistence of PFAS, in combination with other hazardous properties such as mobility, and considers them as equivalent to PBT/vPvB properties, with any release being a proxy for unacceptable risk**:

> Overall, PFASs should be treated as non-threshold substances for the purpose of risk assessment in a similar manner to PBT/vPvB substances. Their releases can be accordingly used as a proxy for risk. To minimise the likelihood of adverse effects in the future, all releases should be minimised.[6]

However, in order to analyse the presence of "an unacceptable risk to human health or the environment" as set out by Article 68 of REACH, one cannot simply rely on the alleged vPvM properties of a substance and consider any release to the environment as a proxy for unacceptable risk as it is the case for PBT/vPvB substances.

First, such an approach dismisses the outcome of previous discussions on the proposal to identify PFHxA as Substance of Very High Concern (SVHC), precisely on the basis of alleged equivalent levels of concern to PBT/vPvB properties. It should be reminded that this proposal raised serious concerns within the REACH Committee and was ultimately withdrawn by the SVHC dossier submitter.

Further, in the framework of Article 57(f) of REACH, the European Court of Justice (hereinafter "CJEU") already determined the criteria that have to be fulfilled in order for a substance to be of an "equivalent level of concern" to PBT or vPvB substances. In case C 323/15 P, the CJEU stated that Article 57(f) REACH requires that it be established on

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[4] Robert C. Buck, Stephen H. Korzeniowski, Evan Laganis, Frank Adamsky, 2021, "Identification and classification of commercially relevant per- and poly-fluoroalkyl substances (PFAS)", *Integrated Environmental Assessment and Management* (17), pp. 1045–1055, https://setac.onlinelibrary.wiley.com/doi/epdf/10.1002/ieam.4450.

[5] EPA, *EPA's Per- and Polyfluoroalkyl Substances (PFAS) Action Plan*.

[6] European Chemicals Agency (ECHA), Annex XV Restriction Report on Per- and polyfluoroalkyl substances (PFAS), https://echa.europa.eu/documents/10162/1c480180-ece9-1bdd-1eb8-0f3f8e7c0c49, p. 48

a case-by-case basis and on the basis of scientific evidence, and that **two cumulative** criteria are fulfilled:

- it must be probable that the hazards arising from the substance's intrinsic properties have **serious effects on human health or the environment**, and
- there must be **scientific evidence** that these effects give rise to an equivalent level of concern to those of CMR (carcinogenic, mutagenic or toxic), PBT or vPvB substances.

This principle was further clarified in a more recent case, T-636/17 of 20 September 2019 concerning endocrine disruptors, in which the Court once more reiterated that the equivalent level of concern requires*:*

> **An actual analysis** of the hazards linked to the intrinsic properties of the substance under consideration, and **the demonstration** that the serious effects on human health or the environment of the substance under consideration give rise to an equivalent level of concern to those of other substances referred to in Article 57(a) to (e) of the same regulation.

Based on this, there is no scientific basis to refer to the potential "irreversible adverse effects on the environment and on human health over time" (p. 50), especially not for PFHxA. Such vague assumptions do not constitute a demonstration of unacceptable risk as required by REACH, nor a sufficient basis to justify the use of the precautionary principle.

3. Hazard

The ATCS acknowledges that persistent chemicals can be a possible concern under certain circumstances due to a potentially increasing presence in the environment from emissions from the manufacture, use and disposal. However, it must be noted that, while persistence is considered an intrinsic property, persistence in and of itself is not an intrinsic hazard. Therefore, it cannot be used as a justification for chemical regulation.

The Restriction Dossier states that "the very high persistence is not sufficient to identify the PFASs as PBT or vPvB substances" and it does not derive a conclusion on bioaccumulation and toxicity criteria for each substance/subgroup.[7] However, it considers persistence in combination with other potential additional hazard properties as equivalent to PBT/vPvB properties, with any release being a proxy for unacceptable risk. This approach, in defining a wide and diverse group of substances such as PFAS as

[7] European Chemicals Agency (ECHA), Annex XV Restriction Report on Per- and polyfluoroalkyl substances (PFAS), p. 47.

"non-threshold substances" due to their persistence,[8] could be used to justify the restriction or even ban of any persistent chemistry without having to prove unacceptable risk. Yet, substances with persistence as intrinsic properties cover a large number of chemicals. The current restriction proposal, as it stands, would mean that any substance, based on these properties represents a risk and should be restricted.

In order to prevent the increasing presence of PFAS in the environment, the ATCS supports and is interested in the continued development of innovative technologies and the best available techniques to effectively monitor and minimize emissions to the environment of C6 fluorotelomers and any potential breakdown products during production and throughout their lifecycle. **A voluntary initiative between industry and authorities in the form of a stewardship program, which could involve producers and downstream users, remains a promising path forward. The ATCS would be more than willing to facilitate such a dialogue between industry and authorities.**

3.1. Specificities of PFHxA and PFHxA-related substances (C6 fluorotelomers)

We would like to note that the properties of certain PFAS cannot be extrapolated to other PFAS. For instance, while the Restriction Dossier acknowledges the high diversity of the PFASs in terms of the bioaccumulation potential[9], it states that "PFAAs have a strong potential for bioaccumulation in humans as shown by the long half-lives due to the protein-binding properties".[10]

However, PFHxA has been detected in the environment at low levels and should not be assumed equal in terms of harm. In the context of the PFHxA restriction proposal, the German Federal Institute for Occupational Safety and Health (BAuA) stated the following:

> […] to date no indications of serious human health risks are documented. […] Considering the absence of clear evidence regarding human health impacts from exposure to PFHxA, the Dossier Submitter concludes that there are currently no impacts to be expected.[11]

This is substantiated by the fact that national agencies, which have assessed the toxicity of PFHxA, have found high safety levels for PFHxA. In 2015 the French Agency for Food,

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[8] European Chemicals Agency (ECHA), Annex XV Restriction Report on Per- and polyfluoroalkyl substances (PFAS), p. 48.

[9] *Ibid,* p. 47.

[10] *Ibid,* p. 29.

[11] Federal Institute for Occupational Safety and Health (BAuA), Annex XV Restriction Report Undecafluorohexanoic acid (PFHxA), its salts and related substances, p. 73, https://echa.europa.eu/documents/10162/c4e04484-c989-733d-33ed-0f023e2a200e.

Environmental and Occupational Health & Safety (ANSES) published an opinion on PFHxA, establishing a chronic toxicity reference value (TRV) of 0.32 mg/kg bodyweight (bw) per day. In 2017, the German Human Biomonitoring (HBM) Commission established drinking water guide values (TWLW, Trinkwasser-Leitwerte) for PFHxA at 6 µg/L.

As a matter of comparison, the toxicity value of PFHxA is several orders of magnitude higher (i.e., safer) than for PFOA, as also shown in Table 1. The study conducted by Luz et al[12] also emphasizes the low toxicity of PFHxA:

Table 1 – Example of Toxicity Values (or R_fD): Long and Short-Chains

	# Fluorinated Carbons		Tox Value (ng/kg-day)	Source	Species and Effect
Long-Chain	8	PFNA C9	**0.74**	NJDEP 2015	Mice: increased maternal liver weight
			3	ATSDR 2018 DRAFT*	Mice: decreased offspring body weight and developmental delays
	8	PFOS C8	**20**	USEPA 2016	Rat: reduced pup body weight
			2	ATSDR 2018 DRAFT*	Rat: thyroid follicular cell damage
	7	PFOA C8	**20**	USEPA 2016	Mice: developmental—reduced ossification, accelerated puberty
			3	ATSDR 2018 DRAFT*	Mice: altered activity and skeletal alterations in offspring
	6	PFHxS C6	**20**	ATSDR 2018 DRAFT*	Rat: thyroid follicular cell damage
Short-Chain	5	PFHxA C6	**250,000**	Luz et al. 2019	Rat: kidney papillary necrosis
			320,000	ANSES 2017	Rat: kidney papillary necrosis
	4	PFBS C4	**10,000**	USEPA 2018 DRAFT	Mice: thyroid—decreased serum T4 Rat: kidney papillary hyperplasia

* intermediate duration

With regard to potential hazards to the environment, the SVHC proposal for PFHxA, issued in 2018, stated that "no adverse effects have been observed in the various tests conducted on ecotoxicity for algae, daphnia and fish covering acute as well as chronic toxicity" (p. 31).

Similarly, PFHxA shows no bioaccumulation potential. **PFHxA constitutes a non-biopersistent substance and is rapidly eliminated from all mammals**.[13] This is

[12]A. L. Anderson Luz, P. Goodrum, P. and J. Durda, 2019, Perfluorohexanoic acid toxicity, part I: Development of a chronic human health toxicity value for use in risk assessment, *Regulatory Toxicology and Pharmacology*, 103, 41–55. doi: 10.1016/j.yrtph.2019.01.019.

[13] Conder, Jason M., Robert A. Hoke, Watze de Wolf, Mark H. Russell, and Robert C. Buck. 2008. "Are PFCAs Bioaccumulative? A Critical Review and Comparison with Regulatory Criteria and Persistent Lipophilic Compounds." *Environmental Science & Technology* 42 (4): 995–1003, https://doi.org/10.1021/es070895g; Han, Xing, Diane L. Nabb, Mark H. Russell, Gerald L. Kennedy, and Robert W. Rickard. 2011. "Renal Elimination of Perfluorocarboxylates (PFCAs)." *Chemical Research in Toxicology* 25 (1): 35–46, https://doi.org/10.1021/tx200363w

illustrated by the low-level frequency of detection (FOD)[14] and low levels in human serum.[15]

The overwhelming weight of scientific evidence indicates that PFHxA does not cause cancer; does not disrupt endocrine (hormone) activity; has not been shown to cause reproductive or developmental harm; does not build up in the human body, and does not become concentrated in the bodies of living organisms. This, in combination with the significantly reduced level of emissions expected as a result of its upcoming restriction, reinforce that PFHxA is not anticipated to present a significant risk to human health or the environment.[16]

4. Exposure

While persistence is not an intrinsic hazard, as it does not in itself imply an adverse effect, appropriate emission minimization techniques should be in place for persistent substances, as has been done with many other types of chemicals.

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[14] Kim, Da-Hye, Mi-Young Lee, and Jeong-Eun Oh. 2014. "Perfluorinated Compounds in Serum and Urine Samples from Children Aged 5–13 Years in South Korea." *Environmental Pollution* 192 (September): 171–78, https://doi.org/10.1016/j.envpol.2014.05.024; Kang, Habyeong, Kyungho Choi, Haeng-Shin Lee, Do-Hee Kim, Na-Youn Park, Sunmi Kim, and Younglim Kho. 2016. "Elevated Levels of Short Carbon-Chain PFCAs in Breast Milk among Korean Women: Current Status and Potential Challenges." *Environmental Research* 148 (July): 351–59, https://doi.org/10.1016/j.envres.2016.04.017. Lee, Sunggyu, Sunmi Kim, Jeongim Park, Hai-Joong Kim, Gyuyeon Choi, Sooran Choi, Sungjoo Kim, et al. 2018. "Perfluoroalkyl Substances (PFASs) in Breast Milk from Korea: Time-Course Trends, Influencing Factors, and Infant Exposure." *Science of the Total Environment* 612 (January): 286–92, https://doi.org/10.1016/j.scitotenv.2017.08.094.

[15] Frisbee, Stephanie J., A. Paul Brooks, Arthur Maher, Patsy Flensborg, Susan Arnold, Tony Fletcher, Kyle Steenland, et al. 2009. "The C8 Health Project: Design, Methods, and Participants." *Environmental Health Perspectives* 117 (12): 1873–82, https://doi.org/10.1289/ehp.0800379; "Concentrations of Selected Persistent Organic Pollutants (POPs) in the Serum of New Zealanders." 2013, http://publichealth.massey.ac.nz/assets/ProjectsPDF/Concentrations-of-Selected-POPs-4-October-2013-FINAL.pdf; Olsen, Geary W., David C. Mair, Cleston C. Lange, Laura M. Harrington, Timothy R. Church, Corinne L. Goldberg, Ross M. Herron, et al. 2017. "Per- and Polyfluoroalkyl Substances (PFAS) in American Red Cross Adult Blood Donors, 2000–2015." *Environmental Research* 157 (August): 87–95, https://doi.org/10.1016/j.envres.2017.05.013; Lee, Jin Heon, Chae Kwan Lee, Chun-Hui Suh, Hee-Sook Kang, Choon-Pyo Hong, and Suk-Nam Choi. 2017. "Serum Concentrations of Per- and Poly-Fluoroalkyl Substances and Factors Associated with Exposure in the General Adult Population in South Korea." *International Journal of Hygiene and Environmental Health* 220 (6): 1046–54, https://doi.org/10.1016/j.ijheh.2017.06.005; Canada, Health. 2013. "Second Report on Human Biomonitoring of Environmental Chemicals in Canada." Www.canada.ca. April 5, 2013, https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/environmental-contaminants/second-report-human-biomonitoring-environmental-chemicals-canada-health-canada-2013.html.

[16] Klaunig, James E., et al. 2015. "Evaluation of the chronic toxicity and carcinogenicity of perfluorohexanoic acid (PFHxA) in Sprague-Dawley rats," *Toxicologic Pathology 43*(2): 209-220, doi: 10.1177/0192623314530532.

ATCS members have been implementing such emission minimization techniques as part of their commitment to sustainable production, and actively promotes the use of Best Available Techniques for minimizing emissions by end-users.

For instance, ATCS members contributed to the development of best practice guidance for the textile sector that provides guidance to minimize emissions of fluorinated – e.g., closed loop water management to avoid discharges to water. This is reflected in industry-based frameworks for responsible and sustainable manufacturing of textile consumer products, such as the bluesign® programme.

For information on emissions, please refer to our contribution on Specific Information Requests, Questions 2 and 3.

4.1. Remediation technologies[17]

4.1.1. Limiting emissions to water

The ATCS would like to highlight that proven full scale water treatment technologies are currently available for the removal of short-chain fluorotelomer-based chemistry from water. These technologies usually employ treatment trains which include ion exchange resins and/or membrane filtration. These *ex-situ* treatment technologies have been applied to drinking water supplies, groundwater remediation and industrial wastewater treatment plants.

- Ion exchange resins

Ion exchange resins are an established treatment technology for many common contaminants in both municipal drinking water and groundwater, including sulphate, chromate, nitrate, chloride and perchlorate. Full scale ion exchange resin systems engineered to treat PFAS impacted water are currently in operation in Australia and the United States.[18] The resins utilize both adsorption and ion exchange, which effectively remove long and short-chained PFAS compounds by attraction of both the polar and

[17] Interstate Technology & Regulation Council, "Remediation Management of Complex Sites," Interstate Technology & Regulation Council, 2017, https://rmcs-1.itrcweb.org/executive-summary/ (accessed May. 18, 2022).

[18] Interstate Technology Regulation Council, "PFAS Technical and Regulatory Guidance Document and Fact Sheets PFAS-1: 12 Treatment Technologies," *Interstate Technology and Regulatory Council*, *PFAS team*, May 2021, https://pfas-1.itrcweb.org/12-treatment-technologies (accessed Jan. 3, 2022).

non-polar properties of PFAS compounds.[19] Ion exchange resins designed to selectively remove PFAS are not subject to the same degree of fouling as carbon-based sorbents.[20]

Ion exchange resins are designed to be regenerable or disposed of after breakthrough of target compounds (single use). Resin regeneration is typically performed within the ion exchange treatment vessel, and results in a highly concentrated regenerant waste that requires further treatment and disposal. Currently available literature regarding PFAS removal has focused on regenerable ion exchange resins. However, single-use resins are gaining traction in the remedial market as they have lower initial capital costs, and the used resin can be disposed of by incineration.[21]

The regenerable ion exchange resin Sorbix LC1 was designed to treat an array of PFAS compounds, specifically short-chain PFAS, and is currently in use in multiple full-scale ion exchange groundwater treatment plants in Australia and the United States. United States-based company Emerging Compounds Treatment Technologies (ECT2) developed designed, fabricated and oversaw the installation of ion exchange resin groundwater treatment plants at two separate Australian Government Department of Defence (Defence) sites formerly used for fire-fighting training. The two Australian plants have a similar design to one another: each is capable of operating at 192 litres per minute (50 gallons per minute) and each contains two vessels filled with Sorbix A3F resin followed by polish vessels containing Sorbix LC1. Influent PFAS concentrations range from 1-120 µg/l and both plants have demonstrated removal of three regulated target PFAS compounds, including perfluorohexane sulfonic acid (PFHxS), below reportable limits of 10 parts per trillion (ppt). ECT2 is currently building a second, larger PFAS removal and resin regeneration system capable of treating 750 litres per minute (200 gallons per minute) at an identified source area on one of the Defence sites.[22]

Additional commercially available ion exchange resins have demonstrated short-chain PFAS removal at the bench scale. Purolite Purofine® PFA694E is a single use resin

[19] Emerging Compounds Treatment Technologies, "Ion exchange resin system removes PFAS at Royal Australian Air Force Base Williamstown," 2018, http://www.ect2.com/case-studies/water/id/39/ion-exchange-resin-system-removes-pfas-at-royal-australian-air-force-base-williamtown.

[20] Interstate Technology Regulation Council, "12 Treatment Technologies".

[21] *Ibid.*

[22] Emerging Compounds Treatment Technologies, "Ion exchange resin system removes PFAS at Royal Australian Air Force Base Williamstown".

being marketed for point of entry and point of use systems for removal of both long and short-chain PFAS.[23]

- Membrane filtration

Two commercially available membrane filtration technologies, reverse osmosis and nanofiltration, have demonstrated effective removal of PFAS regardless of chain length.[24] In each of these technologies, impacted water is forced via high pressure through a filter membrane with a high contact area, producing a high concentration rejectate while allowing the treated filtrate to pass through. Dickenson and Higgins (2016) evaluated fifteen full-scale water treatment systems and concluded reverse osmosis was the most effective PFAS treatment method evaluated in the study: reverse osmosis systems at two California potable reuse treatment plants demonstrated removal of all PFAS to below reportable quantities.[25] Additionally, reverse osmosis techniques have been designed for household under-sink and residential well water PFAS treatment.[26]

It is to be noted that though full-scale implementation of nanofiltration has not yet been demonstrated for PFAS removal, commercially available nanofiltration membrane systems could evolve to be just as effective as reverse osmosis.[27]

Current commercially available treatment technologies (e.g., ion exchange resin, membrane filtration) do not destroy PFAS but concentrate PFAS in the spent media, rejectate water or regenerant solution. Ongoing research is being performed to develop advanced chemical oxidation techniques that are capable of complete PFAS destruction.

The development of a treatment technology that can effectively treat the full suite of PFAS, including precursors, has been challenging given the varying physical and chemical characteristics within this class of compounds. However, available scientific and product literature highlight the possibility of combining remedial technologies in treatment trains for the efficient removal of a wide array of PFAS compounds, including short-chain PFAS, from impacted waters.

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[23] Purolite, "Take Command of Short and Long Chain PFAS in Drinking Water," n.d., https://www.purolite.com/fr/index/core-technologies/industry/potable---groundwater/PFAS-In-Our-Environment/best-pfas-treatment-option (accessed Jan. 3, 2022).

[24] Eric R. Dickenson and Christopher P. Higgins, "Treatment and mitigation strategies for poly- and perfluoroalkyl substances", *Water Research Foundation report 4322*, 2016, https://www.waterrf.org/PublicReportLibrary/4322.pdf.

[25] *Ibid.*

[26] American Water Works Association, "Perfluorinated compounds treatment and removal," n.d., https://www.awwa.org/Portals/0/AWWA/ETS/Resources/AWWAPFCFactSheetTreatmentandRemoval.pdf (accessed Jan. 3, 2022).

[27] Interstate Technology Regulation Council, "12 Treatment Technologies".

Recent research has demonstrated the potential for electrochemical oxidation technologies to effectively treat highly concentrated PFAS waste streams generated during remediation, such as the rejectate from membrane filtration or ion-exchange regenerant waste.

Some companies are specifically marketing their remedial technologies for use in treatment trains for comprehensive PFAS removal. At an Australian demonstration treatment plant for a former fire-fighting training facility, Evocra verified the efficacy of its patented ozofractionation column technology combined with sorbent polishing steps. The ozofractionation columns were effective at removing PFOA and PFOS and precursors from influent wastewater, and subsequent polishing steps with engineered sorbent removed certain residual PFAS.[28]

4.1.2. Limiting emissions to soil

Recent research demonstrates that it is possible to remove PFAS from contaminated soil. The work conducted in the Royal Australian Airforce Base in Townsville, Australia, shows that PFAS leachability can be reduced via in-situ immobilisation by more than 99%, using RemBind®, a powdered product that permanently binds up PFAS. This project demonstrated the way for the safe, sustainable and economical management of PFAS contaminated soil.[29]

In addition, tests carried out in the Moose Creek Facility North Pole, Alaska, demonstrated that it is possible to thermally remediate contaminated soil. The analytical results showed the successful removal of regulated PFAS-compounds from contaminated soil to levels below the target clean-up levels set by the Alaska Department of Environmental Conservation (ADEC). The facility consisted of a British thermal unit per hour (Btu/hr) refractory-lined rotary kiln primary combustion unit that exposed waste material to temperatures of up to 815°C. In order to further control emissions, released gasses were treated in a secondary combustion unit with temperatures up to 1200°C, sufficiently elevated temperatures that break down residual PFAS to a non-detectable level.[30]

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[28] Evocra, "OCRA use in decontamination of PFOS, PFOA and short chain precursor contaminated water," March 10, 2017, https://evocra.com.au/source-assets/images/pdf/evocra-pfas-removal-tech-sheet_v3.pdf (accessed Jan. 3, 2022).

[29] RemBind, "Immobilisation of PFAS Soil from Air Force Base in Australia," n.d., https://rembind.com/uploads/Z091-01-RemBind-Case-Study-PFAS-in-Soil-Immobilisation-of-PFAS-Soil-from-RAAF-Base-in-Australia.pdf (accessed Jan. 3, 2022).

[30] Alaska Department of Environmental Conservation, "NRC Alaska, LLC Moose Creek Facility Thermal Remediation PFAS-Contaminated Soil," September 2019, https://dec.alaska.gov/media/18761/nrc-moose-creek-facility-pfas-sep-2019-case-study-v3f-191101.pdf (accessed Jan. 3, 2022).