PFAS Guidance
Reporting to the National Pollutant Release Inventory

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Environment and Climate Change Canada
National Pollutant Release Inventory and Substance Information Division

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1. Introduction

1.1 Background

The National Pollutant Release Inventory (NPRI) is Canada's legislated, publicly accessible inventory of pollutant releases to air, water and land, as well as disposals and transfers for recycling. Reporting facilities include, but are not limited to, facilities that manufacture a variety of goods, mines, oil and gas operations, power plants and sewage treatment plants. Every year, facilities that meet NPRI reporting requirements must report their releases, disposals and transfers of pollutants by the annual deadline. The NPRI is a key resource for identifying and monitoring sources of pollution in Canada. It supports priority setting and monitoring of environmental performance measures, contributes to the compilation of pollution patterns and trends, provides environmental information to the public, and fulfills international reporting obligations.

Per- and polyfluoroalkyl substances (PFAS) are a class of thousands of human-made substances. Some typical uses of PFAS include as surfactants, lubricants, and repellents (for dirt, water, and grease). PFAS can be found in certain firefighting foams, food packaging, drugs, cosmetics, sunscreens, pesticides, textiles (e.g., carpets, furniture, and clothing), non-stick cookware, vehicles, and electronics. Environment and Climate Change Canada (ECCC) has added reporting requirements for 163 individual PFAS to a new Part 1, Group C, of the NPRI substance list beginning with the 2025 reporting year. The list of PFAS added to the NPRI is provided in Table 1 starting on the following page. Reporting of releases, disposals and transfers for an individual PFAS will be required by any facility that meet the employee threshold and that manufactures, processes, or otherwise uses 1 kilogram or more of that individual PFAS at a concentration of ≥0.1%.

For each individual PFAS, the reporting threshold calculation should be based on the **TOTAL** quantity of a substance:

- manufactured, processed or otherwise used at a concentration by weight greater than or equal to the concentration threshold (0.1%), **plus**
- incidentally manufactured, processed or otherwise used as a by-product at any concentration, **plus**
- contained in tailings at any concentration, **plus**
- contained in waste rock that is not clean or inert at any concentration

If facilities or users of this document have information, they would like to share that could help improve this guidance, or if they find that the recommendations are not suitable for their processes or situations, and that alternative approaches or information may be more accurate or better suited, the NPRI would greatly appreciate their input. Please contact the NPRI Helpdesk – inrp-npri@ec.gc.ca

Should any inconsistencies be found between this guide and the Canada Gazette, Part I Notice with respect to substances in the National Pollutant Release Inventory, the Notice will prevail.

1.2 Purpose

PFAS have been utilized across a wide range of industries and applications. Due to their presence in numerous commercial products and industrial processes, this guidance is not exhaustive but provides a general overview of PFAS manufacture, process or otherwise use in certain sectors and activities. It aims as a start to assist facilities in: (i) examining the manufacture, processing or otherwise use thresholds that have been established in order to determine whether reporting to the NPRI is necessary; and (ii) reporting releases, disposals, and transfers of PFAS to the NPRI. Although this guidance focuses on select sectors and applications, the general principles for determining NPRI reporting thresholds are applicable across various industries. Additionally, the chapter on firefighting foam use may be relevant to many sectors involved in such activities as well as the section on the method for estimating PFAS quantities in stormwater.

To accurately perform threshold calculations for activities involving the 163 PFAS listed in the NPRI under Par 1C, it is important to understand the exemption for articles, as some PFAS may already be present in the manufactured articles used in many sectors.

An "article" is defined as a manufactured item that does not release an NPRI substance when it undergoes processing or any other use. When an article is processed and there are no releases, or the releases are recycled with due care, the NPRI substances in that article need not be included in the threshold calculation. Exercising due care means that the facility generated less than one kilogram of a Part 1A substance as waste during the year. There is no quantitative measure of due care in recycling Part 1C (PFAS). Therefore, if an article containing a Part 1C substance is processed or otherwise used and there are releases, the Part 1C substance in the article must be included in the threshold calculation

When facility-specific data is not readily available, facilities are still required to make reasonable efforts to estimate the quantities of NPRI substances that are manufactured, processed, or otherwise used, as well as their potential releases, disposals, and off-site transfers.

For NPRI reporting purposes, if emissions are already monitored or measured under provincial or federal legislation or a municipal bylaw, those measurements must be used to report to the NPRI. However, all releases, disposals or transfers off site for recycling must be included in threshold calculations and reported, unless otherwise specified, not just those that are measured or monitored. An NPRI report is mandatory for any substances that meet the reporting thresholds, regardless of whether the substance is being measured or monitored for other jurisdictions. If emissions are not monitored or measured under provincial or federal legislation or a municipal bylaw**, reasonable efforts must still be undertaken** to gather information on releases, disposals and transfers of a substance.

What is "**reasonable**" depends on individual circumstances but may include additional monitoring for NPRI substances. In deciding whether additional efforts should be undertaken to generate new information for the purposes of NPRI reporting, the following factors, among others, should be considered:

- the health and environmental risks posed by a substance, including whether the substance has been declared toxic under CEPA;
- the relative contribution of the industrial sector to releases, disposals and transfers for recycling of a substance in Canada;
- the relative contribution of the facility to releases, disposals and transfers for recycling of a substance in Canada; and
- the cost of additional monitoring.

General guidance has been provided on the following sectors/activities:

1. Firefighting Foams
2. Textiles, Upholstery, Leather, Apparel, and Carpet Manufacturing
3. Manufacturing of Transportation Vehicles
4. Oil and Gas Production
5. Mining
6. Recovered Paper Processing
7. Wastewater Facilities
8. Non-Hazardous and Hazardous Waste Off-Site Landfill Facilities

Please note the references to fluoropolymers throughout the document is meant to offer additional information on how the use of PFAS could potentially be present within the identified sectors at the time of this document's publication. Currently fluoropolymers are not included in the list of PFAS added to the NPRI. As knowledge regarding PFAS is ever-changing, this document will be updated as more information becomes available.

Table 1: List of PFAS Added to the NPRI

CAS RN	Substance Name
1078715-61-3	1-Propanaminium, 3-amino-N-(carboxymethyl)-N,N-dimethyl-, N-[2-[(γ-ω-perfluoro-C4-20-alkyl)thio]acetyl] derivs., inner salts
108427-53-8	Perfluorohexanesulfonate
113507-82-7	Perfluoro-2-ethoxyethanesulfonic acid
1169706-83-5	3:3 Fluorotelomer carboxylate, ion(1-)
122499-17-6	Perfluoro-2-propoxypropanoate
126105-34-8	Perfluorodecanesulfonate
13252-13-6	Perfluoro-2-propoxypropanoic acid
142636-88-2	2-Propenoic acid, 2-methyl-, octadecyl ester, polymer with 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,12heneicosafluorododecyl 2-propenoate, 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10heptadecafluorodecyl 2-propenoate and 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10heptadecafluorodecyl 2-propenoate and 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,13,13,14,14,14pentacosafluorotetradecyl 2-propenoate
1432017-36-1	Perfluoro-4-methoxybutanoate
143372-54-7	Siloxanes and Silicones, (3,3,4,4,5,5, 6,6,7,7,8,8,9,9,10,10,10heptadecafluorodecyl)oxy Me, hydroxy Me, Me octyl, ethers with polyethylene glycol mono-Me ether
146689-46-5	Perfluoroheptanesulfonate
149724-40-3	8:2 Fluorotelomer sulfonate, ammonium salt
151772-58-6	Perfluoro-3,6-dioxaheptanoic acid
1621485-21-9	Perfluoro(2-((6-chlorohexyl)oxy)ethanesulfonate)
16517-11-6	Octadecanoic acid, pentatriacontafluoro-
1652-63-7	1-Propanaminium, 3-[[(heptadecafluorooctyl)sulfonyl]amino]-N,N,N-trimethyl-, iodide
165457-57-8	Methyl perfluorohexadecanoate
1691-99-2	1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-(2-hydroxyethyl)
171978-95-3	Perfluorododecanoate
175905-36-9	Perfluoropentanesulfonate
1763-23-1	Perfluorooctane sulfonic acid
17741-60-5	2-Propenoic acid, 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12, 12-heneicosafluorododecyl ester
1799325-94-2	2H,2H,3H,3H-Perfluorooctanoate
1799325-95-3	7:3 Perfluorodecanoate
19430-93-4	1-Hexene, 3,3,4,4,5,5,6,6,6-nonafluoro
196859-54-8	Perfluoroundecanoate
20109-59-5	Sodium perfluoroheptanoate
2043-53-0	Decane, 1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8 -heptadecafluoro-10-iodo-
2058-94-8	Perfluoroundecanoic acid
21049-36-5	Heptanoic acid, tridecafluoro-, potassium salt
2127366-90-7	2,2,3-Trifluoro-3-[1,1,2,2,3,3hexafluoro-3-(trifluoromethoxy) propoxy]propanoate
21615-47-4	Hexanoic acid, undecafluoro-, ammonium salt
21652-58-4	Perfluorooctyl ethylene
21934-50-9	Perfluoroheptanesulfonic acid, sodium salt
2196242-82-5	2-[(8-Chloro-1,1,2,2,3,3,4,4,5,5,6,6,7,7, 8,8-hexadecafluorooctyl)oxy]-1,1,2,2-tetrafluoroethanesulfonate
220689-13-4	Perfluoro-2-ethoxyethanesulfonate
2218-54-4	Butanoic acid, 2,2,3,3,4,4,4-heptafluoro-, sodium salt (1:1)
2250081-67-3	Sodium 4,8-dioxa-3Hperfluorononanoate
2263-09-4	1-Octanesulfonamide, N-butyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-(2-hydroxyethyl)-
2355-31-9	2-(N-Methylperfluorooctanesulfonamido)acetic acid
24448-09-7	1-Octanesulfonamide, 1,1,2,2,3,3,4,4,5,5, 6,6,7,7,8,8,8-heptadecafluoro-N-(2-hydroxyethyl)-N-methyl-
25268-77-3	2-[[(Heptadecafluorooctyl)sulfonyl]methylamino]ethyl acrylate
2706-90-3	Perfluoropentanoic acid
2706-91-4	Perfluoropentanesulfonic acid
27619-96-1	8:2 Fluorotelomer sulfonate, sodium salt
27619-97-2	1-Octanesulfonic acid, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro
27854-31-5	2-(Perfluorooctyl)ethanoic acid

CAS RN	Substance Name
27905-45-9	2-Propenoic acid, 3,3,4,4,5,5,6,6,7,7,8,8, 9,9,10,10,10-heptadecafluorodecyl ester
2795-39-3	Perfluorooctane sulfonic acid, potassium salt
2806-15-7	Sodium perfluorodecanesulfonate
29081-56-9	Perfluorooctane sulfonic acid, ammonium salt
29117-08-6	Poly(oxy-1,2-ethanediyl), α-[2-[ethyl[(heptadecafluorooctyl)sulfonyl]amino]ethyl]-ω-hydroxy-
2923-16-2	trifluoroacetate salt of potassium,
2923-18-4	Trifluoroacetic acid, sodium salt
2966-50-9	Trifluoroacetic acid, silver salt
2991-50-6	2-(N-Ethylperfluorooctanesulfonamido)acetic acid
30334-69-1	Perfluorobutanesulfonamide
307-24-4	Perfluorohexanoic acid
307-35-7	Perfluorooctylsulfonyl fluoride
307-55-1	Perfluorododecanoic acid
307-67-5	Perfluorododecanoic acid, sodium salt
31506-32-8	1-Octanesulfonamide, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8heptadecafluoro-N-methyl-
3336-58-1	Trifluoroacetic acid, ammonium salt
335-66-0	Octanoyl fluoride, pentadecafluoro-
335-67-1	Perfluorooctanoic acid
335-76-2	Perfluorodecanoic acid
335-77-3	Perfluorodecanesulfonic acid
335-95-5	Perfluorooctanoic acid, sodium salt
34362-49-7	1,1,2,2-Tetrahydroperfluorohexadecyl acrylate
343629-43-6	Perfluorododecanesulfonate
34395-24-9	2-Propenoic acid, 3,3,4,4,5,5,6,6,7,7,8,8, 9,9,10,10,11,11,12,12,13,13,14,14, 14-pentacosafluorotetradecyl ester
355-46-4	Perfluorohexanesulfonic acid
356-02-5	3:3 Fluorotelomer carboxylic acid
365971-87-5	Perfluorotetradecanoate
37338-48-0	Poly[oxy(methyl-1,2-ethanediyl)], α-[2-[ethyl[(heptadecafluorooctyl)sulfonyl]amino]ethyl]-ω-hydroxy-
375-22-4	Perfluorobutanoic acid
375-73-5	Perfluorobutanesulfonic acid
375-85-9	Perfluoroheptanoic acid
375-92-8	Perfluoroheptanesulfonic acid
375-95-1	Perfluorononanoic acid
376-06-7	Perfluorotetradecanoic acid
376-27-2	Methyl perfluorooctanoate
377-73-1	Perfluoro-3-methoxypropanoic acid
382-21-8	Perfluoroisobutene
3830-45-3	Perfluorodecanoic acid, sodium salt
38436-16-7	Dichloromethyl(3,3,4,4,5,5,6,6,6nonafluorohexyl)silane
3871-99-6	Perfluorohexanesulfonic acid, potassium salt
39108-34-4	8:2 Fluorotelomer sulfonic acid
39187-41-2	Methyl perfluoro-3,6-dioxaheptanoate
414911-30-1	4:2 Fluorotelomer sulfonate
4151-50-2	1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro
425670-75-3	3,3,4,4,5,5,6,6,7,7,8,8,8Tridecafluorooctane-1-sulfonate
45048-62-2	Perfluorobutanoate
45167-47-3	Perfluoropentanoate
45187-15-3	Perfluorobutanesulfonate
45285-51-6	Perfluorooctanoate
45298-90-6	Perfluorooctanesulfonate
474511-07-4	Perfluorononanesulfonate
481071-78-7	3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10Heptadecafluorodecane-1-sulfonate
507-63-1	Perfluorooctyl iodide
53826-12-3	2-(Perfluorohexyl)ethanoic acid

CAS RN	Substance Name
56773-42-3	Ethanaminium, N,N,N-triethyl-, salt with 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8heptadecafluoro-1-octanesulfonic acid (1:1)
59587-39-2	1-Octanesulfonic acid, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro-, ammonium salt
60871-96-7	Sodium perfluoro-n-undecanoate
6130-43-4	Heptanoic acid, tridecafluoro-, ammonium salt
62037-80-3	Hexafluoropropylene oxide dimer acid, ammonium salt
647-42-7	1-Octanol, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro-
65104-45-2	2-Propenoic acid, 2-methyl-, 3,3,4,4,5,5, 6,6,7,7,8,8,9,9,10,10,11,11,12,12,12heneicosafluorododecyl ester, polymer with 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10, 10-heptadecafluorodecyl 2-methyl2-propenoate, methyl 2-methyl2-propenoate, and 3,3,4,4,5,5,6,6,7,7,8,8,8tridecafluorooctyl 2-methyl-2-propenoate
65530-61-2	Poly(difluoromethylene), α-fluoro-ω-[2-(phosphonooxy)ethyl]
65530-62-3	Poly(difluoromethylene), α,α′-[phosphinicobis(oxy-2,1-ethanediyl)]bis[ω-fluoro
65530-63-4	Ethanol, 2,2′-iminobis-, compd. with α-fluoro-ω-[2-(phosphonooxy)ethyl] poly(difluoromethylene) (2:1)
65530-64-5	Ethanol, 2,2′-iminobis-, compd. with α,α′-[phosphinicobis(oxy-2,1-ethanediyl)] bis[ω-fluoropoly(difluoromethylene)] (1:1)
65530-69-0	Poly(difluoromethylene), α-[2-[(2-carboxyethyl)thio]ethyl]-ω-fluoro-, lithium salt (1:1)
65530-70-3	Poly(difluoromethylene), α,α′-[phosphinicobis(oxy-2,1-ethanediyl)]bis[ω-fluoro-, ammonium salt (1:1)
65530-72-5	Poly(difluoromethylene), α-fluoro-ω-[2-(phosphonooxy)ethyl]-, ammonium salt (1:2)
65530-83-8	Poly(difluoromethylene), α-[2-[(2-carboxyethyl)thio]ethyl]-ω-fluoro
65545-80-4	Poly(oxy-1,2-ethanediyl), α-hydro-ω-hydroxy-, ether with α-fluoro-ω-(2-hydroxyethyl)poly(difluoromethylene) (1:1)
65605-58-5	2-Propenoic acid, 2-methyl-, dodecyl ester, polymer with α-fluoro-ω-[2-[(2-methyl-1-oxo-2-propenyl)oxy]ethyl]poly(difluoromethylene)
65605-73-4	Poly(difluoromethylene), α-fluoro-ω-[2-[(1-oxo-2-propenyl)oxy]ethyl]-, homopolymer
65636-35-3	Ethanaminium, N,N-diethyl-N-methyl-2[(2-methyl-1-oxo-2-propenyl)oxy]-, methyl sulfate, polymer with 2-ethylhexyl 2-methyl-2-propenoate, α-fluoro-ω-[2-[(2-methyl-1-oxo-2propenyl)oxy]ethyl]poly (difluoromethylene), 2-hydroxyethyl 2-methyl-2-propenoate and N-(hydroxymethyl)-2-propenamide
67584-58-1	1-Propanaminium, N,N,N-trimethyl-3-[[(pentadecafluoroheptyl)sulfonyl]amino]-, iodide
678-39-7	1-Decanol, 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10, 10,10-heptadecafluoro-
67905-19-5	Perfluorohexadecanoic acid
68140-18-1	Thiols, C4-10, γ-ω-perfluoro
68140-20-5	Thiols, C6-12, γ-ω-perfluoro
68140-21-6	Thiols, C10-20, γ-ω-perfluoro
68187-47-3	1-Propanesulfonic acid, 2-methyl-, 2-[[1-oxo-3-[(γ-ω-perfluoro-C4-16-alkyl)thio]propyl]amino] derivs., sodium salts
68227-96-3	2-Propenoic acid, butyl ester, telomer with 2-[[(heptadecafluorooctyl)sulfonyl] methylamino]ethyl 2-propenoate, 2-[methyl[(nonafluorobutyl) sulfonyl]amino]ethyl 2-propenoate, α-(2-methyl-1-oxo-2-propenyl)-ωhydroxypoly(oxy-1,4-butanediyl), α-(2-methyl-1-oxo-2-propen-1-yl)-ω[(2-methyl-1-oxo-2-propen-1-yl)oxy]poly (oxy-1,4-butanediyl), 2-[methyl[(1,1,2,2,3,3,4,4,5,5,6,6,7,7,7pentadecafluoroheptyl)sulfonyl] amino]ethyl 2-propenoate, 2-[methyl[(1,1,2,2,3,3,4,4,5,5,6,6,6tridecafluorohexyl)sulfonyl]amino] ethyl 2-propenoate, 2-[methyl[(1,1,2,2,3,3,4,4,5,5,5-undecafluoropentyl) sulfonyl]amino]ethyl 2-propenoate and 1-octanethiol
68259-10-9	1-Butanesulfonic acid, 1,1,2,2,3,3,4,4,4-nonafluoro-, ammonium salt
68259-11-0	Pentanoic acid, nonafluoro-, ammonium salt
68259-12-1	Perfluorononanesulfonic acid
68391-08-2	Alcohols, C8-14, γ-ω-perfluoro
68391-09-3	Sulfonic acids, C6-12-alkane, perfluoro potassium salts
68412-68-0	Phosphonic acid, perfluoro-C6-12-alkyl derivs.
68412-69-1	Phosphinic acid, bis(perfluoro-C6-12-alkyl) derivs.
68957-57-3	1-Propanaminium, N,N,N-trimethyl-3-[[(undecafluoropentyl)sulfonyl]amino]-, iodide
68957-58-4	1-Propanaminium, N,N,N-trimethyl-3-[[(tridecafluorohexyl)sulfonyl]amino]-, iodide
68958-60-1	Poly(oxy-1,2-ethanediyl), α-[2-[ethyl[(pentadecafluoroheptyl)sulfonyl]amino]ethyl]-ω-methoxy-
70887-84-2	2H-Perfluoro-2-decenoic acid
70887-88-6	2H-Perfluoro-2-octenoic acid (6:2)

CAS RN	Substance Name
70969-47-0	Thiols, C8-20, γ-ω-perfluoro, telomers with acrylamide
70983-60-7	1-Propanaminium, 2-hydroxy-N,N,N-trimethyl-, 3-[(γ-ω-perfluoro-C6-20-alkyl)thio] derivs., chlorides
72007-68-2	Perfluorononanoate
72629-94-8	Perfluorotridecanoic acid
72654-51-4	Acetic acid, trifluoro-, rhodium(2+) salt
73829-36-4	Perfluorodecanoate
754-91-6	Perfluorooctanesulfonamide
756426-58-1	Perfluoro(2-((6-chlorohexyl)oxy)ethanesulfonic acid)
757124-72-4	2-(Perfluorobutyl)-1-ethanesulfonic acid
76-05-1	Acetic acid, trifluoro-
763051-92-9	11-Chloroperfluoro-3-oxaundecanesulfonic acid
79780-39-5	Perfluorododecanesulfonic acid
798556-82-8	Perfluorooctadecanoate anion
812-70-4	3-(Perfluoroheptyl)propanoic acid
83329-89-9	11-Chloroperfluoro-3-oxaundecanesulfonate, potassium salt
862374-87-6	Perfluorotridecanoate
863090-89-5	Perfluoro-4-methoxybutanoic acid
865-86-1	1-Dodecanol, 3,3,4,4,5,5,6,6,7,7,8,8,9,9, 10,10,11,11,12,12,12-heneicosafluoro
914637-49-3	2H,2H,3H,3H-Perfluorooctanoic acid
919005-14-4	4,8-Dioxa-3H-perfluorononanoic acid
92612-52-7	Perfluorohexanoate
93572-72-6	Sulfonic acids, C6-12-alkane, perfluoro
98789-57-2	Perfluorononanesulfonic acid, sodium salt

2. Firefighting Foams

2.1 Introduction

A firefighting foam is a stable mass of small air-filled bubbles, which has a lower density than oil, gasoline or water. The foam is made up of three ingredients - water, foam concentrate and air.[1] Firefighting foams are divided into two classifications - Class A and Class B.[2]

Class A foam is specifically designed to combat fires involving ordinary combustible materials such as paper, tires, cloth, rubber, many plastics and wooden structures, as well as wildland fires.[3/4] PFAS are not typically used in Class A foams.[5]

Class B foams are used to combat a fire of flammable and combustible liquids such as crude oil, gasoline, diesel, aviation fuel, kerosene, fuel oil, petroleum greases, tars, oil-based paints, solvents, lacquers and alcohols.[6/7] Class B foams are used to principally form a cohesive floating blanket on flammable and combustible liquids.[8] Unlike other extinguishing agents (e.g., water, dry chemical, CO_2, etc.) a stable aqueous foam can extinguish a flammable or combustible liquid fire by the combined mechanisms of cooling, separating the flame/ignition source from the product surface, suppressing vapours and smothering.[9] It can also secure for extended periods of time against reflash or reignition. As a result of these characteristics, Class B foam is the primary fire-extinguishing agent for all potential hazards or areas where flammable liquids are transported, processed, stored or used as an energy source.[10] PFAS are used in some, but not all, Class B foams.

PFAS act as fluorosurfactants in many Class B firefighting foam concentrates. In this capacity, PFAS reduce surface tension by concentrating at the liquid-air interface which results in repelling hydrocarbons. Both characteristics positively impact the firefighting performance of Class B firefighting foams.[11]

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[1] Chemguard Specialty Chemicals and Equipment (2005), *General Foam Information*.

[2] Adhikari, P. (2018), *Understanding Firefighting Foams*.

[3] Tyco Fire Products (2020), *Types of Firefighting Foam Agents – Properties and Applications*.

[4] Fire Industry Association (2018), *Fact File 87 – Fire, the Environment and Foams*.

[5] Tyco Fire Products (2020), *Types of Firefighting Foam Agents – Properties and Applications*.

[6] Fire Industry Association (2018), *Fact File 87 – Fire, the Environment and Foams*.

[7] American Chemistry Council - Alliance for Telomer Chemistry Stewardship (2020), *C_6 Based Firefighting Foams Offer Reliable, Effective, Efficient Performance to Protect Lives and Fight the Toughest Flammable Liquid Fires.*

[8] Adhikari, P. (2018), *Understanding Firefighting Foams*.

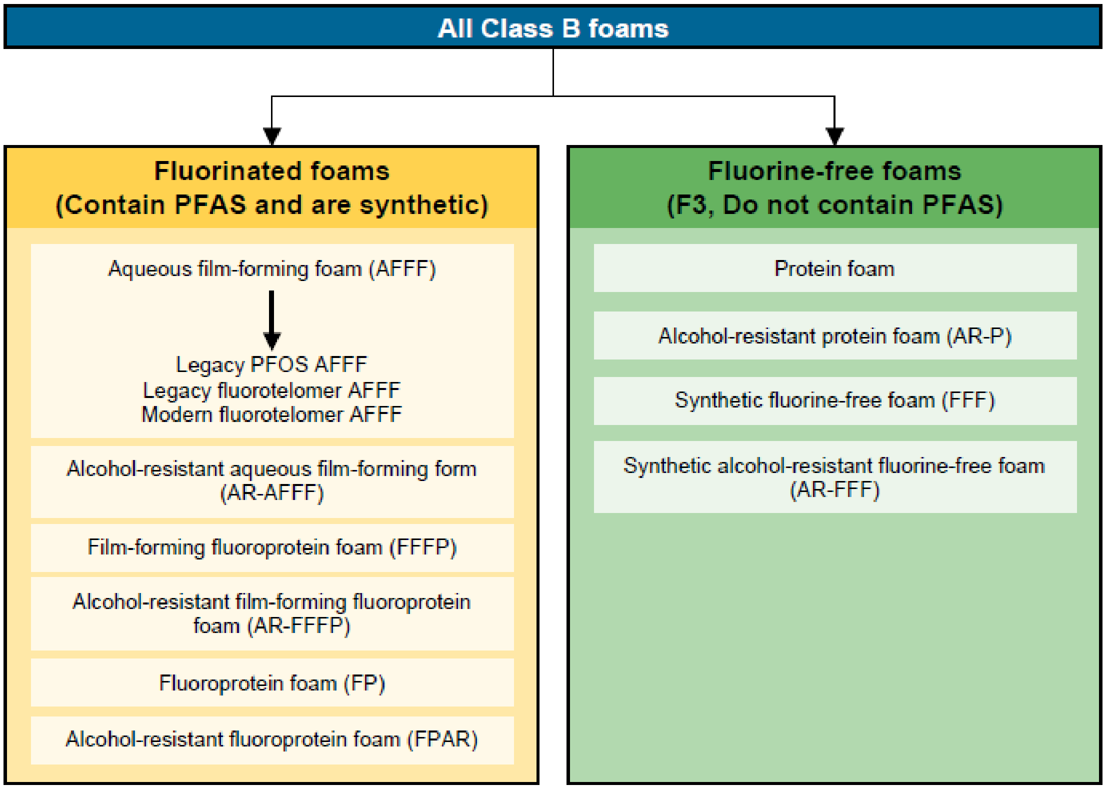
[9] Chemguard Specialty Chemicals and Equipment (2005), *General Foam Information*.

[10] Ibid.

[11] Fire Industry Association (2018), *Fact File 87 – Fire, the Environment and Foams*.

Overall, there are six groups of Class B foams that contain PFAS and four groups of Class B foams that do not contain PFAS.[12]

Figure 1: Types of Class B Foams



Source: Interstate Technology Regulatory Council (2023), *Per- and Polyfluoroalkyl Substances (PFAS).*

Brief summaries of the different types of Class B foams that contain PFAS are as follows:

- **Aqueous Film-Forming Foam** (AFFF) is used for fighting high-hazard flammable liquid fires.[13] AFFF suppresses fires involving petroleum-based products such as liquefied natural gas and rubber as well as flammable and combustible liquids such as diesel fuel, crude oil, and gasoline.[14] AFFF forms an aqueous film that rapidly cuts off the oxygen supply and knocks down the fire. The expanded foam, from which the film is drained, forms a stable blanket that suppresses the release of flammable vapours and cools down the fuel surface extinguishing the fire and preventing reignition. The low surface tension of the water-foam solution enables the aqueous film, although heavier than the burning vapours, to float on top of the liquid surface.[15] The aqueous film is

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[12] Interstate Technology Regulatory Council (2020), *Aqueous Film-Forming Foam (AFFF).*
[13] Ibid.
[14] Tyco Fire Products (2020), *Types of Firefighting Foam Agents – Properties and Applications*.
[15] Viking Corporation (2020), *Viking AFFF 3%M C6 Military Specification Foam Concentrate*.

produced by the fluorochemical surfactant reducing the surface tension of the foam solution.[16]

- **Alcohol-resistant aqueous film-forming foam** (AR-AFFF) is used to fight fires that involve polar solvent/alcohol liquids (e.g., methanol, ethanol, ketones, acetone). These flammable liquids, which readily mix with water, are more difficult to extinguish compared to a hydrocarbon fire. Polar solvent/alcohol liquids destroy any foam blanket that has been generated using standard AFFF. Using plain AFFF concentrate as a base material, a high molecular weight polymer is added during the manufacturing process to produce AR-AFFF. When AR-AFFF is used on a polar solvent fuel fire, the polar solvent fuel tries to absorb water from the foam blanket. A polymer precipitates out forming a physical membrane/barrier between the fuel surface and foam blanket. This barrier then protects the generated foam blanket from destruction by the alcohol fuel.[17]
- **Film-forming fluoroprotein (FFFP) foam** is a derivative of AFFF and fluoroprotein. These concentrates are based on fluoroprotein formulations to which an increased quantity of fluorocarbon surfactants have been added. FFFP concentrates were developed to obtain the quick knockdown of AFFF with the added burnback resistance of standard fluoroprotein foam.[18] FFFP foams release an aqueous film on the surface of the hydrocarbon fuel.[19]
- **Alcohol-resistant film-forming fluoroprotein** (AR-FFFP) **foams** are produced from a combination of protein foam, fluorochemical surfactants and polysaccharide polymer. AR-FFFP foams form an aqueous film on the surface of the hydrocarbon fuel. When used on polar solvents (or water miscible fuels), the polysaccharide polymer forms a tough membrane which separates the foam from the fuel and prevents the destruction of the foam blanket.[20]
- **Fluoroprotein** (FP) **foam** is made by adding special fluorochemical surfactants to protein foam which enhances performance with fast knockdown, improved resistance to fuel pick-up, dry chemical compatibility and an easier flowing foam. They are intended for use on hydrocarbon fuels and select oxygenated fuel additives.[21] FP foam is also used in the hydrocarbon processing industry for storage tank fire fighting.[22/23]
- **Alcohol-resistant fluoroprotein** (FPAR) **foam** combines hydrolyzed protein with fluorochemical surfactants to produce a foam blanket with good heat stability and burnback resistance. It is intended for forceful or gentle firefighting applications of hydrocarbon fuels and gentle firefighting applications of polar solvent fuels.[24]

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[16] National Foam (2002), *A Firefighter's Guide to Foam*.

[17] Chemguard Specialty Chemicals and Equipment (2005), *General Foam Information*.

[18] Adhikari, P. (2018), *Understanding Firefighting Foams*.

[19] National Foam (2002), *A Firefighter's Guide to Foam*.

[20] Ibid.

[21] Ibid.

[22] Tyco Fire Products (2020), *Types of Firefighting Foam Agents – Properties and Applications*.

[23] Chemguard Specialty Chemicals and Equipment (2005), *General Foam Information*.

[24] Sabo Foam (2019), *Univex 3-3 M FPAR Foam Concentrate*.

It should be noted that, fluorinated foams could contain perfluorooctane sulfonate (PFOS), its salts and precursors, perfluorooctanoic acid (PFOA), its salts and precursors long-chain perfluorocarboxylic acids (LC-PFCAs), their salts and precursors and other PFAS substances. For information, see Appendix 1 for a list of PFAS added to the NPRI that could potentially be found in fluorinated foams. However, other PFAS that are not listed in the Appendix 1 might be part of fluorinated foams formulations. When reporting, consult Table 1 List of PFAS Added to the NPRI.

2.2 Determine if NPRI Reporting Thresholds are Met

The NPRI reporting threshold for each individual PFAS is 1 kg manufactured, processed or otherwise used (MPO) at ≥0.1% concentration. To determine if the facility meets this reporting threshold, calculations regarding the firefighting foam concentrate are required.

Step 1: Determine if the Firefighting Foam Concentrate Manufactured, Processed or Otherwise Used Contains PFAS

Class A foam concentrates typically do not contain PFAS. Many Class B foam concentrates contain PFAS, while others do not. To determine if PFAS is contained in the Class B firefighting foam concentrates manufactured, processed or otherwise used at the facility, the following can be undertaken:

- Identify the type of Class B foam concentrate manufactured, processed or otherwise used at the facility to determine if it is one of the six types of Class B foam concentrates that contain PFAS, as described earlier in this chapter. The type of Class B foam concentrate is typically indicated on the container of the concentrate.
- Review the Safety Data Sheet and/or Technical Data Sheet for the Class B foam concentrate manufactured, processed or otherwise used at the facility to identify whether the concentrate contains PFAS or the type of Class B foam concentrate.
- The supplier or the manufacturer of the Class B foam concentrate may be contacted.

If the facility uses Class A foam concentrate and there is uncertainty whether it could contain PFAS, it is recommended that further reasonable efforts be conducted to determine whether PFAS are present in the foam. This may involve reviewing product documentation, contacting the supplier or manufacturer for chemical composition details, consulting published literature or performing analytical testing if necessary.

Step 2: Determine the Individual PFAS and their Concentrations in the Class B Foam Concentrates Manufactured, Processed or Otherwise Used

The NPRI reporting requirements are for individual PFAS. The Safety Data Sheet or the supplier/manufacturer of the Class B foam concentrate may be consulted to determine the concentration of individual PFAS in the concentrate. These individual PFAS need to be identified by Chemical Abstract Service Registry Number (CAS RN).

The list of PFAS (by CAS RN) contained in the foam concentrate should be compared to the list of 163 PFAS that have been added to the NPRI. This list was provided in Chapter 1 of this guidance document.

Only individual PFAS (that have been added to the NPRI) in the Class B foam concentrate that are present at concentrations ≥0.1% may need to be reported to the NPRI.

If the Class B foam concentrate that is being manufactured, processed or otherwise used at the facility does not contain any individual PFAS (that have been added to the NPRI) at concentrations ≥0.1%, then reporting to the NPRI is not required.

If individual PFAS, that have been added to the NPRI, are determined to be present in the Class B foam concentrate that is manufactured, processed or otherwise used at the facility in concentrations ≥0.1%, then proceed onto Step 3.

Step 3: Calculate the Quantity of Class B Foam Concentrate Containing PFAS that was Manufactured, Processed or Otherwise Used for the NPRI Reporting Year

Determine the volume (in litres) of Class B foam concentrate manufactured, processed or otherwise used at the facility from available accounting records, equipment gauges or other means.

If gauges are not available on equipment to determine how much Class B foam concentrate was used during firefighting events (or other events such as equipment malfunctions), then the quantity of Class B foam concentrate that was purchased or transferred from storage to in-service equipment to replace concentrate that was used during firefighting events can be used to estimate quantities consumed.

It is important to note that the purchase of Class B foam concentrate is not considered "processed". However, the transfer of Class B firefighting foam concentrate from storage to in-service equipment or the blending of firefighting foam concentrate is considered to be "processing".

Once the volume of Class B foam concentrate that was manufactured, processed or otherwise used at the facility during the NPRI reporting year is determined, convert this amount in liters to kilograms using the density of the foam. Class B foam concentrate densities are typically in the range of 1.01-1.10 kg/L.[25] The following equation should be used:

$$W_{kg} = V_L \ x \ Density_{kg/L}$$

Where:

- W_{kg} = Quantity of Class B foam concentrate manufactured, processed or otherwise used during the NPRI reporting year, in kilograms.
- V_L = Volume of Class B foam concentrate manufactured, processed or otherwise used during the NPRI reporting year, in liters.
- $Density_{kg/L}$ = Density of the Class B foam concentrate in kg/L.

This calculation needs to be undertaken for each Class B foam concentrate (containing individual PFAS that have been added to the NPRI) that was manufactured, processed or otherwise used at the facility during the NPRI reporting year.

It should be noted that the weight of Class B foam concentrate may already be available in product literature provided by the manufacturer/supplier. In these instances, the above calculation will not be necessary.

Step 4: Calculate the Quantity of Individual PFAS Contained in the Class B Foam Concentrate Manufactured, Processed or Otherwise Used for the NPRI Reporting Year

From Step 2, the concentration of individual PFAS in the Class B foam concentrate manufactured, processed or otherwise used at the facility and which have been added to the NPRI will have been determined. This concentration will typically be outlined in percentage (%) terms. Apply those percentages to the total quantity (in kg) of Class B foam concentrate (containing relevant PFAS) that was manufactured, processed or otherwise used at the facility during the NPRI reporting year. Use the following formula:

$$PFAS^i_{kg} = W^i_{kg} \ x \ Concentration^i_{\%}$$

Where:

- $PFAS^i_{kg}$ = Quantity of PFAS chemical *i* contained in the Class B foam concentrate manufactured, processed or otherwise used at the facility during the NPRI reporting year, in kilograms.
- W^i_{kg} = Quantity of Class B foam concentrate (containing PFAS chemical *i*) manufactured, processed or otherwise used during the NPRI reporting year, in kilograms.
- $Concentration^i_{\%}$ = Concentration of PFAS chemical *i* contained in the Class B foam concentrate manufactured, processed or otherwise used at the facility during the NPRI reporting year, expressed in percentage terms.

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[25] A total of 14 different product specification sheets were reviewed. All of these sheets showed densities in this range. The densities for these 14 products can be found in Appendix A to this report.

The above calculation needs to be repeated for all individual PFAS chemicals that have been added to the NPRI and that are contained in the Class B foam concentrate that was manufactured, processed or otherwise used at the facility during the NPRI reporting year.

The above calculation also needs to be repeated for each different Class B foam concentrate that contains individual PFAS (that have been added to the NPRI) that was manufactured, processed or otherwise used at the facility during the NPRI reporting year.

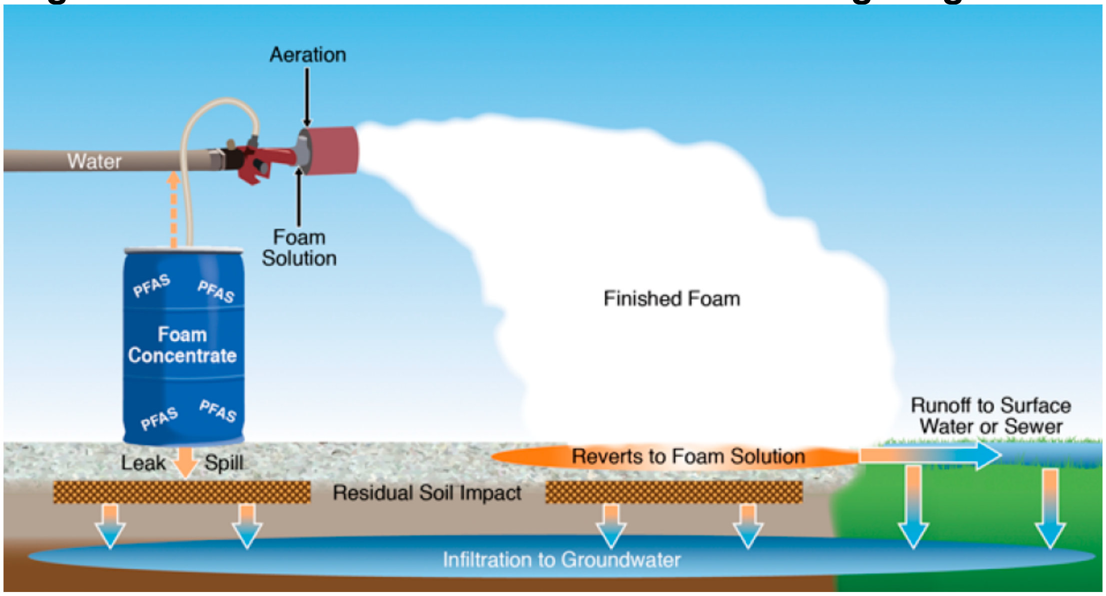
Ensure to aggregate the quantity of individual PFAS (defined as having separate CAS RNs) present in different Class B foam concentrates that are manufactured, processed or otherwise used at the facility during the NPRI reporting year. For individual PFAS calculated to be present in Class B foam concentrates manufactured, processed or otherwise used at the facility in quantities ≥1 kg during the NPRI reporting year, reporting of releases, transfers and disposals to the NPRI is required (as long as those individual PFAS are contained in the Class B foam concentrate at concentrations greater than 0.1%). Please see the next section for guidance.

If there are no individual PFAS (that have been added to the NPRI) that are calculated to be present in Class B foam concentrates that were manufactured, processed or otherwise used in quantities ≥1 kilogram during the NPRI reporting year, then reporting of releases, transfers and disposals of PFAS to the NPRI is not required.

2.3 Estimating Releases, Transfers and Disposals

Releases of PFAS and generation of PFAS-containing waste from firefighting foam concentrate/foam can occur over several different lifecycle stages at a facility. Releases generally occur to surface water, groundwater, stormwater and sewer systems, soil and sediment. PFAS-containing waste could be generated due to firefighting foam use events, spills/leaks/accidental discharges, removal of unused concentrate, etc.

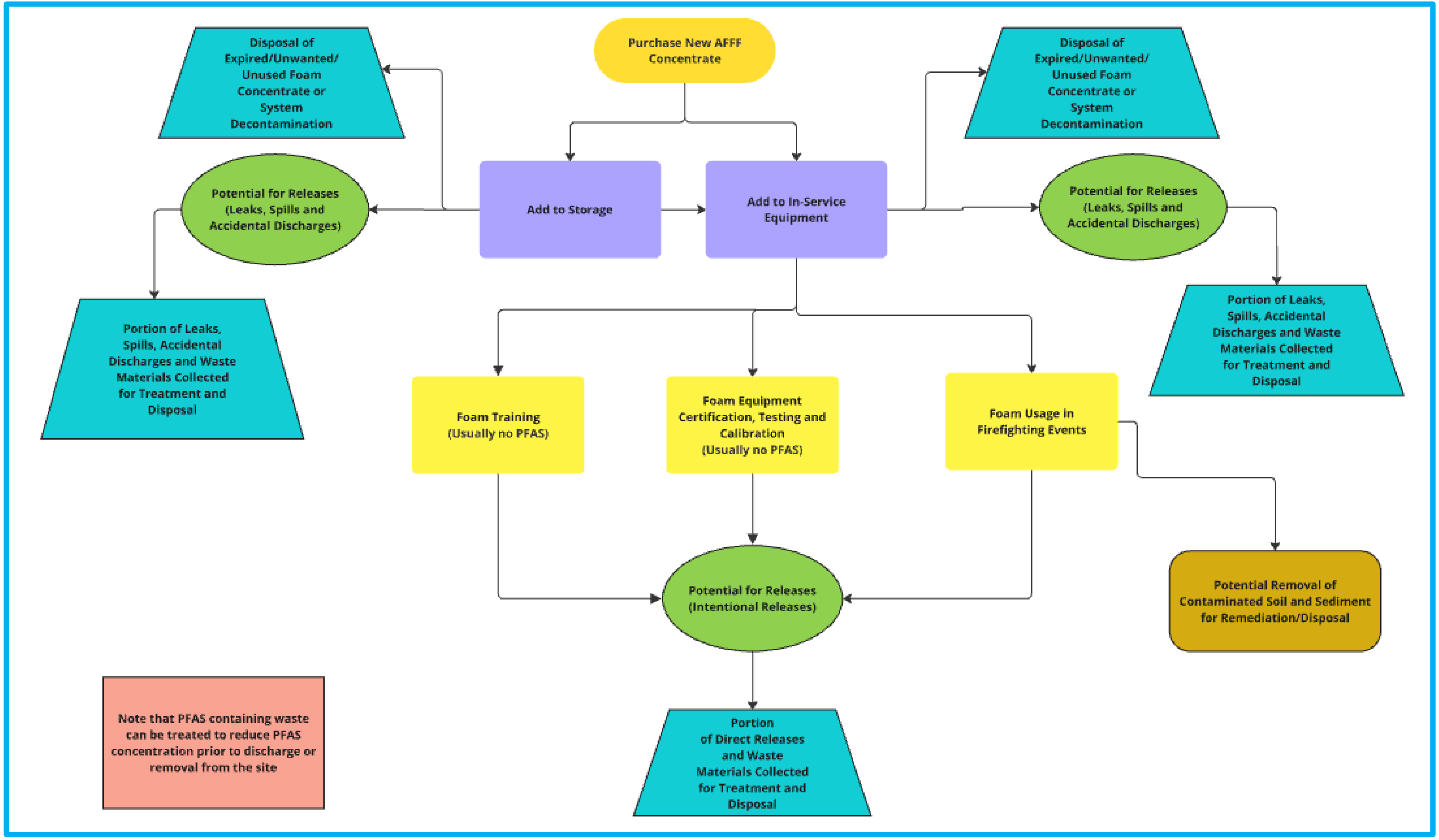
Figure 2: Sources of PFAS Releases from Firefighting Foams



Source: Interstate Technology & Regulatory Council (2023), *PFAS Technical and Regulatory Guidance Document and Fact Sheets*.

For those individual PFAS that met the threshold for reporting to the NPRI, all occurrences of those individual PFAS during manufacturing, processing or other use activities at the facility during the NPRI reporting year have to be taken into consideration when determining releases, transfers and disposals (e.g., even if that individual PFAS is contained in Class B firefighting foam concentrate at less than 0.1% concentration).

Figure 3: Process-Flow Diagram for PFAS Movements in Firefighting Foams and Potential for Releases/Disposals/Transfers



Source: Cheminfo Services Inc.

Step 1: Determine which Activities/Events During the NPRI Reporting Year Resulted in PFAS Releases, Transfers and/or Disposals

Firefighting foam concentrate and foam can be released into the environment, disposed of on-site or transferred off-site as a result of various activities and events. An assessment of these activities and events should be undertaken to determine which occurred during the NPRI reporting year and which involved PFAS. The key activities and events to consider are as follows – please note that other activities and events not listed may be appliable to your facility and should be considered, if relevant:

1. **Use of Firefighting Foams During Firefighting Events** – This can lead to PFAS releases to the environment and the collection of PFAS-containing waste materials (e.g., foam solution, fire wastewater and foam runoff, and rinse water/flushing from the cleaning of equipment at the scene). Releases to the environment may need to be reported to the NPRI when the event occurs at a facility and the threshold is met. In some instances, it is possible to contain and collect these waste streams in a contained area or tank through the use of ditching, dams, berms, booms, dikes or trenches as well as blocking storm drains, culverts or other surface inlets. In addition, collection of large volumes of the foam concentrate or the spent foam solution can be accomplished with pumps or vacuum trucks while absorbent material might suffice to clean up after a smaller release. Collected materials may trigger NPRI reporting even if the firefighting event occurs off the facility site[26/27/28] and then the quantity disposed of or transferred for recycling or treatment before final disposal should be reported.
2. **Disposal of Expired/Unwanted/Unused Foam Concentrate** – Facilities which engage in firefighting operations sometimes have reason to remove PFAS-containing foam concentrates, for instance due to the expiry of the foam concentrate or the movement to fluorine-free foam concentrates. This concentrate could be removed from storage or from actual in-service equipment. There are a variety of initiatives that are used to remove foam concentrate from the facility, for instance through government sponsored initiatives to encourage disposal, programs operated by the manufacturer/supplier, removal by a hazardous waste management company at a cost, donation to fire-fighting training institutes, etc. If being disposed of, this foam concentrate is often transferred for treatment before final disposal to a hazardous waste incinerator or solidified and forwarded to a hazardous waste landfill.
3. **Unplanned Releases** – PFAS-containing concentrate or foam solution can be released from in-service equipment or from storage by spills, leaks and accidental discharges (e.g., due to faculty or malfunctioning equipment). Attempts are typically made to contain and capture these unplanned releases (e.g., drip-trays/bunds around the foam

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[26] Fire Fighting Foam Coalition (2016), *Best Practice Guidance for Use of Class B Fire Fighting Foams***.**

[27] Interstate Technology & Regulatory Council (2023), *PFAS Technical and Regulatory Guidance Document and Fact Sheets*.

[28] Ireland Environmental Protection Agency (undated), *The Changing Nature of Fire-Fighting Foams - Understanding the Risk Posed by PFAS.*

concentrate containers) in which case PFAS-containing waste will typically need to be removed from the facility site.[29]

4. **System Decontamination** – Transitioning to fluorine-free foam concentrates can require the cleaning of system components (e.g., storage containers, stationary and mobile firefighting systems, piping) prior to the introduction of the new foam concentrate. These cleaning operations can involve triple-rinsing with water, hot water rinsing, rinsing with low- or high-temperature solvents or acids, etc. In these instances, PFAS-containing waste (e.g., flush/rinsing water) will be generated, collected and typically transferred for treatment prior to final disposal (e.g., high-temperature incineration, solidification) or disposed off site (e.g., downhole injection).[30]
5. **Certification/Testing/Maintenance of Firefighting Systems** – Fixed and mobile firefighting equipment requires inspection, calibration, and testing to ensure reliable performance during an actual fire event. For instance, testing typically occurs pursuant to the installation of the system and maintenance tests can be conducted annually. Surrogate liquids, fluorine-free foam or water that does not contain PFAS are typically used for this testing/maintenance with containment systems utilized (i.e., for complete containment, capture, and subsequent disposal).[31]
6. **Training** – Periodic training is conducted on fixed and mobile firefighting equipment. Typically, alternative fluids that do not contain PFAS (e.g., fluorine-free foams, training foams or water) are used during this training. This training is normally conducted under conditions conducive to the containment and collection (and subsequent treatment and disposal) of spent foam and wastewater.
7. **Remediation of Contaminated Soil/Sediment** – The use of PFAS-containing firefighting foam concentrate can lead to the contamination of soil/sediment at the facility site. Soil/sediment containing PFAS that is removed for remediation could include the immediate removal of a small amount of these materials after an event to prevent more widespread contamination as well as more extensive and longer-term remediation after an event.[32]

Step 2: Determine Quantity of Class B Foams Released to the Environment or Transferred or Disposed as Waste Materials for Each Relevant Activity/Event

It is necessary to determine the quantity (in litres) of Class B foam concentrate (containing PFAS) that was released to the environment, disposed of or transferred in waste materials for each category of activity/event listed in step 1 that occurred during the NPRI reporting

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[29] Interstate Technology & Regulatory Council (2023), *PFAS Technical and Regulatory Guidance Document and Fact Sheets*.

[30] American Petroleum Institute (2020), *Firefighting Foam Transition Guidance*.

[31] Interstate Technology & Regulatory Council (2023), *PFAS Technical and Regulatory Guidance Document and Fact Sheets*.

[32] Queensland Department of Environment and Heritage Protection (2016), *Operational Policy – Environmental Management of Firefighting Foam*.

year. If there was more than one instance of the activity/event that occurred during the NPRI reporting year, then all have to be taken into consideration.
There are no release factors available to assist in this estimation as these activities/events are unique to each facility in terms of number, size and location of the activity/event. The volume of Class B foam concentrate (in litres) that was released directly to the environment, disposed of or transferred in waste materials may be calculated based upon accounting records, equipment gauges or other means. If gauges are not available on equipment to determine how much Class B foam concentrate was released, disposed of or transferred in waste materials, then the quantity of Class B foam concentrate that was purchased or transferred from storage to in-service equipment to replace concentrate that was released during the specific activity/event can be used to estimate quantities.

Once the volume of Class B foam concentrate that was released to the environment, disposed of or transferred as waste materials at the facility during the NPRI reporting year for each relevant activity/event is determined, convert this amount in liters to kilograms using the density of the foam. Class B foam concentrate densities are typically in the range of 1.01-1.10 kg/L. The following equation should be used:

$$W_{kg} = V_L \ x \ Density_{kg/L}$$

Where:

- W_{kg} = Quantity of Class B foam concentrate released, disposed of or transferred during the NPRI reporting year for each relevant activity/event, in kilograms.
- V_L = Volume of Class B foam concentrate released, disposed of or transferred during the NPRI reporting year for each relevant activity/event, in litres.
- $Density_{kg/L}$ = Density of the Class B foam concentrate in kg/L.

This calculation needs to be undertaken for each activity/event that resulted in discharges of Class B foam concentrate at the facility during the NPRI reporting year, whether directly to the environment (releases) or in waste materials (disposals or transfers).

Step 3: Calculate the Quantity of Individual PFAS Contained in the Class B Foam Concentrate Released During the NPRI Reporting Year

When determining if the NPRI reporting threshold was met (see section 2 of this chapter), the concentration of individual PFAS in the Class B foam concentrate manufactured, processed or otherwise used at the facility and which have been added to the NPRI was determined. This concentration will typically be outlined in percentage (%) terms. Apply those percentages to the total quantity (in kg) of Class B foam concentrate that was released to the environment, disposed of or transferred in waste materials at the facility during the NPRI reporting year as determined in step 2. Use the following formula:

$$PFAS^i_{kg} = W^i_{kg} \ x \ Concentration^i_{\%}$$

Where:

- $PFAS^i_{kg}$ = Quantity of PFAS chemical *i* contained in the Class B foam concentrate released, disposed of or transferred during the NPRI reporting year, in kilograms.
- W^i_{kg} = Quantity of Class B foam concentrate (containing PFAS chemical *i*) released, disposed of or transferred during the NPRI reporting year, in kilograms.
- $Concentration^i_{\%}$ = Concentration of PFAS chemical *i* contained in the Class B foam concentrate that was released, disposed of or transferred during the NPRI reporting year, expressed in percentage terms.

The above calculation needs to be undertaken for each category of activity/event that resulted in releases of Class B foam either directly to the environment or to disposals or transfers of waste materials during the NPRI reporting year. In addition, this calculation needs to be undertaken for each individual PFAS chemical (meeting the NPRI reporting threshold) that has been added to the NPRI and which is contained in the Class B foam concentrate that was released or disposed of at the facility or transferred off-site during the NPRI reporting year.

Step 4: Take into Consideration Any Treatment Technologies Applied

It is important to take into consideration any on-site treatments applied that can reduce the PFAS content of releases/wastes prior to being actually released to the environment, disposed of on-site or removed off-site for treatment/disposal. For instance, finished PFAS-containing foam and runoff water can be treated with granular activated carbon (GAC) filtration (Spent GAC, which accumulates PFAS, can either be disposed of as a PFAS-containing waste or transferred for regeneration. In both cases, the PFAS must be considered respectively as disposed of or further transferred for treatment prior to final disposal) or other methods on-site to reduce PFAS concentrations.[33] The treatment efficiencies, in terms of reducing PFAS concentration, of these technologies should be applied to the quantity of the individual PFAS chemicals that were calculated in step 3 above using the following formula:

$$PFAS^i_{kg-Controlled} = PFAS^i_{kg-Uncontrolled}\ x\ (1\text{-}Treatment\ efficiency_{\%}/100)$$

Where:

- $PFAS^i_{kg\text{-}Controlled}$ = Quantity of PFAS chemical *i* subsequent to the application of treatment technologies to reduce PFAS concentration, in kilograms.
- $PFAS^i_{kg\text{-}Uncontrolled}$ = Quantity of PFAS chemical *i* contained in the Class B foam concentrate released disposed of or transferred during the NPRI reporting year, in kilograms. This quantity is prior to any PFAS treatment technology being applied to material or waste that is collected before releases, disposals or transfers occur.
- Treatment efficiency% = Reduction in PFAS content due to the utilization of treatment technologies, such as granular activated carbon, expressed in percentage terms.

Facilities are encouraged to access information on treatment efficiency from their technology suppliers, taking into account their site-specific conditions, the technologies

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[33] Minnesota Pollution Control Agency (2024), *Firefighting Foam Use, Replacement and Disposal.*

employed, pretreatment methods utilized, and any other factors that may impact the treatment efficiencies of their systems.

Step 5: Allocate Estimated Releases, Disposals and Transfers of PFAS Chemicals According to NPRI Reporting Categories

Step 4 will have estimated the quantity (in kilograms) of individual PFAS chemicals that were released (to the environment or waste materials) during the NPRI reporting year, subsequent to any treatment technologies applied to reduce PFAS concentration. It is then necessary to allocate this quantity to the NPRI reporting categories that have been established for on-site releases or to the on-site/off-site disposals and transfers of waste materials. These categories are as follows:

- Air Emissions – stack/point, storage tanks and related handling, fugitive, spills/other accidental releases, other.
- Water Releases – direct discharges, spills, leaks.
- Land Releases – spills, leaks, other.
- On-site Disposal – landfill, land treatment, underground injection, tailings, waste rock.
- Off-site Disposal – landfill, land treatment, underground injection, storage, tailings, waste rock.
- Transfers for Treatment Prior to Final Disposal– physical treatment, chemical treatment, biological treatment, incineration or thermal, transfer to a municipal wastewater treatment plant.
- Transfers for Recycling – energy recovery, solvent recovery, organic compound recovery, metal recovery, inorganic compound recovery, acid or base recovery, catalyst recovery, pollution abatement residue recovery, used oil refining/reuse.

When assessing the environmental release of PFAS in firefighting activities, both fire training and fire intervention should be considered. The use of firefighting foam can lead to the release of PFAS, which may be released into the air, land, or water bodies. Spent firefighting foam can also be contained for disposal and/or transfer, for example, transferred to a municipal wastewater treatment facility, or other treatment options such as incineration. It is important to note that firefighting foam application can lead to air releases in the form of mist or aerosols. Facilities could consult with suppliers for any available information to help quantify these emissions. Site monitoring data, data from similar applications, expert judgment, and mass balance methods can be used to estimate the quantities of PFAS released, disposed, or transferred.

If no information is available, and there is no containment of the firefighting foam after discharge, air releases can be considered negligible. In this case, the release must be reported to land and/or water. Depending on the circumstances, it should be assumed that 50% of the release enters surface water without treatment or is transferred to a wastewater facility, while the remaining 50% is released to land as a spill.[34/35] If this assumption does not apply, the entire release should be reported as a spill to land. The proposed partitioning approach may be considered by the reporting facility when site-specific data or expert advice is not available. However, It is important to clarify that each reporting facility should assess its own site conditions and consult subject matter experts to determine the most appropriate approach to estimate the environmental partitioning of used firefighting foams given that literature-based assumptions may not be generally applicable.

Quantification of storm water releases is required if a facility has data on the concentration of NPRI-listed PFAS substances in its discharges. Determination of the amount of NPRI PFAS substances released in storm water run-off involves: (i) calculating the total amount of volumetric run-off from the site; and (ii) applying the measured or estimated concentration of PFAS (that have been added to the NPRI Substance List) to that volume.

To calculate the total volume of run-off, the facility must determine the total area drained by each outfall, and the weighted average run-off coefficient for that area. Each coefficient is dependent on a specific area's soil structure, topography, usage and development. The coefficient represents the amount of rainfall that "runs off" the ground as storm water (i.e. does not soak into the ground). One way to calculate the flow rates from stormwater runoff is the Rational Method (Toxic Chemical Release Inventory Reporting Forms and Instructions):

Once the volumetric flows are determined, the facility must apply the correct concentration (found through sampling during the event, average stormwater monitoring data or assumed based on available data) at each outfall, to each outfall's flow. Prescribing stormwater sampling methodologies falls outside the scope of the NPRI. However, facilities may follow any applicable requirements related to stormwater sampling procedures as outlined in their operating permit, approval, authorization, license, certificate, or relevant provincial or territorial environmental programs. The following resources are provided for informational purposes only, as potential guidance on stormwater sampling procedures:

- Ontario Protocol for Conducting a Storm Water Control Study
- USEPA Industrial Stormwater Monitoring and Sampling Guide

$$PFAS^{i}_{kg} = A \times I \times RC \times C_{PFAS^{i}} \times 10^{3}_{l/m^{3}} \times 10^{-12}_{kg/ng}$$

Where:

- $PFAS^{i}_{kg}$: Quantity of PFAS substance *i* discharged during the year via surface runoff, kg/year
- A = Land aera of the facility covered by the stormwater, m^2
- I = Rainfall intensity, which is the average annual precipitation, m/year

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[34] Brooke et al., (2004), *Environmental Risk Evaluation Report: Perfluorooctanesulphonate (PFOS). Environment Agency, Wallingford.*

[35] Zhaoyang et al. (2017), *Pollution Pathways and Release Estimation of Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA) in Central and Eastern China.*

- RC = Runoff coefficient
- C_{PFAS}^{i}: Average surface water concentration, ng/L.

Rainfall intensity can be obtained from an on-site weather station or from the nearest weather station from the Government of Canada. Canadian Climate Normals - Climate - Environment and Climate Change Canada offers normals and average climate information, presented in monthly and annual tables, including precipitation intensity for various locations across Canada.

Averaged storm-water runoff coefficients can be obtained from Toxic Chemical Release Inventory Reporting Forms and Instructions (EPA 2023):

Table 2: Averaged Storm-Water Runoff Coefficients

Type of Use	Run-off Coefficient
Heavy Industrial Use	(RC = 0.75)
Light Industrial Use	(RC = 0.65)
Paved and/or Roofed	(RC = 0.90)
Railroad Yard Areas	(RC = 0.30)
Unimproved Areas	(RC = 0.20)
Grassed Areas	(RC = 0.25)

3. Textiles, Upholstery, Leather, Apparel, and Carpet Manufacturing

3.1 Introduction

PFAS are used in textiles, upholstery, leather, apparel and carpets (TULAC) in two main applications: (i) highly porous fabrics (e.g. Gore-Tex®) used in outdoor wear and camping accessories; and (ii) side-chain fluorinated polymers used as finishes to modify the surfaces of TULAC to impart water, oil, soil and staining resistance.[36] The finishes/treatments are applied to materials in mills/tanneries and as aftermarket applications by professionals or consumers as aqueous dispersions.[37]

TULAC materials treated with PFAS exhibit the following:

- waterproof properties (lower water permeability and wettability);
- chemical resistance and inertness;
- protection against exposure to liquids such as blood and other body fluids, but also chemicals and electrical discharge;
- robust mechanical properties (e.g. resistance to abrasion) and the provision of low friction;
- weatherability including UV protection and resistance to corrosion from salt water; and
- resistance to high temperatures (thermally stable).[38]

The table below contains examples of the main TULAC product-types known to be treated with PFAS, including information on sub-categories and the technical function of the PFAS within each subcategory.

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[36] OECD, (2013), *Synthesis Paper on Per- and Polyfluorinated Chemicals (PFCs).*

[37] European Chemicals Agency, (2023), *Annex to the Annex XV Restriction Report - Proposal for a Restriction, Per- and Polyfluoroalkyl Substances (PFASs).*

[38] Ibid.

Table 3: Overview of TULAC Categories Containing PFAS

Major Use Category	Subcategory-Uses with Examples Included	Technical Function of PFAS
Home Textiles	Carpets and rugs	Water repellence, oil repellence
	Curtains and blinds	Water repellence, oil repellence
	Textile based coverings (e.g. fabrics for soft-furnishings, tablecloths, bedding)	Water repellence, oil repellence
Consumer Apparel and Accessories	Indoor and outdoor wear	Water repellence
	Sportswear	Water repellence, oil repellence
	Footwear	Water repellence, oil repellence
	Accessories (e.g. umbrellas, bags, wallets)	Water repellence
Professional Apparel	Professional sportswear and footwear	Water repellence, oil repellence
	PPE for industrial and professional use (other than sportswear)	Water repellence, oil repellence, stain-resistance, soil protection
Technical Textiles	Outdoor technical textiles (e.g. canvas, awnings, tarps, tents, sails, rope)	Water repellence, oil repellence, stain-resistance, soil protection
	Medical applications (e.g. surgical drapes, gowns, curtains)	Water repellence, oil repellence, stain-resistance
	High performance membranes (e.g. automotive and medical)	Water repellence, oil repellence, stain-resistance, thermal stability
Leather Applications	Leather based goods (e.g. leather bags, wallets, belts)	Water repellence, oil repellence
	Indoor and outdoor wear	Water repellence, oil repellence
	Footwear	Water repellence, oil repellence
	Professional sportswear and footwear	Water repellence, oil repellence
Other	Home fabric treatments (sprays) for leather/textiles	Water repellence, oil repellence, stain-resistance, soil protection

Source: ECHA, (2023), *Annex to the Annex XV Restriction Report - Proposal for a Restriction, Per- and Polyfluoroalkyl Substances (PFASs).*

A variety of PFAS are used within TULAC applications, categorized into perfluoroalkyl acids (PFAAs) and PFAA precursors (including side-chain fluorinated polymers) and polymeric PFASs.[39] Over 75% of the PFAS used in TULAC applications are fluoropolymers, almost half of which is PTFE. Other fluoropolymers used include PVDF, PFPE, FEP, PFA, and others.[40] Polymeric PFAS are not amongst the individual PFAS that have been added to the NPRI.

Leather processing and textile manufacturing are distinct. Two process flow diagrams have been included below – the first for leather processing and the second for textiles.

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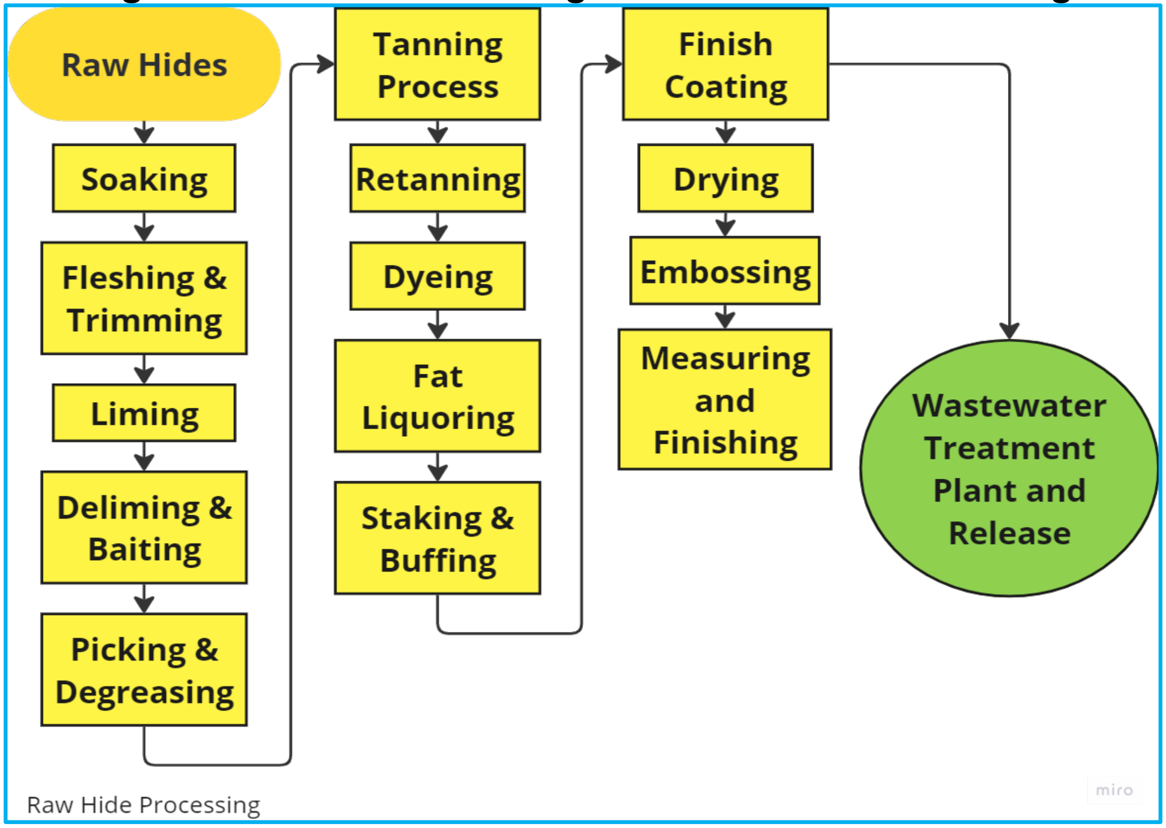
[39] Ibid.

[40] Ibid.

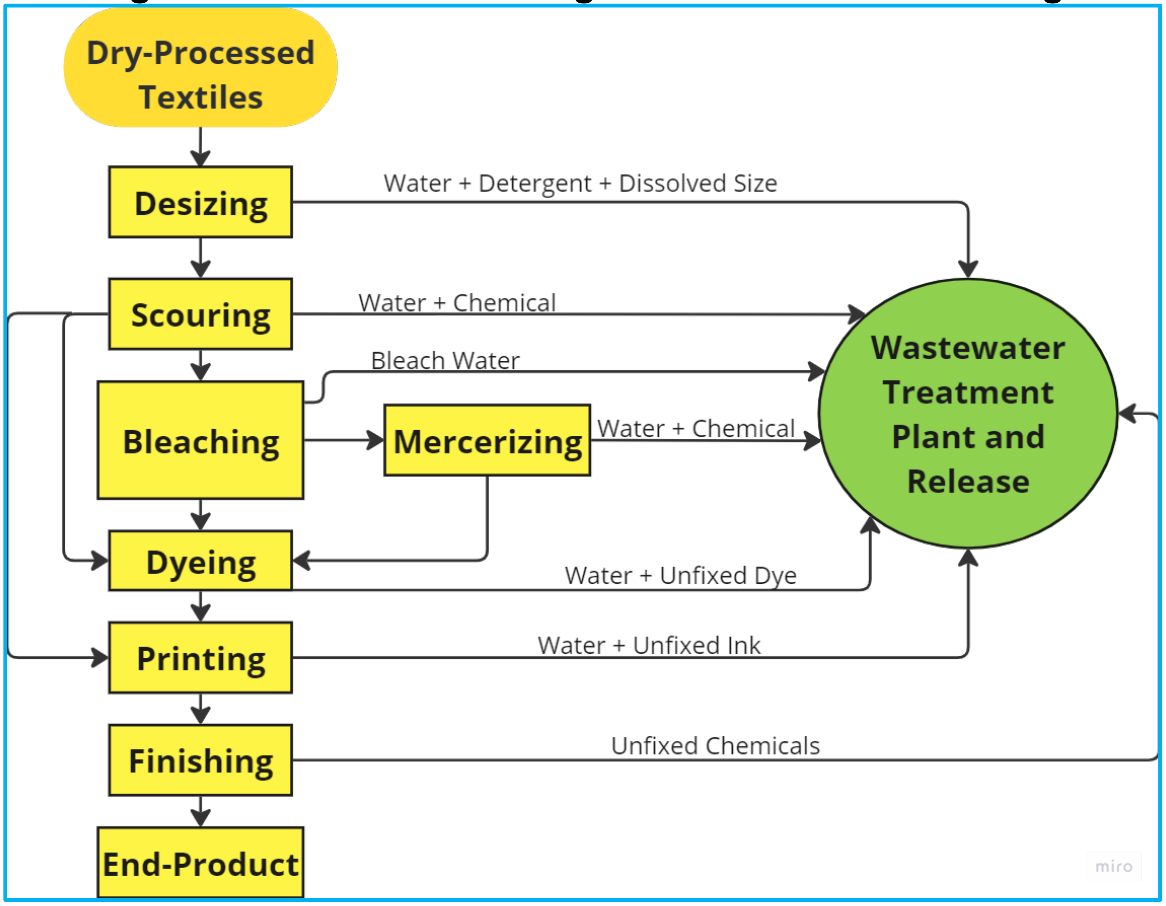
Figure 4: Process Flow Diagram for Leather Processing



Source: Saranya et al., (2018), *Opportunities for Phycoremediation Approach in Tannery Effluent: a Treatment Perspective*.

In textile processing, there are both dry processing stages and wet processing stages that interact differently depending upon the specific product being manufactured and the raw material being used to manufacture the product. As wastewater discharges potentially containing PFAS substances are the focus of this guidance, the dry processing steps are not shown in the following process flow diagram.

Figure 5: Process Flow Diagram for Textile Processing



Source: Sahoo et al., (2012), *Heterogeneous Photocatalysis of Real Textile Wastewater: Evaluation of Reaction Kinetics and Characterization*

3.2 Determine if NPRI Reporting Thresholds are Met

The NPRI reporting threshold for individual PFAS is 1 kg manufactured, processed or otherwise used (MPO) at ≥0.1% concentration. To determine if the facility meets this reporting threshold, inventory tracking for PFAS-containing products is recommended.

Step 1: Identify Products Containing Relevant PFAS Manufactured, Processed, or Otherwise Used at the Facility and the Concentration of Individual PFAS in those Products

Facilities should conduct research to determine which products they MPO that contain any of the 163 PFAS listed in the NPRI. The types of products used within the TULAC sector that contain PFAS were described in the introduction to this chapter. The research to identify the presence of individual PFAS can involve reviewing the Safety Data Sheet and/or Technical Data Sheet for the products that the facility MPOs that have the potential of containing PFAS. Contacting the manufacturer or supplier of these products could also be a source to obtain relevant/necessary information.

Through this research, a determination of the concentration (typically expressed in percentage terms) of each individual PFAS (using a CAS RN) within the products being used can be made. Individual PFAS that have been added to the NPRI must be present in the products manufactured, processed or otherwise used at a concentration of at least 0.1% in order to meet reporting thresholds. If there are no such products manufactured, processed or otherwise used at the facility, then NPRI reporting is not required. If products were identified that contained individual PFAS (that have been added to the NPRI) at a concentration ≥0.1%, then it is necessary to proceed to step 2.

Step 2: Calculate the Weight of Individual PFAS Contained in Products Manufactured, Processed or Otherwise Used for the NPRI Reporting Year

For those products identified as containing individual PFAS (that have been added to the NPRI) at concentrations ≥0.1%, facilities should utilize information on inventory changes (e.g., purchasing records, transfers, amount of product remaining in storage) to quantify the amount of each relevant product manufactured, processed or otherwise used at the facility over the NPRI reporting year.

With the concentration of individual PFAS in the products and the quantity of the product manufactured, processed or otherwise used over the course of the NPRI reporting year available, the following formula can be used to calculate the total quantity of individual PFAS manufactured, processed or otherwise used:

$$PFAS_{kg}^{i} = W_{kg}^{i} \, x Concentration_{\%}^{i}$$

Where:

- $PFAS^{i}_{kg}$ = Weight of PFAS chemical *i* contained in the product manufactured, processed or otherwise used at the facility during the NPRI reporting year, in kilograms.
- W^{i}_{kg} = Weight of the product (containing PFAS chemical *i*) manufactured, processed or otherwise used during the NPRI reporting year, in kilograms.
- $Concentration^{i}_{\%}$ = Concentration of PFAS chemical *i* contained in the product manufactured, processed or otherwise used at the facility during the NPRI reporting year, expressed in percentage terms.

The above calculation needs to be repeated for all individual PFAS chemicals that have been added to the NPRI and that are contained in products (at ≥0.1% concentration) that were manufactured, processed or otherwise used at the facility during the NPRI reporting year.

The above calculation also needs to be repeated for each different product that contains individual PFAS (that have been added to the NPRI) that were manufactured, processed or otherwise used at the facility during the NPRI reporting year.

Aggregate the quantity of individual PFAS (defined as having separate CAS RNs) present in different products that are manufactured, processed or otherwise used at the facility during the NPRI reporting year. For individual PFAS calculated to be present in products manufactured, processed or otherwise used at the facility in quantities ≥1 kg during the NPRI reporting year, reporting of releases, transfers and disposals to the NPRI is required. Please see the next section for guidance.

If there are no individual PFAS (that have been added to the NPRI) that are calculated to be present in products that were manufactured, processed or otherwise used in quantities ≥1 kilogram during the NPRI reporting year, then reporting of releases, transfers and disposals of PFAS to the NPRI is not required.

3.3 Estimating Releases, Transfers and Disposals

3.3.1 Introduction

For those individual PFAS that met the threshold for reporting to the NPRI (as determined in the preceding section), all occurrences of those individual PFAS during manufacturing, processing or use activities at the facility during the NPRI reporting year have to be taken into consideration when determining releases, transfers and disposals (e.g., even if that individual PFAS is contained in products at less than 0.1% concentration).

Two main categories of releases, transfers or disposals generated at TULAC manufacturing facilities could potentially contain PFAS: (i) solid waste from the disposal of off-cuts or other waste textiles/leather treated with PFAS; and (ii) industrial wastewater from emptying industrial baths. However, depending on the physicochemical properties of the PFAS used, they may also be released into the air during textile manufacturing[41]. It is also plausible to assume that PFAS could be emitted into the air during leather processing, particularly when thermal treatments are involved, as leather finishing has been identified by the USEPA NESHAP as a source of certain hazardous air pollutants (USEPA NESHAP For Leather Finishing Operations, AP-42, Compilation of Air Pollutant Emissions Factors from Stationary Sources: 9.15 Leather Tanning).

Industrial wastewater is likely the dominant path for PFAS release from TULAC facilities. PFAS are applied to industrial baths to perform dyeing, bleaching, waterproofing, coating,

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[41] Heydebreck et al. (2016) Emissions of Per- and Polyfluoroalkyl Substances in a Textile Manufacturing Plant in China and Their Relevance for Workers' Exposure.

and for leather, tanning and related steps. When these baths are emptied, PFAS contained in the process water is discharged to wastewater facilities.[42]

Meanwhile, industrial solid waste contaminated with PFAS is most likely relatively minor, for instance off-cuts or other product wastage represent costs and are avoided whenever possible. These solid wastes could potentially be recycled internally, sent to textile recyclers in Canada, or be disposed of.

Very limited data was identified on techniques that could be used to estimate releases, transfers, or disposals of PFAS from TULAC operations. The EU's recent work on PFAS[43] cited another EU document from 2020 on the use of PFAS and fluorine-free alternatives in textiles, upholstery, carpets, leather and apparel.[44] This document – in turn – did not contain original research on estimating releases of PFAS from textile or leather manufacturing/finishing facilities, but instead slightly modified the OECD emission scenario document (ESD) methodologies on leather finishing[45] and textile finishing.[46] The emission estimation techniques below were taken from this OECD documentation.

Two estimation techniques for PFAS releases from TULAC facilities were identified - one for leather manufacturing/finishing facilities and the other textile manufacturing/finishing facilities. These are described below.

3.3.2 Leather Finishing

The leather finishing estimation methodology relies upon a number of facility-specific datapoints. The estimation methodology is therefore divided into three steps: (i) gathering facility-specific information to support PFAS release estimates; (ii) estimating PFAS releases; and (iii) applying the impacts of potential mitigation techniques.

Step 1: Gather Facility-Specific Information to Support PFAS Release Estimates

The following facility-specific information is required to estimate releases of PFAS to water from leather finishing operations – asterisks represent those values for which recommended values (from the OECD Emission Scenario Document (ESD), located at https://one.oecd.org/document/env/jm/mono(2004)13/en/pdf) are available if facility-specific information is unavailable:

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[42] Minnesota Pollution Control Agency, (2023), *PFAS in the Textile and Leather Industries*.

[43] European Chemicals Agency, (2023), *Annex to the Annex XV Restriction Report - Proposal for a Restriction, Per- and Polyfluoroalkyl Substances (PFASs)*

[44] European Commission, (2020), *The Use of PFAS and Fluorine-Free Alternatives in Textiles, Upholstery, Carpets, Leather and Apparel.*

[45] OECD, (2004), *Emission Scenario Document on Leather Processing*.

[46] OECD, (2004), *Emission Scenario Document on Textile Finishing Industry*.

- quantity of rawhides processed per day in tonnes at the facility*;
- fraction of the mass of leather remaining from the rawhide at the chemical application stage of the process*;
- the consumption of the chemical formulation containing the PFAS substance per tonne of leather production*;
- the fraction of the specific PFAS substance that is contained in the mixture (this should already be known by the reporter as it was required information for determining if the facility met the reporting threshold, and should be known for each individual PFAS substance that meets reporting thresholds);
- the degree of fixation to the leather for the product being applied (not for the individual PFAS substance but for the product as a whole);
- the fraction of daily production treated with the product containing the PFAS substance(s)*;
- the fraction of each individual PFAS substance that would be eliminated due to any on-site wastewater treatment*; and
- the number of operating days for the facility during the NPRI reporting year.

The data above will need to be known for each individual PFAS substance that meets NPRI reporting thresholds, so that the calculation shown in Step 2 can be applied for each individual PFAS substance that must be reported.

Step 2: Estimate PFAS Releases to Water from Leather Finishing Operations

Utilizing the data identified in Step 1, complete the following equation[47] for each PFAS that meets the reporting thresholds. This will provide an estimate of releases for each PFAS substance per day from the facility. Multiply the daily release figure by the number of operating days for your facility.

$$E_{water} = Q_{rawhide} \times F_{remaining\,mass} \times Q_{chemical\,formulation} \times F_{chemical} \times (1 - F_{fixation}) \times F_{daily\,production} \times (1 - F_{on-site\,treatment})$$

Where:

- E_{water} = initial release to water (kg/day)
- $Q_{rawhide}$ = quantity of raw hides processed per day. The OECD ESD recommends a value of 15 tonnes per day.
- $F_{remaining\,mass}$ = fraction of mass of leather remaining from raw hide at the application stage. OECD ESD recommends a value of 0.2 for leather finishing.
- $Q_{chemical\,formulation}$ = consumption of chemical formulation containing the substance (mass of substance use per tonne of production). OECD ESD recommends a value of 15 kg/tonne.
- $F_{chemical}$ = fraction of chemical in the formulation applied to the leather.
- $F_{fixation}$ = degree of fixation to leather.

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[47] European Commission, (2020), *The Use of PFAS and Fluorine-Free Alternatives in Textiles, Upholstery, Carpets, Leather and Apparel.*

- $F_{\text{daily production}}$ = fraction of daily production that is treated with the specific chemical. The OECD ESD recommends a default value of 1.
- $F_{\text{on-site treatment}}$ = fraction of chemical elimination by on-site wastewater treatment prior to discharge to a municipal sewage treatment plant. A default value of 0 could be used if no onsite treatment.

European Union documentation indicates that the median number of operating days for a leather finishing site is 225 days per year, but no similar Canadian-specific information was identified. The fixation on leather factor is given as a default value of 0 by the OECD ESD, but this may not accurately reflect the degree of fixation for PFAS substances that are specifically meant to remain on the treated leather. No PFAS-specific factors for this variable were identified.[48]

For potential PFAS air emissions from open top vessel sources, the evaporation model from section 3.7 of Methods for Estimating Air Emissions from Chemical Manufacturing Facilities could be used. Facilities are encouraged to prioritize facility-specific data, such as source testing with mass balance, site-specific emission factors, or engineering estimates and process simulator models, when reporting to the NPRI. Additionally, other estimation methods, such as data from similar facilities or emission factors developed from comparable operations or surrogate substances, may also be used for NPRI reporting.

Step 3: Apply the Impacts of Mitigation Techniques to Release Estimates

Leather finishing facilities generate wastewater, and may apply mitigation techniques to limit the release of certain substances within their wastewater. The efficacy of wastewater treatment systems varies by technology type, flow rate, the specific substance under consideration, and many other factors. If facilities apply mitigation techniques to their wastewater stream that will impact the release of any PFAS quantified under steps 1 and 2 above, they may choose to estimate how these mitigation techniques may impact their releases should the required information be available. Facilities may utilize engineering estimates, available release factors, etc. to quantity the impact of their mitigation techniques.

3.3.3 Textile Finishing

One textile finishing estimation methodology was identified. It relies upon a number of facility-specific datapoints. The estimation methodology is therefore divided into three steps: (i) gathering facility-specific information to support PFAS release estimates; (ii) estimating PFAS releases; and (iii) applying the impacts of potential mitigation techniques. The methodology below is based on an OECD emission scenario document, which can be found at this location: https://www.oecd.org/content/dam/oecd/en/publications/reports/2014/09/textile-finishing_g1g4855e/9789264221185-en.pdf.

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[48] Ibid.

Step 1: Gather Facility-Specific Information to Support PFAS Release Estimates

The following facility-specific information is required to estimate releases of PFAS to water from textile finishing operations – asterisks represent those values for which recommended values are available if facility-specific information is unavailable:

- daily amount of textiles treated (in tonnes)*;
- application amount (kg of the product per tonne of textiles produced)*;
- the fraction of daily production that is treated with the product containing PFAS;
- the fraction of residual liquor that could be released from the process*;
- degree of fixation of the product containing PFAS to the textiles being produced; and
- the number of operating days for the facility per year.

Step 2: Estimate PFAS Releases to Water and Air from Textile Finishing Operations

Utilizing the data identified in Step 1, complete the following equation[49] for each PFAS that meets reporting thresholds. This will provide an emissions estimate for each PFAS substance per day from the facility. Multiply the daily release figure by the number of operating days for your facility.

Water:

$$E_{water} = \{Q_{textile} \times Q_{product} \times F_{product} \times (1 - F_{fixation})\} + \{Q_{textile} \times Q_{product} \times F_{product} \times F_{residual\ liquor}\}$$

Air:

$$E_{air} = Q_{textile} \times Q_{product} \times F_{product} \times F_s$$

Where:

- E_{water} = initial release to water (kg/day).
- E_{air} = initial release to air (kg/day)
- $Q_{textile}$ = daily amount of textile treated (tonnes/day). The OECD ESD recommends a value of 13 tonnes/day.
- $Q_{product}$ = application amount (mass of substance use per mass of fabric). In the absence of specific data, the OECD ESD recommends a value of 20 kg/tonne.
- $F_{product}$ = fraction of textile that is treated with the product containing the substance. This is to account for the fact that not all textiles manufactured on a given day will be treated with the same substance.
- $F_{residual\ liquor}$ = fraction of the residual liquor that could be released from the process. A value of 0.1 is recommended as a first estimation in the OECD (ESD) for padding processes.
- $F_{fixation}$ = degree of fixation. A value of 1 is recommended as a first estimation in the OECD ESD for padding processes.
- F_s = Emission factor to air for the substance (g/g).

The OECD ESD on textile finishing describes the application of functional finishes to all kinds of textiles. Typical application methods include padding (covered via the equation above) and spraying (which the equations above do not cover). Releases to water from spraying operations are likely to occur from overspray. The variables detailed in the equation above rely on default values (in the absence of more specific information), but no default value was identified for the emission factor to air. EU documentation indicates that the median number of operating days for a textile finishing site is 225 days per year, but no similar Canadian-specific information was identified.[50]

For potential PFAS air emissions from open top vessel sources, the evaporation model from section 3.7 of Methods for Estimating Air Emissions from Chemical Manufacturing Facilities could be used. Facilities are encouraged to prioritize facility-specific data, such

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[49] Ibid.

[50] Ibid.

as source testing with mass balance, site-specific emission factors, or engineering estimates and process simulator models, when reporting to the NPRI. Additionally, other estimation methods, such as data from similar facilities or emission factors developed from comparable operations or surrogate substances, may also be used for NPRI reporting.

Step 3: Apply the Impacts of Mitigation Techniques to Release Estimates

Textile finishing facilities generate wastewater and may apply mitigation techniques to limit the release of certain substances within their wastewater. The efficacy of wastewater treatment systems varies by technology type, flow rate, the specific substance under consideration, and many other factors. If facilities apply mitigation techniques to their wastewater stream that will impact the release of any PFAS quantified under steps 1 and 2 above, they may choose to estimate how these mitigation techniques may impact their releases should the required information be available. Facilities may utilize engineering estimates, available release factors, etc. to quantity the impact of their mitigation techniques.

4. Manufacturing of Transportation Vehicles

4.1 Introduction

This chapter provides guidance on the reporting of PFAS to the NPRI for facilities involved in the manufacturing of transportation vehicles. The manufacturing of transportation vehicles not only encompasses the production of automobiles, but also that of aerospace, marine and rail transportation vehicles. In addition, the guidance can be used for niche transportation vehicle manufacturers, for instance the production of off-road vehicles for the mining, forestry, oil and gas and other sectors. The guidance encompassed in this chapter can be used by assembly plants for these different vehicles as well as the component manufacturers that supply these assembly plants with a wide range of parts.

Because of their vast range of properties, PFAS are widely used in the manufacturing of transportation vehicles. PFAS may be used in: body, hull and fuselage construction; sealing applications and lubricants; fuel engine systems; hydraulic fluids; electrical engineering and information technology; coatings and finishes; heating, ventilation, air conditioning and refrigeration (HVACR)-systems; and lifesaving and fire protection.[51]

It appears that a limited set of PFAS may be used in the manufacture of transportation vehicles that may be potentially relevant for NPRI reporting.

4.2 Determine if NPRI Reporting Thresholds are Met

The NPRI reporting threshold for individual PFAS is 1 kg of manufacturing, processing or otherwise use (MPO) at $\geq$0.1% concentration. To determine if the facility meets this reporting threshold, inventory tracking for PFAS-containing products is recommended.

Step 1: Identify Products Containing Relevant PFAS Manufactured, Processed, or Otherwise Used at the Facility and the Concentration of Individual PFAS in those Products

Facilities should review and identify which products they manufacture, process or otherwise use that contain any of the 163 PFAS listed in the NPRI.
To accurately perform threshold calculations for activities involving the 163 PFAS listed in the NPRI under Par 1C, it is important to understand the exemption for articles, as some PFAS may already be present in the manufactured articles used in assembly facilities.

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[51] European Chemicals Agency (2023), *Annex to the Annex XV Restriction Report – Proposal for a Restriction – Substance Name: Per- and Polyfluoroalkyl Substances (PFASs)*.

An "article" is defined as a manufactured item that does not release an NPRI substance when it undergoes processing or any other use. When an article is processed and there are no releases, or the releases are recycled with due care, the NPRI substances in that article need not be included in the threshold calculation. Exercising due care means that the facility generated less than one kilogram of a Part 1A substance as waste during the year. There is no quantitative measure of due care in recycling Part 1C (PFAS). Therefore, if an article containing a Part 1C substance is processed or otherwise used and there are releases, the Part 1C substance in the article must be included in the threshold calculation.

Identifying the presence of individual PFAS in key products manufactured, processed or otherwise used by the facility can involve reviewing the Safety Data Sheet and/or Technical Data Sheet for the relevant products that have the potential of containing PFAS. Contacting the manufacturer or supplier of these products could also be a source to obtain relevant/necessary information.

Through this review, a determination of the concentration (typically expressed in percentage terms) of each individual PFAS (using a CAS RN) within the products being manufactured, processed or otherwise used can be made. Individual PFAS that have been added to the NPRI must be present in the products that are manufactured, processed or otherwise used at a concentration of at least 0.1% in order to meet reporting thresholds. If there are no such products used at the facility, then NPRI reporting of PFAS is not required. If products were identified that contained individual PFAS (that have been added to the NPRI) at a concentration ≥0.1%, then it is necessary to proceed to step 2. Please note that the concentration threshold is not applicable if the substances qualify as a 'by-product' under the NPRI definition.

Step 2: Calculate the Weight of Individual PFAS Contained in Products Manufactured, Processed or Otherwise Used for the NPRI Reporting Year

For those products identified as containing individual PFAS (that have been added to the NPRI) at concentrations ≥0.1%, facilities should utilize information on inventory changes (e.g., purchasing records, transfers, amount of product remaining in storage) to quantify the amount of each relevant product used at the facility over the NPRI reporting year.

With the concentration of individual PFAS in the products and the quantity of the product used over the course of the NPRI reporting year available, the following formula can be used to calculate the total quantity of individual PFAS consumed:

$$PFAS_{kg}^{i} = W_{kg}^{i} \; x \; Concentration_{\%}^{i}$$

Where:

- $PFAS^{i}_{kg}$ = Weight of PFAS chemical *i* contained in the product manufactured, processed or otherwise used at the facility during the NPRI reporting year, in kilograms.
- W_{kg} = Weight of the product containing PFAS chemical *i* that was manufactured, processed or otherwise used during the NPRI reporting year, in kilograms.
- $Concentration^{i}_{\%}$ = Concentration of PFAS chemical *i* contained in the product manufactured, processed or otherwise used at the facility during the NPRI reporting year, expressed in percentage terms.

The above calculation needs to be repeated for all individual PFAS chemicals that have been added to the NPRI and that are contained in products (at ≥0.1% concentration) that were manufactured, processed or otherwise used at the facility during the NPRI reporting year.

The above calculation also needs to be repeated for each different product that contains individual PFAS (that have been added to the NPRI) that were manufactured, processed or otherwise used at the facility during the NPRI reporting year.

Aggregate the quantity of individual PFAS (defined as having separate CAS RNs) present in different products that are manufactured, processed or otherwise used at the facility during the NPRI reporting year. For individual PFAS calculated to be present in products manufactured, processed or otherwise used at the facility in quantities ≥1 kg during the NPRI reporting year, reporting of all releases, transfers and disposals to the NPRI is required[52]. Please see the next section for guidance.

If there are no individual PFAS (that have been added to the NPRI) that are calculated to be present in products that were manufactured, processed or otherwise used in quantities ≥1 kilogram during the NPRI reporting year, then reporting of releases, transfers and disposals of PFAS to the NPRI is not required.

4.3 Estimating Releases, Transfers and Disposals

Before estimating releases, transfers, and disposals, it is important to note that if PFAS (that have been added to the NPRI) are present in the components used in manufacturing transportation vehicles, and these components retain their article status, the NPRI-listed PFAS within them are exempt from threshold calculations and reporting obligations.

Step 1: Quantify the Amount of Individual PFAS Contained in Relevant Products/Processes Manufactured, Processed or Otherwise Used During the NPRI Reporting Year

For those individual PFAS that met the threshold for reporting to the NPRI, all occurrences of those individual PFAS during manufacturing, processing or use activities at the facility during the NPRI reporting year have to be taken into consideration when determining

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[52] As long as those individual PFAS are contained in the relevant products at concentrations greater than 0.1%.

releases, transfers and disposals (e.g., even if that individual PFAS is contained in products at less than 0.1% concentration). Step 2 in the preceding section in this chapter provides guidance on how to quantify the amount of individual PFAS that are manufactured, processed or otherwise used at your facility during the NPRI reporting year.

Step 2: Apply Available Default Release Factors to Estimate Releases to Air, Water and Land During the NPRI Reporting Year

For NPRI reporting, facilities are encouraged to prioritize facility-specific data, such as source testing with mass balance, site-specific emission factors, or engineering estimates, when reporting to the NPRI. Additionally, other estimation methods, such as data from similar facilities or emission factors developed from comparable operations or surrogate substances, may also be used for NPRI reporting. If facilities do not have access to facility-specific data or other estimation methods, they could consider using the approach applied in the European analysis used to estimate releases of PFAS in the transport sector for fluorinated gases and polymeric PFAS[53]. This method involves applying default (worst-case) release factors to specific Environmental Release Categories (ERCs) developed by the European Chemicals Agency (ECHA). However, these are the individual PFAS that have not been added to the NPRI and furthermore, it is important to note that ERCs and pollutant release inventory reporting systems like the NPRI serve distinct functions. ERCs are designed to provide conservative overestimates for environmental exposure and should be used with caution when applied to NPRI reporting. Facilities should use ERCs only as an initial reference for identifying potential release sources or estimating releases, and always with careful consideration alongside more specific input from facility experts.

Step 3: Account For PFAS Disposed of or Sent for Recycling

It is likely that PFAS-containing waste/recyclable materials are generated by facilities involved in the manufacturing of transportation vehicles, for instance rubber/textile/plastic trimmings, waste materials associated with the application of coatings, adhesives and sealants, wastewater treatment sludge, etc. Individual PFAS (that have been added to the NPRI) that are contained in these waste/recyclable materials need to be accounted for. Due to the wide variety of waste materials that could be generated containing PFAS among facilities in this sector, it is difficult to provide guidance on how to estimate the quantities of individual PFAS that are contained in this material.

It is recommended that, where possible, estimates are made of the content of individual PFAS (that have been added to the NPRI and met the reporting threshold) that are contained in materials that are forwarded for recycling or disposal during the NPRI reporting year. The following equation can be used:

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[53] European Chemicals Agency (2023), *Annex to the Annex XV Restriction Report – Proposal for a Restriction – Substance Name: Per- and Polyfluoroalkyl Substances (PFASs)*.

$$PFAS_{kg}^{i} = PFAS_{Waste\%}^{i}\ x\ Waste\ or\ Recylable\ Materials_{kg}^{i}$$

Where:

- $PFAS^{i}_{kg}$ = Weight of PFAS chemical *i* contained in waste or recyclable materials generated during the NPRI reporting year, in kilograms.
- $PFAS^{i}_{Waste\%}$ = Content of PFAS chemical *i* contained in materials that are forwarded for disposal or recycling during the NPRI reporting year, expressed in percentage terms.
- Waste or Recyclable $Materials^{i}_{kg}$ = Quantity of materials containing PFAS chemical *i* that are forwarded for disposal or recycling during the NPRI reporting year, in kilograms.

Facility-specific knowledge can then be used to properly account for the quantity of PFAS chemical *i* in terms of whether it was disposed on-site, disposed of off-site, removed from the facility for recycling, etc.

The above equation would need to be applied to the different waste or recyclable materials, containing PFAS chemical *i* that were disposed of or recycled during the NPRI reporting year. In addition, the above equation would need to be applied to the range of individual PFAS that met the NPRI reporting threshold and that are contained in materials that were disposed of or recycled during the NPRI reporting year.

5. Oil and Gas Production

5.1 Introduction

Both non-polymeric PFAS and polymeric PFAS (like fluoropolymers) are used in a variety of applications within the oil and gas production sector.

The main non-polymeric uses of PFAS in the oil and gas sector are as follows:[54]

- **Anti-foaming Agents** – The use of PFAS in anti-foaming agents represents the largest use of non-polymeric PFAS in the oil and gas sector. PFAS-based products provide anti-foaming properties in drilling fluids. These additives prevent the formation of foam during the preparation of a treatment fluid or slurries at the surface to reduce handling and pumping difficulties that interfere with the performance or quality control of the mixed fluid. They can also be used to aid the separation of water and oil during production. Several fluorinated polysiloxanes are reported to be currently used in anti-foaming agents within the oil and gas industry. The PFAS content in these products is reported to range between 2-5%.
- **Tracers** – Chemical tracers are important in oil and gas reservoir mapping. Functions these tracers provide include tracking the movement of the injected fluid through the oil reservoir, monitoring reservoir performance, investigating unexpected anomalies in flow and verifying suspected geological barriers or flow channels. PFAS-based tracers are used by the oil and gas sector to accurately map flow paths, volumes and the geological structures of oil and gas reservoirs to trace the path of the chemical to a production well in the subsurface environment. PFAS content of some of these tracers is reportedly 100%. Industry input indicates that these tracers are used sporadically in small (10-15 kg) quantities, with fluoroalkane-based tracers being one group of tracers utilized.

Other non-polymeric applications of PFAS in the oil and gas sector that have been noted include the following:[55/56]

- **Stimulation Chemicals** – PFAS can be used as surfactants in enhanced oil well stimulation fluids during water flooding and in non-aqueous (chemical) stimulation fluids for foaming hydrocarbon liquids due to their key desirable properties (i.e., chemical and thermal stability, wetting ability, and low aqueous surface tension).

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[54] Wood Group UK Ltd. (2021), *PFAS in Mining and Petroleum Industry – Use, Emissions and Alternatives*, prepared for the Norwegian Environment Agency.

[55] Glüge, J. et. al. (2020), *An Overview of the Uses of Per- and Polyfluoroalkyl Substances (PFAS) – Electronic Supplementary Information 1*, published in Environmental Science: Processes & Impacts.

[56] Wood Group UK Ltd. (2021), *PFAS in Mining and Petroleum Industry – Use, Emissions and Alternatives*, prepared for the Norwegian Environment Agency.

During water flooding, water is injected into the reservoir to drive the crude oil to the boreholes. Fluorinated surfactants can increase the effective permeability of the formation by modifying the interfacial tension between the reservoir surface and the aqueous liquid phases it is in contact with. In chemical flooding, fluorinated surfactants can be used to render the surfaces of the oil-bearing reservoirs hydrophobic and oleophobic. This supports exploration of petroleum reserves through the displacement of the petroleum streams from the underground sand and rock formations. Fluorinated surfactants can also be used to enhance gas production, for instance by changing low-permeability sandstone gas reservoirs from strongly hydrophilic to weakly hydrophilic. PFAS can also eliminate reservoir capillary forces, dissolve partial solids, reduce clogging, increase efficiency of displacing water with gas, and reduce damage to the solid phase, thereby increasing recovery rates and the permeability rate of the rock core.

- **Surfactant in Hydraulic Fracturing** - Hydraulic fracturing is a method of oil and gas production that involves injecting fracturing fluids into underground rock formations to extract oil and gas. The majority of hydraulic fracturing fluid (up to 97%) is water. The next largest component of hydraulic fracturing fluid is the "proppant," generally sand, which props open the rock crevices. The final components of hydraulic fracturing fluid are additives that serve a number of purposes such as carrying the proppant, preventing corrosion, and minimizing harmful microbial growth.[57] Fluorinated surfactants can be used in fracturing subterranean formations penetrated by a wellbore. The fluorinated surfactants can act as a foaming agent that initiates and extends the fractures in the formation. Fluorinated surfactants have also been patented as foaming agents in liquid CO_2 fracturing fluid systems. The viscous foam reduces the viscosity of the fluid system and makes it easier to remove the fracturing liquid from the oil or gas reservoir.[58] Specific PFAS that have been used in hydraulic fracturing fluid fall into 4 groups: (i) perfluoroalkyl alkanes/cycloalkanes, (ii) fluoroalkyl alcohol substituted polyethylene glycol; (iii) nonionic fluorosurfactants, and (iv) polytetrafluoroethylene.[59]

- **Drilling and Production Chemicals** – Fluorinated surfactants are used as hydrocarbon foaming agents in water-based and organic phase drilling fluids. Foamed drilling fluids have several advantages over non-foamed fluids. For instance, the volume of liquid in a foamed fluid is smaller than in non-foamed fluids, thus, less fluid gets lost in permeable subterranean formations. Foams also have lower densities than non-foamed drilling fluids, and the use of foams lowers potential formation damage when drilling in underbalanced conditions (i.e., when the pressure in the drilling fluid is lower than the pore pressure in the surrounding rock).

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[57] Energy in Depth (2024), *Breaking Down PSR's PFAS Reports*.

[58] Glüge, J. et. al. (2020), *An Overview of the Uses of Per- and Polyfluoroalkyl Substances (PFAS) – Electronic Supplementary Information 1*, published in Environmental Science: Processes & Impacts.

[59] GSI Environmental (2021), *Comment on "Fracking with Forever Chemicals" by Physicians for Social Responsibility, issued July 2021.*

- **Oil and Gas Storage and Containment** – Evaporation of liquid fuels (e.g., gasoline) can be prevented by an aqueous surface film containing anionic surfactants, including PFAS-based chemicals. Evaporation losses can also be reduced by covering the liquid surface of petroleum storage tanks with a floating layer of cereal (e.g., corn, wheat, or perlite) treated with a fluorinated surfactant. Meanwhile, oil spills on water can be contained and prevented from spreading by a chemical barrier containing a fluorinated surfactant.

- **Assist in Pumping Crude Oil to the Surface** - Fluorinated surfactants have been patented to aid reducing the viscosity of crude oil for pumping from the borehole. Viscosity frequently limits the rate crude oil can be produced from a well. Fluorinated surfactants can form crude oil-in-water emulsions that have lower viscosity than the un-emulsified crude and can be pumped more easily.

5.2 Determine if NPRI Reporting Thresholds are Met

The NPRI reporting threshold for individual PFAS is 1 kg manufactured, processed or otherwise used (MPO) at ≥0.1% concentration. To determine if the facility meets this reporting threshold, inventory tracking for PFAS-containing products is recommended.

It is important to note that the exploration for oil or gas, or the drilling of oil or gas wells are activities that are exempt from NPRI reporting.[60] This exemption should be taken into consideration when determining if the activities at your facility during the NPRI reporting year (that manufacture, process or otherwise use PFAS that have been added to the NPRI) meet the NPRI reporting threshold.

Step 1: Identify Products Containing Relevant PFAS Manufactured, Processed, or Otherwise Used at the Facility and the Concentration of Individual PFAS in those Products

Facilities should conduct research to determine which products that they consume contain any of the 163 PFAS listed in the NPRI. The types of products used within the oil and gas sector that contain PFAS were described in the Introduction to this chapter.

The table below presents some specific PFAS that have been identified as being used in the oil and gas production sector and which have been added to the NPRI. There may be other PFAS used in your operations that have also been added to the NPRI. Research is necessary to determine their existence within your operations. This table simply provides some assistance in identifying specific PFAS (i.e., with distinct CAS RNs) that may be manufactured, processed or otherwise used at your facility, and which have been added to the NPRI.

Table 4: PFAS Added to the NPRI Identified as Being Used in Oil and Gas Production

CAS RN	Function
1652-63-7	• Enhanced oil recovery – hydrocarbon foaming agent • Fluorinated surfactants for enhance gas production
1691-99-2	• Heavy crude oil well polymer blocking remover
29117-08-6	• Oil containment
335-67-1	• Enhanced oil recovery - render surfaces of the oil-bearing reservoirs oleophobic
56773-42-3	• Heavy crude oil well polymer blocking remover

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[60] Legal requirements: Canada Gazette notices - Canada.ca.

65545-80-4	• Surface active agent in oil and gas drilling, extraction and support activities • Contained in hydraulic fracturing fluid
678-39-7	• Enhanced oil recovery – hydrocarbon foaming agent
68187-47-3	• Unknown function
70969-47-0	• Unknown function
754-91-6	• Heavy crude oil well polymer blocking remover

Sources:

- Glüge, J. et. al. (2020), *An Overview of the Uses of Per- and Polyfluoroalkyl Substances (PFAS) – Electronic Supplementary Information 1*, published in Environmental Science: Processes & Impacts.
- Environment and Climate Change Canada (2024), *Proposed Addition of Certain Per- and Polyfluoroalkyl Substances (PFAS) to the National Pollutant Release Inventory – Consultation Document*.
- GSI Environmental (2021), *Comment on "Fracking with Forever Chemicals" by Physicians for Social Responsibility, issued July 2021.*

Research to identify the presence of individual PFAS in key products manufactured, processed or otherwise used by the facility can involve reviewing the Safety Data Sheet and/or Technical Data Sheet for the relevant products that have the potential of containing PFAS. Contacting the manufacturer or supplier of these products could also be a source to obtain relevant/necessary information. It is important to identify the CAS RN of PFAS contained in the products that the facility manufactures, processes or otherwise uses so that it can be compared to the list of PFAS (by CAS RN) that have been added to the NPRI.

Through this research, a determination of the concentration (typically expressed in percentage terms) of each individual PFAS (using a CAS RN) within the products being manufactured, processed or otherwise used can be made. Individual PFAS that have been added to the NPRI must be present in the products consumed at a concentration of at least 0.1% in order to meet NPRI reporting thresholds. If there are no such products consumed at the facility, then NPRI reporting is not required. If products were identified that contained individual PFAS (that have been added to the NPRI) at a concentration ≥0.1%, then it is necessary to proceed to step 2.

Step 2: Calculate the Weight of Individual PFAS Contained in Products Manufactured, Processed or Otherwise Used for the NPRI Reporting Year

For those products identified as containing individual PFAS (that have been added to the NPRI) at concentrations ≥0.1%, facilities should utilize information on inventory changes (e.g., purchasing records, transfers, amount of product remaining in storage) to quantify the amount of each relevant product consumed at the facility over the NPRI reporting year.

With the concentration of individual PFAS in the products and the quantity of the product consumed over the course of the NPRI reporting year available, the following formula can be used to calculate the total quantity of individual PFAS manufactured, processed or otherwise used:

$$PFAS_{kg}^{i} = W_{kg}^{i}\ xConcentration_{\%}^{i}$$

Where:

- $PFAS^{i}_{kg}$ = Weight of PFAS chemical *i* contained in the product manufactured, processed or otherwise used at the facility during the NPRI reporting year, in kilograms.
- W^{i}_{kg} = Weight of the product (containing PFAS chemical *i*) manufactured, processed or otherwise used during the NPRI reporting year, in kilograms.
- $Concentration^{i}_{\%}$ = Concentration of PFAS chemical *i* contained in the product manufactured, processed or otherwise used at the facility during the NPRI reporting year, expressed in percentage terms.

The above calculation needs to be repeated for all individual PFAS chemicals that have been added to the NPRI and that are contained in products (at ≥0.1% concentration) that were manufactured, processed or otherwise used at the facility during the NPRI reporting year.

The above calculation also needs to be repeated for each different product that contains individual PFAS (that have been added to the NPRI) that was manufactured, processed or otherwise used at the facility during the NPRI reporting year.

Aggregate the quantity of individual PFAS (defined as having separate CAS RNs) present in different products that are manufactured, processed or otherwise used at the facility during the NPRI reporting year. For individual PFAS calculated to be present in products manufactured, processed or otherwise used at the facility in quantities ≥1 kg during the NPRI reporting year, reporting of releases, transfers and disposals to the NPRI is required[61]. Please see the next section for guidance.

If there are no individual PFAS (that have been added to the NPRI) that are calculated to be present in products that were manufactured, processed or otherwise used in quantities ≥1 kilogram during the NPRI reporting year, then reporting of releases, transfers and disposals to the NPRI is not required.

5.3 Estimating Releases, Transfers and Disposals

It is expected that the PFAS products (e.g., tracers, antifoaming agents) are released into the oil/gas stream as part of their active use, with some PFAS in these products having direct releases to the environment and some PFAS in these products being contained in produced water.

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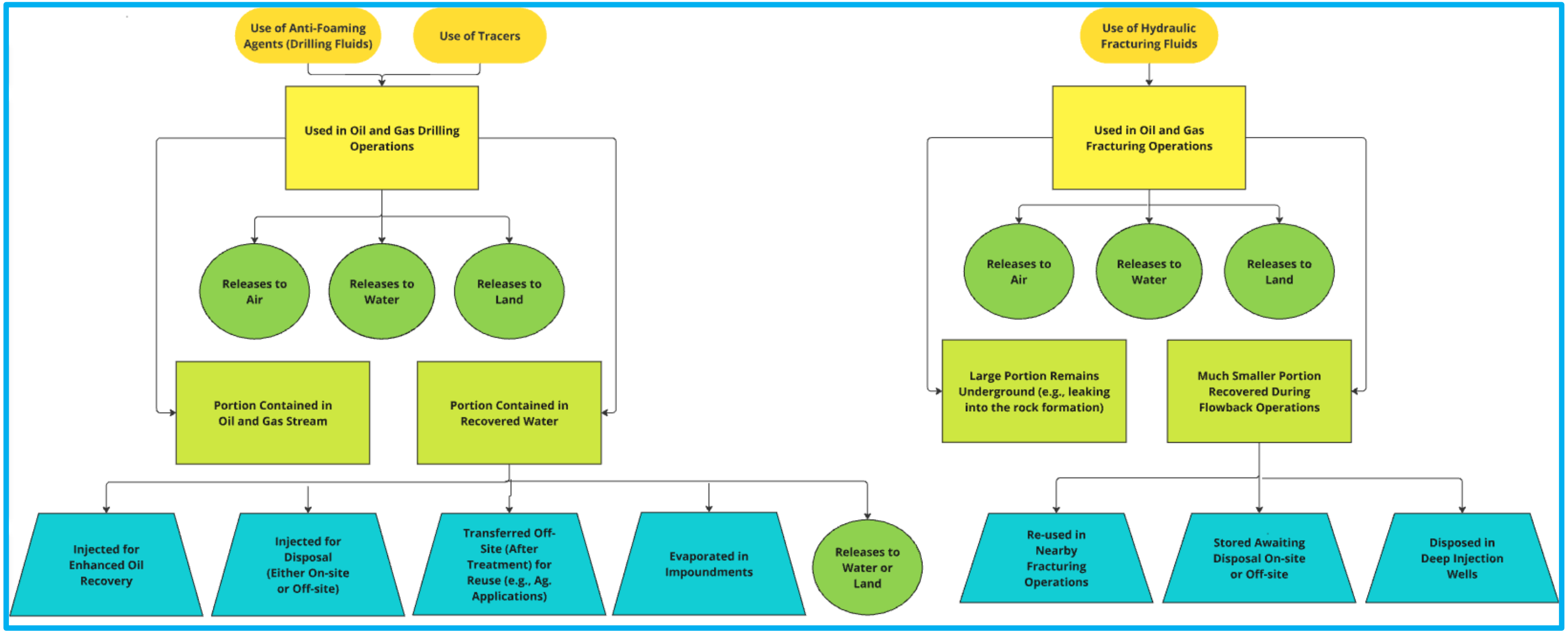
[61] As long as those individual PFAS are contained in the relevant products at concentrations greater than 0.1%.

Due to the diverse number of operations within the oil and gas production sector, each reporting facility should review the products that they consume that could contain PFAS (see the first section in this chapter) to determine if there are any relevant non-polymeric PFAS contained in products outside of tracers, antifoaming agents and additives in hydraulic fracturing fluids.

When reporting to the NPRI, facilities are encouraged to prioritize facility-specific data, such as source testing with mass balance, site-specific emission factors, or engineering estimates and process simulator models. Additionally, other estimation methods, such as data from similar facilities or emission factors developed from comparable operations or surrogate substances, may also be used for NPRI reporting. Please note, releases, transfers and disposals could be also generated from the use of firefighting foams like AFFFs or stormwater runoff which are covered under Chapter 2.

Figure 6: Process-Flow Diagram for PFAS Movements in Oil and Gas Production and Potential for Releases/Disposals/Transfers



Source: Cheminfo Services Inc.

Step 1: Quantify the Amount of Individual PFAS Contained in Relevant Products Manufactured, Processed or Otherwise Used During the NPRI Reporting Year

For those individual PFAS that met the threshold for reporting to the NPRI, all occurrences of those individual PFAS during manufacturing, processing or use activities at the facility during the NPRI reporting year have to be taken into consideration when determining releases, transfer and disposals (e.g., even if that individual PFAS is contained in products at less than 0.1% concentration). Step 2 in the preceding section in this chapter provides guidance on how to quantify the amount of individual PFAS that are manufactured, processed or used at your facility during the NPRI reporting year.

The European analysis[62] assumed that the PFAS content in tracers was 100% while the PFAS content in anti-foaming agents was 2-5%. Meanwhile the majority of hydraulic fracturing fluid (up to 97%) is water with the next largest component of hydraulic fracturing fluid being the proppant. Therefore, PFAS concentrations in hydraulic fracturing fluid are likely less than 1%.

It is recommended that facilities develop more accurate percentages based on a review of the Safety Data Sheet, Technical Data Sheet. Contacting the manufacturer or supplier of these products could also be a source to obtain relevant/necessary information. If more accurate data cannot be obtained through these avenues, then the PFAS concentrations identified above can be applied to the relevant quantity of tracers, anti-foaming agents and hydraulic fracturing fluids that were manufactured, processed or otherwise used during the NPRI reporting year.

Step 2: Apply Available Mass Balance Factors to PFAS Quantities Manufactured, Processed or Otherwise Used for Tracers and Antifoaming Agents

The most relevant existing estimation[63] of releases, transfers and disposals of PFAS from the oil and gas sector applied various different scenarios (including worst-case European Chemical Agency release factors) to the PFAS content in the amount of tracers and anti-foaming agents consumed in Europe. This publication did not analyze hydraulic fracturing fluids, potentially due to the fact the hydraulic fracturing is much less prevalent in the European Union than in North America. Please see step 3 below for guidance on estimating the release, transfer and disposal of PFAS in hydraulic fracturing fluids.

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[62] Ibid.

[63] Ibid

Based upon information contained in the European document, the table below presents a mass balance of PFAS contained in tracers and anti-foaming agents. Release/mass balance factors are presented for two separate activities:

1. Formulation of the tracers and anti-foaming agents into a mixture; and
2. Use of functional fluids at an industrial site (i.e., tracers, anti-foaming agents).

If facility-specific information is available, it should be used instead of the default factors provided in the table below.

Should oil and gas facilities purchase already formulated products, then the release factors/mass balance factors for this formulation activity are not relevant to their operations. Alternatively, if oil and gas facilities actually formulate these products on-site from purchased raw materials, then the release factors/mass balance factors for this formulation activity need to be applied.

Unless more detailed specific data are available to the facility on the use or release patterns of these products, an estimate of releases to air, water, land and waste should be made using the mass balance estimates in the table below. There is a significant uncertainty range associated with these mass balance estimates. This is largely due to lack of data on the precise environmental release and behaviour of chemical products (e.g., anti-foaming agents and tracers) that are applied within oil and gas facilities.

Table 5: Mass Balance of PFAS Contained in Tracers and Anti-Foaming Agents Consumed in the Oil and Gas Sector

Environmental Release Category	**Release Factors/Mass Balance Factors**				
	Released to Air	**Released to Water**	**Released to Land (Soil)**	**Waste (Recovered Water)**	**Retained in Oil and Gas Stream**
Formulation into a Mixture	2.5%	2%	0.01%	-	-
Subsequent to formulation into a mixture, the mass balance of the remaining amount of PFAS is as follows when the product is used:					
Use of Functional Fluid at Industrial Site (tracers, anti-foaming agents)	5%	5%	5%	17%	68%

- Note: A facility needs to take into account whether it is an on-shore or off-shore installation. The European analysis assumed that all releases (associated with usage) to water and land (soil) would be to marine waters at offshore installations, while releases to fresh water and land (soil) for onshore installations would be distributed evenly to these two media. Releases of PFAS to air are not impacted whether the facility is located off-shore or on-shore. The above mass balance factors are for onshore facilities.

Source: Wood Group UK Ltd. (2021), *PFAS in Mining and Petroleum Industry – Use, Emissions and Alternatives*, prepared for the Norwegian Environment Agency.

Tracers and antifoaming agents are expected to be released into the oil/gas stream as part of their active use. For the use of anti-foaming agents, it is expected that the PFAS-containing products will be contained in the injection fluids but, due to the lipophilic nature of the PFAS compounds, they will tend to be retained in the oil/gas stream. A conservative estimate is applied, assuming 80% is retained in the petroleum stream and 20% remains in the recovered/produced water (these percentages are applied after releases to air, water and land occur).[64] In terms of tracers, there is limited specific data available on the precise release patterns or exactly how these substances will behave when released to the environment. In particular, the use phase is extremely challenging to characterize accurately and this is subject to considerable uncertainty.[65] The same assumption (80% retained in petroleum stream, 20% in recovered water) has also been applied for tracers.

According to the European analysis, PFAS contained in antifoaming agents also partially partitions to recovered water. Oil and gas recovered water, also known as produced water, is a non-potable by-product of oil and gas production. It's a mixture of water that was already in the reservoir and water that was injected to extract oil and gas. In addition, a

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[64] Ibid.

[65] Ibid.

portion of the chemicals added during processing of reservoir fluids may partition to the produced water.[66] There are various different fates for recovered water/produced water, including:[67/68]

- **Enhanced Recovery -** Injecting water into conventional hydrocarbon bearing formations to produce additional oil and gas beyond what would be produced using only primary recovery.
- **In-situ Operations** - Use of process water to create steam that heats bitumen, then recovers and recycles the water.
- **Operator Disposal -** Injection of produced water into disposal wells by the operator who generated the water.
- **Commercial Disposal -** Injection of produced water into disposal wells by a third-party being paid to dispose of the water.
- **Surface Discharge -** This includes offshore discharges to surface water as well as onshore discharges to surface waters and land surfaces typically after treatment and when the water meets certain water quality standards.
- **Evaporation -** Evaporation ponds are large impoundments that require a relatively large space to efficiently evaporate water by sunlight. The extent that this technique is used in Canada may be quite limited to non-existent.
- **Beneficial Reuse -** This can include the incorporation of produced water to augment fresh water in hydraulic fracturing fluids or drilling operations in order to complete new wells. Uses outside the oil and gas sector can include agricultural irrigation and dust and ice control on roads (the extent to which these reuse applications are used in Canada is unknown).
- **On-site containment -** For instance, the storage of process water on-site in setting basins and tailing ponds.
- **Reintegrated in the Landscape** - Process water (and tailings) can be reintegrated into the landscape to restore aquatic and terrestrial ecosystems through various reclamation scenarios.

Each facility will need to utilize their own internal records on the fate of recovered water that they generated during the NPRI reporting year in order to determine the fate of the PFAS that partitioned to that recovered water.

Aggregated national data on the fate of produced water generated by the oil and gas sector in Canada was not located. For information purposes, the fate of produced water in the U.S. in 2021 was as follows: (i) 48.3% was injected for enhanced oil recovery; (ii) 37.3% was injected for disposal by the operator; (iii) 10.1% was injected for disposal by commercial operations; (iv) 1.2% was discharged to waterbodies or land surfaces (over 95% of these

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[66] National Energy Board (2010), *Offshore Waste Treatment Guidelines*.

[67] All Consulting (2022), *U.S. Produced Water Volumes and Management Practices in 2021*.

[68] Allen, E. (2008), *Process Water Treatment in Canada's Oil Sands Industry: I. Target Pollutants and Treatment Objectives*, published in the Journal of Environmental Engineering.

discharges were to water bodies); (v) 0.2% was evaporated in either lined or unlined impoundments; (vi) 2.6% was used beneficially within or outside the oil and gas sector; and (vii) 0.4% was categorized as "other" (i.e., spilled, unaccounted for, record errors, or differences in produced versus management). [69]

Step 3: Estimate Fate of PFAS Contained in Hydraulic Fracturing Fluids

There was no identified equivalent mass balance accounting for PFAS contained in hydraulic fracturing fluid which was available for anti-foaming solutions and tracers. In the absence of more precise information or facility-specific data, the assumptions used for the fate of PFAS used in anti-foaming solutions and tracers can be applied for PFAS contained in hydraulic fracturing fluids. However, the default factors for releases to air, water and land presented above for anti-foaming solutions and tracers have been modified based on an understanding of the generation of recovered water from hydraulic fracturing operations and the percentage of fluid that remains underground. To be more specific, a large percentage of the hydraulic fracturing fluid (containing PFAS) remains underground and therefore there is not as much PFAS available to be released to surface air, water and land as indicated in the default factors presented earlier for anti-foaming solutions and tracers.

During hydraulic fracturing, produced saline water (called flowback water) is returned to the surface. Field observations show that as little as (or less than) 10% of the injected fracturing fluid may be recovered during flowback.[70/71] Imbibition (or leak-off) of fracturing water into the rock matrix may be the main mechanism by which fracturing water is lost. It has been suggested that up to 30% of water injected during hydraulic fracturing can be recovered to the surface after flowback operations,[72] however field observations to date indicate approximately 10%. This information was utilized to establish default fates for PFAS contained in hydraulic fracturing fluids that are injected into the well in terms of what percentage of the PFAS contained in hydraulic fracturing fluids remains underground, what percentage returns to the surface contained in flowback fluid and what percentage remains to result in potential releases to surface air, water and land.

The mass balance assumptions applied for PFAS in hydraulic fracturing fluids are outlined in the table below. Oil and gas operators typically produce hydraulic fracturing fluids on-site and therefore it is assumed that there will be releases of PFAS to air, water and land associated with this on-site formulation (as was assumed for the on-site formulation of anti-foaming solutions and tracers).

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[69] All Consulting (2022), *U.S. Produced Water Volumes and Management Practices in 2021*.

[70] Government of Canada, *Understanding the Fate of Non-recovered Fracturing Water and the Source of Produced Salts for Optimizing Fracking Operations*.

[71] Downstream Strategies (2013), *Water Resource Reporting and Water Footprint from Marcellus Shale Development in West Virginia and Pennsylvania*.

[72] Government of Canada, *Understanding the Fate of Non-recovered Fracturing Water and the Source of Produced Salts for Optimizing Fracking Operations*.

Table 6: Mass Balance of PFAS Contained in Hydraulic Fracturing Fluids Consumed in the Oil and Gas Sector

Environmental Release Category	**Release Factors/Mass Balance Factors**				
	Released to Air	**Released to Water**	**Released to Land (Soil)**	**Waste (Flowback Fluid)**	**Remains Underground**
Formulation into a Mixture	2.5%	2%	0.01%	-	-
Subsequent to formulation into a mixture, the mass balance of the remaining amount of PFAS is as follows when the product is used:					
Use of Hydraulic Fracturing Fluids	<1-5%	<1-5%	<1-5%	5-15%	85-95%

Source: Modified based on information contained in Wood Group UK Ltd. (2021), *PFAS in Mining and Petroleum Industry – Use, Emissions and Alternatives*, prepared for the Norwegian Environment Agency.

Surface discharge of flowback fluid is not permitted in Canada, which means it is not released into surface waters, such as lakes and streams. Flowback fluid may be recycled for further hydraulic fracturing, stored or disposed of by injection into deep sub-surface formations, through a licensed disposal well.[73] Additional details on these fates are as follows:

- Because hydraulic fracturing operations do not use water after a well is fractured, opportunities to recycle fracturing fluid (flowback fluid) within the well are limited. However, flowback water can be reused (subsequent to treatment) to fracture a different well, but its reuse depends on transportation and storage logistics. The receiving operation must be nearby and be able to accept the flowback water promptly.[74]
- When it is not able to be re-used, flowback fluid is stored (for days or months) in tanks or lined storage pits at the wellsite.[75]
- When the flowback fluid can no longer be appropriately stored, it is disposed of in deep injection disposal wells or at disposal facilities. The fluid is usually trucked or sent via pipeline to these sites. At a disposal facility (well), the waste fluid is pumped deep underground, into a porous formation, using a wellbore.[76/77]

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[73] Enserva, *Facts About Canada's Energy Industry - What Happens to the Flowback Fluid?*

[74] Alberta Energy Regulator (2024), *Hydraulic Fracturing Water Use.*

[75] Enserva, *Facts About Canada's Energy Industry - What Happens to the Flowback Fluid?*

[76] Ibid.

[77] Enserva, *Facts About Canada's Energy Industry – How is Water Managed in the Fracking Process*?

6. Mining

6.1 Introduction

PFAS substances can be used in the mining sector as follows:[78]/[79]/[80]/[81]

- in firefighting foam like aqueous firefighting foams (e.g. AFFFs) – training or actual use;
- extraction of minerals from ores;
    - in acid mist suppressing agents (leaching and electrowinning processes);
    - in wetting agents (leaching processes);
    - in hydrocarbon foaming agents (ore flotation processes); and
    - in fluorinated surfactants (ore flotation processes).

The use of firefighting foams is covered in separate guidance (Chapter 2). Chapter 2 also includes a section outlining the method that could be used to estimate PFAS quantities in stormwater runoff. The guidance within this section will therefore cover the manufacturing, processing, or otherwise use of products containing PFAS in the extraction of minerals from ores. Overall, three processes in the mining sector utilize products that can contain PFAS substances: (i) leaching; (ii) ore flotation; and (iii) electrowinning processes. Brief descriptions of these processes follow.

Leaching involves dissolving metals from ore using a chemical solution, creating a "leachate" that contains the dissolved metals at higher concentrations than existed within the ore. PFAS substances are used to increase the wetting of sulfuric acid or cyanide that can be used to leach the ore, or as an ingredient in acid mist suppressant.[82] PFAS can be found as ingredients in leaching products or mist suppressants due to their ability to lower surface tension.[83]

Two types of leaching processes have been identified in Canada: (i) heap leaching; and (ii) in-situ leaching. In-situ leaching processes are currently limited in Canada (the first Canadian in-situ leaching project was started at the Pheonix Uranium Deposit in 2023).[84] Facilities practicing in-situ leaching processes while utilizing solutions containing PFAS are encouraged to undertake their own mass-balance calculations to estimate potential releases. Due to variables in site specific geology, technology, hydrology, design, etc., the

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[78] Shanoff, Hains, (2024), *PFAS in Mining: How to Manage Potential Impacts, Risks, and Challenges.*

[79] Barfoot et al., (2022), *PFAS and the Mining Industry: Understanding the Challenges.*

[80] Norwegian Environment Agency, (2021), *PFAS in Mining and Petroleum Industry – Use, Emissions and Alternatives.*

[81] Gluge et al., (2020), *An Overview of the Uses of Per- and Polyfluoroalkyl Substances (PFAS).*

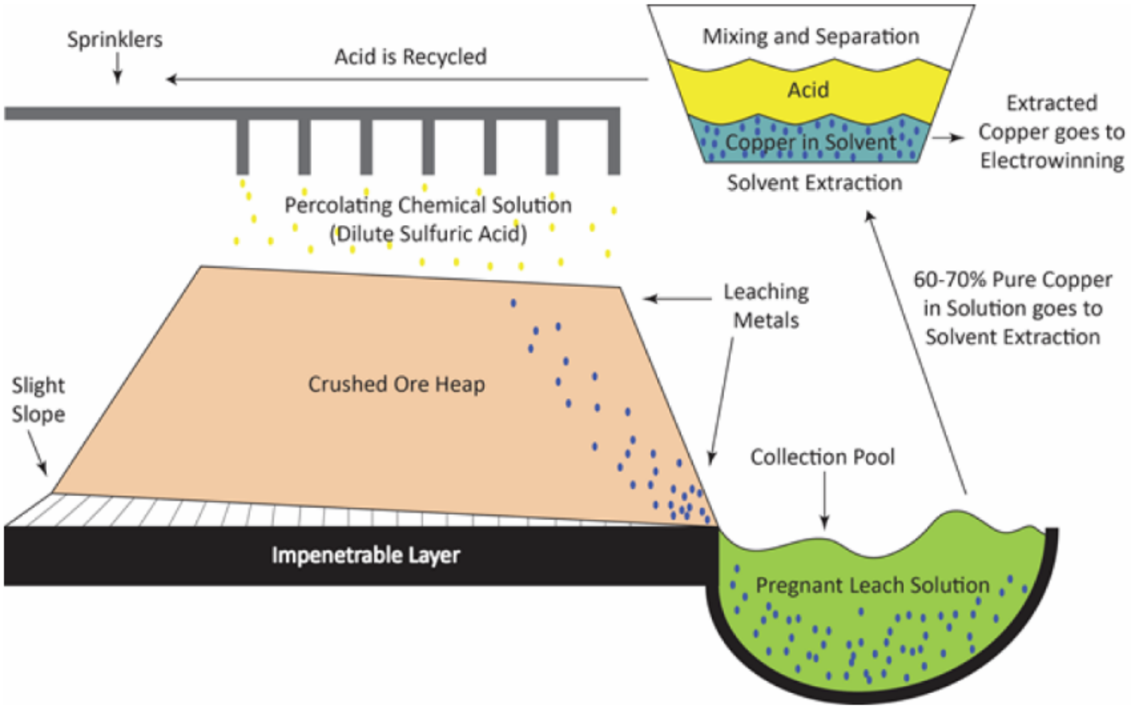
[82] Felix et al., (2023), *PFAS—Emerging Constituents of Concern for Mine Closure Studies*

[83] Gluge et al., (2020), *An Overview of the Uses of Per- and Polyfluoroalkyl Substances (PFAS).*

[84] Li et al., (2024), *A Review of In Situ Leaching (ISL) for Uranium Mining*

provision of a single estimation methodology is not advisable. The following diagram provides an indication of how heap leaching is typically practiced.

Figure 7: Heap Leaching and Solvent Extraction of Oxide Ore



Source: University of Arizona Superfund Research Center, *Copper Mining and Processing: Processing Copper Ores*.

The acid solution from the process is typically recycled or moves through solvent extraction and on to the electrowinning process (described below). The quantity of each individual PFAS (of the 163 that must be reported to the NPRI) that may partition from the acid solution and into the ore waste is unknown. Literature regarding the fate and transport of PFAS in different environmental media was reviewed, but no specific literature on how PFAS within sulfuric acid or cyanide solutions interact with waste ores was identified. Waste ore that has undergone leaching is typically disposed of on-site in tailings areas.

Electrowinning (also referred to as electroextraction) is a further concentration step that typically follows leaching. Electrowinning "is the electrodeposition of metals from their ores that have been put in solution via a process commonly referred to as leaching. The process involves passing an electric current through a solution containing metal ions, causing the metal to plate out onto an electrode."[85]

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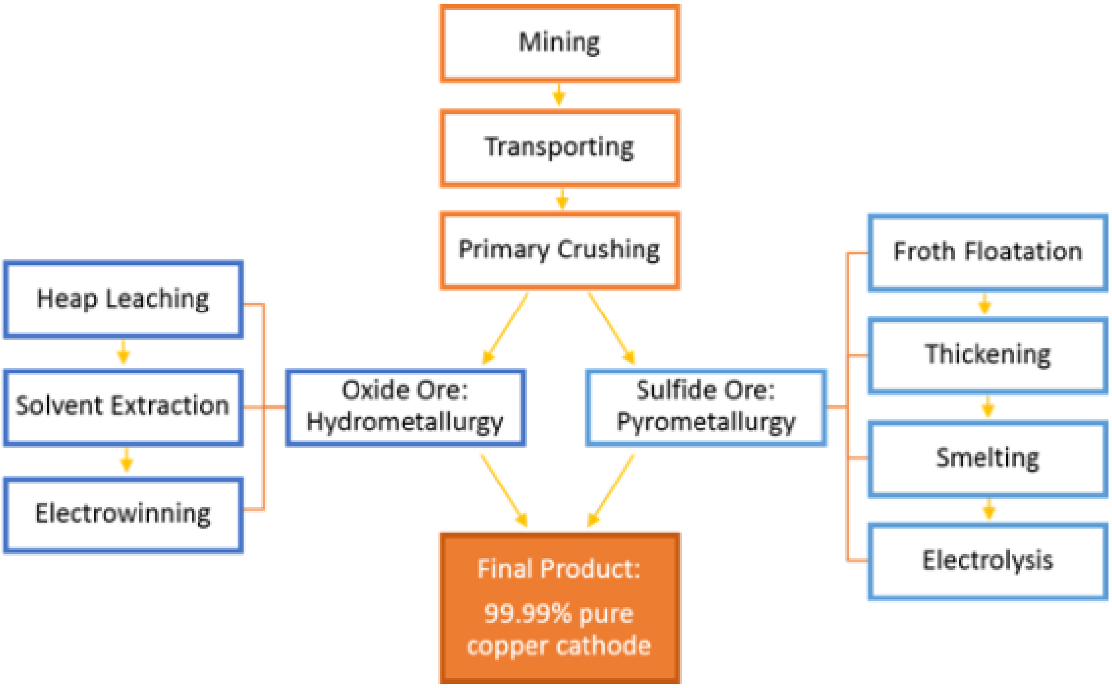
[85] Predest website, (2023), *Electrowinning, a Complete Guide*.

Similar to leaching, **flotation** is used to separate valuable minerals from ore. Typically, crushed ore is mixed with water and chemical additives to make slurry wherein the target minerals are made hydrophobic. Air is then injected into the slurry to form bubbles and the hydrophobic minerals attach to the bubbles and rise to the surface as a froth layer, which is then separated from the remaining unwanted material that did not float.[86]

Leaching and froth flotation may not be used within the same concentration processes, and electrowinning is only utilized near the end of hydrometallurgical concentration processes (that utilize leaching). The following simple process flow diagram is specific to copper but shows some of the typical process steps used in both hydrometallurgical concentration processes and pyrometallurgical concentration processes.

Figure 8: Copper Mining and Concentration Simplified Process Flow Diagram



Source: University of Arizona Superfund Research Center, *Copper Mining and Processing: Processing Copper Ores*.

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[86] HyControl Website, *Mining – Flotation*.

6.2 Determine if NPRI Reporting Thresholds are Met

The NPRI reporting threshold for individual PFAS is 1 kg of manufacturing, processing or otherwise use at ≥0.1% concentration. To determine if your facility meets this reporting threshold, calculations regarding all of the products that your facility has purchased containing PFAS substances are required.

Step 1: Identify Products Containing Relevant PFAS Manufactured, Processed, or Otherwise Used at the Facility and Quantify the Scale of Their Use

Research to identify the presence of individual PFAS in key products manufactured, processed or otherwise used by the facility can involve reviewing the Safety Data Sheet and/or Technical Data Sheet for the relevant products that have the potential of containing PFAS. Contacting the manufacturer or supplier of these products could also be a source to obtain relevant/necessary information. If readily available data can not be obtained, reasonable efforts should be taken to estimate the manufactured, processed or otherwise used. Substances present in these mixtures at concentration of at least 0.1% must be considered in the calculation of whether reporting thresholds were met.

Step 2: Calculate the Weight of Individual PFAS Contained in Products Manufactured, Processed or Otherwise Used for the NPRI Reporting Year

After all products used at the facility containing PFAS have been identified, and the volume of their use has been established, the concentrations of the individual PFAS substances within the products will need to be determined in order to estimate the weight of each individual PFAS substance utilized over the course of the reporting year. This information could be available from product manufacturers. This concentration will typically be outlined in percentage (%) terms. Apply those percentages to the total quantity (in kg) of product that was manufactured, processed or otherwise used at the facility during the NPRI reporting year. Use the following formula:

$$PFAS_{kg}^{i} = W_{kg}\ x\ Concentration_{\%}^{i}$$

Where:

- $PFAS^{i}_{kg}$ = Weight of PFAS chemical *i* contained in the product manufactured, processed or otherwise used at the facility during the NPRI reporting year, in kilograms.
- W_{kg} = Weight of the product manufactured, processed or otherwise used during the NPRI reporting year, in kilograms.
- $Concentration^{i}_{\%}$ = Concentration of PFAS chemical *i* contained in the product manufactured, processed or otherwise used at the facility during the NPRI reporting year, expressed in percentage terms.

The above calculation needs to be repeated for all individual PFAS chemicals that have been added to the NPRI and that are contained in products that were manufactured, processed or otherwise used at the facility during the NPRI reporting year.

The above calculation also needs to be repeated for each different product that contains individual PFAS (that have been added to the NPRI) that were manufactured, processed or otherwise used at the facility during the NPRI reporting year.

Aggregate the quantity of individual PFAS (defined as having separate CAS RNs) present in different products that are manufactured, processed or otherwise used at the facility during the NPRI reporting year. For individual PFAS calculated to be present in products manufactured, processed or otherwise used at the facility in quantities ≥1 kg during the NPRI reporting year, reporting of releases, transfers and disposals to the NPRI is required.[87] Please see the next section for guidance.

If there are no individual PFAS (that have been added to the NPRI) that are calculated to be present in products that were manufactured, processed or otherwise used in quantities ≥1 kilogram during the NPRI reporting year, then reporting of releases, transfers and disposals to the NPRI is not required.

6.3 Estimating Releases, Transfers and Disposals

There are three different processes from which releases or disposals of material streams containing PFAS substances may be generated from mining operations: (i) leaching; (ii) ore flotation; and (iii) electrowinning processes. Electrowinning processes typically follow leaching processes, and therefore these two processes are described together. Ore flotation is described separately. Facilities are encouraged to prioritize facility-specific data, such as source testing with mass balance, site-specific emission factors, or engineering estimates and process simulator models, when reporting to the NPRI. Additionally, other estimation methods, such as data from similar facilities or emission factors developed from comparable operations or surrogate substances, may also be used for NPRI reporting.

For those individual PFAS that met the threshold for reporting to the NPRI, all occurrences of those individual PFAS during manufacturing, processing or use activities at the facility during the NPRI reporting year have to be taken into consideration when determining releases, transfers and disposals (e.g., even if that individual PFAS is contained in a product at less than 0.1% concentration).

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[87] As long as those individual PFAS are MPO at concentrations greater than 0.1%.

6.3.1 Leaching and Electrowinning

PFAS added to a leaching solution will either partition to tailings that are disposed of, or partition to pregnant leachate and eventually be released with effluent from the electrowinning process.

Tailings from leaching processes may get leached again but will eventually be disposed of in a tailings area. No publicly available information on how each of the 163 PFAS that must be reported to the NPRI might partition to either tailings or pregnant leachate (from a cyanide or sulfuric acid solution used in a leaching process) was identified. Therefore, facilities may utilize testing processes that analyze site-specific/process-specific concentrations of PFAS within tailings in order to estimate the total quantity of each of the 163 PFAS that must be reported to the NPRI contained within tailings disposed of during the course of the NPRI reporting year. If no testing data is available, facilities could make reasonable estimates using the best readily available information.

Pregnant leach solution from the leaching process will typically flow through to solvent extraction and electrowinning processes and is not released or disposed of during leaching. Instead, effluent from the electrowinning process (typically acidic in nature and requiring treatment before release) may be recycled back into the process but will eventually undergo treatment before being released. The specific type of treatment the effluent will undergo will depend upon the specific mine site. Facilities may choose to undertake testing of their electrowinning effluent to estimate the total quantity of each of the 163 PFAS that must be reported to the NPRI contained within effluent released during the NPRI reporting year. Effluent should be tested at the point of release as opposed to before treatment in order to ensure that the potential impact of effluent treatment is applied.

For both electrowinning effluent and tailings, calculate annual disposals or releases using the following calculation.

$$PFAS_{kg}^{i} = W_{kg\ or\ L\ kg}\ x\ Concentration_{\%}^{i}$$

Where:

- $PFAS^i_{kg}$= Weight of PFAS chemical *i* contained in the tailings from leaching (kg – disposal) or effluent from electrowinning (liters – releases) at the facility during the NPRI reporting year.
- $W_{kg\ or\ L}$= Weight of the tailings generated while using PFAS containing leaching solution in kg, or volume of the electrowinning effluent generated while using PFAS containing leaching solution, in liters.
- $Concentration^i_{\%}$ = Concentration of PFAS chemical *i* contained in the tailings (kg/kg) or electrowinning effluent (kg/l) during the NPRI reporting year, expressed in percentage terms determined through testing.

The above calculation needs to be repeated for all individual PFAS chemicals that have been added to the NPRI and that are contained in tailings or electrowinning effluent that were utilized in the leaching/electrowinning processes during the NPRI reporting year.

6.3.2 Ore Flotation

Ore flotation generates a tailing stream that may contain PFAS. The minerals that are harvested via flotation are typically sent to smelting processes, where they are smelted at temperatures over 1200°C – which are sufficient to destroy PFAS substances.[88] Therefore, all PFAS substances utilized within the ore flotation process are either disposed of (on-site or off-site) with tailings or destroyed. No information on how each of the 163 PFAS that operators must report to the NPRI might partition through a flotation process was identified. Operators may choose to conduct testing on the tailings exiting flotation processes to establish the quantities of waste PFAS contained within their tailings. If this testing is conducted, the results of this testing can be used to estimate total PFAS contained in tailings generated annually at the facility for reporting purposes. Utilize the following calculation.

$$PFAS_{kg}^{i} = W_{kg}\ x\ Concentration_{\%}^{i}$$

Where:

- $PFAS^{i}_{kg}$ = Weight of PFAS chemical *i* contained in the tailings from flotation at the facility during the NPRI reporting year, in kg.
- W_{kg} = Weight of the tailings generated from flotation while using PFAS containing products, in kg.
- $Concentration^{i}_{\%}$ = Concentration of PFAS chemical *i* contained in the tailings from flotation generated during the NPRI reporting year, expressed in percentage terms determined through testing.

The above calculation needs to be repeated for all individual PFAS chemicals that have been added to the NPRI and that are used in the flotation process during the NPRI reporting year. Aggregate the quantity of individual PFAS (defined as having separate CAS RNs) used in the flotation process during the NPRI reporting year.

If no testing data is available, facilities could make reasonable estimates using the best readily available information about the PFAS utilized in a flotation process that partitions to tailings for disposal. To estimate the quantity of PFAS present in tailings from flotation processes, utilize the following steps.

Step 1: Identify Products Containing Relevant PFAS Used in Flotation Processes at the Facility and Quantify the Scale of Their Use

Facilities should identify whether any products used in the flotation process contain one or more of the 163 PFAS substances listed in the NPRI. This could be done by reviewing the product's Safety Data Sheet (SDS), Technical Data Sheet (TDS), or by contacting the manufacturer or supplier. Using readily available information such as inventory changes, purchasing records, product transfers, or storage amounts or applying reasonable estimates when data is limited, facilities should quantify the amount of each PFAS-containing product used in the flotation process over the NPRI reporting year.

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[88] Scottish Environmental Protection Agency, (2002), *Guidance on Landfill Gas Flaring*.

Step 2: Calculate the Weight of Individual PFAS Contained in Products Used in Flotation Processes for the NPRI Reporting Year

After all products used in the flotation process containing PFAS have been identified, and the volume of their use has been established, the concentrations of the individual PFAS substances within the products will need to be determined in order to estimate the weight of each individual PFAS substance utilized in the flotation process over the course of the reporting year. This information should be available from product manufacturers. This concentration will typically be outlined in percentage (%) terms. Apply those percentages to the total quantity (in kg) of product utilized in the flotation process during the NPRI reporting year. Use the following formula:

$$PFAS_{kg}^{i} = W_{kg}\ x\ Concentration_{\%}^{i}$$

Where:

- $PFAS^{i}_{kg}$ = Weight of PFAS chemical *i* contained in the product used in the flotation process during the NPRI reporting year, in kilograms.
- W_{kg} = Weight of the product used in the flotation process during the NPRI reporting year, in kilograms.
- $Concentration^{i}_{\%}$ = Concentration of PFAS chemical *i* contained in the product used in the flotation process at the facility during the NPRI reporting year, expressed in percentage terms.

The above calculation needs to be repeated for all individual PFAS chemicals that have been added to the NPRI and that are used in the flotation process during the NPRI reporting year. Aggregate the quantity of individual PFAS (defined as having separate CAS RNs) used in the flotation process during the NPRI reporting year.

Step 3: Apply the Impacts of Mitigation Techniques to Release Estimates

Ore flotation generates tailings, and facilities may apply mitigation techniques to limit the release of certain substances within their tailings. The efficacy of tailings treatment systems varies by technology type, flow rate, the specific substance under consideration, and many other factors. If facilities apply mitigation techniques to their tailings stream that will impact the release of any PFAS quantified under steps 1 and 2 above, they may choose to estimate how these mitigation techniques may impact their releases should the required information be available. Facilities may utilize engineering estimates, available release factors, etc. to quantity the impact of their mitigation techniques.

7. Recovered Paper Processing

7.1 Introduction

PFAS have been used in paper and paperboard products since the 1960s, most notably in food contact materials.[89] When paper products – including food contact materials treated with PFAS – enter a recovered paper processing facility, the PFAS substances will flow through the paper recovering process and into facility wastewater and newly manufactured paper products (as non-intentionally added substances or by-products). Please note that releases, transfers, and disposals may also result from the use of firefighting foams like AFFF or from stormwater runoff, both of which are addressed in Chapter 2.

The scope of this section is limited to the recovered paper processing facilities that break down the waste products for the manufacture of new products as opposed to collection or sortation activities that typically take place in separate facilities. Any potential releases of PFAS-containing paper products from collection or sortation processes (typically undertaken at material recovery facilities that handle many different products as opposed to just paper) are not described within this section.

PFAS exiting paper recovered paper processing facilities within new product as non-intentionally added substances are also not considered to be within scope, as these are not releases or transfers, but instead unintentional PFAS within a product. Finally, no suitable information was identified on: (i) potential PFAS releases to air from recovered paper processing facilities; (ii) concentrations of specific PFAS analytes in sludge generated by wastewater treatment at recovered paper processing facilities; and (iii) how to quantify potential PFAS transfers to landfills within rejected paper products containing PFAS.

Therefore, this section provides guidance on how to estimate the quantity of PFAS contained within treated wastewater that is released from recovered paper processing facilities. A process flow diagram showing a recovered paper processing facility is shown below. It shows how fresh water is utilized and recycled within the paper recovering process, and how the water is treated via a wastewater treatment plant within the facility before it is released to the environment.

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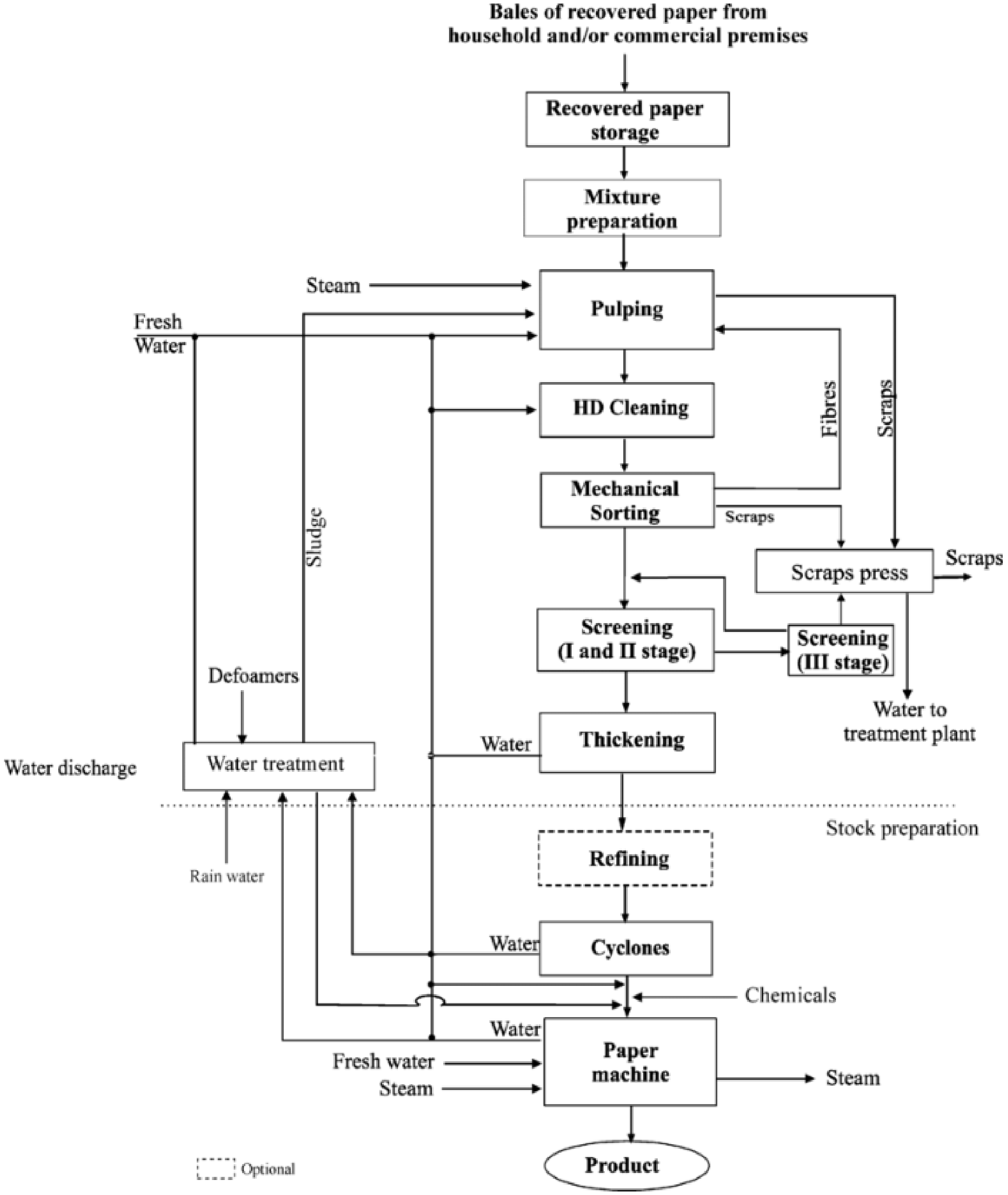
[89] Langberg et al., (2024), *Recycling of Paper, Cardboard, and its PFAS in Norway*.

Figure 9: Process Flow Diagram of a Recovered Paper Processing Facility



Source: Arena et al., (2004), *Environmental Assessment of Paper Waste Management Options by Means of LCA Methodology*

Limited data on the concentrations of specific PFAS substances that flow through recovered paper processing facilities were identified. Two main sources of information on PFAS concentrations in recovered paper processing facilities were found:

- USEPA presented some limited effluent PFAS data from pulp, paper, and paperboard facilities in the United States US EPA, (2021), *Multi-Industry Per- and Polyfluoroalkyl Substances (PFAS) Study – 2021 Preliminary Report*: Since then updated with additional data collected on PFAS use and discharge from other pulp, paper, and paperboard facilities and presented in the subsequent 2023 Final Effluent Guidelines Program Plan 15 (EPA-821-R-22-004). This updated report contains a table that shows concentration ranges and average concentrations for 34 PFAS substances in the wastewater of paper mills based on 4664 samples (not specifically recovered paper processing facilities). Monitoring data from the 52 facilities showed detectable but generally low PFAS levels. As many paper mills utilize post-consumer paper as a feedstock,[90] it can be assumed that some of these mills that are involved in recovered paper processing likely have PFAS within their wastewater due to post-consumer feedstock contaminated with PFAS. No information about the 52 facilities is available, however: (i) only a small subset of paper mills in the U.S. use PFAS substances and therefore products for which PFAS substances are added intentionally make up a very small percentage of overall production; and (ii) the EPA did not identify any paper mills utilizing wastewater treatment technologies known to reduce PFAS, and therefore these figures likely provide a good indication of PFAS concentrations in facility wastewater. Given the fact that these facilities were located in North America, this data has been chosen for use within this guidance.
- Langberg et al., (2024), *Recycling of Paper, Cardboard, and its PFAS in Norway*: This study is for a single pulp mill in Norway, but is specific to a paper recycling facility. It analyzes 37 PFAS within the facility at 8 different sampling points as follows: "(1) reject paper from the initial sorting; (2) pulp of the paper sorted for recycling; (3 and 4) wastewater filtered to separate the dissolved, and particulate phases; (5 and 6) reject from the paper machines PM5 and PM6); and (7 and 8) recycled paper from PM5 and PM6." This study gathered results from only one facility in Norway, and it is unknown if the samples taken from this single facility are representative of average concentrations at paper recycling facilities in North America. Additionally, the study only found 6 PFAS analytes in the pulping stage of the process (sampling point 2) – some of which are not on the NPRI list. A Similar number of analytes were identified at other stages of the process – leaving the data of limited utility for the purposes of this guidance.

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[90] The Paper and Paperboard Packaging Environmental Council (PPEC), (2023), *2022 PPEC Recycled Content Survey: Average Recycled Content of Major Paper Packaging Grades made by Canadian Mills in 2022*

7.2 Determine if NPRI Reporting Thresholds are Met

The NPRI reporting threshold for individual PFAS is 1 kg of manufacturing, processing or otherwise use at ≥0.1% concentration. For recovered paper processing facilities, all substances collected in the waste paper feedstock or produced during wastewater treatment are considered to be "by-products", and as a result, the concentration threshold does not apply (recovered paper processing facilities do not manufacture PFAS, and they do not use PFAS). In order to determine if NPRI reporting thresholds are met, it must be determined if more than 1 kilogram of any specific PFAS substance entered the facility within waste paper during the reporting year. Given that any individual piece of paper may have no PFAS in it, or may have high concentrations of PFAS, the most sensible place (given currently available data) to conduct testing for PFAS in a recovered paper processing facility would be within wastewater. The following estimation methodology can be used to determine if the facility meets the reporting threshold for any individual PFAS.

Step 1: Determine if Individual PFAS Concentrations in the Pulping Step at Your Facility During the NPRI Reporting Year Would Result in Exceeding the 1 kg Threshold

Whether a substance has the potential to reach the 1 kg reporting threshold level in a year will depend, in part, on the concentration of the substance in the paper entering the facility and the annual average throughput of the facility. The facility should review information available in order to identify the NPRI substances present at concentrations sufficient to trigger a reporting requirement. Based on the facility's throughput rate, the following equation can be used to ascertain the concentrations of substances required to exceed the reporting thresholds for the particular facility:

$$C_{PFAS^i} = (1\,kg \times 10^{12}\,ng/kg)/(Q_{facility} \times 1000\,l/m^3 \times 365\,days/year)$$

Where:

$C_{PFAS}{}^{i}$= concentration of a PFAS substance in the wastewater that will trigger a reporting requirement, ng/l, or ppb;

$Q_{facility}$= average daily flow rate of discharge from the facility's wastewater treatment system, m^3/day.

The results of these calculations can be compared to concentrations from monitoring data, literature values and other information sources to determine which substances may be reported. Facilities are encouraged to prioritize facility-specific data, such as source testing with mass balance, site-specific emission factors, or engineering estimates, when evaluating reporting to the NPRI. Additionally, data from similar facilities, comparable operations, or surrogate substances may also be considered. If there has been no testing for the concentration of individual PFAS in a facility or if relevant estimate data is unavailable, then Table 7 in section 7.4 provides available testing data from the U.S. EPA study described in the introduction to this chapter. However, due to limited information on the sampled facilities and the treatment of non-detect data, this dataset may not accurately represent wastewater effluents from recovered paper processing. Reporting facilities should evaluate with the help of facility experts whether the data in Table 7 could be used to estimate possible water releases from their sites.

Step 2: If Possible, Determine the Quantity of Individual PFAS Created within the Paper Recycling Facility

As a general rule, reporting for individual PFAS is triggered by the amount of the individual PFAS initially present in the raw feedstock entering the facility. However, exceptions to the general rule for triggering PFAS reporting on the basis of raw feedstock exist and include:

- PFAS produced as a result of the process (in this case, the quantity of the individual PFAS produced should be used to determine whether the threshold was exceeded); and
- PFAS present in the raw feedstock **and** produced by any processes at the facility. In this case, the quantity of substance in the raw feedstock plus that produced should be used to determine whether the threshold was exceeded.

In the above exceptions, available concentration data from biosolids/sludges and/or effluent could be used to determine if the threshold is met. However, this would require an understanding of whether individual PFAS are generated within the paper recycling facility (and not just contained in the feedstock) and/or what percentage of individual PFAS in the recovered paper processing facility are a result of the feedstock and what percentage were generated within the facility. If this understanding/knowledge of the partitioning/generation of PFAS within a recovered paper processing facility is not available, then the calculations that only rely on the feedstock (as described in step 1 above) should be relied upon to determine if the 1 kg NPRI reporting threshold for individual PFAS has been met. At the time this guidance was written, no information on PFAS concentrations within the sludges generated in wastewater treatment processes employed at recovered paper processing facilities was identified. If this information becomes available in future, it could be utilized in the absence of on-site testing to help determine if thresholds are met.

7.3 Estimating Releases, Transfers and Disposals

For those individual PFAS that met the thresholds for reporting to the NPRI, the following steps need to be undertaken:

Step 1: Determine Individual PFAS Quantities in Wastewater Effluent

Should you have testing available for the concentration of individual PFAS in the effluent (typically expressed in ng/L) from your recovered paper processing facility, then these concentrations should be used.

If there has been no testing for the concentration of individual PFAS in your effluent, reasonable estimates maybe used based on data from similar facilities, comparable operations, or surrogate substances. Table 7 in section 7.4 below provides available testing data from the U.S. EPA study described in the introduction to this chapter, but this should be applied cautiously, in conjunction with more specific input from facility experts and may not be representative of actual operations of the facility.

Once the individual PFAS concentrations have been identified, the following formula should be used to calculate the quantity of individual PFAS that were contained in effluent released from your paper recycling facility during the NPRI reporting year:

$$PFAS^{i}_{kg} = Volume_{L}\ x\ Concentration^{i}_{ng/L}\ \ x\ 10^{-12}_{kg/ng}$$

Where:

- $PFAS^{i}_{kg}$ = Quantity of PFAS chemical *i* contained in effluent released from the paper recycling facility during the NPRI reporting year, in kilograms.
- $Volume_{L}$ = Total volume of effluent released from the paper recycling facility during the NPRI reporting year, in litres.
- $Concentration^{i}_{ng/L}$ = Concentration of PFAS chemical *i* contained in effluent released from the paper recycling facility during the NPRI reporting year, expressed in ng/L.
- $1e\text{-}12_{kg/ng}$ = Conversion factor for nanograms to kilograms. 1 kg = 10^{12} ng.

Step 2: Determine Individual PFAS Quantities in Sludge/Biosolids

In determining whether reporting to the NPRI is required for individual PFAS (see previous section, Step 2), a calculation was made of the quantity of individual PFAS that were contained in the sludge/biosolids that were generated at the facility during the NPRI reporting year. The fate of this quantity of individual PFAS needs to be reported. The fate will typically be either to: (i) off-site disposal – land treatment; (ii) transfers for treatment – incineration; or (iii) off-site disposal – landfill. However, the full set of release/transfer/disposal categories should be reviewed to determine the most appropriate category for the individual PFAS contained in sludge/biosolids. No data on PFAS concentrations within the sludge generated by wastewater treatment systems at recovered paper processing facilities was identified; onsite testing could be used, and further data to support this analysis may be identified in future.

7.4 Table of PFAS Concentrations in Recovered Paper Processing Wastewater

Two studies were identified that provided information on PFAS concentrations at recovered paper processing facilities, as described in the introduction to this chapter. As noted previously, the U.S. EPA study has been selected for use due to its significantly higher number of samples and the fact that it surveyed 52 facilities instead of one, and therefore may have generated more representative average concentration figures. The table below shows the different PFAS analytes that were detected in pulp, paper and paperboard wastewater within these 52 facilities, including the range of concentrations detected and the average concentrations of the samples. The facility may utilize the average concentrations within the samples for any calculation steps described in the sections above if site-specific testing data is unavailable. As previously mentioned, this table is intended only as an indication of the potential presence of PFAS in paper recovery processes and should be used with caution. It should be complemented by more specific input from facility experts, as it may not accurately reflect the actual operations of a given facility.

Table 7: Pulp, Paper, and Paperboard Wastewater PFAS Concentrations (US EPA)

PFAS Subgroup	Analyte[a]	CAS NUMBER	Facilities with Data	Quantified Detections/ Total Sample Results	Concentration Range (ppt)[b]	Average Concentration (ppt)[b]
Perfluoroalkyl carboxylic acids (PFCAs)	Perfluorobutanoic acid (PFBA)	45048-62-2	26	32/43	ND – 638	38.5
	Perfluoropentanoic acid (PFPeA)	45167-47-3	26	33/43	ND – 246	22.7
	Perfluorohexanoic acid (PFHxA)	307-24-4	26	41/43	ND – 640	33.1
	Perfluoroheptanoic acid (PFHpA)	375-85-9	26	39/43	ND – 206	15.2
	Perfluorooctanoic acid (PFOA)	45285-51-6	52	168/229	ND – 680	22.2
	Perfluorononanoic acid (PFNA)	72007-68-2	38	34/57	ND – 52.6	4.08
	Perfluorodecanoic acid (PFDA)	73829-36-4	26	15/43	ND – 19.7	0.969
	Perfluoroundecanoic acid (PFUnA)	196859-54-8	26	9/43	ND – 15.3	0.423
	Perfluorododecanoic acid (PFDoA)	171978-95-3	26	6/43	ND – 20.3	0.469
	Perfluorotridecanoic acid (PFTrA)	72629-94-8	26	5/43	ND – 24.9	0.503
	Perfluorotetradecanoic acid (PFTeA)	376-06-7	26	6/43	ND – 23	0.465
	Perfluorohexadecanoic acid (PFHxDA)	67905-19-5	3	0/7	ND	ND
	Perfluorooctadecanoic acid (PFODA)	16517-11-6	3	2/7	ND – 14.6	2.91
Perfluoroalkane sulfonic acids (PFSAs)	Perfluorobutane sulfonic acid (PFBS)	45187-15-3	38	36/57	ND – 254	4.84
	Perfluoropentane sulfonic acid (PFPeS)	175905-36-9	25	4/42	ND – 1.43	0.122

	Perfluorohexane sulfonic acid (PFHxS)	355-46-4	38	32/57	ND – 59	1.98
	Perfluoroheptane sulfonic acid (PFHpS)	146689-46-5	23	4/40	ND – 0.28	0.03
	Perfluorooctane sulfonic acid (PFOS)	45298-90-6	52	161/231	ND – 810	16.1
	Perfluorononane sulfonic acid (PFNS)	474511-07-4	25	1/42	ND – 2.17	0.022
	Perfluorodecane sulfonic acid (PFDS)	126105-34-8	26	3/43	ND – 5.17	0.117
Perfluoroalkane sulfonamides (FASAs)	Perfluorooctane sulfonamide (PFOSA)	754-91-6	25	1/42	ND – 17.5	0.7
Fluorotelomer sulfonic acids (FTSAs)	4:2 fluorotelomer sulfonic acid (4:2 FTSA)	414911-30-1	23	0/33	ND	ND
	6:2 fluorotelomer sulfonic acid (6:2 FTSA)	425670-75-3	24	19/36	ND – 284	8.7
	8:2 fluorotelomer sulfonic acid (8:2 FTSA)	481071-78-7	24	6/36	ND – 0.821	0.119
Perfluoroalkane sulfonamido ethanols (FASEs), perfluoroalkane	N-methyl perfluorooctane sulfonamide (NMePFOSA)	2355-31-9	18	0/22	ND	ND
	N-ethyl perfluorooctane sulfonamide (NEtPFOSA)	4151-50-2	18	0/22	ND	ND
sulfonamido acetic acids (FASAAs), and N-Alkyl FASAAs	N-methyl perfluorooctane sulfonamido ethanol (NMeFOSE)	24448-09-7	18	2/22	ND – 6.62	0.459
	N-ethyl perfluorooctane sulfonamido ethanol (NEtFOSE)	1691-99-2	18	0/22	ND	ND
	N-methyl perfluorooctane sulfonamido acetic acid (NMeFOSAA)	2355-31-9	26	12/43	ND – 12	1.56
	N-ethyl perfluorooctane sulfonamido acetic acid (NEtFOSAA)	2991-50-6	26	20/44	ND – 46	4.31
Per- and polyfluoroalkyl ether carboxylic acids (PFECAs)	Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	20	10/25	ND – 3.14	0.392
	4,8-dioxa-3H-perfluorononanoic acid (DONA)	919005-14-4	17	0/17	ND	ND
	Sodium dodecafluoro-3H-4, 8- dioxanonanoate (NaDONA)	2250081-67-3	2	0/6	ND	ND
Per- and polyfluoroalkyl ether sulfonic acids (PFESAs)	11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OudS/F-53B Minor)	763051-92-9	16	0/16	ND	ND

Source: Effluent Guidelines Program Plan 15, January 2023

Abbreviations:

ND – non-detection;

ppt – parts-per-trillion (equivalent to nanograms per liter).

a – This table presents data for the PFAS listed in draft EPA Method 1633 analyte list for which sample results are available.

b – In this analysis, EPA treated all non-detection results as zero for the purpose of estimating concentrations. All concentration values are rounded to three significant figures.

8. Wastewater Facilities

8.1 Introduction

This chapter applies to the wastewater treatment sector which refers to wastewater facilities serving communities, and includes, but is not limited to, wastewater facilities owned and/or operated by municipalities; wastewater facilities on federal lands serving communities (such as military bases) and wastewater facilities serving indigenous communities. These wastewater facilities may also be owned and/or operated by private individuals or corporations in public-private partnership situations. This chapter applies to wastewater facilities classified under the North American Industry Classification System (NAICS) code 221320 (sewage treatment facilities) and does not apply to industrial wastewater treatment facilities.

For NPRI purposes, a wastewater facility is defined as a wastewater collection/treatment system that discharges treated or untreated wastewater into surface waters with an annual average flow rate of 10 000 cubic metres per day or more. For NPRI reporting, a wastewater facility includes both treatment and collection systems. For general details about reporting requirements for wastewater facilities under the NPRI and to determine whether a report is required for your facility, consult the Reporting Guidance for the Wastewater Sector to the National Pollutant Release Inventory. **Wastewater facilities with annual average discharge of < 10 000 m3 per day are exempt from reporting for NPRI**. If a facility is not under the above definition (i.e. it is not primarily a wastewater facility but instead meets the definition of a contiguous facility where the minimum employee hours are met), then the annual average flow rate of 10 000 cubic metres per day or more is not relevant and any wastewater treatment plant activities should be regarded as part of the facility's operations.

As further context, the wastewater addressed in this guidance refers to used water from homes, businesses, industries, and institutions that drains into sewers. It contains sanitary sewage and is sometimes combined with stormwater from rain or melting snow draining off rooftops, lawns, parking lots and roads. Treating wastewater before it is released into lakes and rivers reduces the risks posed to human health and the environment. The treatment processes applied can be summarized as follows:[91]

- No treatment: No treatment process or only screening and/or grit removal.
- Primary treatment: Removing a portion of suspended solids and organic matter by physical and/or chemical processes.

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[91] Environment and Climate Change Canada (2023), *Municipal Wastewater Treatment – Canadian Environmental Sustainability Indicators*.

- Secondary treatment: Removing organic matter and suspended solids using biological treatment processes and secondary sedimentation.
- Tertiary treatment: Removing specific substances of concern (solids, nutrients and/or contaminants) after secondary treatment using a number of physical, chemical or biological processes.

The various treatment processes employed at municipal wastewater facilities results in the generation of two major streams released to the environment, specifically treated effluent and a concentrated stream of solids called sludge[92] (or biosolids).

Wastewater facilities provide a critical link between producers and users of PFAS-containing products and the environment.[93] Effluent discharge from wastewater facilities is regarded as an important pathway of PFAS pollution to the aquatic environment,[94] while biosolids produced by wastewater facilities may be land applied for beneficial uses. Air emissions from wastewater facilities may represent an additional source of PFAS and should be considered when monitoring data from the facility are available, or when estimates can be obtained from literature sources or drawn from similar facilities or processes[95][96][97]

PFAS are ubiquitous in municipal wastewater effluent and biosolids.[98] PFAS concentrations in wastewater vary widely, reflecting the diversity of sources. [99] Major point sources include PFAS-producing or -using industrial sites, such as papermaking, textile mills, and electroplating.[100] The use of consumer products can also be a significant contributor to the overall PFAS load to municipal wastewater treatment plants. For

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[92] Yadav, B. et. al. (2022), *Occurrence, Fate, and Persistence of Per- and Poly-fluoroalkyl Substances (PFASs) During Municipal Sludge Treatment*, contained in *Current Developments in Biotechnology and Bioengineering: Sustainable Treatment Technologies for Per- and Poly-fluoroalkyl Substances.*

[93] Cookson, E.S. & Detwiler, R.L. (2022), *Global Patterns and Temporal Trends of Perfluoroalkyl Substances in Municipal Wastewater: A Meta-Analysis*, published in Water Research.

[94] Yadav, B. et. al. (2022), *Occurrence, Fate, and Persistence of Per- and Poly-fluoroalkyl Substances (PFASs) During Municipal Sludge Treatment*, contained in *Current Developments in Biotechnology and Bioengineering: Sustainable Treatment Technologies for Per- and Poly-fluoroalkyl Substances.*

[95] Ahrens et al. (2011) Wastewater Treatment Plant and Landfills as Sources of Polyfluoroalkyl Compounds to the Atmosphere, Environmental Science & Technology, Vol 45/Issue 19

[96] Chen et al. (2020) Comparison of fluorotelomer alcohol emissions from wastewater treatment plants into atmospheric and aquatic environments, Environment International, Volume 139, June 2020, 105718

[97] Lin et al. (2022) Per- and polyfluoroalkyl substances in the atmosphere of waste management infrastructures: Uncovering secondary fluorotelomer alcohols, particle size distribution, and human inhalation exposure, Environment International, Volume 167, September 2022, 107434

[98] Thompson, K.A. et. al. (2022), *Poly- and Perfluoroalkyl Substances in Municipal Wastewater Treatment Plants in the United States: Seasonal Patterns and Meta- Analysis of Long-Term Trends and Average Concentrations*, published in Environmental Science & Technology Water.

[99] Cookson, E.S. & Detwiler, R.L. (2022), *Global Patterns and Temporal Trends of Perfluoroalkyl Substances in Municipal Wastewater: A Meta-Analysis*, published in Water Research.

[100] Thompson, K.A. et. al. (2022), *Poly- and Perfluoroalkyl Substances in Municipal Wastewater Treatment Plants in the United States: Seasonal Patterns and Meta- Analysis of Long-Term Trends and Average Concentrations*, published in Environmental Science & Technology Water.

instance, PFAS stemming from apparel during the washing cycle can contribute to the overall PFAS load to wastewater facilities. Other consumer products that can lead to increased PFAS loading to wastewater facilities include the washing of floors, the use of a wide variety of personal care products, residue from food packaging (e.g. microwave popcorn), automobile washing/cleaning products, etc.[101] Also, landfill leachate is often directed to wastewater facilities thereby providing another potential significant source of PFAS.[102] Finally, environmental recirculation events such as stormwater runoff and groundwater leakage into the sewer system can contribute to PFAS entering wastewater. For instance, PFAS contained in coatings, paints and varnishes, as well as other outdoor protective coverings can be washed away during rain events, in addition to PFAS already being present in rainwater.[103]

Due to the chemical, thermal, and biological stability imparted by their C-F bonds, PFAS are not effectively removed by conventional wastewater treatment processes and are commonly detected in influent, effluent, and biosolids. Furthermore, some PFAS such as fluorotelomer alcohols and perfluorooctane sulfonamides (precursor compounds) can biodegrade to other PFAS including PFAAs during treatment resulting in measured concentrations increasing from influent to effluent[104] (and biosolids).

The main mechanism of removal of PFAS within liquids streams in conventional wastewater processes is adsorption to sludge and suspended particulate matter.[105] Collected sludge is considered biosolids after undergoing appropriate treatments such as digestion, lime stabilization, composting, or heat treatment, to meet regulatory requirements.[106] More information about reporting of NPRI substances in biosolids can be found in the NPRI document Biosolids: Guide to Reporting.

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[101] Krlovic, N. et. al. (2024), *A Source-based Framework to Estimate the Annual Load of PFAS in Municipal Wastewater*, published in Science of the Total Environment

[102] Cookson, E.S. & Detwiler, R.L. (2022), *Global Patterns and Temporal Trends of Perfluoroalkyl Substances in Municipal Wastewater: A Meta-Analysis*, published in Water Research.

[103] Krlovic, N. et. al. (2024), *A Source-based Framework to Estimate the Annual Load of PFAS in Municipal Wastewater*, published in Science of the Total Environment

[104] Ibid.

[105] Ibid.

[106] Zhou, T. et. al. (2024), *Occurrence, Fate, and Remediation for Per-and Polyfluoroalkyl Substances (PFAS) in Sewage Sludge: A Comprehensive Review*, published in the Journal of Hazardous Materials.

8.2 Determine if the NPRI Reporting Threshold is Met For individual PFAS

In general, the NPRI reporting threshold for individual PFAS is 1 kg of manufacturing, processing or otherwise use at ≥0.1% concentration. For wastewater facilities, all PFAS collected in the influent from industrial, commercial, institutional or residential sources, or produced during wastewater treatment are considered to be "by-products", and as a result, the above-noted concentration threshold does not apply.

Given the large number and diverse classes of PFAS substances included in the NPRI, along with their distinct chemical properties, many are likely to be present in both effluents and biosolids—potentially at elevated concentrations due to the transformation of PFAS precursors. Considering the complexity of the wastewater matrix and the variety of biological and physicochemical processes that can affect these PFAS substances fate, it is more appropriate to base the NPRI reporting threshold on estimated quantities in effluents and biosolids, rather than on influent data[107][108][109][110]. This approach provides a more practical and balanced method, offering both flexibility and comprehensive coverage.

There are a limited number of available data sources for individual PFAS to Canadian wastewater facilities. ECCC has conducted extensive testing of wastewater. Wastewater samples were analyzed for PFAS over the 2009-2024 time-period, but not every year. ECCC may continue to periodically analyze PFAS in wastewater samples in the future. A summary of the data collected between 2018 and 2024 are provided in section 8.4, about 40 individual PFAS that have been added to the NPRI. The data collected between 2018 and 2024 are considered approximately representative of current levels of PFAS in wastewater. ECCC used U.S. EPA Method 1633 for measurement of PFAS in aqueous, solid and biosolid samples.

There remains significant variability in data across countries related to PFAS concentrations in wastewater influent, effluent and sludge/biosolids, possibly due to regional variability (e.g., due to variations of GDP per capita).[111] Therefore, only Canadian wastewater effluent and biosolids concentrations are provided within section 8.4 to assist in determining whether NPRI reporting thresholds are met. Whether an individual PFAS has the potential to reach the 1 kg reporting threshold level during the NPRI reporting year

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[107] Lenka et al. (2021) A review of the occurrence, transformation, and removal of poly- and perfluoroalkyl substances (PFAS) in wastewater treatment plants; Water Research 199 (2021) 117187

[108] Lakshminarasimman et al. (2021) Removal and formation of perfluoroalkyl substances in Canadian sludge treatment systems – A mass balance approach, Science of the Total Environment 754 (2021) 142431

[109] Cookson et al. (2022) Global patterns and temporal trends of perfluoroalkyl substances in municipal wastewater: A meta-analysis, Water Research 221 (2022) 118784

[110] Gewurtz et al. (2024) Per- and polyfluoroalkyl substances (PFAS) in Canadian municipal wastewater and biosolids: Recent patterns and time trends 2009 to 2021

[111] Cookson, E.S. & Detwiler, R.L. (2022), *Global Patterns and Temporal Trends of Perfluoroalkyl Substances in Municipal Wastewater: A Meta-Analysis*, published in Water Research.

will depend on it is presence in the treated final effluent and biosolids. The steps to follow to make this determination are as follows:

Step 1: Determine the Quantity of PFAS in Effluent During the NPRI Reporting Year

Should you have testing available for the concentration of individual PFAS (that have been added to the NPRI) in the effluent (typically expressed in ng/L) from your wastewater facility, then these concentrations should be used. If there has been no testing for the concentration of individual PFAS in your effluent, then Table 9[112] in section 8.4 below provides available testing data (at Canadian wastewater treatment plants) from ECCC on about 40 of the individual PFAS that have been added to the NPRI. In addition to the Canadian-specific information, Table 8 provides information on the average concentration of individual PFAS (that have been added to the NPRI, however were not tested for by ECCC) from wastewater treatment facilities in the U.S. Since these are average concentrations across many wastewater facilities in the U.S., they are considered applicable to Canada.

Once the individual PFAS concentrations have been identified, the following formula should be used to calculate the quantity of individual PFAS that were contained in effluent released from your wastewater facility during the NPRI reporting year:

$$PFAS_{kg}^{i} = Volume_{L}\ x\ Concentration_{ng/L}^{i}\ x\ 10_{kg/ng}^{-12}$$

Where:

- $PFAS^{i}_{kg}$ = Quantity of PFAS chemical *i* contained in effluent released from the wastewater treatment plant during the NPRI reporting year, in kilograms.
- $Volume_{L}$ = Total volume of wastewater effluent released from the wastewater treatment plant during the NPRI reporting year, in litres.
- $Concentration^{i}_{ng/L}$ = Concentration of PFAS chemical *i* contained in wastewater effluent released from the wastewater treatment plant during the NPRI reporting year, expressed in ng/L.

$10^{-12}_{kg/ng}$ = Conversion factor for nanograms to kilograms. 1 kg = 10^{12} ng.

Step 2: Determine the Quantity of PFAS in Biosolids During the NPRI Reporting Year

Should you have testing available for the concentration of individual PFAS in the biosolids (typically expressed in ng/g, dry weight basis) generated at your wastewater facility, then these concentrations should be used.

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[112] Gewurtz S. and Smyth S.A (2025) Wastewater Science, Science and Technology Branch, ECCC internal communication.

If there has been no testing for the concentration of individual PFAS in your biosolids, then Table 10[113] in section 8.4 below provides available testing data (at Canadian wastewater treatment plants) from ECCC on about 40 of the individual PFAS that have been added to the NPRI

Once the individual PFAS concentrations have been identified, the following formula should be used to calculate the quantity of individual PFAS that were contained in the biosolids generated at the wastewater facility during the NPRI reporting year.

$$PFAS_{kg}^{i} = W_{tonnes} x 10_{g/tonnes}^{6} \; x \; Concentration_{ng/g}^{i} \; x \; 10_{kg/ng}^{-12}$$

Where:

- $PFAS^{i}_{kg}$ = Quantity of PFAS chemical *i* contained in biosolids generated at the wastewater treatment plant during the NPRI reporting year, in kilograms.
- W_{tonnes} = The total quantity of biosolids generated at the wastewater treatment plant during the NPRI reporting year, in tonnes.
- $Concentration^{i}_{ng/g}$ = Concentration of PFAS chemical *i* contained in biosolids generated at the wastewater treatment plant during the NPRI reporting year, expressed in ng/g, dry weight.
- $10^{-12}_{kg/ng}$ = Conversion factor for nanograms to kilograms. 1 kg = 10^{12} ng.

Step 3: Which PFAS Need to be Reported to the NPRI

Based on the quantity calculated in step 1 and 2, calculate the total quantity from effluent and biosolids at the wastewater facility and compare it to the mass reporting threshold. Each individual NPRI PFAS with a quantity ≥1 kg must be considered for reporting to the NPRI:

$$PFAS_{kgTotal}^{i} = PFAS_{kg\,(effluent)}^{i} + PFAS_{kg\,(biosolids)}^{i}$$

Please note, when available, any estimated releases to air should be added to the total quantity determined to be in effluent and/or biosolids in order to establish if the reporting threshold is met.

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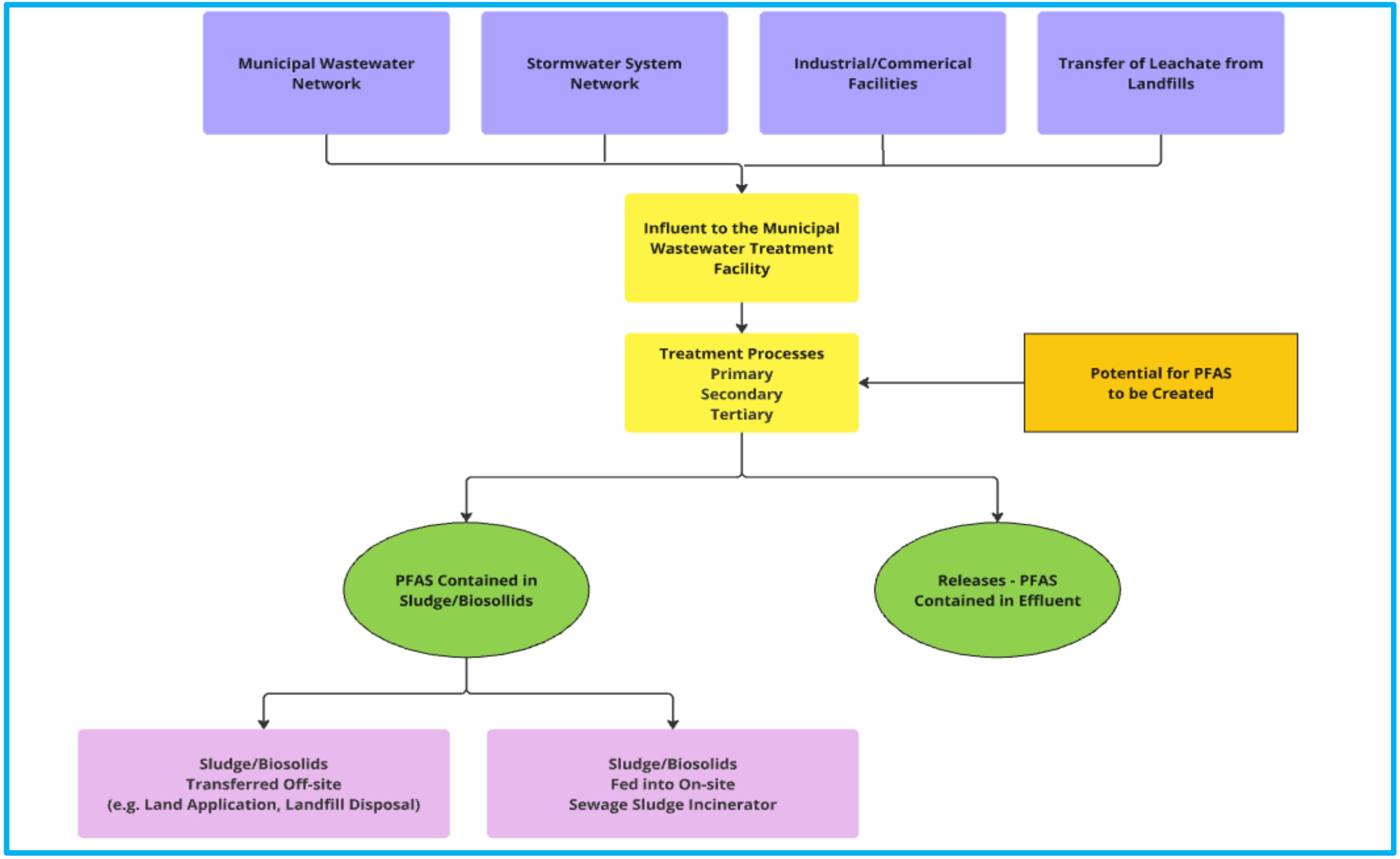
[113] Gewurtz S. and Smyth S.A (2025) Wastewater Science, Science and Technology Branch, ECCC internal communication.

Figure 10: General Process-Flow Diagram for PFAS Movements in Wastewater Plants and Potential for Releases/Disposals/Transfers



Source: Cheminfo Services Inc.

8.3 Estimating Releases, Transfers and Disposals

For those individual PFAS that met the 1 kg threshold for reporting to the NPRI, the following steps need to be undertaken to estimate releases, transfers and disposals:[114]

Step 1: Determine Individual PFAS Quantities in Wastewater Effluent

Should you have testing available for the concentration of individual PFAS (that have been added to the NPRI) in the effluent (typically expressed in ng/L) from your wastewater facility, then these concentrations should be used.

If there has been no testing for the concentration of individual PFAS in your effluent, then Table 9 in section 8.4 below provides available testing data (at Canadian wastewater treatment plants) from ECCC on about 40 of the individual PFAS that have been added to the NPRI.

In addition to the Canadian-specific information, Table 8 below provides information on the average concentration of individual PFAS (that have been added to the NPRI, however were not tested for by ECCC) from wastewater treatment facilities in the U.S. Since these are average concentrations across many wastewater facilities in the U.S., they are considered applicable to Canada.

Table 8: Average Concentration of Individual PFAS in the Effluent from U.S. Municipal Wastewater Facilities

CAS RN	Number of Wastewater Facilities Tested	Average Concentration (ng/L)
1763-23-1	129	82.5
2706-90-3	55	87.1
27619-97-2	44	23.4
307-24-4	71	50.3
335-67-1	129	68.9
335-76-2	69	5.19
355-46-4	78	6.85
375-22-4	44	10.8
375-73-5	61	8.10
375-85-9	70	23.4
375-95-1	76	8.05

Source: Thompson, K.A. et. al. (2022), *Poly- and Perfluoroalkyl Substances in Municipal Wastewater Treatment Plants in the United States: Seasonal Patterns and Meta- Analysis of Long-Term Trends and Average Concentrations*, published in Environmental Science & Technology Water.

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[114] Wastewater facilities should collect information required for NPRI reporting from the Reporting Guidance for the Wastewater Sector to the National Pollutant Release Inventory.

Once the individual PFAS concentrations have been identified, the following formula should be used to calculate the quantity of individual PFAS that were contained in effluent released from your wastewater facility during the NPRI reporting year:

$$PFAS_{kg}^{i} = Volume_{L}\ x\ Concentration_{ng/L}^{i}\ \ x\ 10_{kg/ng}^{-12}$$

Where:

- $PFAS^{i}_{kg}$ = Quantity of PFAS chemical *i* contained in effluent released from the wastewater treatment plant during the NPRI reporting year, in kilograms.
- $Volume_{L}$ = Total volume of wastewater effluent released from the wastewater treatment plant during the NPRI reporting year, in litres.
- $Concentration^{i}_{ng/L}$ = Concentration of PFAS chemical *i* contained in wastewater effluent released from the wastewater treatment plant during the NPRI reporting year, expressed in ng/L.
- $10^{-12}_{kg/ng}$ = Conversion factor for nanograms to kilograms. 1 kg = 10^{12} ng.

The above formula needs to be applied to each individual PFAS that was determined to have met the 1 kg reporting threshold for the NPRI.

Step 2: Determine Individual PFAS Quantities in Biosolids

Should you have testing available for the concentration of individual PFAS in the biosolids (typically expressed in ng/g, dry weight basis) generated at your wastewater facility, then these concentrations should be used.

If there has been no testing for the concentration of individual PFAS in your biosolids, then Table 10 in section 8.4 below provides available testing data (at Canadian wastewater treatment plants) from ECCC on about 40 of the individual PFAS that have been added to the NPRI.

Once the individual PFAS concentrations have been identified, the following formula should be used to calculate the quantity of individual PFAS that were contained in the biosolids generated at the wastewater facility during the NPRI reporting year.

$$PFAS_{kg}^{i} = Quantity_{g}\ x\ Concentration_{ng/g}^{i}\ \ x\ 10_{kg/ng}^{-12}$$

Where:

- $PFAS^{i}_{kg}$ = Quantity of PFAS chemical *i* contained in biosolids generated at the wastewater treatment plant during the NPRI reporting year, in kilograms.
- $Quantity_{g}$ = The total quantity of biosolids generated at the wastewater treatment plant during the NPRI reporting year, in grams.
- $Concentration^{i}_{ng/g}$ = Concentration of PFAS chemical *i* contained in biosolids generated at the wastewater treatment plant during the NPRI reporting year, expressed in ng/g, dry weight.
- $10^{-12}_{kg/ng}$ = Conversion factor for nanograms to kilograms. 1 kg = 10^{12} ng.

The above calculation needs to be completed for each individual PFAS (that meets NPRI reporting thresholds) for which concentration data in biosolids is available. These calculations will aid in the reporting of any PFAS disposals or transfers.

The fate of this quantity of individual PFAS in biosolids needs to be reported. The fate will typically be either to: (i) off-site disposal – land treatment; (ii) transfers for treatment – incineration; (iii) off-site disposal – landfill. However, the full set of release/transfer/disposal categories should be reviewed to determine the most appropriate category for the individual PFAS contained in biosolids.

8.4 Tables of PFAS Concentrations in Wastewater Effluent, and Biosolids

The tables below provide the average concentrations of various individual PFAS in effluents and biosolids from wastewater treatment facilities in Canada, based on measurements conducted by ECCC. They are also available in Excel format.

Table 9: Average of 41 PFAS by Treatment Type in Canadian Wastewater Effluent Collected Between 2018 and 2024

Liquid Treatment Type			**Primary**	**Primary**	**Secondary**	**Secondary**	**Secondary**	**Tertiary/advanced**	**Tertiary/advanced**
Flow from residential inputs			**<90% residential**	**>90% residential**	**<70% residential**	**70% - 90% residential**	**>90% residential**	**<90% residential**	**>90% residential**
PFAS	CAS RN	Units	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)
Perfluoroalkyl carboxylates (PFCAs) – ultrashort-chain									
TFA	76-05-1	ng/L	Not Measured	Not Measured	1281	1736.7	1193	Not Measured	Not Measured
Perfluoroalkyl carboxylates (PFCA) – short and long chain									
PFBA	45048-62-2	ng/L	5.2	3.7	12.4	9.6	10.9	9.2	2.1
PFPeA	45167-47-3	ng/L	4.1	4.3	20.2	13.9	12.6	20.4	10.3
PFHxA	92612-52-7	ng/L	4.3	4.1	22.3	17.3	18.4	26.4	9.4
PFHpA	120885-29-2	ng/L	2.4	1.7	6.6	2.5	3.2	6.5	1.3
PFOA	45285-51-6	ng/L	2.8	3.1	13.5	6.7	9.2	18.0	4.0
PFNA	72007-68-2	ng/L	1.0	1.0	1.2	1.2	1.5	1.4	1.1
PFDA	73829-36-4	ng/L	0.4	0.8	1.3	1.5	1.4	1.7	0.6
PFUnA	196859-54-8	ng/L	<0.51	<0.8	<2.5	0.5	0.4	<0.4	<0.8

PFDoA	171978-95-3	ng/L	<0.51	<0.64	<2	<0.64	0.8	<0.4	<0.8
PFTrDA	862374-87-6	ng/L	<0.51	<0.8	<2.5	<0.8	<0.8	<0.4	<0.8
PFTeDA	365971-87-5	ng/L	<0.51	<0.8	<2.5	<0.8	<0.8	<0.4	<0.8
Perfluoroalkyl sulfonates (PFSA) – short and long									
PFBS	45187-15-3	ng/L	1.7	1.7	6.9	4.1	9.7	4.2	1.0
PFPeS	175905-36-9	ng/L	<0.77	0.5	1.4	<0.8	0.5	0.7	<0.8
PFHxS	108427-53-8	ng/L	1.7	1.4	4.9	1.3	2.6	5.9	2.3
PFHpS	146689-46-5	ng/L	0.7	<0.8	0.4	<0.8	1.9	<0.38	<0.8
PFOS	45298-90-6	ng/L	4.9	5.2	6.4	3.9	11.2	6.2	2.2
PFNS	474511-07-4	ng/L	<0.8	<0.8	<2.5	<0.8	0.9	<0.38	<0.8
PFDS	126105-34-8	ng/L	<0.53	<0.8	<2.5	<0.8	2.5	<0.41	<0.8
PFDoS	343629-43-6	ng/L	<0.49	<0.8	<2.5	<0.8	<0.8	<0.38	<0.8
Fluorotelomer sulfonates (FTS)									
4:2 FTS	414911-30-1	ng/L	<2.05	<3.2	<9.98	<3.19	11.4	<1.62	<3.2
6:2 FTS	425670-75-3	ng/L	2.0	37.4	16.6	16.6	36.2	1.5	<2.88
8:2 FTS	481071-78-7	ng/L	<2.05	1.8	<8.48	<2.71	<3.19	<1.62	1.7
Fluorotelomer carboxylates (FTCA)									
3:3 FTCA	1169706-83-5	ng/L	<1.59	<3.2	<9.98	<3.19	<3.19	Not Measured	Not Measured
5:3 FTCA	1799325-94-2	ng/L	<9.95	<20	<62.4	<19.9	21.8	Not Measured	Not Measured

7:3 FTCA	1799325-95-3	ng/L	<9.95	<20	<62.4	<19.9	<19.9	Not Measured	Not Measured
Fluorooctane sulfonamides									
PFOSA	754-91-6	ng/L	<0.53	1.0	0.6	1.8	0.8	1.2	0.5
N-MeFOSA	31506-32-8	ng/L	<0.59	<0.8	<2.5	<0.8	<0.92	<0.47	<0.92
N-EtFOSA	4151-50-2	ng/L	<1.28	<2.24	<6.99	<2.23	<2.23	1.3	<2
Perfluorooctane sulfonamidoacetic acids									
MeFOSAA	2355-31-9	ng/L	<0.62	<0.8	0.6	2.1	1.0	0.7	0.5
EtFOSAA	2991-50-6	ng/L	<1.6	<1.6	0.7	2.4	1.0	1.2	0.6
Perfluorooctane sulfonamide ethanols									
N-MeFOSE	24448-09-7	ng/L	<5.22	<8	<25	<7.98	<7.98	<4.13	<7.99
N-EtFOSE	1691-99-2	ng/L	<3.98	<8	<25	<7.98	<7.97	3.5	5.6
Per- and polyfluoroether carboxylates									
HFPO-DA	122499-17-6	ng/L	<1.59	<3.2	<9.98	<3.19	<3.19	Not Measured	Not Measured
ADONA	2127366-90-7	ng/L	<1.59	<3.2	<9.98	<3.19	<3.19	Not Measured	Not Measured
NFDHA	39187-41-2	ng/L	<0.8	<1.6	<4.99	<1.6	<1.59	Not Measured	Not Measured
PFMBA	1432017-36-1	ng/L	<0.4	<0.8	<2.5	<0.8	<0.8	Not Measured	Not Measured
PFMPA	377-73-1	ng/L	<0.8	<1.6	<4.99	<1.6	<1.59	Not Measured	Not Measured
Ether sulfonates									
9Cl-PF3ONS	1621485-21-9	ng/L	<1.6	<3.21	<10	<3.2	<3.2	Not Measured	Not Measured

11Cl-PF3OUdS	2196242-82-5	ng/L	<1.59	<3.2	<9.99	<3.19	<3.19	Not Measured	Not Measured
PFEESA	220689-13-4	ng/L	<0.4	<0.8	<2.5	<0.8	<0.8	Not Measured	Not Measured

The average was calculated for detectable PFAS only

When not detected, the maximum detection limit is indicated (For NPRI reporting, the half detection method should be used if the substance is believed present. For more information consult the Guidance for the wastewater sector)

Source: Gewurtz S. and Smyth S.A (2025) Wastewater Science, Science and Technology Branch, ECCC internal communication.

Table 10: Average of 40 PFAS by Solids and Liquid Treatment Type in Canadian Wastewater Samples Collected between 2018 and 2024

Liquid Treatment Type			**Primary**	**Primary**	**Primary**	**Primary**	**Secondary**	**Secondary**	**Secondary**	**Secondary**	**Secondary**	**Tertiary/ advanced**	**Tertiary/ advanced**	**Tertiary/ advanced**
Solids Treatment Type			**Dewatering**	**Dewatering**	**Alkaline**	**Digestion, anaerobic**	**Dewatering**	**Digestion, anaerobic**	**Digestion, anaerobic**	**Digestion, anaerobic**	**Digestion, anaerobic, pelletization**	**Dewatering**	**Dewatering**	**Alkaline**
Flow from residential inputs			**<90%**	**>90%**	**>90%**	**>90%**	**>90%**	**<70%**	**70% to 90%**	**>90%**	**<70%**	**<90%**	**>90%**	**>90%**
PFAS	CAS RN	Units	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)	Average of Detected Concentrations (if non-detect, <Maximum detection limit is shown)
Perfluoroalkyl carboxylates (PFCAs) – ultrashort-chain														
TFA	76-05-1	ng/g (dry weight basis)	Not Measured	Not Measured	Not Measured	Not Measured	Not Measured	Not Measured	Not Measured	Not Measured	Not Measured	Not Measured	Not Measured	Not Measured
Perfluoroalkyl carboxylates (PFCA) – short and long chain														
PFBA	45048-62-2	ng/g (dry weight basis)	59.1	60.7	<1.67	<16.9	<4.87	7.1	<9.41	3.4	<1.6	<1.48	<1.48	<11.1
PFPeA	45167-47-3	ng/g (dry weight basis)	<3.75	<4.02	<0.84	<8.46	1.0	<1.82	1.0	<3.78	<0.8	<0.74	<0.74	1.4

PFHxA	92612-52-7	ng/g (dry weight basis)	<1.87	<2.01	<0.42	1.9	1.6	2.4	1.9	1.6	0.8	0.8	<0.37	0.9
PFHpA	120885-29-2	ng/g (dry weight basis)	<1.87	<2.01	<0.42	<4.23	0.3	0.8	0.4	0.5	<0.4	<0.37	<0.37	0.8
PFOA	45285-51-6	ng/g (dry weight basis)	<1.87	<2.01	<0.42	<4.23	1.7	1.8	1.0	1.0	1.0	3.3	0.9	<0.41
PFNA	72007-68-2	ng/g (dry weight basis)	<1.87	<2.01	<0.41	<4.23	0.8	0.8	0.9	1.6	0.5	1.9	1.6	<0.41
PFDA	73829-36-4	ng/g (dry weight basis)	<1.87	<2.01	<0.41	<4.23	3.6	3.9	2.0	2.6	2.0	6.2	1.7	0.7
PFUnA	196859-54-8	ng/g (dry weight basis)	<1.87	<2.01	<0.41	<4.23	1.1	1.2	1.0	1.1	0.7	1.5	1.4	0.5
PFDoA	171978-95-3	ng/g (dry weight basis)	0.9	0.4	<0.41	2.7	1.6	2.3	1.5	1.9	1.5	2.5	1.2	0.4
PFTrDA	862374-87-6	ng/g (dry weight basis)	<1.87	<2.01	<0.42	5.0	1.0	1.7	1.8	2.2	1.0	1.0	1.1	<2.05
PFTeDA	365971-87-5	ng/g (dry weight basis)	<1.87	<2.01	<0.47	4.3	0.8	1.1	1.0	1.1	<0.51	0.7	0.3	<6.03
Perfluoroalkyl sulfonates (PFSA) – short and long														
PFBS	45187-15-3	ng/g (dry weight basis)	<1.87	<2.01	<0.42	<4.23	<1.22	1.2	1.9	2.2	<0.4	<0.37	<0.37	<0.41

PFPeS	175905-36-9	ng/g (dry weight basis)	<1.87	<2.01	<0.39	<4.25	<1.22	<0.91	<2.36	<1.89	<0.45	<0.34	<0.34	<0.41
PFHxS	108427-53-8	ng/g (dry weight basis)	<1.87	<2.01	0.5	<4.23	19.4	1.1	1.7	0.8	5.5	2.0	0.5	<0.41
PFHpS	146689-46-5	ng/g (dry weight basis)	<5.32	<2.01	<0.41	<4.23	<1.22	1.0	0.5	0.5	<0.41	<0.34	<0.37	<0.41
PFOS	45298-90-6	ng/g (dry weight basis)	2.1	2.9	1.9	4.2	15.1	12.1	6.6	12.5	11.7	12.8	5.7	1.9
PFNS	474511-07-4	ng/g (dry weight basis)	<3.75	<4.02	<0.39	<4.23	<1.22	0.7	<2.35	8.4	<0.4	0.9	2.1	<0.44
PFDS	126105-34-8	ng/g (dry weight basis)	<1.87	<2.01	<0.42	<4.23	1.3	2.3	1.4	1.6	<0.4	1.3	<0.52	1.2
PFDoS	343629-43-6	ng/g (dry weight basis)	<1.87	<2.01	<0.39	<4.23	1.3	0.7	5.4	0.6	<0.4	<0.34	<0.4	<0.41
Fluorotelomer sulfonates (FTS)														
4:2 FTS	414911-30-1	ng/g (dry weight basis)	<7.5	<8.05	<1.63	<16.9	<4.87	<3.64	<9.41	<7.57	<1.6	<1.44	<1.44	<1.64
6:2 FTS	425670-75-3	ng/g (dry weight basis)	<27	<29	<1.47	42.1	<4.39	2.0	2.9	22.2	<1.44	<1.3	<1.3	<1.48
8:2 FTS	481071-78-7	ng/g (dry weight basis)	<7.5	<8.05	<1.63	<14.4	<4.14	<3.64	<8	3.9	<1.36	1.7	<1.44	<1.64
Fluorotelomer carboxylates (FTCA)														

3:3 FTCA	1169706-83-5	ng/g (dry weight basis)	<1.71	<2.21	Not Measured	<16.9	<4.87	<3.31	<9.41	<1.68	<1.6	Not Measured	Not Measured	Not Measured
5:3 FTCA	1799325-94-2	ng/g (dry weight basis)	<10.7	<13.8	Not Measured	118.0	37.5	52.2	73.9	115.0	25.4	Not Measured	Not Measured	Not Measured
7:3 FTCA	1799325-95-3	ng/g (dry weight basis)	<10.7	<13.8	Not Measured	<106	8.5	20.7	13.7	19.1	<10	Not Measured	Not Measured	Not Measured
Fluorooctane sulfonamides														
PFOSA	754-91-6	ng/g (dry weight basis)	<1.87	<2.01	0.4	<4.23	0.4	1.6	1.2	0.9	0.8	1.8	0.4	<0.41
N-MeFOSA	31506-32-8	ng/g (dry weight basis)	<2.16	<2.31	<0.47	<4.23	1.7	0.5	0.5	0.6	<0.4	<0.41	<0.41	<0.47
N-EtFOSA	4151-50-2	ng/g (dry weight basis)	<4.69	<5.03	<1.02	<11.8	<3.41	<2.31	<6.59	1.0	<1.12	<0.9	<0.9	<1.03
Perfluorooctane sulfonamidoacetic acids														
MeFOSAA	2355-31-9	ng/g (dry weight basis)	<1.87	<2.01	0.5	<4.23	3.2	8.5	6.5	8.5	2.8	6.4	4.6	0.9
EtFOSAA	2991-50-6	ng/g (dry weight basis)	1.8	0.8	1.0	<7.21	7.1	7.4	6.9	7.6	4.0	13.4	3.5	2.4
Perfluorooctane sulfonamide ethanols														
N-MeFOSE	24448-09-7	ng/g (dry weight basis)	<18.7	<20.1	<4.17	<42.3	<12.2	10.4	7.1	16.0	4.2	4.8	6.6	7.3
N-EtFOSE	1691-99-2	ng/g (dry	<14.1	5.6	<3.13	<42.3	<12.2	5.8	6.0	5.4	<4	4.6	<2.76	13.5

		weight basis)												
Per- and polyfluoroether carboxylates														
HFPO-DA	122499-17-6	ng/g (dry weight basis)	<1.71	<2.21	Not Measured	<16.9	<4.87	<3.31	<9.41	<1.68	<1.6	Not Measured	Not Measured	Not Measured
ADONA	2127366-90-7	ng/g (dry weight basis)	<1.71	<2.21	Not Measured	<16.9	<4.87	<3.31	<9.41	<1.68	<1.6	Not Measured	Not Measured	Not Measured
NFDHA	39187-41-2	ng/g (dry weight basis)	<0.85	<1.11	Not Measured	<8.46	<2.43	<1.65	<4.71	<0.84	<0.8	Not Measured	Not Measured	Not Measured
PFMBA	1432017-36-1	ng/g (dry weight basis)	<0.43	<0.55	Not Measured	<4.23	<1.22	<0.83	<2.35	<0.42	<0.4	Not Measured	Not Measured	Not Measured
PFMPA	377-73-1	ng/g (dry weight basis)	<0.85	<1.11	Not Measured	<8.46	<2.43	<1.65	<4.71	<0.84	<0.8	Not Measured	Not Measured	Not Measured
Ether sulfonates														
9Cl-PF3ONS	1621485-21-9	ng/g (dry weight basis)	<1.71	<2.22	Not Measured	<17	<4.88	<3.31	<9.44	<1.68	<1.61	Not Measured	Not Measured	Not Measured
11Cl-PF3OUdS	2196242-82-5	ng/g (dry weight basis)	<1.71	<2.22	Not Measured	<16.9	<4.88	<3.31	<9.42	<1.68	<1.6	Not Measured	Not Measured	Not Measured
PFEESA	220689-13-4	ng/g (dry weight basis)	<0.43	<0.55	Not Measured	<4.23	<1.22	<0.83	<2.35	<0.42	<0.4	Not Measured	Not Measured	Not Measured

The average was calculated for detectable PFAS only

When not detected, the maximum detection limit is indicated (For NPRI reporting, the half detection method should be used if the substance is believed present. For more information consult the Guidance for the wastewater sector)

Source: Gewurtz S. and Smyth S.A (2025) Wastewater Science, Science and Technology Branch, ECCC internal communication.

9. Non-Hazardous and Hazardous Waste Off-Site Landfill Facilities

9.1 Introduction

Canadians utilize and dispose of products and materials (e.g, consumer products, contaminated soils and biosolids) that contains PFAS substances every day, and many of these products are eventually sent to landfill. Landfills "can become an indirect pathway of release to the environment. PFAS may leach out of these products and materials and accumulate in landfill leachate and eventually be released to the environment, even if that leachate is sent to a wastewater treatment system."[115] Not all landfills treat leachate which may lead to untreated leachate entering the environment. Moreover, not all on-site or off-site leachate treatment systems, nor the wastewater treatment facilities that may receive this leachate, are equipped with the necessary technology to effectively remove PFAS. PFAS can also be released from landfills to air, as studies have found higher levels of PFAS in the air near landfills than reference levels.[116]

Please note that this chapter applies to off-site landfill facilities classified under NAICS Code 562210 – Waste Treatment and Disposal. It is important to distinguish between Municipal Solid Waste (MSW) Landfills (See Figure 11) and Hazardous Waste Landfills, as they differ in design, operation, maintenance, and regulatory requirements. This distinction significantly influences both the types and quantities of PFAS they receive, as well as the environmental fate of PFAS within each landfill type.

For NPRI purposes, a landfill located on the same site, on contiguous sites, or on adjacent sites with the operating facility—provided they are owned or operated by the same entity and function as a single integrated site—meets the definition of a contiguous facility and should be considered as part of the operating facility, as on-site disposal – landfill. However, if a facility disposes of its waste at a landfill owned by a different entity and/or at a landfill owned by the same company but located at a separate, non-contiguous site, this landfill is considered an off-site disposal facility.

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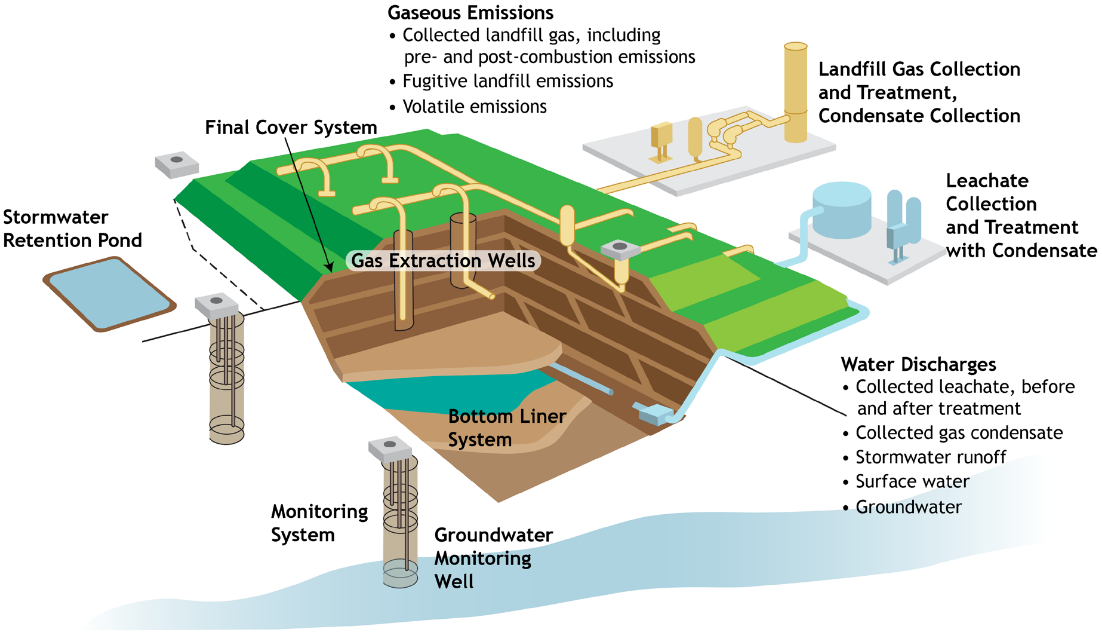
[115] Environment and Climate Change Canada, (2025), *State of Per- and Polyfluoroalkyl Substances (PFAS) Report*.

[116] Ahrens et al., (2011), *Wastewater Treatment Plant and Landfills as Sources of Polyfluoroalkyl Compounds to the Atmosphere*.

Figure 11: Diagram of MSW landfill components and potential PFAS release pathways



Source [Interim Guidance on the Destruction and Disposal of PFAS and Materials Containing PFAS | US EPA]

It should be noted that some MSW landfills may not have leachate and/or landfill gas collection systems. Moreover, not all landfills are equipped to capture landfill gas, and among those that do, some may choose to flare the gas rather than use it for energy recovery.

9.2 Determine if NPRI Reporting Thresholds are Met

The NPRI reporting threshold for individual PFAS is 1 kg of manufacturing, processing or otherwise use (MPO). Since landfills do not intentionally manufacture, process or otherwise use PFAS, these substances are considered by-products for NPRI reporting. Consequently, the 0.1% concentration threshold will not apply and the landfill facility is expected to report the NPRI PFAS substance once it exceeds MPO threshold of 1 kg, regardless of the concentration. In order to determine if NPRI reporting thresholds are met, three different processing operations need to be considered: (i) acceptance and landfilling of waste; (ii) generation of landfill leachate; and (iii) generation of landfill gas.

9.2.1 Acceptance and Landfilling of Waste

There is little data available on the concentration of individual PFAS in municipal solid waste. At the time of publishing this guidance, direct measurements of PFAS concentrations within the solid waste matrix of landfill cells are not readily available in publicly available literature and the majority of studies of PFAS in landfills focus on municipal solid waste (MSW) landfill leachate, with comparatively fewer studies, in the waste material received by the landfill facility.

As most studies focus on leachate and in some cases, on gas emissions as indicators of PFAS presence in landfills. Therefore, information on landfill leachate and landfill gas emissions generated at your landfill facility could be the focus of determining whether your facility needs to report to the NPRI. The total quantity of the NPRI PFAS substance generated from landfill leachate and landfill gas emissions could be used to assess if the facility meets the NPRI threshold of 1 kg.

If information for a specific PFAS in the waste received for disposal is known or could be obtained from the below quantity calculation within the landfill facility, it could be combined or compared with data from leachate and gas emissions to assess whether the MPO threshold for this specific PFAS at the landfill facility is exceeded.

If the quantity or concentration for a specific PFAS in the waste received for disposal is known, it could be used to estimate this PFAS MPO threshold. Another approach could be used which is to approximately estimate the quantity of a specific PFAS within the landfill facility based on the volume of waste within the landfill facility (V); the density of waste (ρ); the specific PFAS concentration (C_i) in the waste material, and fraction (WT_k) of different types of waste material (e.g. paper products, textiles, etc.) within the landfill (Chen et al., 2024)[117]:

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[117] Chen et al. (2024) Evaluation of per- and polyfluoroalkyl substances (PFAS) released from two Florida landfills based on mass balance analyses, Waste Management 175 (2024) 348–359

$$PFAS_i = V \times \rho \times \frac{\sum_{k=1}^{k=m} C_{i_k} WT_k}{\sum_{k=1}^{k=m} WT_k}$$

Where k is the type of waste material and m is the total number of waste materials like paper and paper board, food, plastics, metals, wood, textile, rubber.

For MSW landfill facilities, the V could be estimated from basic geometry considerations using the height, area, and slopes of solid waste disposal area within the evaluated landfills. The ρ of solid waste could be extrapolated as 350 to 500 kg/m3 (Chen et al., 2024). The C_k and WT_k could be obtained from literature review or reasonable estimates maybe used based on data from similar facilities, comparable operations, or surrogate substances. If no specific data or comparable facility data can be obtained, WTk could be retrieved from Environment and Climate Change Canada (2024) Canadian Environmental Sustainability Indicators: Solid waste diversion and disposal and the National waste characterization report : the composition of Canadian residual municipal solid waste.: En14-405/2020E-PDF - Government of Canada Publications - Canada.ca.

The tables below present the concentrations of selected PFAS substances found in certain types of materials that end in the MSW. The listing is not exhaustive and other PFAS maybe present:

Table 11: Median Concentrations of some PFAS Substances in Paper and Paperboard

PFAS	CAS Number	Median Concentration (ng/g)
PFBA	375-22-4	0.7
PFPA	2706-90-3	15.4
PFHxA	307-24-4	1.4
PFHpA	375-85-9	0.025*
PFOA	335-67-1	3.2
PFNA	375-95-1	0.5
PFDA	335-76-2	2.5
PFUnA	4234-23-5	0.025*
PFDoA	307-55-1	2.0
PFTrA	72629-94-8	0.025*
PFTeA	376-06-7	1.3
PFBS	59933-66-3	0.025*
PFHxS	355-46-4	0.025*
PFHpS	375-92-8	0.025*
PFOS	1763-23-1	0.7
PFDS	335-77-3	0.025*
FTOH 4:2	2043-47-2	0.025*
FTOH 6:2	647-42-7	6.0

FTOH 8:2	678-39-7	15.7
FTOH 10:2	865-86-1	4.3

Source: Kotthoff et al. (2015). Perfluoroalkyl and polyfluoroalkyl substances in consumer products. Environ. Sci. Pollut. Res. 22, 14546–14559. https://doi.org/10.1007/s11356-015-4202-7/ Liu, Y. (2022). Characterization of Per- and Polyfluoroalkyl Substances (PFAS) in Broad Solid Waste Streams. University of Florida, Gainesville, Fla https://ufdc.ufl.edu/UFE0059131/00001 (*) below limit of quantification (assumed half LOQ)

Table 12: Average Concentrations of some PFAS Substances in Textiles

PFAS	CAS Number	Mean Concentration (ng/g)
10:2 FTAc	17741-60-5	331.276
10:2 FTOH	865-86-1	527.479
4:2 FTS	414911-30-1, 757124-72-4	0.492
5:3 FTCA	914637-49-3, 1799325-94-2	61.876
6:2 FTCA	56773-42-3	16.250
6:2 FTOH	647-42-7	5039.478
6:2 FTS	27619-97-2, 425670-75-3	17.064
8:2 FTAc	27905-45-9	444.645
8:2 FTOH	678-39-7	713.858
8:2 FTS	39108-34-4, 481071-78-7, 149724-40-3, 27619-96-1	12.508
8:2 FTUCA	70887-84-2	1.240
FBSA	30334-69-1	11.030
FOSA	754-91-6	0.217
N-EtFOSA	4151-50-2, 2991-50-6	0.510
N-EtFOSE	1691-99-2	5194.845
N-MeFOSA	31506-32-8	23.439
N-MeFOSAA	2355-31-9	2.334
N-MeFOSE	24448-09-7	186.088
PFBA	375-22-4, 45048-62-2, 2218-54-4	883.971

PFBS	375-73-5, 45187-15-3, 68259-10-9	142.558
PFDA	3830-45-3, 73829-36-4, 335-76-2	45.888
PFDoDA	307-55-1, 307-67-5	45.223
PFDS	335-77-3, 126105-34-8	2.147
PFHpA	20109-59-5, 21049-36-5, 375-85-9, 6130-43-4	73.585
PFHpS	21934-50-9, 375-92-8, 146689-46-5	2.843
PFHxA	21615-47-4, 307-24-4, 92612-52-7	74.877
PFHxDA	67905-19-5	6.904
PFHxS	108427-53-8, 355-46-4, 3871-99-6	34.233
PFNA	375-95-1, 72007-68-2	53.914
PFNS	474511-07-4, 68259-12-1, 98789-57-2	0.192
PFOA	335-67-1, 335-95-5, 45285-51-6	76.808
PFOS	45298-90-6, 1763-23-1, 2795-39-3	38.132

PFPeA	45167-47-3, 68259-11-0, 2706-90-3	59.944
PFTeDA	365971-87-5, 376-06-7	85.753
PFTrDA	72629-94-8, 862374-87-6	34.884
PFUnDA	2058-94-8, 60871-96-7	49.172

Source: Dewapriyaa P. et al. (2023), Per- and polyfluoroalkyl substances (PFAS) in consumer products: current knowledge and research gaps, Journal of Hazardous Materials Letters, https://www.sciencedirect.com/science/article/pii/S2666911023000126?via%3Dihub

Table 13: Average Concentrations of some PFAS Substances in Electronic Products

PFAS	CAS Number	Mean Concentration (ng/g)
6:2 FTS	27619-97-2, 425670-75-3	0.345
PFBA	375-22-4, 45048-62-2, 2218-54-4	12.605
PFBS	375-73-5, 45187-15-3, 68259-10-9	0.922
PFDA	3830-45-3, 73829-36-4, 335-76-2	0.089
PFDoDA	307-55-1, 307-67-5	0.092
PFDS	335-77-3, 126105-34-8	0.107
PFHpA	20109-59-5, 21049-36-5, 375-85-9, 6130-43-4	0.068
PFHpS	21934-50-9, 375-92-8, 146689-46-5	0.036
PFHxA	21615-47-4, 307-24-4, 92612-52-7	0.150
PFHxS	108427-53-8, 355-46-4, 3871-99-6	0.066
PFNA	375-95-1, 72007-68-2	0.221

PFOA	335-67-1, 335-95-5, 45285-51-6	0.225
PFOS	45298-90-6, 1763-23-1, 2795-39-3	0.346
PFOSA	1763-23-1	0.650
PFPeA	45167-47-3, 68259-11-0, 2706-90-3	0.158
PFTeDA	365971-87-5, 376-06-7	0.096
PFTrDA	72629-94-8, 862374-87-6	0.100
PFUnDA	2058-94-8, 60871-96-7	0.215

Source: Dewapriyaa P. et al. (2023), Per- and polyfluoroalkyl substances (PFAS) in consumer products: current knowledge and research gaps, Journal of Hazardous Materials Letters, https://www.sciencedirect.com/science/article/pii/S2666911023000126?via%3Dihub

Table 14: Average Concentrations of some PFAS Substances in Plastics

PFAS	CAS Number	Mean Concentration (ng/g)
6:2 FTOH	647-42-7	754.000
8:2 FTOH	678-39-7	402.500
MeFOSE	24448-09-7	0.429
N-EtFOSE	1691-99-2	0.025
N-MeFOSA	31506-32-8	0.035
PFBA	375-22-4, 45048-62-2, 2218-54-4	21.702
PFBS	375-73-5, 45187-15-3, 68259-10-9	0.262
PFDA	3830-45-3, 73829-36-4, 335-76-2	0.729
PFDoDA	307-55-1, 307-67-5	0.349
PFDS	335-77-3, 126105-34-8	0.040
PFHpA	20109-59-5, 21049-36-5, 375-85-9, 6130-43-4	5.111
PFHpS	21934-50-9, 375-92-8, 146689-46-5	0.010

PFHxA	21615-47-4, 307-24-4, 92612-52-7	67.605
PFHxDA	67905-19-5	0.350
PFHxS	108427-53-8, 355-46-4, 3871-99-6	15.229
PFNA	375-95-1, 72007-68-2	0.400
PFOA	335-67-1, 335-95-5, 45285-51-6	272.378
PFOS	45298-90-6, 1763-23-1, 2795-39-3	0.052
PFPeA	45167-47-3, 68259-11-0, 2706-90-3	1.997
PFTeDA	365971-87-5, 376-06-7	0.194

Source: Dewapriyaa P. et al. (2023), Per- and polyfluoroalkyl substances (PFAS) in consumer products: current knowledge and research gaps, Journal of Hazardous Materials Letters, https://www.sciencedirect.com/science/article/pii/S2666911023000126?via%3Dihub

Table 15: Average Concentrations of some PFAS Substances in Building Materials

PFAS	CAS Number	Mean Concentration (ng/g)
10:2 FTOH	865-86-1	310.000
4:2 FTS	414911-30-1, 757124-72-4	2.900
6:2 FTOH	647-42-7	1700.000
8:2 FTOH	678-39-7	230.000
PFBA	375-22-4, 45048-62-2, 2218-54-4	16.720
PFBS	375-73-5, 45187-15-3, 68259-10-9	1.012
PFDA	3830-45-3, 73829-36-4, 335-76-2	23.050
PFDoDA	307-55-1, 307-67-5	15.335
PFDS	335-77-3, 126105-34-8	0.283
PFHpA	20109-59-5, 21049-36-5, 375-85-9, 6130-43-4	28.128

PFHpS	21934-50-9, 375-92-8, 146689-46-5	0.520
PFHxA	21615-47-4, 307-24-4, 92612-52-7	19.585
PFHxS	108427-53-8, 355-46-4, 3871-99-6	2.701
PFNA	375-95-1, 72007-68-2	10.159
PFOA	335-67-1, 335-95-5, 45285-51-6	418.200
PFOS	45298-90-6, 1763-23-1, 2795-39-3	1.382
PFPeA	45167-47-3, 68259-11-0, 2706-90-3	6.710
PFTeDA	365971-87-5, 376-06-7	4.732
PFTrDA	72629-94-8, 862374-87-6	2.034
PFUnDA	2058-94-8, 60871-96-7	10.642

Source: Dewapriyaa P. et al. (2023), Per- and polyfluoroalkyl substances (PFAS) in consumer products: current knowledge and research gaps, Journal of Hazardous Materials Letters, https://www.sciencedirect.com/science/article/pii/S2666911023000126?via%3Dihub

Table 16: Average Concentrations of some PFAS Substances in Food contact materials

PFAS	CAS Number	Mean Concentration (ng/g)
10:2 FTOH	865-86-1	1488.034
5:3 FTCA	914637-49-3, 1799325-94-2	16.650
6:2 FTCA	53826-12-3	87.214
6:2 FTOH	647-42-7	2691.991
6:2 FTS	27619-97-2, 425670-75-3	2 980 000.000
6:2 FTUCA	70887-88-6	74.235
8:2 FTCA	27854-31-5	5.150
8:2 FTOH	678-39-7	1496.725
8:2 FTS	39108-34-4, 481071-78-7,	8 590 000.000

	149724-40-3, 27619-96-1	
8:2 FTUCA	70887-84-2	10.400
8:2 PAP		16.000
9Cl-PF3ONS	1621485-21-9	0.004
diSamPAP		1.252
N-EtFOSAA	2991-50-6	14 763.333
N-MeFOSAA	2355-31-9	1720.000
PFBA	375-22-4, 45048-62-2, 2218-54-4	2727.820
PFBS	375-73-5, 45187-15-3, 68259-10-9	0.527
PFDA	3830-45-3, 73829-36-4, 335-76-2	1 308 256.021
PFDoDA	307-55-1, 307-67-5	1 326 002.723
PFDS	335-77-3, 126105-34-8	2000.000
PFHpA	20109-59-5, 21049-36-5, 375-85-9, 6130-43-4	21 312.449
PFHxA	21615-47-4, 307-24-4, 92612-52-7	86 302.378
PFHxDA	67905-19-5	0.375
PFHxS	108427-53-8, 355-46-4, 3871-99-6	4.131
PFNA	375-95-1, 72007-68-2	24 762.373
PFOA	335-67-1, 335-95-5, 45285-51-6	171 258.565
PFODA	16517-11-6	0.418
PFOS	45298-90-6, 1763-23-1, 2795-39-3	2004.062
PFOSA	1763-23-1	35 200.000
PFPeA	45167-47-3, 68259-11-0, 2706-90-3	11 160.885
PFTeDA	365971-87-5, 376-06-7	929 701.726

PFTrDA	72629-94-8, 862374-87-6	16 515.332
PFUnDA	2058-94-8, 60871-96-7	23 862.722

Source: Dewapriyaa P. et al. (2023), Per- and polyfluoroalkyl substances (PFAS) in consumer products: current knowledge and research gaps, Journal of Hazardous Materials Letters, https://www.sciencedirect.com/science/article/pii/S2666911023000126?via%3Dihub

9.2.2 Generation of Landfill Leachate

One of the two streams containing PFAS at landfills which can be used to account for the total quantity generated from the landfill facility that trigger NPRI reporting thresholds is landfill leachate. The following steps should be followed to estimate the quantity generated from landfill leachate:

Step 1: Determine the Quantity of Landfill Leachate Generated by your Landfill During the NPRI Reporting Year

From available metering systems and accounting records, the quantity of landfill leachate generated by your landfill could be tabulated. All landfill leachate that is generated at your landfill should be taken into consideration including leachate that was transferred off-site for treatment, leachate that was treated on-site and untreated leachate that was generated by your facility. All leachates should be aggregated so that the total is available as one number, ideally in litres. Hydrological models commonly recommended or used to meet regulatory agencies' requirements, such as the model HELP (Hydrologic Evaluation of Landfill Performance (HELP) Model | US EPA) may also be used to estimate the leachate generation and other water pathways that could be sources of PFAS substances from landfill facilities.

Step 2: Determine the Concentration of Individual PFAS in Landfill Leachate Generated at Your Facility During the NPRI Reporting Year

Should you have testing available for the concentration of individual PFAS in the landfill leachate (typically expressed in ng/L) generated at your landfill, then these concentrations should be used.

If there has been no testing for the concentration of individual PFAS in your leachate, reasonable estimates may be used based on data from similar facilities, comparable operations, or surrogate substances or from publicly available data sources such as peer-reviewed literature combined with expert judgment and knowledge of the design and operations of the facility. Table 17 in section 9.4 provide some available sampling results conducted by ECCC of landfill leachate for 40 of the individual PFAS that have been added to the NPRI, which may be used as a substitute in the absence of site-specific data for MSW landfill facilities.

Beyond Canada, Zhang et al., (2023)[118] studied data from more than 10 countries (250+ landfills) and provided ranges for 7 PFAS substances in these landfills – all of which are already present in the Canadian dataset. A review of other studies on landfill leachates indicated that the ECCC data had captured the major PFAS that has been found to be present in landfill leachate. Therefore, the Canadian-specific data could be used in determining if the NPRI reporting threshold is met and if necessary, in calculating the quantity of individual PFAS transfers/disposals/releases.

Step 3: Calculate the Quantity of Individual PFAS in the Landfill Leachate Generated During the NPRI Reporting Year

Once the individual PFAS concentrations have been identified, the following formula should be used to calculate the quantity of individual PFAS that were contained in landfill leachate generated at your landfill during the NPRI reporting year:

$$PFAS_{kg}^{i} = Volume_{L}\ x\ Concentration_{ng/L}^{i}\ x\ 10_{kg/ng}^{-12}$$

Where:

- $PFAS^{i}_{kg}$ = Quantity of PFAS chemical *i* contained in landfill leachate generated at the landfill during the NPRI reporting year, in kilograms.
- $Volume_{L}$ = Total volume of landfill leachate generated at the landfill during the NPRI reporting year, in liters.
- $Concentration^{i}_{ng/L}$ = Concentration of PFAS chemical *i* contained in landfill leachate generated at the landfill during the NPRI reporting year, expressed in ng/L.
- $1e\text{-}12_{kg/ng}$ = Conversion factor for nanograms to kilograms. 1 kg = 10^{12} ng.

The above calculation needs to be completed for each individual PFAS for which concentration data in the landfill leachate is available.

9.2.3 Generation of Landfill Gas

The second stream containing PFAS from landfills which can be used to account for the total quantity generated from the landfill facility that trigger NPRI reporting thresholds is landfill gas. Landfill gas has been found to contain PFAS substances – typically in pg/m^3. The following steps should be followed to estimate the quantity generated from landfill gas:

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[118] Zhang et al., (2023), *Poly-and Perfluoroalkyl Substances (PFAS) in Landfills: Occurrence, Transformation and Treatment*

Step 1: Access the Quantity of Landfill Gas Generated Annually at the Landfill Site

It is assumed that the total quantity of landfill gas generated annually at the landfill facility is known. Total landfill gas generated per year will be used in the next step of the calculation below, expressed in m^3. The Landfill Gas Emissions Model (LandGEM) | US EPA can be used to estimate the total landfill gas production and associated emission rates for the facility.

Step 2: Determine the Concentration of Individual PFAS Within Landfill Gas Generated During the NPRI Reporting Year

Should you have testing available for the concentration of individual PFAS in the landfill gas (typically expressed in pg/m^3) generated at your landfill, then these concentrations should be used.

If there has been no testing for the concentration of individual PFAS in your landfill gas, reasonable estimates may be used based on data from similar facilities, comparable operations, or surrogate substances or from publicly available data sources such as peer-reviewed literature combined with expert judgment and knowledge of the design and operations of the facility. Table 18 in section 9.5 provides available testing data from Canadian landfills[119] on landfill gas for 16 of the individual PFAS that have been added to the NPRI (Ahrens et.al)[120]. that may be used in the absence of site-specific data for MSW landfill facilities. Additional data on similar PFAS substances found in landfill gas are also reported by Zhang et al. (2023)[121] and Lin et al. (2024)[122] from studies conducted in other countries.

Step 3: Calculate the Quantity of Individual PFAS in the Landfill Gas Generated During the NPRI Reporting Year

Once the individual PFAS concentrations have been identified, the following formula should be used to calculate the quantity of individual PFAS that were contained in landfill gas generated at your landfill during the NPRI reporting year:

$$PFAS_{kg}^{i} = Volume_{m^3} \ x \ Concentration_{pg/m^3}^{i} \ x \ 10_{kg/pg}^{-15}$$

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[119] Ahrens et al., (2011), *Wastewater Treatment Plant and Landfills as Sources of Polyfluoroalkyl Compounds to the Atmosphere*.

[120] Data has been retrieved for both on-site concentrations of PFAS and upwind concentrations of PFAS. The on-site concentrations of PFAS have been utilized for the purpose of this methodology.

[121] Zhang et al., (2023), *Poly-and Perfluoroalkyl Substances (PFAS) in Landfills: Occurrence, Transformation and Treatment*

[122] Lin et al. (2024) Landfill Gas: A Major Pathway for Neutral Per- and Polyfluoroalkyl Substance (PFAS) Release

Where:

- $PFAS^{i}_{kg}$ = Quantity of PFAS chemical *i* contained in landfill gas generated at the landfill during the NPRI reporting year, in kilograms.
- $Volume_{m3}$ = Total volume of landfill gas generated at the landfill during the NPRI reporting year, in m^3.
- $Concentration^{i}_{pg/m3}$ = Concentration of PFAS chemical *i* contained in landfill leachate generated at the landfill during the NPRI reporting year, expressed in pg/m^3.
- $1e\text{-}15_{kg/ng}$ = Conversion factor for nanograms to kilograms. 1 kg = 10^{15} pg.

The above calculation needs to be completed for each individual PFAS for which concentration data in the landfill gas is available.

Step 4: Which PFAS Need to be Reported to the NPRI

Based on the quantity calculated at step 3 from Section 9.2.2 and 9.2.3, calculate the total quantity generated at the landfill facility and compare it with the mass reporting threshold. Each individual NPRI PFAS substance generated with a quantity ≥1 kg must be considered for reporting to the NPRI if the employee threshold is met.

9.3 Estimating Releases, Transfers and Disposals

Landfills typically transfer treated or untreated leachate to wastewater treatment plants for treatment. However, landfills may release PFAS to surrounding water (e.g. groundwater, surface water) and/or soil depending upon the permeability (or presence) of an adequate liner and leachate collection system. Landfills may also release PFAS to air depending upon the presence of a landfill gas collection and treatment (i.e. flaring) system.

Information to support the estimation of PFAS release, transfer and disposal contained in both landfill leachate and landfill gas are provided in this section.

9.3.1 Landfill Leachate

For those individual PFAS that met the thresholds for reporting to the NPRI, the following steps need to be undertaken:

Step 1: Determine Individual PFAS Quantities in Landfill Leachate

In determining whether reporting to the NPRI is required for individual PFAS (see previous section), a calculation was made of the quantity of individual PFAS that were contained in the landfill leachate generated at the facility during the NPRI reporting year. The fate of this quantity of individual PFAS needs to be reported for those individual PFAS that met the NPRI reporting requirements. Leachate generated at MSW landfill is typically treated either on-site or off-site at a wastewater treatment facility or it may be released into the environment. There wouldn't be any "disposal of leachate". Although hazardous waste landfills usually do not produce leachate, if they do, it would likely be transferred for treatment prior to final disposal. The typical fate of leachate will be transfers for treatment prior to final disposal – transfer to a wastewater treatment facility. However, the full set of release/transfer/disposal categories should be reviewed to determine the most appropriate category for the individual PFAS contained in landfill leachate.

9.3.2 Landfill Gas

Step 1: Determine Individual PFAS Quantities in Landfill Gas

In determining whether reporting to the NPRI is required for individual PFAS (see previous section), a calculation was made of the quantity of individual PFAS that were contained in the landfill gas generated at the facility during the NPRI reporting year. The fate of this quantity of individual PFAS needs to be reported for those individual PFAS that met the NPRI reporting requirements. The fate will typically be releases to air.

In cases where the landfill in question has a landfill gas capture system that either combusts (for energy generation) or flares PFAS[123]/[124], the following additional step must be undertaken.

Step 2: Estimate PFAS Releases After Application of Thermal Treatment

Many landfills in Canada undertake thermal treatment of landfill gas, either to generate energy or to reduce emissions of methane and other pollutants. If the landfill gas combustion system is operating correctly, it should provide sufficient heat and residence time to destroy PFAS substances.

To estimate the quantity of PFAS released to atmosphere after thermal treatment, utilize the following calculation:

$$PFASR^{i}_{kg} = PFAS^{i}_{kg} \times UnCapRate_{\%}$$

Where:

- $PFASR^{i}_{kg}$ = Quantity of PFAS chemical *i* in landfill gas released from the landfill during the NPRI reporting year after landfill gas capture and combustion, in kilograms
- $PFAS^{i}_{kg}$ = Quantity of PFAS chemical *i* in total landfill gas generated at the landfill during the NPRI reporting year, in kilograms
- $UnCapRate_{\%}$ = The amount of landfill gas that is not captured by the landfill gas capture system, expressed in % of total landfill gas generated.

Controlled releases must be reported under the stack or point releases source category. However, there may also be uncontrolled fugitive emissions, and if data is available, the quantity should be considered for reporting under the fugitive releases source category.

9.4 Table of PFAS Concentrations in Landfill Leachate

Provided in the table below are the average concentrations of various individual PFAS measured in landfill leachate, as determined by ECCC.

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[123] PFAS can be destroyed (~99.99%) in thermal treatment systems operating at >850 C.

[124] Weitz et al., (2024), *Review of Per- and Poly-Fluoroalkyl Treatment in Combustion-Based Thermal Waste Systems in the United States*

Table 17: Average Concentration of Individual PFAS in Canadian Landfill Leachate (data from 2020 and 2023)

CAS RN	Concentration (ng/L)
108427-53-8	201.25
1169706-83-5	95.68
122499-17-6	3.31
126105-34-8	0.83
1432017-36-1	0.83
146689-46-5	5.45
1621485-21-9	3.32
1691-99-2	32.82
171978-95-3	4.27
175905-36-9	20.45
1799325-94-2	9600.13
1799325-95-3	629.70
196859-54-8	3.24
2127366-90-7	3.31
2196242-82-5	3.32
220689-13-4	0.84
2355-31-9	88.23
24448-09-7	36.70
2991-50-6	260.28
31506-32-8	1.57
343629-43-6	0.77
365971-87-5	1.54
39187-41-2	1.66
414911-30-1	3.04
4151-50-2	3.30
425670-75-3	93.41
45048-62-2	426.40
45167-47-3	335.71
45187-15-3	533.64
45285-51-6	529.42
45298-90-6	147.64
474511-07-4	0.77
481071-78-7	9.05
72007-68-2	18.18
73829-36-4	16.06
754-91-6	10.17
862374-87-6	1.20
92612-52-7	637.15

Source: Perfluoroalkyl and Polyfluoroalkyl Substances in Canadian Municipal Wastewater Treatment Systems. Accessed at the Open Government Portal (https://open.canada.ca/data/en/dataset/f4e25ea2-e070-448c-9105-129807f5fc3a).

Note: Where non-detects were recorded for some samples, it was assumed that the concentration was half of the detection limit. This assumption was applied in order to calculate the average concentration across all relevant samples (per CAS RN).

9.5 Table of PFAS Concentrations in Landfill Gas

Provided in the table below are the average concentrations of various individual PFAS measured in landfill gas, as determined by Ahrens et al. (2011).

Table 18: Average Concentration of Individual PFAS in Canadian Landfill Gas

CAS	**Average Concentration (pg/m^3)**
647-42-7	3724.50
678-39-7	9335.50
865-86-1	1230.50
31506-32-8	21.05
4151-50-2	13.45
1691-99-2	22.15
45298-90-6	3.91
45048-62-2	101.50
92612-52-7	34.60
375-85-9	10.20
45285-51-6	24.59
72007-68-2	10.31
73829-36-4	11.17
2058-94-8	8.72
307-55-1	10.07
376-06-7	2.77

Source: Ahrens et al., (2011), *Wastewater Treatment Plant and Landfills as Sources of Polyfluoroalkyl Compounds to the Atmosphere*.

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11. Appendix A

11.1 Densities of AFFFs Identified in 14 Product Datasheets

Table 19: Densities of AFFFs Identified in 14 Product Datasheets

Brand	Product Name	Density (kg/L)
Aberdeen Foam	1% AFFF-C6	1.04
HD Fire Protect	1% AFFF HD AFFF 1-C6	1-1.06
HD Fire Protect	AFFF 3%-C6	1.02
Australia Wide Fire Supplies	AFFF 3% Foam Solution	1.01
National Foam	Universal Gold 1%/3% Alcohol AR-AFFF	1.03
International Security and Safety Systems Co.	AFFF Foam Concentrate – EGY 1%, 3%, 6% (all same specific gravity)	1.02
Perimeter Solutions	Arctic 6% Mil-Spec AFFF Foam Concentrate	1.009 – 1.049
Perimeter Solutions	Solberg Arctic 6% AFFF Foam Concentrate	1.005 – 1.025
Viking	Viking AFFF 3%M C6 Military Specification Foam Concentrate	1.03
Viking	Ultraguard C334-LV 3% AR-AFFF Foam Concentrate	1.03
Viking	C6 3% AFFF Foam Concentrate	1.02
Phos-Check	AFFF Class B 1% Foam Concentrate	1.02
Viking	3% AFFF Military Specification Foam Concentrate C-301 MS	1.079
Univex	3-3 M FPAR Foam Concentrate	1.14

11.2 List of PFAS added to the NPRI that could potentially be found in fluorinated firefighting foams

Table 20: List of PFAS added to the NPRI that could potentially be found in fluorinated firefighting foams

CAS RN	Substance Name	Subclass
865-86-1	1-Dodecanol, 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,12-heneicosafluoro-	LC
70983-60-7	1-Propanaminium, 2-hydroxy-N,N,N-trimethyl-, 3-[(γ-ω-perfluoro-C6-20-alkyl)thio] derivs., chlorides	LC
68187-47-3	1-Propanesulfonic acid, 2-methyl-, 2-[[1-oxo-3-[(γ-ω-perfluoro-C4-16-alkyl)thio]propyl]amino] derivs., sodium salts	LC
65605-58-5	2-Propenoic acid, 2-methyl-, dodecyl ester, polymer with α-fluoro-ω-[2-[(2-methyl-1-oxo-2-propenyl)oxy]ethyl]poly(difluoromethylene)	LC
17741-60-5	2-Propenoic acid, 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,12-heneicosafluorododecyl ester	LC
34395-24-9	2-Propenoic acid, 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,13,13,14,14,14-pentacosafluorotetradecyl ester	LC
68391-08-2	Alcohols, C8-14, γ-ω-perfluoro	LC
65636-35-3	Ethanaminium, N,N-diethyl-N-methyl-2-[(2-methyl-1-oxo-2-propenyl)oxy]-, methyl sulfate, polymer with 2-ethylhexyl 2-methyl-2-propenoate, α-fluoro-ω-[2-[(2-methyl-1-oxo-2-propenyl)oxy]ethyl]poly(difluoromethylene), 2-hydroxyethyl 2-methyl-2-propenoate and	LC
65530-64-5	Ethanol, 2,2'-iminobis-, compd. with α,α'-[phosphinicobis(oxy-2,1-ethanediyl)]bis[ω-fluoropoly(difluoromethylene)] (1:1)	LC
65530-63-4	Ethanol, 2,2'-iminobis-, compd. with α-fluoro-ω-[2-(phosphonooxy)ethyl]poly(difluoromethylene) (2:1)	LC
16517-11-6	Octadecanoic acid, pentatriacontafluoro-	LC
335-76-2	Perfluorodecanoic acid	LC
307-55-1	Perfluorododecanoic acid	LC
375-95-1	Perfluorononanoic acid	LC
67905-19-5	Perfluoropalmitic acid	LC
376-06-7	Perfluorotetradecanoic acid	LC
72629-94-8	Perfluorotridecanoic acid	LC
2058-94-8	Perfluoroundecanoic acid	LC
68412-69-1	Phosphinic acid, bis(perfluoro-C6-12-alkyl) derivs.	LC
68412-68-0	Phosphonic acid, perfluoro-C6-12-alkyl derivs.	LC
65530-83-8	Poly(difluoromethylene), α-[2-[(2-carboxyethyl)thio]ethyl]-ω-fluoro-	LC
65545-80-4	Poly(oxy-1,2-ethanediyl), α-hydro-ω-hydroxy-, ether with α-fluoro-ω-(2-hydroxyethyl)poly(difluoromethylene) (1:1)	LC
3830-45-3	Perfluorodecanoic Acid, Sodium Salt	LC
307-67-5	Perfluorododecanoic Acid, Sodium Salt	LC

2806-15-7	Sodium perfluorodecanesulfonate	LC
98789-57-2	Perfluorononanesulfonic acid sodium salt	LC
60871-96-7	Sodium perfluoro-*n*-undecanoate	LC
65530-70-3	Poly(difluoromethylene), α,α'-[phosphinicobis(oxy-2,1-ethanediyl)]bis[ω-fluoro-, ammonium salt (1:1)	LC
65530-69-0	Poly(difluoromethylene), α-[2-[(2-carboxyethyl)thio]ethyl]-ω-fluoro-, lithium salt (1:1)	LC
65530-72-5	Poly(difluoromethylene), α-fluoro-ω-[2-(phosphonooxy)ethyl]-, ammonium salt (1:2)	LC
39108-34-4	8:2 Fluorotelomer sulfonic acid	LC
24448-09-7	1-Octanesulfonamide, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-(2-hydroxyethyl)-N-methyl-	PFOS
31506-32-8	1-Octanesulfonamide, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-methyl-	PFOS
4151-50-2	1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-	PFOS
1691-99-2	1-Octanesulfonamide, N-ethyl-1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-N-(2-hydroxyethyl)-	PFOS
25268-77-3	2-[[(Heptadecafluorooctyl)sulfonyl]methylamino]ethyl acrylate	PFOS
56773-42-3	Ethanaminium, N,N,N-triethyl-, salt with 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-1-octanesulfonic acid (1:1)	PFOS
1763-23-1	Perfluorooctane sulfonic acid	PFOS
307-35-7	Perfluorooctylsulfonyl fluoride	PFOS
29117-08-6	Poly(oxy-1,2-ethanediyl), α-[2-[ethyl[(heptadecafluorooctyl)sulfonyl]amino]ethyl]-ω-hydroxy-	PFOS
2795-39-3	Perfluorooctane sulfonic acid potassium salt	PFOS
29081-56-9	Perfluorooctane sulfonic acid ammonium salt	PFOS
678-39-7	1-Decanol, 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-heptadecafluoro-	PFOA
27905-45-9	2-Propenoic acid, 3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-heptadecafluorodecyl ester	PFOA
2043-53-0	Decane, 1,1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8-heptadecafluoro-10-iodo-	PFOA
335-66-0	Octanoyl fluoride, pentadecafluoro-	PFOA
45285-51-6	Perfluorooctanoate	PFOA
335-67-1	Perfluorooctanoic acid	PFOA
21652-58-4	Perfluorooctyl Ethylene	PFOA
65530-62-3	Poly(difluoromethylene), α,α'-[phosphinicobis(oxy-2,1-ethanediyl)]bis[ω-fluoro-	PFOA
65530-61-2	Poly(difluoromethylene), α-fluoro-ω-[2-(phosphonooxy)ethyl]-	PFOA
70969-47-0	Thiols, C8-20, γ-ω-perfluoro, telomers with acrylamide	PFOA
335-95-5	Perfluorooctanoic acid sodium salt	PFOA
375-73-5	1-Butanesulfonic acid, 1,1,2,2,3,3,4,4,4-nonafluoro-	Other PFAS
375-92-8	Perfluoroheptanesulfonic acid	Other PFAS
307-24-4	Hexanoic acid, undecafluoro-	Other PFAS

2706-90-3	Pentanoic acid, nonafluoro-	Other PFAS
375-22-4	Heptanoic acid, tridecafluoro-	Other PFAS
375-85-9	Heptanoic acid, tridecafluoro-	Other PFAS
68259-12-1	Perfluorononanesulfonic acid	Other PFAS
335-77-3	Perfluorodecanesulfonic acid	Other PFAS
754-91-6	Perfluorooctanesulfonamide	Other PFAS
2355-31-9	2-(N-Methylperfluorooctanesulfonamido)acetic acid	Other PFAS
2991-50-6	2-(N-Ethylperfluorooctanesulfonamido)acetic acid	Other PFAS
757124-72-4	2-(Perfluorobutyl)-1-ethanesulfonic acid	Other PFAS
27619-97-2	1-Octanesulfonic acid, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro-	Other PFAS
13252-13-6	Hexafluoropropylene oxide dimer acid	Other PFAS