Evidence Evaluations for Australian Drinking Water Guidelines Chemical Fact Sheets – PFOS, PFHxS, PFOA, PFBS, and GenX Chemicals

PFOS, PFHxS, PFOA, PFBS, and GenX Chemicals Technical Report

National Health and Medical Research Council

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Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with the National Health and Medical Research Council (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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Acronyms and Abbreviations

Acronym	Definition
∑	Sum
ADD/ADI	Acceptable Daily Dose/Acceptable Daily Intake
ADHD	Attention Deficit Hyperactivity Disorder
AICIS	Australian Industrial Chemicals Introduction Scheme
Alaska DEC	Alaska Department of Environmental Conservation
ALP	Alkaline Phosphatase
ALT	Alanine Transaminase
APVMA	Australian Pesticides and Veterinary Medicines Authority
AST	Aspartate Aminotransferase
ATSDR	US Agency for Toxic Substances and Disease Registry
BfR	German Bundesinstitut für Risikobewertung (Federal Institute for Risk Assessment)
BMDL	Benchmark Dose Limit
BMR	Benchmark Response
BUN	Blood Urea Nitrogen
BW	Body Weight
CAR	Constitutive Androgen Receptor
CAS	Chemical Abstracts Service
CDC	US Centre for Disease Control
CDPH	Connecticut State Department of Public Health
CI	Confidence Interval
CL	Clearance
CNT	Carbon Nanotube
CONTAM Panel	EFSA Panel on Contaminants in the Food Chain
CSF	Cancer Slope Factor
d	Day
DNA	Deoxyribonucleic Acid
DOH	Department of Health (Australia)
DWG	Drinking Water Guideline
DWI	Drinking Water Intake
DWI-BW	Drinking Water Intake Adjusted for Body Weight
DWQI	Drinking Water Quality Institute (New Jersey)
DWTP	Drinking Water Treatment Plant
E2	Oestradiol
EC	European Commission

Acronym	Definition
EFSA	European Food Safety Authority
EPA	Environmental Protection Agency (or Authority)
ESI^-	Negative Electrospray Ionisation
EU	European Union
F1	First Filial Generation
F2	Second Filial Generation
FAO	Food and Agriculture Organization
FSANZ	Food Standards Australia New Zealand
GAC	Granular Activated Carbon
GC/MS	Gas Chromatography Mass Spectrometry
GD	Gestation Day
GenX	Hexafluoropropylene Oxide (HFPO) Ammonium Salt (CAS No 62037-80-3)
GenX chemicals	Hexafluoropropylene Oxide (HFPO) Ammonium Salt (CAS No 62037-80-3) and Hexafluoropropylene Oxide (HFPO) Dimer Acid (CAS No 13252-13-6)
GGT	γ-Glutamyltransferase
GLP	Good Laboratory Practice
HA	Health Advisory
HBGV	Health Based Guidance Value
HBV	Health Based Value
HBWC	Health-Based Water Concentration
HC	Health Canada
HEC	Human Equivalent Concentration
HED	Human Equivalent Dose
HEQ	Human Equivalent
HDL	High Density Lipoprotein
Hib	*Haemophilus influenza T*ype b
HPC	Health Protective Concentration
HPLC	High Performance Liquid Chromatography
HRMS	High-Resolution Mass Spectrometry
hrs or h	Hours or Hour
IARC	International Agency for Research on Cancer
IgG1	Immunoglobulin G1
IgM	Immunoglobulin M
IL-4	Interleukin 4
IPCS	International Programme on Chemical Safety
IU/L	International Units per Litre
iTRAQ	Isobaric Tags for Relative and Absolute Quantitation

Acronym	Definition
JECFA	Joint FAO/WHO Expert Committee on Food Additives
K+ PFBS	PFBS Potassium Salt
Ke	First-order Elimination Rate
Kg	Kilogram
L	Litres
LCMS	Liquid Chromatography-Mass Spectrometer
LOAEC/LOAEL	Lowest Observed Adverse Effect Concentration / Lowest Observed Adverse Effect Level
LOEL	Lowest Observed Effect Level
LOR(D)(Q)	Limit of Reporting (Detection) (Quantification)
m or min	Minute
MAC	Maximum Acceptable Concentration
Maine DHHS	Maine Department of Health and Human Services
Mass DEP	Massachusetts Department of Environmental Protection
Mass DPH	Massachusetts Department of Public Health
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDH	Minnesota Department of Health
MDL	Method Detection Limit
mg	Milligram
MI	Michigan
mmol	Millimole
MOA	Mode of Action
MPART	Michigan PFAS Action Response Team
MRL	Minimum Reporting Level or Minimal Risk Level (ATSDR terminology)
MS/MS	Tandem Mass Spectrometer
NB	*Nota Bene*
NF	Nanofiltration
ng	Nanogram
NHANES	(US) National Health and Nutrition Examination Survey
NHMRC	National Health and Medical Research Council
NJDEP	New Jersey Department of Environmental Protection
NL	Not Listed
NOAEC/NOAEL	No Observed Adverse Effect Concentration/ No Observed Adverse Effect Level
NOM	Natural Organic Matter
NTP	National Toxicology Program

Acronym	Definition
OECD	Organisation for Economic Co-operation and Development
OEHHA	Californian Office of Environmental Health and Hazard Assessment
OHAT	US Office of Health Assessment and Translation (recently changed to Health Assessment and Translation)
OR	Odds Ratio
PBPK	Physiologically Based Pharmacokinetic
PCB	Polychlorinated Biphenyl
PFAA	Perfluorinated Alkyl Acids
PFAS	Per- and Poly-fluoroalkylated Substances
PFBS	Perfluorobutane sulfonic acid (CAS No. 375-73-5).
PFC	Perfluorinated Chemical
PFCA	Perfluorocarboxylic Acids
PFDA	Perfluorodecanoic Acid
PFHpA	Perfluoroheptanoic Acid
PFHxS	Perfluorohexane sulfonic acid (CAS No. 355-46-4)
PFHxSK	PFHxS Potassium Salt
PFNA	Perfluorononanoic Acid
PFOA	Perfluorooctanoic acid (CAS No. 335-67-1)
PFOS	Perfluorooctane sulfonic acid (CAS No. 1763-23-1)
pg	Picogram
pGVs	Provisional Guideline Values
PHG	Public Health Goal
PND	Postnatal Day
POD	Point of Departure
POPs	Persistent Organic Pollutants
PPARα	Peroxisome Proliferator-Activated Receptor Alpha
ppb	Parts per Billion
ppm	Parts per Million
ppq	Parts per Quadrillion
PPS	Preputial Separation
ppt	Parts per Thousand
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PWS	Public Water Supplies
Qtof-MS	Quadrupole Time of Flight Mass Spectroscopy
RfD	Reference Dose
RIVM	Dutch National Institute for Public Health and the Environment
RL	Reference Level

Acronym	Definition
RO	Reverse Osmosis
RPF	Relative Potency Factor
RSC	Relative Source Contribution
SAL	State Action Level
SAW	State Advisory Workgroup (Michigan)
SD	Standard Deviation
SDH	Sorbitol Dehydrogenase
SLR	SLR Consulting Australia Pty Ltd
SRBC	Sheep Red Blood Cell
SWRCB	California State Water Resources Control Board
T3	Triiodothyronine
T4	Thyroxine
TDI	Tolerable Daily Intake
TG	Test Guideline
The Committee	NHMRC Water Quality Advisory Committee
The Guidelines	NHMRC and NRMMC (2011). Australian Drinking Water Guidelines 6 2011; Version 3.8 updated September 2022, National Health and Medical Research Council and Natural Resource Management Ministerial Council, Commonwealth of Australia, Canberra.
TOF Assay	Total Organic Fluorine Assay
TOP Assay	Total Oxidisable Precursor Assay
TRV	Toxicity Reference Value
TSH	Thyroid Stimulating Hormone
TV	Toxicity Values (Michigan)
TWI	Tolerable Weekly Intake
UF	Uncertainty Factor
UFA	Interspecies UF
UFL	LOAEL-to-NOAEL Extrapolation UF
UFS	UF for Subchronic-to-chronic Exposure Duration Extrapolation
µg	Microgram
UPLC	Ultraperformance Liquid Chromatography
US EPA	United States Environmental Protection Agency
UV	Ultraviolet
Vd	Volume of Distribution
WHO	World Health Organization
WSDH	Washington State Department of Health

1.0 Introduction and Background

An Australian drinking water guideline and existing Fact Sheet[1] are available for three per- and polyfluoroalkyl substances (PFAS):

- 70 ng/L for perfluorooctane sulfonic acid + perfluorohexane sulfonic acid (PFOS, Chemical Abstracts Service or CAS No. 1763-23-1 + PFHxS, CAS No. 355-46-4),
- and 560 ng/L for perfluorooctanoic acid (PFOA, CAS No. 335-67-1).
- There is currently no Australian drinking water guideline or existing Fact Sheet for perfluorobutane sulfonic acid (PFBS, CAS No. 375-73-5) and hexafluoropropylene oxide ammonium salt (CAS No 62037-80-3) plus hexafluoropropylene oxide (HFPO) dimer acid (CAS No 13252-13-6) (also termed GenX Chemicals).

The National Health and Medical Research Council (NHMRC) have contracted SLR Consulting Australia Pty Ltd (SLR) to identify existing sources of guidance or guidelines on the impact of exposure to these five PFAS (listed above) in drinking water at levels higher or lower than the current health-based guideline values (where these exist) on human health outcomes. An evidence scan to inform an update to the existing supporting information (e.g. levels detected in Australian drinking water, analysis/detection, monitoring and treatment guidance) provided in the Fact Sheet was also requested to be undertaken.

The findings of this evaluation will be used by NHMRC to develop/update public health advice and/or health-based guideline values (if required) for inclusion in the *Australian Drinking Water Guidelines* (2011) (the Guidelines). The evidence reviews undertaken by SLR were governed by a newly designed methodological framework intended to implement best practice methods for evidence evaluations as per the 2016 *NHMRC Standards for Guidelines*. For each PFAS, SLR was asked to:

- Customise and apply the 'Research Protocol' template provided by NHMRC to answer research questions.
- Produce a Technical Report and an Evaluation Report for each substance.
    - The Technical Report is to capture the details and methods used to undertake each review.
    - The Evaluation Report is to interpret, synthesise and summarise the existing guidance and evidence pertaining to the research questions.

These tasks were performed in collaboration with the NHMRC's Water Quality Advisory Committee (the Committee) and NHMRC.

The report herein is the Technical Report for the five PFAS evaluated (PFOS, PFOA, PFHxS, PFBS and GenX Chemicals). A combined Technical Report was produced since there was a large cross-over between the information for the various PFAS evaluated.

2.0 Research Questions

Research questions for this review were drafted by SLR and peer reviewed and agreed upon by the Committee and NHMRC prior to conducting the search. They are provided in **Table 2-1.**

[1] A single Fact Sheet currently exists for PFOS+PFHxS and PFOA (NHMRC and NRMMC 2011); Advice on new chemicals would either be included in the same Fact Sheet or new Fact Sheets developed as required if determined by NHMRC with advice from the Committee.

Table 2-1 Research Questions for Evidence Evaluation of Health-Related Advice and Supporting Information in Fact Sheets for Five PFAS

#	Research Questions
Health-Related Advice	
Health-based guideline value	
1	What level of PFOS, PFOA, PFHxS, PFBS and GenX Chemicals in drinking water causes adverse health effects?
2	What is the critical human health endpoint that determines this value?
3	What are the justifications for choosing this endpoint?
4	What other recent guideline values exist?
5	If there are existing guidance/guideline values, are the proposed option/s for health-based guideline values relevant to the Australian context?
6	How were they derived and are there any uncertainties with the key studies or the approaches used?
7	Are they suitable to adopt/adapt?
Health considerations	
8	What are the key adverse health hazards from exposure to PFOS, PFOA, PFHxS, PFBS and GenX Chemicals in Australian drinking water?
Typical Australian water levels or exposure profile	
9	What are the typical levels in Australian drinking water supplies, considering distributed drinking water and households using their own bore water, rainwater or surface water for drinking? (1)
10	Do they vary around the country or under certain conditions e.g. drought?
11	What other factors should be considered (e.g. differences between groundwater versus surface water sources)?
Risk summary	
12	What are the risks to human health from exposure to PFOS, PFOA, PFHxS, PFBS and GenX Chemicals in Australian drinking water?
13	Is there evidence of any emerging risks that are not mentioned in the current Fact Sheet that require review or further research?
Supporting information in Fact Sheet	
General description	
14	Is the general description in the Fact Sheet current for all five PFAS under review?
15	What are the chemicals used for and how might people be exposed?
16	How do the chemicals end up in drinking water and in what form?
Measurement	
17	Is the measurement information in the Fact Sheet current?
18	What are the current analytical methods used to measure/detect the concentration of the specified chemicals in water?
19	What are the limits of quantification or limit of reporting for these chemicals in drinking water?
20	What are the indicators of the risks?

#	Research Questions
21	How can we measure this exposure?
Treatment options	
22	Is the information on treatment of drinking water in the Fact Sheet current?
23	What are the available options for removing the specified chemicals from drinking water?
Risk management options	
24	What are the current practices to minimise or manage the risks identified?
(1) Due to resource constraints, data gathering for this research question focused on distributed water from uncontaminated locations; only a few publications were consulted to inform PFAS concentrations in residential/private bore water in proximity to contaminated sites and bore water used for drinking in proximity to fire stations.	

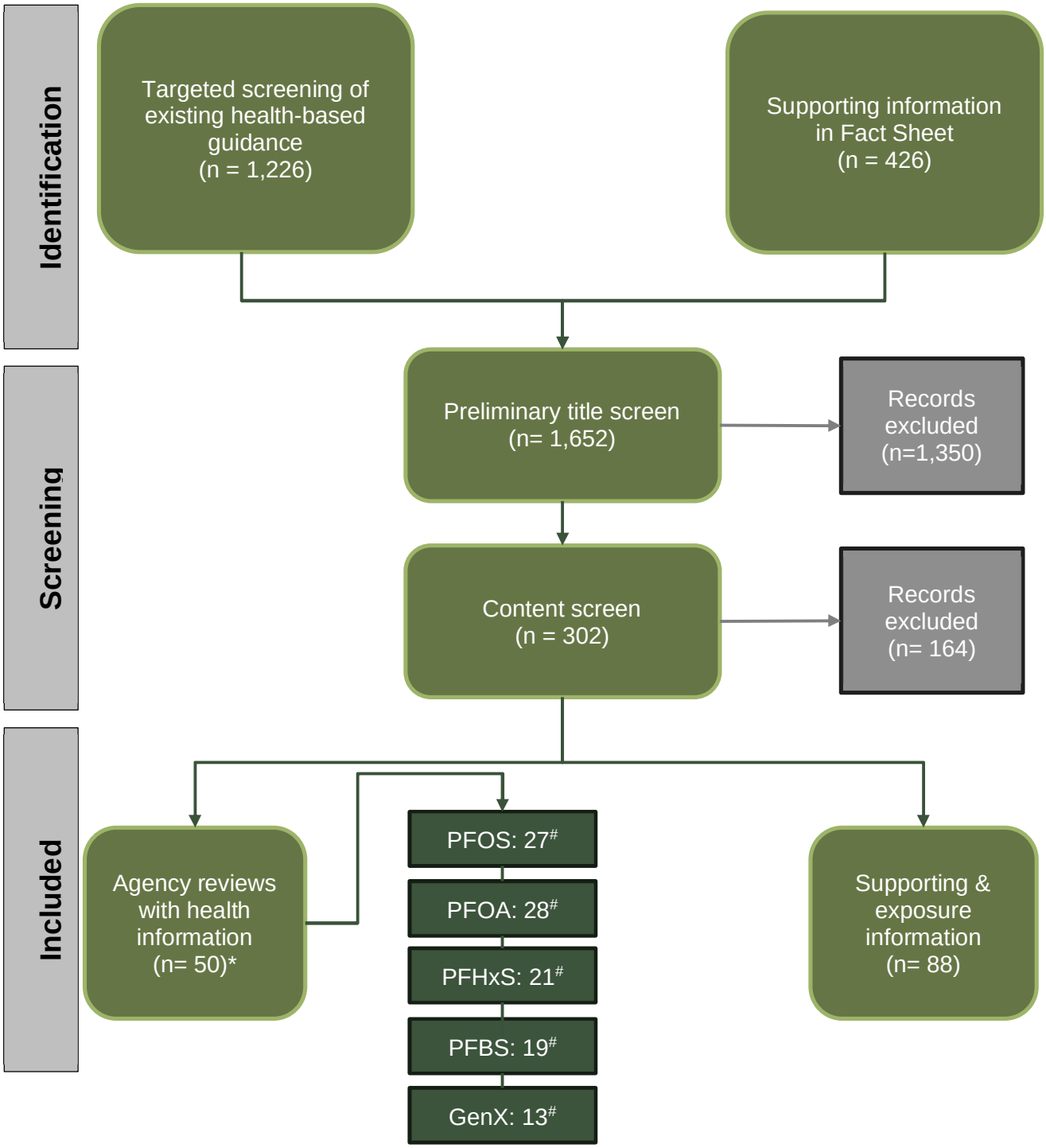
3.0 Evidence Evaluation Methods

3.1 Overview

This section summarises the methods followed to undertake the evidence evaluation review for the five PFAS. The intention is to provide enough detail for a third party to reproduce the search.

It was evident that some flexibility was required in adapting the methodology recorded in the final Research Protocol for the five PFAS to maximise efficiency in sourcing relevant information. Deviations from the final Research Protocol methodology have been recorded in this report (see **Section 3.4**) as well as in **Appendix A** (the literature search screening outcome spreadsheets). **Figure 1** shows an overview of the literature search process followed for the five PFAS. This is presented as a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram that describes the study selection process and numbers of records at each stage of screening (Moher et al. 2009).

Figure 1 Overview of literature search process followed for the five PFAS



*Some reviews derived guidance/guideline values for more than one PFAS.
This value indicates the number of agency reviews that data was extracted from for each individual PFAS as shown in Appendix B of the Technical Report. Not all agency reviews had guideline values/guidance as some were used for supporting information only. Due to resource constraints and with agreement from NHMRC with advice from the Committee, critical evaluation of studies underpinning existing guideline values in the Evaluation Report was prioritised to those studies that had not been previously reviewed and/or considered by an Australian agency for guidance/guideline value development (see **Appendix A** in Evaluation Report).

3.2 Targeted screening of existing health-based guidance

Literature search strategy

The literature search strategy for existing health-based guidance documentation for the five PFAS is summarised in **Table 3-1** below.

Table 3-1 Search strategy for Existing Guidance/Guidelines

Parameter	Comments
Search terms	After a few trial runs of various combinations of search terms, it became apparent that the search terms would need to remain relatively broad so as not to miss pivotal references/reviews. Consequently, the selected search terms were as follows: • (PFOS) • (PFOA) • (PFHxS) • (PFBS) • (GenX) OR (13252-13-6) OR (62037-80-3)
Databases/Agency websites	The following sources were searched: • World Health Organization (WHO): https://www.who.int/ • Food Agriculture Organization of the United Nations (FAO): https://www.fao.org/home/en, https://www.fao.org/food-safety/resources/publications/en/, https://www.fao.org/food/food-safety-quality/scientific-advice/jecfa/en/ • Joint FAO/WHO Expert Committee on Food Additives (JECFA): (Included in FAO search) • European Food Safety Authority (EFSA): https://www.efsa.europa.eu/en • Health Canada: https://www.canada.ca/en/health-canada.html • Dutch National Institute for Public Health and the Environment (RIVM): https://www.rivm.nl/en • German Bundesinstitut für Risikobewertung (BfR – Federal Institute for Risk Assessment)]: https://www.bfr.bund.de/en/home.html • International Programme on Chemical Safety (IPCS) Inchem: http://www.inchem.org/#/search • United States Environmental Protection Agency (US EPA)(1): • US Agency for Toxic Substances and Disease Registry (ATSDR): https://www.atsdr.cdc.gov/ • US Centre for Disease Control (CDC): https://wwwn.cdc.gov/TSP/index.aspx • Californian Office of Health and Hazard Assessment (OEHHA) Public Health Goals (in Drinking Water): https://oehha.ca.gov/water/public-health-goals-phgs • Other US State Health Departments including Minnesota, Washington, Maine, Alabama, Alaska, Connecticut, Vermont, New Jersey, Michigan, and Massachusetts. • Food Standards Australia New Zealand (FSANZ): https://www.foodstandards.gov.au/Pages/default.aspx • Australian Pesticides and Veterinary Medicines Authority (APVMA): https://apvma.gov.au/

Parameter	Comments
	• Other Australian agencies [Australian Industrial Chemicals Introduction Scheme]
Publication Date	The search for existing guidance/guidelines was conducted from December 15, 2016, corresponding to the cut-off date of the literature search conducted as part of the Australian derivation of health-based guidance values for PFOS, PFOA, and PFHxS (FSANZ 2017). No cut-off date was used for PFBS and GenX Chemicals.
Language	English
Study Type	Publicly available agency/industry reports and reviews of guidelines or evidence supporting guidelines (near publication drafts are accepted if available).
Inclusion and exclusion criteria	The following exclusion criteria were used to screen relevance of agency reports/reviews: • NR = Not Relevant. Information not directly relevant to answering research questions. Rationale for non-relevance was provided for transparency in spreadsheet (see **Appendix A**). E.g. o Not HH related = Not human health related (e.g. criteria are for protection of aquatic life). o Not relevant to substance of interest. • NPA = Basis of guideline value or information underpinning review conclusions are Not Publicly Available, e.g. health-based guideline value has used unpublished proprietary information which could not be verified. • L = Language other than English. • Study = Individual animal studies for the five PFAS were excluded during the title screen (only reviews of existing guidance/guidelines were sought). • Super. = Superseded guidelines were excluded in the content screen and were not considered unless it was deemed necessary to understand the development of a certain guideline (e.g. some jurisdictions may have derived a guideline based on a superseded document from a different jurisdiction), i.e. only the most current organisational guideline was included in the title screen in the first instance. • Link = Search items that contain basic text (NPA) but provides links to reports (or other webpages) or other web pages on the Agency's website.
Validation methods used	Preliminary searches were undertaken with more specific search terms [(PFOS) AND (drinking water) OR (toxicity)] as per the Research Protocol. However, upon scanning preliminary search results, the reviewer found these search terms to be too specific, as a number of agency reports did not appear in the results. The search terms were consequently refined to just search for the PFAS name (see **Appendix A**).
Screening methods	Results were screened as follows: *Preliminary title screen* • Titles of results for each search were recorded in an Excel spreadsheet. • The researcher scanned the titles. In a separate column a decision regarding relevance of the result was recorded as per the exclusion criteria. An additional column was included to provide commentary as (and if) required. • A subject expert undertook the search and preliminary title screen. *Content screen*

Parameter	Comments
	• The full text content of reports/reviews selected to be included from the preliminary title screen were reviewed by a subject expert to determine which reports/reviews to include in the data extraction step. Only reports/reviews which provided information relevant to answering the research questions were taken through to the data extraction step.
Documentation of search	Spreadsheets with full search results and screening outcomes (i.e. reasons for exclusion) are provided in **Appendix A.** Overall results presented in **Figure 1**, adapted from the PRISMA figure presented in Moher et al. (2009) and Figure 5 in OHAT (2019).
Retrieval of publications	Relevant results were recorded in an Endnote library and soft copies of files saved into a designated folder on the SLR server for review. The server is backed up on a daily basis.
(1). The search within the US EPA general search engine (https://www.epa.gov/) resulted in hundreds of thousands of hits, regardless of search term refinement. This number of hits was considered unmanageable to screen through with the resources available for this project, especially considering the fact that search results became increasingly less relevant. Consequently, the search was cut off after the first 30 results (subsequent search results were irrelevant to answering the research questions).	

Data Collection and Quality Assessment

For each relevant result for which the full text was sourced:

- The full text was skimmed by a content expert.
- Where existing health-based guidance (in the form of drinking water guidelines or toxicity reference values, i.e. TRVs) was identified, relevant data on the guidance value in relation to the research questions were collected using the format shown in **Table 3-2**. The individual data extraction tables are provided in **Appendix B**.
- For each health-based guidance review, quality of existing guidance/guidelines was assessed using the Assessment Tool (Appendix C in the Research Protocol). The individual completed Assessment tool tables for each guidance/guideline document are provided in **Appendix D**.

Table 3-2 Example of data extraction table format for existing health-based guidance

Agency Report Reference: ***Insert full bibliographical reference for report***		
General Information	Date of data extraction	
	Authors	
	Publication date	
	Publication type	
	Peer reviewed?	
	Country of origin	
	Source of funding	
	Possible conflicts of interest	
Health Considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	
	Exposure timeframe	
	Critical human health endpoint	

Agency Report Reference: ***Insert full bibliographical reference for report***		
	Justification provided by agency for critical endpoint	
	Critical study(ies) underpinning point of departure	
	Species for critical study(ies)	
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10,}$ etc.)	
	Point of departure value (include units)	
	Uncertainty factor(s) & rationale	
	Guideline value (include units)	
	Mode of action for critical health endpoint	
	Genotoxic carcinogen?	
	Identified sensitive sub-populations	
	Any non-health-based considerations?	
Exposure considerations	Principal routes of exposure in general population	
	Levels in drinking water supplies (include location)	
	Any special considerations to exposure levels (e.g. higher in drought?)	
	Typical exposure in general population (include units for intakes & location)	
Risk Summary	Any risks to human health from drinking water identified in agency document?	
	Any emerging risks identified?	

Data summary/synthesis

The data from the various existing health-based guidance/guideline value reviews was summarised in tabular format for each individual research question.

Expert judgement was used to highlight areas of uncertainty or areas where an organisation's methods/interpretation differs from Australian science policy.

3.3 Supporting information in Fact Sheet

In the first instance, the existing guidance/guideline documents identified as per the methods outlined in **Section 3.2** were consulted for supporting information in the Fact Sheet (i.e. general description, uses, measurement techniques and limits of reporting in drinking water, treatment options, etc.).

The information was collated into data extraction tables such as the one in **Table 3-3.** The individual completed data extraction tables for supporting information are provided in **Appendix C.**

Table 3-3 Example of data extraction table format for supporting information in Fact Sheet

Agency Report Reference: ***Insert full bibliographical reference for report***		
General Description	Uses	
	Sources in drinking water	
	Other	
Treatment of drinking water	Treatment technology	
	Effectiveness	
	Any special conditions?	
	Other	
Measurement	Analytical method	
	Limit of determination/ Limit of Reporting (LOR)	
	Other	
Additional information	Any additional non-health related information considered important?	

In addition, a literature search of recent publicly available information was undertaken as per the methodology shown in **Table 3-4** below.

Table 3-4 Search strategy for supporting information in Fact Sheet

Parameter	Comments
Search terms	The selected search terms were: • (PFOS) OR (1763-23-1) AND (treatment OR analysis) AND (drinking water) • (PFOA) OR (335-67-1) AND (treatment OR analysis) AND (drinking water) • (PFHxS) OR (355-46-4) AND (treatment OR analysis) AND (drinking water) • (PFBS) OR (375-73-5) OR (29420-49-3) AND (treatment OR analysis) AND (drinking water) • (GenX) OR (13252-13-6) OR (62037-80-3) AND (treatment OR analysis) AND (drinking water)
Databases/Other sources	The following databases were searched: • Medline/Pubmed/Toxline • Scopus The following industry websites were searched: • Water Services Association of Australia: https://www.wsaa.asn.au/ • Standard Methods for the Examination of Water and Wastewater: https://www.standardmethods.org/

Parameter	Comments
	• US EPA Drinking Water Treatability Database: https://tdb.epa.gov/tdb/home The following Australian commercial laboratories were contacted directly via e-mail or website form for relevant information: • National Measurement Institute • SGS • ALS • Eurofins Data from government/ intergovernmental agencies [i.e. Heads of EPA National Environment Management Plan (HEPA 2020, 2022)] (2)
Publication Date	For the evidence scan for supporting information in the two scientific databases specified, a cut-off date of 2016 was used for all five PFAS to ensure currency of the information.
Language	English
Study Type	• Peer-reviewed, published or in press studies. • Unpublished studies (e.g. government reports). • Key publications provided by NHMRC and the Water Quality Advisory Committee • Australian laboratory information sheets or e-mail responses on measurement methods and limits of determination.
Inclusion and exclusion criteria	The following exclusion criteria were used to screen relevance of information: • NR = Not Relevant. Information not directly relevant to answering research questions. • RT = Research technique (analytical) = does not appear to be commercially applied. • Language = Language other than English. • NPA = Not publicly available. • NL = Chemical not listed under specific treatment process.
Validation methods used	Validation was not undertaken due to resource constraints
Screening methods	Results were screened as follows: *Preliminary title and abstract screen* • Titles of results for each search were recorded in an Excel spreadsheet. Each source was on a separate tab of the spreadsheet. These were collated into a single spreadsheet, excluding duplicates. • The researcher scanned the titles (and abstracts, if required). In a separate column a decision regarding relevance of the result was recorded as per the exclusion criteria. An additional column was included to provide commentary as (and if) required. • Where the researcher was uncertain as to the relevance of a particular result, the researcher discussed the matter with a subject expert prior to making a decision OR the result was considered potentially relevant and included. *Content screen* • The full text content of literature selected to be included from the preliminary title and abstract screen were reviewed by a subject expert to determine which articles to include in the data extraction step. Only

Parameter	Comments
	articles/reviews which provided information relevant to answering the research questions were taken through to the data extraction step. Due to the volume of references retrieved, articles that were deemed to provide only very high-level general information were also excluded at the content screen.
Documentation of search	Spreadsheets with full search results and screening outcomes (i.e. reasons for exclusion) are provided in **Appendix A.** Overall results presented in **Figure 1**, adapted from the PRISMA figure presented in Moher et al. (2009) and Figure 5 in OHAT (2019).
Retrieval of publications	All relevant and potentially relevant results were recorded in an Endnote library and soft copies of files saved into a designated folder on the SLR server for review. The server is backed up on a daily basis.
(1) Key articles identified in this manner (i.e. from existing health-based reviews) will only be cited but not reviewed in detail (i.e. data extraction will not be undertaken separately for these key articles). (2) The evidence scan briefly collated relevant information to answer the research questions. A detailed review and data collation exercise for PFAS data at contaminated sites around Australia is outside the scope of the review.	

The following data were extracted from relevant publications and/or obtained from contacts with Australian laboratories:

- Citation information
- Name of treatment technology (as applicable)
- Name of analytical technique (as applicable)
- Associated Reporting Limit

The individual completed data extraction tables (in the format of **Table 3-3**) for supporting information are provided in **Appendix C.**

3.4 Deviations from Research Protocol

During the literature search and review undertaken in accordance with the final Research Protocol dated 26 May 2023, it became clear that the resources required to undertake the review were severely underestimated due to the vast number of agency/jurisdiction reviews available for the five PFAS included in this report (refer to **Appendix A** and **B**).

It became clear that the number of critical studies underpinning the various guidance/guideline values sourced as part of the literature search were upwards of 25-30 (whereas previously this was anticipated to be between 1-3 per PFAS). As a result, due to resource constraints, a change in scope of the Evaluation Report was proposed to prioritise the resources available to complete the project.

It was proposed by SLR on 28 August 2023 that critical evaluation of studies underpinning guidance/guideline values from national and international jurisdictions be prioritised to those studies that had not been previously reviewed and/or considered by an Australian jurisdiction for guidance/guideline value development. The latest review by an Australian jurisdiction in which guidance values were derived for three of the PFAS under consideration (PFOS+PFHxS and PFOA) was the Food Standards Australia New Zealand (FSANZ 2017b) document. This forms the basis of the current toxicity reference values (TRVs) for PFOS/PFHxS and PFOA which have been used by NHMRC to derive the current guideline values in drinking water for these chemicals. FSANZ (2021) also published a review of

immunomodulation effects, in which the jurisdiction reviewed a number of studies, findings of which were proposed to be used to support discussions in the Evaluation Report on relevant PFAS.

The Committee was consulted and, on 5th September 2023, provided their agreement to the amended proposed scope for the PFAS Evaluation Report.

4.0 Results for PFOS

A summary of the responses to the research questions for PFOS is provided in the tables below.

4.1 Health-based guideline value research question analysis – PFOS

Table 4-1 Synthesis of extracted data for health-based research questions

#	Research Questions	Publications	Response to Research Questions
1	What level of PFOS chemicals in drinking water causes adverse health effects?	**Alaska DEC 2019a, Mass DEP 2022a, MDH 2023a**	• These agencies adopted drinking water guidelines from other agencies. • Mass DEP (2022a) lists numerous values including MCL (PFAS): 20 ng/L for the sum of six PFAS (PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA) (established as enforceable in Massachusetts) as well as listing a number of other health advisories and MCLGs for individual PFAS, however it is unclear how these are proposed to be applied. • MDH (2023a) adopted MCLs equivalent to the MCLG from USEPA (2022d, 2022e) of 4 ng/L for PFOA and PFOS which is based on a minimum reporting level (MRL).
		ATSDR 2018a	Derived 'Environmental Media Evaluation Guide' for PFOS in drinking water of 52 ng/L (adult) and 14 ng/L (child) using the intermediate-duration (14d-365d) TRVs derived in the draft ATSDR toxicological profile, superseded by the final report from ATSDR (2021a).
		BfR 2019a	Did not derive a guideline in drinking water but did adopt the tolerable weekly intake (TWI) of 13 ng/kg/week from EFSA (2018), which equates to 1.9 ng/kg/day.
		CDPH 2023a	Drinking water guideline = 10 ng/L. Derivation not provided.
		DOH 2017	Adopted the FSANZ (2017b) TRV of 20 ng/kg/day (for PFOS + PFHxS) and the NHMRC (2011) DWG of 70 ng/L
		EU 2020, EC 2022	Drinking water guidelines: • 'Sum of PFAS': 100 ng/L (EU 2020 only). • 'PFAS Total': 500 ng/L (EU 2020, EC 2022) *Nota bene* (NB): 'PFAS Total' as the totality of PFAS detected with available analytical methods and monitoring guidelines (EU 2020, EC 2022). 'Sum of PFAS' means the sum of PFAS considered a concern as regards to water intended for human consumption listed in point 3 of Part B of Annex III. This is a subset of 'PFAS Total' substances that contain a perfluoroalkyl moiety with three or more carbons (i.e. $–C_nF_{2n}–$, n ≥ 3) or a perfluoroalkylether moiety with two or more carbons (i. e. $C_nF_{2n}OC_mF_{2m}–$, n and m ≥ 1) (EU 2020). Derivation of these guideline values was not provided.

#	Research Questions	Publications	Response to Research Questions
		EFSA 2020a, RIVM 2021a	Did not derive DWG, but derived a guidance value of for ∑PFOA, PFNA, PFHxS and PFOS of 0.63 ng/kg bw/day (TWI = 4.4 ng/kg bw per week). RIVM (2021a) adopted the TWI from EFSA (2020a).
		FSANZ 2017b	Did not derive DWG, but derived a guidance value for PFOS of 0.02 µg/kg/day (i.e. 20 ng/kg/day) to be applied to the sum of PFOS+PFHxS.
		HC 2018a	Derived a Maximum Acceptable Concentration (MAC) for PFOS in drinking water of 600 ng/L, based on a TDI of 60 ng/kg/day.
		Maine DHHS 2021a	This fact sheet provides a DWG of 20 ng/L for the combined sum of six different PFAS: PFOA, PFOS, PFHpA, PFNA, PFDA, and PFHxS, but does not provide the derivation or the source of this value.
		MDH 2020a, WSDH 2019, 2022b, 2023a	• 15 ng/L, derived using a toxicokinetic model in breast-fed and formula-fed infants and a relative source contribution of 50% for the peak 'reference' serum concentration in the US population during infancy, which produces steady state serum concentrations at approximately 20% of the 'reference' serum concentration. MDH (2020a) indicate, to ensure protection of all segments of the population, the final health-based value for PFOS in drinking water was set at 15 ng/L. • WSDH (2019, 2022b, 2023a) adopted the Reference Dose (RfD) and DWG from MDH (2020a).
		MPART 2019a	DWG of 16 ng/L derived using a model by Goeden et al. (2019) and the following information: • Placental transfer of 43% (MDHHS 2019, as cited in MPART 2019a). • Breastmilk transfer of 1.3% (MDHHS 2019, as cited in MPART 2019a). • Human serum half-life of 1241 days (3.2 years) (Li et al. 2018). • Volume of distribution of 0.23 L/kg (Thompson et al. 2010). • 95th percentile drinking water intake, consumers only, from birth to more than 21 years old (Goeden et al. [2019]). • Upper percentile (mean plus two standard deviations) breast milk intake rate (Goeden et al. [2019]). • Time-weighted average water ingestion rate from birth to 30-35 years of age (to calculate maternal serum concentration at delivery) (Goeden et al. [2019]). • Relative Source Contribution of 50%.

#	Research Questions	Publications	Response to Research Questions
			• Based on National Health and Nutrition Examination Survey (NHANES) 95th percentiles for 3-11 (2013-2014) and over 12 years old (2015-2016) participants (CDC 2019). Note this level in drinking water is not meant to indicate a level where health effects are likely. This level is calculated to be at a point where no or minimal risk exists for people drinking water with a certain PFAS. It is based on a reference level in the US population rather than a health endpoint.
		NJDEP 2019b	Interim Specific Ground Water Criterion (ISGWQC) of 10 ng/L (rounded) was derived from TRV of 1.8 ng/kg/day [(1.8 ng/kg/day x 70 kg x 0.2) ÷ 2L/day = 13 ng/L].
		OEHHA 2019a	• Reference Level (RL) in drinking water for non-cancer effects of 7 ng/L derived from TRV of 1.8 ng/kg-day. [RL = Acceptable Daily Dose or ADD x RSC ÷DWI = 1.8 ng/kg/day × 0.2÷ 0.053 L/kg/day]. • RL for cancer effects = 0.4 ng/L As the cancer RL is below the LoR for PFOS (and PFOA), the State Water Resources Control Board (SWRCB) set the RLs at the lowest levels at which PFOA and PFOS can be reliably detected in drinking water.
		OEHHA 2023a	• Public Health Goal (PHG) – cancer: 1 ng/L [PHG = R ÷ (Cancer Slope Factor or CSF × Drinking Water Intake or DWI) = 10^{-6} ÷ (15.6 (mg/kg-day)$^{-1}$ × 0.053 L/kg-day), (where R = default excess cancer risk level of one in one million and DWI = drinking water intake rate, PHG rounded to 1 ng/L]. • Health Protective concentration (HPC) – non-cancer: 2 ng/L [HPC = ADD x RSC ÷DWI = 0.64 ng/kg/day × 0.2÷ 0.053 L/kg/day (where RSC = relative source contribution, HPC rounded to 2 ng/L)].
		US EPA 2022e, 2022c, 2021b	• Derived an interim health advisory (iHA) of 0.02 ng/L (= RfD * RSC ÷ DWI-BW) where o Draft RfD = 0.0079 ng/kg/day o Relative source contribution (RSC) = 0.2 o DWI-BW (Drinking Water Intake adjusted for body weight) = 0.0701 L/kg/bw/day (the 90th percentile drinking water intake for the selected population). • Also derived a Maximum Contaminant Level Goals (MCLG) of 4 ng/L, i.e. minimum reporting level, MRL)

#	Research Questions	Publications	Response to Research Questions
		WHO 2022	Derived a DWG of 100 ng/L (500 ng/L for Total PFAS) on the basis of practical considerations (not health-based).
2	What is the critical human health endpoint that determines this value?	**Alaska DEC 2019a**	Not stated. These agencies adopted drinking water guidelines from other agencies.
		ATSDR 2018a, 2021a	Delayed eye opening and decreased pup body weight in two-generation reproduction and cross-foster studies in rats (Luebker et al. 2005b).
		BfR 2019a	An increase in total cholesterol levels in the blood in epidemiological studies (Steenland et al. 2009, Eriksen et al. 2013, Nelson et al. 2010). Exposure to PFOS is also considered to be critically related to decreased antibody formation following certain childhood vaccinations.
		EFSA 2020a, RIVM 2021a	Decreased antibody titre following diphtheria vaccination in 1-year old children – a marker of immune response in study by Abraham et al. (2020) (note there was no influence of PFOS or PFOA in infections in this study). RIVM (2021a) adopted the TWI from EFSA (2020a).
		FSANZ 2017b	Decreases in pup weight and weight gain during lactation in Luebker et al. (2005b) two-generation study in rats. Note FSANZ (2017b) derived a range of values using other animal studies, but selected the Luebker et al. (2005b) one as the critical study.
		HC 2018a	Increased liver weight and hepatocellular hypertrophy in 2-year rat study (Butenhoff et al. 2012b).
		MDH 2020a, WSDH 2019, 2022b, 2023a	Increased IL-4 and decreased sheep red blood cell (SRBC) specific IgM levels in mice (Dong et al. 2011). WSDH (2019, 2022b, 2023a) adopted the RfD and DWG from MDH (2020a).
		MPART 2019a, NJDEP 2019b, OEHHA 2019a	Suppression of plaque forming cell response (and increase in liver mass) in mice (Dong et al. 2009). In addition, OEHHA (2019a) also based their cancer TRV on hepatocellular adenomas in male rats, and hepatocellular adenomas/carcinomas in female rats (Butenhoff et al. 2012b). Although it is noted MPART (2019a) did not use the TRV to derive the DWG (they based it on reference concentrations in the general population).
		OEHHA 2023a	• Cancer: Liver and pancreatic tumours in male rats (Butenhoff et al. 2012b). • Non-cancer: Increased cholesterol in humans (Steenland et al. 2009)
		US EPA 2022e, c; 2021b	Decreased antibody titre following diphtheria vaccination in 1-year old children – a marker of immune response in studies by Grandjean et al. (2012) and Budtz-Jorgensen and Grandjean (2018).

#	Research Questions	Publications	Response to Research Questions
		WHO 2022	DWG derived based on practical considerations (not health-based).
3	What are the justifications for choosing this endpoint?	**ATSDR 2021a**	• The most sensitive targets of PFOS toxicity in laboratory animals are similar to those identified in longer term epidemiological studies. These effects include liver damage and increases in serum lipids, decreased antibody response to vaccines, and small decreases in birth weight; epidemiological studies have not consistently found neurological effects to be associated with serum PFOS levels. • The serum PFOS concentrations predicted to occur at the lowest LOAEL values were 24.1, 29.7, and 31.9 mg/L identified in various studies (all cited in ATSDR 2021a); decreases in pup body weight and delays in eye opening were observed at these levels. Luebker et al. (2005a as quoted in ATSDR 2021a) was the only study that identified a NOAEL for these effects. The predicted serum concentration for this NOAEL was selected as the basis for the Minimal Risk Level (MRL).
		BfR 2019a	The EFSA opinion (2018) (as quoted in BfR 2019a) derived a TWI of 13 ng/kg bw per week for PFOS. The value is significantly lower than the health-based guidance values derived previously by EFSA and other international bodies. BfR (2019a) adopted the EFSA (2018) value.
		EFSA 2020a, RIVM 2021a	• Based on observations in animals and humans, the EFSA CONTAM Panel decided to combine its assessment on the sum of four PFAS, i.e. PFOA, PFNA, PFHxS and PFOS as these four PFAS contribute most to the levels observed in human serum, share toxicokinetic properties in humans and show similar accumulation and long half-lives. Also, in terms of effects, these compounds in general show the same effects when studied in animals. As a pragmatic approach, the CONTAM Panel assumed by default equal potencies for effects of these four PFAS on immune outcomes. The CONTAM Panel noted that this TWI is protective for the other potential critical endpoints such as increase in serum cholesterol, reduced birth weight and high serum levels of ALT considered in the previous Opinion on PFOS and PFOA (EFSA CONTAM Panel, EFSA 2018). • According to RIVM (2021a), statistically significant associations were observed between internal PFOA levels and time since last vaccination-adjusted antibody levels for Hib, tetanus IgG1, and diphtheria. No such associations were observed between PFOS levels and Hib, tetanus IgG1, and diphtheria antibodies. Nor were such associations observed for the other two PFAS (PFNA and PFHxS). Multivariate analysis, correcting for PCBs, also revealed a significant influence of PFOA exposure (and not PFOS, PFNA, or PFHxS) on antibody levels. Additionally, statistically significant inverse associations between PFOA exposure and ex-vivo lymphocyte cytokine production (INFγ) after stimulation with tetanus and diphtheria toxoid, confirming the biological relevance of the observed association. The study reported that an association was only found between PFOA and

#	Research Questions	Publications	Response to Research Questions
			the effect on the immune system. However, EFSA does not rule out the possibility that this effect may have been caused by the other three PFAS as well (ESFA 2020a). Therefore, EFSA used the data on internal exposure (plasma levels) to PFOA, PFOS, PFNA and PFHxS and anti-diphtheria and anti-tetanus antibody concentrations to perform dose-response modelling. • Although EFSA recognised that there were potency differences for PFAS on other toxicological endpoints, EFSA was not able to establish Relative Potency Factors (RPFs) for immune effects due to a lack of suitable studies. Therefore, EFSA assumed equipotency. However, knowing that PFAS are not equipotent for other effects (for example liver effects), RIVM (2021a) considers it plausible that various PFAS are also not equipotent for their immune effects. Hence for PFAS not included in the EFSA-4, RIVM (2021a) suggested using RPFs for liver effects from Bil et al. (2021) to adapt TRV for these.
		FSANZ 2017b	• The NOAELs from four studies were chosen for a range of effects and converted to a health-based guidance value (HBGV). The lowest HBGV calculated from the study by Luebker et al. (2005b) was selected. • A literature review commissioned by FSANZ concluded that the weight of evidence from the available animal studies indicates that PFOS can adversely modulate immune system responsiveness (Drew and Hagan 2016). However, there are significant uncertainties regarding species sensitivity, strain sensitivity and the influence of route of administration on immune system modulation by PFOS that have yet to be resolved. As a result, it is not possible to determine a reliable NOAEL or LOAEL for adverse effects on immune function for use in a quantitative risk assessment of PFOS at this time. Drew and Hagan (2016) concluded that the epidemiology data available do not provide compelling evidence for increased incidence of disease associated with PFOS effects on immune function.
		HC 2018a	• Epidemiological studies have shown associations between exposure to PFOS and multiple non-cancer health outcomes, such as reproductive, developmental, and immunological effects. However, these studies cannot be used to derive the non-cancer HBGV for PFOS due to their limitations, including in terms of study design, bias and confounders. • In animals, non-cancer effects observed at the lowest levels of exposure include immunological effects, liver effects, effects on the thyroid and changes in serum lipid levels. The effect observed at the lowest exposure levels was immune system suppression in mice. The lowest LOAEL for immunosuppression data classified by IPCS (2012) as providing the strongest weight of evidence for immunotoxicity was suppression of sheep red blood cell (SRBC)-specific IgM in mice at ≥0.00166 mg/kg bw per day (Peden-Adams et al. 2008). Immune system effects were excluded

#	Research Questions	Publications	Response to Research Questions
			from the quantitative risk assessment due to inconsistencies in NOAELs and LOAELs among studies and uncertainty of the importance of observed effects to human health. • Of note for discussion of clinical importance in humans is the Grandjean et al. (2012) study, which demonstrated that despite decreased vaccine-specific immunoglobulin response in PFOS-exposed children, the number of children with immunoglobulin levels below the clinically-protective level was low. In humans, evidence of immunosuppression is inconsistent – associations are observed between PFOS levels and decreases in antibodies against some (but not all) illnesses, and the influence of PFOS exposure on clinical immunosuppression (i.e. incidence of illnesses) appears to be more tenuous. Therefore, although low PFOS doses appear to be associated with immunosuppression, the data are not considered to be presently reliable for use as a key study for the PFOS assessment.
		MDH 2020a, WSDH 2019, 2022b, 2023a	Immune suppression was identified as the critical effect. Immune System has been identified as an Additivity Health Endpoint. WSDH (2019, 2022b, 2023a) adopted the RfD and DWG from MDH (2020a).
		MPART 2019a	• The Workgroup acknowledged that immune effects in mice were seen at lower doses in Peden-Adams et al. (2008). Serum concentrations from Peden-Adams et al. (2008) were well below both the NOAEL and LOAEL serum concentrations measured from several other studies as described by Pachkowski et al. (2019) and may be an outlier in the database. • For all of the PFAS examined, points of departure were selected from studies with laboratory animal models. This approach does not negate findings associated with epidemiological studies, but reflects that humans experience uncontrolled and imperfectly documented rather than controlled, precisely measured exposures. Additionally, these points of departure reflect adverse health effects that occur at low doses and that are supported by the weight-of-evidence across endpoints and between findings in humans and laboratory animal models. • It is noted MPART (2019a) did not use the TRV to derive the DWG (they based it on reference concentrations in the general population).
		NJDEP 2019b	Dose-response analysis focused on health endpoints from animal studies with exposure durations greater than 30 days, as well as on shorter-term reproductive and developmental endpoints from animal studies involving exposures during gestation and/or the immediate post-natal period (i.e. reproductive/developmental studies). Endpoints were selected for dose-response analysis based on their reporting of serum PFOS concentrations at relevant timepoints. Ultimately, four endpoints were carried forward to non-cancer dose-response analysis but the most sensitive (i.e. lowest) of these was the decreased plaque forming cell response from Dong et al. (2009).

#	Research Questions	Publications	Response to Research Questions
		OEHHA 2019a	• There are no new studies that are more sensitive than the Dong et al. (2009) study for derivation of the noncancer RL for PFOS. • While OEHHA reviewed human epidemiology studies focusing on liver toxicity, immunotoxicity, and thyroid toxicity, an epidemiological analysis is not presented in this document because there were no studies that could be used for point of departure (POD) determination and dose-response assessment. Nonetheless, the epidemiology data suggest that there are associations between PFOA and/or PFOS and suppressed antibody response and increased liver enzymes. These epidemiological data are supportive of the animal toxicology data used to derive the RLs for noncancer effects. The epidemiology data on thyroid hormone levels are inconsistent and, at times, contradictory. • The recent immunotoxicity studies of PFOS are much less sensitive than the Dong et al. (2009) study, which was the basis for OEHHA's interim NL recommendation. Thus, these recent immunotoxicity studies are not considered as critical studies for POD derivation.
		OEHHA 2023a	• PHG (cancer): There are a few epidemiologic studies that show some association of PFOS with breast, liver, and bladder cancer, the results are mixed or the sample sizes are small. Thus, the proposed PHG for PFOS is based on cancer data in laboratory animals. • HPC (non-cancer): Sensitive noncancer endpoints for PFOS are immunotoxicity and alterations in lipid metabolism. Total cholesterol appeared to be a somewhat more sensitive endpoint.
		US EPA 2022e, c; 2021b	• Decreased immune response to vaccination was observed after exposure during a sensitive developmental life stage, and it yields the lowest POD_{HED} among the candidate $PODs_{HED}$. Other candidate RfDs were derived based on other health effects (e.g. development/growth) observed in epidemiology studies; all of the candidate RfDs are associated with low daily oral exposure doses, ranging from 0.1 to 0.001 ng/kg bw/day. • Overall, the current assessment supports the findings from the 2016 Health Advisory Health Assessment that the available evidence is not adequate to quantify or make definitive conclusions about the carcinogenicity of PFOS.
		WHO 2022	• Acknowledging the significant uncertainties and absence of consensus with identifying the critical health endpoint to calculate a HBGV and the rapidly evolving science, a pragmatic solution is proposed for the derivation of provisional guideline values (pGVs). • Although the reduced antibody response following vaccination has been considered by some agencies as the most robust end point based on epidemiological data, it is unclear whether this correlation results in increased rates of infection and hence the clinical implications are uncertain.

#	Research Questions	Publications	Response to Research Questions
			Although animal data would generally be utilised in the absence of adequate human data for risk assessment purposes, there are also areas of uncertainty around the suitability of animal studies for assessing the effects to human health for PFOS and PFOA, including interspecies differences in kinetic parameters such as elimination half-life and clearance rate. Additionally, diverging estimates of the human half-life of PFOA may also add uncertainty to animal-to-human dosimetric adjustments, as well as Physiologically Based Pharmacokinetic (PBPK)-based conversions of human plasma PFAS concentrations to external doses. Finally, the uncertainty and lack of consensus in the critical health end point to derive a HBGV is evident from the diverse range of endpoints utilised by other agencies to derive tolerable daily intakes or similar values, and the resulting range in proposed drinking water values. Although the values derived by several different organisations vary significantly, all have margins of safety. Data analysis also shows that science on PFAS is evolving very rapidly in various areas.
4	What other recent guideline values exist?	**All agency documents reviewed**	The various guideline values retrieved as part of the literature search undertaken are provided in the response to Research Question 1.
5	If there are existing guidance/guideline values, are the proposed option/s for health-based guideline values relevant to the Australian context?	**All agency documents reviewed**	The cancer-derived DWGs derived by some agencies (e.g. OEHHA 2019a, 2023a) are not derived consistent with Australian science policy, since Australian authorities only use low-dose linear extrapolation and cancer slope factor approaches for carcinogens acting through a mutagenic mode of action. The currently available evidence summarised by the various agencies indicates PFAS are unlikely to cause cancer via a mutagenic mode of action (i.e. there is a threshold below which cancer does not occur). Also refer to detailed discussion in **Section 6.0** of the Evaluation Report.
6	How were they derived and are there any uncertainties with the key studies or the approaches used?	**ATSDR 2021a**	• Predicted animal serum No Observed Adverse Effect Concentration (NOAEC) = 7.43 mg/L • POD_{HEC} = (7.43 mg/L x K_e of 3.74 x 10^{-4} x V_d of 0.2 L/kg) ÷ (1) = 0.000515 mg/kg/day • POD_{HEC} ÷ UF of 300 (3x for extrapolation from animals to humans with dosimetric adjustments, 10x for human variability, 10x for concern that immunotoxicity may be more sensitive endpoint than developmental toxicity) = 2 ng/kg/day. • Key study (Luebker et al. 2005a) is well-designed 2-generation study evaluating a number of reproductive and developmental endpoints in adequate number of animals. Although the study was designed to evaluate four PFOS doses, high mortality in the F1 offspring at the two highest doses resulted in a discontinuation of these doses, which limits the amount of data that can be used to establish dose-response relationships.
		ATSDR 2018a	Used oral MRL from ATSDR (2021a):

#	Research Questions	Publications	Response to Research Questions
			• Child (birth-1 year): (2 ng/kg/day x 7.8 kg) ÷ 1.113 L/day = 14 ng/L • Adult: (2 ng/kg/day x 80 kg) ÷ 3.092 L/day = 52 ng/L
		BfR 2019a	After examining EFSA's opinion, BfR believes there is a need for further research on, inter alia, the question of an actual causal relationship between the intake of PFOS (and PFOA) and the increase in total serum cholesterol and the relevance to health of this effect. From the point of view of the BfR, there are considerable uncertainties with regard to the evidence of causality and clinical relevance of the effects on which the TWI derivation was based.
		EFSA 2020a, RIVM 2021a	• $BMDL_{10}$ in 1-year old children for 10% decreased antibody titre following diphtheria vaccination = 17.5 ng/mL for ∑PFOA, PFNA, PFHxS and PFOS. • Taking into account 1 year of breastfeeding and transfer of PFAS in breast milk to the infant, the equivalent serum concentration in mothers was determined by PBPK modelling to be 6.9 ng/mL at 35 years of age. • This corresponds to a dose of 0.63 ng/kg bw/day (or 4.4 ng/kg bw/week). • No uncertainty factor was applied, because the $BMDL_{10}$ is based on infants which are expected to be a sensitive population group. In addition, a decreased vaccination response is considered a risk factor for disease rather than a disease. • *"Overall, both the few number of data points in the critical dataset (n = 101), particularly at higher serum concentrations of PFAS, and the relatively large variability between individuals results in the (mean) dose-response curve not being clear. This introduces uncertainty in the shape of the dose response curve as well as the location of the established Reference Point."* • Overall, the CONTAM Panel considered that the impact of the uncertainties on the risk assessment for the sum of PFOA, PFNA, PFHxS and PFOS is high. • RIVM (2021a) adopted the TRV from EFSA (2020a) but expressed some concerns with the equipotency assumption.
		FSANZ 2017b	• The rat average serum concentration at the NOAEL dose of 0.1 mg/kg/day from Luebker et al. (2005b) was determined to be 7.14 µg/mL. • PBPK modelling was used to derive a HED of 0.0006 mg/kg/day corresponding to this serum concentration in humans. • Applied uncertainty factor of 10x for human variability, 3x for potential differences in toxicodynamics between animals and humans. No additional uncertainty factors were considered

#	Research Questions	Publications	Response to Research Questions
			to be required, and therefore a total uncertainty factor of 30 was applied to all modelled HED, resulting in a HBGV of 0.02 µg/kg/day (applied as a sum of PFOS+PFHxS).
		HC 2018a	• NOAEL in rats: 0.021 mg/kg/day • POD_{HEQ}: 0.0015 mg/kg/day, derived by dividing rat NOAEL by 14 (to account for toxicokinetic differences between rats and humans, derived using PBPK modelling). • Applied uncertainty factor of 2.5x for toxicodynamic interspecies uncertainty and 10x for intraspecies uncertainty (25x total). • 0.0015 mg/kg/day ÷ 25 = 0.00006 mg/kg/day (i.e. 60 ng/kg/day). • Maximum Acceptable Concentration (MAC) (in drinking water: TDI x body weight of an adult x default allocation factor ÷ daily volume of water consumed by an adult = 0.00006 mg/kg/day × 70 kg × 0.2 ÷ 1.5 L/day) = 0.0006 mg/L (i.e. 600 ng/L).
		MDH 2020a, WSDH 2019, 2022b, 2023a	• Animal serum NOAEL = 2.36 µg/mL • Toxicokinetic Adjustment based on Chemical-Specific Clearance Rate = Volume of Distribution (L/kg) x (Ln2/Half-life, days) = 0.23 L/kg x (0.693/1241 days) = 0.00013 L/kg-day. • HED NOAEL = 0.000307 mg/kg/day • UF of 100 applied [3x for interspecies differences for toxicodynamics, 10x for intraspecies variability, and 3x for database uncertainty (impacts on serum thyroxine (T4) in developing animals have been reported at serum concentrations ~3-fold lower than the POD. Additional studies regarding thyroid effects and a more complete assessment of developmental immune effects are warranted.] • RfD = 3.1 ng/kg/day • WSDH (2019, 2022b, 2023a) adopted the RfD and DWG from MDH (2020a).
		MPART 2019a	Derivation of TRV (RfD), which was not used to derive the DWG: • Animal serum NOAEL = 0.674 mg/L • Toxicokinetic Adjustment based on Chemical-Specific Clearance Rate = Volume of Distribution (L/kg) x (Ln2/Half-life, days) = 0.23 L/kg x (0.693/1241 days) = 0.00013 L/kg-day. • HED NOAEL = 0.0000866 mg/kg/day • UF of 30 applied [3x for interspecies differences for toxicodynamics, 10x for intraspecies variability]

#	Research Questions	Publications	Response to Research Questions
			• TRV = 2.89 ng/kg/day
		NJDEP 2019b	• Serum NOAEL: 674 ng/mL (i.e. 0.674 mg/L) • UF of 30 applied [3x for interspecies differences for toxicodynamics, 10x for intraspecies variability] • Target Human Serum Level: 22.5 ng/mL (=674 ÷ 30) • Converted to dose by using a clearance factor of 8.1 x 10^{-5} L/kg/day developed by USEPA (2016a) to relate serum PFOS concentration to administered dose. [22.5 ng/mL x 8.1 x 10^{-5} L/kg/day x 10^{3} mL/L = 1.8 ng/kg/day • This was converted to a ISGWQC of 10 ng/L (rounded) using a 70kg adult body weight, 2 L/day drinking water consumption and relative source contribution of 20% [(1.8 ng/kg/day x 70 kg x 0.2) ÷ 2L/day = 13 ng/L].
		OEHHA 2019a	Cancer endpoint: • $BMDL_{05}$: 0.002 mg/kg/day (male rats) and 0.0027 mg/kg/day (female rats). • $BMDL_{05}$ HED: 0.0011 mg/kg/day (male rats) and 0.0014 mg/kg/day (female rats) • CSF: 45.5 $(mg/kg\text{-}day)^{-1}$ (male rats) and 35.7 $(mg/kg\text{-}day)^{-1}$ (female rats). • RL = R ÷ (CSF × DWI) = 10^{-6} ÷ (45.4 $(mg/kg\text{-}day)^{-1}$ × 0.053 L/kg-day), (where R = default excess cancer risk level of one in one million and DWI = drinking water intake rate, RL rounded to 0.4 ng/L). Non-cancer endpoint: • Animal NOAEL: 0.008 mg/kg/day. • ADD: 22 mg/L (Target human serum concentration) • ADD: 1.8 ng/kg-day. • RL = ADD x RSC ÷DWI = 1.8 ng/kg/day × 0.2÷ 0.053 L/kg/day (where RSC = relative source contribution, RL rounded to 7 ng/L). The State Water Resources Control Board (SWRCB) set the NLs at the lowest levels at which PFOA and PFOS can be reliably detected in drinking water
		OEHHA 2023a	Non-cancer endpoint (from the cross-sectional study by Steenland et al. 2009): • Serum Lowest Observed Adverse Effect Concentration (LOAEC) in humans: 16.4 ng/mL. • ADD = (POD × Clearance or CL) ÷ UF = (16.4 ng/mL × 0.39 mL/kg-day) ÷ 10 = 0.64 ng/kg-day.

#	Research Questions	Publications	Response to Research Questions
			• A UF of √10 rather than 1 for intraspecies variation was applied because the C8 study population was not diverse in terms of race or ethnicity. OEHHA also applied the LOAEC to NOAEC UF of √10 because the Steenland et al. (2009) Ors involved a LOAEC rather than a NOAEC. Cancer endpoint (from the carcinogenicity study): • Animal $BMDL_{05}$: 14.7 mg/L. • Adjustment with human PFOA clearance factor of 3.9×10^{-4} L/kg-day = 0.0057 mg/kg/day • Human $BMDL_{05}$: 0.0032 mg/kg-day (scaled allometrically) [$BMDL_{05}$(human) = $BMDL_{05}$(animal) × $(BW_{animal}/BW_{human})^{1/8}$] [$BMDL_{05}$(human) = 0.0057 mg/kg/day x $(0.687/70kg)^{1/8}$ • Human CSF: 15.6 $(mg/kg/day)^{-1}$
		US EPA 2022e, c; 2021b	• Derived a human serum POD based on a Benchmark Response (BMR) of 5% and a $BMDL_5$ of 0.54 ng/mL (USEPA 2021b), i.e. 5.4 x 10^{-4} mg/L (USEPA 2021b). • The internal dose POD was then converted to a POD_{HED} (USEPA 2021b) using a toxicokinetic model to simulate a dose to mothers and children that results in the same serum concentration at 5 years of age. The resulting POD_{HED} was 0.079 ng/kg/day. • An UF of 10 was applied to account for variability in the response within the human population to derive a draft RfD of 0.0079 ng/kg/day.
		WHO 2022	The pGVs are derived with the objective of reducing human exposure and therefore risk. In deriving the pGVs, global data on occurrence including co-occurrence of PFAS, available analytical methods and treatment achievability were considered. A pGVs of 100 ng/L for PFOS is proposed based on the following considerations: • This value corresponds to greater than 90% removal achievability with high pressure membrane filtration (NF and RO), activated carbon adsorption or ion-exchange, considering that upper-bound concentrations detected in drinking water sources have mostly been in the low µg/L range. • The pGV for PFOS should therefore be achievable, where these technologies are available and have been optimised for PFAS removal. • Although the pGV was not derived based on adverse health effects studies, the value fall within the range of most health-based values derived through national risk assessments.
7	Are they suitable to adopt/adapt?	**ATSDR 2021a**	Yes. This publication meets 90% of must-have, 80% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance value is potentially suitable for

#	Research Questions	Publications	Response to Research Questions
			adoption / adaption. However, refer to **Section 6.0** of the Evaluation Report for more detailed discussions.
		EFSA 2020a	Yes. This publication meets 82.5% of must-have, 55% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance value is potentially suitable for adoption / adaption. However, refer to **Section 6.0** of the Evaluation Report for more detailed discussions.
		FSANZ 2017b	This publication was already adapted for derivation of current Australian DWGs. It meets 90% of must-have, 65% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**).
		HC 2018a	No. This publication meets 58% of must-have, 50% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance value is unlikely suitable for adoption / adaption. However, refer to **Section 6.0** of the Evaluation Report for more detailed discussions.
		MDH 2020a	No. This publication meets 42.5% of must-have, 35% of should-have and 50% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance value is unlikely suitable for adoption / adaption. However, refer to **Section 6.0** of the Evaluation Report for more detailed discussions.
		MPART 2019a	No. This publication meets 67.5% of must-have, 30% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance value is unlikely suitable for adoption / adaption. However, refer to **Section 6.0** of the Evaluation Report for more detailed discussions.
		NJDEP 2019b	Yes. This publication meets 92.5% of must-have, 60% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance value is potentially suitable for adoption / adaption. However, refer to **Section 6.0** of the Evaluation Report for more detailed discussions.
		OEHHA 2019a	No. This publication meets 47.5% of must-have, 45% of should-have and 50% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance / guideline value is unlikely suitable for adoption / adaption.
		OEHHA 2023a	Yes. This publication meets 82.5% of must-have, 80% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance / guideline value is

#	Research Questions	Publications	Response to Research Questions
			potentially suitable for adoption / adaption. However, refer to **Section 6.0** of the Evaluation Report for more detailed discussions.
		US EPA 2022e, c; 2021b	Yes. This publication meets 85% of must-have, 85% of should-have and 50% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance / guideline value is potentially suitable for adoption / adaption. However, refer to **Section 6.0** of the Evaluation Report for more detailed discussions.

4.2 Health considerations research question analysis- PFOS

Table 4-2 Synthesis of extracted data for health consideration related research questions

#	Research Questions	Publications	Response to Research Questions
8	What are the key adverse health hazards from exposure to PFOS chemicals in Australian drinking water?	**Various agency publications**	• Developmental toxicity in rodent studies (ATSDR 2018a, 2021a; FSANZ 2017b). • Increase in total blood cholesterol levels (BfR 2019a, OEHHA 2023a) and decreased antibody formation following certain childhood vaccines in humans (BfR 2019a, EFSA 2020a, US EPA 2021b). • Increased liver weight and hepatocellular hypertrophy in rat study (HC 2018a). • Increased IL-4 and decreased sheep red blood cell (SRBC) specific IgM levels in mice (MDH 2020a, WSDH 2019, 2022b, 2023a). • Suppression of plaque forming cell response and increase in liver mass in mice (MPART 2019a, NJDEP 2019b, OEHHA 2019a). • Hepatocellular adenomas in male rats, and hepatocellular adenomas/carcinomas in female rats (OEHHA 2019a, 2023a).

4.3 Typical Australian water levels or exposure profile -related research question analysis – PFOS

Table 4-3 Synthesis of extracted data for exposure-related research questions

#	Research Questions	Publications	Response to Research Questions
9	What are the typical levels in Australian drinking water supplies, considering distributed drinking water and households using their own bore water, rainwater or surface water for drinking? (NB: Due to limited information, PFAS levels from overseas jurisdictions are noted where extracted from Agency reviews)	QAEHS (2018a, 2018b)	Raw water catchments (pre-treatment): • Summer 2018: 0.24 ng/L – 4.4 ng/L (73% detection rate) • Winter 2018: 3.4 – 5.9 ng/L
		Sydney Water (2023)	Distributed Drinking Water: • PFOS + PFHxS (2011): 1.9-5.7 • PFOS + PFHxS (2019): 1.46-3.32
		WCWA (2019, 2020, 2021)	Distributed Drinking Water: • <50 ng/L • PFOS + PFHxS 90% of ADWG (~60 ng/L)
		WCWA (2023)	Distributed Drinking Water: • PFOS + PFHxS: <2 – 5 ng/L
		WHO (2022)	• PFOS in Australia: Max = 16 ng/L (n=62, 34 locations across Australia)
		GHD (2018), AECOM (2017, 2017b)*	Residential/private bores used for domestic purposes (including drinking) surrounding various Defence sites (contaminated sites): • PFOS: Maximum 39,800 ng/L (RAAF Base Oakey) • PFOS: Maximum 136,000 ng/L (RAAF Base Williamstown) • PFOS: Maximum 80 ng/L (RAAF Base Pearce)

#	Research Questions	Publications	Response to Research Questions
		BSC (2021)*	Bore water used for drinking in proximity to fire stations in Queensland: • PFOS: Maximum 260 ng/L (Ayr, Nelson Bores Raw Water Quality 2010-2020) • PFOS: Maximum 5 ng/L (Home Hill Emergency Raw Water Quality 2013-2020)
		WHO (2022)	PFOS levels reported in different jurisdictions: • Worldwide (max = 4.1 ng/L) • China (median = 0.25 ng/L, tapwater from 79 cities) • Japan (max = 25.1 ng/L, water treatment plants) • Philippines (max = 0.39 ng/L, n = 7) • Thailand (0.33 ng/L, n = 16) • US: PFOS+PFOA (0.02 to 7.22 µg/L) • US (median = 1.62 ng/L, max = 36.9 ng/L, (25 drinking water treatment plants) • EU: (0.1 ng/L as lower bound mean to 3.0 ng/L as upper 7 bound mean) • Turkey (2.04 ng/L, n=94 samples, 33 provinces) • Netherlands, Germany, France and Spain (High variability, average = 0.33 ng/L to 46 ng/L) • Italy (max = <5 ng/L to 117 ng/L).
		OEHHA (2023a)	• Overseas, arithmetic means of ∑PFAS levels in drinking water in California (excluding non-detects) ranges from 25 ng/L to 200 ng/L.
		RIVM (2021a)	• In the Netherlands, drinking water levels for individual PFAS were <5 ng/L similar to that observed in Australia.
		USEPA (2022e, 2021a)	• Public water supply: ∑PFAS = 40 ng/L to 7,000 ng/L (median = 60 ng/L) • Bottled water: ∑PFAS = <4 ng/L • Drinking water treatment plants: Median of = 2.28 ng/L, maximum = 48.3 ng/L

#	Research Questions	Publications	Response to Research Questions
		WSDH 2022b	• PFOS + PFOA ranges up to 60 ng/L reported in most areas and as high as 490 ng/L and 7,740 ng/L in two areas.
10	Do they vary around the country or under certain conditions e.g. drought?	No, from limited amount of literature identified in the public domain and reviewed, the levels in drinking water from Queensland, Sydney and Western Australia were similar and generally less than 6 ng/L (refer to the response to Research Question 9 above). These drinking water PFOS concentrations appear to be within the range quoted within the Fact Sheet for Australia by Thompson et al. (2011a) and lower than seen in various international jurisdictions (including the US and parts of Europe).	
11	What other factors should be considered (e.g. differences between groundwater versus surface water sources)?	HC (2018a), NJDEP (2019b), OEHHA (2023a), WHO (2022)	Individuals living in areas with contaminated drinking water may have an increased proportion of PFAS exposure from drinking water compared to exposure from food and other sources (consumer products).
		The main factor to consider for exposure to PFAS in drinking water is whether drinking water infrastructure is located in the vicinity of potentially contaminating activities (HC 2018a, NJDEP 2019b, OEHHA 2023a, WHO 2022) as identified in response to Research Question 20 (refer to **Section 4.5**).	

* These references were added in at the request of the Committee after their review of the draft reports. They are therefore not specifically included in Appendix B data extractions or Appendix A spreadsheets.

4.4 Risk Summary research question analysis – PFOS

Table 4-4 Synthesis of extracted data for risk-associated research questions

#	Research Questions	Publication	Response to Research Questions
12	What are the risks to human health from exposure to PFOS in Australian drinking water?	Risk of harm from exposure to PFOS in available drinking water data is relatively low based on measured concentrations in most locations (<10 ng/L for PFOS + PFHxS, refer to Research Question 9) when compared to the existing drinking water guidelines for these PFAS (PFOS+PFHxS: 70 ng/L) and/or candidate drinking water guidelines for these PFAS (see **Section 11.0** in Evaluation Report).	
13	Is there evidence of any emerging risks that are not mentioned in the current Fact Sheet that require review or further research?	The general description for sources and exposure of PFAS provided in the fact sheet appears applicable to the PFAS considered in this report (PFOS, PFHxS, PFBS, PFOA and GenX Chemicals).	
		NJDEP (2019a)	The potential for prenatal and early life exposures to environmental contaminants to cause adverse health effects later in life is currently a focus of high interest in both epidemiology and toxicology.
		CPDH (2023a)	Pregnant people, infants and children are at higher risk because of PFAS effects on pregnancy outcomes and foetal, infant and child growth and development.

4.5 Supporting Fact Sheet information research question analysis – All Five PFAS

The supporting information in the fact sheet for PFAS chemicals in the Guidelines consists of the following (NHMRC and NRMMC 2011)[2]:

- **General Description:** "*Per- and poly-fluoroalkyl substances (PFAS) are manufactured chemicals that do not occur naturally in the environment. PFAS chemicals include perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS) amongst a large group of other compounds. PFAS are persistent in the environment, show the potential for bioaccumulation and biomagnification, and are toxic in animal studies (potential developmental, reproductive and systemic toxicity).*

  Due to PFAS water and heat resistance, they have been used in a wide range of consumer products including surface treatments such as non-stick cookware, and notably in aqueous film forming foam used to extinguish fires. While the import of some PFAS in Australia has been reduced since 2002 (Environmental Health Standing Committee, 2017), historical use in firefighting foams has resulted in detections of PFAS at a number of sites including airports, firefighting training facilities and federal government sites. PFAS has also

[2] The reader is referred to NHMRC and NRMMC (2011) for the bibliographical citations shown in the direct quotes as italicised text on this page and the following two pages.

been found in groundwater, surface water, sewage treatment plant effluents and landfill leachates in international studies (Ahrens et al., 2016; Banzhaf et al., 2017).

Humans can be exposed to PFAS present in food, consumer products, dust and drinking water (Health Canada, 2016a; Health Canada, 2016b). The major sources of PFAS are expected to be food and consumer products, including solution-treated carpeting and treated apparel (Tittlemier et al., 2007); however, the proportion of exposure from drinking water can increase in individuals living in areas with drinking water containing PFAS (Health Canada, 2016a; Health Canada, 2016b). Exposure to PFOS and PFOA from both inhalation and dermal routes during showering and bathing is considered negligible (Health Canada, 2016a; Health Canada, 2016b)".

- **Level detected in Australian water:** "*While some water that is in proximity to contaminated sites has been monitored for PFAS, this has not been done routinely for Australian drinking water supplies.*

  Low concentrations of PFAS have been reported in water supplies not impacted by contaminated sites; however, these are unlikely to be of human health concern. A study of drinking water collected from 34 sampling locations around Australia found that levels of PFOS and PFOA were not quantifiable in approximately half the samples (limit of quantification (LOQ) of 0.66 ng/L and 0.5 ng/L, respectively), and PFHxS was not quantifiable in more than 70% of samples (LOQ 0.92 ng/L). Concentrations ranged from <0.66 to 16 ng/L for PFOS, <0.92 to 14 ng/L for PFHxS and <0.5 to 9.7 ng/L for PFOA (Thompson et al., 2011a)."

- **Treatment of drinking water:** *"Standard water treatment technologies including coagulation followed by physical separation, aeration, chemical oxidation, UV irradiation, and disinfection have little or no effect on PFOS or PFOA concentrations (Dickenson and Higgins, 2016; Health Canada, 2016).*

  Granular activated carbon (GAC) and anion exchange (AIX) can remove many PFAS but are less effective at removing shorter chain PFAS, and may only be effective for a limited time. Reverse osmosis is likely to remove shorter chain PFAS (Thompson et al., 2011b). Disposal or treatment of the membrane concentrate stream needs to be considered (WRF, 2016; Dickenson and Higgins, 2016). Researchers are still investigating the most effective and efficient approach to treating PFAS in drinking water and therefore available resources should be taken into consideration during water treatment."

- **Measurement:** "*PFAS can be measured by solid phase extraction followed by a liquid chromatograph coupled to electrospray ionization tandem mass spectrometry (MS/MS) operated in negative ion mode (National Measurement Institute (NMI), 2017; Health Canada, 2016). In drinking water the limit of reporting for this analysis is below the guideline values for these chemicals (NMI, 2017). Other methods may be available (for example, time-of-flight mass spectrometry and ion trap mass analysers). Complementary techniques such as oxidative conversion may be used to determine the presence of precursor compounds, which are capable of biotransforming in the environment to form stable chemicals (e.g. PFOS and PFOA) (Houtz and Sedlak, 2012). As with all analytical chemistry, it is essential to ensure a method limit of detection sensitive enough for the level at which the guideline value is set.*

Appropriate sampling, storage and transportation are critical for analysis. The potential for sample contamination during both sample collection and analysis is very high due to PFAS being used in other products, including waterproof sample labels, and therefore should be carried out by trained personnel.

A laboratory measurement uncertainty of +/- 20-30% was shown in water samples tested for PFOS and PFOA in the NMI's Proficiency Test Report AQA 16-06 PFOS/PFOA in Fish, Soil and Water (2016). Robust averages were calculated using the procedure set out in ISO13528:2015I. Reported or estimated uncertainties should be considered carefully when comparing results (NMI, 2016)."

The table below presents the information identified in the literature search conducted which could be used to inform/amend supporting information for the fact sheet of each of the five PFAS. Available information on typical values in Australian drinking water supplies was addressed in **Table 4-3** as part of an analysis for exposure-related research questions.

Table 4-5 Synthesis of extracted data for research questions relevant to supporting Fact Sheet information.

#	Research Questions	Publication	Response to Research Questions
14	Is the general description in the Fact Sheet current for all five PFAS under review?	The general description for PFOS, PFHxS, and PFOA in the current Fact Sheet appears current based on the responses to the research questions in this table below. It is also relevant for PFBS and GenX Chemicals. From the articles reviewed that comment on sources and provide a general description it is apparent that PFAS are used in numerous industrial applications and formulated within manufactured goods. There are point sources and diffuse sources of PFAS resulting in their releases to the environment. There is no need to update the current general description.	
15	What are the chemicals used for and how might people be exposed?	Abunada et al. (2020), Baldaguez Medina et al. (2021), Bao et al. (2020), Belkouteb et al. (2020), Boyer et al. (2021), Chen et al. (2019), Cornelson et al. (2021), Eke at al. (2020), Gobelius et al. (2019), Hara-Yamamura et al. (2022), HEPA (2020, 2022), Heidari et al. (2021), Huang et al. (2018), Iwabuchi and Sato (2021), Jiao et al. (2022), Karatas et al. (2022), Li et al. (2020, 2023), McNamara et al (2018), Mohammadi et al. (2022), Najm et al. (2021), Pan et al. (2016), Park et al. (2021, 2021b), Sahu (2023), Saleh	PFAS are in numerous industrial applications and manufactured goods. This includes food packaging, firefighting foams, non-stick cookware, clothes and protective coatings for fabrics and carpets, electronics, mist suppressors, and/or fluoropolymer manufacturing.

#	Research Questions	Publication	Response to Research Questions
		et al. (2018), Siriwardena et al. (2021), Sorengard et al. 2020, Tang et al. (2020, 2022), Teymourian et al. (2021), Wang et al. (2021a, 2021b), Yin et al. (2023), Zaggia et al. (2016), Zeng et al. (2019)	
16	How do the chemicals end up in drinking water and in what form?	Boone et al. (2019)	• Directly through nonpoint sources such as runoff and groundwater infiltration • Indirectly from point sources such as firefighting training grounds, industrial facilities, and municipal and industrial wastewater treatment plant effluent, or even through atmospheric deposition
17	Is the measurement information in the Fact Sheet current?	The measurement information for PFOS, PFHxS, and PFOA in the current Fact Sheet appears current based on the responses to Research Question 18 in this table below. High performance liquid chromatography (HPLC) (sometimes replaced with Ultraperformance liquid chromatography or UPLC) coupled to a tandem mass spectrometer (MS/MS) is the most common routine method used for PFAS analysis in articles reviewed and by Australian commercial laboratories (NMI 2023, SGS 2023, ALS 2023, Eurofins 2023). This information is also relevant to PFBS and GenX Chemicals. It could be noted that GenX Chemicals are not routinely measured by Australian laboratories and has only recently been added to analytical schedules offered by some commercial laboratories. Specific PFAS analytical methods are not stated in the Fact Sheet. Commercial laboratories are basing their in-house methods on USEPA Methods 533, 537.1 and 1633 and/or US DoD QSM 5.3. There is no need to update the current general description.	
18	What are the current analytical methods used to measure/detect the concentration of the specified chemicals in water?	Australian commercial laboratories (NMI 2023, SGS 2023, ALS 2023, Eurofins 2023), Bao et al. (2020), Boone et al. (2019), Chen et al. (2019), Chiriac et al. (2023), Cornelson et al. (2021), Dasu et al. (2017), Dixit et al. (2019, 2020), Hara-Yamamura et al. (2022), HEPA (2020, 2022), Huang et al. (2018),	HPLC equipped with a tandem mass spectrometer (MS/MS) operated in negative electrospray ionization (ESI^-), sometimes in multiple reaction monitoring (MRM) modes. The concentrations for PFOS, PFHxS, PFBS and PFOA in water is determined by four Australian commercial laboratories using High performance liquid chromatography/tandem mass spectrometry (HPLC/MS/MS) according to USEPA Methods 533, 537.1 and 1633 and/or US DoD QSM 5.3, table B-15 requirements.

#	Research Questions	Publication	Response to Research Questions
		Liu et al. (2021), McCLeaf et al. (2017), Opoku-Duah and Johnson (2020), Pan et al. (2016), Park et al. (2021, 2021b), Pontius (2019), Ryu et al. (2021), Sahu (2023), Sim et al. (2021), Siriwardena et al. (2021), Soriano et al. (2023), Sun et al. (2017), Tang et al. (2020), Tian and Sun (2019), Wang et al. (2021a), Yuan et al. (2022).	GenX Chemicals are included in supplementary or additional compound analytical list for two laboratories, (NMI 2023, Eurofins 2023) or is in the process of being added to the standard in-house method (SGS 2023). It is not offered by the fourth laboratory (ALS 2023).
		Baldaguez Medina et al. (2021), Hopkins et al. (2018), Liu et al. (2020b), McBeath and Graham (2021), Sorengard et al. 2020, Wang et al. (2021b), Zaggia et al. (2016), Zhang et al. (2021b), Zhao et al. (2018)	Ultraperformance liquid chromatograph (UPLC) interfaced with a triple quadrupole mass spectrometer (UPLC LC/MS/MS)
		HEPA (2020, 2022), Iwabuchi and Sato (2021), Jiao et al. (2022), Karatas et al. (2022), Li et al. (2023), Xiao et al. (2017)	Liquid chromatography quadrupole time of flight mass spectroscopy (Lc-QToF-MS)
		Liu et al. (2020a), Liu et al. (2022), Tian and Sun (2019), Wang et al. (2023)	Ultrahigh performance liquid chromatography-quadrupole high resolution mass spectrometry (UHPLC-Q-HRMS)
		HEPA (2020, 2022)	Total Oxidisable Precursor Assay (TOP Assay)
		HEPA (2020, 2022), Wagner (2013)	Total Organic Fluorine Assay (TOF Assay) as combustion ion chromatography
		Bao et al. (2020)	High performance liquid chromatography (HPLC) equipped with a conductivity detector (CDD)
		Pontius (2019)	Gas Chromatography Mass Spectrometry (GC/MS)
		Gobelius et al. (2019)	Polar organic chemical integrative samplers (POCIS)

#	Research Questions	Publication	Response to Research Questions
		HEPA (2020, 2022)	Particle-induced gamma emission (PIGE) spectroscopy
		Ryu et al. (2021)	• Optical (fluorescence, absorbance, Raman scattering, resonance light scattering or refractive index, colorimetric) • Electrochemical techniques (amperometry/voltammetry, potentiometry, impedimetric sensors, electrochemiluminescence and HPLC technique coupled with non-MS detectors). • Novel lab-on-a-chip sensor for PFOS analysis
19	What are the limits of quantification or limit of reporting for these chemicals in drinking water?	Australian commercial laboratories (NMI 2023, SGS 2023, ALS 2023, Eurofins 2023)	• 1 to 20 ng/L for PFOS, PFHxS, PFBS, PFOA and GenX • 0.2 to 2 ng/L for low or trace analysis. • 0.1 ng/L for ultra trace analysis. Reporting limits are laboratory dependent and only one of four laboratories offered ultra trace analysis
		Belkouteb et al. (2020)	Method detection limit (MDL): 0.–5 - 15 ng/L.
		Brunn et al. (2023)	Good laboratories routinely: about 1 ng/L.
		Chen et al. (2019)	LODs: 0.01 to 0.1 ng/L, and LOQs: 0.05 to 0.5 ng/L.
		Dasu et al. (2017)	0.59 to 3.4 ng/L (Minimum reporting levels for 14 PFAAs)
		Dixit et al. (2019, 2020)	10 ng/L (Lower detection limit)
		Eschauzier et al. (2012)	0.1 – 9.5 ng/L (PFBA, PFPeA, PFHxA, PFOA, PFNA, PFBS, PFOS, PFDA, and PFHxS)
		Gobelius et al. (2019)	0.44 – 0.86 ng/L (PFOS, PFHxS, PFBS, PFOA)
		HEPA (2020, 2022)	10 -50 ng/L (lower for ultra trace analysis)
		Hopkins et al. (2018)	GenX: 5 ng/L
		Inyang and Dickenson (2017)	0–5 - 5 ng/L (PFBA, PFOA, PFPnA, PFHxA, PFHxS, PFOS, PFNA, PFDA, and PFHpA).
		Iwabuchi and Sato (2021)	0.02 – 0.17 ng/L (PFHxA, PFOA, PFDA, PFDoA, PFHxS, PFOS)

#	Research Questions	Publication	Response to Research Questions
		Jiao et al. (2022).	PFOS: 0.054 – 0.181 ng/L, PFHxS: 0.020 – 0.057 ng/L, PFBS: 0.023 – 0.086 ng/L, PFOA: 0.038 – 0.103 ng/L, GenX: 0.05 ng/L
		Li et al. (2023)	0.03 – 0.5 ng/L (PFHxS, PFHxA, FHxSA, N-MeFHxSA, N-Ap-FHxSA, n-TAmp-FHxSA)
		Liu et al. (2020a)	0.0005 – 0.25 ng/L (0–5 - 250 pg/L)
		Liu et al. (2020b)	PFOA: 5.16, PFOS: 33.2 ng/L
		Liu et al. (2021)	30 – 80 ng/L (PFBA, PFBS, PFHxA, PFHxS, PFOA, PFOS)
		McCLeaf et al. (2017)	0.–5 - 0.86 ng/L
		McCLeaf et al. (2023)	0.3 ng/L (PFBS, PFHxS, PFOS and PFOA)
		Najm et al. (2021), Yuan et al. (2022)	2 ng/L
		Park et al. (2021)	<0.5 ng/L
		Pontius (2019)	0.53 – 6.3 ng/L (HFPO-DA, NEtFOSAA, NMeFOSAA, PFBS, PFDA, PFDoA, PFHpA, PFHxS, PFHxA, PFNA, PFOS, PFOA, PFTA, PFTrDA, PFUnA, 11Cl-Pf3OUdS, 9Cl-PF3ONS, ADONA.
		Ryu et al. (2021)	• Fluorescence: 4 – 11 ppb • Absorbance (bioassay): 2.5, 5 ppt • Molecularly imprinted polymer (MIP): 65 ppq and 85 ppq of PFOS in serum and urine sample, respectively
		Sim et al. (2021).	0.20–1.09 ng/L
		Sorengard et al. 2020	0.01 to 1.0 ng/mL
		Soriano et al. (2023)	40 – 700 ng/L (PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFOS, 6:2 FTSA).
		Tang et al. (2020)	0.9 – 6.9 ng/L (PFBA, PFBS, PFHxA, PFHpA, PFOA, PFOS, PFNA, PFDA)
		Wang et al. (2021b)	10 ppb (10 µg/L)

#	Research Questions	Publication	Response to Research Questions
		Zeng et al. (2019)	2.0 ng/L (commercial laboratory)
20	What are the indicators of the risks?	Three important indicators of risk are PFAS levels in food, water and human serum. Currently, there is a dearth of data in Australia for these PFAS risk indicators. Risk from exposure to PFAS in available drinking water data (<10 ng/L for PFOS + PFHxS and <5 ng/L for PFOA, refer to relevant Research Question 9 in **Table 4-3**, **Table 5-3**, and **Table 7-3**) is relatively low based on measured concentrations when compared to the existing drinking water guidelines for these PFAS (PFOS+PFHxS: 70 ng/L and PFOA: 560 ng/L). There is no relevant guideline value for PFBS or GenX Chemicals nor is there drinking water data in Australia for GenX Chemicals. Food is often the major source of PFAS exposure (see responses to this Research Question below). PFAS serum concentrations can be used as another (potentially improved) measure of dose from PFAS exposure. However, this testing is invasive and there is limited Australian data. In SLRs experience, other PFAS such as PFBA and PFHxA are commonly detected in environmental media in Australia. An approach to the assessment of these PFAS as well as PFAS not routinely monitored for in Australia would be of benefit when considering indictors of risk.	
		BfR (2019a)	It is recommended to include drinking water as a source of exposure
		OEHHA (2023a)	7.5 to 23% of PFAS exposure was estimated to be from drinking water.
		EFSA (2020)	Drinking water was identified as an important contributor to exposure to PFOA.
		HC (2018a)	PFAS is not routinely measured in Canadian drinking water. Nonetheless, PFAS intake from drinking water was estimated to be 0.3 ng/day (considered a minor amount to the overall estimated PFAS exposure).
		Maine DHHS (2021a)	Drinking water may result in higher PFAS levels in the blood.
		USEPA 2021b	Drinking water not identified as a major source of PFAS exposure in the US (95% from dietary intake)
		WHO (2022)	PFAS exposure occurs through multiple media including dietary exposure, dust and drinking water.

#	Research Questions	Publication	Response to Research Questions
			Food is the major source (>70%) in areas not characterised by heavy PFAS contamination. Bioaccumulation of PFOS and PFOA is possible in aquatic organisms, in land-based food chains (i.e. plants) and mammals, including farm animals, and humans (EFSA, 2020). The partitioning to albumins in blood, liver and eggs is a key bioaccumulation mechanism for PFAS, in contrast to lipid accumulation that is typical of other Persistent Organic Pollutants (POPs).
		WSDH 2022b	Food and contaminated drinking water result in the greatest portion of the chronic exposure to PFAS for the general public.
21	How can we measure this exposure?	Exposure can be estimated using PFAS directly measured in water and different foodstuffs or from biomonitoring data. PFAS in these media can be directly measured using standard HPLC-MS/MS methods as outlined in response to Research Question 19 in this table above. In SLRs experience, water quality data and biomonitoring data for PFAS are collected routinely to monitor for PFAS exposure by many international jurisdictions. This is not undertaken routinely in Australia except on an ad-hoc (as needed) basis in areas with contaminated sites. Currently, minimal information is available in Australia to estimate exposure to PFAS by Australians and, when estimated, it is often supported by read across data from other jurisdictions (typically from the US, but also Canada and some European locations).	
22	Is the information on treatment of drinking water in the Fact Sheet current?	The treatment information for PFOS, PFHxS, and PFOA in the current Fact Sheet appears current based on the responses to Research Question 23 below. Multiple reviewed articles note that standard/traditional treatment at Drinking Water Treatment Plants are ineffective at removing PFAS. In some cases, PFAS concentrations in drinking water has been found to be higher than raw water (Xiao 2022). Granular activated carbon (GAC), ion exchange resins, reverse osmosis and nanofiltration are common treatment options being employed however each has shortcomings with respect to power consumption, PFAS specificity etc. in line with the treatment information provided in the current Fact Sheet. Alternate methods are being investigated. There is no identified need to change the treatment information provided in the current Fact Sheet.	
23	What are the available options for removing the	Boone et al. (2019), Brunn et al. (2023), Eke at al. (2020), Eschauzier et al. (2012), Gobelius et al. (2019), Hopkins et al. (2018), Jiao et al.	Standard/traditional treatment at a Water Treatment Plant is ineffective.

#	Research Questions	Publication	Response to Research Questions
	specified chemicals from drinking water?	(2022), Li et al. (2023), Pan et al. (2016), Pontius (2019), Sim et al. (2021), Sun et al. (2017), Wang et al. (2021a)	Conventional coagulation, flocculation, sedimentation, and filtration are relatively ineffective for removing PFOA and PFOS (Pontius 2019. Soriano et al. 2023)) The generation of PFOA and PFOS has also been observed in the drinking water disinfection processes (Xiao 2022).
		Belkouteb et al. (2020), Brun et al. (2023), Eschauzier et al. (2012), Gobelius et al. (2019), Hyamen et al. (2023), Heidari et al. (2021), Hopkins et al. (2018), Inyang and Dickenson (2017), Li et al. (2020), Liu et al. (2021), McCLeaf et al. (2017), McNamara et al (2018), Najm et al. (2021), Park et al. (2021b), Pontius (2019), Singh and Singh (2017), Siriwardena et al. (2021), Sorengard et al. 2020, Xiao et al. (2017), Yuan et al. (2022), Zeng et al. (2019).	Granular activated carbon (GAC) filters and activated charcoal. Includes bituminous coal-based re-agglomerated GAC and coconut-based direct activated GAC. GAC is one of the few treatment processes demonstrating significant PFAS removal from water but can be exhausted and must be replaced and disposed or reactivated and reused thus can be costly to operate and maintain (Pontius 2019)
		Inyang and Dickenson (2017), Liu et al. (2021), Wang et al. (2023, 2023b)	Biochars (including Pyrogenic carbonaceous sorbents (PCS))
		Sundaram and Pagilla (2019)	Ozone/biological activated carbon (BAC) filtration
		Tang et al. (2020)	ZnO coated activated carbon (ZnO/AC).
		Liu et al. (2020b)	Powdered activated carbon (PAC) stabilized with polydiallyldimethylammonium chloride (polyDADMAC).
		Wang et al. (2021b)	Clay sorbents
		Harris et al. (2022)	Cellulose fibers functionalized with cationic amines (quaternized wood pulp (QWP))
		Huang et al. (2018), Heidari et al. (2021)	Hydrogel sorbents (Fluoridation and amination of poly(ethylene glycol) diacrylate (PEGDA))

#	Research Questions	Publication	Response to Research Questions
		Boyer et al. (2021), Conte et al. (2015), Cornelson et al. (2021), Dixit et al. (2019, 2020), Hayman et al. (2023), Heidari et al. (2021), Hopkins et al. (2018), Liu et al. (2022, 2022b), McCLeaf et al. (2017), Pontius (2019), Zaggia et al. (2016), Zeng et al. (2019).	Anion exchange resin (AER), Ion exchange resins, Biological ion exchange (BIEX) resins, polymer-stabilized ion exchange resin (S-IXR). Can be effective for removing PFOA, PFOS, and other PFAS (Pontius 2019).
		Brunn et al. (2023), Choi et al. (2021), Hopkins et al. (2018), McCLeaf et al. (2023), Pontius (2019), Singh and Singh (2017).	Reverse osmosis (including pressure assisted-volume retarded osmosis (PA-VRO), high pressure membranes). Proven technology for removing PFOA and PFOS, achieving up to >99% removal (Pontius 2019).
		Brunn et al. (2023), Eke at al. (2020), Hopkins et al. (2018), Iwabuchi and Sato (2021), Li et al. (2020), McCLeaf et al. (2023), Sahu (2023), Singh and Singh (2017), Tang et al. (2022), Yin et al. (2023), Zhao et al. (2018)	Nanofiltration/membranes. This could include: carbon nanotubes (CNT), multiwalled carbon nanotube (MWCNT), nanocomposite membranes composed of sulfonated poly ether ether ketone (SPEEK) and two-dimensional phosphorene, Hollow fibre membrane and ceramics, nano ceramic clay, etc.
		Baldaguez Medina et al. (2021), Karatas et al. (2022), Li et al. (2020), McBeath and Graham (2021), Saleh et al. (2018), Soriano et al. (2023)	Electrooxidation (EO) including Combined asymmetric redox-copolymer/boron-doped diamond (BDD) counter electrode. Also include electrochemical oxidation (sometimes combined with membrane separation (ELOX).
		Wang et al. (2021a)	Advanced oxidation processes (AOP) based on ultraviolet (UV) light
		Abusallout et al. (2021),	• High-photon-flux medium-pressure UV/sulfite process
		Bao et al. (2020)	• UV-activated persulfate (UV/PS) • UV-activated sulfite (UV/sulfite)
		Bao et al. (2020), Brunn et al. (2023)	UV-activated sulfite (UV/sulfite)
		Abunada et al. (2020)	• Immobilization and plasma arc destruction. • Conventional processes of wastewater treatment (ineffective).

#	Research Questions	Publication	Response to Research Questions
			• Destructive Treatment: Advance oxidation processes, Electrochemical oxidation, Incinerations, Sono-chemical, Biodegradation, Photolysis Non-Destructive treatment: Adsorption, Ion exchange, Fractionation
		Lii et al. (2020, 2022c), Saleh et al. (2018)	Photocatalytic processes
		Li et al. (2020)	Thermolytic and sonochemical degradation
		Saleh et al. (2018)	Reductive degradation, Microwave enhanced Fenton process
		Brunn et al. (2023), Opoku-Duah and Johnson (2020), Park et al. (2021)	Electrocoagulation and electrosorption: Still at an experimental stage: Experimental stage
		Heidari et al. (2021)	Unconventional adsorbents: Ionic fluorogel resin, Covalent organic frameworks, Poly (N-[3-(dimethylamino)propyl] acrylamide, methyl chloride quaternary) (DMAPAA-Q), β-cyclodextrin polymers
24	What are the current practices to minimise or manage the risks identified?	Water treatment is one practice used to manage risks associated with PFAS exposure. In areas contaminated with PFAS a common and immediate public health response is to prevent people from drinking PFAS contaminated water. This can be done by restricting use of contaminated raw water sources, sourcing water from alternate (uncontaminated) areas and/or supplying bottled water.	

5.0 Results for PFHxS

A summary of the responses to the research questions for PFHxS is provided in the tables below.

5.1 Health-based guideline value research question analys–s - PFHxS

Table 5-1 Synthesis of extracted data for health-based research questions

#	Research Questions	Publications	Response to Research Questions
1	What level of PFHxS chemicals in drinking water causes adverse health effects?	**Mass DEP 2022a, MDH 2023a**	• These agencies adopted drinking water guidelines from other agencies. • Mass DEP (2022a) lists numerous values including MCL (PFAS): 20 ng/L for the sum of six PFAS (PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA) (established as enforceable in Massachusetts) as well as listing a number of other health advisories and MCLGs for individual PFAS, however it is unclear how these are proposed to be applied. • MDH (2023a) adopted MCLs equivalent to the MCLG from USEPA (2022d, 2022e) of 4 ng/L for PFOA and PFOS which is based on a minimum reporting level (MRL).
		ATSDR 2018a	Derived 'Environmental Media Evaluation Guide' for PFHxS in drinking water of 517 ng/L (adult) and 140 ng/L (child) using the intermediate-duration (14-365d) TRVs derived in the draft ATSDR toxicological profile, superseded by the final report from ATSDR (2021a).
		CDPH 2023a	Drinking water guideline = 49 ng/L. Derivation not provided.
		DOH 2017	Adopted the FSANZ (2017b) TRV of 20 ng/kg/day (for PFOS + PFHxS) and the NHMRC (2011) DWG of 70 ng/L
		EU 2020, EC 2022	Drinking water guidelines: • 'Sum of PFAS': 100 ng/L (EU 2020 only). • 'PFAS Total': 500 ng/L (EU 2020, EC 2022) NB: 'PFAS Total' as the totality of PFAS detected with available analytical methods and monitoring guidelines (EU 2020, EC 2022). 'Sum of PFAS' means the sum of PFAS considered a concern as regards to water intended for human consumption listed in point 3 of Part B of Annex III. This is a subset of 'PFAS Total' substances that contain a perfluoroalkyl moiety with three or more carbons (i.e. $–C_nF_2n–$, n ≥ 3) or a perfluoroalkylether moiety with two or more carbons (i. e. $C_nF_2nOC_mF_{2m}–$, n and m ≥ 1) (EU 2020). Derivation of these guideline values was not provided.

#	Research Questions	Publications	Response to Research Questions
		EFSA 2020a, RIVM 2021a	Did not derive DWG, but derived a guidance value of for ∑PFOA, PFNA, PFHxS and PFOS of 0.63 ng/kg bw/day (TWI = 4.4 ng/kg bw per week). RIVM (2021a) adopted the TWI from EFSA (2020a).
		FSANZ 2017b	Did not derive DWG, but derived a guidance value for PFOS of 0.02 µg/kg/day (i.e. 20 ng/kg/day) to be applied to the sum of PFOS+PFHxS.
		HC 2019a	Derived a Maximum Acceptable Concentration (MAC) for PFHxS in drinking water of 600 ng/L, likely adopted from the value for PFOS which was based on a TDI of 60 ng/kg/day.
		Maine DHHS 2021a	This fact sheet provides a DWG of 20 ng/L for the combined sum of six different PFAS: PFOA, PFOS, PFHpA, PFNA, PFDA, and PFHxS, but does not provide the derivation or the source of this value.
		MDH 2020b	47 ng/L, derived using a toxicokinetic model in breast-fed infants and a relative source contribution of 50% for the peak 'reference' serum concentration in the US population during infancy, which produces steady state serum concentrations at approximately 20% of the 'reference' serum concentration. MDH (2020b) indicate, due to the highly bioaccumulative nature of PFHxS within the human body, serum concentrations are the most appropriate dose metric and the standard equation to derive the HBGV is not appropriate. This is because short-term exposures have the potential to stay in the body for an extended period of time.
		WSDH 2019, 2022b, 2023a	• WSDH (2019, 2022b, 2023a) adopted the RfD from MDH (2020a). • They derived a DWG of 65 ng/L using a toxicokinetic model which predicts the serum concentration in breastfed infants to be at 50% of the serum concentration at the RfD (i.e. 108 x 0.5 = 54 µg/L). The maximum serum levels predicted as a result of 70 ng PFHxS/L in water was 53.7 µg/L in breastfed children and 27.9 µg/L in formula fed children.

#	Research Questions	Publications	Response to Research Questions
		MPART 2019a	DWG of 51 ng/L derived using a model by Goeden et al. (2019) and the following information: • Placental transfer of 80% (MDHHS 2019). • Breastmilk transfer of 1.2% (MDHHS 2019). • Human serum half-life of 1935 days (Li et al. 2018). • Volume of distribution of 0.25 L/kg (MDH 2019 based on Sundstrom et al. 2012). • ^{9}5th percentile drinking water intake, consumers only, from birth to more than 21 years old (Goeden et al. [2019]). • Upper percentile (mean plus two standard deviations) breast milk intake rate (Goeden et al. [2019]). • Time-weighted average water ingestion rate from birth to 30-35 years of age (to calculate maternal serum concentration at delivery) (Goeden et al. [2019]). • Relative Source Contribution of 50%. • Based on NHANES ^{9}5th percentiles for 3-11 (2013-2014) and over 12 years old (2015-2016) participants (CDC 2019). Note this level in drinking water is not meant to indicate a level where health effects are likely. This level is calculated to be at a point where no or minimal risk exists for people drinking water with a certain PFAS. Indeed, the DWG was not derived on health information, it was derived so that it contributes as a specified percentage (50% to peak) of the PFHxS serum concentration in the general population of the US.
		OEHHA 2022a	The health protective concentration (HPC) in drinking water derived for three critical health endpoints were: • 11 ng/L (Increased relative liver weight) using an ADD of 2.9 ng/kg/day. • 60 ng/L (Decreased litter size) using an ADD of 14.3 ng/kg/day. • 2 ng/L (Decreased Total T4) using an ADD of 2.4 ng/kg/day. NB: HPC = ADD × RSC ÷ DWI = ADD × 0.2 ÷ 0.237 L/kg-day, where RSC = relative source contribution and DWI = drinking water intake rate)
		USEPA (2023)	Did not derive DWG, but derived a guidance value (Reference Dose, RfD) for PFHxS of 0.0004 ng/kg bw/day.

#	Research Questions	Publications	Response to Research Questions
2	What is the critical human health endpoint that determines this value?	**ATSDR 2018a, 2021a**	Thyroid follicular epithelial hypertrophy/hyperplasia in a reproductive/developmental toxicity study with rats (Butenhoff et al. 2009).
		EFSA 2020a, RIVM 2021a	Decreased antibody titre following diphtheria vaccination in 1-year old children – a marker of immune response in study by Abraham et al. (2020) (note there was no influence of PFOS or PFOA on infections in this study). RIVM (2021a) adopted the TWI from EFSA (2020a).
		FSANZ 2017b	Decreases in pup weight and weight gain during lactation in Luebker et al. (2005b) two-generation study in rats with PFOS. Note FSANZ (2017b) derived a range of values using other animal studies, but selected the Luebker et al. (2005b) one as the critical study.
		MDH 2020b	• DWG is not based on a health endpoint *per se*, but was set to a level which would result in 20% of the reference PFHxS serum level in the general population. Although MDH (2020b) did derive a RfD for PFHxS of 9.7 ng/kg/day, they did not use the RfD to derive the DWG. • Critical health endpoint for RfD is decreased total thyroxine (T4) in rats (NTP 2022).
		WSDH 2019, 2022b, 2023a	WSDH (2019, 2022b, 2023a) adopted the RfD from MDH (2020b), so critical health endpoint was decreased total thyroxine (T4) in rats (NTP 2022).
		MPART 2019a	• DWG is not based on a health endpoint *per se*, but was set to a level which would result in 20% of the reference PFHxS serum level in the general population (steady state), 50% of peak serum. Although MPART (2019a) did derive a RfD for PFHxS of 9.7 ng/kg/day, they did not use the RfD to derive the DWG. • Critical health endpoint for RfD is decreased total thyroxine (T4) in rats (NTP 2018a).
		OEHHA 2022a	Used three critical health endpoints: • Increased relative liver weight in female rats (NTP 2022). • Decreased litter size in mice (Chang et al. 2008). • Decreased Total T4 in male rats (NTP 2022).
		USEPA (2023)	Decreased serum anti-tetanus antibody concentrations in children (male and female)

#	Research Questions	Publications	Response to Research Questions
3	What are the justifications for choosing this endpoint?	**ATSDR 2021a**	• Since the liver effects were not considered relevant to humans, the lowest LOAEL identified for PFHxS was 1 mg/kg/day for decreases in the number of pups per litter identified in the Chang et al. (2018) study. The investigators noted that the toxicological significance of this alteration was uncertain because there was no clear dose-response and no alterations in the number of implantation sites, number of viable pups, or pup to implant ratios. Thus, the Butenhoff et al. (2009) study, which reported thyroid effects in male rats at a LOAEL of 3 mg/kg/day, with a NOAEL of 1 mg/kg/day, was selected as the principal study. • There are sufficient epidemiological data to identify possible sensitive targets for many of the perfluoroalkyls; however, there are two major limitations to establishing dose-response relationships for these effects and using the epidemiological studies to derive MRLs: accurate identification of environmental exposure levels producing increased risk for adverse effects (exposure estimates and routes of exposure) and likely co-exposure to mixtures of perfluoroalkyls. Other limitations include the cross-sectional design of the majority of epidemiological studies and the potential that reverse causality contributes to the observed associations. The epidemiological databases for several perfluoroalkyls provide valuable information on hazard identification; however, uncertainties regarding doses associated with adverse effects and possible interactions between compounds preclude use of these data to derive MRLs.

#	Research Questions	Publications	Response to Research Questions
		EFSA 2020a, RIVM 2021a	• Based on observations in animals and humans, the EFSA CONTAM Panel decided to combine its assessment on the sum of four PFAS, i.e. PFOA, PFNA, PFHxS and PFOS as these four PFAS contribute most to the levels observed in human serum, share toxicokinetic properties in humans and show similar accumulation and long half-lives. Also, in terms of effects, these compounds in general show the same effects when studied in animals. As a pragmatic approach, the CONTAM Panel assumed by default equal potencies for effects of these four PFAS on immune outcomes. The CONTAM Panel noted that this TWI is protective for the other potential critical endpoints such as increase in serum cholesterol, reduced birth weight and high serum levels of ALT considered in the previous Opinion on PFOS and PFOA (EFSA CONTAM Panel, 2018). • According to RIVM (2021a), statistically significant associations were observed between internal PFOA levels and time since last vaccination-adjusted antibody levels for Hib, tetanus IgG1, and diphtheria. No such associations were observed between PFOS levels and Hib, tetanus IgG1, and diphtheria antibodies. Nor were such associations observed for the other two PFAS (PFNA and PFHxS). Multivariate analysis, correcting for PCBs, also revealed a significant influence of PFOA exposure (and not PFOS, PFNA, or PFHxS) on antibody levels. Additionally, statistically significant inverse associations between PFOA exposure and ex-vivo lymphocyte cytokine production (INFγ) after stimulation with tetanus and diphtheria toxoid, confirming the biological relevance of the observed association. The study reported that an association was only found between PFOA and the effect on the immune system. However, EFSA does not rule out the possibility that this effect may have been caused by the other three PFAS as well (ESFA 2020a). Therefore, EFSA used the data on internal exposure (plasma levels) to PFOA, PFOS, PFNA and PFHxS and anti-diphtheria and anti-tetanus antibody concentrations to perform dose-response modelling. • Although EFSA recognised that there were potency differences for PFAS on other toxicological endpoints, EFSA was not able to establish Relative Potency Factors (RPFs) for immune effects due to a lack of suitable studies. Therefore, EFSA assumed equipotency. However, knowing that PFAS are not equipotent for other effects (for example liver effects), RIVM (2021a) considers it plausible that various PFAS are also not equipotent for their immune effects. Hence for PFAS not included in the EFSA-4, RIVM (2021a) suggested using RPFs for liver effects from Bil et al. (2021) to adapt TRV for these.
		FSANZ 2017b	For PFHxS, FSANZ concluded that there was not enough toxicological and epidemiological information to justify establishing a tolerable daily intake. However, as a precaution, and for the purposes of site investigations, the PFOS tolerable daily intake should apply to PFHxS. In practice, this means that the level of PFHxS exposure should be added to the level of PFOS exposure; and this combined level be compared to the tolerable daily intake for PFOS.

#	Research Questions	Publications	Response to Research Questions
		MDH 2020b	Based on studies in laboratory animals, alterations in serum thyroid hormone levels, in particular thyroxine (T4), appear to be a sensitive effect. (Although it is noted this was not used to derive the DWG).
		WSDH 2019, 2022b, 2023a	Washington state selected the MDH RfD of 9.7 ng/kg-day based on thyroxinemia in adult male rats in the NTP study. This is supported by observations of reduced T4 in pregnant rats and their offspring in a study by Ramhoi et al. (2018). The reduction in litter size observed in mice by Chang et al. (2018) was not supported by two studies in rats. Although the absence of reproductive toxicity in Butenhoff et al. and Ramhoi et al. could possibly be explained by lower serum levels in the rat studies, Washington state preferred to base public health advice on a replicated result.
		MPART 2019a	• The Workgroup selected this thyroid endpoint as it was a measure of a clinical or functional effect rather than observational one. The Workgroup discussed Chang et al. (2018) and concluded that the health outcome (reduction in litter size) was a marginal effect. • For all of the PFAS examined, points of departure were selected from studies with laboratory animal models. This approach does not negate findings associated with epidemiological studies, but reflects that humans experience uncontrolled and imperfectly documented rather than controlled, precisely measured exposures. Additionally, these points of departure reflect adverse health effects that occur at low doses and that are supported by the weight-of-evidence across endpoints and between findings in humans and laboratory animal models.
		OEHHA 2022a	• OEHHA evaluated the health outcomes of the most sensitive animal toxicity studies available in the literature for HPC derivation. In the three selected candidate critical studies, the most sensitive health outcomes included effects on the liver, thyroid, and developing offspring following oral exposure to PFHxS. • OEHHA considered other animal studies and health outcomes (e.g. lipids, thyroid hypertrophy/hyperplasia). However, those endpoints were not as sensitive as those selected and an HPC based on those effects would not adequately protect against these more sensitive effects.
		USEPA (2023)	The selected RfD is based on decreased serum anti-tetanus antibody concentration in children (a susceptible lifestage for this effect) is considered protective of the observed health effects associated with lifetime PFHxS exposure.
4	What other recent guideline values exist?	**All agency documents reviewed**	The various guideline values retrieved as part of the literature search undertaken are provided in the response to Research Question 1.

#	Research Questions	Publications	Response to Research Questions
5	If there are existing guidance/guideline values, are the proposed option/s for health-based guideline values relevant to the Australian context?	**All agency documents reviewed**	Yes, for the most part. Refer to detailed discussion in **Section 7.0** of Evaluation Report.
6	How were they derived and are there any uncertainties with the key studies or the approaches used?	**ATSDR 2021a**	• Rat NOAEL (Butenhoff et al. 2009) = 1 mg/kg/day • Predicted animal serum NOAEC = 73.22 mg/L • POD_{HEC} = (73.22 mg/L x K_e of 2.23 x 10^{-4} x V_d of 0.287 L/kg) ÷ (1) = 0.0047 mg/kg/day • POD_{HEC} ÷ UF of 300 (3x for extrapolation from animals to humans with dosimetric adjustments, 10x for human variability, 10x for database limitations to account for small number of studies examining toxicity of PFHxS following intermediate-duration exposure and the limited scope of these studies in particular studies examining immunotoxicity, a sensitive endpoint for other perfluoroalkyls) = 15.6 ng/kg/day, rounded to 20 ng/kg/day.
		EFSA 2020a, RIVM 2021a	• $BMDL_{10}$ in 1-year old children for 10% decreased antibody titre following diphtheria vaccination = 17.5 ng/mL for ∑PFOA, PFNA, PFHxS and PFOS. • Taking into account 1 year of breastfeeding and transfer of PFAS in breast milk to the infant, the equivalent serum concentration in mothers was determined by PBPK modelling to be 6.9 ng/mL at 35 years of age. • This corresponds to a dose of 0.63 ng/kg bw/day (or 4.4 ng/kg bw/week). • No uncertainty factor was applied, because the $BMDL_{10}$ is based on infants which are expected to be a sensitive population group. In addition, a decreased vaccination response is considered a risk factor for disease rather than a disease. • *"Overall, both the few number of data points in the critical dataset (n = 101), particularly at higher serum concentrations of PFAS, and the relatively large variability between individuals results in the (mean) dose-response curve not being clear. This introduces uncertainty in the shape of the dose response curve as well as the location of the established Reference Point."* • Overall, the CONTAM Panel considered that the impact of the uncertainties on the risk assessment for the sum of PFOA, PFNA, PFHxS and PFOS is high. • RIVM (2021a) adopted the TRV from EFSA (2020a) but expressed some concerns with the equipotency assumption.

#	Research Questions	Publications	Response to Research Questions
		FSANZ 2017b	• The rat average PFOS serum concentration at the NOAEL dose of 0.1 mg/kg/day from Luebker et al. (2005b) was determined to be 7.14 µg/mL. • PBPK modelling was used to derive a PFOS HED of 0.0006 mg/kg/day corresponding to this serum concentration in humans. • Applied uncertainty factor of 10x for human variability, 3x for potential differences in toxicodynamics between animals and humans. No additional uncertainty factors were considered to be required, and therefore a total uncertainty factor of 30 was applied to all modelled HED, resulting in a HBGV of 0.02 µg/kg/day (applied as a sum of PFOS+PFHxS). • In the case of PFHxS, the only toxicology study considered useful for regulatory purposes was a reproductive and developmental study in rats (Butenhoff et al. 2009). There was no evidence of reproductive or developmental toxicity. The NOAEL for reproductive toxicity was 10 mg/kg bw/day, the highest dose tested. The NOAEL for paternal toxicity was 3 mg/kg bw/day (males only), and the NOAEL for offspring toxicity was 10 mg/kg bw/day. • It is reasonable to conclude that the enHealth approach of using the TDI for PFOS is likely to be conservative and protective of public health as an interim measure. The approach recognises that the structure of PFHxS and PFOS are similar, and that there is some evidence of similar potency of PFHxS and PFOS in activating PPARα, which at least partially, mediates the toxicity of perfluroalkylated compounds. Effectively, this means that as a conservative approach, PFHxS and PFOS should be summed for the purposes of a dietary exposure assessment and risk characterisation.
		MDH 2020b, MPART 2019a, WSDH 2019, 2022b, 2023a	RfD derivation (it is noted the RfD was not used to derive the DWG): • Animal serum $BMDL_{20\%}$ of 32.4 µg/mL • Toxicokinetic Adjustment based on Chemical-Specific Clearance Rate = Volume of Distribution (L/kg) x (Ln2/Half-life, days) = 0.25 L/kg x (0.693/1935 days) = 0.00009 L/kg-day. • HED NOAEL = 0.00292 mg/kg/day • UF of 300 applied [3x for interspecies differences for toxicodynamics, 10x for intraspecies variability, and 10x for database uncertainty (to address concerns regarding early life sensitivity to decreased T4 levels as well as lack of 2 generation and immunotoxicity studies)]. • RfD = 9.7 ng/kg/day

#	Research Questions	Publications	Response to Research Questions
		OEHHA 2022a	For increased relative liver weight in female rats: • NOAEL in rats: 3.12 mg/kg/day • Serum $BMDL_{1SD}$: 34.3 µg/mL. • POD Human: 0.00292 mg/kg/day [34.3 mg/L x clearance of 8.5 x 10^{-5} L/kg/day]. • UF of 1,000 [√10x for interspecies toxicodynamic differences, 10x for human variability, 10x for use of a subchronic study, √10 for database uncertainties] applied. • RfD = 2.9 ng/kg/day For decreased number of live pups per litter in mice: • NOAEL in mice: 0.3 mg/kg/day • Serum NOAEL: 16.8 µg/mL ($BMDL_{1SD}$: 13.9 µg/mL) • POD Human: 0.00143mg/kg/day. • UF of 100 [√10x for interspecies toxicodynamic differences, 10x for human variability, √10 for database uncertainties] applied. • RfD = 14.3 ng/kg/day For decreased T4 in male rats: • LOAEL in rats: 0.625 mg/kg/day. • Serum $BMDL_{1SD}$: 28.6 µg/mL. • POD Alt/Human: 0.00243 mg/kg/day. • UF of 1,000 [√10x for interspecies toxicodynamic differences, 10x for human variability, 10x for use of a subchronic study, √10 for database uncertainties] applied. • RfD = 2.4 ng/kg/day
		USEPA (2023)	RfD derivation (it is noted the RfD was not used to derive the DWG): • Serum $BMDL_{1/2SD}$ = 0.000282 x 10^{-4} mg/L. • POD_{HED} = 0.0116 ng/kg/day • UF of 30(3x for interspecies toxicodynamic differences, 10x for human variability) applied. • RfD = 0.0004 ng/kg/day

#	Research Questions	Publications	Response to Research Questions
7	Are they suitable to adopt/adapt?	**ATSDR 2021a**	Yes. This publication meets 90% of must-have, 80% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance value is potentially suitable for adoption / adaption. However, refer to **Section 7.0** of the Evaluation Report for more detailed discussions.
		FSANZ 2017b	This publication was already adapted for derivation of current Australian DWGs. It meets 90% of must-have, 65% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**).
		MDH 2020b	No. This publication meets 50% of must-have, 35% of should-have and 50% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance value is unlikely suitable for adoption / adaption. However, refer to **Section 7.0** of the Evaluation Report for more detailed discussions.
		MPART 2019a	No. This publication meets 67.5% of must-have, 30% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance value is unlikely suitable for adoption / adaption. However, refer to **Section 7.0** of the Evaluation Report for more detailed discussions.
		OEHHA 2022a	Yes. This publication meets 77.5% of must-have, 60% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance / guideline value is potentially suitable for adoption / adaption. However, refer to **Section 7.0** of the Evaluation Report for more detailed discussions.
		USEPA (2023)	Yes. This publication meets 87.5% of must-have, 100% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance / guideline value is potentially suitable for adoption / adaption. However, refer to **Section 7.0** of the Evaluation Report for more detailed discussions.

5.2 Health considerations research question analysis – PFHxS

Table 5-2 Synthesis of extracted data for exposure-related research questions

#	Research Questions	Publications	Response to Research Questions
8	What are the key adverse health hazards from exposure to PFHxS chemicals in Australian drinking water?	**Various agency publications**	• Thyroid follicular epithelial hypertrophy/hyperplasia in a reproductive/developmental toxicity study with rats (ATSDR 2018a, 2021a) • Developmental toxicity in rodent studies with PFOS (FSANZ 2017b). • Decreased thyroxine (T4) levels in rats (MDH 2020b, MPART 2019a, OEHHA 2022a, WSDH 2019, 2022b, 2023a). • Increased relative liver weight in female rats and decreased litter size in mice (OEHHA 2022a). • Decreased serum anti-tetanus antibody concentrations in children (male and female) (USEPA (2023).

5.3 Typical Australian water levels or exposure profile -related research question analysis – PFHxS

Table 5-3 Synthesis of extracted data for exposure-related research questions

#	Research Questions	Publications	Response to Research Questions
9	What are the typical levels in Australian drinking water supplies, considering distributed drinking water and households using their own bore water, rainwater or surface water for drinking? (NB: Due to limited information, PFAS levels from overseas jurisdictions are noted where extracted from Agency reviews)	QAEHS (2018a, 2018b)	Raw water catchments (pre-treatment): • Summer 2018: ~0.24 ng/L – 3 ng/L (41% detection rate) • Winter 2018: 2.5 – 4.6 ng/L
		Sydney Water (2023)	Distributed Drinking Water: • PFOS + PFHxS (2011): 1.9-5.7 ng/L • PFOS + PFHxS (2019): 1.46-3.32 ng/L
		WCWA (2019, 2020, 2021)	Distributed Drinking Water: • PFOS + PFHxS 90% of ADWG (~60 ng/L)
		WCWA (2023)	Distributed Drinking Water: • PFOS + PFHxS: <2 – 5 ng/L
		GHD (2018), AECOM (2017, 2017b)*	Residential/private bores used for domestic purposes (including drinking) surrounding various Defence sites (contaminated sites): • Maximum 33,000 ng/L (RAAF Base Oakey) • Maximum 54,300 ng/L (RAAF Base Williamstown) • Maximum 480 ng/L (RAAF Base Pearce)
		BSC (2021)*	Bore water used for drinking in proximity to fire stations in Queensland: • Maximum 130 ng/L (Ayr, Nelson Bores Raw Water Quality 2010-2020) • Maximum 5 ng/L (Home Hill Raw Water Quality 2013-2020)
		ATSDR (2018a)	• Brazil (Rio): max = 0.15 to 1 ng/L. • Germany: 12.1 ng/L (maximum).
		RIVM (2021a)	• Netherlands: <0.6 ng/L, 0.43 (2017) (Dordrecht, 37 locations)

#	Research Questions	Publications	Response to Research Questions
10	Do they vary around the country or under certain conditions e.g. drought?	No, from literature reviewed levels in drinking water from Queensland, Sydney and Western Australia were similar and generally less than 6 ng/L.	
11	What other factors should be considered (e.g. differences between groundwater versus surface water sources)?	The main factor to consider for exposure to PFAS in drinking water is whether drinking water infrastructure is located in the vicinity of potentially contaminating activities (HC 2018a, NJDEP 2019b, OEHHA 2023a, WHO 2022) as identified in response to Research Question 20 (refer to **Section 4.5**).	

* These references were added in at the request of the Committee after their review of the draft reports. They are therefore not specifically included in Appendix B data extractions or Appendix A spreadsheets.

5.4 Risk Summary research question analysis – PFHxS

Table 5-4 Synthesis of extracted data for risk-associated research questions

#	Research Questions	Publication	Response to Research Questions
12	What are the risks to human health from exposure to PFHxS in Australian drinking water?	Risk from exposure to PFHxS in available drinking water data is relatively low based on measured concentrations (<10 ng/L for PFOS + PFHxS, refer to relevant Research Question 9) when compared to the existing drinking water guidelines for these PFAS (PFOS+PFHxS: 70 ng/L).	
13	Is there evidence of any emerging risks that are not mentioned in the current Fact Sheet that require review or further research?	The general description for sources and exposure of PFAS provided in the fact sheet appears applicable to the PFAS considered in this report (PFOS, PFHxS, PFBS, PFOA and GenX Chemicals).	
		NJDEP (2019a)	The potential for prenatal and early life exposures to environmental contaminants to cause adverse health effects later in life is currently a focus of high interest in both epidemiology and toxicology.
		CPDH (2023a)	Pregnant people, infants and children are at higher risk because of PFAS effects on pregnancy outcomes and foetal, infant and child growth and development.

5.5 Supporting Fact Sheet information research question analysis – PFHxS

Refer to analysis for all five PFAS included in this report in **Section 4.5**.

6.0 Results for PFBS

A summary of the responses to the research questions for PFBS is provided in the tables below.

6.1 Health-based guideline value research question analysis – PFBS

Table 6-1 Synthesis of extracted data for health-based research questions

#	Research Questions	Publications	Response to Research Questions
1	What level of PFBS chemicals in drinking water causes adverse health effects?	**Alaska DEC 2019a, Mass DEP 2022a, MDH 2023a**	Likely adopted values from other agencies: • Alaska DEC (2019a) provides an 'action level' for PFBS in drinking water of 2 ng/L, but does not provide the basis for this value. • Mass DEP (2022a) lists numerous values including MCL (PFAS): 20 ng/L for the sum of six PFAS (PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA) (established as enforceable in Massachusetts) as well as listing a number of other health advisories and MCLGs for individual PFAS (for PFBS, it is 2,000 ng/L), however it is unclear how these are proposed to be applied and how they were derived. • MDH (2023a) adopted MCLs equivalent to the MCLG from USEPA (2022d, 2022e) of 4 ng/L for PFOA and PFOS which is based on a minimum reporting level (MRL). No value is provided for PFBS. EPA is also proposing that four PFAS (PFBS, PFHxS, GenX and PFNA) be evaluated in combination with each other, using an approach called a Hazard Index. A hazard index is calculated by comparing a measured drinking water value with a standard.
		CDPH 2023a	Drinking water guideline = 760 ng/L. Derivation not provided.

#	Research Questions	Publications	Response to Research Questions
		EU 2020, EC 2022	Drinking water guidelines: • 'Sum of PFAS': 100 ng/L (EU 2020 only). • 'PFAS Total': 500 ng/L (EU 2020, EC 2022) NB: 'PFAS Total' as the totality of PFAS detected with available analytical methods and monitoring guidelines (EU 2020, EC 2022). 'Sum of PFAS' means the sum of PFAS considered a concern as regards to water intended for human consumption listed in point 3 of Part B of Annex III. This is a subset of 'PFAS Total' substances that contain a perfluoroalkyl moiety with three or more carbons (i.e. $–C_nF_{2n}–$, n ≥ 3) or a perfluoroalkylether moiety with two or more carbons (i. e. $C_nF_{2n}OC_mF_{2m}–$, n and m ≥ 1) (EU 2020). Derivation of these guideline values was not provided.
		RIVM 2018a	Did not derive DWG but derived a relative potency factor for PFBS of 0.001 relative to PFOA based on comparison of derived BMD_{05} for increased relative liver weight in rats (Lieder et al. 2009b for PFBS, Perkins 2004 for PFOA).
		HC 2019a	Derived a screening Maximum Acceptable Concentration (MAC) for PFBS in drinking water of 15,000 ng/L. Basis not provided.
		MDH 2022e, g	• Short-term and sub-chronic non-cancer based DWG of 100 ng/L derived from TRV of 84 ng/kg/day. • Short-term non-cancer health-based value ($Nhbv_{Short\text{-}term}$) (µg/L) = Reference Dose (mg/kg-d) x Relative Source Contribution x Conversion Factor ÷ Short-term Intake Rate (L/kg-d) = (0.000084 mg/kg-d) x (0.5) x (1000 µg/mg) ÷ (0.290 L/kg-d) = 0.14 µg/L rounded to 0.1 µg/L (equivalent to 100 ng/L) • Subchronic non-cancer health-based value ($Nhbv_{Subchronic}$) (µg/L) = (0.000084 mg/kg-d) x (0.2) x (1000 µg/mg) ÷ (0.074 L/kg-d) = 0.23 rounded to 0.2 µg/L (equivalent to 200 ng/L) • Adopted lower value for both time-points.

#	Research Questions	Publications	Response to Research Questions
		MPART 2019a	DWG of 420 ng/L derived using a TRV (set to protect against decreased T4) of 300 ng/kg/day and the following assumptions: • RSC of 20%. • 7.8 kg infant body weight • 1.106 L/day water consumption by infant • [HBV = (RSC x Toxicity value x Body weight) ÷ water intake; HBV = (0.2 x 300 ng/kg/day x 7.8 kg for 1-year old infant) ÷ 1.106 L/day]
		OEHHA 2021d	Derived a health-protective notification level (NL) for PFBS of 500 ng/L based on a TRV of 600 ng/kg/day as follows: Concentration (C) = ADD × RSC ÷ DWI = 600 ng/kg-day × 0.2 ÷ 0.237 L/kg-day, where RSC = relative source contribution and DWI = drinking water intake rate
		US EPA 2021c, 2022c, k	• Derived an interim health advisory (Iha) of 2,000 ng/L (= RfD * RSC ÷ DWI-BW) where o RfD = 300 ng/kg/day o Relative source contribution (RSC) = 0.2 o DWI-BW = 0.0354 L/kg/bw/day (the 90th percentile drinking water intake for the selected population, women of childbearing age).
		WSDH 2019a, 2023a, 2022b	DWG of 860 ng/L, lowered to 345 ng/L derived using a TRV (set to protect against decreased T4) of 300 ng/kg/day and the following assumptions: • RSC of 20%. • 0.174 L/kg/day water consumption by infant [State Action Level or SAL = (RSC x Toxicity value) ÷ water intake; HBV = (0.2 x 300 ng/kg/day) ÷ 0.174 L/kg/day]
2	What is the critical human health endpoint that determines this value?	**Alaska DEC 2019a**	Not stated.
		ATSDR 2021a	Did not derive a TRV for PFBS.
		MDH 2022e, g	Decreased total thyroxine (T4) in rats (NTP 2022).

#	Research Questions	Publications	Response to Research Questions
		MPART 2019a, US EPA 2021c, 2022c, k; WSDH 2019a, 2023a, 2022b	Decreased serum total thyroxine (T4) in newborn (Postnatal Day or PND 1) mice (Feng et al. 2017).
		OEHHA 2021d	Considered two studies as critical studies, both with decreased T4 as the critical effect: • Decreased T4 levels in PND1 mice (Feng et al. 2017). • Reduction of T4 in non-pregnant female rats (NTP 2022). But TRV was based on mouse study as there were less uncertainties associated with the half-life information.
3	What are the justifications for choosing this endpoint?	**ATSDR 2021a**	There are insufficient data for derivation of an acute-duration, intermediate duration and chronic oral MRL for PFBS. Several studies have evaluated the toxicity of PFBS following intermediate-duration oral exposure and have identified several targets of toxicity. However, none of these studies included measurement of serum PFBS levels that are needed to calculate a HED and MRL derivation.
		MDH 2022e, g	A new toxicity study in rats was available evaluating sensitive thyroid endpoints.
		MPART 2019a	• Selection of total T4 as the critical effect is based on several key considerations that account for cross-species correlations in thyroid physiology and hormone dynamics particularly within the context of a developmental life stage. • The Workgroup evaluated available agency decision documents and selected the study associated with the draft USEPA (2018a) PFBS toxicity value based on thyroid effects. The kidney effects identified in the draft USEPA (2018a) toxicity assessment were identified as a potentially compensatory response. The thyroid effects were identified as having greater functional significance. • For all of the PFAS examined, points of departure were selected from studies with laboratory animal models. This approach does not negate findings associated with epidemiological studies, but reflects that humans experience uncontrolled and imperfectly documented rather than controlled, precisely measured exposures. Additionally, these points of departure reflect adverse health effects that occur at low doses and that are supported by the weight-of-evidence across endpoints and between findings in humans and laboratory animal models.

#	Research Questions	Publications	Response to Research Questions
		OEHHA 2021d	• There were four studies determined to be of acceptable quality, adequate data reporting, and sufficient sensitivity for health-protective concentration derivation. • They included two subchronic oral studies, a two-generation reproductive toxicity study in rats, and a developmental toxicity study. • Thyroid hormone disruption from the Feng et al. (2017) and NTP (2022) studies were the most sensitive endpoints in the PFBS animal toxicity database, and both were considered for health-protective concentration derivation. • OEHHA (2021d) derived an ADD and C using the mouse study rather than the rat study due to uncertainties of kinetics in the rat.
		US EPA 2021c, 2022c, k	The hazards of potential concern for oral PFBS exposure include thyroid, developmental, and kidney effects. Overall, the evidence supports a hazard for thyroid, developmental, and kidney effects based on the evidence from animal studies. The limited evidence for thyroid or renal effects in human studies is equivocal, and no studies evaluating developmental effects following PFBS exposure in humans were available. Thus, data in humans were not considered further, and the available animal studies that evaluated these effects are considered in the derivation of oral RfDs.
		WSDH 2019a, 2023a, 2022b	• Recommend using the EPA draft 2018 assessment of PFBS toxicity with the dosimetric adjustment factor developed by MDH 2017. The USEPA (2018a) toxicological assessment was comprehensive and incorporated recent data available for PFBS from the National Toxicology Program. • Washington State concurred with EPA on thyroid hormone reduction as the most sensitive critical effect and with selection of Feng et al, 2017 as the critical study. They deferred to EPA on selecting a 20 percent reduction in thyroid hormone in the $BMDL_{20}$ as the best compromise between clearly functional deficits in hormone level and measurement variability in human studies. The permanent reduction in thyroid hormones following *in utero* exposure in Feng et al. was associated with development delays and reproductive abnormalities. • This study was supported by the 28-day NTP study showing reduced thyroid hormones in male and female adult rats with a LOAEL of 62.6 mg/kg-day.
4	What other recent guideline values exist?	**All agency documents reviewed**	The various guideline values retrieved as part of the literature search undertaken are provided in the response to Research Question 1.

#	Research Questions	Publications	Response to Research Questions
5	If there are existing guidance/guideline values, are the proposed option/s for health-based guideline values relevant to the Australian context?	**All agency documents reviewed**	Yes, for the most part. See detailed discussion in **Section 8.0** of Evaluation Report.
6	How were they derived and are there any uncertainties with the key studies or the approaches used?	**MDH 2022e, g**	• Animal $BMDL_{1SD}$ = 6.97 mg/kg-d • HED = 0.0084 mg/kg/day [6.97 mg/kg/day x half-life female rat of 1.3 hr ÷ half-life in human of 1,050 hr] • UF of 100 applied [3x for interspecies differences for toxicodynamics, 10x for intraspecies variability, and 3x for database uncertainty due to a lack of available immunotoxicity and developmental neurotoxicity studies (known sensitive effects of other PFAS) as well as lack of a 2-generation study in a more appropriate species]. • RfD = 84 ng/kg/day
		MPART 2019a	Derivation of TRV (RfD), which was used to derive the DWG: • Animal $BMDL_{20}$ = 28.19 mg/kg/day • $BMDL_{20}$-POD_{HED} = 0.0892 mg/kg/day [The $BMDL_{20}$ of 28.19 mg/kg/day was divided by the Dose Adjustment Factor of 316 (human serum half-life/female mouse serum half-life = 665 hours/2.1 hours = 316) (MDH, 2017)]. • UF of 300 applied [3x for interspecies differences for toxicodynamics, 10x for intraspecies variability, 10x for database deficiencies, for the lack of neurodevelopmental, immunotoxicological, and chronic studies]. • TRV = 300 ng/kg/day The Workgroup evaluated the half-life based Dose Adjustment Factor used by the Minnesota Department of Health (MDH) (2017). As that allowed conversion of the point of departure to a human equivalent dose using chemical-specific information, the Workgroup selected this approach over the allometric scaling used in the draft USEPA (2018a) PFBS toxicity assessment. The Workgroup discussed the uncertainty factors selected in the draft USEPA (2018a) toxicity assessment and supported their use.

#	Research Questions	Publications	Response to Research Questions
		OEHHA 2021d	• NOAEL in mice: 50 mg/kg/day. • $BMDL_{1SD}$: 22.2 mg/kg/day. • POD Human: 0.06 mg/kg/day [Ratio of animal to human clearance = (0.056 L/kg/hour x 1000 mL/L x 24 h/day) ÷ 3.9 mL/kg/day = 345; $BMDL_{1SD}$ ÷ Ratio of clearance of 345 = POD Human]. • UF of 100 applied [√10 for interspecies differences for toxicodynamics, 10x for intraspecies variability, √10 for database deficiencies, most notably the absence of a chronic toxicity study]. • TRV = 600 ng/kg/day
		US EPA 2022c, k; 2021c	• $BMDL_{0.5SD}$ human equivalent dose (HED) = 0.095 mg/kg-day for K+PFBS [body weight allometric scaling was used to convert POD in mice to POD_{HED}). • Applied UF of 300 applied [3x for extrapolation from mice to humans, 10x for interindividual differences in human susceptibility, and 10x for deficiencies in the toxicity database]. • RfD for K+PFBS: 320 ng/kg-day • RfD for PFBS (free acid): 280 ng/kg-day rounded to 300 ng/kg-day.
		WSDH 2019a, 2023a, 2022b	Similar derivation to MPART (2019a). Derivation of TRV (RfD), which was used to derive the DWG: • Animal $BMDL_{20}$ = 28.19 mg/kg/day • HED: 0.089 mg/kg/day [The $BMDL_{20}$ of 28.19 mg/kg/day was multiplied by the Dose Adjustment Factor of 0.00315 (female mouse serum half-life/ human serum half-life = 2.1 hours/665 hours) (MDH, 2017)]. • UF of 300 applied [3x for interspecies differences for toxicodynamics, 10x for intraspecies variability, 10x for database deficiencies for lack of long-term exposure studies in animals]. • TRV = 300 ng/kg/day Washington State concurred with the EPA uncertainty factors, but preferred the MDH approach to calculating a dosimetric adjustment factor to account for the likely difference in mouse clearance of PFBS and human clearance of PFBS.
7	Are they suitable to adopt/adapt?	**MDH 2022g**	No. This publication meets 50% of must-have, 35% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance value is unlikely suitable for adoption / adaption. However, refer to **Section 8.0** of the Evaluation Report for more detailed discussions.

#	Research Questions	Publications	Response to Research Questions
		MPART 2019a	No. This publication meets 67.5% of must-have, 30% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance value is unlikely suitable for adoption / adaption. However, refer to **Section 8.0** of the Evaluation Report for more detailed discussions.
		OEHHA 2021d	Potentially. This publication meets 72.5% of must-have, 55% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance / guideline value is potentially suitable for adoption / adaption. However, refer to **Section 8.0** of the Evaluation Report for more detailed discussions.
		US EPA 2022c, k; 2021c	Yes. This publication meets 87.5% of must-have, 80% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance / guideline value is potentially suitable for adoption / adaption. However, refer to **Section 8.0** of the Evaluation Report for more detailed discussions.

6.2 Health considerations research question analysis – PFBS

Table 6-2 Synthesis of extracted data for exposure-related research questions

#	Research Questions	Publications	Response to Research Questions
8	What are the key adverse health hazards from exposure to PFBS chemicals in Australian drinking water?	**Various agency publications**	• Decreased total thyroxine (T4) in rats (MDH 2022g, MPART 2019a, US EPA 2022c, k; 2021c, WSDH 2019a, 2023a, 2022b).

6.3 Typical Australian water levels or exposure profile -related research question analysis – PFBS

Table 6-3 Synthesis of extracted data for exposure-related research questions

#	Research Questions	Publications	Response to Research Questions
9	What are the typical levels in Australian drinking water supplies, considering distributed drinking water and households using their own bore water, rainwater or surface water for drinking? (NB: Due to limited information, PFAS levels from overseas jurisdictions are noted where extracted from Agency reviews)	QAEHS (2018a, 2018b)	In Queensland, raw water catchments (pre-treatment): • Summer 2018: ~0.32 ng/L – 1 ng/L (30% detection rate) • Winter 2018: 1 – 2.2 ng/L
		GHD (2018), AECOM (2017, 2017b)*	Residential/private bores used for domestic purposes (including drinking) surrounding various Defence sites (contaminated sites): • Maximum 4,840 ng/L (RAAF Base Oakey) • Maximum 6,520 ng/L (RAAF Base Williamstown) • Maximum 40 ng/L (RAAF Base Pearce)
		ATSDR (2018a)	• Germany: max = 13.3 ng/L (max, mineral, spring and tap water)
		RIVM (2021a)	• Netherlands: 3.0 ng/L (2015), 3.4 ng/L (2017) (Dordrecht, 37 locations)
		MDH (2022g)	• Minnesota: Up to 300 ng/L (public drinking water)
		USEPA (2021c)	• US: 90 to 370 ng/L (water systems serving Alabama, Colorado, Georgia, the Northern Mariana Islands, and Pennsylvania) • US: 0.43 – 37 ng/L (n = 11 Drinking Water Treatment Plants (DWTPs)) • US: ND to 11.9 ng/L (sourced from Mississippi River). • Hu et al 2019: ND–2.97 ng/L. • Bradley et al. (2020): ND–0.5 ng/L • Europe: 0.015 – 13.2 ng/L (means from 12 studies, max = 69.43 ng/L) • Various: ND – 24 ng/L (Means, 17 studies, DWTP) • US (Bottled water): ND to 1.44 ng/L. • Europe (Bottled water): ND to 51 ng/L

#	Research Questions	Publications	Response to Research Questions
10	Do they vary around the country or under certain conditions e.g. drought?	In Australia, the literature reviewed only resulted in identification of drinking water data from Queensland which was generally less than 2.2 ng/L. This is lower or at the low end of the range for PFBS levels measured in drinking in various international jurisdictions.	
11	What other factors should be considered (e.g. differences between groundwater versus surface water sources)?	HC (2018a), NJDEP (2019b), OEHHA (2023a), WHO (2022)	Individuals living in areas with contaminated drinking water may have an increased proportion of PFAS exposure from drinking water compared to exposure from food and other sources (consumer products).
		The main factor to consider for exposure to PFAS in drinking water is whether drinking water infrastructure is located in the vicinity of potentially contaminating activities (HC 2018a, NJDEP 2019b, OEHHA 2023a, WHO 2022) as identified in response to Research Question 20 (refer to **Section 4.5**).	

* These references were added in at the request of the Committee after their review of the draft reports. They are therefore not specifically included in Appendix B data extractions or Appendix A spreadsheets.

6.4 Risk Summary research question analysis – PFBS

Table 6-4 Synthesis of extracted data for risk-associated research questions

#	Research Questions	Publication	Response to Research Questions
12	What are the risks to human health from exposure to PFBS in Australian drinking water?	Risk from exposure to PFBS in available drinking water data is relatively low based on measured concentrations (<2.2 ng/L, refer to Research Question 9, **Section 6.3**) when compared to the candidate drinking water guidelines for this compound (294 or 1,050 to 2,940 ng/L; refer to the Evaluation Report, **Section 8.3**).	
13	Is there evidence of any emerging risks that are not mentioned in the current Fact Sheet that require review or further research?	The general description for sources and exposure of PFAS provided in the fact sheet appears applicable to the PFAS considered in this report (PFOS, PFHxS, PFBS, PFOA and GenX Chemicals).	
		NJDEP (2019a)	The potential for prenatal and early life exposures to environmental contaminants to cause adverse health effects later in life is currently a focus of high interest in both epidemiology and toxicology.
		CPDH (2023a)	Pregnant people, infants and children are at higher risk because of PFAS effects on pregnancy outcomes and foetal, infant and child growth and development.

6.5 Supporting Fact Sheet information research question analysis – PFBS

Refer to analysis for all five PFAS included in this report in **Section 4.5**.

7.0 Results for PFOA

A summary of the responses to the research questions for PFOA is provided in the tables below.

7.1 Health-based guideline value research question analysis – PFOA

Table 7-1 Synthesis of extracted data for health-based research questions

#	Research Questions	Publications	Response to Research Questions
1	What level of PFOA chemicals in drinking water causes adverse health effects?	**Alaska DEC 2019a, Mass DEP 2022a, MDH 2023a**	• These agencies adopted drinking water guidelines from other agencies. • Mass DEP (2022a) lists numerous values including MCL (PFAS): 20 ng/L for the sum of six PFAS (PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA) (established as enforceable in Massachusetts) as well as listing a number of other health advisories and MCLGs for individual PFAS (including an interim health advisory of 0.004 ng/L for PFOA), however it is unclear how these are proposed to be applied. • MDH (2023a) adopted MCLs equivalent to the MCLG from USEPA (2022d, 2022e) of 4 ng/L for PFOA and PFOS which is based on a minimum reporting level (MRL).
		ATSDR 2018a	• ATSDR (2018a) derived 'Environmental Media Evaluation Guide' for PFOA in drinking water of 78 ng/L (adult) and 21 ng/L (child) using the intermediate-duration (14-365d) TRVs derived in the draft ATSDR toxicological profile, superseded by the final report from ATSDR (2021a).
		BfR 2019a	Did not derive a guideline in drinking water but did adopt the tolerable weekly intake (TWI) of 6 ng/kg/week from EFSA (2018), which equates to 0.86 ng/kg/day.
		CDPH 2023a	Drinking water guideline = 16 ng/L. Derivation not provided.
		DOH 2017	Adopted the FSANZ (2017b) TRV of 160 ng/kg/day and the NHMRC (2011) DWG of 560 ng/L.

#	Research Questions	Publications	Response to Research Questions
		EU 2020, EC 2022	Drinking water guidelines: • 'Sum of PFAS': 100 ng/L (EU 2020 only). • 'PFAS Total': 500 ng/L (EU 2020, EC 2022) NB: 'PFAS Total' as the totality of PFAS detected with available analytical methods and monitoring guidelines (EU 2020, EC 2022). 'Sum of PFAS' means the sum of PFAS considered a concern as regards to water intended for human consumption listed in point 3 of Part B of Annex III. This is a subset of 'PFAS Total' substances that contain a perfluoroalkyl moiety with three or more carbons (i.e. $–C_nF_{2n}–$, n ≥ 3) or a perfluoroalkylether moiety with two or more carbons (i. e. $C_nF_{2n}OC_mF_{2m}–$, n and m ≥ 1) (EU 2020). Derivation of these guideline values was not provided.
		EFSA 2020a, RIVM 2021a	Did not derive DWG, but derived a guidance value of for ∑PFOA, PFNA, PFHxS and PFOS of 0.63 ng/kg bw/day (TWI = 4.4 ng/kg bw per week). RIVM (2021a) adopted the TWI from EFSA (2020a).
		FSANZ 2017b	Did not derive DWG, but derived a guidance value for PFOA of 0.16 µg/kg/day (i.e. 160 ng/kg/day).
		HC 2018b	Derived a Maximum Acceptable Concentration (MAC) for PFOA in drinking water of 200 ng/L, based on a TDI of 21 ng/kg/day. (HBV = TDI x body weight of an adult x default allocation factor ÷ daily volume of water consumed by an adult = 0.000021 mg/kg/day × 70 kg × 0.2 ÷ 1.5 L/day)
		Maine DHHS 2021a	This fact sheet provides a DWG of 20 ng/L for the combined sum of six different PFAS: PFOA, PFOS, PFHpA, PFNA, PFDA, and PFHxS, but does not provide the derivation or the source of this value.
		MDH 2022d, f	35 ng/L, derived using a toxicokinetic model in breast-fed infants and a relative source contribution of 50% for the peak 'reference' serum concentration in the US population during infancy, which produces steady state serum concentrations at approximately 20% of the 'reference' serum concentration. MDH (2022f) indicate, due to the chronic bioaccumulation in the mother and subsequent transfer to breast milk, the breast-fed infant exposure scenario is the most limiting scenario in terms of water concentrations. To ensure protection of all segments of the population, the final health-based value for PFOA in drinking water was set at 35 ng/L.

#	Research Questions	Publications	Response to Research Questions
		MPART 2019a	DWG of 8 ng/L derived using a model by Goeden et al. (2019) and the following information: • Placental transfer of 87% (MDH 2017b). • Breastmilk transfer of 5.2% (MDH 2017b). • Human serum half-life of 840 days (Bartell et al. 2010). • Volume of distribution of 0.17 L/kg (Thompson et al. 2010). • 95th percentile drinking water intake, consumers only, from birth to more than 21 years old (Goeden et al. [2019]). • Upper percentile (mean plus two standard deviations) breast milk intake rate (Goeden et al. [2019]). • Time-weighted average water ingestion rate from birth to 30-35 years of age (to calculate maternal serum concentration at delivery) (Goeden et al. [2019]). • Relative Source Contribution of 50%. • Based on NHANES 95th percentiles for 3-11 (2013-2014) and over 12 years old (2015-2016) participants (CDC 2019). Note this level in drinking water is not meant to indicate a level where health effects are likely. This level is calculated to be at a point where no or minimal risk exists for people drinking water with a certain PFAS. It is based on a reference level in the US population rather than a health endpoint.
		NJDEP 2019a	Interim Specific Ground Water Criterion (ISGWQC) of 10 ng/L (rounded) was derived from TRV of 2 ng/kg/day [(2 ng/kg/day x 70 kg x 0.2) ÷ 2L/day = 14 ng/L].
		OEHHA 2019a	• Reference Level (RL) in drinking water for non-cancer effects of 2 ng/L derived from TRV of 0.45 ng/kg-day. [RL = ADD x RSC ÷DWI = 0.45 ng/kg/day × 0.2÷ 0.053 L/kg/day]. • RL for cancer effects = 0.1 ng/L [RL = R ÷ (CSF × DWI) = 10^{-6} ÷ (143 (mg/kg-day)$^{-1}$ × 0.053 L/kg-day), (where R = default excess cancer risk level of one in one million and DWI = drinking water intake rate, RL rounded to 0.1 ng/L). As the cancer RL is below the LoR for PFOA (and PFOS), the State Water Resources Control Board (SWRCB) set the RLs at the lowest levels at which PFOA and PFOS can be reliably detected in drinking water.

#	Research Questions	Publications	Response to Research Questions
		OEHHA 2023a	• Public Health Goal (PHG) – cancer: 0.007 ng/L [PHG = R ÷ (CSF × DWI) = 10^{-6} ÷ (0.0026 (ng/kg-day)$^{-1}$ × 0.053 L/kg-day), (where R = default excess cancer risk level of one in one million and DWI = drinking water intake rate, PHG rounded to 0.007 ng/L]. • Health Protective concentration (HPC) – non-cancer: 3 ng/L [HPC = ADD x RSC ÷DWI = 0.87 ng/kg/day × 0.2÷ 0.053 L/kg/day (where RSC = relative source contribution, HPC rounded to 3 ng/L)].
		US EPA 2022c, d; 2021a	• Derived an interim health advisory (iHA) of 0.004 ng/L (= RfD * RSC ÷ DWI-BW) where o Draft RfD = 0.0015 ng/kg/day o Relative source contribution (RSC) = 0.2 o DWI-BW = 0.0701 L/kg/bw/day (the 90th percentile drinking water intake for the selected population). • Also derived a Maximum Contaminant Level Goals (MCLG) of 4 ng/L, i.e. minimum reporting level, MRL)
		WHO 2022	Derived a DWG of 100 ng/L (500 ng/L for Total PFAS) on the basis of practical considerations (not health-based).
		WSDH 2019a, 2022b, 2023a	DWG of 10 ng/L (rounded), derived using a TRV from ATSDR (2021a) of 3 ng/kg/day and the following assumptions: • RSC of 50%. • 0.174 L/kg/day water consumption by infant [SAL = (RSC x Toxicity value) ÷ water intake; HBV = (0.5 x 3 ng/kg/day) ÷ 0.174 L/kg/day]
2	What is the critical human health endpoint that determines this value?	**Alaska DEC 2019a**	Not stated. This agency adopted drinking water guidelines from other agencies.
		ATSDR 2018a, 2021a; WSDH 2019, 2022b, 2023a	• Skeletal alterations in adult mouse offspring (Koskela et al. 2016). • WSDH (2019, 2022b, 2023a) adopted the ATSDR (2021a) TRV for PFOA, but cite two studies as its basis (Koskela et al. 2016, Onishchenko et al. 2011).
		BfR 2019a	An increase in total cholesterol levels in the blood in epidemiological studies (Steenland et al. 2009, Eriksen et al. 2013, Nelson et al. 2010).

#	Research Questions	Publications	Response to Research Questions
		EFSA 2020a, RIVM 2021a	Decreased antibody titre following diphtheria vaccination in 1-year old children – a marker of immune response in study by Abraham et al. (2020) (note there was no influence of PFOS or PFOA in infections in this study). RIVM (2021a) adopted the TWI from EFSA (2020a).
		FSANZ 2017b	Decreased body weight gain in neonatal mice after birth at doses of ≥ 3 mg/kg bw/day (Lau et al. 2006). Note FSANZ (2017b) derived a range of values using other animal studies, but selected the Lau et al. (2006) one as the critical study.
		HC 2018b	Hepatocellular hypertrophy in male rats (Perkins et al. 2004).
		MDH 2022f	Delayed ossification, accelerated preputial separation (PPS) in male mice offspring, trend for decreased pup body weight, and increased maternal liver weight (Lau et al. 2006).
		MPART 2019a	Developmental delays (decreased number of inactive periods, altered novelty induced activity and skeletal alteration such as bone morphology and bone cell differentiation in the femurs and tibias) of mice (Onishchenko et al. 2011, Koskela et al. 2016). Although it is noted MPART (2019a) did not use the TRV to derive the DWG (they based it on reference concentrations in the general population).
		OEHHA 2019a	• Non-cancer endpoint: Liver toxicity (and oxidative deoxyribonucleic acid (DNA) damage, changes in mitochondrial membrane potential) in female mice (Li et al. 2017). • Cancer endpoint: Pancreatic and liver tumours in male rats (NTP 2018b).
		NJDEP 2019a	Increased liver weight in male mice (Loveless et al. 2006).
		OEHHA 2023a	• Cancer: Kidney cancer in humans (Vieira et al. 2013; Shearer et al. 2021). • Non-cancer: Increased risk of elevated alanine aminotransferase (ALT) in humans (Gallo et al. 2012).
		US EPA 2022c, d; 2021a	Decreased antibody titre following tetanus vaccination in 7-year old children – a marker of immune response in studies by Grandjean et al. (2012) and Budtz-Jorgensen and Grandjean (2018).
		WHO 2022	DWG derived based on practical considerations (not health-based).

#	Research Questions	Publications	Response to Research Questions
3	What are the justifications for choosing this endpoint?	**ATSDR 2021a**	• Intermediate-duration oral studies of PFOA in animals indicate that the liver, immune system, reproductive system, and the developing organism are the primary targets of toxicity because adverse outcomes were observed at lower doses than other effects and have been consistently observed across studies. A summary of the lower LOAEL values (and associated NOAEL values) for these tissues/systems was presented in the review. Although these studies identified the lowest LOAEL values, not all were considered suitable as the basis of an intermediate-duration oral MRL. • Increases in liver weight, hepatocellular hypertrophy, and alterations in serum lipid levels, in the absence of other degenerative lesions, were not considered appropriate endpoints for deriving MRL. • There are sufficient epidemiological data to identify possible sensitive targets for many of the perfluoroalkyls; however, there are two major limitations to establishing dose-response relationships for these effects and using the epidemiological studies to derive MRLs: accurate identification of environmental exposure levels producing increased risk for adverse effects (exposure estimates and routes of exposure) and likely co-exposure to mixtures of perfluoroalkyls. Other limitations include the cross-sectional design of the majority of epidemiological studies and the potential that reverse causality contributes to the observed associations. • The epidemiological databases for several perfluoroalkyls provide valuable information on hazard identification; however, uncertainties regarding doses associated with adverse effects and possible interactions between compounds preclude use of these data to derive MRLs.
		BfR 2019a	The EFSA opinion (2018) (as quoted in BfR 2019a) derived a TWI of 6 ng/kg bw per week for PFOA. The value is significantly lower than the health-based guidance values derived previously by EFSA and other international bodies. BfR (2019a) adopted the EFSA (2018) value.
		EFSA 2020a, RIVM 2021a	• Based on observations in animals and humans, the EFSA CONTAM Panel decided to combine its assessment on the sum of four PFAS, i.e. PFOA, PFNA, PFHxS and PFOS as these four PFAS contribute most to the levels observed in human serum, share toxicokinetic properties in humans and show similar accumulation and long half-lives. Also, in terms of effects, these compounds in general show the same effects when studied in animals. As a pragmatic approach, the CONTAM Panel assumed by default equal potencies for effects of these four PFAS on immune outcomes. The CONTAM Panel noted that this TWI is protective for the other potential critical endpoints such as increase in serum cholesterol, reduced birth weight and high serum levels of ALT considered in the previous Opinion on PFOS and PFOA (EFSA CONTAM Panel, 2018).

#	Research Questions	Publications	Response to Research Questions
		FSANZ 2017b	• Four NOAELs from three studies were chosen for a range of health endpoints and converted to a HBGV. HBGVs were calculated with the lowest HBGV selected based on the lowest NOAEL from the study by Lau et al. (2006). • PFOA is a PPARα agonist; that is, it induces peroxisome proliferation. PPARα agonists typically cause hepatocellular hypertrophy and markedly increased liver weight in rodents, although primates are refractory to this response. Increased liver weight in rodents in response to a PPARα agonist, in the absence of hepatocellular degeneration or necrosis, is usually regarded as an adaptive response and not predictive of human toxicity (Hall et al. 2012). FSANZ has not interpreted increase in absolute and/or relative liver weight in rodents, in the absence of hepatocellular degeneration or necrosis, as an adverse effect for the purpose of identifying a NOAEL or LOAEL. Similarly, FSANZ has not interpreted increased absolute liver weight in a small number of monkeys (Butenhoff et al. 2002) as an adverse effect because there was no significant effect on relative liver weight, and no histological evidence of hepatocellular hypertrophy or liver lesions. Consequently, the NOAELs and LOAELs identified by FSANZ for some studies differ from those of regulatory agencies that identify increased liver weight as an adverse effect. • Currently available epidemiology data are insufficient to establish a cause-and-effect relationship between PFOA exposure and clinically relevant immunomodulatory effects in humans.
		HC 2018b	• Chronic exposure to PFOA has been associated with both cancer and non-cancer effects in animals and humans. HBVs for both endpoints have been calculated, with the non-cancer effects resulting in a lower, more conservative value. • Liver effects in rats was used to calculate a MAC that is protective of human health from both cancer and non-cancer effects. • In animals, non-cancer effects observed at the lowest levels of exposure include reproductive and developmental effects, liver effects and changes in serum lipid levels. For various reasons, the most appropriate endpoint to derive a HBV for PFOA is hepatocellular hypertrophy (liver effects) in rats, occurring at the same levels as the changes in serum lipid levels. • Epidemiological studies have shown associations between exposure to PFOA and multiple non-cancer health outcomes, such as dysfunctions of the immunological system and alterations in birth weight and lipid levels. However, these studies cannot be used to derive the non-cancer HBV for PFOA due to limitations in terms of design, bias, confounding, and possibility of chance findings. This HBV is considered to be sufficiently protective of both cancer and non-cancer effects of PFOA.

#	Research Questions	Publications	Response to Research Questions
		MDH 2022f	Among the animal studies, decreased postnatal growth leading to developmental effects (e.g. lower pup body weight, delayed eye opening, delayed vaginal opening, and accelerated preputial separation) have been observed. These effects form the basis of the RfD. Co-critical effect(s): In offspring exposed during development: decreased pup body weight; changes in liver weight, histology, and triglycerides; and delayed mammary gland development. In adult animals: liver weight changes accompanied by changes in liver enzyme levels, changes in triglyceride and cholesterol levels, microscopic evidence of cellular damage and bile duct hyperplasia; decreased spleen weight and spleen lymphocytes; decreased IgM response; kidney weight changes and papilla urothelium hyperplasia; increased pancreatic acinar cell hyperplasia; and decreased serum thyroid hormone levels. **Endocrine Toxicity testing**: Three large epidemiological studies provide support for an association between PFOA exposure and incidence or prevalence of thyroid disease in female adults or children, but not in males. In addition, associations between PFOA and Thyroid Stimulating Hormone (TSH) have also been reported in some populations of pregnant females. However, no significant associations were found between PFOA and TSH or thyroid hormones (T4 or T3) in people who have not been diagnosed with thyroid disease. Effects of PFOA on thyroid hormones in animals are generally not as well characterised as those of PFOS. Reduced total and free T4 were reported in adult male rats and monkeys at serum levels 400-fold or more than the serum level corresponding to the RfD. However, these doses were the lowest doses tested within the study and the dose-response relationship of serum total T4 with PFOA exposure has yet to be fully evaluated. As a result, the lowest effective dose remains unknown. Thyroid hormone effects are listed as a co-critical effect and are identified as an Additivity Endpoint. Additional thyroid effects (e.g. follicular cell hypertrophy) were observed at doses that were approximately 500-fold higher than the serum level corresponding to the RfD. Other endocrine effects beyond thyroid have not been well-studied, and study results are not entirely consistent. A few studies reported sperm abnormalities, decreased testosterone, and increased oestradiol in male rats and mice at PFOA levels similar to those which form the basis of the RfD, whereas other studies only reported these effects at higher doses. **Immunotoxicity**: Associations between prenatal, childhood, or adult PFOA exposure and risk of infectious diseases (as a marker of immune suppression) have not been consistently seen in epidemiological studies, although there was some indication of effect modification by gender (i.e. associations seen in female children but not in male children). Three studies examined associations between maternal and/or child serum PFOA levels and vaccine response (measured by antibody levels) in children and adults. The study in adults reported that a reduction in antibody response to one

#	Research Questions	Publications	Response to Research Questions
			of the three influenza strains tested after receiving the flu vaccine was associated with increasing levels of serum PFOA. While decreased vaccine response was associated with PFOA levels in these studies, similar results were also observed with other perfluorinated chemicals and, therefore, could not be attributed specifically to PFOA. Several animal studies demonstrate effects on the spleen and on thymus weights as well as decreased immune response. These effects were observed at serum concentrations similar to the critical study LOAEL. The immune system is listed as one of the co-critical effects and Additivity Endpoints. **Developmental toxicity**: There have been numerous human epidemiological studies examining PFOA exposure and developmental effects. Some studies reported an association between PFOA and birth weight, while others have not. Two epidemiological studies examined development of puberty in females in relation to prenatal exposure to PFOA, however, the results of these two studies are conflicting. Among the animal studies, decreased postnatal growth leading to developmental effects (e.g. lower pup body weight, delayed eye opening, delayed vaginal opening, and accelerated preputial separation) have been observed. These effects form the basis of the RfD. Delayed mammary gland development in female mice exposed *in utero* has been reported. Qualitative and quantitative scoring assessments have identified different thresholds for this effect. MDH had more confidence in using quantitative measurements of mammary gland development and these measures were used in identifying mammary gland development as a co-critical effect. An additional study evaluated the correlation between mammary duct branching patterns and the ability to support pup growth through lactation. No significant impacts were found. Doses resulting in serum concentrations >700-fold higher than the serum concentration corresponding to the RfD resulted in decreased neonatal survival. **Reproductive toxicity**: A series of studies in a high-exposure study population reported associations between PFOA exposure and pregnancy-induced hypertension or preeclampsia. Limited data suggest a correlation between higher PFOA levels in females and decreases in fecundity and fertility, however, loss of body burden via birth and lactation could impact this correlation. No clear effects of PFOA on male fertility endpoints have been identified. Among the animal studies, there was no effect of PFOA on reproductive or fertility parameters in female rats. However, it should be noted that female rats have a very high elimination rate compared to male rats or other species. Increased full litter resorptions and increased stillbirths were observed in pregnant mice exposed at serum concentrations >700-fold higher than the serum concentration corresponding to the RfD.

#	Research Questions	Publications	Response to Research Questions
			No evidence of altered testicular and sperm structure or function was reported in adult male rats exposed to doses producing serum concentrations >350-fold higher than the serum concentration corresponding to the RfD. Increased sperm abnormalities and decreased testosterone have been reported, but typically at serum concentrations 100-fold higher than the serum concentration corresponding to the RfD. **Neurotoxicity**: The human data pertaining to neurotoxicity (including neurodevelopmental effects) of PFOA are limited, but do not indicate the presence of associations between PFOA and a variety of outcomes. Epidemiology studies of children found a weak statistical association between serum PFOA and parental reports of ADHD. Information from animal studies is also quite limited. The offspring of mice fed PFOA throughout gestation had detectable levels of PFOA in their brains at birth. Locomotor activity, anxiety-related or depression-like behaviour, or muscle strength were not altered. Circadian activity tests revealed gender-related differences in exploratory behaviour patterns. These data suggest a need for additional studies to fully understand the neurological effects of PFOA.
		MPART 2019a	• For all of the PFAS examined, points of departure were selected from studies with laboratory animal models. This approach does not negate findings associated with epidemiological studies, but reflects that humans experience uncontrolled and imperfectly documented rather than controlled, precisely measured exposures. Additionally, these points of departure reflect adverse health effects that occur at low doses and that are supported by the weight-of-evidence across endpoints and between findings in humans and laboratory animal models. • It is noted MPART (2019a) did not use the TRV to derive the DWG (they based it on reference concentrations in the general population).
		NJDEP 2019a	Increased relative liver weight is a well-established effect of PFOA that is more sensitive than most other toxicological effects such as immune system toxicity and most reproductive/developmental effects.
		OEHHA 2019a	• Non-cancer endpoint: Li et al. (2017) generated a LOAEL of 0.05 mg/kg-day (administered dose) for changes in mitochondrial membrane potential, increases in biomarkers of apoptosis, and increased oxidative DNA damage in the liver of female mice. This LOAEL corresponds to a serum concentration of 0.97 mg/L, which is lower than the POD of 4.35 mg/L based on increased relative liver weight in male mice (Loveless et al. 2006) that formed the basis for the interim NL. The NOAELs/LOAELs (based on administered dose) determined from the recent immunotoxicity studies are substantially higher than the LOAEL of 0.05 mg/kg-day for liver toxicity from the Li et al. (2017) study, which is selected as a critical study for development of a noncancer RL.

#	Research Questions	Publications	Response to Research Questions
			Therefore, these studies are not considered for POD derivation in support of a final recommendation on the PFOA NL. • Cancer endpoint: Significant increases in hepatocellular adenomas/carcinomas and pancreatic acinar cell adenomas/carcinomas were observed in male rats. Hepatocellular adenoma/carcinoma and pancreatic acinar cell adenoma/carcinoma in male rats were evaluated for RL derivation.
		OEHHA 2023a	• PHG (cancer): Four human studies (Steenland and Woskie 2012; Barry et al. 2013; Vieira et al. 2013; Shearer et al. 2021) with adequate data to evaluate an association between PFOA and kidney cancer all reported strong evidence supporting a true causal association between PFOA and this cancer type. Evaluations of chance, bias, confounding, dose-response, consistency, and biologic plausibility all support these findings. There are a number of potential reasons why a fifth study, the Raleigh et al. (2014) study, could have missed a true effect. Overall, based on these analyses, OEHHA concludes that the positive associations identified in most of the studies of PFOA and kidney cancer are real, and that PFOA is a cause of kidney cancer in humans. • HPC (non-cancer): OEHHA selected the NOAEC of 9.8 ng/mL for elevated ALT from the Gallo et al. (2012) study as the POD for its PFOA ADD calculations. While this study does not provide the lowest POD, it does offer the following advantages for dose-response and risk assessment calculations. o Very large sample size (N=46,452). o Valid method for assessing exposure. o Clinically relevant outcome. o Consistency of findings.
		US EPA 2022c, d; 2021a	• Decreased immune response to vaccination was observed after exposure during a sensitive developmental life stage, and it yields the lowest POD_{HED} among the candidate $PODs_{HED}$. Other candidate RfDs were derived based on other health effects (e.g. development/growth) observed in epidemiology studies; all of the candidate RfDs are associated with low daily oral exposure doses, ranging from 1 to 0.001 ng/kg bw/day. • Candidate draft CSFs from human and animal studies were identified in the draft PFOA document, but one was not selected as the preferred draft CSF for derivation of a 10^{-6} cancer risk concentration. The selection of a CSF is ongoing.
		WHO 2022	• Acknowledging the significant uncertainties and absence of consensus with identifying the critical health endpoint to calculate a HBGV and the rapidly evolving science, a pragmatic solution is proposed for the derivation of provisional guideline values (pGVs).

#	Research Questions	Publications	Response to Research Questions
			• Although the reduced antibody response following vaccination has been considered by some agencies as the most robust end point based on epidemiological data, it is unclear whether this correlation results in increased rates of infection and hence the clinical implications are uncertain. Although animal data would generally be utilised in the absence of adequate human data for risk assessment purposes, there are also areas of uncertainty around the suitability of animal studies for assessing the effects to human health for PFOS and PFOA, including interspecies differences in kinetic parameters such as elimination half-life and clearance rate. Additionally, diverging estimates of the human half-life of PFOA may also add uncertainty to animal-to-human dosimetric adjustments, as well as PBPK-based conversions of human plasma PFAS concentrations to external doses. Finally, the uncertainty and lack of consensus in the critical health end point to derive a HBGV is evident from the diverse range of endpoints utilised by other agencies to derive tolerable daily intakes or similar values, and the resulting range in proposed drinking water values. Although the values derived by several different organisations vary significantly, all have margins of safety. Data analysis also shows that science on PFAS is evolving very rapidly in various areas.
		WSDH 2019a, 2022b, 2023a	• WSDH selected the ATSDR (2021a) MRL of 3 ng/kg–day based on developmental effects in mice as the best basis for drinking water state action levels. In both the EPA and ATSDR evaluations, developmental endpoints yielded health protective values that were as low as or lower than liver injury and immunotoxicity endpoints. There are sufficient supporting toxicity data demonstrating PFOA's developmental toxicity in fish, rats, mice, and monkeys.
4	What other recent guideline values exist?	**All agency documents reviewed**	The various guideline values retrieved as part of the literature search undertaken are provided in the response to Research Question 1.
5	If there are existing guidance/guideline values, are the proposed option/s for health-based guideline values relevant to the Australian context?	**All agency documents reviewed**	Yes, for the most part with some exceptions. For detailed discussion, refer to **Section 9.0** of the Evaluation Report. The cancer-derived DWGs derived by some agencies (e.g. OEHHA 2019a, 2023a) are not derived consistent with Australian science policy, since Australian authorities only use low-dose linear extrapolation and cancer slope factor approaches for carcinogens acting through a mutagenic mode of action. The currently available evidence summarised by the various agencies indicates PFAS are unlikely to cause cancer via a mutagenic mode of action (i.e. there is a threshold below which cancer does not occur).

#	Research Questions	Publications	Response to Research Questions
6	How were they derived and are there any uncertainties with the key studies or the approaches used?	**ATSDR 2021a; WSDH 2019a, 2022b, 2023a**	• Predicted animal serum LOAEL = 8.29 mg/L • POD_{HEC} = (8.29 mg/L x K_e of 4.95 x 10^{-4} x V_d of 0.2 L/kg) ÷ (1) = 0.000821 mg/kg/day • POD_{HEC} ÷ UF of 300 (3x for extrapolation from animals to humans with dosimetric adjustments, 10x for human variability, 10x for use of a LOAEL) = 2.7 ng/kg/day (rounded to 3 ng/kg/day). • The Koskela et al. (2016) study has a number of strengths including examination of several measures of bone status tested at different ages, measurement of bone PFOA levels, and tests to evaluate potential mechanisms of action. To evaluate whether developmental exposure resulted in bone damage in mature animals, the study evaluated bone morphology and bone biomechanical properties; all tests were conducted on femur and tibia bone. Measurement at two ages (13 and 17 months) allowed for an evaluation of whether the effect of PFOA on bone changed as the animals aged. The companion *in vitro* study of osteoclasts and osteoblasts provided mechanistic support for the *in vivo* findings. Additionally, the *in vitro* study evaluated four PFOA concentrations and found concentration-related differences. There are several study limitations that affect the interpretation of the study results; these include the small number of animals tested, use of only one PFOA dose level, inadequate reporting of dietary PFOA levels, and lack of measured serum PFOA levels. Tests of potential alterations in bone mineral density and bone biomechanical properties were only evaluated in 5–6 female offspring per group; however, support for the finding comes from the consistency of the findings at 13 and 17 months of age. The use of only one PFOA dose level does not allow for the establishment of dose-response relationships. This study limitation is mitigated by the extensive intermediate-duration oral exposure database, which allows for an overall assessment of dose-response. The dams were exposed to PFOA dissolved in alcohol and sprayed onto the food pellets. The study did not measure the amount of residual alcohol or the actual amount of PFOA on the food pellets. Koskela et al. (2016) measured PFOA levels in the tibias and femurs but did not measure serum PFOA levels. ATSDR estimated the TWA serum PFOA concentrations using the Wambaugh et al. (2013) model. The lack of measured serum PFOA levels did not allow for validation of whether the model accurately predicted serum levels; the model was validated using data from other intermediate-duration PFOA studies in rats and mice. • WSDH adopted the ATSDR (2021a) TRV.
		ATSDR 2018a	Used oral MRL from ATSDR (2021a): • Child (birth-1 year): (3 ng/kg/day x 7.8 kg) ÷ 1.113 L/day = 21 ng/L • Adult: (3 ng/kg/day x 80 kg) ÷ 3.092 L/day = 78 ng/L

#	Research Questions	Publications	Response to Research Questions
		BfR 2019a	• After examining EFSA's opinion, BfR believes there is a need for further research on, inter alia, the question of an actual causal relationship between the intake of PFOS (and PFOA) and the increase in total serum cholesterol and the relevance to health of this effect. From the point of view of the BfR, there are considerable uncertainties with regard to the evidence of causality and clinical relevance of the effects on which the TWI derivation was based. • Amongst other issues, the BfR addressed questions regarding the suitability of the observed increases in total cholesterol in the epidemiological studies as biomarkers for cardiovascular diseases. Further discussions dealt with the clinical relevance of elevated cholesterol levels against the background of other factors affecting the risk of cardiovascular disease such as age, gender, weight, blood pressure and smoking. In addition, questions were discussed on the causal relationship between PFOS/PFOA in the blood and total cholesterol, in particular with regard to a possible coincidence of elevated serum levels of PFOS and PFOA and higher cholesterol levels, which could be due to, for example, mutual reabsorption from the gut via common membrane transport systems.
		EFSA 2020a, RIVM 2021a	• $BMDL_{10}$ in 1-year old children for 10% decreased antibody titre following diphtheria vaccination = 17.5 ng/mL for ∑PFOA, PFNA, PFHxS and PFOS. • Taking into account 1 year of breastfeeding and transfer of PFAS in breast milk to the infant, the equivalent serum concentration in mothers was determined by PBPK modelling to be 6.9 ng/mL at 35 years of age. • This corresponds to a dose of 0.63 ng/kg bw/day (or 4.4 ng/kg bw/week). • No uncertainty factor was applied, because the $BMDL_{10}$ is based on infants which are expected to be a sensitive population group. In addition, a decreased vaccination response is considered a risk factor for disease rather than a disease. • *"Overall, both the few number of data points in the critical dataset (n = 101), particularly at higher serum concentrations of PFAS, and the relatively large variability between individuals results in the (mean) dose-response curve not being clear. This introduces uncertainty in the shape of the dose response curve as well as the location of the established Reference Point."* • Overall, the CONTAM Panel considered that the impact of the uncertainties on the risk assessment for the sum of PFOA, PFNA, PFHxS and PFOS is high. • RIVM (2021a) adopted the TRV from EFSA (2020a).
		FSANZ 2017b	• The rat average serum concentration at the NOAEL dose of 1 mg/kg/day from Lau et al. (2006) was determined to be 35.1 µg/mL.

#	Research Questions	Publications	Response to Research Questions
			• PBPK modelling was used to derive a HED of 0.0049 mg/kg/day corresponding to this serum concentration in humans. • Applied uncertainty factor of 10x for human variability, 3x for potential differences in toxicodynamics between animals and humans. No additional uncertainty factors were considered to be required, and therefore a total uncertainty factor of 30 was applied to all modelled HED, resulting in a HBGV of 0.16 µg/kg/day.
		HC 2018b	• $BMDL_{10}$ in rats: 0.05 mg/kg/day • POD_{HEQ}: 0.000521 mg/kg/day, derived by dividing rat NOAEL by 96 (to account for toxicokinetic differences between rats and humans, derived using PBPK modelling). • Applied uncertainty factor of 2.5x for toxicodynamic interspecies uncertainty and 10x for intraspecies uncertainty (25x total). • 0.000521 mg/kg/day ÷ 25 = 0.000021 mg/kg/day (i.e. 21 ng/kg/day). • MAC (in drinking water: TDI x body weight of an adult x default allocation factor ÷ daily volume of water consumed by an adult = 0.000021 mg/kg/day × 70 kg × 0.2 ÷ 1.5 L/day) = 0.0002 mg/L (i.e. 200 ng/L).
		MDH 2022f	• Predicted average animal serum NOAEL in maternal animals = 38 µg/mL • Toxicokinetic Adjustment based on Chemical-Specific Clearance Rate = Volume of Distribution (L/kg) x (Ln2/Half-life, days) = 0.17 L/kg x (0.693/840 days) = 0.00014 L/kg-day. • HED NOAEL = 0.0053 mg/kg/day • UF of 300 applied [3x for interspecies differences for toxicodynamics, 10x for intraspecies variability, 3x for use of a LOAEL (with the exception of accelerated preputial separation (PPS), the effects observed at the LOAEL were mild), and 3x for database uncertainty for lack of an acceptable 2-generation study]. • RfD = 18 ng/kg/day
		MPART 2019a	Derivation of TRV (RfD), which was not used to derive the DWG: • Animal LOAEL = 0.3 mg/kg/day • Animal serum LOAEL = 8.29 mg/L • Toxicokinetic Adjustment based on Chemical-Specific Clearance Rate = Volume of Distribution (L/kg) x (Ln2/Half-life, days) = 0.17 L/kg x (0.693/840 days) = 0.00014 L/kg-day.

#	Research Questions	Publications	Response to Research Questions
			• HED LOAEL = 0.001163 mg/kg/day • UF of 300 applied [3x for interspecies differences for toxicodynamics, 10x for intraspecies variability, 3x for use of a LOAEL, 3x for database uncertainties] • TRV = 3.9 ng/kg/day
		NJDEP 2019a	• Serum $BMDL_{10}$: 4,351 ng/mL (i.e. 4.351 mg/L) • UF of 300 applied [3x for interspecies differences for toxicodynamics, 10x for intraspecies variability, 10x for incomplete database due to adverse effects on mammary gland development potentially occurring at doses more than 10-fold lower than those that cause increased relative liver weight] • Target Human Serum Level: 14.5 ng/mL (= 4,351 ÷ 300) • Converted to dose by using a clearance factor of 1.4×10^{-4} L/kg/day developed by USEPA (2016a) to relate serum PFOA concentration to administered dose. [14.5 ng/mL x 1.4×10^{-4} L/kg/day x 10^3 mL/L = 2 ng/kg/day • This was converted to a ISGWQC of 10 ng/L (rounded) using a 70kg adult body weight, 2 L/day drinking water consumption and relative source contribution of 20% [(2 ng/kg/day x 70 kg x 0.2) ÷ 2L/day = 14 ng/L].
		OEHHA 2019a	Cancer endpoint: • $BMDL_{05}$: 0.000648 mg/kg/day (male rats). • $BMDL_{05}$ HED: 0.00035 mg/kg/day (based on body weight scaling, $BMDL_{05(animal)} \times (BW_{animal}/BW_{human})^{1/8} = 0.000648 \times (0.509 \text{ kg}/70\text{kg})^{1/8}$. • CSF: $143 \text{ (mg/kg-day)}^{-1}$ (BMR ÷ $BMDL_{05}$ = 0.05 ÷ 0.00035 mg/kg/day) • RL = R ÷ (CSF × DWI) = 10^{-6} ÷ $(143 \text{ (mg/kg-day)}^{-1} \times 0.053$ L/kg-day), (where R = default excess cancer risk level of one in one million and DWI = drinking water intake rate, RL rounded to 0.1 ng/L). Non-cancer endpoint: • Animal LOAEL: 0.05 mg/kg/day (animal serum: 0.97 mg/L). • ADD: 0.0032 mg/L (Target human serum concentration) [(ADD = POD ÷ UF of 300); UF of 300 consists of 3x for interspecies extrapolation of toxicodynamics, 10x for intraspecies variability, 3x for LOAEL to NOAEL extrapolation, and 3x for potential for developmental toxicity at the point of departure].

#	Research Questions	Publications	Response to Research Questions
			• ADD: 0.45 ng/kg-day. [0.0032 mg/L x 1.4 x 10^{-4} L/kg/day x 10^{6} ng/mg] • RL = ADD x RSC ÷DWI = 0.45 ng/kg/day × 0.2 ÷ 0.053 L/kg/day (where RSC = relative source contribution, RL rounded to 2 ng/L). The State Water Resources Control Board (SWRCB) set the NLs at the lowest levels at which PFOA and PFOS can be reliably detected in drinking water.
		OEHHA 2023a	Non-cancer endpoint (from the study by Gallo et al. 2012): • Serum NOAEC in humans: 9.8 ng/mL. • ADD = (POD × CL) ÷ UF = (9.8 ng/mL × 0.28 mL/kg-day) ÷ 10 = 0.87 ng/kg-day. • A UF of √10 rather than 1 for intraspecies variation was applied because the C8 study population was not diverse in terms of race or ethnicity. Cancer endpoint (from the carcinogenicity studies): • PODs not discernible. • CSF: 0.0026 $(ng/kg/day)^{-1}$ (Geometric mean from two studies)
		US EPA 2022c, d; 2021a	The PODs from human epidemiological studies (immune, developmental and serum lipid endpoints) were derived using benchmark dose modelling but the one selected for RfD derivation was the following: • A human serum POD based on a BMR of 5% and a $BMDL_5$ of 0.17 ng/mL (USEPA 2021a). • The internal dose POD was then converted to a POD_{HED} of 1.49 x 10^{-8} mg/kg/day (USEPA 2021a) using a toxicokinetic model to simulate a dose to mothers and children that results in the same serum concentration. • An UF of 10 was applied to account for variability in the response within the human population to derive a draft RfD of 0.0015 ng/kg/day.

#	Research Questions	Publications	Response to Research Questions
		WHO 2022	The pGVs are derived with the objective of reducing human exposure and therefore risk. In deriving the pGVs, global data on occurrence including co-occurrence of PFAS, available analytical methods and treatment achievability were considered. A pGVs of 100 ng/L for PFOA is proposed based on the following considerations: • This value corresponds to greater than 90% removal achievability with high pressure membrane filtration (NF and RO), activated carbon adsorption or ion-exchange, considering that upper-bound concentrations detected in drinking water sources have mostly been in the low µg/L range. • The pGV for PFOA should therefore be achievable, where these technologies are available and have been optimised for PFAS removal. • Although the pGV was not derived based on adverse health effects studies, the value falls within the range of most health-based values derived through national risk assessments.
7	Are they suitable to adopt/adapt?	**ATSDR 2021a**	Yes. This publication meets 90% of must-have, 80% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance value is potentially suitable for adoption / adaption. However, refer to **Section 9.0** of the Evaluation Report for more detailed discussions.
		EFSA 2020a	Yes. This publication meets 82.5% of must-have, 55% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance value is potentially suitable for adoption / adaption. However, refer to **Section 9.0** of the Evaluation Report for more detailed discussions.
		FSANZ 2017b	This publication was already adapted for derivation of current Australian DWGs. It meets 90% of must-have, 65% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**).
		HC 2018b	No. This publication meets 58% of must-have, 50% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance value is unlikely suitable for adoption / adaption. However, refer to **Section 9.0** of the Evaluation Report for more detailed discussions.
		MDH 2022f	No. This publication meets 42.5% of must-have, 35% of should-have and 50% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance value is unlikely suitable for adoption / adaption. However, refer to **Section 9.0** of the Evaluation Report for more detailed discussions.

#	Research Questions	Publications	Response to Research Questions
		MPART 2019a	No. This publication meets 67.5% of must-have, 30% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance value is unlikely suitable for adoption / adaption. However, refer to **Section 9.0** of the Evaluation Report for more detailed discussions.
		NJDEP 2019a	Yes. This publication meets 90% of must-have, 60% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance value is potentially suitable for adoption / adaption. However, refer to **Section 9.0** of the Evaluation Report for more detailed discussions.
		OEHHA 2019a	No. This publication meets 47.5% of must-have, 45% of should-have and 50% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance / guideline value is unlikely suitable for adoption / adaption. However, refer to **Section 9.0** of the Evaluation Report for more detailed discussions.
		OEHHA 2023a	Yes. This publication meets 82.5% of must-have, 80% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance / guideline value is potentially suitable for adoption / adaption. However, refer to **Section 9.0** of the Evaluation Report for more detailed discussions.
		US EPA 2022c, d; 2021a	Yes. This publication meets 82.5% of must-have, 90% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance / guideline value is potentially suitable for adoption / adaption. However, refer to **Section 9.0** of the Evaluation Report for more detailed discussions.

7.2 Health considerations research question analysis – PFOA

Table 7-2 Synthesis of extracted data for exposure-related research questions

#	Research Questions	Publications	Response to Research Questions
8	What are the key adverse health hazards from exposure to PFOA chemicals in Australian drinking water?	**Various agency publications**	• Skeletal alterations in adult mouse offspring and/or decreased foetal mouse body weight (ATSDR 2018a, 2021a; FSANZ 2017b; WSDH 2019a, 2022b, 2023a). • Delayed ossification, accelerated preputial separation (PPS) in male mice offspring, trend for decreased pup body weight, and increased maternal liver weight (MDH 2022f). • Developmental delays (decreased number of inactive periods, altered novelty induced activity and skeletal alteration such as bone morphology and bone cell differentiation in the femurs and tibias) of mice (MPART 2019a). • Increased liver weight in male mice (NJDEP 2019a). • Increase in total blood cholesterol levels (BfR 2019a) and decreased antibody formation following certain childhood vaccines in humans (EFSA 2020a, US EPA 2021a). • Hepatocellular hypertrophy in rat study (HC 2018b). • Increased risk of kidney cancer and increased ALT in humans (OEHHA 2023a).

7.3 Typical Australian water levels or exposure profile -related research question analysis – PFOA

Table 7-3 Synthesis of extracted data for exposure-related research questions

#	Research Questions	Publications	Response to Research Questions
9	What are the typical levels in Australian drinking water supplies, considering distributed drinking water and households using their own bore water, rainwater or surface water for drinking? (NB: Due to limited information, PFAS levels from overseas jurisdictions are noted where extracted from Agency reviews)	QAEHS (2018a, 2018b)	Raw water catchments (pre-treatment): • Summer 2018: ~0.2 ng/L – 3 ng/L (76% detection rate) • Winter 2018: 2.9 – 4.6 ng/L
		Sydney Water (2023)	Distributed Drinking Water: • 2011: 5.17 – 9.16 ng/L • 2019: 1.7 – 3.8 ng/L
		WCWA (2021)	Distributed Drinking Water: • < 50 ng/L
		WCWA (2023)	Distributed Drinking Water: • <1 – 5 ng/L
		WHO (2022)	• Australia: 9.7 ng/L (maximum, n=62, 34 locations across Australia)
		GHD (2018), AECOM (2017, 2017b)*	Residential/private bores used for domestic purposes (including drinking) surrounding various Defence sites (contaminated sites): • Maximum 2,030 ng/L (RAAF Base Oakey) • Maximum 10,500 ng/L (RAAF Base Williamstown) • Maximum 20 ng/L (RAAF Base Pearce)
		BSC (2021)*	Bore water used for drinking in proximity to fire stations in Queensland: • Maximum 10 ng/L (Ayr, Nelson Bores Raw Water Quality 2010-2020) • Maximum 7 ng/L (Home Hill Raw Water Quality 2013-2020)
		WHO (2022)	• China: 0.75 ng/L (Median, tap water from 79 cities). • Japan: up to 44 ng/L (39 water treatment plants).

#	Research Questions	Publications	Response to Research Questions
			• Philippines: 3.01 ng/L (maximum, n = 7): and Thailand 7.89 ng/L (n = 16). • US: ∑PFOS and PFOA: ranged from 0.02 to 7.22 µg/L. • US: 4.15 ng/L (median) and 104 ng/L (maximum) (25 drinking water treatment plants) • EU: 1 ng/L (lower bound mean) to 3.0 ng/L (upper bound mean) • Turkey: 2.37 ng/L (n=94 samples, 33 provinces) • Netherlands, Germany, France and Spain: High variability. 0.63 – 519 ng/L. • Italy: Maximums ranged from 7 ng/L to 1,475 ng/L.
		ATSDR (2018a)	• Brazil (Rio): maximums ranging from 0.35 to 2.82 ng/L. • Spain (Catalonia): 0.98 ng/L (median) • Germany: 7.4 ng/L (maximum). • China (21 cities): <0.1 to 45.9 ng/L. • US (New Jersey): 5 to 39 ng/L, 100 ng/L (max in a follow up study).
		RIVM (2021a)	• Netherlands: 4.5 ng/L (2015), 2.2 ng/L (2017) (Dordrecht, 37 locations)
		HC (2018b)	• Calgary: <0.51 ng/L (from 2 Water Treatment Plants, WTPs) • Quebec: 2.5 ng/L (median), 98 ng/L (max) (n = 84). • Ontario: 2.1 mg/L (n = 5). • Calgary and Vancouver: 0.2 ng/L
		MDH 2022d	• Minnesota: Up to 1,000 ng/L (public drinking water).
		NJDEP (2019a)	• Cape Fear River (North Carolina): 12.6 ng/L (median), 287 ng/L max) • Upper Mississippi River drainage basin: 2.07 ng/L (median), 125 ng/L (max) • Tennessee River (Alabama): 395+128 ng/L • Moehne River Germany: 519 ng/L • New Jersey Public Water Supplies (PWS): up to 190 ng/L in a groundwater source and up to 64 ng/L in tap water
		OEHHA (2023a)	• California: 20-70 ng/L (drinking water, UCMR3). • California: 12.4 – 14.5 ng/L (means, detects ranging from 33 – 44%)

#	Research Questions	Publications	Response to Research Questions
		USEPA (2022d), USEPA 2021a	• US public water systems (PWSs): 20 ng/L to 349 ng/L (median = 30 ng/L) • Bottled water (domestic and imported): <4 ng/L (n = 30). • US: Median = 4.15 ng/L, maximum = 104 ng/L (from 29 drinking water treatment plants).
		WSDH 2022b	• PFOS + PFOA ranges up to 60 ng/L reported in most areas and as high as 490 ng/L and 7,740 ng/L in two areas.
10	Do they vary around the country or under certain conditions e.g. drought?	No, from literature reviewed levels in drinking water from Queensland, Sydney and Western Australia were similar and generally less than 10 ng/L. Levels were lower in 2019 compared to 2011.	
11	What other factors should be considered (e.g. differences between groundwater versus surface water sources)?	HC (2018a), NJDEP (2019b), OEHHA (2023a), WHO (2022)	Individuals living in areas with contaminated drinking water may have an increased proportion of PFAS exposure from drinking water compared to exposure from food and other sources (consumer products).
		The main factor to consider for exposure to PFAS in drinking water is whether drinking water infrastructure is located in the vicinity of potentially contaminating activities (HC 2018a, NJDEP 2019b, OEHHA 2023a, WHO 2022) as identified in response to Research Question 20 (refer to **Section 4.5**).	

* These references were added in at the request of the Committee after their review of the draft reports. They are therefore not specifically included in Appendix B data extractions or Appendix A spreadsheets.

7.4 Risk Summary research question analysis – PFOA

Table 7-4 Synthesis of extracted data for risk-associated research questions

#	Research Questions	Publication	Response to Research Questions
12	What are the risks to human health from exposure to PFOA in Australian drinking water?	Risk from exposure to PFOA in available drinking water data is relatively low based on measured concentrations (<10 ng/L, refer to relevant Research Question 9, **Section 7.3**) when compared to the existing drinking water guideline for PFOA (560 ng/L). The maximum concentration measured in drinking water is at or below candidate DWGs (9.5 to 70 ng/L); due to uncertainty factors and small RSC incorporated into the derivation of the candidate DWGs, PFOA is unlikely to present a human health risk from drinking water in uncontaminated regions of Australia (see **Section 9.3** in Evaluation Report).	
13	Is there evidence of any emerging risks that are not mentioned in the current Fact Sheet that require review or further research?	The general description for sources and exposure of PFAS provided in the fact sheet appears applicable to the PFAS considered in this report (PFOS, PFHxS, PFBS, PFOA and GenX Chemicals).	
		NJDEP (2019a)	The potential for prenatal and early life exposures to environmental contaminants to cause adverse health effects later in life is currently a focus of high interest in both epidemiology and toxicology.
		CPDH (2023a)	Pregnant people, infants and children are at higher risk because of PFAS effects on pregnancy outcomes and foetal, infant and child growth and development.

7.5 Supporting Fact Sheet information research question analysis – PFOA

Refer to analysis for all five PFAS included in this report in **Section 4.5**.

8.0 Results for GenX Chemicals

A summary of the responses to the research questions for GenX Chemicals is provided in the tables below.

8.1 Health-based guideline value research question analysis – GenX Chemicals

Table 8-1 Synthesis of extracted data for health-based research questions

#	Research Questions	Publications	Response to Research Questions
1	What level of GenX Chemicals in drinking water causes adverse health effects?	**CDPH 2023a**	Drinking water guideline = 19 ng/L. Derivation not provided.
		EU 2020, EC 2022	Drinking water guidelines: • 'Sum of PFAS': 100 ng/L (EU 2020 only). • 'PFAS Total': 500 ng/L (EU 2020, EC 2022) NB: 'PFAS Total' as the totality of PFAS detected with available analytical methods and monitoring guidelines (EU 2020, EC 2022). 'Sum of PFAS' means the sum of PFAS considered a concern as regards to water intended for human consumption listed in point 3 of Part B of Annex III. This is a subset of 'PFAS Total' substances that contain a perfluoroalkyl moiety with three or more carbons (i.e. $–C_nF_{2n}–$, n ≥ 3) or a perfluoroalkylether moiety with two or more carbons (i. e. $C_nF_{2n}OC_mF_{2m}–$, n and m ≥ 1) (EU 2020). Derivation of these guideline values was not provided.
		Mass DEP 2022a	• Provide final health advisory of 10 ng/L (likely adopted from US EPA). • State that GenX should be evaluated using a hazard index approach in combination with PFNA, PFHxS, and PFBS.
		MDH 2023a	• Adopted from US EPA (2021e) guidance, MDH is also proposing that four PFAS (PFBS, PFHxS, GenX and PFNA) be evaluated in combination with each other, using an approach called a Hazard Index. A hazard index is calculated by comparing a measured drinking water value with a standard. SLR presumes the standard is the MCL of 4 ng/L for PFOS and PFOA but this is not clear.

#	Research Questions	Publications	Response to Research Questions
		MPART 2019a	DWG of 370 ng/L derived from TRV of 77 ng/kg/day as follows: [(RSC of 0.2 x 77 ng/kg/day x 80 kg) ÷ 3.353 L/day]
		NC DHHS 2017	Cite a health goal of 140 ng/L for GenX, but basis is not provided.
		NJDEP 2023a	Interim Specific Ground Water Criterion (ISGWQC) of 20 ng/L (rounded) was derived from TRV of 3 ng/kg/day adopted from US EPA (2021e) [(3 ng/kg/day x 70 kg x 0.2) ÷ 2L/day = 21 ng/L].
		RIVM 2018a	Did not derive DWG but derived a relative potency factor for GenX of 0.06 relative to PFOA based on comparison of derived BMD_{05} for increased relative liver weight in rats (Haas unpublished study for GenX, Perkins 2004 for PFOA).
		US EPA 2021e, 2022c, j; WSDH 2023a, 2022b	• Derived a final health advisory (HA) of 10 ng/L (rounded) (= RfD * RSC ÷ DWI-BW) where o RfD = 3 ng/kg/day o Relative source contribution (RSC) = 0.2 o DWI-BW = 0.0469 L/kg/bw/day (the 90th percentile two-day average, consumer only estimate of combined direct and indirect community water ingestion for lactating women). • WSDH (2023a, 2022b) adopted the HA from US EPA.
2	What is the critical human health endpoint that determines this value?	**MPART 2019a, NJDEP 2023a, US EPA 2021e, 2022c,j; WSDH 2023a, 2022b**	Liver effects (increased absolute and relative weight and histopathologic findings, i.e. liver single cell necrosis in parental mice) [unpublished Reproduction/ Developmental Toxicity Study in Mice conducted according to Organisation for Economic Co-operation and Development (OECD) Test Guideline (TG) 421; modified according to the Consent Order, DuPont-18405-1037 (2010)]

#	Research Questions	Publications	Response to Research Questions
3	What are the justifications for choosing this endpoint?	**MPART 2019a**	• For all of the PFAS examined, points of departure were selected from studies with laboratory animal models. This approach does not negate findings associated with epidemiological studies, but reflects that humans experience uncontrolled and imperfectly documented rather than controlled, precisely measured exposures. Additionally, these points of departure reflect adverse health effects that occur at low doses and that are supported by the weight-of-evidence across endpoints and between findings in humans and laboratory animal models. • The Workgroup noted that while primarily industry-funded studies are the only ones available, they followed recognised testing guidelines and/or were published following external peer-review. These studies appear to be sufficient for developing values.
		NJDEP 2023a	As discussed in the January 25, 2022 memorandum from Division of Science and Research (DSR) to the Division of Air Quality (DAQ) (Attachment 1), DSR reviewed the basis of the USEPA (2021e) RfD of 3 ng/kg/day for GenX and concluded that it is scientifically justified and health protective.
		US EPA 2021e, 2022c, j; WSDH 2023a, 2022b	• Overall, the available toxicity studies demonstrate that the liver is particularly sensitive to HFPO dimer acid- and HFPO dimer acid ammonium salt-induced toxicity. • EPA determined that the constellation of liver lesions observed in the rodent are relevant to human health and not a result of PPARα-induced cell proliferation unique to rodents. • WSDH (2023a, 2022b) adopted the US EPA value.
4	What other recent guideline values exist?	**All agency documents reviewed**	The various guideline values retrieved as part of the literature search undertaken are provided in the response to Research Question 1.
5	If there are existing guidance/guideline values, are the proposed option/s for health-based guideline values relevant to the Australian context?	**All agency documents reviewed**	Yes, for the most part. For detailed discussions, refer to **Section 10.0** in Evaluation Report.

#	Research Questions	Publications	Response to Research Questions
6	How were they derived and are there any uncertainties with the key studies or the approaches used?	**MPART 2019a**	Derivation of TRV (RfD): • Animal NOAEL = 0.1 mg/kg/day • Animal $BMDL_{10}$ = 0.15 mg/kg/day • $BMDL_{10}$-POD_{HED} = 0.023 mg/kg/day [$BMDL_{10}$ x (0.0372 kg in male mice/80 kg in humans)$^{3/4}$] • UF of 300 applied [3x for interspecies differences, 10x for intraspecies variability, 3x for subchronic to chronic extrapolation, 3x for database deficiencies including lack of epidemiological, and developmental and immunotoxicological studies in laboratory animals] • TRV = 77 ng/kg/day
		NJDEP 2023a; US EPA 2021e, 2022c,j; WSDH 2023a, 2022b	NJDEP (2023a) and WSDH (2023a, 2022b) adopted the US EPA (2021e) TRV for GenX. • Animal $BMDL_{10}$: 0.09 mg/kg/day • POD_{HED}: 0.01 mg/kg/day • UF of 3000 applied [3x for interspecies differences, 10x for intraspecies variability, 10x for subchronic to chronic extrapolation, 10x for database uncertainties for potentially more sensitive effects]. • RfD = 3 ng/kg/day • This was converted by NJDEP (2023a) to a ISGWQC of 20 ng/L (rounded) using a 70kg adult body weight, 2 L/day drinking water consumption and relative source contribution of 20% [(3 ng/kg/day x 70 kg x 0.2) ÷ 2L/day = 21 ng/L], whereas US EPA (2022c) converted this to a health advisory level of 10 ng/L (rounded) [(3 ng/kg/day x 0.2) ÷ 0.0469L/kg/day = 13 ng/L].
7	Are they suitable to adopt/adapt?	**MPART 2019a**	No. This publication meets 67.5% of must-have, 30% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance value is unlikely suitable for adoption / adaption. However, refer to **Section 10.0** of the Evaluation Report for more detailed discussions.
		US EPA 2021e	Yes. This publication meets 92.5% of must-have, 100% of should-have and 100% of may-have technical and administrative criteria (see **Appendix D**), indicating the guidance / guideline value is potentially suitable for adoption / adaption. However, refer to **Section 10.0** of the Evaluation Report for more detailed discussions.

8.2 Health considerations research question analysis – GenX Chemicals

Table 8-2 Synthesis of extracted data for exposure-related research questions

#	Research Questions	Publications	Response to Research Questions
8	What are the key adverse health hazards from exposure to GenX Chemicals in Australian drinking water?	**Various agency publications**	• Liver effects (increased absolute and relative weight and histopathologic findings, i.e. liver single cell necrosis in parental mice) (MPART 2019a, NJDEP 2023a, US EPA 2021e, WSDH 2023a, 2022b)

8.3 Typical Australian water levels or exposure profile -related research question analysis – GenX Chemicals

Table 8-3 Synthesis of extracted data for exposure-related research questions

#	Research Questions	Publications	Response to Research Questions
9	What are the typical levels in Australian drinking water supplies, considering distributed drinking water and households using their own bore water, rainwater or surface water for drinking? (NB: Due to limited information, PFAS levels from overseas jurisdictions are noted where extracted from Agency reviews)	No information regarding GenX Chemicals levels in Australian drinking water was identified from literature retrieved. Overseas, levels are generally low <5 ng/L except near a production facility in North Carolina.	
		USEPA (2021e), USEPA (2022j)	• North Carolina Cape Fear: 631 ng/L (mean HFPO dimer acid in DWTP C), 400 – 500 ng/L near production facility. • Delaware River: 3–4 ng/L HFPO dimer acid • Kentucky DWTPs 1.32 ng/L to 29.7 ng/L. • Netherlands: 0.25, 0.48, and 11 ng/L (surface water near production facility) • Netherlands: 1.4 to 8.1 ng/L (residential tap water near production facility) • Belgium: 2.9 ng/L (mean), 28 ng/L (max) (11 water suppliers)
10	Do they vary around the country or under certain conditions e.g. drought?	No information regarding GenX Chemicals levels in Australian drinking water was identified from literature retrieved.	
11	What other factors should be considered (e.g. differences between groundwater versus surface water sources)?	HC (2018a), NJDEP (2019b), OEHHA (2023a), WHO (2022)	Individuals living in areas with contaminated drinking water may have an increased proportion of PFAS exposure from drinking water compared to exposure from food and other sources (consumer products).
		The main factor to consider for exposure to PFAS in drinking water is whether drinking water infrastructure is located in the vicinity of potentially contaminating activities (HC 2018a, NJDEP 2019b, OEHHA 2023a, WHO 2022) as identified in response to Research Question 20 (refer to **Section 4.5**).	

8.4 Risk Summary research question analysis – GenX Chemicals

Table 8-4 Synthesis of extracted data for risk-associated research questions

#	Research Questions	Publication	Response to Research Questions
12	What are the risks to human GenX Chemicals in Australian drinking water?	There is no analytical data for GenX Chemicals in drinking water from Australia on which to base a risk finding for this PFAS. The candidate drinking water guidelines for this compound (270 or 10.5 ng/L, refer to the Evaluation Report, Section **10.3**) are higher than GenX Chemicals levels measured overseas (<5 ng/L) except in areas near a production facility in North Carolina (refer to Research Question 9 above, **Table 8-3**).	
13	Is there evidence of any emerging risks that are not mentioned in the current Fact Sheet that require review or further research?	It is not possible to provide a definitive answer to this question for GenX Chemicals based on the lack of available information in Australia for this PFAS (in drinking water, food, consumer products, biomonitoring data). Nonetheless, the general description for sources and exposure of PFAS provided in the fact sheet appears applicable to the PFAS considered in this report (PFOS, PFHxS, PFBS, PFOA and GenX Chemicals).	
		NJDEP (2019a)	The potential for prenatal and early life exposures to environmental contaminants to cause adverse health effects later in life is currently a focus of high interest in both epidemiology and toxicology.
		CPDH (2023a)	Pregnant people, infants and children are at higher risk because of PFAS effects on pregnancy outcomes and foetal, infant and child growth and development.

8.5 Supporting Fact Sheet information research question analysis – GenX Chemicals

Refer to analysis for all five PFAS included in this report in **Section 4.5**.

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Appendix A Literature Search Screening Outcomes Spreadsheets

Evidence Evaluations for Australian Drinking Water Guidelines Chemical Fact Sheets – PFOS, PFHxS, PFOA, PFBS, and GenX Chemicals

PFOS, PFHxS, PFOA, PFBS, and GenX Chemicals Technical Report

National Health and Medical Research Council

SLR Project No.: 640.V30693.20000

17 October 2024

SLR

Table A1: Agency Review Literature Search

Search term: PFOS, PFOA, PFHxS, PFBS, GenX OR 13252-13-6 OR 62037-80-3	**Legend/Abbreviations**		
	NR=not relevant		
	Not HH related=Not human health related		
Date range : 2021 -2023	RQ= Research Question		
Data base searched: WHO/ FAO/ JECFA /EFSA/ US EPA/ ATSDR/ OEHHA/ FSANZ/ APVMA/ IPCS	L=Studies in other than english		
Website address: https://www.who.int/ https://www.fao.org/home/en https://www.fao.org/food-safety/resources/publications/en/ https://www.fao.org/food/food-safety-quality/scientific-advice/jecfa/en/ https://www.efsa.europa.eu/en https://www.epa.gov/ https://www.atsdr.cdc.gov/ https://wwwn.cdc.gov/TSP/index.aspx https://oehha.ca.gov/ https://www.foodstandards.gov.au/Pages/default.aspx https://apvma.gov.au/ https://www.industrialchemicals.gov.au/ http://www.inchem.org/#/search https://www.canada.ca/en/health-canada.html https://www.rivm.nl/en https://www.bfr.bund.de/en/home.html https://www.health.state.mn.us/ https://doh.wa.gov/ https://www.maine.gov/dhhs/ https://health.alaska.gov/dph/epi/pages/phan/default.aspx https://www.alabamapublichealth.gov/ https://portal.ct.gov/DPH https://www.healthvermont.gov/ https://www.nj.gov/health/ https://www.michigan.gov › community-water-supply https://www.mass.gov/orgs/department-of-public-health	DB= Dated Before 2021 AR= Already Reviewed		

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
World Health Organisation (WHO)					
Search results: 1 for PFOS, 1 for PFOA, and Nil for PFBS, GenX and PFHxS. Also Nil for 13252-13-6 and 62037-80-3 (the CAS Numbers for GenX)					
Rolling revision of the Guidelines for Drinking-water Quality	No	NR	Not included from the title screen		
PFOS and PFOA in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality. Draft version for Public comment.	Yes	-	WHO (2022)	**Yes**	Included. DWG available based on prgamatism
Food Agriculture Organization of the United Nations (FAO)					
Search results: 119 for PFOS, 103 for PFOA, 20 for PFHxS, 5 for PFBS and 10 for GenX					
Search cut-off: Only results from first 10 results for each PFAS (duplicates struckthrough) and links followed on webpapes (see indented title of result and purple text) as results were not relevant					
FAO - News Article: Pesticides and industrial chemicals ...	No	NR	Not included from the	NA	NA
National Implementation Plan for the Stockholm Convention. | FAOLEX	No	NR	Not included from the	NA	NA
National Implementation Plan for the Stockholm Convention on ...	No	NR	Not included from the	NA	NA
National Implementation Plan (NIP) for the Stockholm Convention ...	No	NR	Not included from the	NA	NA
National and regional priorities in North America	No	NR	Not included from the	NA	NA
Levels of persistent organic pollutants (POPs) in foods from the first ...	No	NR	Not included from the	NA	NA
JOINT FAO/WHO FOOD STANDARDS PROGRAMME CODEX ...	No	NR	Not included from the	NA	NA
Regulation No. 922 on restrictions in using environmentally ...	No	NR	Not included from the	NA	NA
Fisheries and Aquaculture - openasfa.title - FAO	No	NR	Not included from the	NA	NA
www.fao.org › results › details › LEX-FAOC199760	No	NR	Not included from the	NA	NA
FAO - Food and Agriculture Organization	No	NR	Not included from the	NA	NA
FAO - Food and Agriculture Organization	No	NR	Not included from the	NA	NA
National and regional priorities in North America	No	NR	Not included from the	NA	NA
Kuwait National Implementation Plan to the Stockholm Convention ...	No	NR	Not included from the	NA	NA
Fisheries and Aquaculture - openasfa.title - FAO	No	NR	Not included from the	NA	NA
PIC Circular LI (51) - June 2020	No	NR	Not included from the	NA	NA
Levels of persistent organic pollutants (POPs) in foods from the first ...	No	NR	Not included from the	NA	NA
Chemical risks and JECFA - Food safety and quality	No	NR	Not included from the	NA	NA
Plant Production and Protection Newsletter, June 2022 - Issue #10	No	NR	Not included from the	NA	NA
codex alimentarius commission	No	NR	Not included from the	NA	NA
~~Fisheries and Aquaculture - openasfa.title - FAO~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~FAO - Food and Agriculture Organization~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Levels of persistent organic pollutants (POPs) in foods from the first ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Report 14 - Hazards associated with animal feed	No	NR	Not included from the	NA	NA
Report on the eel stock and fishery in Germany 2007	No	NR	Not included from the	NA	NA
~~PIC Circular LI (51) - June 2020~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Spatial distribution of soil pollution in Asia and the Pacific	No	NR	Not included from the	NA	NA
Pic Circular XLI June 2015	No	NR	Not included from the	NA	NA
rep23/cf16 programme mixte fao/oms sur les normes alimentaires ...	No	L	Not included from the	NA	NA
DRAFT REP23/CF16 1 INTRODUCTION 1. Le Comité du Codex sur ...	No	L	Not included from the	NA	NA
~~Fisheries and Aquaculture - openasfa.title - FAO~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Levels of persistent organic pollutants (POPs) in foods from the first ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
~~Report 14 - Hazards associated with animal feed~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
The protective functions of forests in a changing climate - FAO	No	NR	Not included from the	NA	NA
Planification participative de l'utilisation des terres dans des ...	No	L	Not included from the	NA	NA
Thailand's Readiness for E-Agriculture Strategy, Perspective from ...	No	NR	Not included from the	NA	NA
Investing in carbon neutrality: Utopia or the new green wave?	No	NR	Not included from the	NA	NA
More water, new hope | Storie della FAO | Food and Agriculture ...	No	NR	Not included from the	NA	NA
Sources of soil pollution in North America	No	NR	Not included from the	NA	NA
Search - Food and Agriculture Organization of the United Nations	No	NR	Not included from the	NA	NA
Untitled	No	NR	Not included from the	NA	NA
FAO Biotechnology Glossary in Vietnamese	No	NR	Not included from the	NA	NA
Revisiting the "Magic Box"	No	NR	Not included from the	NA	NA
Desarrollo de Estrategias para el incremento del consumo de ...	No	L	Not included from the	NA	NA
Manual de mejoramiento por mutaciones	No	L	Not included from the	NA	NA
Joint Expert Committee on Food Additives (JECFA)					
Search results: Search ceased. Same search results as obtained obove in the search of Food Agriculture Organization of the United Nations (FAO)					
Food Agriculture Organization of the United Nations (FAO) - Food and Safety Quality					
Search results: Nil for PFOS, PFOA, PFHxS, PFBS and GenX					
European Food Safety Authority (EFSA)					
Search results: 65 for PFOS (2 for scientific output), 41 for PFOA (1 for scientific output), 7 for PFHxS (Nil for scientific output), 3 for PFBS (Nil for scientific output), and Nil for GenX					
Search cut-off: Only results from scientific output and first 10 results for each PFAS shown (duplicates not shown)					
Perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) andtheir salts. Scientific Opinion of the Panel on Contaminants in the Food chain1	Yes	-	EFSA (2008)	Yes. Outdated	Not included. Superceded TDI
Assessment of endocrine disruptive properties of PFOS: EFSA/ECHA guidance case study utilising AOP networks and alternative methods	No	NR	Not included from the	NA	NA
EFSA opinion on two environmental pollutants (PFOS and PFOA) present in food	No	NR	Not included from the	NA	NA
Contaminants update: first of two opinions on PFAS in food	No	NR	Not included from the	NA	NA
PFAS public consultation: draft opinion explained	No	NR	Not included from the	NA	NA
PFAS in food: EFSA assesses risks and sets tolerable intake	No	Link	Not included from the	NA	NA
Risk to human health related to the presence of perfluoroalkyl substances in food	Yes	-	EFSA (2020a)	**Yes.**	Included. TDI available
Outcome of a public consultation on the draft risk assessment of perfluoroalkyl substances in food	No	NR	Not included from the	NA	NA
Risk to human health related to the presence of perfluoroalkyl substances in food	Yes	-	EFSA (2018a)	Yes. Outdated	Not included. Superceded TDI
87th Advisory Forum Meeting	No	NR	Not included from the	NA	NA
Workshop: draft scientific opinion on the risks to human health related to the presence of perfluoroalkyl substances in food	No	NR	Not included from the	NA	NA
126th Plenary meeting of the CONTAM Panel	No	NR	Not included from the	NA	NA
8th meeting of the FCM Network	No	NR	Not included from the	NA	NA
EFSA International Workshop on Risk Assessment of Combined Exposure to Multiple Chemicals	No	NR	Not included from the	NA	NA
EU-FORA – The European Food Risk Assessment Fellowship Programme	No	NR	Not included from the	NA	NA
98th Plenary meeting of the CONTAM Panel – Breaking news	No	NR	Not included from the	NA	NA
US Environment Detection Agency (USEPA)					
Search results: 3,008 for PFOS, 2,413 for PFOA, 185,590 for PFHxS, 903 for PFBS, and 3,397 for GenX					
Search cut-off: Only results from first 30 results for each PFAS (duplicates not shown) and following links to provided on webpapes (see indented title of result and purple text)					
Per- and Polyfluoroalkyl Substances (PFAS)	No	Links only	Not included from the	NA	NA
PFAS Resources, Data and Tools	No	Links only	Not included from the	NA	NA
GenX and PFAS Resources in EPA's Health & Environmental Research Online (HERO)	No	NR	Not included from the	NA	NA
Human Health Toxicity Assessment for GenX Chemicals	No	Links only	Not included from the	NA	NA
Fact Sheet: Human Health Toxicity Assessment for GenX Chemicals (pdf) (166.39 KB, October 2021)	Yes	-	USEPA 2021f	Yes. Summary	Not included. RfD for GenX available. Summary Document. Refer to USEPA (2021d, e)
Technical Fact Sheet: Human Health Toxicity Assessment for GenX Chemicals (pdf) (219.47 KB, October 2021)	Yes	-	USEPA 2021d	Yes. Summary	Not included. RfD for GenX available. Refer to USEPA (2021e)
Final Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (CASRN 13252-13-6 and CASRN 62037-80-3	Yes	-	USEPA 2021e	**Yes.**	Included. RfD for GenX available.
EPA Response to Public Comments on Draft Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (CA	Yes	-	USEPA 2021h	No	Not included. No guidance or guideline values. Coment document.
EPA Response to Additional Focused External Peer Review of Draft Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and I	Yes	-	USEPA 2021g	No	Not Included. Comments of Appropiate GenX RfD.
Draft Toxicity Assessment for GenX Chemicals (pdf) (558.82 KB, November 2018)	Yes	-	USEPA 2018a Draft Tox	Yes. Outdated	Not included. RfDs available. Summary Document. Refer to USEPA (2018d)
Technical Fact Sheet: Draft Toxicity Assessments for GenX Chemicals (pdf) (727.77 KB, December 2018)	Yes	-	USEPA 2018b	Yes. Outdated	Not included. RfDs available. Summary Document. Refer to USEPA (2021d, e)
Federal Register Notice: Request for Public Review and Comment: Draft Human Health Toxicity Assessments for Hexafluoropropylene Oxide Dimer Acid a	Yes	-	USEPA 2018c	No	Not Included. No RfDs or HAs.
Draft Toxicity Assessment: Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (CASRN 13252-13-6 a	Yes	-	USEPA 2018d	Yes. Outdated	Not included. Draft RfD for GenX available. Refer to USEPA (2021d, e)
Response to External Peer Review Comments on the Draft Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammo	Yes	-	USEPA 2018e	No	Not Included. No RfDs or HAs. Comments
Human Health Toxicity Assessment for PFBS	No	Links only	Not included from the	NA	NA
Fact Sheet: Toxicity Assessment for PFBS (4 pp, 104 K, About PDF)	Yes	-	USEPA 2021i	Yes. Summary	Not included. RfD available Summary document. Refer USEPA (2021c)
Technical Fact Sheet: Toxicity Assessment for PFBS (7 pp, 221 K, About PDF)	Yes	-	USEPA 2021j	Yes. Summary	Not included. RfD available Summary document. Refer USEPA (2021c)
Press Release announced the final Human Health Toxicity Assessment for PFBS (Apr 8, 2021)	No	Links only	Not included from the	NA	NA
Human Health Toxicity Values for Perfluorobutane Sulfonic Acid and Related Compound Potassium Perfluorobutane Sulfonate	No	Links only	Not included from the	NA	NA
Human Health Toxicity Values for Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (	Yes	-	USEPA 2021c	**Yes.**	Included. RfD for PFBS available. Also see USEPA (2021k)
Human Health Toxicity Values for Perfluorobutane Sulfonic Acid and Related Compound Potassium Perfluorobutane Sulfonate (Public Comment D	Yes	-	USEPA 2018f	Yes. Outdated	Not included. RfD available for PFBS.
Final Report & Supporting Materials for the 2021 Human Health Toxicity Assessment for PFBS	No	NPA	Not included from the	NA	NA
Report & Supporting Materials for the 2018 draft Human Health Toxicity Assessment for PFBS	No	NPA	Not included from the	NA	NA
Health & Environmental Research Online (HERO)	No	NR	Not included from the	NA	NA
Interim Recommendations for Addressing Groundwater Contaminated with PFOA and PFOS	No	NR	Not included from the	NA	NA
Contact Us About PFOA, PFOS and Other PFAS	No	NR	Not included from the	NA	NA
Aquatic Life Criteria - Perfluorooctane Sulfonate (PFOS)	No	Not HH	Not included from the	NA	NA
Drinking Water Health Advisories for PFOA and PFOS	No	Links only	Not included from the	NA	NA
Press Release (June 15, 2022)	No	NPA	Not included from the	NA	NA
Drinking Water Health Advisories for PFAS Fact Sheet for Communities (PFOA, PFOS, GenX Chemicals and PFBS) (pdf) (all languages)	Yes	-	USEPA 2022a	Yes. Summary	Not included. Interim HAs available Summary document.
Questions and Answers: HAs for PFOA, PFOS, GenX Chemicals and PFBS	No	NPA	Not included from the	NA	NA
Drinking Water Health Advisories for PFAS Fact Sheet for Public Water Systems (PFOA, PFOS, GenX Chemicals and PFBS) (pdf)	Yes	-	USEPA 2022b	Yes. Summary	Not included. Interim HAs and LORs available. Summary document.
Utility Webinar: Drinking Water Health Advisories for Four Per- and Polyfluoroalkyl Substances (PFAS) PFOA, PFOS, GenX chemicals, and PFBS (English) (pdf)	No	NPA	Not included from the	NA	NA
Drinking Water Health Advisories for Four Per- and Polyfluoroalkyl Substances (PFAS) PFOA, PFOS, GenX chemicals, and PFBS (English) (pdf)	Yes	-	Not downloaded.	Yes. Summary	Not included. Interim HAs and LORs available Summary document. Refer USEPA (2022c)

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX Chemicals, and PFBS) (pdf) (342.87 KB, June 2022, EPA 822-F-22-002)	Yes	-	USEPA 2022c	**Yes. Supporting Document**	Included. Interim HAs and RfDs available. Refer to USEPA (2022d,e,j&k)
Interim Drinking Water Health Advisory: Perfluorooctanoic Acid (PFOA) CASRN 335-67-1 (pdf) (612.13 KB, June 2022, EPA 822-R-22-003)	Yes	-	USEPA 2022d	**Yes**	Included. Interim HAs and RfDs available.
External Peer Review Draft: Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctanoic Acid (PFOA) (CASRN 335-67-1)	Yes	-	USEPA 2021a	**Yes. Supporting Document**	Included. Draft Document for public coment. Supports USEPA (2022d)
Interim Drinking Water Health Advisory: Perfluorooctane Sulfonic Acid (PFOS) CASRN 1763-23-1 (pdf) (622.38 KB, June 2022, EPA 822-R-22-004)	Yes	-	USEPA 2022e	**Yes**	Included. Interim HAs and RfDs available.
External Peer Review Draft: Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctane Sulfonic Acid (PFOS) (CASRN 176	Yes	-	USEPA 2021b	**Yes. Supporting Document**	Included. Draft Document for public coment. Supports USEPA (2022e)
Fact Sheet on PFOA and PFOS Drinking Water Health Advisories (pdf) (November 2016)	Yes	-	USEPA 2016a	Yes. Outdated	Not included. Interim HAs available. Summary document. Refer USEPA (216c, 2016e)
EPA Memorandum "Clarification about the Appropriate Application of the PFOA and PFOS Drinking Water Health Advisories" (pdf) (November 2016)	Yes	-	USEPA 2016b	No	Not included. Clarification on use of Interim HAs.
FR Notice on the Health Advisories for PFOA and PFOS (May 25, 2016)	Yes	-	USEPA 2016h	Yes. Outdated	Not included. Interim HAs available. Summary document. Refer USEPA (216c, 2016e)
2016 PFOA Health Advisory (pdf)	Yes	-	USEPA 2016c	Yes. Outdated	Not included. Interim HAs and RfDs available for PFOA. Also refer to USEPA (2016d) if neded for RfD info
2016 PFOA Health Effects Support Document (pdf)	Yes	-	USEPA 2016d	Yes. Outdated	Not included. RfDs available for PFOA.
2016 PFOS Health Advisory (pdf)	Yes	-	USEPA 2016e	Yes. Outdated	Not included. Interim HAs and RfDs available for PFOS. Also refer to USEPA (2016f) if neded for RfD info
2016 PFOS Health Effects Support Document (pdf)	Yes	-	USEPA 2016f	Yes. Outdated	Not included. RfDs available for PFOS.
2016 EPA Response to Peer Review Comments (pdf)	Yes	-	USEPA 2016g	No	Not included. Comments document
2009 Provisional Health Advisory (pdf)	Yes	-	USEPA 2009	Yes. Outdated	Not included. Interim HAs and RfDs available for PFOS. Summary Document
2014 Draft Health Effects Document for Perfluorooctanoic Acid (PFOA)	Yes	-	USEPA 2014a	Yes. Outdated	Not included. RfDs available for PFOA.
2014 Draft Health Effects Document for Perfluorooctane Sulfonate (PFOS)	Yes	-	USEPA 2014b	Yes. Outdated	Not included. RfDs available for PFOS.
Peer Reviewer Summary Report: External Peer Review of EPA's Draft Health Effects Documents for Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFO	Yes	-	USEPA 2014c	No	Not included. Peer review document. Coments Document.
Proposed Designation of Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS) as CERCLA Hazardous Substances	No	NR	Not included from the	NA	NA
EPA Advances Science to Protect the Public from PFOA and PFOS in Drinking Water	No	NR	Not included from the	NA	NA
~~Health Effects Document for Perfluorooctane Sulfonate (PFOS)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Emerging Contaminants Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA)	No	NR	Not included from the	NA	NA
Peer Review of Health Effects Documents for PFOA and PFOS	Yes	-	USEPA 2014d	No	Not included. Peer review document. Coments Document.
PFOS and PFOS: Analytics | Science Inventory | US EPA	No	NR	Not included from the	NA	NA
PFOA y PFOS - PREGUNTAS Y RESPUESTAS	No	L	Not included from the	NA	NA
PFOS Chromium Electroplater Study	No	NR	Not included from the	NA	NA
PFOs Chromium Electroplater Study Final Report	No	NR	Not included from the	NA	NA
PFOS and PFOSA in Bottlenose Dolphins: An Investigation into Two Unusually High Mortality Epizootics | Science Inventory | US EPA	No	Not HH	Not included from the	NA	NA
EPA Announces Proposed Decision to Regulate PFOA and PFOS in Drinking Water	No	NR	Not included from the	NA	NA
PFOS and PFOSA in Bottlenose Dolphins: An Investigation into Two Unusually High Mortality Events | Science Inventory | US EPA	No	Not HH	Not included from the	NA	NA
PFOS and PFOSA in Bottlenose Dolphins: An Investigation into Two Unusual Mortality Epizootics (WDA) | Science Inventory | US EPA	No	Not HH	Not included from the	NA	NA
PFOS and PFOSA in Bottlenose Dolphins: An Investigation into Two High Mortality Epizootics (NRMMSTSN2009) | Science Inventory | US EPA	No	Not HH	Not included from the	NA	NA
Questions and Answers Drinking Water Health Advisories for PFOA, PFOS, GenX Chemicals and PFBS	No	NR	Not included from the	NA	NA
Questions and Answers Drinking Water Health Advisories for PFOA, PFOS, GenX Chemicals and PFBS	No	NR	Not included from the	NA	NA
Avisos de salud sobre el PFOA y PFOS en el agua potable	No	L	Not included from the	NA	NA
What They Are Saying EPA Announces Proposed Decision to Regulate PFOA and PFOS in Drinking Water	No	NR	Not included from the	NA	NA
HOJA INFORMATIVA Presencia de PFOA y PFOS en el agua potable Avisos de salud	No	L	Not included from the	NA	NA
Avisos de salud sobre las PFAS para el PFOA, el PFOS, las sustancias químicas GenX, el PFBS	No	L	Not included from the	NA	NA
PFOA and PFOS: Treatment and Analytics | Science Inventory | US EPA	No	NR	Not included from the	NA	NA
DEVELOPMENTAL TOXICITY OF PFOS AND PFOA | Science Inventory | US EPA	No	NR	Not included from the	NA	NA
Sorption of PFOA and PFOS to Aquifer Sediment | Science Inventory | US EPA	No	NR	Not included from the	NA	NA
~~Health Effects Document for Perfluorooctane Sulfonate (PFOS) | Science Inventory | US EPA~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
During its years of operation, the Washington County Sanitary Landfill near St. Paul, Minnesota accepted both municipal and industrial solid waste. Several years of ground	No	NR	Not included from the	NA	NA
Multigenerational PFOS exposure in zebrafish (Danio rerio) | Science Inventory | US EPA	No	Not HH	Not included from the	NA	NA
~~Drinking Water Health Advisories for PFOA and PFOS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Per- and Polyfluoroalkyl Substances (PFAS)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Aquatic Life Criteria - Perfluorooctanoic Acid (PFOA)	No	Not HH	Not included from the	NA	NA
~~Proposed Designation of Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS) as CERCLA Hazardous Substances~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Health Effects Document for Perfluorooctanoic Acid (PFOA)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Emerging Contaminants Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Health Effects Document for PFOA (Perfluorooctanoic Acid) | Science Inventory | US EPA~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Emerging Contaminants Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Drinking Water Health Advisories for PFOA and PFOS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Superfund	No	NR	Not included from the	NA	NA
Perfluorooctanoic Acid (PFOA) Site Related Environmental Assessment Program Status Report July 25, 2007 to August 2008	No	NR	Not included from the	NA	NA
~~Health Effects Support Document for Perfluorooctanoic Acid (PFOA)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Emerging Contaminants Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Health Effects Document for PFOA (Perfluorooctanoic Acid) | Science Inventory | US EPA~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Technical Fact Sheet Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA) November 2017~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Contact Us About PFOA, PFOS and Other PFAS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~INTERIM Drinking Water Health Advisory: Perfluorooctanoic Acid (PFOA) CASRN 335-67-1~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Developmental Toxicity of Perfluorooctanoic Acid (Pfoa) After Cross Foster and Restricted Gestational Exposures. | Science Inventory | US EPA	No	Study	Not included from the	NA	NA
Modeling the Pharmacokinetics of Perfluorooctanoic Acid (PFOA) During Gestation and Lactation in Mice | Science Inventory | US EPA	No	Study	Not included from the	NA	NA
Final Aquatic Life Ambient Water Quality Criteria for Perfluorooctanoic Acid (PFOA) June 2023	No	Not HH	Not included from the	NA	NA
Draft Aquatic Life Ambient Water Quality Criteria for Perfluorooctanoic Acid (PFOA) April 2022	No	Not HH	Not included from the	NA	NA
Toxicity of Perfluorooctane Sulfonate (PFOS), Perfluorooctanoic Acid (Pfoa), and Related Organic Fluorochemicals | Science Inventory | US EPA	No	Project summary	A host of organic fluor	NA	NA
EFFECTS OF PERFLUOROOCTANOIC ACID (PFOA) ON MICE EXPOSED IN UTERO AT SPECIFIC GESTATIONAL STAGES | Science Inventory | US EPA	No	Study	Not included from the	NA	NA
Testing the Uterotrophic Activity of Perfluorooctanoic Acid (PFOA) in the Immature CD-1 Mouse | Science Inventory | US EPA	No	Study	Not included from the	NA	NA
Extent of Sorption and Biodegradability of Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS) in Aquifer Sediment | Science Inventory | US EPA	No	Not HH	Not included from the	NA	NA
Extent of Sorption and Biodegradation of Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic Acid (PFOS) in Aquifer Sediment | Science Inventory | US EPA	No	Not HH	Not included from the	NA	NA
E.I. DuPont de Nemours and Company PFOA Settlements	No	NR	Not included from the	NA	NA
Disposition of Perfluorooctanoic Acid (PFOA) in Pregnant and Lactating CD-1 Mice and Their Pups | Science Inventory | US EPA	No	Study	Not included from the	NA	NA
Extent of Sorption and Biodegradability of Perfluorooctanoic Acid (PFOA) and Perfluorooctanesulfonic acid (PFOS) in Aquifer Sediment (Maryland) | Science Inventory | US	No	Not HH	Not included from the	NA	NA
An Evaluation of Gestational Exposure to Perfluorooctanoic Acid (PFOA): Effects on Body Composition and Physiological Factors | Science Inventory | US EPA	No	Study	Not included from the	NA	NA

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
PFHxS (355-46-4) | Health & Environmental Research Online (HERO) | US EPA	No	Study links	Not included from the	NA	NA
PFHxS and Developmental Neurotoxicity: Does Thyroid Hormone Action Play a Role? | Science Inventory | US EPA	No	Study	Not included from the	NA	NA
IRIS Toxicological Review of Perfluorohexanesulfonic Acid (PFHxS) and Related Salts (Public Comment and External Review Draft) | Science Inventory | US EPA	No	Project plan summa	Not included from the	NA	NA
Systematic Review Protocol for the Perfluorohexanesulfonic Acid (PFHxS) IRIS Assessment (Preliminary Assessment Materials) | Science Inventory | US EPA	No	Protocol - study link	Not included from the	NA	NA
Exposure to PFOS, PFHxS, or PFHxA, but not GenX, Nafion BP1, or ADONA, Elicits Developmental Neurotoxicity in Larval Zebrafish | Science Inventory | US EPA	No	Not HH	Not included from the	NA	NA
Systematic Review Protocol for the PFBA, PFHxA, PFHxS, PFNA, and PFDA IRIS Assessments CASRN 335-76-2 (PFDA) CASRN 375-95-1 (PFNA) CASRN 307-24-4 (PFHxA) CASRN	No	Protocol - study link	Not included from the	NA	NA
EDG Database Entry - Ramjoh PFHxS Data	No	NR	Not included from the	NA	NA
Public Notices at U.S. EPA	No	NR	Not included from the	NA	NA
Toxicological Review of Perfluorohexanoic Acid (PFHxA) and Related Compounds Ammonium and Sodium Perfluorohexanoate (PFHxA-NH4 and PFHxA-Na) Supplemental In	No	NR	Not included from the	NA	NA
Toxicological Review for PFHxA (PDF) (250 pp, 1.30 M)	No	NR	USEPA 2023a	NA	NA
IRIS Executive Summary for PFHxA (PDF) (70 pp, 480 K)	No	NR	USEPA 2023b	NA	NA
Toxicological Review of Perfluorohexanoic Acid (PFHXA) and Related Salts - Supplemental Information	No	Links	Not included from the	NA	NA
Systematic Review Protocol for the PFAS IRIS Assessments (2021)	No	NR	Not included from the	NA	NA
~~Systematic Review Protocol for the Perfluorohexanoic Acid (PFHXA) IRIS Assessment (Preliminary Assessment Materials, 2019)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
IRIS Toxicological Review of Perfluorohexanoic Acid (PFHXA) and Related Salts (Public Comment and External Review Draft, 2022)	No	NR	USEPA 2022f	NA	NA
IRIS Toxicological Review of Perfluorohexanoic Acid (PFHXA) and Related Salts (Interagency Science Consultation Draft, 2021)	No	Archived	Not included from the	NA	NA
External Peer Review Activities for PFHXA Integrated Risk Information System (IRIS) Assessment (Feb 2022)	No	NPA	Not included from the	NA	NA
USEPA 2022h Toxicological Review of Perfluorohexanoic Acid (PFHXA) and Related Salts (Interagency Science Discussion Draft, 2023)	No	Archived	Not included from the	NA	NA
IRIS SummplementToxicological Review of Perfluorohexanoic Acid (PFHXA) and Related Salts (Public Comment and External Review Draft, 2022)	No	NR	USEPA 2022g	NA	NA
PFHxA (307-24-4) | Health & Environmental Research Online (HERO) | US EPA	No	Study	Not included from the	NA	NA
Assessing the effects of dietary exposure to PFOS and PFHxS in mummichogs (Fundulus heteroclitus) | Science Inventory | US EPA	No	NR	Not included from the	NA	NA
Perfluorohexane sulfonate (PFHxS) Induces Maternal Hypothyroxinemia but Does not Result in Developmental Neurotoxicity by a Thyroid-Mediated Mechanism | Science I	No	Study	Not included from the	NA	NA
Maternal Exposure to Perfluorohexane Sulfonate (PFHxS) Alters Glucose and Lipid Dynamics During the Postnatal Period in the Rat | Science Inventory | US EPA	No	Study	Not included from the	NA	NA
Exposure to PFOS, PFHxS, or PFHxA, but not GenX, ADONA, PFOA, or Nafion BP1 Elicits Developmental Neurotoxicity in Larval Zebrafish | Science Inventory | US EPA	No	Not HH	Not included from the	NA	NA
Developmental Exposure to Perfluorohexane Sulfonate (PFHxS) induces hypothyroxinemia in Rat Dams and Offspring: Examination of the Thyroid Gland and Behavior | Sci	No	Study	Not included from the	NA	NA
The Impact of Sample Timing and Study Confidence on Mean Birth Weight Differences Detected in a Meta-analysis of PFHxS | Science Inventory | US EPA	No	Study	Not included from the	NA	NA
Developmental Exposure to Perfluorohexane Sulfonate (PFHxS) Induces Hypothyroxinemia in Rat Dams and Offspring: Examination of Thyroid Gland and Behavior | Scienc	No	Study	Not included from the	NA	NA
Evaluating thyroid hormone disruption: Investigations of long-term neurodevelopmental effects in rats after perinatal exposure to perfluorohexane sulfonate (PFHxS) | Sci	No	Study	Not included from the	NA	NA
Systematic Review Protocol for the PFBA, PFHxA, PFHxS, PFNA, and PFDA (Anionic and Acid Forms) IRIS Assessments Supplemental Information Appendix A October 2019 U	No	Protocol	Not included from the	NA	NA
U.S.-Mexico Border Program	No	NR	Not included from the	NA	NA
EPA in the U.S. Virgin Islands	No	NR	Not included from the	NA	NA
U.S. Environmental Protection Agency	No	NR	Not included from the	NA	NA
Toxicological Review of Perfluorohexanoic Acid (PFHxA) and Related Compounds Ammonium and Sodium Perfluorohexanoate (PFHxA-NH4 and PFHxA-Na) [CASRN 307244	No	NR	Not included from the	NA	NA
Systematic Review Protocol for the Perfluorohexanoic Acid (PFHxA) IRIS Assessment (Preliminary Assessment Materials, 2019) | Science Inventory | US EPA	No	NR	Not included from the	NA	NA
Approved Air Quality Implementation Plans in the U.S. Virgin Islands	No	NR	Not included from the	NA	NA
EPA's Voluntary Methane Programs for the Oil and Natural Gas Industry	No	NR	Not included from the	NA	NA
External Peer Review Activities for PFHxA Integrated Risk Information System (IRIS) Assessment (Feb 2022) | Science Inventory | US EPA	No	NR	Not included from the	NA	NA
Toxicological Review of Perfluorohexanoic Acid (PFHxA) and Related Salts (Final Report, 2023) | Science Inventory | US EPA	No	NR	Not included from the	NA	NA
IRIS Toxicological Review of Perfluorohexanoic Acid (PFHxA) and Related Salts (External Review Draft) | Science Inventory | US EPA	No	NR	Not included from the	NA	NA
IRIS Toxicological Review of Perfluorohexanoic Acid (PFHxA) and Related Salts (External Review Draft) | Science Inventory | US EPA	No	NR	Not included from the	NA	NA
Drinking Water Health Advisories for GenX Chemicals and PFBS	No	Links only	Not included from the	NA	NA
Press Release (June 15, 2022)	No	NR	Not included from the	NA	NA
~~Federal Register Notice on Lifetime Drinking Water Health Advisories for Four Perfluoroalkyl Substances (June 21, 2022)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Drinking Water Health Advisories for PFAS Fact Sheet for Communities (PFOA, PFOS, GenX Chemicals and PFBS) (pdf)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Questions and Answers: HAs for PFOA, PFOS, GenX Chemicals and PFBS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Drinking Water Health Advisories for PFAS Fact Sheet for Public Water Systems (PFOA, PFOS, GenX Chemicals and PFBS) (pdf)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX Chemicals, and PFBS) (pdf) (342.87 KB, June 2022, EPA 822-F-22-002)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Drinking Water Health Advisory: Hexafluoropropylene Oxide (HFPO) Dimer Acid (CASRN 13252-13-6) and HFPO Dimer Acid Ammonium Salt (CASRN 62037-80-3), Also I	Yes	-	USEPA 2022j	**Yes**	Included. Interim HAs and RfDs available.
~~Final Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (CASRN 13252-13-6 and CASRN 62037-80-3) Also Known~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Drinking Water Health Advisory: Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-49-3)	Yes	-	USEPA 2022k	**Yes.**	Included. RfD for PFBS available. Also see USEPA (2021k)
~~Human Health Toxicity Values for Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-49-3)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
PFBS (375-73-5) | Health & Environmental Research Online (HERO) | US EPA	No	Study links	Not included from the	NA	NA
Learn about the Human Health Toxicity Assessment for PFBS	No	Baisc	Not included from the	NA	NA
~~Fact Sheet: Toxicity Assessment for PFBS (4 pp, 104 K, About PDF)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Technical Fact Sheet: Toxicity Assessment for PFBS (7 pp, 221 K, About PDF)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Press Release announced the final Human Health Toxicity Assessment for PFBS (Apr 8, 2021)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Final Report & Supporting Materials for the 2021 Human Health Toxicity Assessment for PFBS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Report & Supporting Materials for the 2018 draft Human Health Toxicity Assessment for PFBS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Report The EPA's January 2021 PFBS Toxicity Assessment Did Not Uphold the Agency's Commitments to Scientific Integrity and Information Quality	No	Links only	Not included from the	NA	NA
Report At a Glance (pdf) (298.95 KB)	Yes	-	USEPA 2023c	No	Not included. No guidance/guideline values.
Full Report (pdf) (1.6 MB)	Yes	-	USEPA 2023d	No	Not included. No guidance/guideline values.
Update: EPA Response to Report (pdf) (219.37 KB)	Yes	-	USEPA 2023e	No	Not included. No guidance/guideline values.
Update: IG Response (pdf) (196.89 KB)	Yes	-	USEPA 2023f	No	Not included. No guidance/guideline values.
~~Fact Sheet: Draft Toxicity Assessments for Genx Chemicals and PFBS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Human Health Toxicity Assessment for Perfluorobutane Sulfonic Acid (PFBS; CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-	No	NR	Not included from the	NA	NA
Drinking Water Health Advisories for Four Per- and Polyfluoroalkyl Substances (PFAS) PFOA, PFOS, GenX chemicals, and PFBS (English)	No	NR	Not included from the	NA	NA
Notification EPA's January 2021 PFBS Toxicity Assessment	No	NR	Not included from the	NA	NA
EPA Requires Reporting on Releases and Other Waste Management of Certain PFAS, Including PFBS	No	NR	Not included from the	NA	NA
EPA News Release EPA Requires Reporting on Releases and Other Waste Management of Certain PFAS, Including PFBS	No	NR	Not included from the	NA	NA
Questions and Answers Drinking Water Health Advisories for PFOA, PFOS, GenX Chemicals and PFBS	No	NPA	Not included from the	NA	NA
Podcast Overview of OIG Report The EPA's January 2021 PFBS Toxicity Assessment Did Not Uphold the Agency's Commitments to Scientific Integrity and Information Qualit	No	NR	Not included from the	NA	NA
Avisos de salud sobre las PFAS para el PFOA, el PFOS, las sustancias químicas GenX, el PFBS	No	Links	Not included from the	NA	NA
Approaches to Hazard and Dose-Response Assessment of PFAS: PFBS Example | Science Inventory | US EPA	No	NR	Not included from the	NA	NA
Complexity of fetal thyroid hormone economy during gestation: Lessons learned from the assessment of in utero exposure to PFBS. | Science Inventory | US EPA	No	NR	Not included from the	NA	NA

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
Human Health Toxicity Assessment for Perfluorobutane Sulfonic Acid (PFBS; CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Human Health Toxicity Assessment for Perfluorobutane Sulfonic Acid (PFBS; CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
EPA's January 2021 PFBS Toxicity Assessment Did Not Uphold the Agency's Commitments to Scientific Integrity and Information Quality	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Provisional Peer-Reviewed Toxicity Values for Perfluorobutane Sulfonic Acid (PFBS) and Related Compound Potassium Perfluorobutane Sulfonate | Science Inventory | US	Yes	-	USEPA (2021k)	Yes	Included
Technical Fact Sheet Drinking Water Health Advisories for Four PFAS PFOA PFOS GenX chemicals and PFBS June 2022	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
EPA's Office of Inspector General	No	NR, Links repeated	Not included from the	NA	NA
EPA's Office of Inspector General	No	Link not working	Not included from the	NA	NA
~~At a Glance: The EPA's January 2021 PFBS Toxicity Assessment Did Not Uphold the Agency's Commitments to Scientific Integrity and Information Quality~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
EDG Database Entry - PFBS tissue concentrations and liver gene expression in mice	No	Study	Not included from the	NA	NA
Pharmacokinetic Profile of Perfluorobutane Sulfonate and Activation of Hepatic Nuclear Receptor Target Genes in Mice (Journal) | Science Inventory | US EPA	No	Study	Not included from the	NA	NA
Pharmacokinetic Profiles of Perfluorobutane Sulfonate and Activation of Hepatic Genes in Mice (Presentation) | Science Inventory | US EPA	No	Study	Not included from the	NA	NA
Human Health Toxicity Values for Perfluorobutane Sulfonic Acid and Related Compound Potassium Perfluorobutane Sulfonate (Public Comment Draft, 2018) | Science Inve	No	Links	Not included from the	NA	NA
Human Health Toxicity Values for Perfluorobutane Sulfonic Acid and Related Compound Potassium Perfluorobutane Sulfonate (Public Comment Draft) (PDF, 151 pp,	Yes	-	USEPA 2018f		Not included. Outdated
News Release: Nov 14, 2018	No	NR	Not included from the	NA	NA
Fact Sheet: PFBS Human Toxicity (PDF, 6 pp, 572 KB, about PDF)	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Technical Fact Sheet: Draft Assessment for PFBS (PDF, 9 pp, 745 KB, about PDF)	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
EPA Response to Peer Review Comments on the 2018 Draft Report (PDF, 68 pp, 576 KB, about PDF)	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
HERO: Collected scientific literature on PFBS toxicity	No	Study links	Not included from the	NA	NA
FR Notice: Nov 21, 2018	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Drinking Water Health Advisories for PFAS Fact Sheet for Communities (PFOA, PFOS, GenX Chemicals and PFBS)	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Technical Fact Sheet Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX Chemicals, and PFBS)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
U.S. EPA, Pesticides, Label, SINESTO PFB, 5/21/2010	No	NR	Not included from the	NA	NA
U.S. EPA, Pesticides, Label, SINESTO PFB, 2/10/2009	No	NR	Not included from the	NA	NA
Chemours 2022 RFC 22001 - GenX Chemicals Toxicity Assessment	No	NR	Not included from the	NA	NA
Human Health Toxicity Assessments for GenX Chemicals	No	Links	Not included from the	NA	NA
~~Fact Sheet: Human Health Toxicity Assessment for GenX Chemicals (pdf) (166.39 KB, October 2021)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Technical Fact Sheet: Human Health Toxicity Assessment for GenX Chemicals (pdf) (219.47 KB, October 2021)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Final Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (CASRN 13252-13-6 and CASRN 62037-80-3) Also Known~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~EPA Response to Public Comments on Draft Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (CASRN 13252-1~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~EPA Response to Additional Focused External Peer Review of Draft Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammoniu~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Draft Toxicity Assessment for GenX Chemicals (pdf) (558.82 KB, November 2018)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Technical Fact Sheet: Draft Toxicity Assessments for GenX Chemicals (pdf) (727.77 KB, December 2018)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Federal Register Notice: Request for Public Review and Comment: Draft Human Health Toxicity Assessments for Hexafluoropropylene Oxide Dimer Acid and its Ammo~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Draft Toxicity Assessment: Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (CASRN 13252-13-6 and CASRN 62~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Response to External Peer Review Comments on the Draft Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (C~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Drinking Water Health Advisories for GenX Chemicals and PFBS	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Third Party Correspondence to RFC #22001 - GenX Chemicals Toxicity Assessment Response to Chemours Request for Correction of GenX Toxicity Assessment	No	NR	Not included from the	NA	NA
Questions and Answers Drinking Water Health Advisories for PFOA, PFOS, GenX Chemicals and PFBS	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
GenX Chemicals (CASRN 13252-13-6 and CASRN 62037-80-3) | Health & Environmental Research Online (HERO) | US EPA	No	Study links	Not included from the	NA	NA
Technical Fact Sheet Drinking Water Health Advisories for Four PFAS PFOA PFOS GenX chemicals and PFBS June 2022	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Fact Sheet: Draft Toxicity Assessments for Genx Chemicals and PFBS	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Drinking Water Health Advisories for Four Per- and Polyfluoroalkyl Substances (PFAS) PFOA, PFOS, GenX chemicals, and PFBS (Spanish)	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Drinking Water Health Advisories for Four Per- and Polyfluoroalkyl Substances (PFAS) PFOA, PFOS, GenX chemicals, and PFBS (Spanish)	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Climate Change Adaptation Resource Center (ARC-X)	No	NR	Not included from the	NA	NA
EPA Response to RFC 22001 - GenX Chemicals Toxicity Assessment	No	NR	Not included from the	NA	NA
GenX and Other Chemicals of Emerging Concern | Science Inventory | US EPA	No	Presentation	Not included from the	NA	NA
Third Party Correspondence to RFC #22001 – GenX Chemicals Toxicity Assessment; EPA issued advisories	No	NR	Not included from the	NA	NA
Avisos de salud sobre las PFAS para el PFOA, el PFOS, las sustancias químicas GenX, el PFBS	No	L	Not included from the	NA	NA
GenX (FRD-902, ammonium (2,3,3,3-tetrafluoro-2-(heptafluoropropoxy)propanoate) Does Not Display Estrogenic, (anti)androgenic or Glucocorticoid-like Activity In Vitro W	No	Study	Not included from the	NA	NA
Gen-X Energy Group, Inc. Related Administrative Settlement Agreements	No	NR	Not included from the	NA	NA
Dosimetry and Potential Bioaccumulation of a GenX Oligomer HFPO-TeA | Science Inventory | US EPA	No	Study	Not included from the	NA	NA
Everything you wanted (and Didn't Want) to know about GenX and your Drinking Water | Science Inventory | US EPA	No	Presentation	Not included from the	NA	NA
Latent, sex-specific metabolic health effects in CD-1 mouse offspring exposed to PFOA or HFPO-DA (GenX) during gestation | Science Inventory | US EPA	No	Study	Not included from the	NA	NA
~~Exposure to PFOS, PFHxS, or PFHxA, but not GenX, Nafion BP1, or ADONA, Elicits Developmental Neurotoxicity in Larval Zebrafish | Science Inventory | US EPA~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
In utero exposure to hexafluoropropylene oxide-dimer acid (GenX) produces low birth weight and neonatal mortality | Science Inventory | US EPA	No	Study	Not included from the	NA	NA
Adverse maternal, fetal, and postnatal effects of Hexafluoropropylene oxide dimer acid (GenX) from oral gestational exposure in Sprague Dawley rats | Science Inventory |	No	Study	Not included from the	NA	NA
~~Exposure to PFOS, PFHxS, or PFHxA, but not GenX, ADONA, PFOA, or Nafion BP1 Elicits Developmental Neurotoxicity in Larval Zebrafish | Science Inventory | US EPA~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Adverse effects of oral gestational exposure to hexafluoropropylene oxide dimer acid (GenX) in the Sprague-Dawley rat | Science Inventory | US EPA	No	Study	Not included from the	NA	NA
Exposure to perfluorooctanoic acid (PFOA) or GenX during gestation disrupts maternal and fetal liver gene expression in CD-1 mice | Science Inventory | US EPA	No	Study	Not included from the	NA	NA
~~Adverse effects of oral gestational exposure to hexafluoropropylene oxide dimer acid (GenX) in the Sprague-Dawley rat- Presentation | Science Inventory | US EPA~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Developmental exposure to perfluorooctanoic acid (PFOA) or GenX disrupts biologic pathways in maternal and fetal liver in CD-1 mice | Science Inventory | US EPA	No	Study	Not included from the	NA	NA
Gene expression changes in maternal, fetal, and neonatal tissues from exposure to hexafluoropropylene oxide-dimer acid (HFPO-DA, GenX) | Science Inventory | US EPA	No	Study	Not included from the	NA	NA
~~Adverse effects of oral gestational exposure to hexafluoropropylene oxide dimer acid (GenX) in the Sprague-Dawley rat. SETAC | Science Inventory | US EPA~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Evaluation of Maternal, Embryo, and Placental Effects in CD-1 Mice following Gestational Exposure to Perfluorooctanoic Acid (PFOA) or Hexafluoropropylene Oxide Dimer A	No	Study	Not included from the	NA	NA
Food Safety Australia New Zealand (FSANZ)					
Search results: 25 for PFOS, 15 for PFOA, 11 for PFHxS, 3 for PFBS and Nil for GenX (or HFPO-DA)					
Search cut-off: Nil					
Appendix 3 - Summary of PFOS analytical results for 27th…	No	NR	Not included from the	NA	NA
Perfluorinated compounds	No	Links only	Not included from the	NA	NA
24th Australian Total Diet Study (ATDS) Phase 2	No	NR	Not included from the	NA	NA
27th ATDS	No	NR	Not included from the	NA	NA
PFAS and Immunomodulation: Review and Update	Yes	-	FSANZ (2021)	No	Not included. Refer to FSANZ (2017b). Summarises Agency TDIs
NSW EPA report.	No	NR	Not included from the	NA	NA

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
27th ATDS report	No	NR	Not included from the	NA	NA
~~PFAS and Immunomodulatory Review and Update 2021~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
27th Australian Total Diet Study	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Results of 27th Australian Total Diet Study released	No	Links only	Not included from the	NA	NA
Appendix 1 - Compounds analysed, analytical limits and…	No	NR	Not included from the	NA	NA
~~24th Total Diet Study_Phase 2~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Report on Emerging and Ongoing Issues – Annual Report 2018	No	NR	Not included from the	NA	NA
Report on Emerging and Ongoing Issues – 2017	No	NR	Not included from the	NA	NA
fsanz-annual-report-2019-20-accessible	No	NR	Not included from the	NA	NA
ATDS analysis summary	No	NR	Not included from the	NA	NA
FS News Spring_Summer 2009_FINAL _2_	No	NR	Not included from the	NA	NA
FSANZ Annual Report 2016-17 Other	No	NR	Not included from the	NA	NA
P1034 Packaging 1CFS SD3 Risk Profile Mar2016	No	NR	Not included from the	NA	NA
FSANZ Annual Report 2016-17 Preliminary information	No	NR	Not included from the	NA	NA
Food Standards Annual Report 2017-18	No	NR	Not included from the	NA	NA
FSANZ Annual Report 2016-17	No	Links only	Not included from the	NA	NA
Health-based guidance values for PFAS for use in site investigations in Australia	Yes	-	DOH 2017	**Yes**	Included. DWG available
Perfluorinated chemicals in food	No	Links only	Not included from the	NA	NA
Perfluorinated chemicals in food – consolidated report	Yes	-	FSANZ (2017a)	Yes. Summary	Not included. Refer to FSANZ (2017b)
Perfluorinated chemicals in food – summary of consolidated report	No	NR	Not included from the	NA	NA
Perfluorinated chemicals in food – hazard assessment – summary	No	NR	Not included from the	NA	NA
Perfluorinated chemicals in food – dietary exposure assessment – summary	No	NR	Not included from the	NA	NA
Perfluorinated chemicals in food – frequently asked questions	No	NR	FAQs only	NA	NA
perfluorinated-chemicals-in-food-hazard-assessment	Yes	-	FSANZ (2017b)	**Yes**	Included from Content Screen.TDI available.
Perfluorinated chemicals in food – hazard assessment – critical review of pharmacokinetic modelling	Yes	-	FSANZ (2017c)	No	Not included. Refer to FSANZ (2017b). Summarises Agency TDIs
Perfluorinated chemicals in food – hazard assessment – PFAS immunomodulation review	Yes	-	FSANZ (2017d)	No	Not included. Review of toxicity data only.
Perfluorinated chemicals in food – dietary exposure assessment	Yes	-	FSANZ (2017e)	Yes. Summary	Not included. Refer to FSANZ (2017b)
Perfluorinated chemicals in food – dietary exposure assessment – occurrence and dietary exposure literature review	No	NR	Not included from the	NA	NA
Perfluorinated chemicals in food – dietary exposure assessment – occurrence data report	No	NR	Not included from the	NA	NA
Perfluorinated chemicals in food – summary of other controls for perfluorinated chemicals	No	NR	Not included from the	NA	NA
Perfluorinated chemicals in food – criteria for the establishment of maximum levels in food	No	NR	Not included from the	NA	NA
~~Health-based guidance values for PFAS for use in site investigations in Australia~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
FSANZ Annual Report 2018-2019	No	NR	Not included from the	NA	NA
~~FSANZ Annual Report 2016-17 Chapter 4~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Survey of Chemical Migration from Food Contact Packaging…	No	NR	Not included from the	NA	NA
Appendix 5 - Detailed dietary exposure results for the 27…	No	NR	Not included from the	NA	NA
~~PFAS and Immunomodulatory Review and Update 2021~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Perfluorinated compounds~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Appendix 3 - Summary of PFOS analytical results for 27th…~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Appendix 1 - Compounds analysed, analytical limits and…~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~24th Total Diet Study_Phase 2~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Report on Emerging and Ongoing Issues – Annual Report 2018~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Report on Emerging and Ongoing Issues – 2017~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
FS News Spring_Summer 2009_FINAL _2_	No	NR	Not included from the	NA	NA
~~FSANZ Annual Report 2016-17 Other~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~P1034 Packaging 1CFS SD3 Risk Profile Mar2016~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~FSANZ Annual Report 2016-17 Preliminary information~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~FSANZ Annual Report 2016-17~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~FSANZ Annual Report 2016-17 Chapter 4~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Survey of Chemical Migration from Food Contact Packaging…~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS and Immunomodulatory Review and Update 2021~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Perfluorinated compounds~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Appendix 3 - Summary of PFOS analytical results for 27th…~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~27th ATDS report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Appendix 1 - Compounds analysed, analytical limits and…~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Report on Emerging and Ongoing Issues – Annual Report 2018~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Report on Emerging and Ongoing Issues – 2017~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~FSANZ Annual Report 2016-17 Other~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~FSANZ Annual Report 2016-17~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~FSANZ Annual Report 2016-17 Chapter 4~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Survey of Chemical Migration from Food Contact Packaging…~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Appendix 1 - Compounds analysed, analytical limits and…~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS and Immunomodulatory Review and Update 2021~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Survey of Chemical Migration from Food Contact Packaging…~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA

Australian Industrial Chemicals Introduction Scheme (AICIS)					
Search result: 1 for PFOS, PFHxS, and PFBS, 9 for PFOA and nil for GenX chemicals					
Per- and poly-fluorinated substances (PFAS)	No	Links only	Not included from the	NA	NA
National Industrial Chemicals Notification and Assessment Scheme (NICNAS) published 6 alerts between 2002 and 2008	No	NR	Not included from the	NA	NA
Perfluorobutanesulfonate (PFBS) and its direct precursors	Yes	-	NICNAS (2020a)	No	Not included. Does not identify a guideline/guidance value .
Indirect precursors of perfluorobutanesulfonate (PFBS)	Yes	-	NICNAS (2020b)	No	Not included. Does not identify a guideline/guidance value .
Perfluorooctanoic acid (PFOA) and its direct precursors	Yes	-	NICNAS (2015a)	No	Not included. Does not identify a guideline/guidance value .
Perfluorooctane sulfonate (PFOS) and its direct precursors	Yes	-	NICNAS (2015b)	No	Not included. Does not identify a guideline/guidance value .
Perfluoroalkyl sulfonates (PFSA) (>C8) and their direct precursors	Yes	-	NICNAS (2018a)	No	Not included. Does not identify a guideline/guidance value .

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
Perfluoroalkane sulfonates (PFSA) (C5-C7) and their direct precursors	Yes	-	NICNAS (2018b)	No	Not included. Does not identify a guideline/guidance value .
Short chain perfluorocarboxylic acids and their direct precursors	Yes	-	NICNAS (2016a)	No	Not included. Does not identify a guideline/guidance value .
Indirect precursors of perfluorooctane sulfonate (PFOS)	Yes	-	NICNAS (2016b)	No	Not included. Does not identify a guideline/guidance value .
Indirect precursors of perfluorooctanoic acid (PFOA)	Yes	-	NICNAS (2016c)	No	Not included. Does not identify a guideline/guidance value .
Perfluoroheptanoic acid and its direct precursors	No	NR	Not included from the	NA	NA
Indirect precursors of long-chain perfluorocarboxylic acids (PFCAs)	Yes	-	NICNAS (2019a)	No	Not included. Does not identify a guideline/guidance value .
Indirect precursors of short chain perfluorocarboxylic acids (PFCAs)	No	NR	Not included from the	NA	NA
Indirect precursors of perfluoroalkane sulfonic acids (PFSA) (C5-C7)	Yes	-	NICNAS (2020c)	No	Not included. Does not identify a guideline/guidance value .
Direct precursors to perfluorocyclohexane sulfonate and related perfluoroalkylcyclohexane sulfonates	Yes	-	NICNAS (2015c)	No	Not included. Does not identify a guideline/guidance value .
Perfluorinated derivatives of phosphonic and phosphinic acids	No	NR	Not included from the	NA	NA
6:2 Fluorotelomer siloxanes and silicones	No	NR	Not included from the	NA	NA
6:2 Fluorotelomer sulfonate derivatives	No	NR	Not included from the	NA	NA
Carbamic acid, [2-(sulfothio)ethyl]-, C-(.gamma.-.omega.-perfluoro-C6-9- alkyl) esters, monosodium salts	No	NR	Not included from the	NA	NA
Call for information: import or export of decaBDE, PFOA, its salts, and PFOA-related compounds at any time after 30 June 2022	No	NR	Not included from the	NA	NA
New rules coming mid-2023 on decaBDE, PFOA-related compounds	No	NR	Not included from the	NA	NA
~~Per- and poly-fluorinated substances (PFAS)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
decaBDE and PFOA-related compounds – authorisation required from 21 July 2023	No	NR	Not included from the	NA	NA
Chemicals listed in the Rotterdam and Stockholm Conventions	No	NR	Not included from the	NA	NA
Apply for annual import authorisation - Rotterdam Convention	No	NR	Not included from the	NA	NA
Consultation Hub	No	NR	Not included from the	NA	NA
Apply for annual export authorisation - Rotterdam Convention	No	NR	Not included from the	NA	NA
News and notices hub	No	NR	Not included from the	NA	NA
Australian Pesticides and Veterinary Medicine Authority (APVMA)					
Search result: Nil results for PFOS, PFOHxS, PFBS, PFOA and GenX chemicals					
IPCS Inchem Search					
Search results: 2 for PFOS, 3 for PFOA, 1 for PFBS, Nil for PFHxS and GenX					
Search cut-off (after irrelevant results)					
Some Chemicals Used as Solvents and in Polymer Manufacture (IARC Monograph, Volume 110, 2017)	Yes	-	IARC (2017)	No	Not included. Does not identify a guideline/guidance value .
Principles and methods for the risk assessment of chemicals in food - Chapter 5: Dose-Response Assessment and Derivation of Health-Based Guidance Values (EHC 240, Up	No	NR	Not included from the	NA	NA
~~Some Chemicals Used as Solvents and in Polymer Manufacture (IARC Monograph, Volume 110, 2017)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Perfluorooctanoic acid (ICSC)	No	NR	Not included from the	NA	NA
~~Principles and methods for the risk assessment of chemicals in food - Chapter 5: Dose-Response Assessment and Derivation of Health-Based Guidance Values (EHC 240, Up~~	~~NoR~~	~~Repeated~~	~~Chapter 5 Dose-respo~~	NA	NA
~~Some Chemicals Used as Solvents and in Polymer Manufacture (IARC Monograph, Volume 110, 2017)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Californian Office of Health and Hazard Assessment (OEHHA)					
Search results: 293 for PFOS, 202 for PFOA, 81 for PFHxS, 21 for PFBS, 10 for GenX					
Search cut-off: Only results from first 30 results for each PFAS (duplicates struckthrough) and links followed on webpapes (see indented title of result and purple text)					
Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonic Acid ...	No	Link	OEHHA held the webi	NA	NA
Second draft PHG for PFOA and PFOS	Yes	-	OEHHA (2023a)	**Yes**	Included. 2nd Draft DWGs
Second public review draft full notice	No	NR	Not included from the	NA	NA
Submit comments electronically	No	NR	Not included from the	NA	NA
Draft technical support document	Yes	-	OEHHA (2021a)	Yes. Outdated	Not included. 1st Draft DWGs. Refer to OEHHA (2023a)
First public review draft full notice	No	NR	Not included from the	NA	NA
Comment Submissions - Announcement of Availability of a Draft Technical Support Document and Public Workshop for Proposed Public Health Goals for Perfluorooct	No	NR	Not included from the	NA	NA
Workshop agenda	No	NR	Not included from the	NA	NA
Workshop slides	No	NR	Not included from the	NA	NA
Webinar agenda	No	NR	Not included from the	NA	NA
Notification levels for PFOA and PFOS	Yes	-	OEHHA (2019a)	**Yes**	Included. DWGs available
Initiation notice	No	NR	Not included from the	NA	NA
Information Submission - Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS) in Drinking Water 1	No	NR	Not included from the	NA	NA
Perfluorooctane sulfonate (PFOS) - OEHHA	No	NR	Not included from the	NA	NA
Evidence on the Carcinogenicity of PFOS and its salts and ...	Yes	-	OEHHA (2021b)	No	Not included. Does not identify a guideline/guidance value .
Notice to Interested Parties Chemicals Listed Effective December 24 ...	No	NR	Not included from the	NA	NA
Notice of Intent to List Perfluorooctanoic Acid (PFOA) and ...	No	NR	Not included from the	NA	NA
~~Perfluorooctane Sulfonate (PFOS) - OEHHA~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Perfluorooctane sulfonate (PFOS) and its salts and ...	No	NR	Not included from the	NA	NA
Perfluorooctane sulfonate (PFOS) and Its Salts and Transformation ...	No	Age	Not included from the	NA	NA
~~Notification Level Recommendations for Perfluorooctanoic Acid and ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Notification Level Recommendations for Perfluorooctanoic Acid ...	No	NR (Links)	Not included from the	NA	NA
Chemicals Listed Effective November 10, 2017 as Known to the ...	No	NR	Not included from the	NA	NA
~~Public Health Goals for Perfluorooctanoic Acid and Perfluorooctane ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Perfluorooctane Sulfonate (PFOS) - OEHHA~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Notice to Interested Parties. November 10, 2017	No	NR	Not included from the	NA	NA
Information Submission - Perfluorooctanoic Acid (PFOA) and ...	No	NR	Not included from the	NA	NA
Perfluorooctane Sulfonic Acid (PFOS) and Its Salts and ...	No	NR (Links)	Not included from the	NA	NA
Evidence on the Carcinogenicity of PFOS and its salts and ...	No	NR	Not included from the	NA	NA
Notice of Intent to List: Perfluorooctanoic acid (PFOA) and ...	No	NR	Not included from the	NA	NA
Epidemiologic studies of PFOA and PFOS	No	NR	Not included from the	NA	NA
Meeting Synopsis from the Carcinogen Identification Committee ...	No	NR	Not included from the	NA	NA
Announcement of Availability of a Draft Technical Support Document ...	No	NR	Not included from the	NA	NA
Chemicals Selected by OEHHA for Consideration for Listing by the ...	No	NR (Links)	Not included from the	NA	NA
Announcement of the Carcinogen Identification Committee Meeting ...	No	NR	Not included from the	NA	NA

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
Comment by Community Water Systems Alliance on Comment ...	No	NR	Not included from the	NA	NA
Comment Submissions - Notice of Availability of Hazard ...	No	NR	Not included from the	NA	NA
Public Health Goal Initiation Webinar: PFOA and PFOS Toxicity and ...	No	NR	Not included from the	NA	NA
PFOA PFOS Peer Review Comments	No	NR	Not included from the	NA	NA
Notification Levels for PFOA and PFOS in California drinking water	No	NR	Not included from the	NA	NA
NTP monograph. Immunotoxicity Associated with Exposure to ...	No	Links only	Not included from the	NA	NA
Immunotox of Exposure to PFOA and PFOS	Yes	-	NTP (2016)	No	Not included. Does not identify a guideline/guidance value .
3M Comments on Hazard Identification Materials and Potential ...	No	NR	Not included from the	NA	NA
~~Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonic Acid ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Notice to Interested Parties Chemical Listed Effective February 25 ...	No	NR	Not included from the	NA	NA
Perfluorooctanoic Acid (PFOA) - OEHHA	No	NR	Not included from the	NA	NA
Notification Level Recommendations for Perfluorooctanoic Acid and ...	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Notice of Intent to List Perfluorooctanoic Acid (PFOA) and ...	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Notification Level Recommendations for Perfluorooctanoic Acid ...	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Perfluorooctanoic Acid (PFOA) - OEHHA	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Public Health Goals for Perfluorooctanoic Acid and Perfluorooctane ...	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Notice of Intent to List PFOA	No	NR	Not included from the	NA	NA
Chemicals Listed Effective November 10, 2017 as Known to the ...	No	NR	Not included from the	NA	NA
Proposed Public Health Goals for Perfluorooctanoic Acid (PFOA ...	No	NR	Not included from the	NA	NA
Human Epidemiologic Studies of Perfluorooctanoic Acid (PFOA) and ...	No	NR	Not included from the	NA	NA
Notice to Interested Parties. November 10, 2017	No	NR	Not included from the	NA	NA
Information Submission - Perfluorooctanoic Acid (PFOA) and ...	No	NR	Not included from the	NA	NA
Notice of Intent to List: Perfluorooctanoic acid (PFOA) and ...	No	NR	Not included from the	NA	NA
Perfluorooctanoic Acid (PFOA) - OEHHA	No	NR (Links)	Not included from the	NA	NA
NTP Study of PFOA Chronic Toxicity and Carcinogenicity with and ...	No	NR (Links)	Not included from the	NA	NA
Announcement of Availability of a Draft Technical Support Document ...	No	NR	Not included from the	NA	NA
American Chemistry Council Comments on the Notice of Intent to ...	No	NR	Not included from the	NA	NA
Experimental Data Reviewed for Notification Level (NL ...	No	NR	Not included from the	NA	NA
Chemicals Selected by OEHHA for Consideration for Listing by the ...	No	NR (Links)	Not included from the	NA	NA
Memorandum: Recommendation for interim notification levels for ...	No	NR	Not included from the	NA	NA
~~NTP Study of PFOA Chronic Toxicity and Carcinogenicity with and ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
2009 CIC consultation perfluorooctanoic acid and its salts	No	NR	Not included from the	NA	NA
~~NTP monograph. Immunotoxicity Associated with Exposure to ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Comment by Queensland Department of Environment and Science ...	No	NR	Not included from the	NA	NA
Extension of the Public Comment Period for the Notice of Intent To ...	No	NR	Not included from the	NA	NA
PFOA PFOS Peer Review Comments	No	NR	Not included from the	NA	NA
Public Health Goal Initiation Webinar: PFOA and PFOS Toxicity and ...	No	NR	Not included from the	NA	NA
Comment by Comments from: EWG, CEH, NRDC, CWA, CALPIRG ...	No	NR	Not included from the	NA	NA
Notification Level Recommendation for Perfluorohexane Sulfonic ...	No	NR (Links)	Not included from the	NA	NA
Notification Level Recommendation Perfluorohexane Sulfonic Acid ...	Yes	-	OEHHA (2022a)	**Yes**	Included. DWG available.
Perfluorohexane Sulfonic Acid (PFHxS) - OEHHA	No	NR	Not included from the	NA	NA
Chemicals Selected for Consideration for Listing by the DARTIC and ...	No	NR	Not included from the	NA	NA
~~Perfluorohexane Sulfonic Acid (PFHxS) - OEHHA~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Comment by The 3M Company on Comment Submissions ...	No	NR	Not included from the	NA	NA
Comment Submissions - Chemicals Selected for Consideration for ...	No	NR	Not included from the	NA	NA
- OEHHA	No	NR	Not included from the	NA	NA
Lauren Zeise	No	NR	Not included from the	NA	NA
Reports - OEHHA	No	NR	Not included from the	NA	NA
Notices - OEHHA	No	NR	Not included from the	NA	NA
Comment-20371-The 3M Company - OEHHA	No	NR	Not included from the	NA	NA
Notification Levels for Chemicals in Drinking Water - OEHHA	No	NR	Not included from the	NA	NA
Revised Table 4.1 PFNA: Epidemiologic studies of male ...	No	NR	Not included from the	NA	NA
Report - OEHHA	No	NR (Links)	Not included from the	NA	NA
Latest News - Page 18 | OEHHA	No	NR	Not included from the	NA	NA
Proposition 65 - Page 4 | OEHHA	No	NR	Not included from the	NA	NA
Document Search - Page 12 | OEHHA	No	NR	Not included from the	NA	NA
Evidence on the Male Reproductive Toxicity of Perfluorononanoic ...	No	NR	Not included from the	NA	NA
Prioritization: Chemicals Identified for Consultation with the ...	No	NR	Not included from the	NA	NA
Document Search - Page 13 | OEHHA	No	Study Links	Not included from the	NA	NA
Latest News - Page 10 | OEHHA	No	NR (Links)	Not included from the	NA	NA
~~Evidence on the Carcinogenicity of Perfluorooctane Sulfonic Acid ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
September 2020 notice Prioritization: Chemicals for consultation by ...	No	NR	Not included from the	NA	NA
~~Public Health Goals for Perfluorooctanoic Acid and Perfluorooctane ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
December 10, 2020 Meeting of the Developmental and ...	No	NR	Not included from the	NA	NA
Water Chemicals - OEHHA	No	NR	Not included from the	NA	NA
Announcement of the Developmental and Reproductive Toxicant ...	No	NR	Not included from the	NA	NA
Comment by Natural Resources Defense Council on Comment ...	No	NR	Not included from the	NA	NA
Public Comments - OEHHA	No	NR	Not included from the	NA	NA
Perfluorobutane Sulfonic Acid (PFBS) - OEHHA	No	NR (Links)	Not included from the	NA	NA
Notification Level Recommendation Perfluorobutane Sulfonic Acid ...	Yes	-	OEHHA (2021d)	**Yes**	Included. DWG available.
Notification Levels for Chemicals in Drinking Water - OEHHA	No	NR	Not included from the	NA	NA
~~Notification Level Recommendation Perfluorohexane Sulfonic Acid ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Evidence on the Carcinogenicity of Perfluorooctane Sulfonic Acid ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Public Health Goals for Perfluorooctanoic Acid and Perfluorooctane ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
Comment by Silent Spring Institute on Comment Submissions ...	No	NR	Not included from the	NA	NA
Initiation of Process to Develop/Update Public Health Goals in ...	No	NR	Not included from the	NA	NA
Comment by Silent Spring Institute on Comment Submissions ...	No	NR	Not included from the	NA	NA
Chemicals - OEHHA	No	NR (Links)	Not included from the	NA	NA
~~Revised Table 4.1 PFNA: Epidemiologic studies of male ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Comment by Department of Defense on Comment Submissions ...	No	NR	Not included from the	NA	NA
~~Public Health Goals (PHGs) - OEHHA~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
2015 Prioritization of Chemicals for DARTIC	No	NR	Not included from the	NA	NA
~~Evidence on the Male Reproductive Toxicity of Perfluorononanoic ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Prioritization: Chemicals Identified for Consultation with the ...	No	NR	Not included from the	NA	NA
Notice to Interested Parties Chemical Listed Effective February 25 ...	No	NR	Not included from the	NA	NA
Comment by Comments of the PFAS Regulatory Coalition on ...	No	NR	Not included from the	NA	NA
Comment by Comments from: EWG, CEH, NRDC, CWA, CALPIRG ...	No	NR	Not included from the	NA	NA
Chemicals Considered or Listed Under Proposition 65 - OEHHA	No	NR	Not included from the	NA	NA
Notification Level Recommendation Perfluorohexane Sulfonic Acid ...	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Notification Level Recommendation Perfluorobutane Sulfonic Acid ...	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Public Health Goals for Trihalomethanes in Drinking Water	No	NR	Not included from the	NA	NA
Evidence on the Carcinogenicity of Perfluorooctane Sulfonic Acid ...	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Public Health Goals for Perfluorooctanoic Acid and Perfluorooctane ...	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Comment by Queensland Department of Environment and Science ...	No	NR	Not included from the	NA	NA
Chemicals - OEHHA	No	NR	Not included from the	NA	NA
US Agency for Toxic Substances and Disease Registry (ATSDR) Toxic Substances Portal					
Search results: 1 result for PFOS, PFOA and for PFHxS, Nil for PFBS and GenX					
Perfluoroalkyls (355-67-1)	Yes	-	ATSDR (2021a)	Yes	Included. TDI available (MRL)
US Agency for Toxic Substances and Disease Registry (ATSDR)					
Search results: > 10 pages of 10 results for PFOS, PFOA, and PFHxS, 36 for PFBS, and 23 for GenX					
Search cut-off: Only results from first 30 results for each PFAS (duplicates struckthrough) and links followed on webpapes (see indented title of result and purple text)					
PFAS in the US population	No	NR	Not included from the	NA	NA
PFAS chemicals overview	No	NR	Not included from the	NA	NA
Final Report: Findings Across Ten Exposure Assessment (EA) Sites | Per- and Polyfluoroalkyl Substances (PFAS) and Your Health	No	NR	Not included from the	NA	NA
Potential health effects of PFAS chemicals	No	NR	Not included from the	NA	NA
Investigating PFAS in PA, VA, DE, and WV	No	NR	Not included from the	NA	NA
Spokane County, WA PFAS Exposure Assessment	No	NR	Not included from the	NA	NA
PFAS Pease Study	No	NR	Not included from the	NA	NA
Fairbanks North Star Borough (AK) PFAS Exposure Assessment	No	NR	Not included from the	NA	NA
Investigating PFAS in AK and WA	No	NR	Not included from the	NA	NA
El Paso County, CO PFAS Exposure Assessment	No	NR	Not included from the	NA	NA
Investigating PFAS in MS and NC	No	NR	Not included from the	NA	NA
Berkeley County, WV PFAS Exposure Assessment	No	NR	Not included from the	NA	NA
New Castle County, DE PFAS Exposure Assessment	No	NR	Not included from the	NA	NA
Investigating PFAS in Michigan	No	NR	Not included from the	NA	NA
Lubbock County, TX PFAS Exposure Assessment	No	NR	Not included from the	NA	NA
Blood testing for PFAS	No	NR	Not included from the	NA	NA
PFAS Progress Newsletter — May 2023 | Per- and Polyfluoroalkyl Substances (PFAS) and Your Health	No	NR	Not included from the	NA	NA
PFAS chemical exposure	No	NR	Not included from the	NA	NA
Orange County, NY PFAS Exposure Assessment	No	NR	Not included from the	NA	NA
Hampden County, MA PFAS Exposure Assessment	No	NR	Not included from the	NA	NA
Perfluoroalquilos (Perfluoroalkyls)	No	L	Not included from the	NA	NA
PFAS Minimal Risk Levels and Environmental Media Evaluation Guides	Yes	-	ATSDR (2018a)	**Yes**	Included. DWG available. Reference to ASTDR (2018b).
PFAS Exposure Assessment Community Update	No	NR (Links)	Not included from the	NA	NA
Resumen de Salud Pública: Perfluoroalquilos (Perfluoroalkyls)	No	L	Not included from the	NA	NA
Las PFAS en la población de los Estados Unidos	No	L	Not included from the	NA	NA
Frequently Asked Questions about PFAS Chemicals	No	NR	Not included from the	NA	NA
Introducción a las sustancias químicas PFAS	No	L	Not included from the	NA	NA
Estimating Levels of PFAS in Your Blood | Per- and Polyfluoroalkyl Substances (PFAS) and Your Health	No	NR	Not included from the	NA	NA
OATMAN WATER COMPANY	No	NR	Not included from the	NA	NA
Willow Grove Naval Air and Air Reserve LHC	No	NR	Not included from the	NA	NA
~~PFAS in the US population~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Final Report: Findings Across Ten Exposure Assessment (EA) Sites | Per- and Polyfluoroalkyl Substances (PFAS) and Your Health~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Potential health effects of PFAS chemicals~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Investigating PFAS in PA, VA, DE, and WV~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS chemicals overview~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Spokane County, WA PFAS Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Investigating PFAS in AK and WA~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~El Paso County, CO PFAS Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Lubbock County, TX PFAS Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Investigating PFAS in MS and NC~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Blood testing for PFAS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Berkeley County, WV PFAS Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~New Castle County, DE PFAS Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Frequently Asked Questions about PFAS Chemicals~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Hampden County, MA PFAS Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
~~Orange County, NY PFAS Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Investigating PFAS in VT, NH, and MA	No	NR	Not included from the	NA	NA
Perfluoroalquilos (Perfluoroalkyls)	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
PFAS Progress Newsletter — May 2023 | Per- and Polyfluoroalkyl Substances (PFAS) and Your Health	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Resumen de Salud Pública: Perfluoroalquilos (Perfluoroalkyls)	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS Minimal Risk Levels and Environmental Media Evaluation Guides~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Investigating PFAS in Michigan~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
PFAS Exposure Assessment Community Update	No	NR (Links)	Not included from the	NA	NA
Fairbanks North Star Borough (AK) PFAS Exposure Assessment	No	NR	Not included from the	NA	NA
~~Las PFAS en la población de los Estados Unidos~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
PFAS Information for Clinicians and Environmental Health Professionals	No	Links only	Not included from the	NA	NA
Clinician Information and Guidance	Yes	-	ATSDR (2019)	Yes. From other Agency	Not included. DWG from other agency (USEPSA).
PFAS and Breastfeeding pdf icon[PDF – 510 KB]	No	NR	Not included from the	NA	NA
~~Toxicological Profile for PFAS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~ATSDR's Minimal Risk Levels (MRLs) and Environmental Media Evaluation Guides (EMEGs) for PFAS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Understanding MRLs	No	NR	Not included from the	NA	NA
Community Stress Resource Cente	No	NR	Not included from the	NA	NA
~~PFAS chemical exposure~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Introducción a las sustancias químicas PFAS	No	L	Not included from the	NA	NA
PFAS Progress Newsletter — June 2021 | Per- and Polyfluoroalkyl Substances (PFAS) and Your Health	No	NR	Not included from the	NA	NA
Public Health Statement for Perfluoroalkyls	No	NR	Not included from the	NA	NA
NIEHS Perfluorinated Chemicals (PFCs) fact sheet	No	NR	Not included from the	NA	NA
Evaluation pf PFAS in private Wells near Saint Gobain Performance Plastics site in Southern New Hampshire	No	NR	Not included from the	NA	NA
Pease Air Force Base Health Consultation	No	NR	Not included from the	NA	NA
~~ATSDR Perfluoroalkyls (PFAS) Tox Profile~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Willow Grove Naval Air and Air Reserve LHC~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
El Paso PFAS EA Biological Results Letter Example	No	NR	Not included from the	NA	NA
PFAS EA Orange County NY Biological Letter Example	No	NR	Not included from the	NA	NA
PFAS Exposure Assessment Results Letter Lubbock Example	No	NR	Not included from the	NA	NA
PFAS Test Results Biological Example Letter - Berkeley County	No	NR	Not included from the	NA	NA
Site D Example Biological Letter	No	NR	Not included from the	NA	NA
Site G - Biological Letter Example	No	NR	Not included from the	NA	NA
PFAS Site A example letter_05-20-2020	No	NR	Not included from the	NA	NA
Site C Biological Example Letter_May 2020	No	NR	Not included from the	NA	NA
Pease Air Force Base Private Residential Drinking Water Wells Health Consultation Public Comment Version	No	NR	Not included from the	NA	NA
Perfluorinated Chemicals (PFCs).	No	NR	Not included from the	NA	NA
Security-Widefield, CO PFAS Exposure Assessment Report	No	NR	Not included from the	NA	NA
~~Per- and Polyfluoroalkyl Substances (PFAS)Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Lubbock County, TX PFAS Exposure Assessment Report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Per- and Polyfluoroalkyl Substances (PFAS) Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Exposure Assessment Protocol: Biological and Environmental Sampling of Per- and Polyfluoroalkyl Substances (PFAS)	No	NR	Not included from the	NA	NA
~~Berkeley County, WV PFAS Exposure Assessment Report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS Exposure Assessments Final Report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Spokane County, WA PFAS Exposure Assessment Report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Per- and Polyfluoroalkyl Substances (PFAS) Exposure Assessment REPORT	No	NR	Not included from the	NA	NA
~~Hampden County, MA PFAS Exposure Assessment Report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Guidance for Assessment of Per- and Polyfluoroalkyl Substances (PFAS) in Fish and Other Aquatic Organisms	No	NR	Not included from the	NA	NA
Per- and Polyfluoroalkyl Substances (PFAS)Exposure Assessment	No	NR	Not included from the	NA	NA
~~Per- and Polyfluoroalkyl Substances (PFAS)Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Berkeley County, WV PFAS Exposure Assessment Appendix A, B, C	No	NR	Not included from the	NA	NA
Health Consultation	No	NR	Not included from the	NA	NA
~~Final Report: Findings Across Ten Exposure Assessment (EA) Sites | Per- and Polyfluoroalkyl Substances (PFAS) and Your Health~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Spokane County, WA PFAS Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~El Paso County, CO PFAS Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Orange County, NY PFAS Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Berkeley County, WV PFAS Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Lubbock County, TX PFAS Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Fairbanks North Star Borough (AK) PFAS Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~New Castle County, DE PFAS Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Hampden County, MA PFAS Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS Minimal Risk Levels and Environmental Media Evaluation Guides~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Frequently Asked Questions about PFAS Chemicals~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS in the US population~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS chemicals overview~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Perfluoroalquilos (Perfluoroalkyls)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Estimating Levels of PFAS in Your Blood | Per- and Polyfluoroalkyl Substances (PFAS) and Your Health~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS Progress Newsletter — May 2023 | Per- and Polyfluoroalkyl Substances (PFAS) and Your Health~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
PFAS Exposure Assessment Spokane County (WA) Community Level Results	No	NR	Not included from the	NA	NA
~~Lubbock County, TX PFAS Exposure Assessment Report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Hampden County, MA PFAS Exposure Assessment Report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Spokane County, WA PFAS Exposure Assessment Report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Security-Widefield, CO PFAS Exposure Assessment Report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Berkeley County, WV PFAS Exposure Assessment Report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS Exposure Assessments Final Report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
~~Per- and Polyfluoroalkyl Substances (PFAS)Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Per- and Polyfluoroalkyl Substances (PFAS) Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Per- and Polyfluoroalkyl Substances (PFAS) Exposure Assessment REPORT~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Pease Air Force Base Private Residential Drinking Water Wells Health Consultation Public Comment Version~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Evalyasyon Ekspozisyon PFAS Rezime Kominote	No	L	Not included from the	NA	NA
~~OATMAN WATER COMPANY~~	~~No~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
PFAS Progress Newsletter — August 2020 | Per- and Polyfluoroalkyl Substances (PFAS) and Your Health	No	NR	Not included from the	NA	NA
~~PFAS Exposure Assessment Community Update~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~El Paso PFAS EA Biological Results Letter Example~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS EA Orange County NY Biological Letter Example~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS Exposure Assessment Results Letter Lubbock Example~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS Test Results Biological Example Letter - Berkeley County~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Site D Example Biological Letter~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Site G - Biological Letter Example~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS Site A example letter_05-20-2020~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Site C Biological Example Letter_May 2020~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Per- and Polyfluoroalkyl Substances (PFAS) Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS Exposure Assessments Final Report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Exposure Assessment Protocol: Biological and Environmental Sampling of Per- and Polyfluoroalkyl Substances (PFAS)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Spokane County, WA PFAS Exposure Assessment Report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Security-Widefield, CO PFAS Exposure Assessment Report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Per- and Polyfluoroalkyl Substances (PFAS)Exposure Assessment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Lubbock County, TX PFAS Exposure Assessment Report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Per- and Polyfluoroalkyl Substances (PFAS) Exposure Assessment REPORT~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Evaluation pf PFAS in private Wells near Saint Gobain Performance Plastics site in Southern New Hampshire~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Berkeley County, WV PFAS Exposure Assessment Report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Hampden County, MA PFAS Exposure Assessment Report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Board of Scientific Counselors Meeting Minutes June 2018	No	NR	Not included from the	NA	NA
Human health effects of drinking water exposures to per- and poly-fluoroalkyl substances (PFAS): A multi-site cross-sectional study Protocol	No	NR	Not included from the	NA	NA
ATSDR Perfluoroalkyls (PFAS) Tox Profile	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Health Canada (HC)					
Search results: 428 for PFOS, 242 for PFOA, 45 for PFHxS, 30 for PFBS, 20 for GenX					
Search cut-off: Only results from first 10 results for each PFAS (duplicates struckthrough) and links followed on webpapes					
Perfluorooctane sulfonate (PFOS)	No	NR (Links)	Not included from the	NA	NA
Perfluorooctane sulfonate (PFOS), its salts and precursors - information sheet	No	NR (Links)	Not included from the	NA	NA
Toxic substances list: perfluorooctane sulfonate (PFOS), its salts and precursors	No	NR (Links)	Not included from the	NA	NA
Water talk: PFOS, PFOA and other PFAS in drinking water	Yes	-	HC (2019a)	**Yes**	Included. DWG available. Basis of DWG not provided.
Guidelines for Canadian Drinking Water Quality: Guideline Technical Document – Perfluorooctanoic Acid (PFOA)	Yes	-	HC (2018b)	**Yes**	Included. DWG available.
Guidelines for Canadian Drinking Water Quality: Guideline Technical Document – Perfluorooctane Sulfonate (PFOS)	Yes	-	HC (2018a)	**Yes**	Included. DWG available.
Draft objective for per- and polyfluoroalkyl substances in Canadian drinking water	Yes	-	HC (2023a)	No	Not included. Objective document for HC (2023b)
M8500-21R029 - Precision Firearm Optics (PFO) - Award Notice | CanadaBuys	No	NR	Not included from the	NA	NA
M8500-21R029 - Precision Firearm Optics (PFO) - Contract History | CanadaBuys	No	NR	Not included from the	NA	NA
~~M8500-21R029 - Precision Firearm Optics (PFO) - Contract History | CanadaBuys~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~M8500-21R029 - Precision Firearm Optics (PFO) - Contract History | CanadaBuys~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~M8500-21R029 - Precision Firearm Optics (PFO) - Contract History | CanadaBuys~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~M8500-21R029 - Precision Firearm Optics (PFO) - Contract History | CanadaBuys~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Perfluorooctanoic Acid (PFOA), its salts and precursors	No	NA (Links)	Not included from the	NA	NA
Final Screening Assessment on Perfluorooctanoic Acid (PFOA), its Salts and its Precursors	Yes	-	HC (2012a)	No	Not included.
Toxic substances list: perfluorooctanoic acid (PFOA), its salts and precursors	No	NA (Links)	Not included from the	NA	NA
Perfluorooctanoic Acid (PFOA), its salts, and its precursors - information sheet	No	NR	Not included from the	NA	NA
~~Water talk: PFOS, PFOA and other PFAS in drinking water~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Substance prohibition summary for PFOA, long-chain PFCAs and related substances	No	NR	Not included from the	NA	NA
Environment and Climate Change Canada	No	NR	Not included from the	NA	NA
Consultation on perfluorooctanoic acid (PFOA) in drinking water	No	NR	Not included from the	NA	NA
Perfluorooctanoic Acid (PFOA) in Drinking Water	Yes	-	HC (2016d)	Yes. Outdated	Not included. DWG available. Superceded by HC (2018b)
~~Guidelines for Canadian Drinking Water Quality: Guideline Technical Document – Perfluorooctanoic Acid (PFOA)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Appendix A: Summary of Health Effects Information for PFOA	No	NR	Not included from the	NA	NA
~~Guidelines for Canadian Drinking Water Quality: Guideline Technical Document – Perfluorooctanoic Acid (PFOA)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Per- and polyfluoroalkyl substances (PFAS) in Canadians	No	NR (Links)	Not included from the	NA	NA
Excel reporting form for responding to: Notice with respect to perfluorohexane sulfonic acid, its salts and its precursors (PFHxS)	No	NR	Not included from the	NA	NA
Supporting document: Ecological state of the science report on Short-chain (C4–C7) Perfluorocarboxylic Acids (SC-PFCAs) Short-chain (C4–C7) Perfluorosulfonic Acids (SC-PF	No	Not HH	Not included from the	NA	NA
Guidance manual for responding to : Notice with respect to perfluorohexane sulfonic acid, its salts and its precursors (PFHxS), published in the Canada Gazette, Part I, on O	No	NR	Not included from the	NA	NA
Guide d'orientation pour répondre à : l'Avis concernant l'acide perfluorohexane sulfonique, ses sels et ses précurseurs (PFHxS), publié dans la Partie I de la Gazette du Cana	No	L	Not included from the	NA	NA
Draft objective for per- and polyfluoroalkyl substances in Canadian drinking water: Exposure considerations	No	NR	Not included from the	NA	NA
MARC21	No	NR	Not included from the	NA	NA
Draft state of per- and polyfluoroalkyl substances (PFAS) report	No	NR	Not included from the	NA	NA
Information gathering initiatives	No	NR	Not included from the	NA	NA
Draft objective for per- and polyfluoroalkyl substances in Canadian drinking water: Exposure considerations	No	NR	Not included from the	NA	NA
Supporting document: Ecological state of the science report on Short-chain (C4–C7) Perfluorocarboxylic Acids (SC-PFCAs) Short-chain (C4–C7) Perfluorosulfonic Acids (SC-PF	No	Not HH	Not included from the	NA	NA
~~Water talk: PFOS, PFOA and other PFAS in drinking water~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Draft objective for per- and polyfluoroalkyl substances in Canadian drinking water: Overview	No	NR	Not included from the	NA	NA
Draft state of per- and polyfluoroalkyl substances (PFAS) report	Yes	-	HC (2023b)	No	Not included. Refer to HC (2019a, 2018a, 2018b)
Draft objective for per- and polyfluoroalkyl substances in Canadian drinking water: Treatment considerations	No	NR	Not included from the	NA	NA

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
Page 6: Sixth Report on Human Biomonitoring of Environmental Chemicals in Canada	No	NR	Not included from the	NA	NA
John McDougall Appointed President of the National Research Council of Canada	No	NR	Not included from the	NA	NA
CNSN Station Book Index	No	NR	Not included from the	NA	NA
Draft objective for per- and polyfluoroalkyl substances in Canadian drinking water: References and appendices	No	NR	Not included from the	NA	NA
so as an adverb - Search for entries starting with S - Writing Tips - TERMIUM Plus® - Translation Bureau	No	NR	Not included from the	NA	NA
so as an adverb - Search for entries starting with S - Writing Tips - TERMIUM Plus® - Bureau de la traduction	No	NR	Not included from the	NA	NA
so as an adverb - Search for entries starting with S - Writing Tips - TERMIUM Plus® - Bureau de la traduction	No	NR	Not included from the	NA	NA
so as an adverb - Search for entries starting with S - Writing Tips - TERMIUM Plus® - Translation Bureau	No	NR	Not included from the	NA	NA
Approved aircraft type maintenance training	No	NR	Not included from the	NA	NA
Service Difficulty Reports (SDR) - Engine	No	NR	Not included from the	NA	NA
Social and Political Orientations – Generation Z: Portrait of a New Generation of Young Canadians and How They Compare to Older Canadians – Elections Canada	No	NR	Not included from the	NA	NA
~~Draft state of per- and polyfluoroalkyl substances (PFAS) report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Certificats de reconstitution (LCSA) - Corporations Canada	No	L	Not included from the	NA	NA
Additional references found from Health Canada during a generic search of their website					
PFAS-Screening-Values-Fact-Sheet-EN.pdf	Yes	-	HC (2016a)	Yes. Outdated	Not included. DWG available. Superceded by HC (2019a, 2018a, 2018b)
PFOS in Drinking Water perfluorooctane-sulfonate-eng	Yes	-	HC (2016b)	Yes. Outdated	Not included. DWG available. Superceded by HC (2018a)
Water Talk DWSV PFAS H144-47-2017-eng	Yes	-	HC (2016c)	Yes. Outdated	Not included. DWG available. Superceded by HC (2019a, 2018a, 2018b)
National Institute for Public Health and the Environment (RIVM)					
Search results: 15 for PFOS, 23 for PFOA, 21 for GenX, and Nil for PFHxS and PFBS					
PFAS	No	L (Links)	Not included from the	NA	NA
Soil risk limits for the use of soil and dredging spoil containing PFAS for arable farming and livestock breeding (Dutch report, English synopsis)	No	L	Not included from the	NA	NA
Risicogrenzen voor PFOS, PFOA en GenX voor toepassen van grond en bagger (Dutch only)	No	L	Not included from the	NA	NA
Richtlijn aanleveren gegevens ten behoeve van landsdekkend beeld PFAS (Dutch only)	No	L	Not included from the	NA	NA
Risk assessment of GenX and PFOA in vegetable garden crops in Dordrecht, Papendrecht and Sliedrecht (Dutch report, English synopsis)	No	L	Not included from the	NA	NA
Risicoschatting PFOA in drinkwater (Dutch only)	No	L	Not included from the	NA	NA
Risk assessment and presence of FRD-903 in drinking water and drinking water sources for a selection of drinking water production locations in the Netherlands (Dutc	No	L	Not included from the	NA	NA
Brief over Advies richtwaarde PFOA Drinkwater (Dutch only)	No	L	Not included from the	NA	NA
Afleiding richtwaarde voor PFOA in drinkwater (Dutch only)	No	L	Not included from the	NA	NA
Evaluation of substances used in the GenX technology by Chemours, Dordrecht	Yes	-	RIVM (2019a)	No	Not included. Air guideline value is available.
Per- and polyfluoroalkyl substances (PFASs) in food contact materials	Yes	-	RIVM (2019b)	Yes. Outdated	Not included. Opinion on Health based guidance value available.
Risk assessment of the emission of PFOA : Location: Dupont/Chemours, Dordrecht, The Netherlands (Dutch report, English synopsis)	No	L	Not included from the	NA	NA
Mixture exposure to PFAS: A Relative Potency Factor approach	Yes	-	RIVM (2018a)	**Yes**	Included. RPFs described.
Per- and polyfluorinated substances in waste incinerator flue gases	No	NR	Not included from the	NA	NA
~~New method for toxicological assessment of perfluoro mixtures~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Temporary background values for PFAS in Dutch soil	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Discussion regarding health-based guidance value of PFOA	No	Summary	Not included from the	NA	NA
Nitrogen and PFAS suddenly big societal issues in the Netherlands	No	NR	Not included from the	NA	NA
New risk limits for PFAS in surface water	No	L	Not included from the	NA	NA
RIVM newsletter issue 2 online	No	NR	Not included from the	NA	NA
Reports Environment and Safety 2016	No	NR	Not included from the	NA	NA
Reports Environment and Safety 2020	No	NR	Not included from the	NA	NA
Reports Environment and Safety Division 2011	No	NR	Not included from the	NA	NA
Q&A on the proposal for a ban on the use of PFAS (restriction)	No	NR	Not included from the	NA	NA
Risk assessments Front Office Food and Product Safety	No	Links	Not included from the	NA	NA
Revised risk assessment of GenX and PFOA in food part 1: toxicity of GenX and PFOA and intake through contaminated dairy products, eggs and fish (published April 2	No	L	Not included from the	NA	NA
Revised risk assessment of GenX and PFOA in food part 2: transfer of GenX, PFOA and PFOS in ditch water and silage to edible products of food producing animals (pu	Yes	-	RIVM (2021a)	**Yes**	Included. TDI from other agency (EFSA 2020a) and RDFs described RIVM 2018a
Risk assessment of GenX and PFOA in food. Part 1: Toxicity of GenX and PFOA and intake through contaminated food of animal origin [in English] (July 2019)	Yes	-	RIVM (2018b)	Yes. Outdated	Not included.
Risk assessment of GenX and PFOA in food. Part 2: Transfer of GenX and PFOA in ditchwater and silage to edible products of food producing animals [in English] (July 2	Yes	-	RIVM (2019c)	Yes. Outdated	Not included.
Articles Environment and Safety Division 2012	No	NR	Not included from the	NA	NA
Articles Public Health and Health Services 2021	No	NR	Not included from the	NA	NA
Articles Public Health and Healthcare 2013	No	NR	Not included from the	NA	NA
Proposal for water quality standards for PFOA	Yes	-	RIVM (2017a)	Yes. Outdated	Not included. Contains DWG and outdated TDI for PFOA.
Blood analysis local residents confirms longtime exposure to PFOA	No	NR	Not included from the	NA	NA
~~Discussion regarding health-based guidance value of PFOA~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~New method for toxicological assessment of perfluoro mixtures~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Temporary background values for PFAS in Dutch soil~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Nitrogen and PFAS suddenly big societal issues in the Netherlands~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Relevant publications	No	NR	Not included from the	NA	NA
New risk limits for PFAS in surface water	No	L	Not included from the	NA	NA
~~Risk assessments Front Office Food and Product Safety~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Reports Environment and Safety 2017	No	NR	Not included from the	NA	NA
~~RIVM newsletter issue 2 online~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Reports Environment and Safety 2016~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
More knowledge required about environmental effect of GenX	No	L	Not included from the	NA	NA
~~Reports Environment and Safety 2020~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Reports Public Health and Health Services 2021	No	NR	Not included from the	NA	NA
Reports Public Health and Health Services 2019	No	NR	Not included from the	NA	NA
Reports Public Health and Health Services 2018	No	NR	Not included from the	NA	NA
~~Q&A on the proposal for a ban on the use of PFAS (restriction)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Reports Environment and Safety 2018	No	NR	Not included from the	NA	NA
~~More knowledge required about environmental effect of GenX~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
~~New method for toxicological assessment of perfluoro-mixtures~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Relevant publications~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Risk assessments Front Office Food and Product Safety~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Proposal for water quality standards for PFOA~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~RIVM newsletter issue 2 online~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~New risk limits for PFAS in surface water~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Reports Environment and Safety 2019~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Reports Public Health and Health Services 2021~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Reports Public Health and Health Services 2019~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Reports Public Health and Health Services 2018~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
National Institute for Public Health and the Environment	No	NR	Not included from the	NA	NA
~~Q&A on the proposal for a ban on the use of PFAS (restriction)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Reports Environment and Safety 2016~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Articles Environment and Safety 2017	No	NR	Not included from the	NA	NA
~~Reports Environment and Safety 2020~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Reports Environment and Safety 2017~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
RIVM2025 terminology	No	NR	Not included from the	NA	NA
Articles Environment and Safety 2018	No	NR	Not included from the	NA	NA
German Bundesinstitut für Risikobewertung (BfR – Federal Institute for Risk Assessment)					
Search results: 15 for PFOS, 18 for PFOA, 1 for PFHxS, and Nil for PFBS, and GenX.					
Search cut-off: Nil					
1) Opinion: New health-based guidance values for the industrial chemicals PFOS and PFOA	Yes	-	BFR (2019a)	**Yes (other agency)**	Included. Adopts EFSA TWI for PFOA and PFOS from 2018.
2) Communication: Perfluorooctanoic acid (PFOA) and perfluorooctane sulphonate (PFOS) put to the test	No	NR	Not included from the	NA	NA
3) Opinion: Health risks from PFOS and PFOA in food are unlikely according to the scientific knowledge currently available	No	NR	Not included from the	NA	NA
4) FAQ: Here to stay: per- and polyfluoroalkyl substances (PFAS) in food and in the environment	No	NR	Not included from the	NA	NA
5) Opinion: PFAS maximum levels in feedstuffs: BfR recommends improved analytical methods	No	NR	Not included from the	NA	NA
6) Communication: Industrial chemical PFBA does not accumulate excessively in lungs and kidneys	No	NR	Not included from the	NA	NA
7) Opinion: PFAS in food: BfR confirms critical exposure to industrial chemicals	No	NR	Not included from the	NA	NA
8) Communication: Per- and polyfluoroalkyl substances (PFAS): New opinion from the European Food Safety Authority	No	NR	Not included from the	NA	NA
9) Communication: Perfluoroalkyl and polyfluoroalkyl substances (PFAS): European Food Safety Authority draft opinion opens for public consultation	No	NR	Not included from the	NA	NA
10) Opinion: The consumption of sheep or beef liver can contribute considerably to the total intake of per- and polyfluoroalkyl substances (PFAS)	No	NR	Not included from the	NA	NA
11) Communication: New study shows: One-year-old children demonstrate lower concentration of vaccine antibodies with high PFOA concentration in the blood	No	NR	Not included from the	NA	NA
12) Associations between internal exposure to perfluorinated substances (PFAS) and the risk of cardiovascular diseases and type 2 diabetes in the EPIC-Potsdam study	No	Study	Not included from the	NA	NA
13) Press information: Digital tools for more safety in the food chain	No	NR	Not included from the	NA	NA
14) Press information: Per and polyfluorinated alkyl substances put to the test	No	NR	Not included from the	NA	NA
15) Strategies for health protection, pollution Control and Elimination of Next generAtion RefractIve Organic chemicals from Soil, vadose zone and water. (SCENARIOS)	No	NR	Not included from the	NA	NA
1) Communication: Self-experiment: Body can absorb fluorine-containing chemical PFOA through the skin	No	NR	Not included from the	NA	NA
~~2) Opinion: New health-based guidance values for the industrial chemicals PFOS and PFOA~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~3) Communication: Perfluorooctanoic acid (PFOA) and perfluorooctane sulphonate (PFOS) put to the test~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~4) Communication: ... study shows: One-year-old children demonstrate lower concentration of vaccine antibodies with high PFOA concentration in the blood~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~5) Opinion: Health risks from PFOS and PFOA in food are unlikely according to the scientific knowledge currently available~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~6) FAQ: Here to stay: per- and polyfluoroalkyl substances (PFAS) in food and in the environment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~7) Opinion: PFAS maximum levels in feedstuffs: BfR recommends improved analytical methods~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~8) Communication: Industrial chemical PFBA does not accumulate excessively in lungs and kidneys~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~9) Opinion: PFAS in food: BfR confirms critical exposure to industrial chemicals~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~10) Communication: Per- and polyfluoroalkyl substances (PFAS): New opinion from the European Food Safety Authority~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~11) Communication: Perfluoroalkyl and polyfluoroalkyl substances (PFAS): European Food Safety Authority draft opinion opens for public consultation~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
12) Opinion: The consumption of sheep or beef liver can contribute considerably to the total intake of per- and polyfluoroalkyl substances (PFAS)	No	NR	Not included from the	NA	NA
13) Press information: Does perfluorooctanoic acid damage the human liver?	No	NR	Not included from the	NA	NA
~~14) Associations between internal exposure to perfluorinated substances (PFAS) and the risk of cardiovascular diseases and type 2 diabetes in the EPIC-Potsdam study~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~15) Strategies for health protection, pollution Control and Elimination of Next generAtion Refractive Organic chemicals from Soil, vadose zone and water. (SCENARIOS)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
16) Research on endocrine disruptors and hormone-like substances	No	NR	Not included from the	NA	NA
17) Toxic substances in consumer products, cosmetics and tobacco	No	NR	Not included from the	NA	NA
~~18) Press information: Per and polyfluorinated alkyl substances put to the test~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
1) Strategies for health protection, pollution Control and Elimination of Next generAtion RefractIve Organic chemicals from Soil, vadose zone and water. (SCENARIOS)	No	NR	Not included from the	NA	NA
Minnesota Department of Health (MDH)					
Search results: 191 for PFOS, 255 for PFOA, 191 for PFHxS, 77 for PFBS, and 76 for GenX.					
Search cut-off: Only results from first 10 results for each PFAS (duplicates struckthrough) and links followed on webpapes (see indented title of result and purple text) as results were not relevant					
PFOS and Groundwater	No	NR	Not included from the	NA	NA
PFOS Toxicological Summary Sheet Minnesota Department of ...	Yes	-	MDH (2020a)	**Yes**	Included. DWG and TDI available. Refer to MDH (2023a)
Best Practice for Perfluorooctane Sulfonate (PFOS) Guidelines ...	No	NR	Not included from the	NA	NA
Per- and Polyfluoroalkyl Substances (PFAS) - MN Dept. of Health	No	Links only	Not included from the	NA	NA
PFAS and Health	No	Links only	Not included from the	NA	NA
PFBS and Drinking Water (PDF)	Yes	-	MDH (2022e)	Yes	Not included. DWG available. Summary document (refer to MDH 2022g).
Toxicological Summary for: perfluorohexane sulfonate (PFHxS) (PDF)	Yes	-	MDH (2020b)	**Yes**	Included. DWG and TDI available
PFOS and Groundwater (PDF)	No	NR	Not included from the	NA	NA
PFBA and Drinking Water (PDF)	No	NR	Not included from the	NA	NA
MDH (2021a) Toxicological Summary for: Perfluorohexanoate (PFHxA) (PDF)	No	NR	Not included from the	NA	NA
PFOA and Drinking Water (PDF)	Yes	-	MDH (2022d)	Yes	Not included. DWG available. Summary document (refer to MDH 2021b).
Per- and polyfluoroalkyl substances (PFAS) and Health	Yes	-	MDH (2022a)	Yes	Not included. Summary document.
Evaluating Concurrent Exposures to Multiple Chemicals	No	NR	Not included from the	NA	NA
Air Toxicological Summary for Perfluorobutanoic acid (PDF)	No	NR	Not included from the	NA	NA

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
Air Toxicological Summary for Perfluorohexanesulfonic acid (PDF)	Yes	-	MDH (2021c)	Yes. Air guideline	Not included. Air guideline based on TDI from MDH (2020b).
Air Toxicological Summary for Perfluorohexanoic acid (PDF)	No	NR	Not included from the	NA	NA
Air Toxicological Summary for Perfluorooctanoic acid (PDF)	Yes	-	MDH (2021b)	Yes. Air guideline	Not included. Air guideline based on TDI from MDH (2020a).
Air Toxicological Summary for Perfluorooctane sulfonic acid (PDF)	Yes	-	MDH (2022c)	Yes. Air guideline	Not included. Air guideline based on TDI from MDH (2022f).
Health Consultation - PFOS Detections in the City of Brainerd, MN	No	NR	Not included from the	NA	NA
Summary Sheet: PFOS	No	NR (Date)	Not included from the	NA	NA
~~Perfluorooctane sulfonic acid Air Toxicological Summary June 2021 ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
History of MDH Activities - Per- and Polyfluoroalkyl Substances ...	No	NR	Not included from the	NA	NA
Health department issues new guidance values for two ...	No	NR	Not included from the	NA	NA
Per- and Polyfluoroalkyl Substances (PFAS) Sites in Minnesota - MN ...	No	NR	Not included from the	NA	NA
~~PFOA Information Sheet April 2022~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Perfluorooctanoic acid Toxicological Summary Minnesota ...	Yes	-	MDH (2022f)	**Yes**	Included. DWG and TDI available. Refer to MDH (2023a)
~~Air Toxicological Summary for: Perfluorooctanoic Acid (PFOA)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Perfluorooctanoate Toxicological Summary March 2022~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Per- and polyfluoroalkyl substances (PFAS) and Health~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Summary Sheet: PFOA	No	Old	Not included from the	NA	NA
~~History of MDH Activities - Per- and Polyfluoroalkyl Substances ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Evaluation of Perfluorochemical Removal by a Small, In-home Filter	No	NR	Not included from the	NA	NA
Community Brief:East Metro PFC Biomonitoring Study Follow-Up ...	No	NR	Not included from the	NA	NA
~~Per- and Polyfluoroalkyl Substances (PFAS) - MN Dept. of Health~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
PFHxS and Groundwater	No	NR	Not included from the	NA	NA
~~PFHxS Toxicological Summary Sheet Minnesota Department of ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Health department issues new guidance values for two ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Air Toxicological Summary for: Perfluorohexanesulfonic acid (PFHxS)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
East Metro PFC3 Biomonitoring Project report ot the Community	No	NR	Not included from the	NA	NA
~~Evaluation of Perfluorochemical Removal by a Small, In-home Filter~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
East Metro PFC Biomonitoring Follow-up Project: December 2011 ...	No	NR	Not included from the	NA	NA
~~History of MDH Activities - Per- and Polyfluoroalkyl Substances ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Human Health-Based Water Guidance Table - MN Dept. of Health	No	NR	Not included from the	NA	NA
Class B Firefighting Foam- Municipal Well Investigative Sampling ...	No	NR	Not included from the	NA	NA
PFBS and Drinking Water	No	Basic	Not included from the	NA	NA
Perfluorobutane Sulfonate (PFBS) Toxicological Summary, March ...	Yes	-	MDH (2022g)	**Yes**	Included. DWG and TDI available
Summary Sheet: Perfluorobutane sulfonate Minnesota Department ...	Yes	-	MDH (2011)	Yes. Outdated.	Not included. DWG and TDI available. Refer to MDH (2022g)
~~Air Toxicological Summary for: Perfluorobutane Sulfonic Acid (PFBS)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Human Health-Based Water Guidance Table - MN Dept. of Health~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
MDH Response to ACC PFAS comments March 2023	No	NR	Not included from the	NA	NA
~~History of MDH Activities - Per- and Polyfluoroalkyl Substances ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS and Health - MN Dept. of Health~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Air Guidance Values - MN Dept. of Health	No	NR	Not included from the	NA	NA
American Chemistry Council Comment on PFAS Health Risk Limits ...	No	NR	Not included from the	NA	NA
Comparison of State Water Guidance and Federal Drinking Water ...	No	NR	Not included from the	NA	NA
https://www.health.state.mn.us/communities/environ...	No	NR	Not included from the	NA	NA
Per- and Polyfluoroalkyl Substances (PFAS) and Private Wells - MN ...	No	NR	Not included from the	NA	NA
Joint agency statement on draft federal limits on PFAS in drinking ...	Yes	-	MDH (2023a)	**Yes. Draft**	Included. MCL from USEPA (XXXX).
PFAS Resources for Health Care Providers - MN Dept. of Health	No	NR	Not included from the	NA	NA
~~PFAS Standards for Drinking Water - MN Dept. of Health~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS Resources for Health Care Providers~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Interactive Dashboard for PFAS Testing in Drinking Water - MN Dept ...	No	NR	Not included from the	NA	NA
Comparison of State Water Guidance and Federal Drinking Water ...	No	NR	Not included from the	NA	NA
Waterline: Fall 2022 - MN Dept. of Health	No	NR	Not included from the	NA	NA
Washington State Department of Health (WSDH)					
Search results: 184 for PFOS, 95 for PFOA, 92 for PFHxS, 83 for PFBS, and 10 for GenX.					
Search cut-off: Only results from first 10 results for each PFAS (duplicates struckthrough)					
2022 Fish Advisory Evaluation PFOS	No	NR	Not included from the	NA	NA
PFAS | Washington State Department of Health	Yes	-	WSDH (2021a)	Yes. Summary	Not included. Summary document. Refer to WSDH (2022b)
Chemical Action Plan for PFAS, Washington State Department of Ecology (PDF)	Yes	-	WSDH (2022b)	**Yes. Draft**	Included. Draft DWG available (dervied by WSDH)
Fish consumption advisory issued for several King County lakes ...	No	NR	Not included from the	NA	NA
2022 EPA Health Advisory Levels for Four PFAS	Yes	-	WSDH (2022a)	Yes. Draft	Not included. Outdated Summary document. Refer to WSDH (2022b)
334-488 PFAS Timeline	No	NR	Not included from the	NA	NA
Collecting Drinking Water Compliance Samples	No	NR	Not included from the	NA	NA
Home Water Treatment for PFAS	No	NR	Not included from the	NA	NA
PFAS Point-Of-Use Filter Options	No	NR	Not included from the	NA	NA
Draft Recommended State Action Levels for Per- and Polyfluoroalkyl ...	Yes	-	WSDH (2019a)	**Yes. Draft**	Included. Draft DWG available (dervied by WSDH)
DOH Approach to Developing PFAS State Action Levels	Yes	-	WSDH (2020a)	Yes. Draft	Not included. Interim DWG from USEPA announced. Refer to WSDH (2019a, 2022b)
~~PFAS | Washington State Department of Health~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~2022 EPA Health Advisory Levels for Four PFAS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Collecting Drinking Water Compliance Samples~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~DOH Approach to Developing PFAS State Action Levels~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~334-488 PFAS Timeline~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS Point-Of-Use Filter Options~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Home Water Treatment for PFAS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
2023 EPA Proposal to Regulate PFAS in Drinking Water	Yes	-	WSDH (2023a)	**Yes. Draft**	Included. Health based Water Values from USEPA announced.
PFAS in the News	No	NR	Not included from the	NA	NA

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
How to Reduce Exposure to PFAS in Your Tap Water	No	NR	Not included from the	NA	NA
~~Recommended State Action Levels for Per- and Polyfluoroalkyl ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~2022 EPA Health Advisory Levels for Four PFAS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Draft Recommended State Action Levels for Per- and Polyfluoroalkyl ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~DOH Approach to Developing PFAS State Action Levels~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
DRINKING WATER WARNING	No	NR	Not included from the	NA	NA
~~2023 EPA Proposal to Regulate PFAS in Drinking Water~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Summary of Rule Changes for PFAS Standards	No	NR	Not included from the	NA	NA
DRINKING WATER WARNING	No	NR	Not included from the	NA	NA
Small Business Economic Impact Statement Chapter 246-290 WAC ...	No	NR	Not included from the	NA	NA
RULE-MAKING ORDER CR-103P (December 2017)	No	NR	Not included from the	NA	NA
~~2022 EPA Health Advisory Levels for Four PFAS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Recommended State Action Levels for Per- and Polyfluoroalkyl ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Draft Recommended State Action Levels for Per- and Polyfluoroalkyl ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~DOH Approach to Developing PFAS State Action Levels~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS | Washington State Department of Health~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~DRINKING WATER WARNING~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Summary of Rule Changes for PFAS Standards~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~2023 EPA Proposal to Regulate PFAS in Drinking Water~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~DRINKING WATER WARNING~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~DOH Approach to Developing PFAS State Action Levels~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~2022 EPA Health Advisory Levels for Four PFAS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS | Washington State Department of Health~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Pharmaceutical Firms Opened between Feb 19 thru May 22, 2020	No	NR	Not included from the	NA	NA
~~2023 EPA Proposal to Regulate PFAS in Drinking Water~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Pharmaceutical Firms Opened between May 22 thru July 10, 2020	No	NR	Not included from the	NA	NA
~~Recommended State Action Levels for Per- and Polyfluoroalkyl ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Draft Recommended State Action Levels for Per- and Polyfluoroalkyl ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Disability Organizations | Washington State Department of Health	No	NR	Not included from the	NA	NA
CLIA Waived Tests and CPT Codes	No	NR	Not included from the	NA	NA
Sex Chromosome Problems Discovered Through Prenatal ...	No	NR	Not included from the	NA	NA
Maine Department of Health and Human Services (Maine DHHS)					
Search results: PFOS (Number of results not shown). Search not undertaken beyond PFOS as Maine DHHS has an interim value for the sum of six different PFAS: PFOA, PFOS, PFHpA, PFNA, PFDA, and PFHxS and same search terms were being found),					
Search cut-off: Only results from first 10 results for PFOS and no evidence of guideline documents when following links on webpages found.					
Maine DWP - PFAS in Public Water Systems	Yes	-	Maine DHHS (2023a)	No	NA
What are PFOS, PFOA and PFAS? - Maine	Yes	-	Maine DHHS (2021a)	**Yes**	Included. Summary Document.
Maine PFAS Screening Levels	Yes	-	Maine DHHS (2021b)	Yes. Summary	Not Included. Summary Document. Refer to Maine DHHS (2021a)
PFAS Sampling Guidance for Public Water Systems - Maine	No	NR	Not included from the	NA	NA
Frequently Asked Questions: PFAS in Recreationally Caught ... - Maine	No	NR	Not included from the	NA	NA
Maine CDC Issues Additional Advisories on Eating ... - Maine DHHS	No	NR	Not included from the	NA	NA
Maine Drinking Water Program Home Page	No	NR	Not included from the	NA	NA
Maine Center for Disease Control & Prevention | Maine DHHS	No	NR	Not included from the	NA	NA
Maine CDC Drinking Water Program PFAS FAQs	No	NR	Not included from the	NA	NA
Division of Environmental and Community Health - Maine	No	NR	Not included from the	NA	NA
Alabama Department of Public Health (ADPH)					
Search results: 23 results for PFOS, 7 for PFOA, 1 for PFHxS, and Nil for PFBs and GenX. Website links to other Agency documents only.					
Search cut-off: Only results from first 10 results for PFOS shown.					
Fact Sheet: PFOA & PFOS Drinking Water Health Advisories	No	Other Agency	Not included from the	NA	NA
Frequently Asked Questions – PFOA and PFOS	No	NR	Not included from the	NA	NA
Public Health Statement for Perfluoroalkyls	No	Other Agency	Not included from the	NA	NA
Alabama Fish Consumption Advisories 2021	No	NR	Not included from the	NA	NA
NEWS RELEASE ALABAMA DEPARTMENT OF PUBLIC HEALTH	No	NR	Not included from the	NA	NA
NEWS RELEASE ALABAMA DEPARTMENT OF PUBLIC HEALTH	No	NR	Not included from the	NA	NA
NEWS RELEASE ALABAMA DEPARTMENT OF PUBLIC HEALTH	No	NR	Not included from the	NA	NA
2013 Alabama Fish Consumption Advisory Waterbody Location ...	No	NR	Not included from the	NA	NA
2014 Current and Historical Alabama Fish Consumption Advisory ...	No	NR	Not included from the	NA	NA
Alabama Fish Consumption Guidelines Current as of September ...	No	NR	Not included from the	NA	NA
~~Frequently Asked Questions – PFOA and PFOS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Fact Sheet: PFOA & PFOS Drinking Water Health Advisories~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Public Health Statement for Perfluoroalkyls~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~NEWS RELEASE ALABAMA DEPARTMENT OF PUBLIC HEALTH~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~NEWS RELEASE ALABAMA DEPARTMENT OF PUBLIC HEALTH~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~NEWS RELEASE ALABAMA DEPARTMENT OF PUBLIC HEALTH~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Toxicology | Alabama Department of Public Health (ADPH)	No	NR (Links)	Not included from the	NA	NA
Agencies respond to the Town of Centre Water Works and Sewer ...	No	NR	Not included from the	NA	NA
Untitled	No	NR	Not included from the	NA	NA
~~Public Health Statement for Perfluoroalkyls~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Alaska Department of Environment and Conservation					
Search results: 613 results for PFOS, 581 for PFOA, 283 results for PFHxS, 368 for PFBS, and for GenX					
Search cut-off: Only results from first 10 results for each PFAS shown.					
Aqueous Film Forming Foam (AFFF)	No	NR	Not included from the	NA	NA

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
DEC PFAS Page	No	NR (Links)	Not included from the	NA	NA
DEC Revised Tech Memo on Action Levels for PFAS in Water (PDF).	Yes	-	Alaska DEC (2019a)	**Yes. Summary**	Included. DWGs available.
Eielson Air Force Base PFOS Plume	No	NR	Not included from the	NA	NA
Fairbanks International Airport PFAS groundwater contamination	No	NR	Not included from the	NA	NA
Per- and polyfluoroalkyl substances (PFAS) in Alaska's Fish	No	NR	Not included from the	NA	NA
Action Plan and Levels for PFAS	No	NR (Links)	Not included from the	NA	NA
~~DEC Revised Tech Memo on Action Levels for PFAS in Water (PDF).~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Alaska Department of Environmental Conservation Office of the ...	No	NR	Not included from the	NA	NA
WHAT YOU NEED TO KNOW	No	NR	Not included from the	NA	NA
Untitled	No	NR	Not included from the	NA	NA
Perfluorooctane sulfonate. (PFOS) is a long-chain PFAS found in legacy stocks of AFFF and as a breakdown product of precursor compounds. Perfluorooctanoic acid ...	No	NR	Not included from the	NA	NA
~~Aqueous Film Forming Foam (AFFF)~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~DEC PFAS Page~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Action Plan and Levels for PFAS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Final Expanded PFOS, PFOA, and PFBS SI Report for Eielson AFB ...	No	NR	Not included from the	NA	NA
Additional Evaluation of PFOS and PFOA in Groundwater and ...	No	NR	Not included from the	NA	NA
ATSDR, NCEH Fact Sheet.	No	Other Agency	Not included from the	NA	NA
~~WHAT YOU NEED TO KNOW~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
dec.alaska.gov › media › 2016-11-03-clear-pfc-sample-results	No	NR	Not included from the	NA	NA
~~Untitled~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Per- and polyfluoroalkyl substances (PFAS) in Alaska's Fish	No	NR	Not included from the	NA	NA
ATSDR, NCEH Fact Sheet.	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Per- and polyfluoroalkyl substances (PFAS) in Alaska's Fish	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Alaska Department of Environmental Conservation Office of the ...	No	NR	Not included from the	NA	NA
Eielson AFB PFAS May- October 2020.xlsx	No	NR	Not included from the	NA	NA
dec.alaska.gov › media › pfas-drinking-water-action-levels-techni...	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Division of Spill Prevention and Response	No	NR	Not included from the	NA	NA
ANALYTICAL RESULTS FOR TRACE ELEMENTS AND PER- AND ...	No	NR	Not included from the	NA	NA
Laboratories Certified to Perform Chemical Analyses of Drinking Water	No	NR	Not included from the	NA	NA
State of Alaska Department of Environmental Conservation Fish ...	No	NR	Not included from the	NA	NA
COMPLETE PFAS SAMPLING RESULTS	No	NR	Not included from the	NA	NA
Final Expanded PFOS, PFOA, and PFBS SI Report for Eielson AFB ...	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
COMPLETE PFAS SAMPLING RESULTS	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Per- and polyfluoroalkyl substances (PFAS) in Alaska's Fish	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Alaska Department of Environmental Conservation Office of the ...	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Eielson AFB PFAS May- October 2020.xlsx	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Laboratories Certified to Perform Chemical Analyses of Drinking Water	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Anchorage Airport Water Supply Well PFAS Results - Initial Page 1 ...	No	NR	Not included from the	NA	NA
COMPLETE PFAS SAMPLING RESULTS	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
pfas-drinking-water-action-levels-technical-memorandum-10-2-19.pdf	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
COMPLETE PFAS SAMPLING RESULTS	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Alaska Department of Health (Alaska DOH) Public Health Alert Network (PHAN)					
Search results: 12 results for PFOS, 12 for PFOA, 2 results for PFHxS, 1 result for GenX and Nil results for PFBS.					
Perfluorooctane Sulfonate (PFOS) Fact Sheet	Yes	-	Alaska DOH (2016a)	Yes. Outdated	Not included. DWGs available. Summary document only. Refer to Alaska DEC (2019a)
Perfluorooctane Sulfonate (PFOS) Fact Sheet	Yes	-	Alaska DOH (2015a)	Yes. Outdated	Not included. DWGs available. Summary document only. Refer to Alaska DEC (2019a)
Department of Health and Social Services Perfluoroalkyl ...	No	NR	Not included from the	NA	NA
Department of Health and Social Services Perfluoroalkyl ...	No	NR	Not included from the	NA	NA
Department of Health and Social Services Perfluoroalkyl ...	No	NR	Not included from the	NA	NA
Department of Health and Social Services Perfluoroalkyl ...	No	NR	Not included from the	NA	NA
Department of Health and Social Services Perfluoroalkyl ...	No	NR	Not included from the	NA	NA
Department of Health and Social Services	No	Link did not work	Not included from the	NA	NA
Department of Health and Social Services	Yes	-	Alaska DHSS (2019a)	Yes. Summary	Not included. DWGs available. Summary document only. Refer to Alaska DEC (2019a)
PFAS Health Information	No	Link	Not included from the	NA	NA
Fact sheet on Perfluoroalkyl Substances (PFAS) in Drinking Water	Yes	-	Alaska DHSS (2019b)	Yes. Summary	Not included. DWGs available. Summary document only. Refer to Alaska DEC (2019a)
Frequently asked questions about Perfluoroalkyl Substances (PFAS)	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Information about fish consumption from Kimberly Lake	No	NR	Not included from the	NA	NA
Epidemiology Bulletin: Per- and Polyfluoroalkyl Substances in Three Alaska Communities	No	NR	Not included from the	NA	NA
ATSDR: An Overview of the Science and Guidance for Clinicians on Per- and Polyfluoroalkyl Substances (PFAS), Revised 12/6/2019	No	Other Agency	Not included from the	NA	NA
Fish Facts and Consumption Guidelines	No	NR	Not included from the	NA	NA
Food Safety for First Nations People of Canada: A Manual for ...	No	NR	Not included from the	NA	NA
~~Department of Health and Social Services Perfluoroalkyl ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Department of Health and Social Services Perfluoroalkyl ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Department of Health and Social Services Perfluoroalkyl ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Department of Health and Social Services~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Department of Health and Social Services~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Perfluorooctane Sulfonate (PFOS) Fact Sheet~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS Health Information~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Department of Health and Social Services Perfluoroalkyl ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Department of Health and Social Services Perfluoroalkyl ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Perfluorooctane Sulfonate (PFOS) Fact Sheet~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Department of Health and Social Services~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Department of Health and Social Services~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
TranscriptsAHCC_2011AHCC 11 ...	No	NR	Not included from the	NA	NA

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
Connecticut State Department of Public Health (CDPH)					
Search results: 258 results for PFOS,					
Search cut-off: Only results from first 30 results for PFOS and for PFOA shown. Search halted as only generic documents found that contained basic information on select PFAS.					
Per- and Polyfluoroalkyl Substances in Public Water Systems	Yes	-	CDPH (2023b)	Yes. Summary	Not included. DWGs available. Summary Document. Refer to CDPH (2023a)
EPA Approved Laboratories for PFOA and PFOS analysis.xlsx	No	NR	Not included from the	NA	NA
Connecticut Department of Public Health issues consumption ...	No	NR	Not included from the	NA	NA
Drinking Water Action Level for Perfluorinated Alkyl Substances ...	Yes	-	CDPH (2019a)	Yes. Outdated	Not included. DWGs available. Refer to CDPH (2023a, 2023b)
fish advisory	No	NR	Not included from the	NA	NA
Drinking Water Action Level for Perfluorinated Alkyl Substances ...	Yes	-	CPDH (2016a)	Yes. Outdated	Not included. DWGs available. Refer to CDPH (2023a, 2023b)
PFAS Overview and Implications for Private Wells in Connecticut	No	NR	Not included from the	NA	NA
Per- and Polyfluoroalkyl Substances (PFAS) in Groundwater	No	NR	Not included from the	NA	NA
PFAS Herbicides and Agricultural Properties	No	NR	Not included from the	NA	NA
PFAS	Yes	-	CDPH (2023a)	**Yes. Summary**	Included. DWGs available. Summary Document
PFAS Overview	No	NR	Not included from the	NA	NA
Advisory Information for Aqueous Film Forming Foam (AFFF ...	No	NR	Not included from the	NA	NA
PFAS June 2022	No	NR	Not included from the	NA	NA
PFAS in Drinking Water FS.pub	No	NR	Not included from the	NA	NA
Per- and polyfluoroalkyl Substances (PFAS) in Drinking Water ...	No	NR	Not included from the	NA	NA
An Emerging Contaminant in Drinking Water	No	NR	Not included from the	NA	NA
1 Attorneys General of the States of California, Colorado ...	No	NR	Not included from the	NA	NA
Green@GreenToxicology.com Green Toxicology LLC www ...	No	NR	Not included from the	NA	NA
Attorney General Tong Urges EPA to Protect Drinking Water from ...	No	NR	Not included from the	NA	NA
Perfluoroalkyl Substances (PFAS) in Drinking Water:	No	NR	Not included from the	NA	NA
Connecticut Department of Energy and Environmental Protection	No	NR	Not included from the	NA	NA
~~PFASs in Drinking Water FS.pub~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
An Emerging Contaminant in Drinking Water	No	NR	Not included from the	NA	NA
~~Per- and polyfluoroalkyl Substances (PFAS) in Drinking Water ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
1 Comments on ATSDR's Toxicological Profile for Perfluoroalkyls ...	No	NR	Not included from the	NA	NA
If I Catch It, Can I Eat It?	No	NR	Not included from the	NA	NA
DWS Circular Letter #2022-30 To: All Public Water Systems, Chief ...	No	NR	Not included from the	NA	NA
DWS Circular Letter #2022-29 To: Local Directors of Health and ...	No	NR	Not included from the	NA	NA
Current Water Quality Challenges	No	NR	Not included from the	NA	NA
https://portal.ct.gov/-/media/DEEP/site_clean_up/c...	No	NR	Not included from the	NA	NA
~~Per- and Polyfluoroalkyl Substances~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Drinking Water Action Level for Perfluorinated Alkyl Substances ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~EPA Approved Laboratories for PFOA and PFOS analysis.xlsx~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PFAS Overview and Implications for Private Wells in Connecticut~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Green@GreenToxicology.com Green Toxicology LLC www ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Drinking Water Action Level for Perfluorinated Alkyl Substances ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
1 Comments on ATSDR's Toxicological Profile for Perfluoroalkyls ...			Not included from the	NA	NA
PFAS in Drinking Water FS.pub			Not included from the	NA	NA
PFAS Overview			Not included from the	NA	NA
Vermont Department of Health (VDOH)					
Search results: 5 results for PFOS, 21 for PFOA, 3 for PFHxS, 1 for PFBS. Search abondoned as links to generic documents only. No toxicological profiles published.					
Search cut-off: Only results from first 10 results for PFOA shown					
Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) in Drinking Water	No	NR	Not included from the	NA	NA
Public Drinking Water	No	NR	Not included from the	NA	NA
PFOA in Drinking Water 2016	No	NR	Not included from the	NA	NA
Perfluorooctanyl sulphonic acid (PFOS) and its salts (CAS 1763-23-1)	No	NR	Not included from the	NA	NA
Chemical Disclosure Program for Children's Products	No	NR	Not included from the	NA	NA
~~PFOA in Drinking Water 2016~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
PFOA Blood Testing 2018	No	NR	Not included from the	NA	NA
~~Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) in Drinking Water~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Emergency Preparedness	No	NR	Not included from the	NA	NA
~~Public Drinking Water~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Preparedness for Communities	No	NR	Not included from the	NA	NA
Health Alerts & Advisories	No	NR	Not included from the	NA	NA
A-Z Drinking Water Contaminants	No	NR	Not included from the	NA	NA
Residential Drinking Water Testing	No	NR	Not included from the	NA	NA
Private Labs that Test for PFOA	No	NR	Not included from the	NA	NA
~~Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) in Drinking Water~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Perfluorohexanesulfonic acid (PFHxS) (CAS 355-46-4)	No	NR	Not included from the	NA	NA
~~Chemical Disclosure Program for Children's Products~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) in Drinking Water~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Department of Environmental Protection New Jersey (NJDEP)					
Search results: 71 results for PFOS, 73 for PFOA, 11 for PFHxS, 13 for PFBS, and 9 for GenX. Links followed (in purple text)					
Search cut-off: Only the first 10 results for each PFAS is shown					
supporting-documents-for-sierra-club-new-jersey-comments.pdf	No	NR	Not included from the	NA	NA
EPA update Biosolids and PFAS	No	Other Agency	Not included from the	NA	NA
NJDEP| Division of Science and Research | PFAS	No	Links	PFAS. Recommended I	NA	NA

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
Memorandum Guidance for PFOA in Drinking water	No	Age	Not included from the	NA	NA
Reference Concentrations for PFOA and PFOS in 2019 a	Yes	-	NJDEP (2019c)	Yes	Not included. RfC available. Refer to NJDEP (2019a, 2019b)
Screening Reference Concentration for GenX	Yes	-	NJDEP (2019d)	Yes. Outdated	Not included. RfD available. Refer to NJDEP (2023a)
PFOS risk assessment	Yes	-	Pachkowski et al. (201	Yes	Not included. RfD available. Refer to NJDEP (2019b)
Scientific support for the development of these standards	No	Links	Technical Support Doc	NA	NA
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA) and its ammonium salt (GenX) (CASRN: 13252-13-6 & 62037-80-3)	Yes	-	NJDEP (2023a)	**Yes**	Included. DWG and RfD (from USEPA) available
Perfluorooctanoic Acid (PFOA) (CASRN: 335-67-1) Technical Support Document	Yes	-	NJDEP (2019a)	**Yes**	Included. DWG and RfD available
Perfluorooctane Sulfonate (PFOS) (CASRN: 1763-23-1) Technical Support Document	Yes	-	NJDEP (2019b)	**Yes**	Included. DWG and RfD available
Perfluorononanoic Acid (PFNA) (CASRN: 375-95-1) Technical Support Document	No	NR	Not included from the	NA	NA
NJDEP| Division of Science and Research | OQA Bulletin Board	No	NR	Not included from the	NA	NA
Position Statement on Monitoring PFAS - NJ Clean Water Council	No	NR	Not included from the	NA	NA
What the UCMR3 Data is Telling Us	No	NR	Not included from the	NA	NA
NJDEP| Division of Science and Research | Division Peer-Reviewed Publications	No	NR	Not included from the	NA	NA
317726	No	NR	Not included from the	NA	NA
SC NJ 2023 - PFAS WASTEWATER	No	NR	Not included from the	NA	NA
Document5	No	NR	Not included from the	NA	NA
~~NJDEP| Division of Science and Research | PFAS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PA Update_Biosolids and PFAS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~supporting-documents-for-sierra-club-new-jersey-comments.pdf~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~What the UCMR3 Data is Telling Us~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~NJDEP| Division of Science and Research | OQA Bulletin Board~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Position Statement on Monitoring PFAS - NJ Clean Water Council~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Microsoft Word - Document5~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~NJDEP| Division of Science and Research | Division Peer-Reviewed Publications~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~317726~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
NJDEP| Division of Science and Research | Certified Laboratories	No	NR	Not included from the	NA	NA
~~supporting-documents-for-sierra-club-new-jersey-comments.pdf~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~What the UCMR3 Data is Telling Us~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Indentification of Perfluoroalkyl Compounds (PFCs) in the Metedeconk River Watershed	No	NR	Not included from the	NA	NA
Indentification of Perfluoroalkyl Compounds (PFCs) in the Metedeconk River Watershed	No	NR	Not included from the	NA	NA
Investigation of Levels of Perfluorinated Compounds in New Jersey Fish, Surface Water, and Sediment.pdf	No	NR	Not included from the	NA	NA
Indentification of Perfluoroalkyl Compounds (PFCs) in the Metedeconk River Watershed	No	NR	Not included from the	NA	NA
Technical Support Document-Interim Specific GRound Water Quality Criterion for Chloroperfluoropolyether Carboxylates	No	NR	Not included from the	NA	NA
~~/Technical Support Document ISGQWC for PFOS.pdf~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
PowerPoint Presentation	No	NR	Not included from the	NA	NA
Human Health Standards & Risk Assessment for Non-Risk Assessors	No	NR	Not included from the	NA	NA
~~supporting-documents-for-sierra-club-new-jersey-comments.pdf~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~What the UCMR3 Data is Telling Us~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Indentification of Perfluoroalkyl Compounds (PFCs) in the Metedeconk River Watershed~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Indentification of Perfluoroalkyl Compounds (PFCs) in the Metedeconk River Watershed~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Indentification of Perfluoroalkyl Compounds (PFCs) in the Metedeconk River Watershed~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Reconnaissance of Contaminants of Emerging Concern in Wastewater and Sludge	No	NR	Not included from the	NA	NA
A Reconnaissance of Contaminants of Emerging Concern in Wastewater and Sludge from Three Publicly Owned Treatment Works in New Jersey	No	NR	Not included from the	NA	NA
~~Investigation of Levels of Perfluorinated Compounds in New Jersey Fish, Surface Water, and Sediment~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Technical Support Document ISGQWC for PFOS.pdf~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~PowerPoint Presentation~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~NJDEP| Division of Science and Research | PFAS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~supporting-documents-for-sierra-club-new-jersey-comments.pdf~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Microsoft Word - SC NJ 2023 - PFAS WASTEWATER~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
NJDEP| Environmental Standards | Compendium of Environmental Standards	No	NR	Not included from the	NA	NA
~~Human Health Standards & Risk Assessment for Non-Risk Assessors~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Technical Support Document-Interim Specific GRound Water Quality Criterion for Chloroperfluoropolyether Carboxylates~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~NJDEP - News Release 19/P021 - Affirming National Leadership Role, New Jersey Proposes Stringent Drinking Water Standards for PFOA and PFOS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
NJDEP - News Release 19/P018 - DEP Directs Five Chemical Companies to Fund Removal of Extensive PFAS Contamination Throughout State	No	NR	Not included from the	NA	NA
12-18-13	No	NR	Not included from the	NA	NA
Michigan Department of the Environment (MDOE) (and Michigan PFAS Action Response Team or MPART)					
Search results: Nil results for PFOS, PFOA, PFHxS, PFBS, and GenX. A generic google search undertaken for "michigan PFAS drinking water"					
PFAS Drinking Water Rules (Found in google search)	No	Links only	Not included from the	NA	NA
PFAS Rules Overview	Yes	-	MDOE (2020a)	Yes. Summary	Not included. MCLs available. Summary only. Refer to MPART (2019a)
PFAS Rules Quick Reference Guide	No	Basic	Not included from the	NA	NA
Michigan PFAS Response	No	Links only	Not included from the	NA	NA
Drinking Water and Wells	No	Links only	Not included from the	NA	NA
Learn more about Michigan's PFAS MCLs	Yes	Links	MPART (2023a)	Yes. Summary	Not included. MCLs available. Summary only. Refer to MPART (2019a)
How the U.S. EPA regulates drinking water contaminants	No	NR	Not included from the	NA	NA
Science Advisory Workgroup 2019 Report	Yes	-	MPART (2019a)	**Yes**	Included. MCLs and RfD available.
Massachusetts Department of Public Health (Mass DPH)					
Search results: 5 results for PFOS, 8 for PFOA,3 for PFHxS, 5 for PFBS, and nil for GenX. A generic google search undertaken for "michigan PFAS drinking water"					
EPA Proposed Maximum Contaminant Level (MCL) for PFAS	No	Links only	Not included from the	NA	NA
EPA Proposed Maximum Contaminant Level (MCL) for PFAS	Yes	Links	Mass DPH (2023a)	**Yes**	Included. MCLs available (from USEPA). Summary only.
Drinking Water Health Advisories for PFAS Fact Sheet for Communities and Questions	No	Other Agencies	Not included from the	NA	NA
Answers: Drinking Water Health Advisories for PFOA, PFOS, GenX, PFBS FAQs.	No	Other Agencies	Not included from the	NA	NA
Comments on PFAS National Primary Drinking Water Regulation Rulemaking	Yes	-	MassDEP (2023b)	Yes	Not included. MCLs available. Comments and Summary only.

	Preliminary title screen			*Content screen*	
Title of result	**Included from title screen**	**Reason for Exclusion**	**Comment/Referenc**	**Provides relevant guidelines/guidance?**	**Comment (TDI = Tolerable Daily Intake or similar, DWG = Drinking Water Guideline**
Air Force PublicAffairs PFOS/PFOA FREQUENTLY ASKED ...	No	NR	Not included from the	NA	NA
Technical Fact Sheet – Perfluorooctane Sulfonate (PFOS) and ...	No	Other Agencies	Not included from the	NA	NA
Untitled	No	NR	Not included from the	NA	NA
Sample Title Slide - Massachusetts National Guard	No	NR	Not included from the	NA	NA
How to Interpret my PFAS Laboratory Report	No	NR	Not included from the	NA	NA
~~EPA Proposed Maximum Contaminant Level (MCL) for PFAS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Per- and Polyfluoroalkyl Substances (PFAS) in drinking water	No	Links	Not included from the	NA	NA
~~Air Force PublicAffairs PFOS/PFOA FREQUENTLY ASKED ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Technical Fact Sheet – Perfluorooctane Sulfonate (PFOS) and ...~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Per- and Polyfluoroalkyl Substances (PFAS) Dataset	No	NR	Not included from the	NA	NA
~~Untitled~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Sample Title Slide - Massachusetts National Guard~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~How to Interpret my PFAS Laboratory Report~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~EPA Proposed Maximum Contaminant Level (MCL) for PFAS~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
~~Per- and Polyfluoroalkyl Substances (PFAS) Dataset~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Office of Research & Standards Final Recommendations for PFAS Toxicity Guidance	Yes	-	MassDEP (2018a)	Yes. Outdated.	Not included. MCLs available. See Mass DPH (2023a) and Mass DEP (2022a, 2023a)
EPA's New Health Advisories For Some PFAS	Yes	-	MassDEP (2022a)	**Yes**	Included. MCLs available. Summary only.
~~Per- and Polyfluoroalkyl Substances (PFAS) Dataset~~	~~NoR~~	~~Repeated~~	~~Duplicate entry. See fi~~	NA	NA
Technical Basis for Issuing Fish Advisories	No	NR	Not included from the	NA	NA
Interim Guidance on Sampling and Analysis for PFAS at Disposal Sites Regulated under the Massachusetts Contingency Plan (June 2022)	No	NR	Not included from the	NA	NA
Additional Papers					
Toxicological Profile for Perfluoroalkyls Draft for Public Comment	Yes	-	ATSDR (2018b)	Yes.	Not included. TDI available (Draft MRL). Refer to ATSDR (2021a)
Internal RPFs for the Risk Assessment of PFAS in Human Biomonitoring	Yes	-	Bil (2022)	Yes.	Not included. Relative potency factors for PFAS avialable. USE RIVM (2019b)
fortschreibung_der_uba-pfc-bewertungen_bundesgesundheitsbl_2017-60_s_350-352	Yes	-	BFT (2017)	Yes.	Not included. DWG available. Summary Document. Refer to BfR (2019)
Opinion on Grounbdwater Quality Standards scheer_o_035	Yes	-	EC (2022)	Yes.	Included. DWG available. Summary Document
Directive for Drinking Water CELEX_32020L2184_EN_TXT	Yes	-	EU (2020)	Yes.	Included. DWG available. Summary Document
PFCs DWGV 2011-0126 (CS)	Yes	-	HC (2011)	Yes. Outdated	Not included. DWG available. Summary Document
Water Talk - PFAS MACS and Screening Values-EN-2019-0423 FINAL	Yes	-	HC (2019)	Yes. Outdated	Not included. DWG available. Summary Document
Updated PFAS SSV Memo April2022 finalEN	Yes	-	HC (2022)	Yes. Summary	Not included. DWG available. Summary Document
Provisional evaluation of PFT in drinking water with the guide substances PFOA and PFOS as examples	Yes	-	TKA (2006)	Yes. Outdated	Not included. DWG and RfD available.
GenX Health information	Yes	-	NC (2017)	Yes.	Included. DWG available. Summary Document

Table A2: Supporting Information Literature Search

Search term:
•(PFOS) OR (1763-23-1) AND (treatment OR analysis) AND (drinking water)
•(PFOA) OR (335-67-1) AND (treatment OR analysis) AND (drinking water)
•(PFHxS) OR (355-46-4) AND (treatment OR analysis) AND (drinking water)
•(PFBS) OR (375-73-5) OR (29420-49-3) AND (treatment OR analysis) AND (drinking water)
•(GenX) OR (13252-13-6) OR (62037-80-3) AND (treatment OR analysis) AND (drinking water)
Date range : For the evidence scan for supporting information in the two scientific databases specified, a cut-off date of 2016 was used for all 5 PFAS to ensure currency of the information.
Data base searched: The following databases were searched:
•Medline/Pubmed/Toxline
•Scopus
The following industry websites were searched:
•Water Services Association of Australia: https://www.wsaa.asn.au/
•Standard Methods for the Examination of Water and Wastewater: https://www.standardmethods.org/
The following Australian commercial laboratories were contacted directly via e-mail or website form for relevant information:
•National Measurement Institute
•SGS
•ALS
•Eurofins
Data from government/ intergovernmental agencies [i.e. Heads of EPA National Environment Management Plan (HEPA 2020, 2022)]
Date of search: August 2023

Legend/Abbreviations
NR=not relevant
L = Language other than english

	Preliminary title screen			*Content screen*	
Title of result	**Included in title screen**	**Reason for Exclusion**	**Comment/Reference**	**Included in content screen?**	**Comment**
Search results: 416 (plu 8 additional papers)					
[Contamination Levels and Exposure Risk via Drinking Water from Perfluoroalkyl Acids in Seven Major Drainage Basins of China]	No	NR	Not relevant	NA	Excluded in title screen
[Distribution, Tansformation, and Fate of Per-and Polyfluoroalkyl Substances in Drinking Water Treatment]	No	L	Chinese	NA	Included
[Research on the establishment of standard limits for perfluorooctanoic acid and perfluorooctane sulfonate in the "Standards for Drinking Water Quality（GB5749-2022）"in China]	No	L	Chinese	NA	Excluded in title screen
A Bayesian hierarchical model for estimating national PFAS drinking water occurrence	Yes	-	Cadwallader et al (2022)	No	Appears to be an estimated exposure rather than measure exposure
A method for detecting perfluorooctanoic acid and perfluorooctane sulfonate in water samples using genetically engineered bacterial biosensor	No	RT	Research technique	NA	Excluded in title screen
A mortality study on male subjects exposed to polyfluoroalkyl acids with high internal dose of perfluorooctanoic acid	No	NR	Not relevant	NA	Excluded in title screen
A Multi-Pronged Approach for Managing PFAS in Water Resource Reclamation Facilities	Yes	-	Landry (2021)	No	Excluded in content screen. Conference paper
A Nested Case-Control Study of Serum Per- and Polyfluoroalkyl Substances and Testicular Germ Cell Tumors among U.S. Air Force Servicemen	No	NR	Not relevant	NA	Excluded in title screen
A Pathology Review of the Lower Gastrointestinal Tract in Relation to Ulcerative Colitis in Rats and Cynomolgus Macaques Treated With Ammonium Perfluorooctanoate	No	NR	Not relevant	NA	Excluded in title screen
A pilot study on extractable organofluorine and per- and polyfluoroalkyl substances (PFAS) in water from drinking water treatment plants around Taihu Lake, China: what is missed by	Yes	-	Jiao et al (2022)	**Yes**	Included
A Probabilistic Approach to Evaluate the Risk of Decreased Total Triiodothyronine Hormone Levels following Chronic Exposure to PFOS and PFHxS via Contaminated Drinking Water	No	NR	Not relevant	NA	Excluded in title screen
A rapid assessment bioaccumulation screening (RABS) study design for emerging per-and polyfluoroalkyl substances in mice exposed to industrially impacted surface water	No	NR	Not relevant	NA	Excluded in title screen
A review of contamination of surface-, ground-, and drinking water in Sweden by perfluoroalkyl and polyfluoroalkyl substances (PFASs)	No	NR	Not relevant	NA	Excluded in title screen
A review of emerging PFAS contaminants: sources, fate, health risks, and a comprehensive assortment of recent sorbents for PFAS treatment by evaluating their mechanism	Yes	-	Teymorurian et al (2021)	**Yes**	Included
A review on degradation of perfluorinated compounds based on ultraviolet advanced oxidation	Yes	-	Wang et al (2021a)	**Yes**	Included
A sensitive method for simultaneous determination of 12 classes of per- and polyfluoroalkyl substances (PFASs) in groundwater by ultrahigh performance liquid chromatography coup	Yes	-	Liu et al (2020a)	**Yes**	Included
A study of reverse causation: Examining the associations of perfluorooctanoic acid serum levels with two outcomes	No	NR	Not relevant	NA	Excluded in title screen
A transgenerational toxicokinetic model and its use in derivation of Minnesota PFOA water guidance	No	NR	Not relevant	NA	Excluded in title screen
ADONA and perfluoroalkylated substances in plasma samples of German blood donors living in South Germany	No	NR	Not relevant	NA	Excluded in title screen
Adsorption behavior of per- And polyfluoralkyl substances (PFASs) to 44 inorganic and organic sorbents and use of dyes as proxies for PFAS sorption	Yes	-	Sorengard et al (2020)	**Yes**	Included
Adsorption of perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) by aluminum-based drinking water treatment residuals	Yes	-	Zhang et al (2021a)	**Yes**	Included
Adverse effects of in vitro GenX exposure on rat thyroid cell viability, DNA integrity and thyroid-related genes expression	No	NR	Not relevant	NA	Excluded in title screen
Air Emissions Damages from Municipal Drinking Water Treatment Under Current and Proposed Regulatory Standards	No	NR	Not relevant	NA	Excluded in title screen
Alternatives Evaluation for Compliance with Proposed MCLs for PFOS and PFOA	Yes	-	Horai et al (2021)	No	Excluded in content screen. Conference paper
An (Eco)Toxicity Life Cycle Impact Assessment Framework for Per-And Polyfluoroalkyl Substances	No	NR	Not relevant	NA	Excluded in title screen
An analysis of the use of the relative source contribution term in derivation of drinking water standards using perfluorooctanoic acid as an example	No	NR	Not relevant	NA	Excluded in title screen
An evaluation of health-based federal and state PFOA drinking water guidelines in the United States	No	NR	Not relevant	NA	Excluded in title screen
An overview of per-and polyfluoroalkyl substances (Pfas) in the environment: Source, fate, risk and regulations	Yes	-	Abunada et al (2020)	**Yes**	Included
An Overview of the Formation of PFOA and PFOS in Drinking-Water and Wastewater Treatment Processes	Yes	-	Xiao et al (2022)	**Yes**	Included
An ultra-sensitive method for the analysis of perfluorinated alkyl acids in drinking water using a column switching high-performance liquid chromatography tandem mass spectrometr	Yes	-	Dasu et al (2017)	**Yes**	Included
Analysis of GenX and Other Per- and Polyfluoroalkyl Substances in Environmental Water Samples	Yes	-	Tian et al (2019)	**Yes**	Included
Analysis of hexafluoropropylene oxide-dimer acid (HFPO-DA) by liquid chromatography-mass spectrometry (LC-MS): Review of current approaches and environmental levels	No	NR	Not relevant	NA	Excluded in title screen
Analysis of PFAAs in American alligators part 2: Potential dietary exposure of South Carolina hunters from recreationally harvested alligator meat	No	NR	Not relevant	NA	Excluded in title screen
Anion exchange resin removal of per- and polyfluoroalkyl substances (PFAS) from impacted water: A critical review	Yes	-	Boyer et al (2021)	**Yes**	Included
Are perfluoroalkyl substances in water and fish from drinking water source the major pathways towards human health risk?	No	NR	Not relevant	NA	Excluded in title screen
Assessing Human Health Risks from Per- and Polyfluoroalkyl Substance (PFAS)-Impacted Vegetable Consumption: A Tiered Modeling Approach	No	NR	Not relevant	NA	Excluded in title screen
Assessing per- and polyfluoroalkyl substances (PFAS) in sediments and fishes in a large, urbanized estuary and the potential human health implications	No	NR	Not relevant	NA	Excluded in title screen
Assessing the human health risks of perfluorooctane sulfonate by in vivo and in vitro studies	No	NR	Not relevant	NA	Excluded in title screen
Assessment of individual-based perfluoroalkly substances exposure by multiple human exposure sources	Yes	-	Kim et al (2019)	No	Not related to RQ
Assessment of per- and polyfluoroalkyl substances in Biscayne Bay surface waters and tap waters from South Florida	No	NR	Not relevant	NA	Excluded in title screen
Assessment of perfluoroalkyl substances levels in tap and bottled water samples from Turkey	No	NR	Not relevant	NA	Excluded in title screen
Association between serum concentrations of perfluoroalkyl substances (PFAS) and expression of serum microRNAs in a cohort highly exposed to PFAS from drinking water	No	NR	Not relevant	NA	Excluded in title screen
Association of exposure to perfluoroalkyl substances and risk of the acute coronary syndrome: A case-control study in Shijiazhuang Hebei Province	No	NR	Not relevant	NA	Excluded in title screen
Associations between Mixture of Perfluoroalkyl Substances and Lipid Profile in a Highly Exposed Adult Community in the Veneto Region	No	NR	Not relevant	NA	Excluded in title screen
Associations between perfluoroalkyl substances and lipid profile in a highly exposed young adult population in the Veneto Region	No	NR	Not relevant	NA	Excluded in title screen
Associations between perfluoroalkyl substances and serum lipids in a Swedish adult population with contaminated drinking water	No	NR	Not relevant	NA	Excluded in title screen
Associations between perfluoroalkyl substances and thyroid hormones after high exposure through drinking water	No	NR	Not relevant	NA	Excluded in title screen
Associations between PFAS occurrence and multimorbidity as observed in an electronic health record cohort	No	NR	Not relevant	NA	Excluded in title screen
Bayesian Estimation of Human Population Toxicokinetics of PFOA, PFOS, PFHxS, and PFNA from Studies of Contaminated Drinking Water	Yes	-	Chiu et al (2022)	No	Not included. Paper on toxicodynamics, not related to treatment or measurment.
Biomonitoring for perfluorochemicals in a Minnesota community with known drinking water contamination	No	NR	Not relevant	NA	Excluded in title screen

	Preliminary title screen			*Content screen*	
Title of result	**Included in title screen**	**Reason for Exclusion**	**Comment/Reference**	**Included in content screen?**	**Comment**
Biomonitoring of emerging contaminants, perfluoroalkyl and polyfluoroalkyl substances (PFAS), in New Jersey adults in 2016–2018	No	NR	Not relevant	NA	Excluded in title screen
Biomonitoring of perfluorinated compounds in children and adults exposed to perfluorooctanoate-contaminated drinking water	No	NR	Not relevant	NA	Excluded in title screen
Bubble-Nucleation-Based Method for the Selective and Sensitive Electrochemical Detection of Surfactants	No	NR	Not relevant	NA	Excluded in title screen
Calibration and application of passive sampling for per- and polyfluoroalkyl substances in a drinking water treatment plant	Yes	-	Gobelius et al (2019)	**Yes**	Included
Can sustained exposure to PFAS trigger a genotoxic response? A comprehensive genotoxicity assessment in mice after subacute oral administration of PFOA and PFBA	No	NR	Not relevant	NA	Excluded in title screen
Cancer incidence in a Swedish cohort with high exposure to perfluoroalkyl substances in drinking water	No	NR	Not relevant	NA	Excluded in title screen
Centurial Persistence of Forever Chemicals at Military Fire Training Sites	Yes	-	Ruyle et al (2023a)	No	Case study, not related to drinking water
Characteristic and human exposure risk assessment of per- and polyfluoroalkyl substances: A study based on indoor dust and drinking water in China	No	NR	Not relevant	NA	Excluded in title screen
Characteristics, pollution patterns and risks of Perfluoroalkyl substances in drinking water sources of Taiwan	No	NR	Not relevant	NA	Excluded in title screen
Characteristics, source apportionment and health risk assessment of perfluoroalkyl acids in typical drinking water sources of eastern China	No	NR	Not relevant	NA	Excluded in title screen
Characterizing the Air Emissions, Transport, and Deposition of Per- and Polyfluoroalkyl Substances from a Fluoropolymer Manufacturing Facility	No	NR	Not relevant	NA	Excluded in title screen
Chemical Characterization of a Legacy Aqueous Film-Forming Foam Sample and Developmental Toxicity in Zebrafish (Danio rerio)	No	NR	Not relevant	NA	Excluded in title screen
Chlorinated polyfluoroalkyl ether sulfonic acids in fish, dust, drinking water and human serum: From external exposure to internal doses	No	NR	Not relevant	NA	Excluded in title screen
Chronic Reproductive Toxicity Thresholds for Northern Bobwhite Quail (Colinus virginianus) Exposed to Perfluorohexanoic Acid (PFHxA) and a Mixture of Perfluorooctane Sulfonic Acid	No	NR	Not relevant	NA	Excluded in title screen
Combined effects of BPA and PFOS on fetal cardiac development: In vitro and in vivo experiments	No	NR	Not relevant	NA	Excluded in title screen
Comparison of activated carbons for removal of perfluorinated compounds from drinking water	Yes	-	McNamara et al (2018)	**Yes**	Included
Comprehension and perceptions of study participants upon receiving perfluoroalkyl substance exposure biomarker results	No	NR	Not relevant	NA	Excluded in title screen
Computational Analysis of the Binding Mechanism of GenX and HSA	Yes	-	Delva-Wiley et al (2021)	No	Health-related paper
Concentration, spatial distribution, and health risk assessment of PFASs in serum of teenagers, tap water and soil near a Chinese fluorochemical industrial plant	No	NR	Not relevant	NA	Excluded in title screen
Concentrations of perfluoroalkyl substances in human milk from Ireland: Implications for adult and nursing infant exposure	No	NR	Not relevant	NA	Excluded in title screen
Contaminants of emerging concern in drinking water: Quality assessment by combining chemical and biological analysis	Yes	-	Valbonesi et al (2021)	No	Case study. Little information about PFAS.
Contamination and health risk of precursors of PFAAs in urban aquatic environment; [城市水环境 PFAAs 前驱体污染特征及健康风险]	No	NR	Not relevant	NA	Excluded in title screen
Contamination Levels and Exposure Risk via Drinking Water from Perfluoroalkyl Acids in Seven Major Drainage Basins of China; [中国七大流域全氟烷基酸污染水平与饮水暴露风险	No	NR	Not relevant	NA	Excluded in title screen
Contamination profiles and risk assessment of per- and polyfluoroalkyl substances in groundwater in China	No	NR	Not relevant	NA	Excluded in title screen
Contribution of air-water interface in removing PFAS from drinking water: Adsorption, stability, interaction and machine learning studies	Yes	-	Yuan et al (2023)	No	Not included. Theoretical paper based on simulated results.
Critical endpoints of PFOA and PFOS exposure for regulatory risk assessment in drinking water: Parameter choices impacting estimates of safe exposure levels	No	NR	Not relevant	NA	Excluded in title screen
Cross-sectional associations between serum PFASs and inflammatory biomarkers in a population exposed to AFFF-contaminated drinking water	No	NR	Not relevant	NA	Excluded in title screen
Current Breast Milk PFAS Levels in the United States and Canada: After All This Time, Why Don't We Know More?	No	NR	Not relevant	NA	Excluded in title screen
Deep urban groundwater vulnerability in India revealed through the use of emerging organic contaminants and residence time tracers	No	NR	Not relevant	NA	Excluded in title screen
Degradation of hexafluoropropylene oxide oligomer acids as PFOA alternatives in simulated nanofiltration concentrate: Effect of molecular structure	Yes	-	Bao et al (2020)	**Yes**	Included
Degradation of Per- and Polyfluoroalkyl Substances with Hydrated Electrons: A New Mechanism from First-Principles Calculations	Yes	-	Biswas et al (2022)	No	Not included. Research technique. Specialised and unlikely to be applied in near future.
Degradation of perfluorooctane sulfonate: Via in situ electro-generated ferrate and permanganate oxidants in NOM-rich source waters	Yes	-	McBeath & Graham (2021)	**Yes**	Included
Demographic and exposure characteristics as predictors of serum per- and polyfluoroalkyl substances (PFASs) levels - A community-level biomonitoring project in Pennsylvania	Yes	-	Nair et al (2021)	No	Case study. Not related to RQ
Demographic, life-style and physiological determinants of serum per- and polyfluoroalkyl substance (PFAS) concentrations in a national cross-sectional survey of Swedish adolescents	No	NR	Not relevant	NA	Excluded in title screen
Derivation of a Human In Vivo Benchmark Dose for Perfluorooctanoic Acid From ToxCast In Vitro Concentration-Response Data Using a Computational Workflow for Probabilistic Qua	No	NR	Not relevant	NA	Excluded in title screen
Derivation of a Human In Vivo Benchmark Dose for Perfluorooctanoic Acid From ToxCast In Vitro Concentration–Response Data Using a Computational Workflow for Probabilistic Qua	No	NR	Not relevant	NA	Excluded in title screen
Deriving environmental quality standards for perfluorooctanoic acid (PFOA) and related short chain perfluorinated alkyl acids	No	NR	Not relevant	NA	Excluded in title screen
Determinants of per- and polyfluoroalkyl substances (PFAS) in midlife women: Evidence of racial/ethnic and geographic differences in PFAS exposure	No	NR	Not relevant	NA	Excluded in title screen
Determinants of plasma concentrations of perfluoroalkyl and polyfluoroalkyl substances in pregnant women from a birth cohort in Shanghai, China	No	NR	Not relevant	NA	Excluded in title screen
Determinants of serum concentrations of perfluoroalkyl acids (PFAAs) in school children and the contribution of low-level PFAA-contaminated drinking water	No	NR	Not relevant	NA	Excluded in title screen
Determinants of serum half-lives for linear and branched perfluoroalkyl substances after long-term high exposure—A study in Ronneby, Sweden	No	NR	Not relevant	NA	Excluded in title screen
Determination of adsorbable organic fluorine from aqueous environmental samples by adsorption to polystyrene-divinylbenzene based activated carbon and combustion ion chromat	Yes	-	Wagner et al (2013)	**Yes**	Included
Determination of perfluoroalkylated substances (PFASs) in drinking water from the Netherlands and Greece	No	NR	Not relevant	NA	Excluded in title screen
Developing potency factors for thyroid hormone disruption by PFASs using TTR-TRβ CALUX® bioassay and assessment of PFASs mixtures in technical products	No	NR	Not relevant	NA	Excluded in title screen
Development and application of an LC-MS method to the determination of poly- and perfluoroalkyl substances (PFASs) in drinking, sea and surface water samples	Yes	-	Huerta et al (2022)	No	Compares concentration in different water matrices but does not provide relevant info for RQ
Developmental language disorders in preschool children after high exposure to perfluoroalkyl infstances from contaminated drinking water in Ronneby, Sweden	No	NR	Not relevant	NA	Excluded in title screen
Developmental perfluorooctane sulfonate exposure inhibits long-term potentiation by affecting AMPA receptor trafficking	Yes	-	Zhang et al (2019)	No	Health-related study
Dietary and maternal sociodemographic determinants of perfluoroalkyl and polyfluoroalkyl substance levels in pregnant women	No	NR	Not relevant	NA	Excluded in title screen
Dietary intake, drinking water ingestion and plasma perfluoroalkyl substances concentration in reproductive aged Chinese women	No	NR	Not relevant	NA	Excluded in title screen
Different adsorption behavior between perfluorohexane sulfonate (PFHxS) and perfluorooctanoic acid (PFOA) on granular activated carbon in full-scale drinking water treatment plant	Yes	-	Park et al (2021b)	**Yes**	Included
Distribution characteristics and health risk assessment of perfluoroalkyl substances in aquatic environment of Hangzhou-Jiaxing-Huzhou region in Zhejiang Province	No	NR	Not relevant	NA	Excluded in title screen
Distribution characteristics of perfluorinated compounds in sludge wastewater and sludge from drinking water treamtment plant; [饮用水厂排泥水及污泥中全氟化合物分布特征]	No	NR	Not relevant	NA	Excluded in title screen
Distribution of perfluorinated compounds in drinking water treatment plant and reductive degradation by UV/SO(3)(2-) process	Yes	-	Sun et al (2017)	**Yes**	Included
Distribution of perfluorinated compounds in lake taihu (China): Impact to human health and water standards	No	NR	Not relevant	NA	Excluded in title screen
Distribution, source identification and health risk assessment of PFASs and two PFOS alternatives in groundwater from non-industrial areas	No	NR	Not relevant	NA	Excluded in title screen
Distribution, source identification and health risk assessment of PFASs in groundwater from Jiangxi Province, China	No	NR	Not relevant	NA	Excluded in title screen
Distribution, Tansformation, and Fate of Per-and Polyfluoroalkyl Substances in Drinking Water Treatment; [饮用水处理过程中全氟化合物的分布、 转化及去向]	No	L	Chinese	NA	Excluded in title screen
Does regulating per- and polyfluoroalkyl substances represent a meaningful opportunity for health risk reduction?	No	NR	Not relevant	NA	Excluded in title screen
Does soil track-in contribute to house dust concentrations of perfluoroalkyl acids (PFAAs) in areas affected by soil or water contamination?	No	NR	Not relevant	NA	Excluded in title screen
Does Using Corsi-Rosenthal Boxes to Mitigate COVID-19 Transmission Also Reduce Indoor Air Concentrations of PFAS and Phthalates?	No	NR	Not relevant	NA	Excluded in title screen
Domestic Dogs and Horses as Sentinels of Per- and Polyfluoroalkyl Substance Exposure and Associated Health Biomarkers in Gray's Creek North Carolina	No	NR	Not relevant	NA	Excluded in title screen
Drinking water nanofiltration with concentrate foam fractionation-A novel approach for removal of per- and polyfluoroalkyl substances (PFAS)	Yes	-	McCleaf et al (2023)	**Yes**	Included
Drinking Water-Associated PFAS and Fluoroethers and Lipid Outcomes in the GenX Exposure Study	Yes	-	Rosen et al (2022)	No	Health-related study
Dual-functional phosphorene nanocomposite membranes for the treatment of perfluorinated water: An investigation of perfluorooctanoic acid removal via filtration combined with u	Yes	-	Eke et al (2020)	**Yes**	Included
Ecological and health risk assessment of perfluorooctane sulfonate in surface and drinking water resources in China	No	NR	Not relevant	NA	Excluded in title screen
Effectiveness of household water purifiers in removing perfluoroalkyl substances from drinking water	Yes	-	Iwabuchi et al (2021)	**Yes**	Included
Effects of perfluorobutane sulfonate and perfluorooctane sulfonate on lipid homeostasis in mouse liver	No	NR	Not relevant	NA	Excluded in title screen
Effects of Perfluorooctanoic Acid on Gut Microbiota and Microbial Metabolites in C57BL/6J Mice	No	NR	Not relevant	NA	Excluded in title screen
Efficient adsorptive removal of short-chain perfluoroalkyl acids using reed straw-derived biochar (RESCA)	Yes	-	Liu et al (2021)	**Yes**	Included
Efficient Reductive Destruction of Perfluoroalkyl Substances under Self-Assembled Micelle Confinement	Yes	-	Chen et al (2020)	No	Not included. Novel treatment for waste streams and PFAS enriched concentrates
Efficient removal of GenX (HFPO-DA) and other perfluorinated ether acids from drinking and recycled waters using anion exchange resins	Yes	-	Dixit et al (2020)	**Yes**	Included
Electrochemical technologies for per- and polyfluoroalkyl substances mitigation in drinking water and water treatment residuals	Yes	-	Ryan et al (2021)	No	Not included. Review paper for proof of concept (electoroxidation and electrocoagulation)
Electrochemosensor for Trace Analysis of Perfluorooctanesulfonate in Water Based on a Molecularly Imprinted Poly(o-phenylenediamine) Polymer	Yes	-	Karimian et al (2018)	No	Appears to be a research technique not a commercially available procedure
Elevated concentrations of perfluorohexanesulfonate and other per- and polyfluoroalkyl substances in Baiyangdian Lake (China): Source characterization and exposure assessment	No	NR	Not relevant	NA	Excluded in title screen
Elucidating the removal of organic micropollutants on biological ion exchange resins	Yes	-	Liu et al (2022)	**Yes**	Included
Embryonic exposure to PFAS causes long-term, compound-specific behavioral alterations in zebrafish	No	NR	Not relevant	NA	Excluded in title screen
Emerging Chlorinated Polyfluorinated Polyether Compounds Impacting the Waters of Southwestern New Jersey Identified by Use of Nontargeted Analysis	No	NR	Not relevant	NA	Excluded in title screen

	Preliminary title screen			*Content screen*	
Title of result	**Included in title screen**	**Reason for Exclusion**	**Comment/Reference**	**Included in content screen?**	**Comment**
Emerging contaminants migration from pipes used in drinking water distribution systems: a review of the scientific literature	Yes	-	Mohammadi et al (2022)	**Yes**	Included
Emerging investigator series: Electrochemically-mediated remediation of GenX using redox-copolymers	Yes	-	Baldaguez et al (2021)	**Yes**	Included
Emerging investigator series: Rapid defluorination of 22 per- And polyfluoroalkyl substances in water using sulfite irradiated by medium-pressure UV	Yes	-	Abusallout et al (2021)	**Yes**	Included
Emerging poly- and perfluoroalkyl substances in the aquatic environment: A review of current literature	Yes	-	Xiao et al (2017)	No	Describes new PFAS substances but does not provide relevant info for RQ
Engineering human liver fatty acid binding protein for detection of poly- and perfluoroalkyl substances	No	RT	Not relevant	NA	Excluded in title screen
Enhanced adsorption of per- and polyfluoroalkyl substances (PFAS) by edible, nutrient-amended montmorillonite clays	Yes	-	Wang et al (2021b)	**Yes**	Included
Enhanced adsorption of PFOA with nano MgAl2O4@CNTs: influence of pH and dosage, and environmental conditions	Yes	-	Yin et al (2023)	**Yes**	Included
Enhanced perfluorooctanoic acid (PFOA) accumulation by combination with in-situ formed Mn oxides under drinking water conditions	No	NR	Not relevant	NA	Excluded in title screen
Enhanced toxicity effects of iron particles together with PFOA in drinking water	No	NR	Not relevant	NA	Excluded in title screen
Enhanced treatment of perfluoroalkyl acids in groundwater by membrane separation and electrochemical oxidation	Yes	-	Soriano et al (2020)	**Yes**	Included
Enhancement of per- and polyfluoroalkyl substances removal from water by pyrogenic carbons: Tailoring carbon surface chemistry and pore properties	Yes	-	Wang et al (2023a)	**Yes**	Included
Environment occurrence of perfluoroalkyl acids and associated human health risks near a major fluorochemical manufacturing park in southwest of China	No	NR	Not relevant	NA	Excluded in title screen
Environmental contamination and human exposure to PFASs near a fluorochemical production plant: Review of historic and current PFOA and GenX contamination in the Netherlands	No	NR	Not relevant	NA	Excluded in title screen
Environmental levels and human body burdens of per- and poly-fluoroalkyl substances in Africa: A critical review	No	NR	Not relevant	NA	Excluded in title screen
EPA's Unprecedented Interim Drinking Water Health Advisories for PFOA and PFOS	Yes	-	Cotruvo et al (2023)	No	Related to blood PFAS levels
Estimated transfer of perfluoroalkyl substances (Pfas) from maternal serum to breast milk in women highly exposed from contaminated drinking water: A study in the ronneby mothe	No	NR	Not relevant	NA	Excluded in title screen
Estimating historical exposure to perfluoroalkyl acids in Security, Fountain, and Widefield Colorado: use of water-infrastructure blending and toxicokinetic models	No	NR	Not relevant	NA	Excluded in title screen
Estimation of per- and poly-fluoroalkyl substances mass loads in the Danube River using passive sampling	No	NR	Not relevant	NA	Excluded in title screen
Estimation of Serum PFOA Concentrations from Drinking and Non-Drinking Water Exposures	No	NR	Not relevant	NA	Excluded in title screen
EU need to protect its environment from toxic per- and polyfluoroalkyl substances	No	NR	Not relevant	NA	Excluded in title screen
Evaluating perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) removal across granular activated carbon (GAC) filter-adsorbers in drinking water treatment plants	Yes	-	Yuan et al (2022)	**Yes**	Included
Evaluation of a national data set for insights into sources, composition, and concentrations of per- and polyfluoroalkyl substances (PFASs) in U.S. drinking water	No	NR	Not relevant	NA	Excluded in title screen
Evaluation of maternal, embryo, and placental effects in CD-1 mice following gestational exposure to perfluorooctanoic acid (PFOA) or hexafluoropropylene oxide dimer acid (HFPO-D	No	NR	Not relevant	NA	Excluded in title screen
Evaluation of Residues in Hen Eggs After Exposure of Laying Hens to Water Containing Per- and Polyfluoroalkyl Substances	No	NR	Not relevant	NA	Excluded in title screen
Exploring the source, migration and environmental risk of perfluoroalkyl acids and novel alternatives in groundwater beneath fluorochemical industries along the Yangtze River, China	No	NR	Not relevant	NA	Excluded in title screen
Exposure of Preconception Couples to Legacy and Emerging Per- and Polyfluoroalkyl Substances: Variations Within and Between Couples	No	NR	Not relevant	NA	Excluded in title screen
Exposure to perfluorooctanoic acid leads to promotion of pancreatic cancer	No	NR	Not relevant	NA	Excluded in title screen
External and internal human exposure to PFOA and HFPOs around a mega fluorochemical industrial park, China: Differences and implications	No	NR	Not relevant	NA	Excluded in title screen
Extraction of PFOA from dilute wastewater using ionic liquids that are dissolved in N-octanol	Yes	-	Zhang et al (2021)	**Yes**	Included
field notes	No	NR	Not relevant	NA	Excluded in title screen
First report on the sources, vertical distribution and human health risks of legacy and novel per- and polyfluoroalkyl substances in groundwater from the Loess Plateau, China	No	NR	Not relevant	NA	Excluded in title screen
Fluoro-functionalized paper-based solid-phase extraction for analysis of perfluorinated compounds by high-performance liquid chromatography coupled with electrospray ionization-t	Yes	-	He et al (2019)	No	Appears to be a research technique not a commercially available procedure
Generation Mechanism of Perfluorohexanesulfonic Acid from Polyfluoroalkyl Sulfonamide Derivatives During Chloramination in Drinking Water	Yes	-	Li et al (2023)	**Yes**	Included
GenX Contamination of the Cape Fear River, North Carolina: Analytical Environmental Chemistry Uncovers Multiple System Failures	No	NR	Not relevant	NA	Excluded in title screen
GenX is not always a better fluorinated organic compound than PFOA: A critical review on aqueous phase treatability by adsorption and its associated cost	Yes	-	Heidari et al (2021)	**Yes**	Included
Geochemical and Hydrologic Factors Controlling Subsurface Transport of Poly- and Perfluoroalkyl Substances, Cape Cod, Massachusetts	No	NR	Not relevant	NA	Excluded in title screen
Gestational perfluoroalkyl substance exposure and body mass index trajectories over the first 12 years of life	No	NR	Not relevant	NA	Excluded in title screen
Global distribution of perfluorochemicals (PFCs) in potential human exposure source-A review	Yes	-	Jian et al (2017)	**Yes**	Included
Global occurrence and probabilistic environmental health hazard assessment of per- and polyfluoroalkyl substances (PFASs) in groundwater and surface waters	Yes	-	Sims et al (2021)	No	Spatial distribution of PFAS worldwide, not necessarily drinking water
Guideline levels for PFOA and PFOS in drinking water: the role of scientific uncertainty, risk assessment decisions, and social factors	No	NR	Not relevant	NA	Excluded in title screen
Half-lives of PFOS, PFHxS and PFOA after end of exposure to contaminated drinking water	Yes	-	Li et al (2018)	No	Health-related studies
Hexafluoropropylene Oxide Dimer Acid (Genx) Exposure Induces Apoptosis In Hepg2 Cells	No	NR	Not relevant	NA	Excluded in title screen
High exposure to perfluorinated compounds in drinking water and thyroid disease. A cohort study from Ronneby, Sweden	No	NR	Not relevant	NA	Excluded in title screen
High in Utero Exposure to Perfluoroalkyl Substances from Drinking Water and Birth Weight: A Cohort Study among Infants in Ronneby, Sweden	No	NR	Not relevant	NA	Excluded in title screen
High polarity analyte(s) in aqueous media: determination of L-PFOA and L-PFOS in ground water	Yes	-	Bilsel et al (2022)	No	ears to be a research technique not a commercially available procedure. Not necessarily drinking water
High-resolution mass spectrometry-based strategies for the target analysis and suspect screening of per- and polyfluoroalkyl substances in aqueous matrices	Yes	-	Koronaiou et al (2022)	No	Appears to be a research technique not a commercially available procedure
Household low pile carpet usage was associated with increased serum PFAS concentrations in 2005–2006	No	NR	Not relevant	NA	Excluded in title screen
Human exposure pathways to poly- and perfluoroalkyl substances (PFAS) from indoor media: A systematic review	Yes	-	DeLuca et al (2022)	No	Investigates PFAS in household dust mainly
Human exposure pathways to poly- and perfluoroalkyl substances (PFAS) from indoor media: A systematic review protocol	No	NR	Not relevant	NA	Excluded in title screen
Human exposure to per- and polyfluoroalkyl substances (PFAS) through drinking water: A review of the recent scientific literature	Yes	-	Domingo & Nadal (2019)	No	Not included. Review paper on levels found in drinking water worldwide.
Hydroxyl-radical based advanced oxidation processes can increase perfluoroalkyl substances beyond drinking water standards: Results from a pilot study	No	NR	Not relevant	NA	Excluded in title screen
Identification and quantification of linear and branched isomers of perfluorooctanoic and perfluorooctane sulfonic acids in contaminated groundwater in the veneto region	Yes	-	Pellizzaro et al (2018)	No	Research technique
Identification, characterization, and human health risk assessment of perfluorinated compounds in groundwater from a suburb of Tianjin, China	No	NR	Not relevant	NA	Excluded in title screen
Identifying Human Specific Adverse Outcome Pathways of Per- and Polyfluoroalkyl Substances Using Liver-Chimeric Humanized Mice	No	NR	Not relevant	NA	Excluded in title screen
Impact of Hurricane Maria on Drinking Water Quality in Puerto Rico	No	NR	Not relevant	NA	Excluded in title screen
Impact of natural organic matter characteristics and inorganic anions on the performance of ion exchange resins in natural waters	No	NR	Not relevant	NA	Excluded in title screen
Impact of treatment processes on the removal of perfluoroalkyl acids from the drinking water production chain	Yes	-	Eschauzier et al (2012)	**Yes**	Included
In Situ Sequestration of Perfluoroalkyl Substances Using Polymer-Stabilized Powdered Activated Carbon	Yes	-	Liu et al (2020b)	**Yes**	Included
Inflammatory bowel disease and biomarkers of gut inflammation and permeability in a community with high exposure to perfluoroalkyl substances through drinking water	No	NR	Not relevant	NA	Excluded in title screen
Influence of contaminated drinking water on perfluoroalkyl acid levels in human serum - A case study from Uppsala, Sweden	No	NR	Not relevant	NA	Excluded in title screen
Influence of contaminated drinking water on perfluoroalkyl acid levels in human serum--A case study from Uppsala, Sweden	No	NR	Not relevant	NA	Excluded in title screen
In-situ sequestration of perfluoroalkyl substances using polymer-stabilized ion exchange resin	Yes	-	Liu et al (2022b)	**Yes**	Included
Interface hydrogen bonding dominated perfluorooctanoic acid (PFOA) accumulation by iron particles in drinking water pipes	No	NR	Not relevant	NA	Excluded in title screen
Investigation into perfluoroalkyl substances (PFASs) in a cranberry bog: method development and sampling results	No	NR	Not relevant	NA	Excluded in title screen
Investigation of distribution, sources and flux of perfluorinated compounds in major southern Indian rivers and their risk assessment	No	NR	Not relevant	NA	Excluded in title screen
In-vitro and in-silico assessment of per- and polyfluoroalkyl substances (PFAS) in aqueous film-forming foam (AFFF) binding to human serum albumin	Yes	-	Li et al (2021)	No	Related to bioaccumulation
Ion exchange removal and resin regeneration to treat per- and polyfluoroalkyl ether acids and other emerging PFAS in drinking water	Yes	-	Liu et al (2021)	No	Included
Ion exchange solid phase microextraction coupled to liquid chromatography/laminar flow tandem mass spectrometry for the determination of perfluoroalkyl substances in water sam	Yes	-	Olomukoro et al (2021)	No	Appears to be a research technique not a commercially available procedure
Ion-Exchange Treatment of Perfluorinated Carboxylic Acids in Water: Comparison of Polystyrenic and Polyacrylic Resin Structures and Impact of Sulfate on Their Performance	No	NR	Not relevant	NA	Excluded in title screen
Key scientific issues in developing drinking water guidelines for perfluoroalkyl acids: Contaminants of emerging concern	Yes	-	Post et al (2017)	No	Drinking water guidelines for PFAAS
Laboratory-scale and pilot-scale stabilization and solidification (S/S) remediation of soil contaminated with per- and polyfluoroalkyl substances (PFASs)	No	NR	Not relevant	NA	Excluded in title screen
Legacy and alternative per- and polyfluoroalkyl substances in the U.S. general population: Paired serum-urine data from the 2013-2014 National Health and Nutrition Examination Sur	No	NR	Not relevant	NA	Excluded in title screen
Legacy and emerging airborne per- and polyfluoroalkyl substances (PFAS) collected on PM(2.5) filters in close proximity to a fluoropolymer manufacturing facility	No	NR	Not relevant	NA	Excluded in title screen
Legacy and emerging per- and polyfluoroalkyl substances (PFASs) in multi-media around a landfill in China: Implications for the usage of PFASs alternatives	No	NR	Not relevant	NA	Excluded in title screen
Legacy and emerging per- and poly-fluoroalkyl substances in surface seawater from northwestern Pacific to Southern Ocean: Evidences of current and historical release	No	NR	Not relevant	NA	Excluded in title screen
Legacy perfluoroalkyl acids and their oxidizable precursors in plasma samples of Norwegian women	No	NR	Not relevant	NA	Excluded in title screen
Long-distance transport of per- and polyfluoroalkyl substances (PFAS) in a Swedish drinking water aquifer	No	NR	Not relevant	NA	Excluded in title screen

	Preliminary title screen			*Content screen*	
Title of result	**Included in title screen**	**Reason for Exclusion**	**Comment/Reference**	**Included in content screen?**	**Comment**
Long-term investigation on the removal of perfluoroalkyl substances in a full-scale drinking water treatment plant in the Veneto Region, Italy	No	NR	Not relevant	NA	Excluded in title screen
Low-pressure volume retarded osmosis for removal of per- and polyfluoroalkyl substances	Yes	-	Choi et al (2021)	**Yes**	Included
Making the invisible visible: Results of a community-led health survey following PFAS contamination of drinking water in Merrimack, New Hampshire	No	NR	Not relevant	NA	Excluded in title screen
Managing health risks of perfluoroalkyl acids in aquatic food from a river-estuary-sea environment affected by fluorochemical industry	No	NR	Not relevant	NA	Excluded in title screen
Managing organics in the "PFAS age"	No	NR	Not relevant	NA	Excluded in title screen
Maternal exposure to perfluorobutane sulfonate (PFBS) during pregnancy: evidence of adverse maternal and fetoplacental effects in New Zealand White (NZW) rabbits	No	NR	Not relevant	NA	Excluded in title screen
Measurement of Novel, Drinking Water-Associated PFAS in Blood from Adults and Children in Wilmington, North Carolina	No	NR	Not relevant	NA	Excluded in title screen
Metabolomic, Lipidomic, Transcriptomic, and Metagenomic Analyses in Mice Exposed to PFOS and Fed Soluble and Insoluble Dietary Fibers	No	NR	Not relevant	NA	Excluded in title screen
Microbial plankton responses to perfluoroalkyl acids and their alternatives in the aquatic environment	No	NR	Not relevant	NA	Excluded in title screen
Minimizing the environmental impact of PFAS by using specialized coagulants for the treatment of PFAS polluted waters and for the decontamination of firefighting equipment	Yes	-	Cornelsen et al (2021)	**Yes**	Included
MITIGATION OF PFAS IN PUBLIC WATER SYSTEMS Future Steps for Ensuring Safer Drinking Water	Yes	-	Voularopoulos et al (2022)	No	Conference meeting presentation
Model-based investigation of the formation, transmission, and health risk of perfluorooctanoic acid, a member of PFASs group, in drinking water distribution systems	Yes	-	Abhijith et al (2021)	No	luoroalkyl amides (FAs) transformation to perfluorooctanoic acid (PFOA) during disinfection
Modeling micropollutant removal by nanofiltration and reverse osmosis membranes: considerations and challenges	Yes	-	Osorio et al (2022)	No	Not included. A modelling exercise looking at improving sorption of NF and RO.
Multiple pollutants in groundwater near an abandoned Chinese fluorine chemical park: concentrations, correlations and health risk assessments	No	NR	Not relevant	NA	Excluded in title screen
Nitrifying Microorganisms Linked to Biotransformation of Perfluoroalkyl Sulfonamido Precursors from Legacy Aqueous Film-Forming Foams	Yes	-	Ruyle et al (2023b)	No	Not included. Not applicable to treating drinking water at a treatment plant.
Nontarget analysis and fluorine atom balances of transformation products from UV/sulfite degradation of perfluoroalkyl contaminants	Yes	-	Bower et al (2023)	No	Not included. Could not source the paper.
Occurrence and distribution of per-and polyfluoroalkyl substances (PFAS) in surface and groundwaters in an urbanized and agricultural area, Southern Brazil	No	NR	Not relevant	NA	Excluded in title screen
Occurrence and distribution of perfluorooctane sulfonate and perfluorooctanoic acid in three major rivers of Xinjiang, China	No	NR	Not relevant	NA	Excluded in title screen
Occurrence and fate of poly- and perfluoroalkyl substances (PFAS) in urban waters of New Zealand	No	NR	Not relevant	NA	Excluded in title screen
Occurrence and implications of per and polyfluoroalkyl substances in animal feeds used in laboratory toxicity testing	No	NR	Not relevant	NA	Excluded in title screen
Occurrence and removal of poly/perfluoroalkyl substances (PFAS) in municipal and industrial wastewater treatment plants	Yes	-	Barisci & Suri (2021)	No	Not included. Review article relted to wastewater treatment plants
Occurrence and source identification of perfluoroalkyl acids (PFAAs) in the Metedeconk River Watershed, New Jersey	No	NR	Not relevant	NA	Excluded in title screen
Occurrence and spatial distribution of perfluorinated compounds in groundwater receiving reclaimed water through river bank infiltration	No	NR	Not relevant	NA	Excluded in title screen
Occurrence and transport behaviors of perfluoroalkyl acids in drinking water distribution systems	Yes	-	Chen et al (2019)	**Yes**	Included
Occurrence of legacy and emerging poly- and perfluoroalkyl substances in water: A case study in Tianjin (China)	No	NR	Not relevant	NA	Excluded in title screen
Occurrence of perfluorinated compounds (PFCs) in drinking water of North Rhine-Westphalia, Germany and new approach to assess drinking water contamination by shorter-chained	No	NR	Not relevant	NA	Excluded in title screen
Occurrence of perfluoroalkyl substances (PFAS) in garden produce at homes with a history of PFAS-contaminated drinking water	No	NR	Not relevant	NA	Excluded in title screen
Occurrence, distribution, and risk assessment of perfluoroalkyl acids in drinking water sources from the lower Yangtze River	No	NR	Not relevant	NA	Excluded in title screen
Occurrence, sources and health risk of polyfluoroalkyl substances (PFASs) in soil, water and sediment from a drinking water source area	No	NR	Not relevant	NA	Excluded in title screen
Online serum PFOA calculator for adults	No	NR	Not relevant	NA	Excluded in title screen
Oral perfluorooctane sulfonate (PFOS) lessens tumor development in the APC(min) mouse model of spontaneous familial adenomatous polyposis	No	NR	Not relevant	NA	Excluded in title screen
Oral perfluorooctane sulfonate (PFOS) lessens tumor development in the APCmin mouse model of spontaneous familial adenomatous polyposis	No	NR	Not relevant	NA	Excluded in title screen
Organic micropollutants measured in roof-harvested rainwater from rural and urban environmental justice communities in Arizona	No	NR	Not relevant	NA	Excluded in title screen
Organophosphate flame retardants and perfluoroalkyl substances in drinking water treatment plants from Korea: Occurrence and human exposure	Yes	-	Sim et al (2021)	**Yes**	Included
Outside the Safe Operating Space of a New Planetary Boundary for Per- and Polyfluoroalkyl Substances (PFAS)	Yes	-	Cousins et al (2022)	No	Not related to RQ
Ozone-based water treatment (O3, O3/UV, O3/H2O2) for removal of organic micropollutants, bacteria inactivation and regrowth prevention	No	NR	Not relevant	NA	Excluded in title screen
Patterns in Serum Toxicokinetics in Peromyscus Exposed to Per- and Polyfluoroalkyl Substances	No	NR	Not relevant	NA	Excluded in title screen
Per- and polyfluoroalkyl substance (PFAS) exposure assessment in a community exposed to contaminated drinking water, New Hampshire, 2015	No	NR	Not relevant	NA	Excluded in title screen
Per- And Polyfluoroalkyl Substance (PFAS) Transport from Groundwater to Streams near a PFAS Manufacturing Facility in North Carolina, USA	No	NR	Not relevant	NA	Excluded in title screen
Per and poly-fluoroalkyl substances (PFAS) as a contaminant of emerging concern in surface water: A transboundary review of their occurrences and toxicity effects	No	NR	Not relevant	NA	Excluded in title screen
Per- and polyfluoroalkyl substances (PFAS) in breast milk and infant formula: A global issue	No	NR	Not relevant	NA	Excluded in title screen
Per- and polyfluoroalkyl substances (PFAS) in river discharge: Modeling loads upstream and downstream of a PFAS manufacturing plant in the Cape Fear watershed, North Carolina	No	NR	Not relevant	NA	Excluded in title screen
Per- and polyfluoroalkyl substances (PFAS) in United States tapwater: Comparison of underserved private-well and public-supply exposures and associated health implications	Yes	-	Smalling et al (2023)	No	PFAS presence in some places in the U.S not relevant for RQ
Per- and Polyfluoroalkyl Substances (PFAS): Significance and Considerations within the Regulatory Framework of the USA	No	NR	Not relevant	NA	Excluded in title screen
Per- and polyfluoroalkyl substances (PFASs) in groundwater from a contaminated site in the North China Plain: Occurrence, source apportionment, and health risk assessment	No	NR	Not relevant	NA	Excluded in title screen
Per- and polyfluoroalkyl substances (PFASs) in the blood of two colobine monkey species from China: Occurrence and exposure pathways	No	NR	Not relevant	NA	Excluded in title screen
Per- and polyfluoroalkyl substances (PFASs) in water, soil and plants in wetlands and agricultural areas in Kampala, Uganda	No	NR	Not relevant	NA	Excluded in title screen
Per- and Polyfluoroalkyl Substances Differentially Inhibit Placental Trophoblast Migration and Invasion In Vitro	Yes	-	Szilagyi et al (2020)	No	Health-related study
Per- and Polyfluoroalkyl Substances in Dust Collected from Residential Homes and Fire Stations in North America	No	NR	Not relevant	NA	Excluded in title screen
Per- and polyfluoroalkyl substances in source and treated drinking waters of the United States	Yes	-	Boone et al (2019)	**Yes**	Included
Per- and Polyfluoroalkyl Substances in Swedish Groundwater and Surface Water: Implications for Environmental Quality Standards and Drinking Water Guidelines	Yes	-	Gobeliu et al (2018)	No	Not related to RQ
Per- and polyfluoroalkyl substances in water and wastewater: A critical review of their global occurrence and distribution	Yes	-	Kurwadkar et al (2021)	No	Not included. Review document on occurrence and distribution.
Per- and polyfluoroalkyl substances removal with granular activated carbon and a specialty adsorbent: A case study	Yes	-	Najm et al (2021)	**Yes**	Included
Per-and polyfluoroalkyl substances (Pfas): Significance and considerations within the regulatory framework of the usa	No	NR	Not relevant	NA	Excluded in title screen
Per-and Polyfluoroalkyl Substances in Groundwater from the Great Miami Buried-Valley Aquifer, Southwestern Ohio, 2019–20	No	NR	Not relevant	NA	Excluded in title screen
Perfluorinated compound correlation between human serum and drinking water: Is drinking water a significant contributor?	Yes	-	Wu et al (2023)	No	Not included. Not a paper about treatment or measurement.
Perfluorinated compounds in infiltrated river rhine water and infiltrated rainwater in coastal dunes	No	NR	Not relevant	NA	Excluded in title screen
Perfluorinated compounds in tap water from China and several other countries	Yes	-	Mak et al (2009)	No	Not included. Not a paper about treatment or measurement.
Perfluorinated compounds in the environment and the blood of residents living near fluorochemical plants in Fuxin, China	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkane substances in national samples from global monitoring plan projects (2017-2019)	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl Acids (PFAAs) in Serum from 2-4-Month-Old Infants: Influence of Maternal Serum Concentration, Gestational Age, Breast-Feeding, and Contaminated Drinking Water	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl acids (PFAAs) in the Pra and Kakum River basins and associated tap water in Ghana	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl acids in aqueous samples from Germany and Kenya	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl acids in children and their mothers: Association with drinking water and time trends of inner exposures-Results of the Duisburg birth cohort and Bochum cohort studies	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl acids in children and their mothers: Association with drinking water and time trends of inner exposures--Results of the Duisburg birth cohort and Bochum cohort studie	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl acids in drinking water of China in 2017: Distribution characteristics, influencing factors and potential risks	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl acids in municipal landfill leachates from China: Occurrence, fate during leachate treatment and potential impact on groundwater	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl acids in surface waters and tapwater in the Qiantang River watershed-Influences from paper, textile, and leather industries	Yes	-	Lu et al (2017)	No	Not included. Not a paper about treatment or measurement.
Perfluoroalkyl acids in the aquatic environment of a fluorine industry-impacted region: Spatiotemporal distribution, partition behavior, source, and risk assessment	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl acids in the water cycle from a freshwater river basin to coastal waters in eastern China	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl and polyfluoroalkyl substances (PFASs) in groundwater: current understandings and challenges to overcome	Yes	-	Zhao et al (2022)	No	Focused on groundwater instead of drinking water
Perfluoroalkyl Chemicals and Male Reproductive Health: Do PFOA and PFOS Increase Risk for Male Infertility?	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl substances (PFAS) in drinking water and risk for polycystic ovarian syndrome, uterine leiomyoma, and endometriosis: A Swedish cohort study	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl substances (PFAS) in river and ground/drinking water of the Ganges River basin: Emissions and implications for human exposure	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl Substances (PFASs) in Rivers and Drinking Waters from Qingdao, China	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl substances (PFASs) in the Ugandan waters of Lake Victoria: Spatial distribution, catchment release and public exposure risk via municipal water consumption	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl substances (PFASs) in wastewater treatment plants and drinking water treatment plants: Removal efficiency and exposure risk	Yes	-	Pan et al (2016)	**Yes**	Included

	Preliminary title screen			*Content screen*	
Title of result	**Included in title screen**	**Reason for Exclusion**	**Comment/Reference**	**Included in content screen?**	**Comment**
Perfluoroalkyl substances and likelihood of stroke in persons with and without diabetes	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl substances and thyroid stimulating hormone levels in a highly exposed population in the Veneto Region	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl substances are associated with elevated blood pressure and hypertension in highly exposed young adults	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl substances are inversely associated with coronary heart disease in adults with diabetes	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl substances assessment in drinking waters from Brazil, France and Spain	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl substances in groundwater and home-produced vegetables and eggs around a fluorochemical industrial park in China	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl substances in Romanian wastewater treatment plants: Transfer to surface waters, environmental and human risk assessment	Yes	-	Chiriac et al (2023)	**Yes**	Included
Perfluoroalkyl substances in the Daling River with concentrated fluorine industries in China: seasonal variation, mass flow, and risk assessment	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl substances in the surface water and fishes in Chaohu Lake, China	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl substances in the urine and hair of preschool children, airborne particles in kindergartens, and drinking water in Hong Kong	No	NR	Not relevant	NA	Excluded in title screen
Perfluoroalkyl Substances in U.S. market basket fish and shellfish	No	NR	Not relevant	NA	Excluded in title screen
Perfluorooctane sulfonic acid (PFOS) exposure during pregnancy increases blood pressure and impairs vascular relaxation mechanisms in the adult offspring	No	NR	Not relevant	NA	Excluded in title screen
Perfluorooctane sulfonic acid modulates expression of placental steroidogenesis-associated genes and hormone levels in pregnant rats	No	NR	Not relevant	NA	Excluded in title screen
Perfluorooctanesulfonate (PFOS) Conversion from N-Ethyl-N-(2-hydroxyethyl)-perfluorooctanesulfonamide (EtFOSE) in male Sprague Dawley rats after inhalation exposure	No	NR	Not relevant	NA	Excluded in title screen
Perfluorooctanoic Acid (PFOA) Exposure and Abnormal Alanine Aminotransferase: Using Clinical Consensus Cutoffs Compared to Statistical Cutoffs for Abnormal Values	No	NR	Not relevant	NA	Excluded in title screen
Perfluorooctanoic Acid (PFOA) Incorporated into Iron Particles Promoted the Formation of Disinfection Byproducts under Drinking Water Conditions	No	NR	Not relevant	NA	Excluded in title screen
Perfluorooctanoic acid (PFOA) removal from real landfill leachate wastewater and simulated soil leachate by electrochemical oxidation process	Yes	-	Karatas et al (2022)	**Yes**	Included
Perfluorooctanoic Acid (PFOA): Environmental Sources, Chemistry, Toxicology, and Potential Risks	No	NR	Not relevant	NA	Excluded in title screen
Perfluorooctanoic acid activates multiple nuclear receptor pathways and skews expression of genes regulating cholesterol homeostasis in liver of humanized PPARα mice fed an Amer	No	NR	Not relevant	NA	Excluded in title screen
Perfluorooctanoic acid induces liver and serum dyslipidemia in humanized PPARα mice fed an American diet	No	NR	Not relevant	NA	Excluded in title screen
PFAS and drinking water: Selected EPA and congressional actions	Yes	-	Humphreys et al (2022)	No	Not included. Summary document of water concentrations in DWTPs.
PFAS Concentrations and Cardiometabolic Traits in Highly Exposed Children and Adolescents	No	NR	Not relevant	NA	Excluded in title screen
PFAS in drinking water and serum of the people of a southeast Alaska community: A pilot study	No	NR	Not relevant	NA	Excluded in title screen
PFAS in the Drinking Water Source: Analysis of the Contamination Levels, Origin and Emission Rates	Yes	-	Mussabek et al (2023)	No	Case study
PFAS levels in paired drinking water and serum samples collected from an exposed community in Central North Carolina	No	NR	Not relevant	NA	Excluded in title screen
PFAS: forever chemicals—persistent, bioaccumulative and mobile. Reviewing the status and the need for their phase out and remediation of contaminated sites	Yes	-	Brunn et al (2023)	**Yes**	Included
PFASs intake from fish, eggs and drinking water in Greece in relation to the safety limits for weekly intake proposed in the EFSA scientific opinion of 2020	No	NR	Not relevant	NA	Excluded in title screen
PFASs: What can we learn from the European Human Biomonitoring Initiative HBM4EU	Yes	-	Uhl et al (2023)	No	Not related to RQ
PFOA and PFOS Are Generated from Zwitterionic and Cationic Precursor Compounds during Water Disinfection with Chlorine or Ozone	No	NR	Not relevant	NA	Excluded in title screen
PFOA and PFOS removal by ion exchange for water reuse and drinking applications: Role of organic matter characteristics	Yes	-	Dixit et al (2019)	**Yes**	Included
PFOA and ulcerative colitis	No	NR	Not relevant	NA	Excluded in title screen
PFOS dominates PFAS composition in ambient fine particulate matter (PM(2.5)) collected across North Carolina nearly 20 years after the end of its US production	No	NR	Not relevant	NA	Excluded in title screen
Photodegradation of per- and polyfluoroalkyl substances in water: A review of fundamentals and applications	Yes	-	Liu et al (2022c)	**Yes**	Included
Physiologically based pharmacokinetic modeling of human exposure to perfluorooctanoic acid suggests historical non drinking-water exposures are important for predicting current s	No	NR	Not relevant	NA	Excluded in title screen
Plasma and Skin Per- and Polyfluoroalkyl Substance (PFAS) Levels in Dairy Cattle with Lifetime Exposures to PFAS-Contaminated Drinking Water and Feed	No	NR	Not relevant	NA	Excluded in title screen
Plasma concentrations of perfluoroalkyl acids and their determinants in youth and adults from Nunavik, Canada	No	NR	Not relevant	NA	Excluded in title screen
Plasma eicosapentaenoic acid, a biomarker of fish consumption, is associated with perfluoroalkyl carboxylic acid exposure in residents of Kyoto, Japan: a cross-sectional study	No	NR	Not relevant	NA	Excluded in title screen
Pollutant degradation behaviors in a heterogeneous Fenton system through Fe/S-doped aerogel	No	NR	Not relevant	NA	Excluded in title screen
Polyfluorinated organic micropollutants removal from water by ion exchange and adsorption	Yes	-	Conte et al (2015)	**Yes**	Included
Polyfluoroalkyl substance exposure in the Mid-Ohio River Valley, 1991-2012	No	NR	Not relevant	NA	Excluded in title screen
Potential Effectiveness of Point-of-Use Filtration to Address Risks to Drinking Water in the United States	Yes	-	Brown et al (2017)	No	Did not measure PFAS
Pre- and Postapplication Thermal Treatment Strategies for Sorption Enhancement and Reactivation of Biochars for Removal of Per- and Polyfluoroalkyl Substances from Water	Yes	-	Wang et al (2023b)	**Yes**	Included
Predicting the risk of GenX contamination in private well water using a machine-learned Bayesian network model	Yes	-	Roostaei et al (2021)	No	Not included. Mechanistic model (predictive)
Preferential Retention and Transport of Perfluorooctanesulfonic Acid in a Dolomite Aquifer	Yes	-	Jahn et al (2023)	No	Transport of PFAS in groundwater
Preliminary assessment of general population exposure to perfluoroalkyl substances through diet in Greece	No	NR	Not relevant	NA	Excluded in title screen
Preliminary observations on perfluorinated compounds in plasma samples (1977-2004) of young German adults from an area with perfluorooctanoate-contaminated drinking water	No	NR	Not relevant	NA	Excluded in title screen
Prenatal exposure to PFOS and PFOA in a pregnant women cohort of Catalonia, Spain	No	NR	Not relevant	NA	Excluded in title screen
Preparation of hollow-fiber nanofiltration membranes of high performance for effective removal of PFOA and high resistance to BSA fouling	Yes	-	Tang et al (2022)	**Yes**	Included
Prevalence of per- and polyfluoroalkyl substances (PFASs) in drinking and source water from two Asian countries	No	NR	Not relevant	NA	Excluded in title screen
Proposal for coordinated health research in PFAS-contaminated communities in the United States	No	NR	Not relevant	NA	Excluded in title screen
Quantifying Indirect Contribution from Precursors to Human Body Burden of Legacy PFASs Based on Paired Blood and One-Week Duplicate Diet	No	NR	Not relevant	NA	Excluded in title screen
Quantitative Approach Using Matrix-Assisted Laser Desorption/Ionization Time-of-Flight (MALDI-ToF) Mass Spectrometry	No	NR	Not relevant	NA	Excluded in title screen
Quantitative determination of perfluoroalkyl substances (PFAS) in soil, water, and home garden produce	No	NR	Not relevant	NA	Excluded in title screen
Quantitative relationships of perfluoroalkyl acids in drinking water associated with serum concentrations above background in adults living near contamination hotspots in Sweden	No	NR	Not relevant	NA	Excluded in title screen
Rapid Removal of Poly- and Perfluoroalkyl Substances with Quaternized Wood Pulp	Yes	-	Harris et al (2022)	**Yes**	Included
Recent progress in the detection of emerging contaminants PFASs	Yes	-	Ryu et al (2021)	**Yes**	Included
Recent US State and Federal Drinking Water Guidelines for Per- and Polyfluoroalkyl Substances	Yes	-	Post (2021)	No	Does not provide relevant information for RQ
Recently Detected Drinking Water Contaminants: GenX and Other Per- and Polyfluoroalkyl Ether Acids	Yes	-	Hopkins et al (2018)	**Yes**	Included
Regeneration of per- and polyfluoroalkyl substance-laden granular activated carbon using a solvent based technology	Yes	-	Siriwardena et al (2021)	**Yes**	Included
Regulation of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) in drinking water: A comprehensive review	Yes	-	Pontius (2019)	**Yes**	Included
Rejection of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) by severely chlorine damaged RO membranes with different salt rejection ratios	Yes	-	Hara-Yamamura et al (2022)	**Yes**	Included
Relationship between perfluorooctanoate and perfluorooctane sulfonate blood concentrations in the general population and routine drinking water exposure	No	NR	Not relevant	NA	Excluded in title screen
Remediation of perfluorooctanoic acid (PFOA) with nano ceramic clay: Synthesis, characterization, scale-up and regenerations	Yes	-	Sahu (2023)	**Yes**	Included
Remediation of poly- and perfluorinated chemical substances (PFAS) in the environment by ionizing technology	Yes	-	Pillai (2022)	**Yes**	Included
Removal efficiency of multiple poly- and perfluoroalkyl substances (PFASs) in drinking water using granular activated carbon (GAC) and anion exchange (AE) column tests	Yes	-	McCleaf et al (2017)	**Yes**	Included
Removal of COD, NH(4)-N, and perfluorinated compounds from wastewater treatment plant effluent using ZnO-coated activated carbon	Yes	-	Tang et al (2020)	**Yes**	Included
Removal of per- and polyfluoroalkyl substances (PFASs) in a full-scale drinking water treatment plant: Long-term performance of granular activated carbon (GAC) and influence of flow	Yes	-	Belkouteb et al (2020)	**Yes**	Included
Removal of Perfluorooctanoic Acid and Microcystins from Drinking Water by Electrocoagulation	Yes	-	Opoku-Duah et al (2020)	**Yes**	Included
Removal of poly- and per-fluoroalkyl substances from aqueous systems by nano-enabled water treatment strategies	Yes	-	Saleh et al (2018)	**Yes**	Included
Removal of short- and long-chain perfluorinated compounds from surface water by coagulation	Yes	-	Park et al (2021)	**Yes**	Included
Removing per- and polyfluoroalkyl substances from groundwaters using activated carbon and ion exchange resin packed columns	Yes	-	Zeng et al (2020)	**Yes**	Included
Resilient water treatment technologies and challenges for the removal of emerging contaminants - Perfluorinated compounds	Yes	-	Singh et al (2017)	**Yes**	Included
Retrospective exposure reconstruction using approximate Bayesian computation: A case study on perfluorooctanoic acid and preeclampsia	No	NR	Not relevant	NA	Excluded in title screen
Reusable Functionalized Hydrogel Sorbents for Removing Long- and Short-Chain Perfluoroalkyl Acids (PFAAs) and GenX from Aqueous Solution	Yes	-	Huang et al (2018)	**Yes**	Included
Risk assessment for PFOA and kidney cancer based on a pooled analysis of two studies	No	NR	Not relevant	NA	Excluded in title screen
Risk Assessment of Per- and Polyfluoroalkyl Substance Mixtures: A Relative Potency Factor Approach	No	NR	Not relevant	NA	Excluded in title screen
Risk assessment of PFASs in drinking water using a probabilistic risk quotient methodology	Yes	-	Thomaidi et al (2020)	No	Does not provide relevant information for RQ

	Preliminary title screen			*Content screen*	
Title of result	**Included in title screen**	**Reason for Exclusion**	**Comment/Reference**	**Included in content screen?**	**Comment**
Risk exposure assessment of per- and polyfluoroalkyl substances (PFASs) in drinking water and atmosphere in central eastern China	No	NR	Not relevant	NA	Excluded in title screen
Robust trace analysis of polar (C(2)-C(8)) perfluorinated carboxylic acids by liquid chromatography-tandem mass spectrometry: method development and application to surface water	No	NR	Not relevant	NA	Excluded in title screen
Seasonal Variation of Water Quality in Unregulated Domestic Wells	No	NR	Not relevant	NA	Excluded in title screen
Serum concentrations of perfluorinated alkyl substances in farmers living in areas affected by water contamination in the Veneto Region (Northern Italy)	No	NR	Not relevant	NA	Excluded in title screen
Serum concentrations of PFASs and exposure-related behaviors in African American and non-Hispanic white women	No	NR	Not relevant	NA	Excluded in title screen
Serum concentrations of selected perfluoroalkyl substances for US females compared to males as they age	No	NR	Not relevant	NA	Excluded in title screen
Serum Half-Lives for Short- and Long-Chain Perfluoroalkyl Acids after Ceasing Exposure from Drinking Water Contaminated by Firefighting Foam	No	NR	Not relevant	NA	Excluded in title screen
Serum half-lives for short-and long-chain perfluoroalkyl acids after ceasing exposure from drinking water contaminated by firefighting foam	No	NR	Not relevant	NA	Excluded in title screen
Serum levels of perfluoroalkyl substances (PFAS) in adolescents and young adults exposed to contaminated drinking water in the Veneto region, Italy: A cross-sectional study based on	No	NR	Not relevant	NA	Excluded in title screen
Serum per- and polyfluoroalkyl substance (PFAS) concentrations and predictors of exposure among pregnant African American women in the Atlanta area, Georgia	No	NR	Not relevant	NA	Excluded in title screen
Serum perfluoroalkyl substances in residents following long-term drinking water contamination from firefighting foam in Ronneby, Sweden	No	NR	Not relevant	NA	Excluded in title screen
Short-chain per- and polyfluoroalkyl substances in aquatic systems: Occurrence, impacts and treatment	Yes	-	Li et al (2020)	**Yes**	Included
Simultaneous determination of multiple perfluoroalkyl and polyfluoroalkyl substances in aquatic products by ultra-performance liquid chromatography-tandem mass spectrometry wi	Yes	-	Hu et al (2023)	No	Food exposure pathway
Simultaneous determination of perfluoroalkyl phosphonates, carboxylates, and sulfonates in drinking water	No	NR	Not relevant	NA	Excluded in title screen
Sociodemographic and behavioral determinants of serum concentrations of per- and polyfluoroalkyl substances in a community highly exposed to aqueous film-forming foam contam	No	NR	Not relevant	NA	Excluded in title screen
Sorption of Poly- and Perfluoroalkyl Substances (PFASs) Relevant to Aqueous Film-Forming Foam (AFFF)-Impacted Groundwater by Biochars and Activated Carbon	Yes	-	Xiao et al (2017)	**Yes**	Included
Spatial and temporal analyses of perfluorooctanoic acid in drinking water for external exposure assessment in the Ruhr metropolitan area, Germany: The 'PerSpat'-Project	No	NR	Not relevant	NA	Excluded in title screen
Spatial and temporal trends in perfluorooctanoic and perfluorohexanoic acid in well, surface, and tap water around a fluoropolymer plant in Osaka, Japan	No	NR	Not relevant	NA	Excluded in title screen
Spatiotemporal distribution and potential sources of perfluoroalkyl acids in Huangpu River, Shanghai, China	No	NR	Not relevant	NA	Excluded in title screen
Spatio-temporal trends in livestock exposure to per- and polyfluoroalkyl substances (PFAS) inform risk assessment and management measures	No	NR	Not relevant	NA	Excluded in title screen
Stabilization and solidification remediation of soil contaminated with poly- and perfluoroalkyl substances (PFASs)	Yes	-	Sorengard et al (2019)	No	Soil remediation
Stabilization of per- and polyfluoroalkyl substances (PFASs) with colloidal activated carbon (PlumeStop®) as a function of soil clay and organic matter content	Yes	-	Sorengard et al (2019)	No	Soil remediation
Study on the effects of cations and anions on the removal of perfluorooctane sulphonate by nanofiltration membrane	Yes	-	Zhao et al (2018)	**Yes**	Included
Surface-modified biopolymers for removing mixtures of per- and polyfluoroalkyl substances from water: Screening and removal mechanisms	No	NR	Not relevant	NA	Excluded in title screen
Swimming with PFAS in public and private pools	No	NR	Not relevant	NA	Excluded in title screen
Systematic Evidence Mapping of Potential Exposure Pathways for Per- and Polyfluoroalkyl Substances Based on Measured Occurrence in Multiple Media	Yes	-	Holder et al (2023)	No	Not related to RQ
Tap Water Contributions to Plasma Concentrations of Poly- and Perfluoroalkyl Substances (PFAS) in a Nationwide Prospective Cohort of U.S. Women	No	NR	Not relevant	NA	Excluded in title screen
Target and nontarget screening of PFAS in drinking water for a large-scale survey of urban and rural communities in Québec, Canada	No	NR	Not relevant	NA	Excluded in title screen
Temporal and spatial analysis of per and polyfluoroalkyl substances in surface waters of Houston ship channel following a large-scale industrial fire incident	No	NR	Not relevant	NA	Excluded in title screen
Temporal Trends of Per- and Polyfluoroalkyl Substances in Delaware River Fish, USA	No	NR	Not relevant	NA	Excluded in title screen
Temporal trends of suspect- and target-per/polyfluoroalkyl substances (PFAS), extractable organic fluorine (EOF) and total fluorine (TF) in pooled serum from first-time mothers in Up	No	NR	Not relevant	NA	Excluded in title screen
Temporal trends of suspect-and target-per/polyfluoroalkyl substances (PFAS), extractable organic fluorine (EOF) and total fluorine (TF) in pooled serum from first-time mothers in Upp	No	NR	Not relevant	NA	Excluded in title screen
The association between perfluoroalkyl substances and lipid profile in exposed pregnant women in the Veneto region, Italy	No	NR	Not relevant	NA	Excluded in title screen
The derivation of a Reference Dose (RfD) for perfluorooctane sulfonate (PFOS) based on immune suppression	Yes	-	Pachkowski et al (2019)	No	Health-related study
The effect of chronic exposure to a low concentration of perfluorooctanoic acid on cognitive function and intestinal health of obese mice induced by a high-fat diet	No	NR	Not relevant	NA	Excluded in title screen
The effect of drinking water contaminated with perfluoroalkyl substances on a 10-year longitudinal trend of plasma levels in an elderly Uppsala cohort	No	NR	Not relevant	NA	Excluded in title screen
The effectiveness of PFAS management options on groundwater quality in contaminated land using numerical modelling	Yes	-	Mahinroosta et al (2021)	No	Not relevant for RQ
The impact of risk management measures on the concentrations of per- and polyfluoroalkyl substances in source and treated drinking waters in Ontario, Canada	Yes	-	Kleywegt et al (2020)	No	Not related to RQ
The impact of two fluoropolymer manufacturing facilities on downstream contamination of a river and drinking water resources with per- and polyfluoroalkyl substances	No	NR	Not relevant	NA	Excluded in title screen
The last straw: Characterization of per- and polyfluoroalkyl substances in commercially-available plant-based drinking straws	No	NR	Not relevant	NA	Excluded in title screen
The occurrence and distributions of per- and polyfluoroalkyl substances (PFAS) in groundwater after a PFAS leakage incident in 2018	No	NR	Not relevant	NA	Excluded in title screen
The PFOA substitute GenX detected in the environment near a fluoropolymer manufacturing plant in the Netherlands	No	NR	Not relevant	NA	Excluded in title screen
The role of exposure to per- and polyfluoroalkyl substances in racial/ethnic disparities in hypertension: Results from the study of Women's health across the nation	No	NR	Not relevant	NA	Excluded in title screen
The use of carbon adsorbents for the removal of perfluoroalkyl acids from potable reuse systems	Yes	-	Inyang & Dickenson (2017)	**Yes**	Included
Time Trends in Per- and Polyfluoroalkyl Substances (PFASs) in California Women: Declining Serum Levels, 2011-2015	No	NR	Not relevant	NA	Excluded in title screen
Trace and bulk organics removal during ozone–biofiltration treatment for potable reuse applications	Yes	-	Sundaram et al (2020)	**Yes**	Included
Transforming Waste into Value: Eco-Friendly Synthesis of MOFs for Sustainable PFOA Remediation	Yes	-	El Jery et al (2023)	No	Not included. Technique for treating PET bottles to destroy PFAS.
Treatment of emerging organic pollutants using ionizing technology-a state of the art discussion	No	NR	Not relevant	NA	Excluded in title screen
Treatment of perfluoroalkyl acids by heat-activated persulfate under conditions representative of in situ chemical oxidation	Yes	-	Bruton et al (2018)	No	Not included. Remediation technique for heavily contaminated groundwater
Ultra-low current electrospray ionization of chloroform solution for the analysis of perfluorinated sulfonic acids	Yes	-	Wang et al (2023)	No	Appears to be a research technique not a commercially available procedure
Ultratrace analysis of per- and polyfluoroalkyl substances in drinking water using ice concentration linked with extractive stirrer and high performance liquid chromatography - tander	No	RT	Research technique	NA	Excluded in title screen
Ultratrace analysis of per- and polyfluoroalkyl substances in drinking water using ice concentration linked with extractive stirrer and high performance liquid chromatography – tander	Yes	-	Skaggs & Logue (2021)	No	Appears to be a research technique not a commercially available procedure
Unsaturated PFOS and other PFASs in human serum and drinking water from an afff-impacted community	No	NR	Not relevant	NA	Excluded in title screen
Use of strong anion exchange resins for the removal of perfluoroalkylated substances from contaminated drinking water in batch and continuous pilot plants	Yes	-	Zaggia et al (2016)	**Yes**	Included
Validation of quantitative measurements and semi-quantitative estimates of emerging perfluoroethercarboxylic acids (PFECAs) and hexfluoroprolyene oxide acids (HFPOAs)	No	NR	Not relevant	NA	Excluded in title screen
Water quality impacts on sorbent efficacy for per- and polyfluoroalkyl substances treatment of groundwater	Yes	-	Hayman et al (2023)	**Yes**	Included
What Limits Will the World Health Organization Recommend for PFOA and PFOS in Drinking Water?	Yes	-	Southerland & Birnbaun (2023)	No	Not included. Critique of WHOs water quality guideline
Worldwide drinking water occurrence and levels of newly-identified perfluoroalkyl and polyfluoroalkyl substances	Yes	-	Kabore et al (2018)	No	Not related to RQ
Additional Papers					
Catchment and Drinking Water Quality Micro Pollutant Monitoring Program – Passive Sampling. Report 8 – Summer 2018.	Yes	-	QAEHS (2018) (Also referenced as SEQWater 2018)	Yes	Included
Catchment and Drinking Water Quality Micro Pollutant Monitoring Program – Passive Sampling. Report 9 – Winter 2018.	Yes	-	QAEHS (2018) (Also referenced as SEQWater 2018)	Yes	Included
Sydney Water (2023). PFAS and Drinking Water. Sydney Water.	Yes	-	Sydney Water (2023)	Yes	Included
Advice Article. PFAS & Esperance Town Water Supply Scheme. 2023.	Yes	-	WCWA (2023)	Yes	Included
Drinking Water Quality. Annual Report 2018-19.	Yes	-	WCWA (2019)	Yes	Included
Drinking Water Quality. Annual Report 2019-20.	Yes	-	WCWA (2020)	Yes	Included
Drinking Water Quality. Annual Report 2020-21.	Yes	-	WCWA (2021)	Yes	Included
Drinking Water Quality. Annual Report 2021-22	Yes	-	WCWA (2022b)	Yes	Included

Appendix B Data Extraction Tables – Health-based Guidance/Guidelines

Evidence Evaluations for Australian Drinking Water Guidelines Chemical Fact Sheets – PFOS, PFHxS, PFOA, PFBS, and GenX Chemicals

PFOS, PFHxS, PFOA, PFBS, and GenX Chemicals Technical Report

National Health and Medical Research Council

SLR Project No.: 640.V30693.20000

17 October 2024

B.1 PFOS Existing Health-based Guidance

B.1.1 Alaska DEC (2019a)

Agency Report Reference: Alaska DEC (2019a). Technical Memorandum Action Levels for PFAS in Water and Guidance on Sampling Groundwater and Drinking Water. Date: August 20, 2018, Updated: October 2, 2019. Division of spill prevention and response. Contaminated sites program and Division of environmental health Drinking water program. Alaska Department of Environmental Conservation (Alaska DEC).		
General Information	Date of data extraction	07 August 2023
	Authors	Alaska Department of Environmental Conservation (Alaska DEC).
	Publication date	October 2, 2019
	Literature search timeframe	Not stated
	Publication type	Agency Technical Memorandum. Summary Document.
	Peer reviewed?	Not stated
	Country of origin	US (Alaska)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Maximum contaminant levels (MCLs) Lifetime health advisories (LHAs)
	Exposure timeframe	Not stated
	Critical human health endpoint	Not stated
	Justification provided by agency for critical endpoint	Not stated
	Critical study(ies) underpinning point of departure	Not stated
	Species for critical study(ies)	Not stated
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10,}$ etc.)	Not stated
	Point of departure value (include units)	Not stated
	Uncertainty factor(s) & rationale	Not stated
	Guideline value (include units)	PFOS+PFOA: 70 ng/L NB: In 2018, Alaska DEC previously set action level of 70 ng/L for PFOS, PFOA, PFNA, PFHxS, and PFHpA. A separate action level for the shorter-chain PFBS was set at 2.0 µg/L.

Agency Report Reference: Alaska DEC (2019a). Technical Memorandum Action Levels for PFAS in Water and Guidance on Sampling Groundwater and Drinking Water. Date: August 20, 2018, Updated: October 2, 2019. Division of spill prevention and response. Contaminated sites program and Division of environmental health Drinking water program. Alaska Department of Environmental Conservation (Alaska DEC).		
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Not stated
	Identified sensitive sub-populations	Not stated
	Any non-health-based considerations?	Not stated
Exposure considerations	Principal routes of exposure in general population	Not stated
	Levels in drinking water supplies (include location)	Not stated
	Any special considerations to exposure levels (e.g. higher in drought?)	Not stated
	Typical exposure in general population (include units for intakes & location)	Not stated
Risk Summary	Any risks to human health from drinking water identified in agency document?	Not stated
	Any emerging risks identified?	Not stated
Any other relevant information that should be captured?		Alaska relies on and adopts the U.S. Environmental Protection Agency's (EPA's) drinking water maximum contaminant levels (MCLs), rather than establishing state specific MCLs. The EPA had not yet established MCLs for PFAS.
Assessed in Appendix D?		No, adopted from other agency, no basis provided.

B.1.2 ATSDR (2018a)

Agency Report Reference: ATSDR (2018a). ATSDR's Minimal Risk Levels (MRLs) and Environmental Media Evaluation Guides (EMEGs) for Perfluoroalkyls (PFAS). November 2018. Agency for Toxic Substances and Disease Registry (ATSDR).		
General Information	Date of data extraction	03 August 2023
	Authors	Agency for Toxic Substances and Disease Registry (ATSDR).
	Publication date	November 2018.
	Literature search timeframe	Not stated
	Publication type	Agency Guidance (Summary Document)
	Peer reviewed?	Not stated

Agency Report Reference: ATSDR (2018a). ATSDR's Minimal Risk Levels (MRLs) and Environmental Media Evaluation Guides (EMEGs) for Perfluoroalkyls (PFAS). November 2018. Agency for Toxic Substances and Disease Registry (ATSDR).		
	Country of origin	US
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Environmental Media Evaluation Guides (EMEGs)
	Exposure timeframe	Not stated
	Critical human health endpoint	Not stated
	Justification provided by agency for critical endpoint	Not stated
	Critical study(ies) underpinning point of departure	Not stated
	Species for critical study(ies)	Not stated
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Not stated
	Point of departure value (include units)	Not stated
	Uncertainty factor(s) & rationale	Not stated
	Guideline value (include units)	52 ng/L (adult) and 14 ng/L (child)
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Not stated
	Identified sensitive sub-populations	Not stated
	Any non-health-based considerations?	Not stated
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-

Agency Report Reference: ATSDR (2018a). ATSDR's Minimal Risk Levels (MRLs) and Environmental Media Evaluation Guides (EMEGs) for Perfluoroalkyls (PFAS). November 2018. Agency for Toxic Substances and Disease Registry (ATSDR).		
	Any emerging risks identified?	-
Any other relevant information that should be captured?		ATSDR has developed MRL screening values for perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorohexane sulfonic acid (PFHxS) and perfluorononanoic acid (PFNA) that can be converted into drinking water concentrations for adults and children. ATSDR bases this calculation on an infant (age birth to one year old) weighing 7.8 kg and an intake rate of 1.113 liters per day. For an adult's drinking water exposure, ATSDR bases this calculation on a body weight of 80 kg and an intake rate of 3.092 liters per day. Scientists may use different assumptions when calculating concentrations from dosages.
Assessed in Appendix D?		No, but TRVs forming the basis of these guideline values (ATSDR 2021a) are assessed.

B.1.3 ATSDR (2021a)

Agency Report Reference: ATSDR (2021a). Toxicological Profile for Perfluoroalkyls. Released May 2021. Agency for Toxic Substances and Disease Registry (ATSDR).		
General Information	Date of data extraction	03 August 2023
	Authors	Agency for Toxic Substances and Disease Registry (ATSDR).
	Publication date	May 2021.
	Literature search timeframe	Not date limited. The current literature search was intended to update the draft toxicological profile for perfluoroalkyls released for public comment in 2015. The following main databases were searched in March 2008, September/October 2013, May 2016, and September 2018: • PubMed • National Library of Medicine's TOXLINE • Scientific and Technical Information Network's TOXCENTER
	Publication type	Agency Guideline
	Peer reviewed?	Yes
	Country of origin	US
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Minimum Risk Level (MRL)

Agency Report Reference: ATSDR (2021a). Toxicological Profile for Perfluoroalkyls. Released May 2021. Agency for Toxic Substances and Disease Registry (ATSDR).		
	Exposure timeframe	Intermediate (14 to 365 days)
	Critical human health endpoint	Delayed eye opening and decreased pup body weight
	Justification provided by agency for critical endpoint	The most sensitive targets of PFOS toxicity in laboratory animals are similar to those identified in longer term epidemiological studies. These effects include liver damage and increases in serum lipids, decreased antibody response to vaccines, and small decreases in birth weight; epidemiological studies have not consistently found neurological effects to be associated with serum PFOS levels. The serum PFOS concentrations predicted to occur at the lowest LOAEL values were 24.1, 29.7, and 31.9 µg/mL identified in the Luebker et al. (2005b), Luebker et al. (2005a), and Lau et al. (2003) studies (all as quoted in ATSDR 2021a); decreases in pup body weight and delays in eye opening were observed at these levels. Luebker et al. (2005a as quoted in ATSDR 2021a) was the only study that identified a NOAEL for these effects. The predicted serum concentration for this NOAEL dose was selected as the basis for the MRL.
	Critical study(ies) underpinning point of departure	Two-generation reproduction and cross-foster studies in rats (Luebker et al. 2005a, as quoted in ATSDR 2021a). • Luebker DJ, Case MT, York RG, et al. 2005a. Two-generation reproduction and cross-foster studies of perfluorooctanesulfonate (PFOS) in rats. Toxicol 215:126-148 (as quoted in ATSDR 2021a).
	Species for critical study(ies)	Rat
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	LOAEL, HED LOAEL
	Point of departure value (include units)	• NOAEL: 7.43 mg/L • LOAEL: 29.7 mg/L • HED: 0.000515 mg/kg/day
	Uncertainty factor(s) & rationale	300 A total uncertainty factor of 30 (3 for extrapolation from animals to humans with dosimetric adjustments and 10 for human variability) and a modifying factor of 10 for concern that immunotoxicity may be a more sensitive endpoint than developmental toxicity.
	Guideline value (include units)	MRL: 2 ng/kg/day (rounded from 1.7 ng/kg/day)
	Mode of action for critical health endpoint	The mode of action for most health outcomes associated with perfluoroalkyl exposure has not

Agency Report Reference: ATSDR (2021a). Toxicological Profile for Perfluoroalkyls. Released May 2021. Agency for Toxic Substances and Disease Registry (ATSDR).		
		been fully characterised in humans or laboratory animals. Some perfluoroalkyl-induced effects observed in rats and mice appear to be mediated through the PPARα-dependent and -independent mechanisms (see Section 2.20 in ATSDR 2021a for additional information). Interpretation of the relevance of the effects observed in laboratory animals is complicated since it is generally agreed that humans and nonhuman primates are refractory, or at least less responsive than rodents, to PPARα-mediated effects (Corton et al. 2014; Klaunig et al. 2003; Maloney and Waxman 1999). While studies in mice have identified specific effects that require PPARα activation, for example, postnatal viability (Abbott et al. 2007) and some immunological effects (Yang et al. 2002b), other effects such as hepatomegaly and antigen-specific antibody response (DeWitt et al. 2016) were reported to be PPARα-independent (Yang et al. 2002b).
	Genotoxic carcinogen?	Results do not provide evidence for genotoxicity of PFOS, except for one *in vitro* study showing cell transformation and one report of increased micronuclei formation following *in vivo* exposure.
	Identified sensitive sub-populations	It is not known whether children are more or less susceptible than adults to the effects of exposure to perfluoroalkyls because there are no studies that specifically addressed this question. Several studies have examined the possible associations between perfluoroalkyl exposure and health outcomes in children living in an area with high PFOA contamination and in the general population. Although some studies have found statistically significant associations, they are not adequate for establishing causality.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	• Brazil (Rio): max = 0.58 to 6.7 ng/L. • China (21 cities): <0.1 to 14.8 ng/L. SLR note there are other studies discussed that report PFBS in groundwater however concentrations were not shown in ATSDR (2021a)
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	• Modelled value: Adult uptake doses estimated for low, medium, and high exposure scenarios were approximately 7, 15, and 30 ng/kg body weight/day, respectively, for PFOS.

Agency Report Reference: ATSDR (2021a). Toxicological Profile for Perfluoroalkyls. Released May 2021. Agency for Toxic Substances and Disease Registry (ATSDR).		
		• Western countries: investigators estimated average daily exposure level of 1.6 ng/kg body weight/day for PFOS. Upper daily exposure levels were determined to be 8.8 ng/kg body weight/day for PFOS.
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	The available epidemiological data identify several potential health hazards of PFOS in humans as listed below: • Pregnancy-induced hypertension/pre-eclampsia. • Liver damage, as evidenced by increases in serum enzymes and decreases in serum bilirubin levels. • Increases in serum lipids, particularly total cholesterol and LDL cholesterol. • Decreased antibody response to vaccines. • Small (<20 g or 0.7 ounces per 1 ng/mL increase in blood perfluoroalkyl level) decreases in birth weight. There are sufficient epidemiological data to identify possible sensitive targets for many of the perfluoroalkyls; however, there are two major limitations to establishing dose-response relationships for these effects and using the epidemiological studies to derive MRLs: accurate identification of environmental exposure levels producing increased risk for adverse effects (exposure estimates and routes of exposure) and likely co-exposure to mixtures of perfluoroalkyls. Other limitations include the cross-sectional design of the majority of epidemiological studies and the potential that reverse causality contributes to the observed associations. The epidemiological databases for several perfluoroalkyls provide valuable information on hazard identification; however, uncertainties regarding doses associated with adverse effects and possible interactions between compounds preclude use of these data to derive MRLs. Although pharmacokinetic model parameters were not available for the strain/sex of the animals tested in the immunotoxicity studies, most of the studies did provide measured serum PFOS levels. The serum PFOS levels at the NOAEL and LOAEL doses are presented in Table A-17 of ATSDR 2021a. The measured serum PFOS levels associated with altered immune responses are approximately 1–10 times lower than the serum concentration predicted to occur at the NOAEL dose. These data suggest that immunotoxicity

Agency Report Reference: ATSDR (2021a). Toxicological Profile for Perfluoroalkyls. Released May 2021. Agency for Toxic Substances and Disease Registry (ATSDR).		
		may be a more sensitive effect than developmental toxicity.
Any other relevant information that should be captured?		There are insufficient data for derivation of an acute-duration oral MRL for PFOS. ATSDR did not identify an adequate study with an exposure duration of ≥365 days. Immune function was not examined following chronic-duration oral exposure in laboratory animal studies. Given the concern that immunotoxicity may occur at lower doses than liver toxicity, a chronic-duration oral MRL for PFOS is not recommended at this time.
Assessed in Appendix D?		Yes

B.1.4 BfR (2019a)

Agency Report Reference: BfR (2019a). New health-based guidance values for the industrial chemicals PFOS and PFOA BfR opinion No 032/2019 of 21 August 2019. German Federal Institute for Risk Assessment. Bundesinstitut für Risikobewertung (BFR).		
General Information	Date of data extraction	04 August 2023
	Authors	German Federal Institute for Risk Assessment. Bundesinstitut für Risikobewertung (BFR).
	Publication date	21 August 2019
	Literature search timeframe	Not stated
	Publication type	Agency Guidance
	Peer reviewed?	Not stated.
	Country of origin	Germany
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Tolerable Weekly Intake (TWI)
	Exposure timeframe	Lifetime The values indicate the weekly doses that can be consumed over the course of a lifetime without causing any appreciable health effects in humans.
	Critical human health endpoint	PFOS: An increase in total cholesterol levels in the blood in epidemiological studies. Exposure to PFOS is considered to be critically related to decreased antibody formation following certain childhood vaccinations.
	Justification provided by agency for critical endpoint	The EFSA opinion (2018) (as quoted in BfR 2019a) derives tolerable weekly intakes (TWIs) of

Agency Report Reference: BfR (2019a). New health-based guidance values for the industrial chemicals PFOS and PFOA BfR opinion No 032/2019 of 21 August 2019. German Federal Institute for Risk Assessment. Bundesinstitut für Risikobewertung (BFR).		
		6 ng/kg bw per week for PFOA and 13 ng/kg bw per week for PFOS. The values are significantly lower than the health-based guidance values derived previously by EFSA and other international bodies. Reference presumed by SLR to be EFSA (2018a) below: • EFSA (European Food Safety Authority, Scientific Panel on Contaminants in the Food Chain (CONTAM)) (2018a): Risk to human health related to the presence of perfluorooctane sulfonic acid and perfluorooctanoic acid in food. EFSA Journal 2018; 16(5):5194 After examining EFSA's opinion, the BfR believes there is a need for further research on, inter alia, the question of an actual causal relationship between the intake of PFOS and PFOA and the increase in total serum cholesterol and the relevance to health of this effect. From the point of view of the BfR, there are considerable uncertainties with regard to the evidence of causality and clinical relevance of the effects on which the TWI derivation was based. Despite uncertainties regarding the derivation of TWI values and the need for further scientific research, the BfR recommends using these newly derived TWI values from EFSA in future assessments of PFOS and PFOA concentrations in foods.
	Critical study(ies) underpinning point of departure	Data from three epidemiological studies: • Steenland K, Tinker S, Frisbee S, Ducatman A, Vaccarino V (2009): Association of perfluorooctanoic acid and perfluorooctane sulfonate with serum lipids among adults living near a chemical plant. Am J Epidemiol 170(10):1268-78 (as quoted in BfR 2019a). • Eriksen KT, Raaschou-Nielsen O, McLaughlin JK, Lipworth L, Tjønneland A, Overvad K, Sørensen M (2013): Association between plasma PFOA and PFOS levels and total cholesterol in a middle-aged Danish population. PLoS One. 2013;8(2):e56969 (as quoted in BfR 2019a). • Nelson JW, Hatch EE, Webster TF (2010): Exposure to polyfluoroalkyl chemicals and cholesterol, body weight, and insulin resistance in the general U.S. population. Environ Health Perspect 118(2):197-202
	Species for critical study(ies)	Humans

Agency Report Reference: BfR (2019a). New health-based guidance values for the industrial chemicals PFOS and PFOA BfR opinion No 032/2019 of 21 August 2019. German Federal Institute for Risk Assessment. Bundesinstitut für Risikobewertung (BFR).		
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10,}$ etc.)	BMDL5
	Point of departure value (include units)	22 ng/mL
	Uncertainty factor(s) & rationale	Not applicable
	Guideline value (include units)	TWI = 13 ng/kg/week (equivalent to 1.9 ng/kg/day)
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Not stated
	Identified sensitive sub-populations	First years of life. The question of a particularly sensitive time window, which may exist during childhood, is unclear. One focus of further investigations should be on the first years of life. During this period, in which vaccines are often administered as a primary immunisation, there is a relatively high PFOS/PFOA exposure in long-term breastfed children. The studies available so far only examined children who were 3 years or older.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	Presumed to be food. In principle, it is recommended to include drinking water as a source of exposure.
	Levels in drinking water supplies (include location)	Drinking Water Germany (n = 55, 3 with detects) • Lower bound: 0.96 ng/kg (mean), 10 ng/kg (P95). • Upper bound: 9.9 ng/kg (mean), 11 ng/kg (P95). Mineral Water Germany (n = 334, 32 with detects) • Lower bound: 0.38 ng/kg (mean), 3 ng/kg (P95). • Upper bound: 1.4 ng/kg (mean), 3.3 ng/kg (P95).
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	**Intake with mean consumption** **Age Group** / **Lower Bound** / **Upper Bound** Infants (<1 year) 1.89 14.21* Toddlers (1 - <3 years) 5.39 38.78* Children (3 - <10 years) 4.34 32.20*

<table>
<tr><th colspan="3">Agency Report Reference: BfR (2019a). New health-based guidance values for the industrial chemicals PFOS and PFOA BfR opinion No 032/2019 of 21 August 2019. German Federal Institute for Risk Assessment. Bundesinstitut für Risikobewertung (BFR).</th></tr>
<tr><td></td><td></td><td>
Adol. (10 - <18 years) 4.48 21.07*
Adults (18 - <65 years) 3.50 10.15
Elderly (65 - <75 years) 5.60 12.25
Very elderly (≥75 years) 4.83 11.62
*Exceeds the TWI values of 13 ng PFOS/kg bw per week
Intake with P95 consumption
<table>
<tr><th><u>Age Group</u></th><th><u>Lower Bound</u></th><th><u>Upper Bound</u></th></tr>
<tr><td>Infants (<1 year)</td><td>8.33</td><td>44.52*</td></tr>
<tr><td>Toddlers (1 - <3 years)</td><td>14.63*</td><td>79.94*</td></tr>
<tr><td>Children (3 - <10 years)</td><td>10.99</td><td>60.76*</td></tr>
<tr><td>Adol. (10 - <18 years)</td><td>8.40</td><td>39.20*</td></tr>
<tr><td>Adults (18 - <65 years)</td><td>8.82</td><td>23.52*</td></tr>
<tr><td>Elderly (65 - <75 years)</td><td>13.72*</td><td>28.14*</td></tr>
<tr><td>Very elderly (≥75 years)</td><td>11.83</td><td>24.85*</td></tr>
</table>
*Exceeds the TWI values of 13 ng PFOS/kg bw per week.
</td></tr>
<tr><td rowspan="2">Risk Summary</td><td>Any risks to human health from drinking water identified in agency document?</td><td>Water is not discussed.
NB: According to E’SA's exposure assessment, the new TWIs for PFOS and PFOA in Europe are exceeded by parts of the population when considering mean concentrations in food as well as mean and high consumption quantities.</td></tr>
<tr><td>Any emerging risks identified?</td><td>-</td></tr>
<tr><td colspan="2">Any other relevant information that should be captured?</td><td>From the point of view of the BfR, considerable uncertainties also exist with regard to the evidence of causality and clinical relevance of the effects used as the basis for the TWI derivation. The question of the clinical relevance of this parameter (total blood cholesterol), which EFSA has used to derive the TWI, is identified by EFSA itself as uncertain.
Amongst other issues, the BfR addressed questions regarding the suitability of the observed increases in total cholesterol in the epidemiological studies as biomarkers for cardiovascular diseases. Further discussions dealt with the clinical relevance of elevated cholesterol levels against the background of other factors affecting the risk of cardiovascular disease such as age, gender, weight, blood pressure and smoking. In addition, questions were discussed on the causal relationship between PFOS/PFOA in the blood and total cholesterol, in particular with regard to a possible coincidence of elevated serum levels of PFOS and PFOA and higher cholesterol levels, which could be due to, for example, mutual reabsorption from the gut via common membrane transport systems.</td></tr>
</table>

Agency Report Reference: BfR (2019a). New health-based guidance values for the industrial chemicals PFOS and PFOA BfR opinion No 032/2019 of 21 August 2019. German Federal Institute for Risk Assessment. Bundesinstitut für Risikobewertung (BFR).	
Assessed in Appendix D?	No, but the latest EFSA (2020a) guidance values are assessed (EFSA 2020a has superseded EFSA 2018).

B.1.5 CDPH (2023a)

Agency Report Reference: CDPH (2023a). Per- and polyfluoroalkyl Substances (PFAS). 2023. Connecticut State Department of Public Health (CDPH)		
General Information	Date of data extraction	07 August 2023
	Authors	Connecticut State Department of Public Health (CDPH)
	Publication date	2023
	Literature search timeframe	Not stated
	Publication type	Agency webpage.
	Peer reviewed?	Not stated.
	Country of origin	US (Connecticut)
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	CT Drinking Water Action Level
	Exposure timeframe	Not stated.
	Critical human health endpoint	Immune effects.
	Justification provided by agency for critical endpoint	CT DPH develops its drinking water Action Levels by considering health impacts to the most sensitive and most exposed populations across all stages of human development.
	Critical study(ies) underpinning point of departure	Not stated.
	Species for critical study(ies)	Animal studies
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Not stated.
	Point of departure value (include units)	Not stated.
	Uncertainty factor(s) & rationale	Not stated.
	Guideline value (include units)	10 ng/L
	Mode of action for critical health endpoint	Not stated.

Agency Report Reference: CDPH (2023a). Per- and polyfluoroalkyl Substances (PFAS). 2023. Connecticut State Department of Public Health (CDPH)		
	Genotoxic carcinogen?	Not stated.
	Identified sensitive sub-populations	Pregnant people, infants and children are at higher risk because of PFAS effects on pregnancy outcomes and foetal, infant and child growth and development.
	Any non-health-based considerations?	Not stated.
Exposure considerations	Principal routes of exposure in general population	Not stated.
	Levels in drinking water supplies (include location)	Not stated.
	Any special considerations to exposure levels (e.g. higher in drought?)	Not stated.
	Typical exposure in general population (include units for intakes & location)	Not stated.
Risk Summary	Any risks to human health from drinking water identified in agency document?	Not stated.
	Any emerging risks identified?	Not stated.
Any other relevant information that should be captured?		The chemical-specific approach reflects the evolving scientific evidence on the toxicity of PFAS and is more protective of public health than the summed approach used previously in CT.
Assessed in Appendix D?		No, no basis provided.

B.1.6 DOH (2017)

Agency Report Reference: DOH (2017). Health-based Guidance Values for PFAS. 2017. Department of Health (DOH), Australian Government.		
General Information	Date of data extraction	02 August 2023
	Authors	Department of Health (DOH), Australian Government.
	Publication date	Undated. Known to have been released in 2017.
	Literature search timeframe	Not stated
	Publication type	Agency Guideline. Summary Document.
	Peer reviewed?	FSANZ's report and recommended health-based guidance values have been nationally and internationally peer reviewed.
	Country of origin	Australia
	Source of funding	Not stated

Agency Report Reference: DOH (2017). Health-based Guidance Values for PFAS. 2017. Department of Health (DOH), Australian Government.		
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Health-based guidance values (HBGV) including: • Tolerable daily intake (TDI) • Drinking water quality guideline value (DWG)
	Exposure timeframe	Lifetime
	Critical human health endpoint	Not stated (refer to FSANZ 2017b). The tolerable daily intake for PFOS and PFOA are derived from the results of toxicity studies in laboratory animals. FSANZ concluded that the current available epidemiological data on human health is not suitable to support the derivation of tolerable daily intake levels for PFOS and PFOA.
	Justification provided by agency for critical endpoint	Not stated (refer to FSANZ 2017b)
	Critical study(ies) underpinning point of departure	Not stated (refer to FSANZ 2017b)
	Species for critical study(ies)	Not stated (refer to FSANZ 2017b)
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Not stated (refer to FSANZ 2017b)
	Point of departure value (include units)	Not stated (refer to FSANZ 2017b)
	Uncertainty factor(s) & rationale	Not stated (refer to FSANZ 2017b)
	Guideline value (include units)	• TDI: 20 ng/kg.bw/day (as a sum, PFOS+PFHxS) • DWG: 70 ng/L (as a sum, PFOS+PFHxS)
	Mode of action for critical health endpoint	Not stated (refer to FSANZ 2017b)
	Genotoxic carcinogen?	Not stated (refer to FSANZ 2017b)
	Identified sensitive sub-populations	Not stated (refer to FSANZ 2017b). The tolerable daily intakes include conservative assumptions to ensure the protection of public health.
	Any non-health-based considerations?	Not stated (refer to FSANZ 2017b)
Exposure considerations	Principal routes of exposure in general population	Not stated (refer to FSANZ 2017b)
	Levels in drinking water supplies (include location)	Not stated (refer to FSANZ 2017b)
	Any special considerations to exposure levels (e.g. higher in drought?)	Not stated (refer to FSANZ 2017b)

Agency Report Reference: DOH (2017). Health-based Guidance Values for PFAS. 2017. Department of Health (DOH), Australian Government.		
	Typical exposure in general population (include units for intakes & location)	Not stated (refer to FSANZ 2017b)
Risk Summary	Any risks to human health from drinking water identified in agency document?	Not stated (refer to FSANZ 2017b)
	Any emerging risks identified?	Not stated (refer to FSANZ 2017b)
Any other relevant information that should be captured?		The health-based guidance values are protective of human health; are a precautionary measure for use when conducting site investigations; and are to assist in providing advice to affected communities on how to minimise exposure to PFAS.
Assessed in Appendix D?		No, adopted from FSANZ (2017b), which is assessed separately.

B.1.7 EU (2020), EC (2022)

Agency Report Reference: EU (2020). Directives. Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the Quality of Water Intended for Human Consumption (recast) (Text with EEA relevance). L 435/2, 23.12.2020. European Union (EU). **Supporting Documentation:** EC (2022). Final Opinion on Groundwater quality standards for proposed additional pollutants in the annexes to the Groundwater Directive (2006/118/EC) Scientific Committee on Health, Environmental and Emerging Risks SCHEER. 18 July 2022. DG Health and Food Safety. European Commission (EC).		
General Information	Date of data extraction	08 August 2023
	Authors	Scientific Committee on Health, Environmental and Emerging Risks (SCHEER), European Commission (EC).
	Publication date	18 July 2022
	Literature search timeframe	Not stated
	Publication type	Agency Guidance
	Peer reviewed?	Not stated
	Country of origin	Luxembourg (Europe)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Technical guidelines Environmental Quality Standard – Drinking water, human health ($EQS_{dw,hh}$) (EC 2022)
	Exposure timeframe	Not stated
	Critical human health endpoint	Not stated

Agency Report Reference: EU (2020). Directives. Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the Quality of Water Intended for Human Consumption (recast) (Text with EEA relevance). L 435/2, 23.12.2020. European Union (EU). **Supporting Documentation:** EC (2022). Final Opinion on Groundwater quality standards for proposed additional pollutants in the annexes to the Groundwater Directive (2006/118/EC) Scientific Committee on Health, Environmental and Emerging Risks SCHEER. 18 July 2022. DG Health and Food Safety. European Commission (EC).		
	Justification provided by agency for critical endpoint	Not stated
	Critical study(ies) underpinning point of departure	Not stated
	Species for critical study(ies)	Not stated
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10,}$ etc.)	Not stated
	Point of departure value (include units)	Not stated
	Uncertainty factor(s) & rationale	Not stated
	Guideline value (include units)	Technical Guidelines: 100 ng/L (EU 2020 only) Technical Guidelines and $EQS_{dw,hh}$: PFAS Total: 500 ng/L (EU 2020, EC 2022) NB: 'Total PFAS' as the totality of per- and polyfluoroalkyl substances detected with available analytical methods and monitoring guidelines (EU 2020, EC 2022). 'Sum of PFAS' means the sum of per- and polyfluoroalkyl substances considered a concern as regards to water intended for human consumption listed in point 3 of Part B of Annex III. This is a subset of 'PFAS Total' substances that contain a perfluoroalkyl moiety with three or more carbons (i.e. $–C_nF_{2n}–$, n ≥ 3) or a perfluoroalkylether moiety with two or more carbons (i. e. $C_nF_{2n}OC_mF_{2m}–$, n and m ≥ 1) (EU 2020).
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Not stated
	Identified sensitive sub-populations	Not stated
	Any non-health-based considerations?	Not stated
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	-

<table>
<tr><td colspan="3">Agency Report Reference: EU (2020). Directives. Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the Quality of Water Intended for Human Consumption (recast) (Text with EEA relevance). L 435/2, 23.12.2020. European Union (EU).
Supporting Documentation: EC (2022). Final Opinion on Groundwater quality standards for proposed additional pollutants in the annexes to the Groundwater Directive (2006/118/EC) Scientific Committee on Health, Environmental and Emerging Risks SCHEER. 18 July 2022. DG Health and Food Safety. European Commission (EC).</td></tr>
<tr><td rowspan="2"></td><td>Any special considerations to exposure levels (e.g. higher in drought?)</td><td>-</td></tr>
<tr><td>Typical exposure in general population (include units for intakes & location)</td><td>-</td></tr>
<tr><td rowspan="2">Risk Summary</td><td>Any risks to human health from drinking water identified in agency document?</td><td>-</td></tr>
<tr><td>Any emerging risks identified?</td><td>-</td></tr>
<tr><td colspan="2">Any other relevant information that should be captured?</td><td>-</td></tr>
<tr><td colspan="2">Assessed in Appendix D?</td><td>No, no basis provided.</td></tr>
<tr><td colspan="3">Sum of PFAS
The following substances shall be analysed based on the technical guidelines developed in accordance with Article 13(7):
• Perfluorobutanoic acid (PFBA)
• Perfluoropentanoic acid (PFPA)
• Perfluorohexanoic acid (PFHxA)
• Perfluoroheptanoic acid (PFHpA)
• Perfluorooctanoic acid (PFOA)
• Perfluorononanoic acid (PFNA)
• Perfluorodecanoic acid (PFDA)
• Perfluoroundecanoic acid (PFUnDA)
• Perfluorododecanoic acid (PFDoDA)
• Perfluorotridecanoic acid (PFTrDA)
• Perfluorobutane sulfonic acid (PFBS)
• Perfluoropentane sulfonic acid (PFPS)
• Perfluorohexane sulfonic acid (PFHxS)
• Perfluoroheptane sulfonic acid (PFHpS)
• Perfluorooctane sulfonic acid (PFOS)
• Perfluorononane sulfonic acid (PFNS)
• Perfluorodecane sulfonic acid (PFDS)
• Perfluoroundecane sulfonic acid
• Perfluorododecane sulfonic acid
• Perfluorotridecane sulfonic acid</td></tr>
</table>

B.1.8 EFSA (2020a)

Agency Report Reference: EFSA (2020). Risk to human health related to the presence of perfluoroalkyl substances in food. Adopted: 9 July 2020. European Food Safety Authority (EFSA).		
General Information	Date of data extraction	01 August 2023
	Authors	EFSA CONTAM Panel (EFSA Panel on Contaminants in the Food Chain), Schrenk, D., Bignami, M., Bodin, L., Chipman, J.K., del Mazo J., Grasl-Kraupp, B., Hogstrand, C., Hoogenboom, L.R., Leblanc, J-C., Nebbia, C.S., Nielsen, E., Ntzani E., Petersen, A., Sand, S., Vleminckx, C., Wallace, H., Barregard, L., Ceccatelli, S., Cravedi, J-P., Halldorsson, T.I., Haug, L.S., Johansson, N., Knutsen, H.K., Rose, M, Roudot, A-C., Van Loveren, H., Vollmer, G., Mackay, K., Riolo, F. and Schwerdtle, T.
	Publication date	Adopted: 9 July 2020
	Literature search timeframe	Not stated
	Publication type	Not stated
	Peer reviewed?	Not stated
	Country of origin	European Union
	Source of funding	Requestor: European Commission
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Tolerable weekly intakes (TWIs)
	Exposure timeframe	-
	Critical human health endpoint	Immune outcomes in children
	Justification provided by agency for critical endpoint	Based on observations in animals and humans, the CONTAM Panel decided to combine its assessment on the sum of four PFAS, i.e. PFOA, PFNA, PFHxS and PFOS. At present, these four PFAS contribute most to the levels observed in human serum. In humans, these four PFAS share toxicokinetic properties and show similar accumulation and long half-lives. Also, in terms of effects, these compounds in general show the same effects when studied in animals. This also applies to several other PFAS, but the critical studies in humans did not report these in the blood of the participants. Current data do not allow the derivation of potency factors for the critical endpoint. As a pragmatic approach, the CONTAM Panel assumed by default equal potencies for effects of these four PFAS on immune outcomes.
	Critical study(ies) underpinning point of departure	A study with children from Germany showing an inverse association between serum levels of PFOA, but also the sum of PFOA, PFNA, PFHxS and PFOS, and antibody titres against haemophilus influenzae type b (Hib), diphtheria

Agency Report Reference: EFSA (2020). Risk to human health related to the presence of perfluoroalkyl substances in food. Adopted: 9 July 2020. European Food Safety Authority (EFSA).		
		and tetanus in serum sampled from 1-year-old children, predominantly breastfed. Abraham et al., 2020; Appendix K
	Species for critical study(ies)	Children
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Serum $BMDL_{10}$ for lower antibody titres against diphtheria
	Point of departure value (include units)	17.5 ng/mL for ∑PFOA, PFNA, PFHxS and PFOS. Using a PBPK model, and assuming 12 months of breastfeeding, it was estimated that the $BMDL_{10}$ in infants corresponds to an intake by the mother of 0.63 ng/kg bw per day for the sum of the four PFAS. Such intake would result in a serum level in the mother at 35 years of age of 6.9 ng/mL. See modelling in Appendix K. NB: Higher POD calculated using the Faroe Island study of 27 ng/mL with wide BMDL-BMDU bands (Refer to Appendix L and Section 3.4.1 EFSA (2020a) with an excerpt below (refer to Question "*Any other relevant information that should be captured?*"). • Abraham K, Mielke H, Fromme H, Volkel W, Menzel J, Peiser M, Zepp F, Willich SN and Weikert C, 2020. Internal exposure to perfluoroalkyl substances (PFASs) and biological marker in 101 healthy 1-year-old children: associations between levels of perfluorooctanoic acid (PFOA) and vaccine response. Archives of Toxicology, 94, 2131–2147.
	Uncertainty factor(s) & rationale	No additional uncertainty factors need to be applied, because the $BMDL_{10}$ is based on infants which are expected to be a sensitive population group, as is true for many immunotoxic chemicals. In addition, a decreased vaccination response is considered a risk factor for disease rather than a disease. The TWI should prevent mothers reach a body burden that results in levels in milk that would lead to serum levels in the infant associated with a decrease in vaccination response. As a result, the higher exposure of breastfed infants is taken into account in the derivation of the TWI and the intake by infants should therefore not be compared to this TWI.
	Guideline value (include units)	Daily intake for ∑PFOA, PFNA, PFHxS and PFOS: 0.63 ng/kg bw/day (TWI = 4.4 ng/kg bw per week)
	Mode of action for critical health endpoint	No mode of action of immunotoxicity by PFAS has been established. Data from in vivo and in vitro studies on PFOS and PFOA suggest that immunotoxic effects may originate from

Agency Report Reference: EFSA (2020). Risk to human health related to the presence of perfluoroalkyl substances in food. Adopted: 9 July 2020. European Food Safety Authority (EFSA).		
		modulation of PPARs, NF-jB regulated gene transactivation and/or regulation of apoptosis.
	Genotoxic carcinogen?	For PFOS and PFOA, no evidence for a direct genotoxic mode of action was identified. For PFAS other than PFOS and PFOA, the number of studies and data are limited. However, structural similarity for PFHxS and PFOS, as well as for PFNA and PFOA, indicates that also for these PFAS a direct genotoxic mode of action is unlikely.
	Identified sensitive sub-populations	Children
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	For PFOS and PFOA, 'Fish and other seafood' was the most important contributor to the mean lower bound (LB) exposure, followed by 'Eggs and egg products', 'Meat and meat products', and 'Fruit and fruit products'. For PFOA, 'Vegetables and vegetable products' and 'Drinking water' were also important contributors. For several of the other PFAS, 'Fish and other seafood', 'Fruit and fruit products, 'Vegetables and vegetable products', 'Drinking water', as well as 'Starchy roots and tubers' were the most important food groups. Although for infants and children 'Food for infants and small children' was a major contributor, this was highly uncertain since this was based on few samples with detected values. For the combined exposure to PFOA, PFNA, PFHxS and PFOS, the main contributing food categories were 'Fish meat', 'Fruit and fruit products' and 'Eggs and egg products', observed for all population groups.
	Levels in drinking water supplies (include location)	Concerning drinking water, there were a considerable number of analytical results (206–452) for nine PFAS, varying between 78% and 100% left-censored. To calculate the mean occurrence for drinking water, occurrence values for FoodEx level 2 categories of water (tap, well and bottled) were weighted according to the consumption of these categories. The highest mean LB level was for PFHxA, followed by PFHxS, PFBS and PFOA, being, respectively, 2.2, 1.8, 1.5, and 1.3 ng/L. Despite the low LOQ cut-off applied (0.010 ng/L), mean upper bound (UB) levels were a factor of two higher.
	Any special considerations to exposure levels (e.g. higher in drought?)	Two main processes are thought to lead to contamination of food with PFAS, namely bioaccumulation in aquatic and terrestrial food chains, and transfer from contact materials used in food processing and packaging.

Agency Report Reference: EFSA (2020). Risk to human health related to the presence of perfluoroalkyl substances in food. Adopted: 9 July 2020. European Food Safety Authority (EFSA).		
	Typical exposure in general population (include units for intakes & location)	Mean Exposure Ranges (ng/kg bw per day) across surveys and age groups: • PFOS LB: 0.23 to 2.6, UB: 3.3 to 31. • PFOA LB: 0.1 to 0.6, UB: 3.0 to 29. • PFHxS LB: 0.04 to 0.36, UB: 2.5 to 29.0. • ∑PFOA, PFNA, PFHxS and PFOS (infants): LB: 2.4–12.2, UB: 42.8–115 High (95th percentile) Exposure Ranges (ng/kg bw per day) across surveys and age groups: • PFOS LB: 1.0 to 8.5, UB: 6.25 to 62. • PFOA LB: 0.2 to 2.1, UB: 5.6 to 59. • PFHxS LB: 0.09 to 0.86, UB: 4.6 to 57.6. • ∑PFOA, PFNA, PFHxS and PFOS: LB: 1.3 (adults) to 27.9 (infants) and UB: 21.9 (very elderly) to 229 (toddlers)
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	Concerning potential adverse effects, studies on effects of other PFAS, and in particular those of PFNA and PFHxS on the immune system should be conducted. Studies for the potential critical effects that allow for a derivation of potency factors for PFAS should be conducted. In addition, studies to characterise the mode of action of immunotoxicity and mammary gland development of PFASs should be performed. The effects of PFAS on thyroid hormone levels and potential consequences for neurodevelopment should be further investigated. More longitudinal epidemiological studies are needed on human endpoints, in particular prospective vaccination studies covering more varied types of vaccines, different populations, as well as more studies on other immune outcomes including risk of infections. Most epidemiological studies examine associations between health-related outcomes and single PFAS separately in spite of co-exposures. For risk assessment, results for the sum of several PFAS should be reported.
Any other relevant information that should be captured?		This TWI should prevent that mothers reach a body burden that results in levels in milk that would lead to serum levels in the infant associated with a decrease in vaccination response. As a result, the higher exposure of breastfed infants is taken into account in the derivation of the TWI and the intake by infants should therefore not be compared with this TWI. The CONTAM Panel noted that this TWI is protective for the other potential critical endpoints

Agency Report Reference: EFSA (2020). Risk to human health related to the presence of perfluoroalkyl substances in food. Adopted: 9 July 2020. European Food Safety Authority (EFSA).	
	such as increase in serum cholesterol, reduced birth weight and high serum levels of ALT considered in the previous Opinion on PFOS and PFOA (EFSA CONTAM Panel, 2018). A study on children in the Faroe Islands (Grandjean et al., 2012) showed several inverse associations between serum levels of PFOA, PFNA, PFHxS and PFOS, as well as the sum of PFOA, PFHxS and PFOS at five years of age, before booster vaccination, and antibody titres against diphtheria and tetanus at both the age of 5, shortly after booster vaccination, and at 7.5 years. In the previous Opinion (EFSA CONTAM Panel, 2018), BMD analysis was performed on the PFOS data in 5-year-old children from the Faroe Islands, resulting in a BMD05 and BMDL05 of, respectively, 11.6 and 10.5 ng/mL. However, the modelling approach was criticised during the expert meeting (EFSA/ CONTAM/3503), including the use of the antibody titre in the lowest decile as the reference value rather than extrapolate and evaluate the BMR for a serum PFOS concentration of zero. Data for PFOA were not modelled, since the levels were much lower than those for PFOS, and there were no indications that PFOA was more potent than PFOS. For this study, additional data on the sum of PFOA, PFNA, PFHxS and PFOS were obtained (see Appendix L). Modelling of the data by EFSA with the recommended BMD modelling software (PROAST and BMDS) resulted in wide BMDL-BMDU intervals, as a consequence of extrapolating to zero exposure, well below the lowest observed serum levels. Therefore, the CONTAM Panel identified a NOAEC serum level at the age of 5 years for the sum of PFOA, PFNA, PFHxS and PFOS of 27.0 ng/mL, based on decreased antibody titres for diphtheria at the age of 7 years. Overall, both the few number of data points in the critical dataset (n = 101), particularly at higher serum concentrations of PFAS, and the relatively large variability between individuals results in the (mean) dose-response curve not being clear. This introduces uncertainty in the shape of the dose response curve as well as the location of the established Reference Point. Similar issues as with the modelling of human data were observed with animal data on effects on the immune response. In two independent studies on effects of PFOS on the antibody response after immunisation of mice with sheep red blood cells, the BMD modelling resulted in wide BMDL/BMDU confidence intervals and extrapolation outside the range of observed PFOS serum levels.

Agency Report Reference: EFSA (2020). Risk to human health related to the presence of perfluoroalkyl substances in food. Adopted: 9 July 2020. European Food Safety Authority (EFSA).	
Assessed in Appendix D?	Yes

B.1.9 FSANZ (2017b)

Agency Report Reference: FSANZ (2017). Hazard assessment report – Perfluorooctane Sulfonate (PFOS), Perfluorooctanoic Acid (PFOA), Perfluorohexane Sulfonate (PFHxS). Food Standards Australia New Zealand (FSANZ).		
General Information	Date of data extraction	02 August 2023
	Authors	Food Standards Australia New Zealand (FSANZ)
	Publication date	Undated. Known to have been released in 2018.
	Literature search timeframe	Five years. Search strategy in PubMed, with results retrieved for the final search on 15 December, 2016
	Publication type	Agency Guideline Document
	Peer reviewed?	Not stated.
	Country of origin	Australia
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Health-based guidance values (HBGV) • Tolerable daily intake (TDI)
	Exposure timeframe	Lifetime
	Critical human health endpoint	NOAEL = 0.1 mg/kg/day in study by Luebker et al. (2005b, as quoted in FSANZ 2017b) based on: • Parental toxicity: decreased body weight gain and food consumption in the F0 generation. • Offspring toxicity: Significant decreases in pup weight and weight gain during lactation (NOAEL = 0.1 mg/kg/day). NB: The NOAEL for reproductive toxicity was 0.4 mg/kg bw/day based on increased numbers of dams with all pups dying on postnatal days (PNDs) 1–4.
	Justification provided by agency for critical endpoint	The NOAELs from four studies were chosen for a range of effects and converted to a HBGV. The lowest HBGV calculated from the study by Luebker et al. (2005b, as quoted in FSANZ 2017b) was selected. A literature review commissioned by FSANZ concluded that the weight of evidence from the available animal studies indicates that PFOS can adversely modulate immune system responsiveness (Drew and Hagan 2016). However, there are significant uncertainties

Agency Report Reference: FSANZ (2017). Hazard assessment report – Perfluorooctane Sulfonate (PFOS), Perfluorooctanoic Acid (PFOA), Perfluorohexane Sulfonate (PFHxS). Food Standards Australia New Zealand (FSANZ).		
		regarding species sensitivity, strain sensitivity and the influence of route of administration on immune system modulation by PFOS that have yet to be resolved. As a result, it is not possible to determine a reliable NOAEL or LOAEL for adverse effects on immune function for use in a quantitative risk assessment of PFOS at this time. Drew and Hagan (2016) concluded that the epidemiology data available do not provide compelling evidence for increased incidence of disease associated with PFOS effects on immune function.
	Critical study(ies) underpinning point of departure	Two-generation reproductive toxicity in the rat (Luebker et al. 2005b). NB: Candidate HBGV were also calculated using data from these studies • subchronic toxicity study in nonhuman primates (Seacat et al. 2002) • chronic toxicity and carcinogenicity study in rats (Butenhoff et al. 2012/Thomford 2002) • developmental toxicity in the rat (Thibodeaux et al. 2003/Lau et al. 2003).
	Species for critical study(ies)	Female rat
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Human Equivalent Dose (HED). HEDs were derived from modelled animal average PFOS serum concentrations using PBPK modelling based on established NOAELs from animal studies.
	Point of departure value (include units)	0.0006 mg/kg/day (Five HEDs from four studies selected as the POD: 0.0006, 0.0007, 0.0013, 0.0031 and 0.0037 mg/kg/day)
	Uncertainty factor(s) & rationale	For all studies a default uncertainty factor of 10 has been applied to account for human variability. For interspecies variability, a default uncertainty factor of 3 has been applied to account for potential differences in toxicodynamics between animals and humans. An uncertainty factor to account for interspecies differences in toxicokinetics is not required due to the use of PBPK modelling to derive HEDs. No additional uncertainty factors were considered to be required, and therefore a total uncertainty factor of 30 was applied to all modelled HEDs.
	Guideline value (include units)	TDI: 20 ng/kg/day NB: Applied as a sum of PFOS+PFHxS (refer to **Section B.2.8**).

Agency Report Reference: FSANZ (2017). Hazard assessment report – Perfluorooctane Sulfonate (PFOS), Perfluorooctanoic Acid (PFOA), Perfluorohexane Sulfonate (PFHxS). Food Standards Australia New Zealand (FSANZ).		
		(Five TDI from four studies calculated and the lowest value selected as the TDI: 100, 20, 100, 40 and 20 ng/kg/day)
	Mode of action for critical health endpoint	Mechanisms of toxicity have not been fully elucidated but are likely to at least partly involve activation of PPARα. Activation of other nuclear receptors such as CAR and PXR has also been observed and PFOS administration has been found to induce the expression of a range of genes involved in lipid metabolism, fatty acid uptake and xenobiotic metabolism. The strong protein binding affinity of PFOS, for example to FABP in the liver, may also contribute to its toxicological profile.
	Genotoxic carcinogen?	The weight of evidence from a range of genotoxicity studies suggests that this occurs through a non-genotoxic mechanism.
	Identified sensitive sub-populations	-
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		-
Assessed in Appendix D?		Yes.

B.1.10 HC (2018a)

Agency Report Reference: HC (2018a). Guidelines for Canadian Drinking Water Quality Guideline Technical Document Perfluorooctane Sulfonate (PFOS). December 2018. Health Canada (HC). Government of Canada.		
General Information	Date of data extraction	03 August 2023
	Authors	Health Canada (HC). Government of Canada.

Agency Report Reference: HC (2018a). Guidelines for Canadian Drinking Water Quality Guideline Technical Document Perfluorooctane Sulfonate (PFOS). December 2018. Health Canada (HC). Government of Canada.		
	Publication date	December 2018.
	Literature search timeframe	Not stated
	Publication type	Agency Guidance
	Peer reviewed?	This document was endorsed by the Federal-Provincial-Territorial Committee on Drinking Water of the Federal-Provincial-Territorial Committee on Health and the Environment.
	Country of origin	Canada
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Tolerable Daily Intake (TDI), Health-based Value (HBV) or Maximum acceptable concentration (MAC)
	Exposure timeframe	Lifetime
	Critical human health endpoint	Hepatocellular hypertrophy (liver effects) in rats (Butenhoff et al., 2012b as quoted in HC 2019a)
	Justification provided by agency for critical endpoint	Liver effects in rats was used to calculate a MAC that is protective of human health from both cancer and non-cancer effects. Epidemiological studies have shown associations between exposure to PFOS and multiple non-cancer health outcomes, such as reproductive, developmental, and immunological effects. However, these studies cannot be used to derive the non-cancer HBV for PFOS due to their limitations, including in terms of study design, bias and confounders. In animals, non-cancer effects observed at the lowest levels of exposure include immunological effects, liver effects, effects on the thyroid and changes in serum lipid levels. For various reasons described in section 10.2, the most appropriate endpoint to derive a HBV for PFOS is hepatocellular hypertrophy (liver effects) in rats, supported quantitatively by the estimated value for thyroid effects in monkeys. The effect observed at the lowest exposure levels was immune system suppression in mice. The lowest LOAEL for immunosuppression data classified by IPCS (2012) as providing the strongest weight of evidence for immunotoxicity was suppression of SRBC-specific IgM in mice at ≥0.00166 mg/kg bw per day (Peden-Adams et al., 2008). Immune system effects were excluded from the quantitative risk assessment due to inconsistencies in NOAELs and LOAELs among studies and uncertainty of the importance of observed effects to human health

Agency Report Reference: HC (2018a). Guidelines for Canadian Drinking Water Quality Guideline Technical Document Perfluorooctane Sulfonate (PFOS). December 2018. Health Canada (HC). Government of Canada.		
	Critical study(ies) underpinning point of departure	Chronic dietary toxicity and carcinogenicity study in rats (Butenhoff et al., 2012b as quoted in HC 2019a). • Butenhoff, J.L., Chang, S.C., Olsen, G.W. and Thomford, P.J. (2012b). Chronic dietary toxicity and carcinogenicity study with potassium perfluorooctanesulfonate in Sprague Dawley rats. Toxicology, 293(1–3): 1–15 (as quoted in HC 2019a).
	Species for critical study(ies)	Rats
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10,}$ etc.)	NOAEL, POD_{HEQ}
	Point of departure value (include units)	NOAEL: 0.021 mg/kg/day POD_{HEQ}: 0.0015 mg/kg/day
	Uncertainty factor(s) & rationale	25 An interspecies uncertainty factor of 2.5 was used to reflect only the toxicodynamic component of the default interspecies uncertainty factor, because the toxicokinetic differences between animals and humans were already incorporated when calculating the POD_{HEQ}. Likewise, default values of 10 were applied for the intraspecies uncertainty factor. The default value was assumed to be sufficient in the absence of data on intraspecies differences.
	Guideline value (include units)	TDI: 60 ng/kg/day HBV or MAC: 600 ng/L (HBV = TDI x body weight of an adult x default allocation factor ÷ daily volume of water consumed by an adult = 0.00006 mg/kg/day × 70 kg × 0.2 ÷ 1.5 L/day)
	Mode of action for critical health endpoint	The modes of action for PFOS and PFOA are not fully understood and it is likely that multiple pathways are involved in their toxic effects. The largest body of evidence points to PPARα ligand-dependent activation by PFOS and PFOA as a key initiating event in the development of liver toxicities. However, although some toxicity by PFOS and PFOA is attributable to PPARα activation, PPARα-independence has also been proposed. Although the mode of action for PFOS and PFOA-induced toxicities has yet to be elucidated, the similarity in the mechanisms activated by each compound is sufficient to suggest similar modes of action are at play.
	Genotoxic carcinogen?	Neither PFOS nor PFOA are considered to be direct-acting genotoxic chemicals

Agency Report Reference: HC (2018a). Guidelines for Canadian Drinking Water Quality Guideline Technical Document Perfluorooctane Sulfonate (PFOS). December 2018. Health Canada (HC). Government of Canada.		
	Identified sensitive sub-populations	Screening values are also established at a level designed to protect the health of Canadians, including children, based on a lifetime exposure to the substance.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	Exposure is mainly from food and consumer products, however, the proportion of exposure from drinking water can increase in individuals living in areas with contaminated drinking water.
	Levels in drinking water supplies (include location)	PFOS is not regularly monitored at water treatment plants in Canada, the analysis has been performed for a few locations. When detected in drinking water, it is usually found below 0.001 µg/L. • Calgary: <0.85 ng/L (from 2 Water Treatment Plants, WTPs) • Quebec: 1.0 ng/L (median), 36 ng/L (max) (n = 84). • Ontario: 3.3 mg/L (n = 5).
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	The estimated total daily intake of PFAS (estimates not provided for individual PFAS) in Canadians was reported to be 410 ng/day for the general population of Canada (Tittlemier et al., 2007). Drinking water ingestion, estimated at 0.3 ng/day, contributed only a minor amount to the overall estimated exposure.
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		The health effects of PFOS and PFOA are similar and well documented. Recent scientific evidence shows that PFOS and PFOA affect the same organ in similar ways. Thus, when PFOA and PFOS are found together in drinking water, the best approach to protect human health is to consider both chemicals together when comparing to the guideline values. This is done by adding the ratio of the observed concentration for PFOS to its MAC with the ratio of the observed concentration for PFOA to its MAC; if the result is below or equal to one, then the water is considered safe for drinking. Science currently does not justify the use of this approach for other PFAS.

Agency Report Reference: HC (2018a). Guidelines for Canadian Drinking Water Quality Guideline Technical Document Perfluorooctane Sulfonate (PFOS). December 2018. Health Canada (HC). Government of Canada.	
	At the time of the review undertaken by HC (2018a), the carcinogenicity of PFOS had not been evaluated by the International Agency for Research on Cancer (IARC). HC (2018a) indicated chronic exposure to PFOS has been associated with both cancer and non-cancer effects in animals and humans. HBVs for both endpoints have been calculated, with the non-cancer effects resulting in a lower, more conservative HBV.
Assessed in Appendix D?	Yes.

B.1.11 Maine DHHS (2021a)

Agency Report Reference: Maine DHHS (2021a). PFOS, PFOA and other PFAS Questions and Answers. Updated 7/07/2021. Maine Department of Health and Human Services (Maine DHHS).		
General Information	Date of data extraction	07 August 2023
	Authors	Maine Department of Health and Human Services (Maine DHHS).
	Publication date	Updated 7/07/2021
	Literature search timeframe	Not stated
	Publication type	Agency Summary document (Questions and answer Fact Sheet)
	Peer reviewed?	Not stated
	Country of origin	US (Maine)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Interim State drinking water standard
	Exposure timeframe	Not stated
	Critical human health endpoint	According to the U.S. Agency for Toxic Substances and Disease Registry, some, but not all, studies in people who have higher PFOS or PFOA levels in the blood have shown that these chemicals may: • increase the risk of kidney and testicular cancer; • increase cholesterol levels; • increase the risk of high blood pressure or pre-eclampsia in pregnant women; • lower infant birth weights; however, the decrease in birth weight is small and may not affect the infant's health; • decrease how well the body responds to vaccinations;
	Justification provided by agency for critical endpoint	

Agency Report Reference: Maine DHHS (2021a). PFOS, PFOA and other PFAS Questions and Answers. Updated 7/07/2021. Maine Department of Health and Human Services (Maine DHHS).		
		• cause changes in liver enzyme levels.
	Critical study(ies) underpinning point of departure	Not stated
	Species for critical study(ies)	Not stated
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Not stated
	Point of departure value (include units)	Not stated
	Uncertainty factor(s) & rationale	Not stated
	Guideline value (include units)	20 ng/L For the combined sum of six different PFAS: PFOA, PFOS, PFHpA, PFNA, PFDA, and PFHxS
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Not stated
	Identified sensitive sub-populations	Not stated
	Any non-health-based considerations?	Not stated
Exposure considerations	Principal routes of exposure in general population	Drinking water with PFAS can result in higher levels of these chemicals in the blood.
	Levels in drinking water supplies (include location)	Not stated
	Any special considerations to exposure levels (e.g. higher in drought?)	Not stated
	Typical exposure in general population (include units for intakes & location)	Not stated
Risk Summary	Any risks to human health from drinking water identified in agency document?	Not stated
	Any emerging risks identified?	Not stated
Any other relevant information that should be captured?		-
Assessed in Appendix D?		No, no basis provided.

B.1.12 Mass DEP (2022a)

Agency Report Reference: Mass DEP (2022a). Important Information. EPA's New Health Advisories for Some PFAS. August 11, 2022. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP). **Supporting Documentation:** Mass DEP (2023a). EPA Proposed Maximum Contaminant Level (MCL) for PFAS. April 12, 2023. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP).		
General Information	Date of data extraction	08 August 2023
	Authors	Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP).
	Publication date	August 11, 2022
	Literature search timeframe	Not stated
	Publication type	Agency Letter
	Peer reviewed?	Not stated
	Country of origin	US (Massachusetts)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	• EPA's Health Advisories • Maximum Contaminant Level (MCL) • Maximum Contaminant Level Goals (MCLGs) (Mass DPH 2023a)
	Exposure timeframe	Lifetime
	Critical human health endpoint	Not stated
	Justification provided by agency for critical endpoint	Not stated
	Critical study(ies) underpinning point of departure	Not stated
	Species for critical study(ies)	Not stated
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Not stated
	Point of departure value (include units)	Not stated
	Uncertainty factor(s) & rationale	Not stated
	Guideline value (include units)	• MCL (PFAS): 20 ng/L for the sum of six PFAS (PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA) (established as enforceable in Massachusetts) The two EPA Interim Health Advisories and two Final Health Advisories are: • Interim Health Advisory for PFOA: 0.004 ng/L • Interim Health Advisory for PFOS: 0.02 ng/L

Agency Report Reference: Mass DEP (2022a). Important Information. EPA's New Health Advisories for Some PFAS. August 11, 2022. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP). **Supporting Documentation:** Mass DEP (2023a). EPA Proposed Maximum Contaminant Level (MCL) for PFAS. April 12, 2023. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP).		
		• Final Health Advisory for GenX: 10 ng/L • Final Health Advisory for PFBS: 2,000 ng/L MCLGs from Mass DPH (2023a): • PFOS: 4 ng/L • PFOA: 4 ng/L • PFNA, PFHxS, PFBS, & GenX: Hazard Index of 1. NB: Massachusetts will adopt PFAS drinking water regulations that are at least as stringent as the federal standards (Mass DEP 2023a). NB: Mass DEP (2023a) is proposing to address four additional PFAS (GenX, PFBS, PFNA, and PFHxS) as a mixture using a Hazard Index. A Hazard Index accounts for the increased risk from mixtures of PFAS (Mass DEP 2023a). SLR note that it is not clear how the Hazard Index will be calculated, i.e. which MCLG, HA or MCL will be used for the calculation.
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Not stated
	Identified sensitive sub-populations	Not stated
	Any non-health-based considerations?	The Interim Health Advisories for PFOS and PFOA are far lower than detectable levels using the currently available laboratory analytical methods and equipment.
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		-

Agency Report Reference: Mass DEP (2022a). Important Information. EPA's New Health Advisories for Some PFAS. August 11, 2022. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP). **Supporting Documentation:** Mass DEP (2023a). EPA Proposed Maximum Contaminant Level (MCL) for PFAS. April 12, 2023. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP).	
Assessed in Appendix D?	No, adopted from other agency, no basis provided.

B.1.13 MDH (2020a)

Agency Report Reference: MDH (2020a). Toxicological Summary for: Perfluorooctane sulfonate. August 2020. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH).		
General Information	Date of data extraction	04 August 2023
	Authors	Minnesota Department of Health (MDH)
	Publication date	August 2020
	Literature search timeframe	Not stated
	Publication type	Agency Guideline
	Peer reviewed?	Not stated
	Country of origin	US (Minnesota)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Reference Dose (RfD) Non-Cancer Health-Based Value (nHBV)
	Exposure timeframe	Short-term, subchronic, and chronic durations
	Critical human health endpoint	Increased IL-4 and decreased SRBC specific IgM levels
	Justification provided by agency for critical endpoint	Immune suppression was identified as the critical effect and forms the basis of the RfD. Immune System has been identified as an Additivity Health Endpoint.
	Critical study(ies) underpinning point of departure	Subchronic toxicity test in mice. Dong et al 2011 (as quoted in MDH 2022f). • Dong, G., MM Liu, D Wang, L Zheng, ZF Liang, YH Jin, (2011). "Sub-chronic effect of perfluorooctanesulfonate (PFOS) on the balance of type 1 and type 2 cytokine in adult C57BL6 mice." Archives of Toxicology 85: 1235-1244.
	Species for critical study(ies)	Mice
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	NOAEL, HED

Agency Report Reference: MDH (2020a). Toxicological Summary for: Perfluorooctane sulfonate. August 2020. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH).		
	Point of departure value (include units)	NOAEL = 2.36 µg/mL HED = 0.000307 mg/kg/day
	Uncertainty factor(s) & rationale	100 3 for interspecies differences (for toxicodynamics), 10 for intraspecies variability, and 3 for database uncertainty (impacts on serum thyroxine (T4) in developing animals have been reported at serum concentrations ~3-fold lower than the POD. Additional studies regarding thyroid effects and a more complete assessment of developmental immune effects are warranted.)
	Guideline value (include units)	• RfD: 3.1 ng/kg/day • nHBV: 15 ng/L NB: Refer to News Release from MDH (2023a) for MCLs and Hazard index approach for assessing PFOS, PFOA, PFHxS, PFBS and GenX.
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Not stated NB: Suggestive Evidence of Carcinogenic Potential
	Identified sensitive sub-populations	-
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	A database uncertainty factor was incorporated into the RfD calculation, in part, due to the need for a more comprehensive assessment of potential developmental immune effects.
Any other relevant information that should be captured?		Co-critical effect(s): decreased pup body weight; increased fasting serum insulin and glucose in pups; suppressed SRBC response, increased NK

Agency Report Reference: MDH (2020a). Toxicological Summary for: Perfluorooctane sulfonate. August 2020. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH).	
	cell activity and decreased IgM; decreased total and free T4 (maternal and pups); decreased adrenal weight, decreased serum corticosterone and adrenocorticotropic hormone levels in serum, and corticotropin-releasing hormone concentration in hypothalamus; and changes in cholesterol and histological changes in the liver (adults) **Endocrine Toxicity testing**: Human epidemiological studies have examined a number of endocrine targets, including thyroid hormone levels and/or thyroid disease, reproductive hormones and insulin levels. Results from these studies have provided limited support for an association between PFOS and thyroid endpoints. Stronger associations were found in populations at risk for iodine deficiency or positive anti-TPO antibodies (a marker for autoimmune thyroid disease). Investigators from one laboratory have reported increased follicle stimulating hormone (FSH) and decreased luteinizing hormone (LH) and testosterone at doses similar in magnitude to the critical study LOAEL. However, there are concerns regarding the study design and these effects are not listed as co-critical at this time. Decreases in adrenal gland weight as well as serum corticosterone and adrenocorticotropic hormone levels have been observed at doses similar in magnitude to the critical study LOAEL. Changes in expression of POMC (proopiomelanocortin), ACTHr (adrenocorticotropic hormone receptor) and CRH (corticotropin-releasing hormone) genes were also observed. These effects have been included as co-critical effects. Multiple studies in laboratory animals have reported decreased serum thyroid levels, in particular, thyroxin (T4) in offspring and adult animals at exposure levels similar in magnitude to the critical effect. Transcriptional changes of genes, in part regulated by thyroid hormones, involved in neurodevelopment have also been reported. However, the biological or functional significance of these changes are not clear. A NOAEL for thyroid hormone impacts in offspring has not been identified. As a result, a database uncertainty factor has been incorporated into the RfD calculation. Changes in total and free T4 have been identified as co-critical effects and Thyroid (E) has been identified as an Additivity Endpoint. **Immunotoxicity**: Human epidemiology studies have evaluated associations for three categories of altered immune response: immunosuppression (altered antibody response, infectious disease resistance), hypersensitivity (asthma, eczema,

Agency Report Reference: MDH (2020a). Toxicological Summary for: Perfluorooctane sulfonate. August 2020. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH).	
	allergies), and autoimmunity. The strongest evidence comes from fairly consistent associations with antibody response to vaccines. However, consistent associations between serum PFOS and rates of infectious disease have not been reported. Studies in laboratory animals have shown that PFOS exposure alters several immunologic measures (e.g. suppression of SRBC response and/or natural killer cell activity) in adult animals. A single developmental immune study evaluating effects resulting from in utero exposure only has been conducted. A database uncertainty factor was incorporated into the RfD calculation, in part, due to the need for a more comprehensive assessment of potential developmental immune effects. Immune suppression was identified as the critical effect and forms the basis of the RfD. Immune System has been identified as an Additivity Health Endpoint. **Developmental toxicity**: Human epidemiology studies have suggested an association between prenatal PFOS serum levels and lower birth weight, however, this association has not been consistent. Studies conducted in laboratory animals have identified several sensitive developmental effects, including decreased pup body weight, changes in energy metabolism (e.g. glucose levels, lipid metabolism) and decreased thyroid hormone levels. Some of these developmental effects were identified as co-critical effects and are included as an Additivity Health Endpoint. Additional effects, including increased pup death, were observed at higher exposure levels. **Reproductive toxicity**: Human epidemiology studies have evaluated alterations in reproductive hormones, menstrual cycle length, onset of menopause, endometriosis, breastfeeding duration, effects on sperm, and fertility. Findings have not been consistent across studies or there are too few studies to interpret the results. Since menstruation, parturition and breastfeeding are elimination routes the possibility of reverse causation has been raised for several of the endpoints evaluated in females. An association between preconception serum PFOS, gestational diabetes, and pregnancy induced hypertension has been reported in populations with serum PFOS concentrations of 0.012-0.017 µg/mL (or 12 – 17 µg/L). Studies in laboratory animals indicate that fertility is not a sensitive endpoint, with post-implantation loss, decreases in male reproductive organ weights, decreased epididymal sperm count, and

Agency Report Reference: MDH (2020a). Toxicological Summary for: Perfluorooctane sulfonate. August 2020. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH).	
	evidence of blood-testes-barrier disruption at exposure levels higher than those causing developmental or immune toxicity. **Neurotoxicity**: There have been limited evaluations of neurotoxicity in humans. Human epidemiological studies have not provided consistent associations between exposure to PFOS and neurobehavioral, neuropsychiatric or cognitive outcomes in childhood or adulthood. A limited number of developmental neurotoxicity and adult neurotoxicity studies have been conducted in laboratory animals. Increased motor activity and decreased habituation of male offspring was reported following gestational and lactational exposure at levels higher than those causing the critical effect. Results from studies using water maze tests for learning and memory in animals exposed during development or as adults have yielded inconsistent results or effects only at higher dose levels.
Assessed in Appendix D?	Yes

B.1.14 MDH (2023a)

Agency Report Reference: MDH (2023a). News Release. Joint agency statement on draft federal limits on PFAS in drinking water. March 14, 2023. Minnesota Department of Health (MDH).		
General Information	Date of data extraction	04 August 2023
	Authors	Minnesota Department of Health (MDH)
	Publication date	March 14, 2023
	Literature search timeframe	Not stated
	Publication type	News Release. Agency Joint Statement
	Peer reviewed?	Not stated
	Country of origin	US (Minnesota)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Maximum Contaminant Levels (MCLs)
	Exposure timeframe	Not stated
	Critical human health endpoint	Not applicable (MCL based on non-health-based considerations)
	Justification provided by agency for critical endpoint	The EPA is proposing Maximum Contaminant Levels (MCLs) for two per- and polyfluoroalkyl substances (PFAS) - PFOA and PFOS - in drinking water.

Agency Report Reference: MDH (2023a). News Release. Joint agency statement on draft federal limits on PFAS in drinking water. March 14, 2023. Minnesota Department of Health (MDH).		
	Critical study(ies) underpinning point of departure	Not applicable (MCL based on non-health-based considerations)
	Species for critical study(ies)	Not applicable (MCL based on non-health-based considerations)
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Not applicable (MCL based on non-health-based considerations)
	Point of departure value (include units)	Not applicable (MCL based on non-health-based considerations)
	Uncertainty factor(s) & rationale	Not applicable (MCL based on non-health-based considerations)
	Guideline value (include units)	MCL = 4 ng/L
	Mode of action for critical health endpoint	Not applicable (MCL based on non-health-based considerations)
	Genotoxic carcinogen?	Not applicable (MCL based on non-health-based considerations)
	Identified sensitive sub-populations	Not applicable (MCL based on non-health-based considerations)
	Any non-health-based considerations?	Not stated. NB: The MCLs adopted by MDH (2023a) are equivalent to the MCLG from USEPA (2022d, 2022e) of 4 ng/L for PFOA and PFOS which is based on a minimum reporting level (MRL).
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		NB: EPA is also proposing that four PFAS (PFBS, PFHxS, GenX and PFNA) be evaluated in combination with each other, using an approach called a Hazard Index. A hazard index is calculated by comparing a measured drinking water value with a standard.
Assessed in Appendix D?		No, adopted from other agency, no health basis.

B.1.15 MPART (2019a)

Agency Report Reference: MPART (2019a). Health-Based Drinking Water Value Recommendations for PFAS in Michigan. June 27, 2019. Michigan Science Advisory Workgroup. Michigan's PFAS Action Response Team (MPART).		
General Information	Date of data extraction	08 August 2023
	Authors	Michigan's PFAS Action Response Team (MPART).
	Publication date	June 27, 2019
	Literature search timeframe	Not stated.
	Publication type	Agency Guidance
	Peer reviewed?	Not stated.
	Country of origin	US (Michigan)
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Toxicity value Drinking water Health-based value (HBV)
	Exposure timeframe	Not stated
	Critical human health endpoint	Suppression of plaque forming cell response and increase in liver mass
	Justification provided by agency for critical endpoint	For all of the PFAS examined, points of departure were selected from studies with laboratory animal models. This approach does not negate findings associated with epidemiological studies, but reflects that humans experience uncontrolled and imperfectly documented rather than controlled, precisely measured exposures. Additionally, these points of departure reflect adverse health effects that occur at low doses and that are supported by the weight-of-evidence across endpoints and between findings in humans and laboratory animal models.
	Critical study(ies) underpinning point of departure	60-day immunotoxicity study in adult mice (Dong et al. 2009). • Dong GH, Zhang YH, Zheng L, Liu W, Jin YH, He QC. (2009). Chronic effects of perfluorooctanesulfonate exposure on immunotoxicity in adult male C57BL/6 mice. Arch Toxicol. 83(9):805-815.
	Species for critical study(ies)	Mice
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10,}$ etc.)	NOAEL, $NOAEL_{HED}$:

Agency Report Reference: MPART (2019a). Health-Based Drinking Water Value Recommendations for PFAS in Michigan. June 27, 2019. Michigan Science Advisory Workgroup. Michigan's PFAS Action Response Team (MPART).		
	Point of departure value (include units)	NOAEL: 0.5 mg/kg/day or 0.674 mg/L in serum Serum based Point of Departure: 0.674 mg/mL $NOAEL_{HED}$ = 0.0000866 mg/kg/day
	Uncertainty factor(s) & rationale	30 1 for LOAEL to NOAEL, 10 for human variability, 3 ($10^{0.5}$) for animal to human difference (toxicodynamics), 1 for subchronic to chronic, and 1 for database deficiencies. The Workgroup reviewed the uncertainty factors selected by MDH (2019) and adjusted the database uncertainty factor to 1 based on the critical study selection. With consideration of the selected immunotoxicity endpoint, the database uncertainty factor of 1 was supported by the assessments by USEPA (2016), NJDEP (2018), ATSDR (2018) and New Hampshire (2019).
	Guideline value (include units)	Toxicity Value: 2.89 ng/kg/day Drinking water HBV: 16 ng/L
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Not stated
	Identified sensitive sub-populations	Not clearly stated although an UF was applied for the lack of information on early-life sensitivity for PFHxS (also summarised in same document).
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		The mammary gland effects observed in studies with PFOA may be representative of endocrine effects at doses below the selected POD.
Assessed in Appendix D?		Yes

B.1.16 NJDEP (2019b)

Agency Report Reference: NJDEP (2019b). Technical Support Document: Interim Specific Ground Water Criterion for Perfluorooctane Sulfonate (PFOS) (CAS #: 1763-23-1; Chemical Formula: C8HF17O3S). March 6, 2019. New Jersey Department of Environmental Protection (NJDEP).		
General Information	Date of data extraction	08 August 2023
	Authors	Department of Environmental Protection. State of New Jersey (NJDEP)
	Publication date	March 6, 2019
	Literature search timeframe	Through 2016
	Publication type	Agency Guidance
	Peer reviewed?	Not stated
	Country of origin	US (State of New Jersey)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Reference Dose (RfD) Health-based water concentration or Interim Specific Ground Water Criterion (ISGWQC)
	Exposure timeframe	Chronic (lifetime) drinking water exposure
	Critical human health endpoint	Decreased plaque forming cell response in mice (Dong et al. 2009)
	Justification provided by agency for critical endpoint	Dose-response analysis focused on health endpoints from animal studies with exposure durations greater than 30 days, as well as on shorter-term reproductive and developmental endpoints from animal studies involving exposures during gestation and/or the immediate post-natal period (i.e. reproductive/developmental studies). Endpoints were selected for dose-response analysis based on their reporting of serum PFOS concentrations at relevant timepoints. Ultimately, four endpoints were carried forward to non-cancer dose-response analysis: • increased relative liver weight, adult mice (Dong et al., 2009 as quoted in NJDEP 2019b) • decreased plaque forming cell response, adult mice (Dong et al., 2009 as quoted in NJDEP 2019b) • increased hepatocellular hypertrophy, adult rats (Butenhoff et al., 2012 as quoted in NJDEP 2019b) • increased relative liver weight, adult mice (Dong et al., 2012a as quoted in NJDEP 2019b) The ISGWQC of 10 ng/L value based on decreased plaque forming cell response from Dong et al. (2009 as quoted in NJDEP 2019b) is

Agency Report Reference: NJDEP (2019b). Technical Support Document: Interim Specific Ground Water Criterion for Perfluorooctane Sulfonate (PFOS) (CAS #: 1763-23-1; Chemical Formula: C8HF17O3S). March 6, 2019. New Jersey Department of Environmental Protection (NJDEP).		
		the lowest of the potential ISGWQCs for non-carcinogenic effects.
	Critical study(ies) underpinning point of departure	60-day immunotoxicity study in mice • Dong GH, Zhang YH, Zheng L, Liu W, Jin YH, He QC. 2009. Chronic effects of perfluorooctanesulfonate exposure on immunotoxicity in adult male C57BL/6 mice. Arch Toxicol. 83:805-815.
	Species for critical study(ies)	Adult mice
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	$BMDL_{10}$, Target Human Serum Level.
	Point of departure value (include units)	NOAEL: 674 ng/mL Target Human Serum Level: 22.5 ng/L (=$BMDL_{10}$ ÷ UF x 0.001 mL/L = 674 ÷ 30 x 0.001) Converted to dose by using a clearance factor of 8.1 x 10^{-5} L/kg/day was developed by USEPA (2016a) to relate serum PFOS concentration to administered dose. Assuming an average U.S. daily water consumption rate, the clearance factor predicts a serum:drinking water ratio of 197:1 resulting in a ISGWQC of 10 ng/L (rounded).
	Uncertainty factor(s) & rationale	30 UF of 3 was applied to account for interspecies differences in toxicodynamics. The typical UF of 3 for toxicokinetic variability between species was not included because the risk assessment is based on comparison of internal dose (serum levels) rather than administered dose. In addition, for each of the candidate studies the default UF of 10 was applied to account for potential differences in sensitivity to PFOS among humans including sensitive sub-populations. These two UF result in a total UF of 30.
	Guideline value (include units)	RfD: 1.8 ng/kg/day Health-based water concentration (ISGWQC): 10 ng/L (rounded to one significant figure)
	Mode of action for critical health endpoint	• Liver effects: PFOS effects on the rodent liver do not appear to primarily operate through a PPARα- dependent Mode of Action (MOA), including at doses resulting in liver tumours. PPARα may make only a minor contribution. Other receptors including PPARβ/δ, PPARγ, constitutive activated receptor (CAR), pregnane X receptor (PXR), hepatocyte nuclear factor 4-α (HNF-4α), and possibly oestrogen receptorα (ERα), may also be

Agency Report Reference: NJDEP (2019b). Technical Support Document: Interim Specific Ground Water Criterion for Perfluorooctane Sulfonate (PFOS) (CAS #: 1763-23-1; Chemical Formula: C8HF17O3S). March 6, 2019. New Jersey Department of Environmental Protection (NJDEP).		
		activated by PFOS, suggesting alternative, non-PPARα-dependent MOAs. • Immune Effects: It appears that PPARα may play a role in some immune effects caused by PFOS in rodents. • Developmental/foetal effects: The MOAs for these effects are not known.
	Genotoxic carcinogen?	PFOS does not appear to be genotoxic or mutagenic
	Identified sensitive sub-populations	These elevated exposures during infancy and early childhood are of particular concern because early life may be a sensitive time period for the toxicity of PFOS.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	it appears that food and possibly house dust (reflecting consumer products use and breakdown) are the primary sources of human exposure to PFOS. In communities with drinking water contaminated by PFOS, drinking water can be an important exposure source even if PFOS concentrations are relatively low.
	Levels in drinking water supplies (include location)	For the two NJDEP occurrence studies and most of the additional data submitted to NJDEP, analysis of samples was performed by certified laboratories with Reporting Levels (RLs) that were generally 4-5 ng/L or lower.
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		The estimated cancer risk at the ISGWQC of 10 ng/L is close to the New Jersey cancer risk goal of one in one million. Thus, a ISGWQC of 10 ng/L based on immune system toxicity is considered to be both scientifically appropriate and health protective.
Assessed in Appendix D?		Yes

B.1.17 OEHHA (2019a)

Agency Report Reference: OEHHA (2019a). Notification Level Recommendations. Perfluorooctanoic Acid and Perfluorooctane Sulfonate in Drinking Water. August 2019. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.		
General Information	Date of data extraction	02 August 2023.
	Authors	Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.
	Publication date	August 2019.
	Literature search timeframe	Unrestricted.
	Publication type	Agency Guidance Document.
	Peer reviewed?	Yes.
	Country of origin	US (California)
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	• Cancer Slope Factor (CSF). • Acceptable Daily Dose (ADD) • Reference Levels (RL) for cancer and non-cancer endpoints. • Notification Levels (NLs)
	Exposure timeframe	Lifetime
	Critical human health endpoint	• Non-cancer endpoint: Decreased plaque forming cell response (Dong et al., 2009 as quoted in OEHHA 2019a). • Cancer endpoint: Hepatocellular adenomas in male rats, and hepatocellular adenomas/carcinomas in female rats (Butenhoff et al., 2012a as quoted in OEHHA 2019a).
	Justification provided by agency for critical endpoint	• Non-cancer endpoint: There are no new studies that are more sensitive than the Dong et al. (2009) study for derivation of the noncancer RL for PFOS. While OEHHA reviewed human epidemiology studies focusing on liver toxicity, immunotoxicity, and thyroid toxicity, an epidemiological analysis is not presented in this document because there were no studies that could be used for point of departure (POD) determination and dose-response assessment. Nonetheless, the epidemiology data suggest that there are associations between PFOA and/or PFOS and suppressed antibody response and increased liver enzymes. These epidemiological data are supportive of the animal toxicology data used to derive the RLs for noncancer effects. The

Agency Report Reference: OEHHA (2019a). Notification Level Recommendations. Perfluorooctanoic Acid and Perfluorooctane Sulfonate in Drinking Water. August 2019. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.		
		epidemiology data on thyroid hormone levels are inconsistent and, at times, contradictory. The recent immunotoxicity studies of PFOS are much less sensitive than the Dong et al. (2009) study, which was the basis for OEHHA's interim NL recommendation. Thus, these recent immunotoxicity studies are not considered as critical studies for POD derivation. • Cancer endpoint: Not stated.
	Critical study(ies) underpinning point of departure	• Non-cancer endpoint: Immunotoxicity study (Dong et al., 2009 as quoted in OEHHA 2019a). • Cancer endpoint: Chronic dietary toxicity and carcinogenicity study (Butenhoff et al., 2012a as quoted in OEHHA 2019a).
	Species for critical study(ies)	Cancer and non-cancer endpoints: Humans.
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Various: NOAEL, $BMDL_{05}$, HED
	Point of departure value (include units)	Cancer endpoint: • $BMDL_{05}$: 0.002 mg/kg/day (male rats) and 0.0027 mg/kg/d (female rats). • $BMDL_{05}$ HED: 0.0011 mg/kg/day (male rats) and 0.0014 mg/kg/d (female rats) Non-cancer endpoint: • NOAEL: 0.008 mg/kg/day.
	Uncertainty factor(s) & rationale	Non-cancer endpoint: A total UF of 30 is applied in calculating the ADD for PFOS: 3 for interspecies extrapolation and 10 for intraspecies variability. PFOS is not known to be metabolised in animals or humans, and because PFOS serum concentration is the dose metric used in the dose-response analysis, the pharmacokinetic components of the interspecies and intraspecies uncertainty factors are reduced (by 3 each). The subchronic to chronic uncertainty factor is not necessary. Cancer endpoint: ASFs are not included when deriving the cancer RL for PFOA because the NTP (2018b) study provided evidence that early life exposure did not increase tumour incidences later in life. Because it is anticipated that PFOS behaves in a similar manner as PFOA, OEHHA is excluding ASFs in the RL derivation for cancer.
	Guideline value (include units)	Cancer endpoint: • CSF: 45.5 $(mg/kg\text{-}day)^{-1}$ (male rats) and 35.7 $(mg/kg\text{-}day)^{-1}$ (female rats).

Agency Report Reference: OEHHA (2019a). Notification Level Recommendations. Perfluorooctanoic Acid and Perfluorooctane Sulfonate in Drinking Water. August 2019. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.		
		• RL: 0.4 ng/L. NB: RL = R ÷ (CSF × DWI) = 10^{-6} ÷ (45.4 (mg/kg-day)$^{-1}$ × 0.053 L/kg-day), (where R = default excess cancer risk level of one in one million and DWI = drinking water intake rate, RL rounded to 0.4 ng/L). Non-cancer endpoint: • ADD: 22 mg/L (Target human serum concentration) • ADD: 1.8 ng/kg-day. • RL: 7 ng/L. NB: RL = ADD x RSC ÷DWI = 1.8 ng/kg/day × 0.2÷ 0.053 L/kg/day (where RSC = relative source contribution, RL rounded to 7 ng/L). The State Water Resources Control Board (SWRCB) set the NLs at the lowest levels at which PFOA and PFOS can be reliably detected in drinking water
	Mode of action for critical health endpoint	Non-cancer endpoint: • It has been established that PFOS can induce hepatotoxicity via activation of the nuclear receptor PPARα. However, PPARα activation does not explain all of the observed hepatotoxicity. It has been suggested that PFOS may interact with other nuclear receptors, including CAR, PXR, PPARβ/δ, PPARγ, HNF4α, and ERα. • Immunotoxicity of PFOS may be PPARα mediated, or it may be due to lipid imbalance or be a stress response, but the specific mechanism remains unclear. • Several recent mechanistic studies showed that PFOA, PFOS, and other medium-chain PFAS bind to the thyroxine transport protein transthyretin. Also showed that PFOS can bind to thyroid hormone receptors. Cancer endpoint: Not discussed.
	Genotoxic carcinogen?	There is minimal evidence to indicate PFOS is genotoxic or mutagenic
	Identified sensitive sub-populations	-
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	Oral ingestion is the primary route of exposure to PFOS in drinking water, and inhalation and dermal exposures are considered negligible.

Agency Report Reference: OEHHA (2019a). Notification Level Recommendations. Perfluorooctanoic Acid and Perfluorooctane Sulfonate in Drinking Water. August 2019. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.		
		NB: Refer to the draft document, OEHHA (2023a) in **Section B.1.18**.
	Levels in drinking water supplies (include location)	- NB: Refer to the draft document, OEHHA (2023a) in **Section B.1.18**.
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	- NB: Refer to the draft document, OEHHA (2023a) in **Section B.1.18**.
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		The cancer RLs cited above are lower than the levels of PFOA and PFOS that can be reliably detected in drinking water using currently available technologies. In light of this, OEHHA recommends that the State Water Resources Control Board (SWRCB) set the NLs at the lowest levels at which PFOA and PFOS can be reliably detected in drinking water using available and appropriate technologies.
Assessed in Appendix D?		Yes

B.1.18 OEHHA (2023a)

Agency Report Reference: OEHHA (2023a). Public Health Goals. Second Public Review Draft. Perfluorooctanoic Acid and Perfluorooctane Sulfonic Acid in Drinking Water. July 2023. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.		
General Information	Date of data extraction	02 August 2023.
	Authors	Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.
	Publication date	July 2023.
	Literature search timeframe	Unrestricted.
	Publication type	Agency Guidance Document.
	Peer reviewed?	Yes.
	Country of origin	US (California)
	Source of funding	Not stated.

Agency Report Reference: OEHHA (2023a). Public Health Goals. Second Public Review Draft. Perfluorooctanoic Acid and Perfluorooctane Sulfonic Acid in Drinking Water. July 2023. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.		
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Cancer endpoint: • Cancer Slope Factor (CSF). • Public Health Goal (PHG) Non-cancer endpoint • Acceptable Daily Dose (ADD) • Health-Protective Concentration (HPC) (also referred to as 'C' in OEHHA 2023a).
	Exposure timeframe	Lifetime
	Critical human health endpoint	• PHG: Liver and pancreatic tumours in male rats (Butenhoff et al., 2012b as quoted in OEHHA 2023d). • HPC: Increased cholesterol in humans (Steenland et al., 2009 as quoted in OEHHA 2023d)
	Justification provided by agency for critical endpoint	• PHG (cancer): There are a few epidemiological studies that show some association of PFOS with breast, liver, and bladder cancer, the results are mixed or the sample sizes are small. Thus, the proposed PHG for PFOS is based on cancer data in laboratory animals. • HPC (non-cancer): Sensitive noncancer endpoints for PFOS are immunotoxicity and alterations in lipid metabolism. Total cholesterol appeared to be a somewhat more sensitive endpoint.
	Critical study(ies) underpinning point of departure	• PHG: Chronic dietary toxicity and carcinogenicity study (Butenhoff et al., 2012b as quoted in OEHHA 2023d). • HPC: Cross-sectional study (Steenland et al., 2009 as quoted in OEHHA 2023d)
	Species for critical study(ies)	• PHG: Male rats. • HPC: Humans.
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Various: LOAEC, $BMDL_{SD}$, $BMDL_{10}$, HED
	Point of departure value (include units)	Non-cancer endpoint (from the cross-sectional study): • Human LOAEC: 16.4 ng/mL. • ADD = (POD × CL) ÷ UF = (16.4 ng/mL × 0.39 mL/kg-day) ÷ 10 = 0.64 ng/kg-day. Cancer endpoint (from the carcinogenicity study): • Animal $BMDL_{05}$: 14.7 mg/L.

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		• Adjustment with human PFOA clearance factor of 3.9×10^{-4} L/kg-day = 0.0057 mg/kg/day • Human $BMDL_{05}$: 0.0032 mg/kg-day (scaled allometrically) [$BMDL_{05}$(human) = $BMDL_{05}$(animal) × $(BW_{animal}/BW_{human})^{1/8}$] [$BMDL_{05}$(human) = 0.0057 mg/kg/day x $(0.687/70kg)^{1/8}$ • Human CSF: 15.6 $(mg/kg/day)^{-1}$
	Uncertainty factor(s) & rationale	Non-cancer endpoint: A UF of √10 rather than 1 for intraspecies variation was applied because the C8 study population was not diverse in terms of race or ethnicity. OEHHA also applied the LOAEC to NOAEC UF of √10 because the Steenland et al. (2009) ORs involved a LOAEC rather than a NOAEC. Cancer endpoint: Uncertainty factors are not used for CSF derivation.
	Guideline value (include units)	Cancer endpoint: • CSF: 15.6 $(mg/kg/day)^{-1}$. • PHG: 1 ng/L. NB: PHG = R ÷ (CSF × DWI) = 10^{-6} ÷ (15.6 $(mg/kg\text{-}day)^{-1}$ × 0.053 L/kg-day), (where R = default excess cancer risk level of one in one million and DWI = drinking water intake rate, PHG rounded to 1 ng/L). Non-cancer endpoint: • ADD: 0.64 ng/kg/day. • HPC: 2 ng/L. NB: HPC = ADD x RSC ÷DWI = 0.64 ng/kg/day × 0.2÷ 0.053 L/kg/day (where RSC = relative source contribution, HPC rounded to 2 ng/L).
	Mode of action for critical health endpoint	Cancer endpoint: PPARα activation by PFOA and PFOS has been previously proposed as a key event in the induction of carcinogenesis observed in mice and rats. The key events identified in the proposed tumour progression pathway are 1) activation of PPARα, 2) perturbation of cell proliferation and apoptosis, and 3) selective clonal expansion. NB: It is suggested that the liver tumour induction observed from exposure to some PPARα activators in rats and mice is not relevant to human cancer risk assessment. It is likely that carcinogenesis occurs through multiple MOAs. Non-cancer endpoint: Mechanistic evidence was not discussed for PFOS and lipid homeostasis.

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		PFOA has been shown to disrupt lipid metabolism in the liver. One way PFOA does this is by changing the expression and activity of enzymes involved in fatty acid metabolism. Changes in fatty acid metabolism have been linked to liver disease. PFOA increases acyl-CoA oxidase activity in rat liver, and carboxylesterase mRNA and protein levels in male mice. Carboxylesterases play a role in lipid metabolism and homeostasis.
	Genotoxic carcinogen?	There is some positive evidence of genotoxicity for PFOA and PFOS. For PFOS, there is some evidence of mutagenicity, and positive evidence of chromosomal effects and DNA damage. Therefore, genotoxicity cannot be dismissed as a possible mode of action for PFOS.
	Identified sensitive sub-populations	-
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	The major exposure contribution in adults is food (71-87%), followed by drinking water (7.5-23%). Contaminated drinking water can also become the main source of exposure
	Levels in drinking water supplies (include location)	• US: Several UCMR3-tested areas in California had 40-200 ng/L PFOS in drinking water (UCMR3 = US EPA's Third Unregulated Contaminant Monitoring Rule). • In the subset of UCMR3 results for California with average PFOS concentration of 57 ng/L. • More recent drinking water monitoring program carried out by State Water Resources Control Board (SWRCB). Arithmetic means excluding non-detects: o 25.5 ng/L (n=570, 45% detect) o 24.5 ng/L (n=653, 47% detect) o 26.1 ng/L (n = 920, 40% detect) o 22.8 ng/L (n=772, 42% detect)
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	For PFOS, exposure levels for an intermediate exposure scenario for infants, children and adults were at 54.6, 22.1 and 15.3 ng/kg-day, respectively.
Risk Summary	Any risks to human health from drinking water identified in agency document?	SLR note that the PHG (1 ng/L) and HPC (2 ng/L) are lower than PFOS concentration reported in drinking water (22.8 – 25.5 ng/L).

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		SLR note that the ADD (0.64 ng/kg/day) is lower than PFOS intake modelled from foods (15.3 to 54.6 ng/kg/day).
	Any emerging risks identified?	-
Any other relevant information that should be captured?		-
Assessed in Appendix D?		Yes

B.1.19 RIVM (2021a)

Agency Report Reference: RIVM (2021a). Revised Risk Assessment of GenX And PFOA in Food. Part 1: Toxicity of GenX and PFOA and intake through contaminated Dairy products, eggs and fish. 01-09-2021 (final version). Rijksinstituut voor Volksgezondheid en Milieu (RIVM). **Supporting Documentation:** RIVM (2018a). Mixture exposure to PFAS: A Relative Potency Factor approach. RIVM Report 2018-0070. Rijksinstituut voor Volksgezondheid en Milieu (RIVM).		
General Information	Date of data extraction	03 August 2023
	Authors	Rijksinstituut voor Volksgezondheid en Milieu (RIVM)
	Publication date	01-09-2021
	Literature search timeframe	Not stated.
	Publication type	Agency Risk Assessment
	Peer reviewed?	Not stated.
	Country of origin	Netherlands
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Tolerable weekly intake (TWI). Daily intake RIVM uses the TWI established by EFSA together with relative potency factors (RPFs) for PFAS for the risk assessment of this group of compounds (including GenX and PFBS). The EFSA-4 = PFOA, PFOS, PFNA and PFHxS.
	Exposure timeframe	Chronic
	Critical human health endpoint	• TWI: immune effects (Abraham et al. 2020, as quoted in RIVM 2021a) • RPFs: liver effects (Bil et al., 2021, as quoted in RIVM 2021a)
	Justification provided by agency for critical endpoint	Statistically significant associations were observed between internal PFOA levels and time since last vaccination-adjusted antibody levels for Hib,

Agency Report Reference: RIVM (2021a). Revised Risk Assessment of GenX And PFOA in Food. Part 1: Toxicity of GenX and PFOA and intake through contaminated Dairy products, eggs and fish. 01-09-2021 (final version). Rijksinstituut voor Volksgezondheid en Milieu (RIVM). **Supporting Documentation:** RIVM (2018a). Mixture exposure to PFAS: A Relative Potency Factor approach. RIVM Report 2018-0070. Rijksinstituut voor Volksgezondheid en Milieu (RIVM).		
		tetanus IgG1, and diphtheria. No such associations were observed between PFOS levels and Hib, tetanus IgG1, and diphtheria antibodies. Nor were such associations observed for the other two PFAS (PFNA and PFHxS). Multivariate analysis, correcting for PCBs, also revealed a significant influence of PFOA exposure (and not PFOS, PFNA, or PFHxS) on antibody levels. Additionally, statistically significant inverse associations between PFOA exposure and ex-vivo lymphocyte cytokine production (INFγ) after stimulation with tetanus and diphtheria toxoid, confirming the biological relevance of the observed association. The study above reported that an association was only found between PFOA and the effect on the immune system. However, EFSA does not rule out the possibility that this effect may have been caused by the other three PFAS as well (ESFA, 2020). Therefore, EFSA used the data on internal exposure (plasma levels) to PFOA, PFOS, PFNA and PFHxS and anti-diphtheria and anti-tetanus antibody concentrations to perform dose-response modelling. Although EFSA recognised that there were potency differences for PFAS on other toxicological endpoints, EFSA was not able to establish Relative Potency Factors (RPFs) for immune effects due to a lack of suitable studies. Therefore, EFSA assumed equipotency. However, knowing that PFAS are not equipotent for other effects (for example liver effects), RIVM considers it plausible that various PFAS are also not equipotent for their immune effects.
	Critical study(ies) underpinning point of departure	Immune effects (EFSA-4): Cross-sectional study in humans (Abraham et al. 2020, as quoted in RIVM 2021a). • Abraham K, Mielke H, Fromme H, Volkel W, Menzel J, Peiser M, Zepp F, Willich SN and Weikert C (2020). Internal exposure to perfluoroalkyl substances (PFASs) and biological marker in 101 healthy 1-year-old children: associations between levels of perfluorooctanoic acid (PFOA) and vaccine response. Archives of Toxicology, 94, 2131–2147 (as quoted in RIVM 2021a). Liver effects (23 PFAS including PFBS and GenX) (Bil et al., 2021, as quoted in RIVM 2021a) • Bil W, Zeilmaker M, Fragki S, Lijzen J, Verbruggen E, Bokkers B (2021). Risk Assessment of Per- and Polyfluoroalkyl

Agency Report Reference: RIVM (2021a). Revised Risk Assessment of GenX And PFOA in Food. Part 1: Toxicity of GenX and PFOA and intake through contaminated Dairy products, eggs and fish. 01-09-2021 (final version). Rijksinstituut voor Volksgezondheid en Milieu (RIVM). **Supporting Documentation:** RIVM (2018a). Mixture exposure to PFAS: A Relative Potency Factor approach. RIVM Report 2018-0070. Rijksinstituut voor Volksgezondheid en Milieu (RIVM).		
		Substance Mixtures: A Relative Potency Factor Approach. Environmental Toxicology and Chemistry, 40, 859-870. DOI: 10.1002/etc.4835 (as quoted in RIVM 2021a).
	Species for critical study(ies)	• EFSA-4: Humans • PFAS with RPFs: Rats
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	• EFSA-4: $BMDL_{10}$ • PFAS with RPFs: Not stated (refer to Bil et al., 2021, as quoted in RIVM 2021a for further information).
	Point of departure value (include units)	• EFSA-4 $BMDL_{10}$: 17.5 ng/mL • PFAS with RPFs: Not stated (refer to Bil et al., 2021, as quoted in RIVM 2021a for further information).
	Uncertainty factor(s) & rationale	-
	Guideline value (include units)	• TWI (for EFSA-4): 4.4 ng/kg/wk. • Daily Intake (for EFSA-4): 0.63 ng/kg/day • RPF for GenX: 0.06 (unitless) • RPF for PFBS: 0.001 (unitless) (refer to RIVM 2018a) Applied as the sum of four PFAS: PFOA, PFOS, perfluorononanoic acid (PFNA) and PFHxS, i.e. ∑EFSA-4).
	Mode of action for critical health endpoint	-
	Genotoxic carcinogen?	-
	Identified sensitive sub-populations	-
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	Netherlands (Dordrecht, 37 locations) • PFBS: 3.0 ng/L (2015), 3.4 (2017) • GenX: No data • PFOS: <0.6 ng/L, 0.41 (2017) • PFOA: 4.5 ng/L, 2.2 (2017) • PFHxS: <0.6 ng/L, 0.43 (2017) • Sum of PFAS: 23.8 to 27.4 ng/L, 19.3- 21.3 ng/L (2017).

Agency Report Reference: RIVM (2021a). Revised Risk Assessment of GenX And PFOA in Food. Part 1: Toxicity of GenX and PFOA and intake through contaminated Dairy products, eggs and fish. 01-09-2021 (final version). Rijksinstituut voor Volksgezondheid en Milieu (RIVM). **Supporting Documentation:** RIVM (2018a). Mixture exposure to PFAS: A Relative Potency Factor approach. RIVM Report 2018-0070. Rijksinstituut voor Volksgezondheid en Milieu (RIVM).		
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	RIVM recently performed an indicative dietary exposure assessment according to the RPF approach, based on data from 2009, which showed that exposure to the EFSA-4 via drinking water and food exceeded the TWI.
	Any emerging risks identified?	GenX was not part of the EFSA opinion and no epidemiological studies are available for this substance. However, an immunotoxicity study in mice and a chronic/carcinogenicity study in rats provide evidence of immunosuppressive effects of GenX.
Any other relevant information that should be captured?		RIVM considers that, in view of the available scientific information referred above, it is better justified to account for relative potencies for PFAS than the assumption of equipotency made by EFSA. As already mentioned it is, however, recommended that the RPFs are validated for immune effects in due course.
Assessed in Appendix D?		No, because TRV was adopted from EFSA (2020a).

B.1.20 USEPA (2022e, 2021b, 2022c)

Agency Report Reference: USEPA (2022e). Interim Drinking Water Health Advisory: Perfluorooctane Sulfonic Acid (PFOS) CASRN 1763-23-1. EPA Publication # EPA/822/R-22/004. June 2022. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2021b). External Peer Review Draft. Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctane Sulfonic Acid (PFOS) (CASRN 1763-23-1) in Drinking Water. EPA Document No. 822D21002. December 2021. DRAFT. DO NOT CITE OR QUOTE. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).		
General Information	Date of data extraction	01 August 2023
	Authors	U.S. Environmental Protection Agency, Office of Water (4304T). Office of Science and Technology.

Agency Report Reference: USEPA (2022e). Interim Drinking Water Health Advisory: Perfluorooctane Sulfonic Acid (PFOS) CASRN 1763-23-1. EPA Publication # EPA/822/R-22/004. June 2022. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2021b). External Peer Review Draft. Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctane Sulfonic Acid (PFOS) (CASRN 1763-23-1) in Drinking Water. EPA Document No. 822D21002. December 2021. DRAFT. DO NOT CITE OR QUOTE. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).		
		Health and Ecological Criteria Division, Washington, DC 20460.
	Publication date	June 2022
	Literature search timeframe	No date restrictions identified by SLR in the Literature Search Strategy.
	Publication type	Agency Guideline
	Peer reviewed?	The document underwent a technical edit by the contractor Tetra Tech (contract number 68HERC20D0016). This Health Advisory document was provided for review by staff in the following EPA program Offices: Office of Water, Office of Chemical Safety and Pollution Prevention, Office of Pollution Prevention and Toxics, Office of Land and Emergency Management, Office of Policy, Office of Children's Health Protection, Office of Research and Development
	Country of origin	US
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	• Interim Health Advisory (iHA) • draft chronic reference dose (RfD) • Maximum Contaminant Level Goals (MCLG)
	Exposure timeframe	Lifetime. NB: iHA is for 0- to < 5-year-old children because PFOS exposure was measured in 5-year-old children in the critical study, and it is reasonable to expect that PFOS exposure levels were similar from birth through age 5
	Critical human health endpoint	Developmental immune health outcome (decreased serum anti-diphtheria antibody concentration in children)
	Justification provided by agency for critical endpoint	Decreased immune response to vaccination was observed after exposure during a sensitive developmental life stage, and it yields the lowest point of departure (POD) human equivalent dose (POD_{HED}) among the candidate $PODs_{HED}$. Other candidate RfDs were derived based on other health effects (e.g. development/growth) observed in epidemiology studies; all of the candidate RfDs

Agency Report Reference: USEPA (2022e). Interim Drinking Water Health Advisory: Perfluorooctane Sulfonic Acid (PFOS) CASRN 1763-23-1. EPA Publication # EPA/822/R-22/004. June 2022. United States Environmental Protection Agency (USEPA).

Supporting Documentation: USEPA (2021b). External Peer Review Draft. Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctane Sulfonic Acid (PFOS) (CASRN 1763-23-1) in Drinking Water. EPA Document No. 822D21002. December 2021. DRAFT. DO NOT CITE OR QUOTE. United States Environmental Protection Agency (USEPA).

Supporting Documentation: USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).

		are associated with low daily oral exposure doses, ranging from 0.1 to 0.001 ng/kg.bw-day
	Critical study(ies) underpinning point of departure	Epidemiological study (Grandjean et al., 2012; Budtz-Jorgensen and Grandjean, 2018). • Grandjean, P., E.W. Andersen, E. Budtz-Jørgensen, F. Nielsen, K. Mølbak, P. Weihe, and C. Heilmann. 2012. Serum vaccine antibody concentrations in children exposed to perfluorinated compounds. JAMA 307:391–397 (as quoted in USEPA 2021d) • Budtz-Jørgensen, E., and P. Grandjean. 2018. Application of benchmark analysis for mixed contaminant exposures: mutual adjustment of perfluoroalkylate substances associated with immunotoxicity. PLoS One 13(10):e0205388.
	Species for critical study(ies)	Epidemiological studies in children
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Point of departure human equivalent dose (POD_{HED}) Note (refer to USEPA 2021b for details): The PODs from human epidemiological studies (immune, developmental and serum lipid endpoints) were derived using benchmark dose modelling (see Appendix B.1) and included: • A serum POD based on a BMR of 5% and a $BMDL_5$ of 0.54 ng/mL (USEPA 2021b), i.e. 5.4 x 10^{-4} mg/L (USEPA 2021b). • The internal dose POD was then converted to a POD_{HED} (USEPA 2021b) using a toxicokinetic model to simulate selected epidemiological studies to obtain a chronic dose that would result in the internal POD obtained from dose-response modelling.
	Point of departure value (include units)	0.079 ng/kg/day (POD_{HED}) (USEPA 2021b)
	Uncertainty factor(s) & rationale	An intraspecies uncertainty factor (UFH) of 10 was applied to the selected draft POD_{HED} to account for variability in the response within the human population in accordance with methods described in EPA's *A Review of the Reference Dose and Reference Concentration Processes* (U.S. EPA, 2002b). EPA applied a value of 1 for the remaining four uncertainty factors (UF): interspecies UF (UFA), because the critical effect was observed in

Agency Report Reference: USEPA (2022e). Interim Drinking Water Health Advisory: Perfluorooctane Sulfonic Acid (PFOS) CASRN 1763-23-1. EPA Publication # EPA/822/R-22/004. June 2022. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2021b). External Peer Review Draft. Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctane Sulfonic Acid (PFOS) (CASRN 1763-23-1) in Drinking Water. EPA Document No. 822D21002. December 2021. DRAFT. DO NOT CITE OR QUOTE. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).		
		humans and there is no need to account for uncertainty associated with animal-to-human extrapolation; lowest-observed-adverse-effect level (LOAEL)-to-no-observed-adverse- effect level (NOAEL) extrapolation UF (UFL), because a benchmark lower dose confidence limit (BMDL) instead of a LOAEL was used as the basis for POD_{HED} derivation; subchronic-to-chronic exposure duration extrapolation UF (UFS), because the critical effect on the developing immune system in children was observed after exposure during gestation and/or early childhood, a sensitive period that can lead to severe effects without lifetime exposure; and a database UF (UFD), because the database of animal and human studies on the effects of PFOS is comprehensive.
	Guideline value (include units)	• RfD: 0.0079 ng/kg/day • iHA: 0.02 ng/L (= RfD * RSC ÷ DWI-BW) where o Relative source contribution (RSC) = 0.2 o DWI-BW = 0.0701 L/kg/bw/day (the 90th percentile drinking water intake for the selected population). • MCLG: 4 ng/L, i.e. minimum reporting level, MRL)
	Mode of action for critical health endpoint	-
	Genotoxic carcinogen?	• From USEPA 2021b: Other results for markers of genotoxic effects (e.g. sperm Y:X chromosome ratio, sperm DNA methylation, etc.) in sperm were inconsistent (USEPA 2021b). Notes on carcinogenicity: • The available human and animal studies provide suggestive evidence of carcinogenic potential. Given the identified uncertainties in the available evidence (see Section 2.0 for further information), the draft PFOS document concluded that these data did not support a quantitative characterisation of cancer risk associated with PFOS exposure. • From USEPA 2021b: Overall, the current assessment supports the findings from the

Agency Report Reference: USEPA (2022e). Interim Drinking Water Health Advisory: Perfluorooctane Sulfonic Acid (PFOS) CASRN 1763-23-1. EPA Publication # EPA/822/R-22/004. June 2022. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2021b). External Peer Review Draft. Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctane Sulfonic Acid (PFOS) (CASRN 1763-23-1) in Drinking Water. EPA Document No. 822D21002. December 2021. DRAFT. DO NOT CITE OR QUOTE. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).		
		2016 Health Advisory Health Assessment that the available evidence is not adequate to quantify or make definitive conclusions about the carcinogenicity of PFOS.
	Identified sensitive sub-populations	EPA considered the sensitive life stage of exposure associated with the critical effect on which the draft chronic RfD was based.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	• For PFOS, dietary intake was by far the greatest contributor to aggregate exposure (contributing 95% of total estimated PFOS intake), but intake from ingestion of house dust represented the dominant pathway for some of the top 20% most highly exposed individuals (USEPA 2021b). • The most important contributors for PFOS were “Fish and other seafood,” “Eggs and egg products,” and “Meat and meat products.” (USEPA 2021b).
	Levels in drinking water supplies (include location)	• US public water systems (PWSs): detections ranged from 40 ng/L to 7,000 ng/L with median = 60 ng/L and 90th percentile concentration = 250 ng/L) (n = 36,792, PWSs = 4,920) • Bottled water (domestic and imported): <4 ng/L (n = 30) (USEPA 2021b). • US: Median of = 2.28 ng/L, maximum = 48.3 ng/L (from 29 drinking water treatment plants) (USEPA 2021b).
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	Median chronic dietary exposures of PFOS for children and adults were estimated as 1.02 and 0.58 ng/kg-body weight/day, respectively (USEPA 2021b).
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-

Agency Report Reference: USEPA (2022e). Interim Drinking Water Health Advisory: Perfluorooctane Sulfonic Acid (PFOS) CASRN 1763-23-1. EPA Publication # EPA/822/R-22/004. June 2022. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2021b). External Peer Review Draft. Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctane Sulfonic Acid (PFOS) (CASRN 1763-23-1) in Drinking Water. EPA Document No. 822D21002. December 2021. DRAFT. DO NOT CITE OR QUOTE. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).	
Any other relevant information that should be captured?	Cumulative exposures (from USEPA 2022c): Use the Hazard Index (HI) approach to assess the potential noncancer risk of a mixture of PFOA, PFOS, GenX chemicals, and PFBS (USEPA 2022c), i.e. HI = (Conc.$_{PFOA}$ ÷HA$_{PFOA}$) + (Conc.$_{PFOS}$÷HA$_{PFOS}$) + (Conc.$_{PFBS}$ ÷ HA$_{PFBS}$) +(Conc.$_{GenX}$ ÷HA$_{GenX}$). EPA expects to propose an MCLG and NPDWR for PFOS in the fall of 2022 and to promulgate a final MCLG and NPDWR by the fall of 2023 after considering public comment. EPA will complete its revisions to address the final Science Advisory Board (SAB) report's comments on the proposed PFOS MCLG and NPDWR. EPA may update or remove the iHA for PFOS at that time. Based, however, on the updated systematic review of the best available science on PFOS exposure and health effects and taking into consideration the work EPA is doing now to address SAB comments, the health-based drinking water values for PFOS (HA and MCLG) are anticipated to remain below the current UCMR 5 analytical MRL (0.004 µg/L or 4 ng/L). Sorption-based treatment processes such as granular activated carbon (GAC), powdered activated carbon (PAC), and anion exchange (AIX), as well as high-pressure membrane processes such as nanofiltration (NF) and reverse osmosis (RO), have been shown to successfully remove PFOS from drinking water to below the 0.004 µg/L MRL for UCMR 5
Assessed in Appendix D?	Yes

B.1.21 WHO (2022)

Agency Report Reference: WHO (2022). PFOS and PFOA in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality. 29 September 2022. Version for public review. WHO/SDE/WSH/XXXXXX. World Health Organisation (WHO).		
General Information	Date of data extraction	01 August 2023
	Authors	World Health Organisation (WHO)
	Publication date	29 September 2022
	Literature search timeframe	Not stated. Contains references from 2022.

Agency Report Reference: WHO (2022). PFOS and PFOA in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality. 29 September 2022. Version for public review. WHO/SDE/WSH/XXXXXX. World Health Organisation (WHO).		
	Publication type	Agency Guideline Document
	Peer reviewed?	Not stated
	Country of origin	Not stated
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Oral Tolerable Daily Intake provisional guideline values (pGVs)
	Exposure timeframe	Not relevant
	Critical human health endpoint	Acknowledging the significant uncertainties and absence of consensus with identifying the critical health endpoint to calculate a HBGV and the rapidly evolving science, a pragmatic solution is therefore proposed for the derivation of provisional guideline values (pGVs).
	Justification provided by agency for critical endpoint	Not relevant.
	Critical study(ies) underpinning point of departure	Not relevant.
	Species for critical study(ies)	Not relevant.
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Not relevant.
	Point of departure value (include units)	Not relevant.
	Uncertainty factor(s) & rationale	Not relevant.
	Guideline value (include units)	DWG = 100 ng/L NB: DWG = 500 ng/L for Total PFAS
	Mode of action for critical health endpoint	Not relevant.
	Genotoxic carcinogen?	Not relevant.
	Identified sensitive sub-populations	Not relevant.
	Any non-health-based considerations?	The pGVs are derived with the objective of reducing human exposure and therefore risk. In deriving the pGVs, global data on occurrence including co-occurrence of PFAS, available analytical methods and treatment achievability were considered. A pGVs of 0.1 µg/L for PFOS is proposed based on the following considerations: • This value corresponds to greater than 90% removal achievability with high pressure membrane filtration (NF and RO), activated

Agency Report Reference: WHO (2022). PFOS and PFOA in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality. 29 September 2022. Version for public review. WHO/SDE/WSH/XXXXXX. World Health Organisation (WHO).		
		carbon adsorption or ion-exchange (section 9.4), considering that upper-bound concentrations detected in drinking water sources have mostly been in the low µg/L range. • The pGV for PFOS should therefore be achievable, where these technologies are available and have been optimised for PFAS removal. • Although the pGV was not derived based on adverse health effects studies, the value fall within the range of most health-based values derived through national risk assessments.
Exposure considerations	Principal routes of exposure in general population	Human exposure to PFAS, including PFOS and PFOA, occurs through multiple media and routes; dietary exposure, dust and drinking water are key exposure routes for which quantitative exposure data are available. Other studies support food as being the major source (>70%) of exposure to PFOS and PFOA in the general population living in areas not characterised by heavy contamination by PFAS.
	PFOS Levels in drinking water supplies (include location)	• Worldwide: 4.1 ng/L (Kaboré et al. 2018). • China: 0.25 ng/L (Median, LOQ = 0.01 ng/L). Tap water sampled from the household kitchen from 79 cities. • Japan: up to 25.1 ng/L PFOS (not detected in 22 samples). Water sampled from 39 water treatment plants between January and March 2020. • Philippines: 0.39 ng/L (maximum, n = 7): and Thailand 0.33 ng/L (n = 16). • Australia: 16 ng/L (maximum, n=62, 34 locations across Australia) • US: ∑PFOS and PFOA: ranged from 0.02 to 7.22 µg/L. • US: 1.62 ng/L (median) and 36.9 ng/L (maximum) (25 drinking water treatment plants across the USA) • EU: 0.1 ng/L (lower bound mean) to 3.0 ng/L (upper 7 bound mean) • Turkey: 2.04 ng/L (n=94 samples, 33 provinces) • Netherlands, Germany, France and Spain: High variability. 0.33 ng/l (average, Lleida, Spain) to 46 ng/L (average, unspecified area in Spain). • Italy: Maximums ranged from LOQ (5 ng/L) to 117 ng/L.
	Any special considerations to exposure levels (e.g. higher in drought?)	Living in areas characterised by heavy contamination by PFAS.

Agency Report Reference: WHO (2022). PFOS and PFOA in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality. 29 September 2022. Version for public review. WHO/SDE/WSH/XXXXXX. World Health Organisation (WHO).		
		Bioaccumulation of PFOS and PFOA is possible in aquatic organisms, in land-based food chains (i.e. plants) and mammals, including farm animals, and humans (EFSA, 2020). The partitioning to albumins in blood, liver and eggs is a key bioaccumulation mechanism for PFAS, in contrast to lipid accumulation that is typical of other POPs.
	Typical exposure in general population (include units for intakes & location)	In the evaluation carried out by EFSA (2020a), the contribution of drinking water to overall PFOS and PFOA intake (as lower bound mean exposure) in the general population was found to be highest in the infant age group, with a maximum of 10% and 60% respectively. Trudel et al. (2008) reported that comparable levels of PFAS uptake would be expected in North America and Europe from food and water. Intakes from food: • US: 3 – 220 ng/kg bw/day • Canada: 250 ng/day (PFOS and PFOA) in adults • Germany: 1.4 ng/kg bw/day (median)
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		Although the reduced antibody response following vaccination has been considered by some agencies as the most robust end point based on epidemiological data, it is unclear whether this correlation results in increased rates of infection and hence the clinical implications are uncertain. Although animal data would generally be utilised in the absence of adequate human data for risk assessment purposes, there are also areas of uncertainty around the suitability of animal studies for assessing the effects to human health for PFOS and PFOA as discussed earlier, including interspecies differences in kinetic parameters such as elimination half-life and clearance rate. Additionally, diverging estimates of the human half-life of PFOA may also add uncertainty to animal-to-human dosimetric adjustments, as well as PBPK-based conversions of human plasma PFAS concentrations to external doses. Finally, the uncertainty and lack of consensus in the critical health end point to derive a HBGV is evident from the diverse range of endpoints utilised by other agencies to derive tolerable daily intakes or similar values, and the resulting range in proposed drinking water values described in Table A.1 (see appendix). Although the values derived by several different organisations vary significantly, all have margins of safety. Data analysis

Agency Report Reference: WHO (2022). PFOS and PFOA in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality. 29 September 2022. Version for public review. WHO/SDE/WSH/XXXXXX. World Health Organisation (WHO).	
	also shows that science on PFAS is evolving very rapidly in various areas.
Assessed in Appendix D?	No, as the DWG is not health-based.

B.1.22 WSDH (2019a, 2023a, 2022b)

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (WSDH). WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (WSDH). **Supporting Documentation:** WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (WSDH).		
General Information	Date of data extraction	04 August 2023
	Authors	Washington State Department of Health (SWDH).
	Publication date	November 2019
	Literature search timeframe	Not applicable
	Publication type	Agency Guidance and Fact Sheets
	Peer reviewed?	Not stated
	Country of origin	US (Washington)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	For the State Action Level (SAL): Reference Dose (RfD) or Allowable daily intake (ADI) (WSDH 2022b) WA State Action Level (SAL) EPA Health Advisory Levels (WSDH 2023a) EPA Proposed Maximum contamination levels (MCLs) (WSDH 2023a)
	Exposure timeframe	Chronic
	Critical human health endpoint	SAL: immune endpoints (increased IL-4, reduced antigen response) in adult male mice
	Justification provided by agency for critical endpoint	SAL: We concurred with Minnesota Department of Health and the New Hampshire Department of Environmental Services on their derivation of the RfD for PFOS. The RfD without rounding of the DAF is 3.0 ng/kg-day. The RfD is based on immune effects in Dong et al. 2011. While rodents are sensitive to both immune and developmental

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (WSDH). WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (WSDH). **Supporting Documentation:** WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (WSDH).		
		effects of PFOS, reduced antibody response to an antigen appears to be a more sensitive endpoint in rodents. Serum levels in mice at the LOAEL in Dong et al 2011 were similar to the serum levels in rats at the NOAEL for developmental effects in Luebker et al 2005a. While there are uncertainties in the toxicokinetics for the mouse strains used in various immune studies, the critical study, Dong et al. 2011, measured PFOS levels in mouse serum at the end of the experiment. The experiment was 60 days long and was supported by two other 60-day studies in the same strain of mouse with similar serum measurements indicating reproducibility
	Critical study(ies) underpinning point of departure	SAL: Sub chronic toxicity study in adult mice (Dong et al. 2011 as quoted in WSDH 2019a) • Dong, G.H., et al., Sub-chronic effect of perfluorooctanesulfonate (PFOS) on the balance of type 1 and type 2 cytokine in adult C57BL6 mice. Arch Toxicol, 2011. 85(10): p. 1235-44.
	Species for critical study(ies)	SAL: Adult mice
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	NOAEL, LOAEL, HED
	Point of departure value (include units)	NOAEL: 0.0167 mg/kg/day NOAEL: 2.36 mg/L LOAEL: 10.75 mg/L HED: 0.000302 mg/kg/day
	Uncertainty factor(s) & rationale	SAL: 100 (10-UFH, 3 -UFA, 3-UFD) Minnesota applied a ten-fold uncertainty factor (UFH) for human variability in response and a three-fold uncertainty factor (UFA) for possible differences between the mouse and humans. They applied an additional three-fold factor (UFD) for database uncertainty based on the need for a more complete assessment of developmental exposures and immune effects and T4 thyroid hormone reductions. They noted that two studies in developing rats reported decreased serum thyroxine (T4) in dams and pups at serum levels equivalent to the NOAEL of Dong et al 2011.

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (WSDH). WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (WSDH). **Supporting Documentation:** WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (WSDH).		
	Guideline value (include units)	• SAL: RfD or ADI: 3 ng/kg/day (WSDH 2022b) • USEPA RfD: 20 ng/kg/day (WSDH 2022b) • SAL: 15 ng/L • Health Advisory Level: 0.02 (refer to data extraction for USEPA 2022e for derivation) • MCL: 4 ng/L (WSDH 2023a)
	Mode of action for critical health endpoint	Not stated.
	Genotoxic carcinogen?	PFOS does not appear to be mutagenic or genotoxic but chronic rodent studies observed liver, thyroid and mammary gland tumours.
	Identified sensitive sub-populations	Infants and children are sensitive life stages for immune effects associated with PFOS exposure. Infants and children receive a number of vaccinations to protect them from serious infectious diseases before the age of five. Suppressed antibody production erodes the protection of vaccines and represents a functional decrease in interception and clearance of infectious agents.
	Any non-health-based considerations?	The MCL (4 ng/L) is the lowest concentration of PFOA and PFOS that can be reliably measured by the lab methods required by EPA (drinking water testing methods 533 and 537.1) (WSDH 2023a).
Exposure considerations	Principal routes of exposure in general population	PFAS exposure in the home occurs during product use and exposure to house dust containing PFAS. The greatest portion of the chronic exposure to PFAS for the general public, specifically to PFOS and PFOA, results from the intake of contaminated drinking water and foods (WSDH 2022b)
	Levels in drinking water supplies (include location)	Results of PFAS testing of drinking water in Washington state for PFAS (**PFOS + PFOA concentration**) (data from WSDH 2022b): • Issaquah Water System – Well #4: 490 ng/L then LOD (after GAC filter installed) • Issaquah Water System – Well #5: Up to 40 ng/L. • Sammamish Plateau Water and Sewer District: Up to 40 ng/L. • City of DuPont Water System (2 wells): 30ng/L • City of DuPont Water System (4 wells): 14 – 60 ng/L

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (WSDH). WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (WSDH). **Supporting Documentation:** WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (WSDH).		
		• JBLM - Lewis (two wells): 51 ng/L. • Ft. Lewis (five wells): 15 – 71 ng/L • McChord Field (four wells): 216-250 ng/L • Lakewood Water District (6 wells): 17 – 63 ng/L. • Parkland Light and Water Well #9: 7 – 42 ng/L • Town of Coupeville, Evergreen Mobile Home Park, Group B wells, and 20 private wells: 6 – 7,740 ng/L. • Town of Coupeville water system (one well): 22 – 61 ng/L. • City of Airway Heights (two wells): 1,400 – 1,500 ng/L. • Fairchild AFB (88 wells): 73 – 5,700 ng/L • Fairchild AFB (78 wells): LOD – 70 ng/L • Naval Base Kitsap- Bangor 2 wells: >70 ng/L • Naval Base Kitsap- Bangor 93 wells: LOD – 70 ng/L
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	
Any other relevant information that should be captured?		Any change to a SAL or adopting a state MCL requires rulemaking (WSDH 2023a). In the meantime, we will continue to implement our requirements under our existing SALs (WSDH 2023a).

Compilation of Health-based value for subchronic/ chronic oral intake (ng/kg-day)

Type of PFAA Chem.	Authoritative body responsible for value (year)	Health-based value for subchronic/ chronic oral intake (ng/kg-day)
PFOS	EPA RfD (2016)	20

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (WSDH).

WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (WSDH).

Supporting Documentation: WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (WSDH).

PFOS	ATSDR MRL (2021)	2
PFOS	New Jersey (NJ) DWQI RfD (2018)	1.8
PFOS	New Hampshire (NH) DES (2019)	3
PFOS	Minnesota Department of Health (MDH) RfD (2019)	3.1
PFOS	Michigan (MI) Science Advisory Workgroup (SAW) Toxicity Value (TV) (2019)	2.89
PFOS	California (CA) OEHHA Acceptable Daily Dose (ADD) (2019)	1.8
PFOA	EPA RfD (2016)	20
PFOA	ATSDR MRL (2021)	2
PFOA	NJ DWQI RfD (2017)	2
PFOA	NH DES RfD (2019)	6.1
PFOA	MI SAW TV (2019)	3.9
PFOA	CA OEHHA ADD (2019)	0.45
PFNA	ATDSR MRL (2021)	3
PFNA	NJ DWQI RfD (2015)	0.74
PFNA	NH DES (2019)	4.3
PFNA	MI SAW TV (2019)	2.2
PFHxS	ATDSR MRL (2021)	20
PFHxS	MDH RfD (2019)	9.7
PFHxS	NH DES RfD (2019)	4
PFHxS	MI SAW TV (2019)	9.7
PFBS	EPA RfD (2021)	300
PFBS	MDH RfD (2017)	430
PFBS	MI SAW TV (2019)	300
PFBS	CA OEHHA ADD (2021)	600
PFHxA	MI SAW TV (2019)	83,000
GenX	MI SAW TV (2019)	77
GenX	EPA (2018)	80
PFBA	MDH (2018)	2,900

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (WSDH). WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (WSDH). **Supporting Documentation:** WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (WSDH).	
Assessed in Appendix D?	No, as the TRV is adopted from another agency (MDH 2020a).

B.2 PFHxS Existing Health-based Guidance

B.2.1 Alaska DEC (2019a)

Agency Report Reference: Alaska DEC (2019a). Technical Memorandum Action Levels for PFAS in Water and Guidance on Sampling Groundwater and Drinking Water. Date: August 20, 2018, Updated: October 2, 2019. Division of spill prevention and response. Contaminated sites program and Division of environmental health Drinking water program. Alaska Department of Environmental Conservation (Alaska DEC).		
Refer to the data extraction table for PFOS: **Section B.1.1** as the Action Level from Alaska DEC (2019a) for PFOS+PFOA. In 2018, Alaska DEC previously set action level the sum of PFOS, PFOA, PFNA, PFHxS, and PFHpA. A separate action level was set for PFBS.		
Health considerations	Guideline value (include units)	PFOS+PFOA: 70 ng/L NB: In 2018, Alaska DEC previously set action level of 70 ng/L for PFOS, PFOA, PFNA, PFHxS, and PFHpA. A separate action level for the shorter-chain PFBS was set at 2.0 µg/L.
Assessed in Appendix D?		No, adopted from other agency, no basis provided.

B.2.2 ATSDR (2018a)

Agency Report Reference: ATSDR (2018a). ATSDR's Minimal Risk Levels (MRLs) and Environmental Media Evaluation Guides (EMEGs) for Perfluoroalkyls (PFAS). November 2018. Agency for Toxic Substances and Disease Registry (ATSDR).		
General Information	Date of data extraction	03 August 2023
	Authors	Agency for Toxic Substances and Disease Registry (ATSDR).
	Publication date	November 2018.
	Literature search timeframe	Not stated
	Publication type	Agency Guidance (Summary Document)
	Peer reviewed?	Not stated
	Country of origin	US
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Environmental Media Evaluation Guides (EMEGs)
	Exposure timeframe	Not stated
	Critical human health endpoint	Not stated

Agency Report Reference: ATSDR (2018a). ATSDR's Minimal Risk Levels (MRLs) and Environmental Media Evaluation Guides (EMEGs) for Perfluoroalkyls (PFAS). November 2018. Agency for Toxic Substances and Disease Registry (ATSDR).		
	Justification provided by agency for critical endpoint	Not stated
	Critical study(ies) underpinning point of departure	Not stated
	Species for critical study(ies)	Not stated
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Not stated
	Point of departure value (include units)	Not stated
	Uncertainty factor(s) & rationale	Not stated
	Guideline value (include units)	517 ng/L (adult) and 140 ng/L (child)
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Not stated
	Identified sensitive sub-populations	Not stated
	Any non-health-based considerations?	Not stated
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		ATSDR has developed MRL screening values for perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorohexane sulfonic acid (PFHxS) and perfluorononanoic acid (PFNA) that can be converted into drinking water concentrations for adults and children. ATSDR bases this calculation on an infant (age birth to one year old) weighing 7.8 kg and an intake rate of 1.113 liters per day. For an adult's drinking water exposure, ATSDR bases this

Agency Report Reference: ATSDR (2018a). ATSDR's Minimal Risk Levels (MRLs) and Environmental Media Evaluation Guides (EMEGs) for Perfluoroalkyls (PFAS). November 2018. Agency for Toxic Substances and Disease Registry (ATSDR).	
	calculation on a body weight of 80 kg and an intake rate of 3.092 liters per day. Scientists may use different assumptions when calculating concentrations from dosages.
Assessed in Appendix D?	No, but TRVs forming the basis of these guideline values (ATSDR 2021a) are assessed.

B.2.3 ATSDR (2021a)

Agency Report Reference: ATSDR (2018a). Toxicological Profile for Perfluoroalkyls. Released May 2021. Agency for Toxic Substances and Disease Registry (ATSDR).		
General Information	Date of data extraction	03 August 2023
	Authors	Agency for Toxic Substances and Disease Registry (ATSDR).
	Publication date	May 2021.
	Literature search timeframe	Not date limited. The current literature search was intended to update the draft toxicological profile for perfluoroalkyls released for public comment in 2015. The following main databases were searched in March 2008, September/October 2013, May 2016, and September 2018: • PubMed • National Library of Medicine's TOXLINE • Scientific and Technical Information Network's TOXCENTER
	Publication type	Agency Guideline
	Peer reviewed?	Yes
	Country of origin	US
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Minimum Risk Level (MRL)
	Exposure timeframe	Intermediate (14 to 365 days)
	Critical human health endpoint	Thyroid follicular epithelial hypertrophy/hyperplasia
	Justification provided by agency for critical endpoint	Since the liver effects were not considered relevant to humans, the lowest LOAEL identified for PFHxS was 1 mg/kg/day for decreases in the number of pups per litter identified in the Chang et al. (2018) study. The investigators noted that the toxicological significance of this alteration was uncertain because there was no clear dose-response and no alterations in the number of

Agency Report Reference: ATSDR (2018a). Toxicological Profile for Perfluoroalkyls. Released May 2021. Agency for Toxic Substances and Disease Registry (ATSDR).		
		implantation sites, number of viable pups, or pup to implant ratios. Thus, the Butenhoff et al. (2009a) study, which reported thyroid effects in male rats at LOAEL of 3 mg/kg/day, with a NOAEL of 1 mg/kg/day, was selected as the principal study.
	Critical study(ies) underpinning point of departure	Reproductive and developmental study in rats (Butenhoff et al. 2009a as quoted in ASTDR 2021a). Butenhoff JL, Chang SC, Ehresman DJ, et al. 2009a. Evaluation of potential reproductive and developmental toxicity of potassium perfluorohexanesulfonate in Sprague Dawley rats. Reprod Toxicol 27:331-341. (as quoted in ATSDR 2021a).
	Species for critical study(ies)	Rat
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	NOAEL, HED NOAEL
	Point of departure value (include units)	• NOAEL: 1mg/kg/day • HED NOAEL: 0.0047 mg/kg/day
	Uncertainty factor(s) & rationale	300 (3 for extrapolation from animals to humans with dosimetric adjustments and 10 for human variability) and a modifying factor of 10 for database limitations.
	Guideline value (include units)	MRL: 20 ng/kg/day
	Mode of action for critical health endpoint	The mode of action for most health outcomes associated with perfluoroalkyl exposure has not been fully characterized in humans or laboratory animals. Some perfluoroalkyl-induced effects observed in rats and mice appear to be mediated through the PPARα-dependent and -independent mechanisms (see Section 2.20 for additional information). Interpretation of the relevance of the effects observed in laboratory animals is complicated since it is generally agreed that humans and nonhuman primates are refractory, or at least less responsive than rodents, to PPARα-mediated effects (Corton et al. 2014; Klaunig et al. 2003; Maloney and Waxman 1999). While studies in mice have identified specific effects that require PPARα activation, for example, postnatal viability (Abbott et al. 2007) and some immunological effects (Yang et al. 2002b), other effects such as hepatomegaly and antigen-specific antibody response (DeWitt et al. 2016) were reported to be PPARα-independent (Yang et al.
	Genotoxic carcinogen?	Little information is available on the genotoxicity of other perfluoroalkyl compounds, with available studies focused on DNA damage. No DNA

Agency Report Reference: ATSDR (2018a). Toxicological Profile for Perfluoroalkyls. Released May 2021. Agency for Toxic Substances and Disease Registry (ATSDR).		
		damage was found in HepG2 cells incubated with 100 or 400 µM PFHxS or PFBS for 24 hours
	Identified sensitive sub-populations	It is not known whether children are more or less susceptible than adults to the effects of exposure to perfluoroalkyls because there are no studies that specifically addressed this question. Several studies have examined the possible associations between perfluoroalkyl exposure and health outcomes in children living in an area with high PFOA contamination and in the general population. Although some studies have found statistically significant associations, they are not adequate for establishing causality.
	Any non-health-based considerations?	
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	• Brazil (Rio): max = 0.15 to 1 ng/L. • Germany: 12.1 ng/L (maximum). SLR note there are other studies discussed that report PFHxS in groundwater however concentrations were not shown in ATSDR (2021a)
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	The available epidemiological data identify several potential health hazards of PFOS in humans as listed below: • Liver damage, as evidenced by increases in serum enzymes and decreases in serum bilirubin levels. • Decreased antibody response to vaccines. There are sufficient epidemiological data to identify possible sensitive targets for many of the perfluoroalkyls; however, there are two major limitations to establishing dose-response relationships for these effects and using the epidemiological studies to derive MRLs: accurate identification of environmental exposure levels producing increased risk for adverse effects (exposure estimates and routes of exposure) and likely co-exposure to mixtures of perfluoroalkyls. Other limitations include the cross-sectional design of the majority of epidemiological studies and the

Agency Report Reference: ATSDR (2018a). Toxicological Profile for Perfluoroalkyls. Released May 2021. Agency for Toxic Substances and Disease Registry (ATSDR).		
		potential that reverse causality contributes to the observed associations. The epidemiological databases for several perfluoroalkyls provide valuable information on hazard identification; however, uncertainties regarding doses associated with adverse effects and possible interactions between compounds preclude use of these data to derive MRLs.
Any other relevant information that should be captured?		There are insufficient data for derivation of an acute-duration oral MRL for PFHxS. The acute oral database for PFHxS was not considered adequate for derivation of an MRL due to the short duration of the only available study and the lack of pharmacokinetic model parameters for calculating an HED.
Assessed in Appendix D?		Yes

B.2.4 CDPH (2023a)

Agency Report Reference: CDPH (2023a). Per- and polyfluoroalkyl Substances (PFAS). 2023. Connecticut State Department of Public Health (CDPH)		
General Information	Date of data extraction	07 August 2023
	Authors	Connecticut State Department of Public Health (CDPH)
	Publication date	2023
	Literature search timeframe	Not stated
	Publication type	Agency webpage.
	Peer reviewed?	Not stated.
	Country of origin	US (Connecticut)
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	CT Drinking Water Action Level
	Exposure timeframe	Not stated.
	Critical human health endpoint	Thyroid effects
	Justification provided by agency for critical endpoint	CT DPH develops its drinking water Action Levels by considering health impacts to the most sensitive and most exposed populations across all stages of human development.
	Critical study(ies) underpinning point of departure	Not stated.
	Species for critical study(ies)	Animal studies

Agency Report Reference: CDPH (2023a). Per- and polyfluoroalkyl Substances (PFAS). 2023. Connecticut State Department of Public Health (CDPH)		
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Not stated.
	Point of departure value (include units)	Not stated.
	Uncertainty factor(s) & rationale	Not stated.
	Guideline value (include units)	49 ng/L
	Mode of action for critical health endpoint	Not stated.
	Genotoxic carcinogen?	Not stated.
	Identified sensitive sub-populations	Pregnant people, infants and children are at higher risk because of PFAS effects on pregnancy outcomes and foetal, infant and child growth and development.
	Any non-health-based considerations?	Not stated.
Exposure considerations	Principal routes of exposure in general population	Not stated.
	Levels in drinking water supplies (include location)	Not stated.
	Any special considerations to exposure levels (e.g. higher in drought?)	Not stated.
	Typical exposure in general population (include units for intakes & location)	Not stated.
Risk Summary	Any risks to human health from drinking water identified in agency document?	Not stated.
	Any emerging risks identified?	Not stated.
Any other relevant information that should be captured?		The chemical-specific approach reflects the evolving scientific evidence on the toxicity of PFAS and is more protective of public health than the summed approach used previously in CT.
Assessed in Appendix D?		No, no basis provided.

B.2.5 DOH (2017)

Agency Report Reference: DOH (2017). Health-based Guidance Values for PFAS. 2017. Department of Health (DOH), Australian Government.
Refer to the data extraction table for PFOS: **Section B.1.6** as the TDI from DOH (2017) is for the sum of PFOS and PFHxS (i.e. PFOS + PFHxS).

Agency Report Reference: DOH (2017). Health-based Guidance Values for PFAS. 2017. Department of Health (DOH), Australian Government.		
Health considerations	Guideline value (include units)	• TDI: 20 ng/kg.bw/day (as a sum, PFOS+PFHxS) • DWG: 70 ng/L (as a sum, PFOS+PFHxS)
		For PFHxS, FSANZ concluded that there was not enough toxicological and epidemiological information to justify establishing a tolerable daily intake. However, as a precaution, and for the purposes of site investigations, the PFOS tolerable daily intake should apply to PFHxS. In practice, this means that the level of PFHxS exposure should be added to the level of PFOS exposure; and this combined level be compared to the tolerable daily intake for PFOS.
Assessed in Appendix D?		No, adopted from FSANZ (2017b), which is assessed separately.

B.2.6 EU (2020), EC (2022)

Agency Report Reference: EC (2022). Final Opinion on Groundwater quality standards for proposed additional pollutants in the annexes to the Groundwater Directive (2006/118/EC) Scientific Co **Agency Report Reference:** EU (2020). Directives. Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the Quality of Water Intended for Human Consumption (recast) (Text with EEA relevance). L 435/2, 23.12.2020. European Union (EU). **Supporting Documentation:** EC (2022). Final Opinion on Groundwater quality standards for proposed additional pollutants in the annexes to the Groundwater Directive (2006/118/EC) Scientific Committee on Health, Environmental and Emerging Risks SCHEER. 18 July 2022. DG Health and Food Safety. European Commission (EC).mmittee on Health, Environmental and Emerging Risks SCHEER. 18 July 2022. DG Health and Food Safety. European Commission (EC).		
Refer to the data extraction table for PFOS: **Section B.1.7** noting the value is for Sum of PFAS or Total PFAS.		
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Quality Standard for surface water - drinking water and human health ($EQS_{dw,hh}$)
	Guideline value (include units)	Technical Guidelines: 100 ng/L (EU 2020 only) Technical Guidelines and $EQS_{dw,hh}$: PFAS Total: 500 ng/L (EU 2020, EC 2022) NB: 'Total PFAS' as the totality of per- and polyfluoroalkyl substances detected with available analytical methods and monitoring guidelines (EU 2020, EC 2022). 'Sum of PFAS' means the sum of per- and polyfluoroalkyl substances considered a concern as regards to water intended for human consumption listed in point 3 of Part B of Annex III. This is a subset of 'PFAS Total' substances that contain a perfluoroalkyl moiety with three or more carbons (i.e. $–C_nF_{2n}–$, n ≥ 3) or a perfluoroalkylether moiety with two or more

Agency Report Reference: EC (2022). Final Opinion on Groundwater quality standards for proposed additional pollutants in the annexes to the Groundwater Directive (2006/118/EC) Scientific Co **Agency Report Reference:** EU (2020). Directives. Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the Quality of Water Intended for Human Consumption (recast) (Text with EEA relevance). L 435/2, 23.12.2020. European Union (EU). **Supporting Documentation:** EC (2022). Final Opinion on Groundwater quality standards for proposed additional pollutants in the annexes to the Groundwater Directive (2006/118/EC) Scientific Committee on Health, Environmental and Emerging Risks SCHEER. 18 July 2022. DG Health and Food Safety. European Commission (EC).mmittee on Health, Environmental and Emerging Risks SCHEER. 18 July 2022. DG Health and Food Safety. European Commission (EC).		
		carbons (i. e. $C_nF_{2n}OC_mF_{2m}$–, n and m ≥ 1) (EU 2020).
Assessed in Appendix D?		No, no basis provided.

B.2.7 EFSA (2020a)

Agency Report Reference: EFSA (2020). Risk to human health related to the presence of perfluoroalkyl substances in food. Adopted: 9 July 2020. European Food Safety Authority (EFSA)		
Refer to the data extraction table for PFOS: **Section B.1.8** as the TWI from EFSA (2020a) is for the sum of four PFAS, i.e. ∑PFOA, PFNA, PFHxS and PFOS.		
Health considerations	Guideline value (include units)	Daily intake for ∑PFOA, PFNA, PFHxS and PFOS: 0.63 ng/kg bw/day (TWI = 4.4 ng/kg bw per week)
Assessed in Appendix D?		Yes

B.2.8 FSANZ (2017b)

Agency Report Reference: FSANZ (2017). Hazard assessment report – Perfluorooctane Sulfonate (PFOS), Perfluorooctanoic Acid (PFOA), Perfluorohexane Sulfonate (PFHxS). Food Standards Australia New Zealand (FSANZ)		
General Information	Date of data extraction	02 August 2023
	Authors	Food Standards Australia New Zealand (FSANZ)
	Publication date	Undated. Known to have been released in 2018.
	Literature search timeframe	Five years. Search strategy in PubMed, with results retrieved for the final search on 15 December, 2016
	Publication type	Agency Guideline Document
	Peer reviewed?	Not stated.
	Country of origin	Australia
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Health-based guidance values (HBGV) • Tolerable daily intake (TDI)

Agency Report Reference: FSANZ (2017). Hazard assessment report – Perfluorooctane Sulfonate (PFOS), Perfluorooctanoic Acid (PFOA), Perfluorohexane Sulfonate (PFHxS). Food Standards Australia New Zealand (FSANZ)		
	Exposure timeframe	Lifetime
	Critical human health endpoint	There are currently substantial deficiencies in the toxicological and epidemiological database that preclude establishing a TDI for PFHxS, or a group TDI for perfluoroalkyl compounds.
	Justification provided by agency for critical endpoint	In the case of PFHxS, the only toxicology study considered useful for regulatory purposes was a reproductive and developmental study in rats (Butenhoff et al. 2009). There was no evidence of reproductive or developmental toxicity. The NOAEL for reproductive toxicity was 10 mg/kg bw/day, the highest dose tested. The NOAEL for paternal toxicity was 3 mg/kg bw/day (males only), and the NOAEL for offspring toxicity was 10 mg/kg bw/day. It is reasonable to conclude that the enHealth approach of using the TDI for PFOS is likely to be conservative and protective of public health as an interim measure. The approach recognises that the structure of PFHxS and PFOS are similar, and that there is some evidence of similar potency of PFHxS and PFOS in activating PPARα, which at least partially, mediates the toxicity of perfluroalkylated compounds. Effectively, this means that as a conservative approach, PFHxS and PFOS should be summed for the purposes of a dietary exposure assessment and risk characterisation.
	Critical study(ies) underpinning point of departure	Not applicable (refer to PFOS data extraction, **Section B.1.9**)
	Species for critical study(ies)	Not applicable (refer to PFOS data extraction, **Section B.1.9**)
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10,}$ etc.)	Not applicable (refer to PFOS data extraction, **Section B.1.9**)
	Point of departure value (include units)	Not applicable (refer to PFOS data extraction, **Section B.1.9**)
	Uncertainty factor(s) & rationale	Not applicable (refer to PFOS data extraction, **Section B.1.9**)
	Guideline value (include units)	TDI: 20 ng/kg/day NB: Applied as a sum of PFOS+PFHxS
	Mode of action for critical health endpoint	Not applicable (refer to PFOS data extraction, **Section B.1.9**)
	Genotoxic carcinogen?	Not stated.
	Identified sensitive sub-populations	-

Agency Report Reference: FSANZ (2017). Hazard assessment report – Perfluorooctane Sulfonate (PFOS), Perfluorooctanoic Acid (PFOA), Perfluorohexane Sulfonate (PFHxS). Food Standards Australia New Zealand (FSANZ)		
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		-
Assessed in Appendix D?		Yes

B.2.9 HC (2019a)

Agency Report Reference: HC (2019a). Water talk: Summary of drinking water values for PFOS, PFOA and other PFAS. Health Canada (HC). Government of Canada.		
General Information	Date of data extraction	03 August 2023
	Authors	Health Canada (HC). Government of Canada.
	Publication date	April 2019.
	Literature search timeframe	Not stated
	Publication type	Agency Guidance (Summary Document)
	Peer reviewed?	Not stated
	Country of origin	Canada
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Maximum acceptable concentration (MAC)
	Exposure timeframe	Lifetime
	Critical human health endpoint	-

Agency Report Reference: HC (2019a). Water talk: Summary of drinking water values for PFOS, PFOA and other PFAS. Health Canada (HC). Government of Canada.		
	Justification provided by agency for critical endpoint	Scientific information is limited on the majority of PFAS. The drinking water screening values for most other PFAS were developed using PFOS and PFOA as surrogates, whereas they are expected to be less toxic because of their chemical structure.
	Critical study(ies) underpinning point of departure	-
	Species for critical study(ies)	-
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	-
	Point of departure value (include units)	-
	Uncertainty factor(s) & rationale	Health Canada has developed screening values for a number of other PFAS at the request of several jurisdictions. As with formal guidelines, when screening values are developed, Health Canada includes a margin of safety (or 'buffer zone')
	Guideline value (include units)	PFHxS: 600 ng/L
	Mode of action for critical health endpoint	-
	Genotoxic carcinogen?	-
	Identified sensitive sub-populations	Screening values are also established at a level designed to protect the health of Canadians, including children, based on a lifetime exposure to the substance.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	

Agency Report Reference: HC (2019a). Water talk: Summary of drinking water values for PFOS, PFOA and other PFAS. Health Canada (HC). Government of Canada.	
Any other relevant information that should be captured?	Only PFOS and PFOA have been studied sufficiently to develop Guideline Technical Documents under the Guidelines for Canadian Drinking Water Quality. Short-term exposure to PFAS in drinking water at levels slightly higher than the maximum acceptable concentrations (MAC) or screening values, below, is not expected to result in health effects as these values are based on a lifetime of exposure to the substance. When guideline values are developed, Health Canada includes a margin of safety (or 'buffer zone'). As such, guideline values such as maximum acceptable concentrations (MACs) are established at a level designed to protect the health of Canadians, including children, based on a lifetime exposure to the substance.
Assessed in Appendix D?	No, likely adopted from the value for PFOS.

B.2.10 Maine DHHS (2021a)

Agency Report Reference: Maine DHHS (2021a). PFOS, PFOA and other PFAS Questions and Answers. Updated 7/07/2021. Maine Department of Health and Human Services (Maine DHHS).		
Refer to the data extraction table for PFOS: **Section B.1.11** as the Interim State drinking water standard from Maine DHHS (2021a) is for the combined sum of six different PFAS: PFOA, PFOS, PFHpA, PFNA, PFDA, and PFHxS.		
Health considerations	Guideline value (include units)	20 ng/L For the combined sum of six different PFAS: PFOA, PFOS, PFHpA, PFNA, PFDA, and PFHxS
Assessed in Appendix D?		No, no basis provided.

B.2.11 Mass DEP (2022a)

Agency Report Reference: Important Information. Mass DEP (2022a). EPA's New Health Advisories for Some PFAS. August 11, 2022. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP). **Supporting Documentation:** Mass DEP (2023a). EPA Proposed Maximum Contaminant Level (MCL) for PFAS. April 12, 2023. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP).		
Refer to the data extraction table for PFOS: **Section B.1.12**		
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	• EPA's Health Advisories • Maximum Contaminant Level (MCL) • Maximum Contaminant Level Goals (MCLGs) (Mass DPH 2023a)
	Guideline value (include units)	• MCL (PFAS6): 20 ng/L for the sum of six PFAS (PFOS, PFOA, PFHxS, PFNA, PFHpA,

Agency Report Reference: Important Information. Mass DEP (2022a). EPA's New Health Advisories for Some PFAS. August 11, 2022. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP). **Supporting Documentation:** Mass DEP (2023a). EPA Proposed Maximum Contaminant Level (MCL) for PFAS. April 12, 2023. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP).		
		and PFDA) (established an enforceable level in Massachusetts) The two EPA Interim Health Advisories and two Final Health Advisories are: • Interim Health Advisory for PFOA: 0.004 ng/L • Interim Health Advisory for PFOS: 0.02 ng/L • Final Health Advisory for GenX: 10 ng/L • Final Health Advisory for PFBS: 2,000 ng/L MCLGs from Mass DPH (2023a): • PFOS: 4 ng/L • PFOA: 4 ng/L • PFNA, PFHxS, PFBS, & GenX: Hazard Index of 1. NB: Massachusetts will adopt PFAS drinking water regulations that are at least as stringent as the federal standards (Mass DEP 2023a). NB: Mass DEP (2023a) is proposing to address four additional PFAS (GenX, PFBS, PFNA, and PFHxS) as a mixture using a Hazard Index. A Hazard Index accounts for the increased risk from mixtures of PFAS (Mass DEP 2023a). SLR note that it is not clear how the Hazard Index will be calculated, i.e. which MCLG, HA or MCL will be used for the calculation.
Assessed in Appendix D?		No, adopted from other agencies.

B.2.12 MDH (2020b)

Agency Report Reference: MDH (2020b). Toxicological Summary for: Perfluorohexane sulfonate. August 2020. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH).		
General Information	Date of data extraction	04 August 2023
	Authors	Minnesota Department of Health (MDH)
	Publication date	August 2020
	Literature search timeframe	Not stated
	Publication type	Agency Guideline
	Peer reviewed?	Not stated
	Country of origin	US (Minnesota)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated

Agency Report Reference: MDH (2020b). Toxicological Summary for: Perfluorohexane sulfonate. August 2020. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH).		
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Reference Dose (RfD) Non-Cancer Health-Based Value (nHBV)
	Exposure timeframe	Short-term, subchronic, and chronic durations
	Critical human health endpoint	Decreased total T4
	Justification provided by agency for critical endpoint	Based on studies in laboratory animals, alterations in serum thyroid hormone levels, in particular thyroxine (T4), appear to be a sensitive effect.
	Critical study(ies) underpinning point of departure	NTP 2018a (as quoted in MDH (2020b). • NTP. (2018a). National Toxicology Program. TOX-96: Toxicity Report Tables and Curves for Short-term Studies: Perfluorinated Compounds: Sulfonates.
	Species for critical study(ies)	Rats
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10,}$ etc.)	$BMDL_{20}$, HED
	Point of departure value (include units)	$BMDL_{20}$ = 32.4 µg/mL HED = 0.00292 mg/kg/day
	Uncertainty factor(s) & rationale	300 3 for interspecies differences (for toxicodynamics), 10 for intraspecies variability, and 10 for database uncertainty to address concerns regarding early life sensitivity to decreased thyroxine (T4) levels as well as lack of 2 generation or immunotoxicity studies.
	Guideline value (include units)	• RfD: 9.7 ng/kg/day • nHBV: 47 ng/L NB: Refer to News Release from MDH (2023a) for MCLs and Hazard index approach for assessing PFOS, PFOA, PFHxS, PFBS and GenX.
	Mode of action for critical health endpoint	-
	Genotoxic carcinogen?	-
	Identified sensitive sub-populations	Early years. NB: Study results [for critical effect] suggest that pups may be more sensitive than adult nonpregnant animals.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	-

Agency Report Reference: MDH (2020b). Toxicological Summary for: Perfluorohexane sulfonate. August 2020. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH).		
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		The POD is based on decreased serum T4 levels in adult male rats however, decreased serum T4 levels have also been reported in pregnant and lactating rats and pups. Unfortunately, serum PFHxS levels were not measured in pregnant or lactating rats or pups at the NOAEL and LOAEL dose levels, however, study results suggest that pups may be more sensitive than adult nonpregnant animals. A database uncertainty factor (DB UF) has been incorporated into the RfD derivation, in part, due to concerns that early life stages may be more sensitive. Several epidemiology studies have examined the potential association between PFHxS and suppression of the immune system. Inverse or no associations were observed in these studies. In general, available studies have not found an association between PFHxS and infectious disease resistance or with hypersensitivity outcomes. Immunotoxicity has not been studied in laboratory animals. An RSC of 0.5 (50%) was selected for the peak serum concentration during infancy. The RSC of 0.5 during infancy resulted in chronic (steady-state) serum concentrations at approximately 0.2 of the 'reference' serum concentration.
Assessed in Appendix D?		Yes.

B.2.13 MDH (2023a)

Agency Report Reference: MDH (2023a). News Release. Joint agency statement on draft federal limits on PFAS in drinking water. March 14, 2023. Minnesota Department of Health (MDH)
Refer to the data extraction table for PFOS: **Section B.1.14** for further information.

Agency Report Reference: MDH (2023a). News Release. Joint agency statement on draft federal limits on PFAS in drinking water. March 14, 2023. Minnesota Department of Health (MDH)		
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Hazard Index Approach
	Guideline value (include units)	EPA is also proposing that four PFAS (PFBS, PFHxS, GenX and PFNA) be evaluated in combination with each other, using an approach called a Hazard Index. A hazard index is calculated by comparing a measured drinking water value with a standard. SLR presumes the standard is the MCL of 4 ng/L for PFOS and PFOA.
	Any non-health-based considerations?	Not stated. NB: The MCLs adopted by MDH (2023a) are equivalent to the MCLG from USEPA (2022d, 2022e) of 4 ng/L for PFOA and PFOS which is based on a minimum reporting level (MRL).
Assessed in Appendix D?		No, adopted from other agency, no health basis.

B.2.14 MPART (2019a)

Agency Report Reference: MPART (2019a). Health-Based Drinking Water Value Recommendations for PFAS in Michigan. June 27, 2019. Michigan Science Advisory Workgroup. Michigan's PFAS Action Response Team (MPART).		
General Information	Date of data extraction	08 August 2023
	Authors	Michigan's PFAS Action Response Team (MPART).
	Publication date	June 27, 2019
	Literature search timeframe	Not stated.
	Publication type	Agency Guidance
	Peer reviewed?	Not stated.
	Country of origin	US (Michigan)
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Toxicity value Drinking water Health-based value (HBV)
	Exposure timeframe	Not stated
	Critical human health endpoint	Decreased serum free thyroxin (T4) levels were observed in adult male rats. Co-critical effects: decreased free and total T4, triiodothyronine (T3), and changes in cholesterol levels and increased hepatic focal necrosis.
	Justification provided by agency for critical endpoint	The Workgroup selected this thyroid endpoint as it was a measure of a clinical or functional effect rather than observational one.

Agency Report Reference: MPART (2019a). Health-Based Drinking Water Value Recommendations for PFAS in Michigan. June 27, 2019. Michigan Science Advisory Workgroup. Michigan's PFAS Action Response Team (MPART).		
		The Workgroup discussed Chang et al. (2018) and concluded that the health outcome (reduction in litter size) was a marginal effect. For all of the PFAS examined, points of departure were selected from studies with laboratory animal models. This approach does not negate findings associated with epidemiological studies, but reflects that humans experience uncontrolled and imperfectly documented rather than controlled, precisely measured exposures. Additionally, these points of departure reflect adverse health effects that occur at low doses and that are supported by the weight-of-evidence across endpoints and between findings in humans and laboratory animal models.
	Critical study(ies) underpinning point of departure	28-day oral toxicity study in Sprague Dawley rats (NTP, 2018a). • NTP 2018a TOX-96: Toxicity Report Tables and Curves for Short-term Studies: Perfluorinated Compounds: Sulfonates and personal communication between MDH and NTP project manager Dr. Chad Blystone (as cited in the HRA Toxicology Review worksheet for PFHxS, last revised 3/8/2019).
	Species for critical study(ies)	Rats
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10,}$ etc.)	LOAEL, $BMDL_{20}$, HED
	Point of departure value (include units)	LOAEL: 0.625 mg/kg/day $BMDL_{20}$: 32.4 mg/L HED = 0.00292 mg/kg/day
	Uncertainty factor(s) & rationale	300 1 for LOAEL to NOAEL, 10 for human variability, 3 ($10^{0.5}$) for animal to human variability (toxicodynamic differences), 1 for subchronic to chronic, 10 for database deficiencies – to address concerns for early life sensitivity and lack of 2-generation or immunotoxicity studies.
	Guideline value (include units)	Toxicity Value: 9.7 ng/kg/day Drinking water HBV: 51 ng/L
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Not stated
	Identified sensitive sub-populations	Not clearly stated although an UF was applied for the lack of information on early-life sensitivity.
	Any non-health-based considerations?	-

Agency Report Reference: MPART (2019a). Health-Based Drinking Water Value Recommendations for PFAS in Michigan. June 27, 2019. Michigan Science Advisory Workgroup. Michigan's PFAS Action Response Team (MPART).		
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		The mammary gland effects may be representative of endocrine effects at doses below the selected POD.
Assessed in Appendix D?		Yes

B.2.15 OEHHA (2022a)

Agency Report Reference: OEHHA (2022a). Notification Level Recommendation. Perfluorohexane Sulfonic Acid in Drinking Water. March 2022. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.		
General Information	Date of data extraction	02 August 2023.
	Authors	Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.
	Publication date	March 2022.
	Literature search timeframe	Unrestricted.
	Publication type	Agency Guidance Document.
	Peer reviewed?	Yes.
	Country of origin	US (California)
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	• Acceptable Daily Dose (ADD) • Health-Protective Concentration (HPC)
	Exposure timeframe	

Agency Report Reference: OEHHA (2022a). Notification Level Recommendation. Perfluorohexane Sulfonic Acid in Drinking Water. March 2022. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.		
	Critical human health endpoint	There are three of critical human health endpoints: • Increased relative liver weight in female rats (NTP, 2019 as quoted in OEHHA 2022a) • Decreased number of live pups per litter in mice (Chang et al., 2018 as quoted in OEHHA 2022a). • Decreased thyroid hormone levels (T4) in male rats (NTP, 2019 as quoted in OEHHA 2022a)
	Justification provided by agency for critical endpoint	OEHHA evaluated the health outcomes of the most sensitive animal toxicity studies available in the literature for HPC derivation. In the three selected candidate critical studies, the most sensitive health outcomes included effects on the liver, thyroid, and developing offspring following oral exposure to PFHxS. OEHHA considered other animal studies and health outcomes (e.g. lipids, thyroid hypertrophy/hyperplasia). However, those endpoints were not as sensitive as those listed in Table 6 and an HPC based on those effects would not adequately protect against these more sensitive effects. For the studies/endpoints where OEHHA could not develop BMDLs, NOAEL values were used as PODs.
	Critical study(ies) underpinning point of departure	There are two critical studies: • 28-day toxicity studies in male and female rats (NTP, 2019 as quoted in OEHHA 2022a). • Reproductive and developmental toxicity study in CD-1 mice (Chang et al., 2018 as quoted in OEHHA 2022a).
	Species for critical study(ies)	Male and female rats (NTP, 2019 as quoted in OEHHA 2022a) and CD-1 mice (Chang et al., 2018 as quoted in OEHHA 2022a).
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10,}$ etc.)	NOAEL, $BMDL_{1SD}$: and POD_{HED} for both studies
	Point of departure value (include units)	The most sensitive PODs for the three types of endpoints range from 16.8–34.3 µg/mL and differ only about 2-fold among each other. For increased relative liver weight in female rats (NTP, 2019 as quoted in OEHHA 2022a). • NOAEL: 3.12 mg/kg/day • $BMDL_{1SD}$: 34.3 µg/mL. • POD Human: 0.00292 mg/kg/day.

Agency Report Reference: OEHHA (2022a). Notification Level Recommendation. Perfluorohexane Sulfonic Acid in Drinking Water. March 2022. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.		
		For decreased number of live pups per litter in mice (Chang et al., 2018 as quoted in OEHHA 2022a). • NOAEL: 0.3 mg/kg/day • NOAEL: 16.8 µg/mL ($BMDL_{1SD}$: 13.9 µg/mL) • POD Human: 0.00143mg/kg/day. For Decreased thyroid hormone levels (T4) in male rats (NTP, 2019 as quoted in OEHHA 2022a). • LOAEL: 0.625 mg/kg/day. • $BMDL_{1SD}$: 28.6 µg/mL. • POD Alt/Human: 0.00243 mg/kg/day.
	Uncertainty factor(s) & rationale	Uncertainty factors for candidate critical endpoints were: • Intraspecies UFH = 10 (all endpoints). Reduced from the default value of 30. The toxicokinetic components of the intraspecies UFH was reduced by √10 as PFHxS is not known to be metabolized in animals or humans, and because a toxicokinetic adjustment was applied to the animal POD to derive a human equivalent dose. • Interspecies UFA = √10 (all endpoints). Reduced from the default value of 10. The toxicokinetic components of the interspecies UFA was reduced by √10 for the same reason as outlined above for UFH. • Sub-chronic UFS = 1 for the developmental study and 10 for the sub-chronic studies. • Database deficiency UFD = √10 (all endpoints). There are no studies of potential immunotoxicity or carcinogenicity. Composite factors used: • 100 for decreased number of live pups. • 1,000 for decreased thyroid hormone levels (T4) in male rats and increased relative liver weight in female rats.
	Guideline value (include units)	The ADD derived for three of critical health endpoints were: • 2.9 ng/kg/day (Increased relative liver weight). • 14.3 ng/kg/day (Decreased litter size). • 2.4 ng/kg/day (Decreased Total T4). The HPC derived for three of critical health endpoints were: • 11 ng/L (Increased relative liver weight). • 60 ng/L (Decreased litter size).

Agency Report Reference: OEHHA (2022a). Notification Level Recommendation. Perfluorohexane Sulfonic Acid in Drinking Water. March 2022. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.		
		• 2 ng/L (Decreased Total T4). NB: HPC = ADD × RSC ÷ DWI = ADD × 0.2 ÷ 0.237 L/kg-day, where RSC = relative source contribution and DWI = drinking water intake rate)
	Mode of action for critical health endpoint	Not stated.
	Genotoxic carcinogen?	Not stated. NB: There were insufficient data to evaluate the potential carcinogenicity of PFHxS.
	Identified sensitive sub-populations	Infants have been identified as a sensitive group for the effects of decreased total T4.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	PFHxS exposure from tap water is expected to be predominantly from oral exposure. Inhalation exposure to PFHxS from tap water during household uses is negligible. OEHHA concludes that dermal absorption of PFHxS from tap water under conditions of household use is unlikely. Thus, inhalation and dermal exposures to PFHxS due to tap water use are expected to be negligible.
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	There are no studies of potential immunotoxicity or carcinogenicity. The lack of such studies is a concern because immunotoxicity and positive results in cancer bioassays have been observed for other PFAS such as PFOS and PFOA.
Any other relevant information that should be captured?		-
Assessed in Appendix D?		Yes

B.2.16 RIVM (2021a)

Agency Report Reference: RIVM (2021a). Revised Risk Assessment of GenX And PFOA in Food. Part 1: Toxicity of GenX and PFOA and intake through contaminated Dairy products, eggs and fish. 01-09-2021 (final version). Rijksinstituut voor Volksgezondheid en Milieu (RIVM). **Supporting Documentation:** RIVM (2018a). Mixture exposure to PFAS: A Relative Potency Factor approach. RIVM Report 2018-0070. Rijksinstituut voor Volksgezondheid en Milieu (RIVM).		
Refer to the data extraction table for PFOS: **Section B.1.19** as the Tolerable Weekly Intake (TWI) and Daily Intake from RIVM (2021a) were established by EFSA for the EFSA-4 (PFOA, PFOS, PFNA and PFHxS) as a sum together with relative potency factors (RPFs) for PFAS for the risk assessment of this group of compounds (including GenX and PFBS).		
Health considerations	Guideline value (include units)	• TWI (for EFSA-4): 4.4 ng/kg/wk. • Daily Intake (for EFSA-4): 0.63 ng/kg/day • RPF for GenX: 0.06 (unitless) • RPF for PFBS: 0.001 (unitless) (refer to RIVM 2018a).
Exposure considerations	Levels in drinking water supplies (include location)	Netherlands (Dordrecht, 37 locations) • PFBS: 3.0 ng/L (2015), 3.4 (2017) • GenX: No data • PFOS: <0.6 ng/L, 0.41 (2017) • PFOA: 4.5 ng/L, 2.2 (2017) • PFHxS: <0.6 ng/L, 0.43 (2017) • Sum of PFAS: 23.8 to 27.4 ng/L, 19.3- 21.3 ng/L (2017).
Assessed in Appendix D?		No, because TRV was adopted from EFSA (2020a).

B.2.17 USEPA (2023)

Agency Report Reference: USEPA (2023). IRIS Toxicological Review of Perfluorohexanesulfonic Acid (PFHxS, CASRN 335-46-4) and Related Salts. EPA Publication # EPA/635/R-23/148a. External Review Draft. July 2023. United States Environmental Protection Agency (USEPA).		
General Information	Date of data extraction	07 September 2023
	Authors	Center for Public Health and Environmental Assessment. Office of Research and Development. U.S. Environmental Protection Agency Washington.
	Publication date	July 2023.
	Literature search timeframe	No date restrictions identified by SLR in the Literature Search Strategy.
	Publication type	Agency Guideline
	Peer reviewed?	Yes. This assessment was provided for review to scientists in EPA's program and regional offices. Comments were submitted by: Office of Air and Radiation (OAR), Office of Air Quality and Standards (OAQPS), Office of Land and Emergency Management (OLEM), Office of Children's Health Protection (OCHP), Office of

Agency Report Reference: USEPA (2023). IRIS Toxicological Review of Perfluorohexanesulfonic Acid (PFHxS, CASRN 335-46-4) and Related Salts. EPA Publication # EPA/635/R-23/148a. External Review Draft. July 2023. United States Environmental Protection Agency (USEPA).		
		Water, Region 1, Region 3, Region 4, and Region 8. This assessment was provided for review to other federal agencies and the Executive Office of the President (EOP).
	Country of origin	US
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Reference dose (RfD)
	Exposure timeframe	Lifetime
	Critical human health endpoint	Decreased serum anti-tetanus antibody concentrations in children (male and female)
	Justification provided by agency for critical endpoint	The immune organ-/system-specific osRfD is based on the lowest overall POD_{HED} and UFC; therefore, the selected RfD based on decreased serum anti-tetanus antibody concentration in children (a susceptible lifestage for this effect) is considered protective of the observed health effects associated with lifetime PFHxS exposure.
	Critical study(ies) underpinning point of departure	Epidemiological study (Grandjean et al., 2012; Budtz-Jorgensen and Grandjean, 2018). • Grandjean, P., E.W. Andersen, E. Budtz-Jørgensen, F. Nielsen, K. Mølbak, P. Weihe, and C. Heilmann. 2012. Serum vaccine antibody concentrations in children exposed to perfluorinated compounds. JAMA 307:391–397 (as quoted in USEPA 2021d) • Budtz-Jørgensen, E., and P. Grandjean. 2018. Application of benchmark analysis for mixed contaminant exposures: mutual adjustment of perfluoroalkylate substances associated with immunotoxicity. PloS One 13(10):e0205388.
	Species for critical study(ies)	Children (male and female)
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	• $BMDL_{1/2SD}$ • Human equivalent dose POD (POD_{HED})
	Point of departure value (include units)	• Serum $BMDL_{1/2SD}$ = 0.000282 x 10^{-4} mg/L. • POD_{HED} = 0.0116 ng/kg/day
	Uncertainty factor(s) & rationale	A composite uncertainty factor of 30 to account for interindividual differences in human susceptibility (UFH = 10) and deficiencies in the toxicity evidence base (UFD = 3).
	Guideline value (include units)	RfD = 0.0004 ng/kg/day Note: An RfD of 0.2 ng/kg/day was derived for thyroid effects (decreased serum total T4 levels in

Agency Report Reference: USEPA (2023). IRIS Toxicological Review of Perfluorohexanesulfonic Acid (PFHxS, CASRN 335-46-4) and Related Salts. EPA Publication # EPA/635/R-23/148a. External Review Draft. July 2023. United States Environmental Protection Agency (USEPA).		
		F1 Wistar rats) using an uncertainty factor of 100 and a POD_{HED} of 24.9 ng/kg/day.
	Mode of action for critical health endpoint	Exposure to PFHxS was associated with the activation of several molecular signalling pathways and altered cellular functions thought to be involved in the MOA for liver toxicity of well-studied PFAS such as PFOA and PFOS. Although the MOA for PFHxS-induced immunosuppressive responses in humans is unknown, early-life exposures may alter the immune system and lead to unpredictable outcomes later in life or during other susceptible lifestages of reduced immunocompetence such as pregnancy, advanced lifestages, or immunocompromised states (IPCS, 2012) that show increased sensitivity with continuous, longer-term exposures.
	Genotoxic carcinogen?	No animal in vivo, mutagenicity or genotoxicity studies were identified.
	Identified sensitive sub-populations	Given the effects seen in the developing individuals (i.e. altered thyroid and immune functions), prenatal and early postnatal lifestages represent a potentially sensitive population for the effects of PFHxS exposure.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	The general population may be exposed to PFAS via inhalation of indoor or outdoor air, ingestion of drinking water and food, and dermal contact with PFAS-containing products. The oral route of exposure has been considered the most important route of exposure among the general population.
	Levels in drinking water supplies (include location)	EPA conducted monitoring for several PFAS in drinking water as part of the third Unregulated Contaminant Monitoring Rule (UCMR) (U.S. EPA, 2016c). Under the UCMR3, all public water systems (PWSs) serving more than 10,000 people and a representative sample of 800 PWSs serving 10,000 or fewer people were monitored for 30 unregulated contaminants between January 2013 and December 2015. PFHxS was among the 30 contaminants monitored and was detected above the minimum reporting level (MRL) of 0.03 µg/L in 55 of the 4,920 PWSs tested and in 207 of the 36,971 samples collected.
	Any special considerations to exposure levels (e.g. higher in drought?)	Populations that may experience exposures greater than those of the general population may include individuals in occupations that require frequent contact with PFHxS-containing products,

Agency Report Reference: USEPA (2023). IRIS Toxicological Review of Perfluorohexanesulfonic Acid (PFHxS, CASRN 335-46-4) and Related Salts. EPA Publication # EPA/635/R-23/148a. External Review Draft. July 2023. United States Environmental Protection Agency (USEPA).		
		such as individuals who install and treat carpets or firefighters. Populations living near fluorochemical facilities where environmental contamination has occurred may also be more highly exposed. Populations that rely primarily on seafood for most of their diet, possibly including some native American tribes, may also be disproportionately exposed to PFHxS.
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		-

B.2.18 WSDH (2019a, 2023a, 2022b)

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (SWDH). **Supporting Documentation:** WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (SWDH). **Supporting Documentation:** WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (SWDH).		
General Information	Date of data extraction	04 August 2023
	Authors	Washington State Department of Health (SWDH).
	Publication date	November 2019
	Literature search timeframe	Not applicable
	Publication type	Agency Guidance and Fact Sheets
	Peer reviewed?	Yes
	Country of origin	US (Washington)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Reference Dose (RfD) or Allowable daily intake (ADI) (WSDH 2022b) WA State Action Level (SAL)

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (SWDH).

Supporting Documentation: WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (SWDH).

Supporting Documentation: WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (SWDH).

		Health-based water concentration (HBWC) (WSDH 2023a)
	Exposure timeframe	Short-term and chronic
	Critical human health endpoint	SAL: Reduced thyroid hormone (T4) in rats (developmental concern)
	Justification provided by agency for critical endpoint	SAL: We selected the MDH RfD of 9.7 ng/kg-day based on thyroxinemia in adult male rats in the NTP study. This is supported by observations of reduced T4 in pregnant rats and their offspring in Ramhoi et al. 2018. The reduction in litter size observed in mice by Chang et al. was not supported by two studies in rats. Although the absence of reproductive toxicity in Butenhoff et al. and Ramhoi et al. could possibly be explained by lower serum levels in the rat studies, we preferred to base public health advice on a replicated result.
	Critical study(ies) underpinning point of departure	SAL: 28-day oral gavage study in adult rats NTP 2019 (as quoted in WSDH 2019a). • National Toxicology Program (NTP), NTP Technical Report on the Toxicity Studies of Perfluoroalkyl Sulfonates (Perfluorobutane Sulfonic Acid, Perfluorohexane Sulfonate Potassium Salt, and Perfluorooctane Sulfonic Acid) Administered by Gavage to Sprague Dawley Rats P.H. Service, Editor. 2019, U.S. Department of Health and Human Services: Research Triangle Park, NC. (note this report was revised in 2022)
	Species for critical study(ies)	SAL: Rats (WSDH 2022b)
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	LOAEL, BMDL, HED
	Point of departure value (include units)	• LOAEL: 0.625 mg/kg-day. • BMDL: 32.4 mg/L • HED: 0.00292 mg/kg/day
	Uncertainty factor(s) & rationale	300 (UFH=10, UFA=3, UFD=10
	Guideline value (include units)	• ADI or RfD: 9.7 ng/kg/day • SAL: 65 ng/L (WSDH 2023a) (in draft document WSDH 2019a where derivation is explained, this was 70 ng/L). • HBWC: 9 ng/L (WSDH 2023a)

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (SWDH). **Supporting Documentation:** WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (SWDH). **Supporting Documentation:** WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (SWDH).		
		Health-based water concentration (HBWC) are the "acceptable" values used to create a ratio of observed/acceptable for each of 4 PFAS (PFNA, PFHxS, PFBS and GenX). If the ratios add up to more than 1.0, action must be taken to lower PFAS in the drinking water (WSDH 2023a).
	Mode of action for critical health endpoint	Not stated.
	Genotoxic carcinogen?	Not stated.
	Identified sensitive sub-populations	Sensitive populations. Maternal thyroid insufficiency during pregnancy can affect the neurodevelopment of children. Women of childbearing age and developing foetuses are sensitive subgroups for this outcome.
	Any non-health-based considerations?	Not for PFHxS. For PFOS and PFOA only. The MCL (4 ng/L) is the lowest concentration of PFOA and PFOS that can be reliably measured by the lab methods required by EPA (drinking water testing methods 533 and 537.1) (WSDH 2023a).
Exposure considerations	Principal routes of exposure in general population	PFAS exposure in the home occurs during product use and exposure to house dust containing PFAS. The greatest portion of the chronic exposure to PFAS for the general public, specifically to PFOS and PFOA, results from the intake of contaminated drinking water and foods (WSDH 2022b)
	Levels in drinking water supplies (include location)	Results of **Total PFAS** testing of drinking water in Washington state including detections for PFBS (data from WSDH 2022b): • Issaquah Water System – Well #4: 796 ng/L then LOD (after GAC filter installed) (PFAS Detected: PFOS, PFHxS, PFHpA, PFOA, PFNA, PFBS). • Issaquah Water System – Well #5: Up to 60 ng/L (PFAS Detected: PFOS, PFHxS). • Sammamish Plateau Water and Sewer District: Up to 40 ng/L. (PFAS Detected: PFOS, PFHxS, PFNA, PFOA, PFBS). • Ft. Lewis (five wells): 15 – 71 ng/L(PFAS Detected: PFOA, PFOS, PFHxS, PFHpA, PFBS, PFHxA, PFNA). • McChord Field (four wells): 216-250 ng/L. (PFAS Detected: PFOA, PFOS, PFHxS, PFHpA, PFBS).

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (SWDH).

Supporting Documentation: WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (SWDH).

Supporting Documentation: WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (SWDH).

		• Town of Coupeville, Evergreen Mobile Home Park, Group B wells, and 20 private wells: 6 – 7,740 ng/L. (PFAS Detected: PFOS, PFOA, PFHxS, PFHxA, PFHpA, PFNA, PFBS). • Town of Coupeville water system (one well): 35 – 139 ng/L. (PFAS Detected: PFOA, PFHxS, PFHpA).
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	
Any other relevant information that should be captured?		Any change to a SAL or adopting a state MCL requires rulemaking (WSDH 2023a). In the meantime, we will continue to implement our requirements under our existing SALs (WSDH 2023a). PFNA is comparable to our SAL, PFHxS is lower than our SAL, and PFBS is higher than our SAL. We'll read EPA's support documentation to understand why they differ (WSDH 2023a). SLR Note: Also refer to compilation of Health-based value for subchronic/ chronic oral intake (ng/kg-day) in **Section B.1.22**.

Compilation of Health-based value for subchronic/ chronic oral intake (ng/kg-day)

Type of PFAA Chem.	Authoritative body responsible for value (year)	Health-based value for subchronic/ chronic oral intake (ng/kg-day)
PFHxS	ATDSR MRL (2021)	20
PFHxS	MDH RfD (2019)	9.7
PFHxS	NH DES RfD (2019)	4
PFHxS	MI SAW TV (2019)	9.7

Assessed in Appendix D?	No, as the TRV is adopted from another agency (MDH 2020b).

B.3 PFBS Existing Health-based Guidance

B.3.1 Alaska DEC (2019a)

Agency Report Reference: Alaska DEC (2019a). Technical Memorandum Action Levels for PFAS in Water and Guidance on Sampling Groundwater and Drinking Water. Date: August 20, 2018, Updated: October 2, 2019. Division of spill prevention and response. Contaminated sites program and Division of environmental health Drinking water program. Alaska Department of Environmental Conservation (Alaska DEC).		
Refer to the data extraction table for PFOS: **Section B.1.1** as the Action Level from Alaska DEC (2019a) for PFOS+PFOA. In 2018, Alaska DEC previously set an action level for the sum of PFOS, PFOA, PFNA, PFHxS, and PFHpA. A separate action level was set for PFBS.		
Health considerations	Guideline value (include units)	PFOS+PFOA: 70 ng/L NB: In 2018, Alaska DEC previously set an action level of 70 ng/L for PFOS, PFOA, PFNA, PFHxS, and PFHpA. A separate action level for the shorter-chain PFBS was set at 2.0 µg/L.
Assessed in Appendix D?		No, no basis provided.

B.3.2 ATSDR (2021a)

Agency Report Reference: ATSDR (2018a). Toxicological Profile for Perfluoroalkyls. Released May 2021. Agency for Toxic Substances and Disease Registry (ATSDR).		
General Information	Date of data extraction	03 August 2023
	Authors	Agency for Toxic Substances and Disease Registry (ATSDR).
	Publication date	May 2021.
	Literature search timeframe	Not date limited. The current literature search was intended to update the draft toxicological profile for perfluoroalkyls released for public comment in 2015. The following main databases were searched in March 2008, September/October 2013, May 2016, and September 2018: • PubMed • National Library of Medicine's TOXLINE • Scientific and Technical Information Network's TOXCENTER
	Publication type	Agency Guideline
	Peer reviewed?	Yes
	Country of origin	US
	Source of funding	Not stated
	Possible conflicts of interest	Not stated

Agency Report Reference: ATSDR (2018a). Toxicological Profile for Perfluoroalkyls. Released May 2021. Agency for Toxic Substances and Disease Registry (ATSDR).		
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Minimum Risk Level (MRL)
	Exposure timeframe	Intermediate (14 to 365 days)
	Critical human health endpoint	-
	Justification provided by agency for critical endpoint	There are insufficient data for derivation of an acute-duration, intermediate duration and chronic oral MRL for PFBS. Several studies have evaluated the toxicity of PFBS following intermediate-duration oral exposure and have identified several targets of toxicity. However, none of these studies included measurement of serum PFBS levels that are needed to calculate a HED and MRL derivation.
	Critical study(ies) underpinning point of departure	-
	Species for critical study(ies)	-
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	-
	Point of departure value (include units)	-
	Uncertainty factor(s) & rationale	-
	Guideline value (include units)	-
	Mode of action for critical health endpoint	The mode of action for most health outcomes associated with perfluoroalkyl exposure has not been fully characterised in humans or laboratory animals. Some perfluoroalkyl-induced effects observed in rats and mice appear to be mediated through the PPARα-dependent and -independent mechanisms. Interpretation of the relevance of the effects observed in laboratory animals is complicated since it is generally agreed that humans and nonhuman primates are refractory, or at least less responsive than rodents, to PPARα-mediated effects (Corton et al. 2014; Klaunig et al. 2003; Maloney and Waxman 1999). While studies in mice have identified specific effects that require PPARα activation, for example, postnatal viability (Abbott et al. 2007) and some immunological effects (Yang et al. 2002b), other effects such as hepatomegaly and antigen-specific antibody response (DeWitt et al. 2016) were reported to be PPARα-independent (Yang et al. 2002b). In the absence of data to the contrary, ATSDR assumes that the health effects observed in laboratory animals are relevant to humans.

Agency Report Reference: ATSDR (2018a). Toxicological Profile for Perfluoroalkyls. Released May 2021. Agency for Toxic Substances and Disease Registry (ATSDR).		
	Genotoxic carcinogen?	Little information is available on the genotoxicity of other perfluoroalkyl compounds, with available studies focused on DNA damage. No DNA damage was found in HepG2 cells incubated with 100 or 400 µM PFHxS or PFBS for 24 hours
	Identified sensitive sub-populations	It is not known whether children are more or less susceptible than adults to the effects of exposure to perfluoroalkyls because there are no studies that specifically addressed this question. Several studies have examined the possible associations between perfluoroalkyl exposure and health outcomes in children living in an area with high PFOA contamination and in the general population. Although some studies have found statistically significant associations, they are not adequate for establishing causality.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	• Germany (mineral, spring and tap water): max = 13.3 ng/L. • SLR note there are other studies discussed that report PFBS in groundwater however concentrations were not shown in ATSDR (2021a)
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		
Assessed in Appendix D?		Yes, but not for PFBS, as no guidance value was derived for this PFAS.

B.3.3 CDPH (2023a)

Agency Report Reference: CDPH (2023a). Per- and polyfluoroalkyl Substances (PFAS). 2023. Connecticut State Department of Public Health (CDPH)		
	Date of data extraction	07 August 2023

Agency Report Reference: CDPH (2023a). Per- and polyfluoroalkyl Substances (PFAS). 2023. Connecticut State Department of Public Health (CDPH)		
General Information	Authors	Connecticut State Department of Public Health (CDPH)
	Publication date	2023
	Literature search timeframe	Not stated
	Publication type	Agency webpage.
	Peer reviewed?	Not stated.
	Country of origin	US (Connecticut)
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	CT Drinking Water Action Level
	Exposure timeframe	Not stated.
	Critical human health endpoint	Thyroid effects
	Justification provided by agency for critical endpoint	CT DPH develops its drinking water Action Levels by considering health impacts to the most sensitive and most exposed populations across all stages of human development.
	Critical study(ies) underpinning point of departure	Not stated.
	Species for critical study(ies)	Animal studies
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Not stated.
	Point of departure value (include units)	Not stated.
	Uncertainty factor(s) & rationale	Not stated.
	Guideline value (include units)	760 ng/L
	Mode of action for critical health endpoint	Not stated.
	Genotoxic carcinogen?	Not stated.
	Identified sensitive sub-populations	Pregnant people, infants and children are at higher risk because of PFAS effects on pregnancy outcomes and foetal, infant and child growth and development.
	Any non-health-based considerations?	Not stated.
Exposure considerations	Principal routes of exposure in general population	Not stated.
	Levels in drinking water supplies (include location)	Not stated.

Agency Report Reference: CDPH (2023a). Per- and polyfluoroalkyl Substances (PFAS). 2023. Connecticut State Department of Public Health (CDPH)		
	Any special considerations to exposure levels (e.g. higher in drought?)	Not stated.
	Typical exposure in general population (include units for intakes & location)	Not stated.
Risk Summary	Any risks to human health from drinking water identified in agency document?	Not stated.
	Any emerging risks identified?	Not stated.
Any other relevant information that should be captured?		The chemical-specific approach reflects the evolving scientific evidence on the toxicity of PFAS and is more protective of public health than the summed approach used previously in CT.
Assessed in Appendix D?		No, no health basis provided.

B.3.4 EU (2020), EC (2022)

Agency Report Reference: EC (2022). Final Opinion on Groundwater quality standards for proposed additional pol **Agency Report Reference:** EU (2020). Directives. Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the Quality of Water Intended for Human Consumption (recast) (Text with EEA relevance). L 435/2, 23.12.2020. European Union (EU). **Supporting Documentation:** EC (2022). Final Opinion on Groundwater quality standards for proposed additional pollutants in the annexes to the Groundwater Directive (2006/118/EC) Scientific Committee on Health, Environmental and Emerging Risks SCHEER. 18 July 2022. DG Health and Food Safety. European Commission (EC).lutants in the annexes to the Groundwater Directive (2006/118/EC) Scientific Committee on Health, Environmental and Emerging Risks SCHEER. 18 July 2022. DG Health and Food Safety. European Commission (EC).		
Refer to the data extraction table for PFOS: **Section B.1.7** noting the value is for Sum of PFAS or Total PFAS.		
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Quality Standard for surface water – drinking water and human health ($EQS_{dw,hh}$)
	Guideline value (include units)	Technical Guidelines: 100 ng/L (EU 2020 only) Technical Guidelines and $EQS_{dw,hh}$: PFAS Total: 500 ng/L (EU 2020, EC 2022) NB: 'Total PFAS' as the totality of per- and polyfluoroalkyl substances detected with available analytical methods and monitoring guidelines (EU 2020, EC 2022). 'Sum of PFAS' means the sum of per- and polyfluoroalkyl substances considered a concern as to regards water intended for human consumption listed in point 3 of Part B of Annex III. This is a subset of 'PFAS Total' substances that contain a perfluoroalkyl moiety with three or more carbons (i.e. $–C_nF_{2n}–$, n ≥ 3) or a perfluoroalkylether moiety with two or more

Agency Report Reference: EC (2022). Final Opinion on Groundwater quality standards for proposed additional pol **Agency Report Reference:** EU (2020). Directives. Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the Quality of Water Intended for Human Consumption (recast) (Text with EEA relevance). L 435/2, 23.12.2020. European Union (EU). **Supporting Documentation:** EC (2022). Final Opinion on Groundwater quality standards for proposed additional pollutants in the annexes to the Groundwater Directive (2006/118/EC) Scientific Committee on Health, Environmental and Emerging Risks SCHEER. 18 July 2022. DG Health and Food Safety. European Commission (EC).lutants in the annexes to the Groundwater Directive (2006/118/EC) Scientific Committee on Health, Environmental and Emerging Risks SCHEER. 18 July 2022. DG Health and Food Safety. European Commission (EC).		
		carbons (i. e. $C_nF_{2n}OC_mF_{2m}$–, n and m ≥ 1) (EU 2020).
Assessed in Appendix D?		No, no health basis provided.

B.3.5 HC (2019a)

Agency Report Reference: HC (2019a). Water talk: Summary of drinking water values for PFOS, PFOA and other PFAS. Health Canada (HC). Government of Canada.		
General Information	Date of data extraction	03 August 2023
	Authors	Health Canada (HC). Government of Canada.
	Publication date	April 2019.
	Literature search timeframe	Not stated
	Publication type	Agency Guidance (Summary Document)
	Peer reviewed?	Not stated
	Country of origin	Canada
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Maximum acceptable concentration (MAC)
	Exposure timeframe	Lifetime
	Critical human health endpoint	-
	Justification provided by agency for critical endpoint	Scientific information is limited on the majority of PFAS. The drinking water screening values for most other PFAS were developed using PFOS and PFOA as surrogates, whereas they are expected to be less toxic because of their chemical structure.
	Critical study(ies) underpinning point of departure	-
	Species for critical study(ies)	-
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	-

Agency Report Reference: HC (2019a). Water talk: Summary of drinking water values for PFOS, PFOA and other PFAS. Health Canada (HC). Government of Canada.		
	Point of departure value (include units)	-
	Uncertainty factor(s) & rationale	Health Canada has developed screening values for a number of other PFAS at the request of several jurisdictions. As with formal guidelines, when screening values are developed, Health Canada includes a margin of safety (or 'buffer zone')
	Guideline value (include units)	PFBS: 15,000 ng/L
	Mode of action for critical health endpoint	-
	Genotoxic carcinogen?	-
	Identified sensitive sub-populations	Screening values are also established at a level designed to protect the health of Canadians, including children, based on a lifetime exposure to the substance.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	
Any other relevant information that should be captured?		Only PFOS and PFOA have been studied sufficiently to develop Guideline Technical Documents under the Guidelines for Canadian Drinking Water Quality. Short-term exposure to PFAS in drinking water at levels slightly higher than the maximum acceptable concentrations (MAC) or screening values, below, is not expected to result in health effects as these values are based on a lifetime of exposure to the substance. When guideline values are developed, Health Canada includes a margin of safety (or 'buffer zone'). As such, guideline values such as maximum acceptable concentrations (MACs) are established at a level designed to protect the

Agency Report Reference: HC (2019a). Water talk: Summary of drinking water values for PFOS, PFOA and other PFAS. Health Canada (HC). Government of Canada.	
	health of Canadians, including children, based on a lifetime exposure to the substance.
Assessed in Appendix D?	No, no health basis provided.

B.3.6 Mass DEP (2022a)

Agency Report Reference: Important Information. EPA's New Health Advisories for Some PFAS. August 11, 2022. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP). **Supporting Documentation:** Mass DEP (2023a). EPA Proposed Maximum Contaminant Level (MCL) for PFAS. April 12, 2023. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP).		
Refer to the data extraction table for PFOS: **Section B.1.12**.		
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	• EPA's Health Advisories • Maximum Contaminant Level (MCL) • Maximum Contaminant Level Goals (MCLGs) (Mass DPH 2023a)
	Guideline value (include units)	• MCL (PFAS6): 20 ng/L for the sum of six PFAS (PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA) (established an enforceable in Massachusetts) The two EPA Interim Health Advisories and two Final Health Advisories are: • Interim Health Advisory for PFOA: 0.004 ng/L • Interim Health Advisory for PFOS: 0.02 ng/L • Final Health Advisory for GenX: 10 ng/L • Final Health Advisory for PFBS: 2,000 ng/L MCLGs from Mass DPH (2023a): • PFOS: 4 ng/L • PFOA: 4 ng/L • PFNA, PFHxS, PFBS, & GenX: Hazard Index of 1. NB: Massachusetts will adopt PFAS drinking water regulations that are at least as stringent as the federal standards (Mass DEP 2023a). NB: Mass DEP (2023a) is proposing to address four additional PFAS (GenX, PFBS, PFNA, and PFHxS) as a mixture using a Hazard Index. A Hazard Index accounts for the increased risk from mixtures of PFAS (Mass DEP 2023a). SLR note that it is not clear how the Hazard Index will be calculated, i.e. which MCLG, HA or MCL will be used for the calculation.
Assessed in Appendix D?		No, adopted from other agencies. No basis provided.

B.3.7 MDH (2022g, 2022e)

Agency Report Reference: MDH (2022g). Toxicological Summary for: Perfluorobutane sulfonate. March 2022. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH). **Supporting Documentation:** MDH (2022e). PFBS and Drinking Water. March 2022. Minnesota Department of Health (MDH).		
General Information	Date of data extraction	04 August 2023
	Authors	Minnesota Department of Health (MDH)
	Publication date	March 14, 2023
	Literature search timeframe	Not stated
	Publication type	Agency Guideline
	Peer reviewed?	Not stated
	Country of origin	US (Minnesota)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Reference Dose (RfD) Short-term Non-Cancer Health-Based Value ($nHBV_{Short-term}$) Subchronic Non-Cancer Health-Based Value ($nHBV_{Subchronic}$)
	Exposure timeframe	Short-term and chronic durations
	Critical human health endpoint	Decreased total T4
	Justification provided by agency for critical endpoint	A new toxicity study in rats evaluating sensitive thyroid endpoints.
	Critical study(ies) underpinning point of departure	National Toxicology Program 2019 (as quoted in MDH (2022g). • National Toxicology Program. (2019). "Toxicity studies of perfluoroalkyl sulfonates administered by gavage to Sprague Dawley (Hsd:Sprague Dawley SD) rats (TOX-96)." from https://cebs.niehs.nih.gov/cebs/publication/TOX-96.
	Species for critical study(ies)	Rats
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	$BMDL_{1SD}$, HED
	Point of departure value (include units)	$BMDL_{1SD}$ = 6.97 mg/kg-d HED = 0.0084 mg/kg/day [6.97 mg/kg/day x half-life female rat of 1.3 hr ÷ half-life in human of 1,050 hr]
	Uncertainty factor(s) & rationale	100 3 for interspecies differences (for toxicodynamics), 10 for intraspecies variability, and 3 for database uncertainty due to a lack of available immunotoxicity and developmental neurotoxicity studies (known

Agency Report Reference: MDH (2022g). Toxicological Summary for: Perfluorobutane sulfonate. March 2022. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH). **Supporting Documentation:** MDH (2022e). PFBS and Drinking Water. March 2022. Minnesota Department of Health (MDH).		
		sensitive effects of other PFAS) as well as lack of a 2-generation study in a more appropriate species
	Guideline value (include units)	• RfD: 84 ng/kg/day • $nHBV_{Short\text{-}term}$: 100 ng/L • $nHBV_{Subchronic}$: 100 ng/L ($nHBV_{Short\text{-}term}$ adopted) $nHBV_{Short\text{-}term}$ (µg/L) = Reference Dose (mg/kg-d) x Relative Source Contribution x Conversion Factor ÷ Short-term Intake Rate (L/kg-d) = (0.000084 mg/kg-d) x (0.5) x (1000 µg/mg) ÷ (0.290 L/kg-d) = 0.14 µg/L rounded to 0.1 µg/L (equivalent to 100 ng/L) $nHBV_{Subchronic}$ (µg/L) = (0.000084 mg/kg-d) x (0.2) x (1000 µg/mg) ÷ (0.074 L/kg-d) = 0.23 rounded to 0.2 µg/L (equivalent to 200 ng/L) NB: Refer to News Release from MDH (2023a) for MCLs and Hazard index approach for assessing PFOS, PFOA, PFHxS, PFBS and GenX.
	Mode of action for critical health endpoint	-
	Genotoxic carcinogen?	-
	Identified sensitive sub-populations	-
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	You can be exposed to PFBS if you use products containing PFBS or treated with stain-resistant coatings containing PFBS. PFBS is more easily eliminated from the body than some PFAS, such as PFOA and PFOS. As a result, the build-up in the body over time is much lower. For people living in areas affected by PFAS release or disposal, drinking water may be a major source of PFBS exposure.
	Levels in drinking water supplies (include location)	PFBS has been detected in private drinking water wells and public drinking water systems in several parts of Minnesota where known industrial use or disposal of PFBS occurred in the past. PFBS has been detected in sources of public drinking water at levels up to 300 ng/L.
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-

Agency Report Reference: MDH (2022g). Toxicological Summary for: Perfluorobutane sulfonate. March 2022. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH). **Supporting Documentation:** MDH (2022e). PFBS and Drinking Water. March 2022. Minnesota Department of Health (MDH).		
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		The calculated Subchronic RfD (0.00054 mg/kg-d) is higher than the Short-Term RfD (0.000084 mg/kg-d), which is based on thyroid effects. The Subchronic RfD must be protective of all types of adverse effects that could occur as a result of subchronic exposure, including short-term effects (MDH 2008, page 34). Therefore, the Short-Term RfD is used in place of the calculated Subchronic RfD when deriving subchronic water guidance.
Assessed in Appendix D?		Yes.

B.3.8 MDH (2023a)

Agency Report Reference: MDH (2023a). News Release. Joint agency statement on draft federal limits on PFAS in drinking water. March 14, 2023. Minnesota Department of Health (MDH)		
Refer to the data extraction table for PFOS: **Section B.1.14**.		
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Hazard Index Approach
	Guideline value (include units)	EPA is also proposing that four PFAS (PFBS, PFHxS, GenX and PFNA) be evaluated in combination with each other, using an approach called a Hazard Index. A hazard index is calculated by comparing a measured drinking water value with a standard. SLR presumes the standard is the MCL of 4 ng/L for PFOS and PFOA.
	Any non-health-based considerations?	Not stated. NB: The MCLs adopted by MDH (2023a) are equivalent to the MCLG from USEPA (2022d, 2022e) of 4 ng/L for PFOA and PFOS which is based on a minimum reporting level (MRL).
Assessed in Appendix D?		No, no basis provided but likely adopted from another agency.

B.3.9 MPART (2019a)

Agency Report Reference: MPART (2019a). Health-Based Drinking Water Value Recommendations for PFAS in Michigan. June 27, 2019. Michigan Science Advisory Workgroup. Michigan's PFAS Action Response Team (MPART).		
General Information	Date of data extraction	08 August 2023
	Authors	Michigan's PFAS Action Response Team (MPART).
	Publication date	June 27, 2019
	Literature search timeframe	Not stated.
	Publication type	Agency Guidance
	Peer reviewed?	Not stated.
	Country of origin	US (Michigan)
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Toxicity value Drinking water Health-based value (HBV)
	Exposure timeframe	Not stated
	Critical human health endpoint	Decreased serum total thyroxine (T4) in newborn (PND 1) mice
	Justification provided by agency for critical endpoint	Selection of total T4 as the critical effect is based on several key considerations that account for cross-species correlations in thyroid physiology and hormone dynamics particularly within the context of a developmental life stage. The Workgroup evaluated available agency decision documents and selected the study associated with the draft USEPA (2018) PFBS toxicity value based on thyroid effects. The kidney effects identified in the draft USEPA (2018) toxicity assessment were identified as a potentially compensatory response. The thyroid effects were identified as having greater functional significance. For all of the PFAS examined, points of departure were selected from studies with laboratory animal models. This approach does not negate findings associated with epidemiological studies, but reflects that humans experience uncontrolled and imperfectly documented rather than controlled, precisely measured exposures. Additionally, these points of departure reflect adverse health effects that occur at low doses and that are supported by the weight-of-evidence across endpoints and between findings in humans and laboratory animal models.
	Critical study(ies) underpinning point of departure	Developmental toxicity studies in mice (Feng et al. 2017). • Feng, X; Cao, X; Zhao, S; Wang, X; Hua, X; Chen, L; Chen, L. (2017). Exposure of pregnant mice to perfluorobutanesulfonate causes hypothyroxinemia and developmental

Agency Report Reference: MPART (2019a). Health-Based Drinking Water Value Recommendations for PFAS in Michigan. June 27, 2019. Michigan Science Advisory Workgroup. Michigan's PFAS Action Response Team (MPART).		
		abnormalities in female offspring. Toxicol Sci 155: 409-419.
	Species for critical study(ies)	Mice
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	$BMDL_{20}$, POD_{HED}
	Point of departure value (include units)	$BMDL_{20}$ = 28.19 mg/kg/day $BMDL_{20}$-POD_{HED} = 0.0892 mg/kg/day [The $BMDL_{20}$ of 28.19 mg/kg/day was divided by the Dose Adjustment Factor of 316 (human serum half-life/female mouse serum half-life = 665 hours/2.1 hours = 316) (MDH, 2017)].
	Uncertainty factor(s) & rationale	300 1 for LOAEL to NOAEL, 10 for human variability, 3 (100.5) for animal to human variability, 1 for subchronic to chronic, 10 for database deficiencies, for the lack of neurodevelopmental, immunotoxicological, and chronic studies.
	Guideline value (include units)	Toxicity Value: 300 ng/kg/day Drinking water HBV: 420 ng/L [HBV = (RSC x Toxicity value x Body weight) ÷ water intake; HBV = (0.2 x 300 ng/kg/day x 7.8 kg for 1-year old infant) ÷ 1.106 L/day]
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Not stated
	Identified sensitive sub-populations	Not clearly stated although an UF was applied for the lack of information on early-life sensitivity.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-

Agency Report Reference: MPART (2019a). Health-Based Drinking Water Value Recommendations for PFAS in Michigan. June 27, 2019. Michigan Science Advisory Workgroup. Michigan's PFAS Action Response Team (MPART).	
Any other relevant information that should be captured?	-
Assessed in Appendix D?	Yes.

B.3.10 OEHHA (2021d)

Agency Report Reference: OEHHA (2021d). Notification Level Recommendation. Perfluorobutane Sulfonic Acid in Drinking Water. January 2021. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.		
General Information	Date of data extraction	02 August 2023.
	Authors	Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.
	Publication date	January 2021.
	Literature search timeframe	Unrestricted.
	Publication type	Agency Guidance Document.
	Peer reviewed?	Yes.
	Country of origin	US (California)
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	• Acceptable Daily Dose (ADD) • Health-Protective Concentration (C)
	Exposure timeframe	
	Critical human health endpoint	• Decreased T4 levels in PND1 mice (Feng et al. 2017 as quoted in OEHHA 2021d). • Reduction of the thyroid hormone, thyroxine (T4), in non-pregnant female rats (NTP, 2019 as quoted in OEHHA 2021d).
	Justification provided by agency for critical endpoint	There were four studies determined to be of acceptable quality, adequate data reporting, and sufficient sensitivity for health-protective concentration derivation. They included two subchronic oral studies, a two-generation reproductive toxicity study in rats, and a developmental toxicity study. Thyroid hormone disruption from the Feng et al. (2017) and NTP (2022) studies were the most sensitive endpoints in the PFBS animal toxicity database, and both were considered for health-protective concentration derivation.

Agency Report Reference: OEHHA (2021d). Notification Level Recommendation. Perfluorobutane Sulfonic Acid in Drinking Water. January 2021. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.		
		NB: OEHHA (2021d) derived an ADD and C using the mouse study rather than the rat study due to uncertainties of kinetics in the rat.
	Critical study(ies) underpinning point of departure	• Developmental toxicity study (Feng et al. 2017 as quoted in OEHHA 2021d). • 28-day oral gavage study in adult rats (NTP, 2019 as quoted in OEHHA 2021d)
	Species for critical study(ies)	Non-pregnant female rats
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	NOAEL, LOAEL, $BMDL_{1SD}$: and POD_{HED} for both studies.
	Point of departure value (include units)	From the developmental toxicity study (Feng et al. 2017 as quoted in OEHHA 2021d). • NOAEL: 50 mg/kg/day. • $BMDL_{1SD}$: 22.2 mg/kg/day. • POD Human: 0.06 mg/kg/day [Ratio of animal to human clearance = (0.056 L/kg/h x 1000 mL/L x 24 h/day) ÷ 3.9 mL/kg/day = 345; $BMDL_{1SD}$ ÷ Ratio of clearance of 345 = POD Human]. From the 28-day oral gavage study in adult rats (NTP, 2019 as quoted in OEHHA 2021d) • LOAEL: 62.6 mg/kg/day. • $BMDL_{1SD}$: 6.9 mg/kg/day. • POD Alt/Human: 0.007mg/kg/day. NB: Despite having a lower POD, OEHHA decided against using the NTP (2022) study to derive an ADD because of large toxicokinetic differences between female rats and humans, and uncertainty around the utility of the rat model for effects in humans of maternal thyroid hormone disruption on foetal development.
	Uncertainty factor(s) & rationale	For the developmental toxicity study (Feng et al. 2017 as quoted in OEHHA 2021d): Applied an interspecies UF of √10 to account for potential differences in pharmacodynamics when extrapolating data from animal studies to humans. Because PFBS is not known to be metabolised in animals or humans, and because a pharmacokinetic adjustment was applied to the animal POD to derive a human equivalent dose, the pharmacokinetic components of the interspecies and intraspecies UF were reduced by √10 each. Therefore, the intraspecies UF was reduced from OEHHA's default of 30 to 10 to account for human variability. Additionally, an additional UF of √10 was applied for database deficiencies, most notably the absence of a

Agency Report Reference: OEHHA (2021d). Notification Level Recommendation. Perfluorobutane Sulfonic Acid in Drinking Water. January 2021. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.		
		chronic toxicity study. This resulted in a composite UF of 100.
	Guideline value (include units)	• ADD: 600 ng/kg/day • C: 500 ng/L NB: C = ADD × RSC ÷ DWI = 0.0006 mg/kg-day × 0.2 ÷ 0.237 L/kg-day, where RSC = relative source contribution and DWI = drinking water intake rate)
	Mode of action for critical health endpoint	While the mode of action (MOA) by which PFBS disrupts thyroid hormones is unknown at this time, the resulting reduction of T3 and T4 in animal models supports a thyroid hazard.
	Genotoxic carcinogen?	Not stated. NB: There were no studies of the carcinogenicity of PFBS
	Identified sensitive sub-populations	Infants are less able to tolerate decreases in T4 because they have less than one day's worth of T4 stores compared to adults, who have several weeks' worth. Also, infants have higher exposure to drinking water contaminants because they consume more water (when fed reconstituted formula) on a body weight basis than adults. NB: Female rats were also more sensitive to thyroid hormone perturbation than males
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	PFBS exposure from tap water is expected to be predominantly from oral exposure. According to the Norwegian Geotechnical Institute (NGI, 2018), the volatilization of PFBS and K+PFBS from water is negligible, and the air-phase presence is due to direct emissions into the air or contaminated water droplets or particles. Although no studies were found that evaluated the absorption of PFBS following dermal exposure, based on typical household uses of tap water, like showering and bathing, dermal absorption is not anticipated to be a significant route of exposure. Thus, inhalation and dermal exposures to PFBS during household uses of tap water are expected to be negligible.
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	The European Food Safety Authority (EFSA) estimated dietary exposures to PFBS ranged from 0.03−1.89 nanograms per kilogram per day (ng/kg-

Agency Report Reference: OEHHA (2021d). Notification Level Recommendation. Perfluorobutane Sulfonic Acid in Drinking Water. January 2021. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.		
		day) (minimum) to 0.10−3.72 ng/kg-day (maximum)
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	There are also no studies of potential immunotoxicity or carcinogenicity, which is a concern as to effects on immunotoxicity and positive results in cancer bioassays have been observed for other PFAS such as PFOS and PFOA.
Any other relevant information that should be captured?		-
Assessed in Appendix D?		Yes.

B.3.11 RIVM (2018a)

Agency Report Reference: RIVM (2018a). Mixture exposure to PFAS: A Relative Potency Factor approach. RIVM Report 2018-0070. Rijksinstituut voor Volksgezondheid en Milieu (RIVM).		
General Information	Date of data extraction	03 August 2023
	Authors	Rijksinstituut voor Volksgezondheid en Milieu (RIVM)
	Publication date	2018
	Literature search timeframe	Not stated.
	Publication type	Agency Guidance
	Peer reviewed?	Not stated.
	Country of origin	Netherlands
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Relative Potency Factor (RPF)
	Exposure timeframe	Chronic
	Critical human health endpoint	Relative liver weight (for all PFAS)
	Justification provided by agency for critical endpoint	In general, the RPFs based on absolute and relative liver weight are similar, and the RPFs based on hypertrophy are below those based on liver weight. Since the set of RPFs derived from relative liver weight is the most complete set, the use of the RPFs derived from this endpoint is suggested. Due to the uncertainties in the RPFs, it is

Agency Report Reference: RIVM (2018a). Mixture exposure to PFAS: A Relative Potency Factor approach. RIVM Report 2018-0070. Rijksinstituut voor Volksgezondheid en Milieu (RIVM).		
		considered appropriate to round them off to one significant digit.
	Critical study(ies) underpinning point of departure	PFBS: Two-generation reproduction study in rats (Lieder, 2009b as quoted in RIVM 2018b). • Lieder, P.H., York, R.G., Hakes, D.C., Chang, S.C., Butenhoff, J.L. (2009b). A two-generation oral gavage reproduction study with potassium perfluorobutanesulfonate (K+PFBS) in Sprague Dawley rats. Toxicology B, 259(1-2): 33-45. PFOA: 13-Week dietary toxicity study in rats (Perkins, 2004 as quoted in RIVM 2018a) • Perkins, R., Butenhoff, J., Kennedy, G. and Palazzolo, M. (2004). 13-Week dietary toxicity study of ammonium perfluorooctanoate (APFO) in male rats. Drug and Chemical Toxicology 27: 361-378 (as cited in SIAR, 2006).
	Species for critical study(ies)	Rats
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	BMD_{05}
	Point of departure value (include units)	**Derived BMD in mg/kg bw/day for two models (Table A7).** **PFAS** **Exp** **Hill** PFBS 224.8 232 PFOA 0.288 0.2938
	Uncertainty factor(s) & rationale	Not applicable.
	Guideline value (include units)	0.001 (unitless)
	Mode of action for critical health endpoint	PFAS are known to cause effects on the liver (though the mode of action remains unknown).
	Genotoxic carcinogen?	Not stated
	Identified sensitive sub-populations	-
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	Netherlands (Dordrecht, 37 locations) • PFBS: 3.0 ng/L (2015), 3.4 (2017) • GenX: No data • PFOS: <0.6 ng/L, 0.41 (2017) • PFOA: 4.5 ng/L, 2.2 (2017) • PFHxS: <0.6 ng/L, 0.43 (2017)

Agency Report Reference: RIVM (2018a). Mixture exposure to PFAS: A Relative Potency Factor approach. RIVM Report 2018-0070. Rijksinstituut voor Volksgezondheid en Milieu (RIVM).		
		• Sum of PFAS: 23.8 to 27.4 ng/L, 19.3- 21.3 ng/L (2017).
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	PFOA equivalents are calculated for a mixture of PFAS congeners, while neglecting the conversion of environmental PFAS precursors to these congeners. The extent to which this introduces uncertainty in the calculation of PFOA equivalents depends on the occurrence of the precursors in the media of interest
Any other relevant information that should be captured?		The RPF approach taken rests on the assumption of dose-addition, i.e. the absence of any interaction between mixture congeners in inducing liver toxicity. Verifying this assumption requires the availability of toxicity studies in which mixture toxicity is directly compared with that of its constituting congeners. Unfortunately, such studies are not available for PFAS. Therefore, for the time being, the assumption made concerning the dose addition of PFAS congeners still needs to be verified.
Assessed in Appendix D?		No, as no guidance value or guideline value were derived specifically for PFBS. Only a potency factor relative to PFOA is provided.

B.3.12 USEPA (2021c)

Agency Report Reference: USEPA (2021c). Human Health Toxicity Values for Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-49-3). EPA/600/R-20/345F. April 2021. United States Environmental Protection Agency (USEPA).		
General Information	Date of data extraction	01 August 2023
	Authors	U.S. Environmental Protection Agency, Office of Water (4304T). Health and Ecological Criteria Division, Washington, DC 20460.
	Publication date	April 2021
	Literature search timeframe	No date restrictions identified by SLR in the Literature Search Strategy. Initial database searches were conducted on July 18, 2017 using four online scientific databases

Agency Report Reference: USEPA (2021c). Human Health Toxicity Values for Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-49-3). EPA/600/R-20/345F. April 2021. United States Environmental Protection Agency (USEPA).		
		(PubMed, Web of Science [WOS], TOXLINE, and TSCATS via TOXLINE) and updated on February 28, 2018; May 1, 2019; and May 15, 2020. The literature search focused on chemical name and synonyms (see Table A-1) with no limitations on publication type, evidence stream (i.e. human, animal, in vitro, and in silico) or health outcomes. Beyond database searches, references were also identified from studies submitted under the Toxic Substances Control Act (TSCA) and from review of other government documents (e.g. Agency for Toxic Substances and Disease Registry [ATSDR]) and combined with the results of the database search. Search results are retained in the U.S. EPA's Health and Environmental Research Online (HERO) database.
	Publication type	Agency Guideline
	Peer reviewed?	Yes
	Country of origin	US
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Oral RfDs
	Exposure timeframe	Subchronic and chronic NB: Chronic RfD shown below.
	Critical human health endpoint	Perturbation of thyroid hormone levels (e.g. T4) was used as the critical effect for deriving a subchronic and chronic RfD Decreased serum total T4 observed in newborn (Postnatal Day [PND] 1) mice
	Justification provided by agency for critical endpoint	The hazards of potential concern for oral PFBS exposure include thyroid, developmental, and kidney effects. Overall, the evidence supports a hazard for thyroid, developmental, and kidney effects based on the evidence from animal studies. The limited evidence for thyroid or renal effects in human studies is equivocal, and no studies evaluating developmental effects following PFBS exposure in humans were available. Thus, data in humans were not considered further, and the available animal studies that evaluated these effects are considered in the derivation of oral RfDs.
	Critical study(ies) underpinning point of departure	The gestational exposure study in mice was selected as the principal study for deriving the RfD based on thyroid effects (Feng et al. 2017). Feng, X; Cao, X; Zhao, S; Wang, X; Hua, X; Chen, L; Chen, L. (2017). Exposure of pregnant mice to

Agency Report Reference: USEPA (2021c). Human Health Toxicity Values for Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-49-3). EPA/600/R-20/345F. April 2021. United States Environmental Protection Agency (USEPA).		
		perfluorobutanesulfonate causes hypothyroxinemia and developmental abnormalities in female offspring. Toxicol Sci 155: 409-419. http://dx.doi.org/10.1093/toxsci/kfw219 (as quoted in USEPA 2021c)
	Species for critical study(ies)	Mice
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	$BMDL_{0.5SD}$ human equivalent dose (HED)
	Point of departure value (include units)	0.095 mg/kg-day for K+PFBS [body weight allometric scaling was used to convert POD in mice to POD_{HED}).
	Uncertainty factor(s) & rationale	A composite uncertainty factor (UFC) of 300 to account for extrapolation from mice to humans (UFA of 3), for interindividual differences in human susceptibility (UFH of 10), and deficiencies in the toxicity database (UFD of 10) (a value of 1 was applied for UFS and UFL)
	Guideline value (include units)	• RfD for K+PFBS: 320 ng/kg-day • RfD for PFBS (free acid): 280 ng/kg-day rounded to 300 ng/kg-day. The overall confidence in the subchronic RfD for thyroid effects is medium.
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Lack of genotoxic activity (see Table 5, USEPA 2021c)
	Identified sensitive sub-populations	Early life stages as well as pregnant women are potentially susceptible to PFBS exposure.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	PFBS has been detected in humans, confirming exposure to this PFAS; however, the magnitude of human exposure likely depends on factors such as occupation (e.g. processing and/or manufacture of PFBS or PFBS-containing products and chrome electroplating) and living conditions (e.g. proximity to locations that make or use PFBS-containing products and nearby well-water use).
	PFBS Levels in drinking water supplies (include location)	It has also been found in food contact materials, dust, and source and finished drinking water. • US: 0.09 to 0.37 µg/L (water systems serving Alabama, Colorado, Georgia, the Northern Mariana Islands, and Pennsylvania)

Agency Report Reference: USEPA (2021c). Human Health Toxicity Values for Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-49-3). EPA/600/R-20/345F. April 2021. United States Environmental Protection Agency (USEPA).		
	Any special considerations to exposure levels (e.g. higher in drought?)	Oral exposure via drinking water might be expected in areas where contamination has been reported.
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	Note: there are no PFBS studies available that have specifically evaluated health effect domains of emerging concern across the PFAS class such as immunotoxicity and mammary gland development. Further, neurodevelopmental effects are of particular concern when perturbations in thyroid hormone occur during a sensitive early life stage, and the absence of a study evaluating neurodevelopmental effects following PFBS exposure is a source of uncertainty in the assessment.
Any other relevant information that should be captured?		- (refer to USEPA 2022k)
Assessed in Appendix D?		Yes.

B.3.13 USEPA (2022k, 2022c)

Agency Report Reference: USEPA (2022k). Drinking Water Health Advisory: Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-49-3). EPA/822/R-22/006. June 2022. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).		
General Information	Date of data extraction	01 August 2023
	Authors	U.S. Environmental Protection Agency, Office of Water (4304T). Office of Science and Technology. Health and Ecological Criteria Division, Washington, DC 20460.
	Publication date	June 2022
	Literature search timeframe	Not stated (NB: The literature search for Relative Source Contribution is specified)
	Publication type	Agency Guideline

Agency Report Reference: USEPA (2022k). Drinking Water Health Advisory: Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-49-3). EPA/822/R-22/006. June 2022. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).		
	Peer reviewed?	This Health Advisory document was provided for review by staff in the following EPA program Offices: Office of Water, Office of Chemical Safety and Pollution Prevention, Office of Pollution Prevention and Toxics, Office of Land and Emergency Management, Office of Policy, Office of Children's Health Protection, Office of Research and Development
	Country of origin	US
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	• Health Advisory (HA) • Chronic reference dose (RfD)
	Exposure timeframe	Lifetime
	Critical human health endpoint	Decreased serum levels of the T4 in newborn mice
	Justification provided by agency for critical endpoint	In Feng et al. (2017), developmental effects occurred at PND 1 and were sustained through pubertal (PND 30) and adult periods (PND 60). This is consistent with the potential for long-term health consequences of gestational-only PFBS exposure and suggests that gestation is at least one critical window for PFBS.
	Critical study(ies) underpinning point of departure	The oral gestational exposure study in mice was selected as the principal study for deriving the RfD based on thyroid effects (Feng et al. 2017). • Feng, X; Cao, X; Zhao, S; Wang, X; Hua, X; Chen, L; Chen, L. (2017). Exposure of pregnant mice to perfluorobutanesulfonate causes hypothyroxinemia and developmental abnormalities in female offspring. Toxicol Sci 155: 409-419. http://dx.doi.org/10.1093/toxsci/kfw219 (as quoted in USEPA 2021c)
	Species for critical study(ies)	Mice
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	$BMDL_{0.5SD}$ human equivalent dose (HED)
	Point of departure value (include units)	0.095 mg/kg-day for K+PFBS
	Uncertainty factor(s) & rationale	This POD (HED) served as the critical effect and was divided by a composite UF (UFC) of 300. The UFC is based on an animal-to-human UF (UFA) of

Agency Report Reference: USEPA (2022k). Drinking Water Health Advisory: Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-49-3). EPA/822/R-22/006. June 2022. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).		
		3 to account for extrapolation from mice to humans; an intrahuman UF (UFH) of 10 to account for interindividual differences in human susceptibility; and a database UF (UFD) of 10 to account for deficiencies in the toxicity database. A value of 1 was applied for the extrapolation from subchronic to a chronic exposure duration UF (UFS) because extrapolation from subchronic to chronic was not needed, and UFL because a LOAEL to NOAEL approach was not used
	Guideline value (include units)	• RfD for K+PFBS: 320 ng/kg-day • RfD for PFBS (free acid): 280 ng/kg-day rounded to 300 ng/kg-day. • HA: 2,000 ng/L (= RfD * RSC ÷ DWI-BW) where o Relative source contribution (RSC) = 0.2 o DWI-BW = 0.0354 L/kg/bw/day (the 90th percentile drinking water intake for the selected population, Women of childbearing age).
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Not stated (refer to USEPA 2021c)
	Identified sensitive sub-populations	Potentially sensitive populations include the developing embryo and foetus (exposed to PFBS via the pregnant woman) and women of childbearing age who may be or become pregnant.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	Not stated (refer to USEPA 2021c)
	Levels in drinking water supplies (include location)	It has also been found in food contact materials, dust, and source and finished drinking water. • US: 0.09 to 0.37 µg/L (water systems serving Alabama, Colorado, Georgia, the Northern Mariana Islands, and Pennsylvania) • US: 0.43 – 37 ng/L (n = 11 DWTPs) • US: ND to 11.9 ng/L (sourced from Mississippi River). • Hu et al 2019: ND–2.97 ng/L) • Bradley et al. (2020): ND–0.5 ng/L • Europe: Across these 12 studies, mean PFBS concentrations ranged from 0.015 in Sweden to 13.2 ng/L in the Netherlands (Ullah et al.,

Agency Report Reference: USEPA (2022k). Drinking Water Health Advisory: Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-49-3). EPA/822/R-22/006. June 2022. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).		
		2011) and the maximum PFBS concentration was 69.43 ng/L • Four of the 17 studies (DWTPs): Range from ND in Faroe Islands to 24 ng/L in Netherlands • US (Bottled water): ND to 1.44 ng/L. • Europe (Bottled water): ND to 51 ng/L (in four of seven studies from European countries)
	Any special considerations to exposure levels (e.g. higher in drought?)	Overall, studies that analysed water from sites receiving inputs from or in proximity to known sources of PFAS (as reported by study authors) did not provide a consistent pattern of detection; increased PFBS detection frequencies (DFs) or concentrations were not only observed in studies of sites with known sources of PFAS contamination.
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	- (refer to USEPA 2021c)
Any other relevant information that should be captured?		Cumulative exposures (from USEPA 2022c): Use the Hazard Index (HI) approach to assess the potential noncancer risk of a mixture of PFOA, PFOS, GenX chemicals, and PFBS (USEPA 2022c), i.e. HI = $(Conc._{PFOA} \div HA_{PFOA}) + (Conc._{PFOS} \div HA_{PFOS}) + (Conc._{PFBS} \div HA_{PFBS}) + (Conc._{GenX} \div HA_{GenX})$. High-pressure membrane processes such as nanofiltration (NF) and reverse osmosis (RO) are generally effective at removing organic solutes and dissolved ions and have been shown to successfully reduce or remove PFBS from drinking water
Assessed in Appendix D?		No, as the TRV is already assessed in US EPA 2021c.

B.3.14 WSDH (2019a, 2023a, 2022b)

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (SWDH).

Supporting Documentation: WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (SWDH).

Supporting Documentation: WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (SWDH).

General Information	Date of data extraction	04 August 2023
	Authors	Washington State Department of Health (SWDH).
	Publication date	November 2019
	Literature search timeframe	Not applicable
	Publication type	Agency Guidance and Fact Sheets
	Peer reviewed?	Yes
	Country of origin	US (Washington)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	For the SAL: Reference Dose (RfD) or Allowable daily intake (ADI) (WSDH 2022b) WA State Action Level (SAL) EPA Health Advisory Levels Health-based water concentration (HBWC) (WSDH 2023a)
	Exposure timeframe	EPA will regulate PFAS as chronic contaminants.
	Critical human health endpoint	Reduced thyroid hormone (T4) in mice (developmental concern) (WSDH 2022b)
	Justification provided by agency for critical endpoint	We recommend using the EPA 2018 assessment of PFBS toxicity with the dosimetric adjustment factor developed by MDH 2017. The EPA 2018 toxicological assessment was comprehensive and incorporated recent data available for PFBS from the National Toxicology Program. We concurred with EPA on thyroid hormone reduction as the most sensitive critical effect and with selection of Feng et al, 2017 as the critical study. We deferred to EPA on selecting a 20 percent reduction in thyroid hormone in the BMDL20 as the best compromise between clearly functional deficits in hormone level and measurement variability in human studies. The permanent reduction in thyroid hormones following in utero exposure in Feng et al. was associated with development delays and reproductive abnormalities. This study was supported by the 28-day NTP study showing reduced thyroid hormones in male and female adult rats with a LOAEL of 62.6 mg/kg-day.

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (SWDH). **Supporting Documentation:** WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (SWDH). **Supporting Documentation:** WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (SWDH).		
	Critical study(ies) underpinning point of departure	Developmental study in mice (Feng et al, 2017, as quoted in WSDH 2019a) • Feng, X., et al., Exposure of Pregnant Mice to Perfluorobutanesulfonate Causes Hypothyroxinemia and Developmental Abnormalities in Female Offspring. Toxicol Sci, 2017. 155(2): p. 409-419.
	Species for critical study(ies)	SAL: Mice (WSDH 2022b)
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	$BMDL_{20}$, HED
	Point of departure value (include units)	$BMDL_{20}$: 28.19 mg/kg/day HED: 0.089 mg/kg/day [The $BMDL_{20}$ of 28.19 mg/kg/day was multiplied by the Dose Adjustment Factor of 0.00315 (female mouse serum half-life/ human serum half-life = 2.1 hours/665 hours) (MDH, 2017)].
	Uncertainty factor(s) & rationale	300 UFH=10, UFA=3 and UFD=10 Uncertainty factors included a 10x for human variability and a 3x for interspecies uncertainty. For chronic duration exposures, EPA used a 10x UF for database deficiencies citing an additional concern that long-term exposure studies in animals are lacking. EPA increased the UFD to 10 for chronic exposures citing additional uncertainty regarding how longer-term exposures might affect hazard identification and dose-response assessment for PFBS via the oral route.
	Guideline value (include units)	• SAL RfD or ADI: 300 ng/kg/day • SAL: 860 ng/L (WSDH 2019a) [300 ng/kg/day x 0.5 RSC ÷ intake for infant = 860 ng/L] or 345 ng/L (WSDH 2022b) • Health Advisory Level: 2,000 (refer to data extraction for USEPA 2022k for derivation) • HBWC: 2,000 ng/L (WSDH 2023a) Note: WSDH (2019a) issued an addendum (November 2019) that changed the SAL from 1,300 ng/L to 860 ng/L based on intakes rates for an infant and RSC of 50% rather than intake rates for a lactating woman and RSC of 20%.

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (SWDH). **Supporting Documentation:** WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (SWDH). **Supporting Documentation:** WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (SWDH).		
		Health-based water concentration (HBWC) are the "acceptable" values used to create a ratio of observed/acceptable for each of 4 PFAS (PFNA, PFHxS, PFBS and GenX). If the ratios add up to more than 1.0, action must be taken to lower PFAS in the drinking water.
	Mode of action for critical health endpoint	Not stated.
	Genotoxic carcinogen?	Not stated.
	Identified sensitive sub-populations	Special populations. It is important to protect the developing foetus and children from overexposure to PFBS via drinking water. A number of developmental effects were observed in animal studies with PFBS. Maternal intake of drinking water will affect foetal exposure and lactational transfer. Infants and children also have higher drinking water intake than adults.
	Any non-health-based considerations?	Not for PFBS. For PFOS and PFOA only. The MCL (4 ng/L) is the lowest concentration of PFOA and PFOS that can be reliably measured by the lab methods required by EPA (drinking water testing methods 533 and 537.1) (WSDH 2023a).
Exposure considerations	Principal routes of exposure in general population	PFAS exposure in the home occurs during product use and exposure to house dust containing PFAS. The greatest portion of the chronic exposure to PFAS for the general public, specifically to PFOS and PFOA, results from the intake of contaminated drinking water and foods (WSDH 2022b)
	Levels in drinking water supplies (include location)	Results of Total PFAS testing of drinking water in Washington state including detections for PFBS (data from WSDH 2022b): • Issaquah Water System – Well #4: 796 ng/L then LOD (after GAC filter installed) (PFAS Detected: PFOS, PFHxS, PFHpA, PFOA, PFNA, PFBS). • Sammamish Plateau Water and Sewer District: Up to 40 ng/L. (PFAS Detected: PFOS, PFHxS, PFNA, PFOA, PFBS). • Ft. Lewis (five wells): 15 – 71 ng/L(PFAS Detected: PFOA, PFOS, PFHxS, PFHpA, PFBS, PFHxA, PFNA). • McChord Field (four wells): 216-250 ng/L. (PFAS Detected: PFOA, PFOS, PFHxS, PFHpA, PFBS).

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (SWDH).

Supporting Documentation: WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (SWDH).

Supporting Documentation: WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (SWDH).

		• Town of Coupeville, Evergreen Mobile Home Park, Group B wells, and 20 private wells: 6 – 7,740 ng/L. (PFAS Detected: PFOS, PFOA, PFHxS, PFHxA, PFHpA, PFNA, PFBS).
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	
Any other relevant information that should be captured?		We concurred with the EPA uncertainty factors, but preferred the MDH approach to calculating a dosimetric adjustment factor to account for the likely difference in mouse clearance of PFBS and human clearance of PFBS. Any change to a SAL or adopting a state MCL requires rulemaking (WSDH 2023a). In the meantime, we will continue to implement our requirements under our existing SALs (WSDH 2023a). PFNA is comparable to our SAL, PFHxS is lower than our SAL, and PFBS is higher than our SAL. We'll read EPA's support documentation to understand why they differ (WSDH 2023a). SLR Note: Also refer to compilation of Health-based value for subchronic/ chronic oral intake (ng/kg-day) in **Section B.1.22**.

Compilation of Health-based value for subchronic/ chronic oral intake (ng/kg-day)

Type of PFAA Chem.	**Authoritative body responsible for value (year)**	**Health-based value for subchronic/ chronic oral intake (ng/kg-day)**
PFBS	EPA RfD (2021)	300
PFBS	MDH RfD (2017)	430
PFBS	MI SAW TV (2019)	300
PFBS	CA OEHHA ADD (2021)	600

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (SWDH). **Supporting Documentation:** WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (SWDH). **Supporting Documentation:** WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (SWDH).	
Assessed in Appendix D?	No, as the TRV is adopted from another agency (US EPA draft 2018, with MDH half-life adjustment).

B.4 PFOA Existing Health-based Guidance

B.4.1 Alaska DEC (2019a)

Agency Report Reference: Alaska DEC (2019a). Technical Memorandum Action Levels for PFAS in Water and Guidance on Sampling Groundwater and Drinking Water. Date: August 20, 2018, Updated: October 2, 2019. Division of spill prevention and response. Contaminated sites program and Division of environmental health Drinking water program. Alaska Department of Environmental Conservation (Alaska DEC).		
Refer to the data extraction table for PFOS: **Section B.1.1** as the Action Level from Alaska DEC (2019a) for PFOS+PFOA. In 2018, Alaska DEC previously set action level the sum of PFOS, PFOA, PFNA, PFHxS, and PFHpA. A separate action level was set for PFBS.		
Health considerations	Guideline value (include units)	PFOS+PFOA: 70 ng/L NB: In 2018, Alaska DEC previously set action level of 70 ng/L for PFOS, PFOA, PFNA, PFHxS, and PFHpA. A separate action level for the shorter-chain PFBS was set at 2.0 µg/L.
Assessed in Appendix D?		No, adopted from other agency, no basis provided

B.4.2 ATSDR (2018a)

Agency Report Reference: ATSDR (2018a). ATSDR's Minimal Risk Levels (MRLs) and Environmental Media Evaluation Guides (EMEGs) for Perfluoroalkyls (PFAS). November 2018. Agency for Toxic Substances and Disease Registry (ATSDR).		
General Information	Date of data extraction	03 August 2023
	Authors	Agency for Toxic Substances and Disease Registry (ATSDR).
	Publication date	November 2018.
	Literature search timeframe	Not stated
	Publication type	Agency Guidance (Summary Document)
	Peer reviewed?	Not stated
	Country of origin	US
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Environmental Media Evaluation Guides (EMEGs)
	Exposure timeframe	Not stated
	Critical human health endpoint	Not stated
	Justification provided by agency for critical endpoint	Not stated

Agency Report Reference: ATSDR (2018a). ATSDR's Minimal Risk Levels (MRLs) and Environmental Media Evaluation Guides (EMEGs) for Perfluoroalkyls (PFAS). November 2018. Agency for Toxic Substances and Disease Registry (ATSDR).		
	Critical study(ies) underpinning point of departure	Not stated
	Species for critical study(ies)	Not stated
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Not stated
	Point of departure value (include units)	Not stated
	Uncertainty factor(s) & rationale	Not stated
	Guideline value (include units)	78 ng/L (adult) and 21 ng/L (child)
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Not stated
	Identified sensitive sub-populations	Not stated
	Any non-health-based considerations?	Not stated
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		ATSDR has developed MRL screening values for perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorohexane sulfonic acid (PFHxS) and perfluorononanoic acid (PFNA) that can be converted into drinking water concentrations for adults and children. ATSDR bases this calculation on an infant (age birth to one year old) weighing 7.8 kg and an intake rate of 1.113 liters per day. For an adult's drinking water exposure, ATSDR bases this calculation on a body weight of 80 kg and an intake rate of 3.092 liters per day. Scientists may

Agency Report Reference: ATSDR (2018a). ATSDR's Minimal Risk Levels (MRLs) and Environmental Media Evaluation Guides (EMEGs) for Perfluoroalkyls (PFAS). November 2018. Agency for Toxic Substances and Disease Registry (ATSDR).	
	use different assumptions when calculating concentrations from dosages.
Assessed in Appendix D?	No, but TRVs forming the basis of these guideline values (ATSDR 2021a) are assessed.

B.4.3 ATSDR (2021a)

Agency Report Reference: ATSDR (2018a). Toxicological Profile for Perfluoroalkyls. Released May 2021. Agency for Toxic Substances and Disease Registry (ATSDR).		
General Information	Date of data extraction	03 August 2023
	Authors	Agency for Toxic Substances and Disease Registry (ATSDR).
	Publication date	May 2021.
	Literature search timeframe	Not date limited. The current literature search was intended to update the draft toxicological profile for perfluoroalkyls released for public comment in 2015. The following main databases were searched in March 2008, September/October 2013, May 2016, and September 2018: • PubMed • National Library of Medicine's TOXLINE • Scientific and Technical Information Network's TOXCENTER
	Publication type	Agency Guideline
	Peer reviewed?	Yes
	Country of origin	US
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Minimum Risk Level (MRL)
	Exposure timeframe	Intermediate (14 to 365 days)
	Critical human health endpoint	Skeletal alterations in adult offspring
	Justification provided by agency for critical endpoint	Intermediate-duration oral studies of PFOA in animals indicate that the liver, immune system, reproductive system, and the developing organism are the primary targets of toxicity because adverse outcomes were observed at lower doses than other effects and have been consistently observed across studies. A summary of the lower LOAEL values (and associated NOAEL values) for these tissues/systems is presented in Table A-6; given the large number of studies, this table is limited to

Agency Report Reference: ATSDR (2018a). Toxicological Profile for Perfluoroalkyls. Released May 2021. Agency for Toxic Substances and Disease Registry (ATSDR).		
		studies that identified LOAEL values of ≤4 mg/kg/day. Although these studies identified the lowest LOAEL values, not all were considered suitable as the basis of an intermediate-duration oral MRL. Increases in liver weight, hepatocellular hypertrophy, and alterations in serum lipid levels, in the absence of other degenerative lesions, were not considered appropriate endpoints for deriving MRL.
	Critical study(ies) underpinning point of departure	Developmental study in mice (Koskela et al. 2016). Koskela A, Finnila MA, Korkalainen M, et al. 2016. Effects of developmental exposure to perfluorooctanoic acid (PFOA) on long bone morphology and bone cell differentiation. Toxicol Appl Pharmacol 301:14-21 (as quoted in ATSDR 2021a).
	Species for critical study(ies)	Mouse
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	LOAEL, HED LOAEL
	Point of departure value (include units)	HED LOAEL: 0.000821 mg/kg/day [(Css x Ke x Vd) ÷ AF = (8.29 mg/L) x 0.693/1,400 d x 0.2 L/kg ÷ 1 =]
	Uncertainty factor(s) & rationale	300 (10 for use of a LOAEL, 3 for extrapolation from animals to humans with dosimetric adjustments, and 10 for human variability)
	Guideline value (include units)	MRL: 3 ng/kg/day
	Mode of action for critical health endpoint	The mode of action for most health outcomes associated with perfluoroalkyl exposure has not been fully characterised in humans or laboratory animals. Some perfluoroalkyl-induced effects observed in rats and mice appear to be mediated through the PPARα-dependent and -independent mechanisms (see Section 2.20 for additional information). Interpretation of the relevance of the effects observed in laboratory animals is complicated since it is generally agreed that humans and nonhuman primates are refractory, or at least less responsive than rodents, to PPARα-mediated effects (Corton et al. 2014; Klaunig et al. 2003; Maloney and Waxman 1999). While studies in mice have identified specific effects that require PPARα activation, for example, postnatal viability (Abbott et al. 2007) and some immunological effects (Yang et al. 2002b), other effects such as hepatomegaly and antigen-specific antibody response (DeWitt et al. 2016) were reported to be PPARα-independent (Yang et al. 2002b), other effects such as hepatomegaly and antigen-specific antibody response (DeWitt et al. 2016) were

Agency Report Reference: ATSDR (2018a). Toxicological Profile for Perfluoroalkyls. Released May 2021. Agency for Toxic Substances and Disease Registry (ATSDR).		
		reported to be PPARα-independent (Yang et al. 2002b).
	Genotoxic carcinogen?	In general, results show that PFOA can produce DNA damage, but is not mutagenic at noncytotoxic concentrations.
	Identified sensitive sub-populations	It is not known whether children are more or less susceptible than adults to the effects of exposure to perfluoroalkyls because there are no studies that specifically addressed this question. Several studies have examined the possible associations between perfluoroalkyl exposure and health outcomes in children living in an area with high PFOA contamination and in the general population. Although some studies have found statistically significant associations, they are not adequate for establishing causality.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	Levels of perfluoroalkyls have been measured in indoor air, outdoor air, dust, food, surface water, and various consumer products. For populations that have elevated levels of perfluoroalkyls in water supplies, the primary route of exposure is expected to be ingestion of contaminated drinking water.
	Levels in drinking water supplies (include location)	• Brazil (Rio): max = 0.35 to 2.82 ng/L. • Spain (Catalonia): 0.98 ng/L (median) • Germany: 7.4 ng/L (maximum). • China (21 cities): <0.1 to 45.9 ng/L. • US (New Jersey): 5 to 39 ng/L, 100 ng/L (max in a follow up study). SLR note there are other studies discussed that report PFBS in groundwater however concentrations were not shown in ATSDR (2021a)
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	• Modelled value: Adult uptake doses estimated for low, medium, and high exposure scenarios were approximately 0.4, 2.5, and 41–47 ng/kg body weight/day, respectively, for PFOA. • Western countries: investigators estimated average daily exposure level of 2.9 ng/kg body weight/day for PFOA. Upper daily exposure levels were determined to be 12.6 ng/kg body weight/day for PFOA.
Risk Summary	Any risks to human health from drinking water identified in agency document?	-

Agency Report Reference: ATSDR (2018a). Toxicological Profile for Perfluoroalkyls. Released May 2021. Agency for Toxic Substances and Disease Registry (ATSDR).		
	Any emerging risks identified?	The available epidemiological data identify several potential health hazards of PFOA in humans as listed below: • Pregnancy-induced hypertension/pre-eclampsia. • Increases in serum hepatic enzymes, particularly alanine aminotransferase, and decreases in serum bilirubin levels. • Increases in serum lipids, particularly total cholesterol and LDL cholesterol. • Decreased antibody response to vaccines • Small (<20 g or 0.7 ounces per 1 ng/mL increase in blood perfluoroalkyl level) decreases in birth weight. Epidemiological studies have not evaluated the potential association between serum PFOA levels and impaired development of bone. A small number of studies in adults have examined potential associations with osteoarthritis risk. There are sufficient epidemiological data to identify possible sensitive targets for many of the perfluoroalkyls; however, there are two major limitations to establishing dose-response relationships for these effects and using the epidemiological studies to derive MRLs: accurate identification of environmental exposure levels producing increased risk for adverse effects (exposure estimates and routes of exposure) and likely co-exposure to mixtures of perfluoroalkyls. Other limitations include the cross-sectional design of the majority of epidemiological studies and the potential that reverse causality contributes to the observed associations. The epidemiological databases for several perfluoroalkyls provide valuable information on hazard identification; however, uncertainties regarding doses associated with adverse effects and possible interactions between compounds preclude use of these data to derive MRLs.
Any other relevant information that should be captured?		There are insufficient data for derivation of an acute-duration oral MRL for PFOA. The chronic-duration database for PFOA was not considered adequate for MRL derivation due to uncertainty in the selection of the critical effect.
Assessed in Appendix D?		Yes.

B.4.4 BfR (2019a)

Agency Report Reference: BfR (2019a). New health-based guidance values for the industrial chemicals PFOS and PFOA BfR opinion No 032/2019 of 21 August 2019. German Federal Institute for Risk Assessment. Bundesinstitut für Risikobewertung (BFR).		
General Information	Date of data extraction	04 August 2023
	Authors	German Federal Institute for Risk Assessment. Bundesinstitut für Risikobewertung (BFR).
	Publication date	21 August 2019
	Literature search timeframe	Not stated
	Publication type	Agency Guidance
	Peer reviewed?	Not stated.
	Country of origin	Germany
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Tolerable Weekly Intake (TWI)
	Exposure timeframe	Lifetime The values indicate the weekly doses that can be consumed over the course of a lifetime without causing any appreciable health effects in humans.
	Critical human health endpoint	An increase in total cholesterol levels in the blood in epidemiological studies. Exposure to PFOA was also associated with interference with a liver enzyme.
	Justification provided by agency for critical endpoint	The EFSA opinion (2018) (as quoted in BfR 2019a) derives tolerable weekly intakes (TWIs) of 6 ng/kg bw per week for PFOA and 13 ng/kg bw per week for PFOS. The values are significantly lower than the health-based guidance values derived previously by EFSA and other international bodies. Reference presumed by SLR to be EFSA (2018a) below: • EFSA (European Food Safety Authority, Scientific Panel on Contaminants in the Food Chain (CONTAM)) (2018a): Risk to human health related to the presence of perfluorooctane sulfonic acid and perfluorooctanoic acid in food. EFSA Journal 2018; 16(5):5194 After examining EFSA's opinion, the BfR believes there is a need for further research on, inter alia, the question of an actual causal relationship between the intake of PFOS and PFOA and the increase in total serum cholesterol and the relevance to health of this effect. From the point of view of the BfR, there are considerable uncertainties with regard to the evidence of

Agency Report Reference: BfR (2019a). New health-based guidance values for the industrial chemicals PFOS and PFOA BfR opinion No 032/2019 of 21 August 2019. German Federal Institute for Risk Assessment. Bundesinstitut für Risikobewertung (BFR).		
		causality and clinical relevance of the effects on which the TWI derivation was based. Despite uncertainties regarding the derivation of TWI values and the need for further scientific research, the BfR recommends using these newly derived TWI values from EFSA in future assessments of PFOS and PFOA concentrations in foods.
	Critical study(ies) underpinning point of departure	Data from three epidemiological studies: • Steenland K, Tinker S, Frisbee S, Ducatman A, Vaccarino V (2009): Association of perfluorooctanoic acid and perfluorooctane sulfonate with serum lipids among adults living near a chemical plant. Am J Epidemiol 170(10):1268-78 (as quoted in BfR 2019a). • Eriksen KT, Raaschou-Nielsen O, McLaughlin JK, Lipworth L, Tjønneland A, Overvad K, Sørensen M (2013): Association between plasma PFOA and PFOS levels and total cholesterol in a middle-aged Danish population. PLoS One. 2013;8(2):e56969 (as quoted in BfR 2019a). • Nelson JW, Hatch EE, Webster TF (2010): Exposure to polyfluoroalkyl chemicals and cholesterol, body weight, and insulin resistance in the general U.S. population. Environ Health Perspect 118(2):197-202
	Species for critical study(ies)	Humans
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10,}$ etc.)	BMDL5
	Point of departure value (include units)	9.3 ng/mL
	Uncertainty factor(s) & rationale	Not applicable
	Guideline value (include units)	TWI = 6 ng/kg/week (equivalent to 0.86 ng/kg/day).
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Not stated
	Identified sensitive sub-populations	First years of life. The question of a particularly sensitive time window, which may exist during childhood, is unclear. One focus of further investigations should be on the first years of life. During this period, in which vaccines are often administered as a primary immunisation, there is a relatively high PFOS/PFOA exposure in long-term breastfed

<table>
<tr><th colspan="3">Agency Report Reference: BfR (2019a). New health-based guidance values for the industrial chemicals PFOS and PFOA BfR opinion No 032/2019 of 21 August 2019. German Federal Institute for Risk Assessment. Bundesinstitut für Risikobewertung (BFR).</th></tr>
<tr><td></td><td></td><td>children. The studies available so far only examined children who were 3 years or older.</td></tr>
<tr><td></td><td>Any non-health-based considerations?</td><td>-</td></tr>
<tr><td rowspan="4">Exposure considerations</td><td>Principal routes of exposure in general population</td><td>Presumed to be food.
In principle, it is recommended to include drinking water as a source of exposure.</td></tr>
<tr><td>Levels in drinking water supplies (include location)</td><td>Drinking Water Germany (n = 59, 6 with detects)
• Lower bound: 5 ng/kg (mean), 6 ng/kg (P95).
• Upper bound: 15 ng/kg (mean), 6 ng/kg* (P95).
Mineral Water Germany (n = 334, 32 with detects)
• Lower bound: 0.26 ng/kg (mean), 2 ng/kg (P95).
• Upper bound: 1.1 ng/kg (mean), 2 ng/kg (P95).
* SLR notes this value appears to be incorrect.</td></tr>
<tr><td>Any special considerations to exposure levels (e.g. higher in drought?)</td><td>-</td></tr>
<tr><td>Typical exposure in general population (include units for intakes & location)</td><td>Intake with mean consumption
<table><tr><th><u>Age Group</u></th><th>Lower Bound</th><th>Upper Bound</th></tr><tr><td>Infants (<1 year)</td><td>3.78</td><td>23.45*</td></tr><tr><td>Toddlers (1 - <3 years)</td><td>9.45*</td><td>49.14*</td></tr><tr><td>Children (3 - <10 years)</td><td>7.14*</td><td>39.69*</td></tr><tr><td>Adol. (10 - <18 years)</td><td>4.76</td><td>27.30*</td></tr><tr><td>Adults (18 - <65 years)</td><td>2.10</td><td>10.64*</td></tr><tr><td>Elderly (65 - <75 years)</td><td>1.89</td><td>11.27*</td></tr><tr><td>Very elderly (≥75 years)</td><td>1.96</td><td>11.76*</td></tr></table>*Exceeds the TWI values of 6 ng PFOA/kg bw per week

Intake with P95 consumption
<table><tr><th><u>Age Group</u></th><th>Lower Bound</th><th>Upper Bound</th></tr><tr><td>Infants (<1 year)</td><td>14.21*</td><td>64.05*</td></tr><tr><td>Toddlers (1 - <3 years)</td><td>21.00*</td><td>100.66*</td></tr><tr><td>Children (3 - <10 years)</td><td>14.56*</td><td>76.09*</td></tr><tr><td>Adol. (10 - <18 years)</td><td>9.31*</td><td>49.21*</td></tr><tr><td>Adults (18 - <65 years)</td><td>4.55</td><td>24.36*</td></tr><tr><td>Elderly (65 - <75 years)</td><td>4.27</td><td>25.62*</td></tr><tr><td>Very elderly (≥75 years)</td><td>4.76</td><td>26.67*</td></tr></table>*Exceeds the TWI values of 6 ng PFOA/kg bw per week</td></tr>
</table>

Agency Report Reference: BfR (2019a). New health-based guidance values for the industrial chemicals PFOS and PFOA BfR opinion No 032/2019 of 21 August 2019. German Federal Institute for Risk Assessment. Bundesinstitut für Risikobewertung (BFR).		
Risk Summary	Any risks to human health from drinking water identified in agency document?	Water is not discussed. NB: According to EFSA's exposure assessment, the new TWIs for PFOS and PFOA in Europe are exceeded by parts of the population when considering mean concentrations in food as well as mean and high consumption quantities.
	Any emerging risks identified?	-
Any other relevant information that should be captured?		From the point of view of the BfR, considerable uncertainties also exist with regard to the evidence of causality and clinical relevance of the effects used as the basis for the TWI derivation. The question of the clinical relevance of this parameter (total blood cholesterol), which EFSA has used to derive the TWI, is identified by EFSA itself as uncertain. Amongst other issues, the BfR addressed questions regarding the suitability of the observed increases in total cholesterol in the epidemiological studies as biomarkers for cardiovascular diseases. Further discussions dealt with the clinical relevance of elevated cholesterol levels against the background of other factors affecting the risk of cardiovascular disease such as age, gender, weight, blood pressure and smoking. In addition, questions were discussed on the causal relationship between PFOS/PFOA in the blood and total cholesterol, in particular with regard to a possible coincidence of elevated serum levels of PFOS and PFOA and higher cholesterol levels, which could be due to, for example, mutual reabsorption from the gut via common membrane transport systems.
Assessed in Appendix D?		No, but the latest EFSA (2020a) guidance values are assessed (EFSA 2020a has superseded EFSA 2018).

B.4.5 CDPH (2023a)

Agency Report Reference: CDPH (2023a). Per- and polyfluoroalkyl Substances (PFAS). 2023. Connecticut State Department of Public Health (CDPH)		
General Information	Date of data extraction	07 August 2023
	Authors	Connecticut State Department of Public Health (CDPH)
	Publication date	2023
	Literature search timeframe	Not stated
	Publication type	Agency webpage.
	Peer reviewed?	Not stated.

Agency Report Reference: CDPH (2023a). Per- and polyfluoroalkyl Substances (PFAS). 2023. Connecticut State Department of Public Health (CDPH)		
	Country of origin	US (Connecticut)
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	CT Drinking Water Action Level
	Exposure timeframe	Not stated.
	Critical human health endpoint	Developmental effects
	Justification provided by agency for critical endpoint	CT DPH develops its drinking water Action Levels by considering health impacts to the most sensitive and most exposed populations across all stages of human development.
	Critical study(ies) underpinning point of departure	Not stated.
	Species for critical study(ies)	Animal studies
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Not stated.
	Point of departure value (include units)	Not stated.
	Uncertainty factor(s) & rationale	Not stated.
	Guideline value (include units)	16 ng/L
	Mode of action for critical health endpoint	Not stated.
	Genotoxic carcinogen?	Not stated.
	Identified sensitive sub-populations	Pregnant people, infants and children are at higher risk because of PFAS effects on pregnancy outcomes and foetal, infant and child growth and development.
	Any non-health-based considerations?	Not stated.
Exposure considerations	Principal routes of exposure in general population	Not stated.
	Levels in drinking water supplies (include location)	Not stated.
	Any special considerations to exposure levels (e.g. higher in drought?)	Not stated.
	Typical exposure in general population (include units for intakes & location)	Not stated.

Agency Report Reference: CDPH (2023a). Per- and polyfluoroalkyl Substances (PFAS). 2023. Connecticut State Department of Public Health (CDPH)		
Risk Summary	Any risks to human health from drinking water identified in agency document?	Not stated.
	Any emerging risks identified?	Not stated.
Any other relevant information that should be captured?		The chemical-specific approach reflects the evolving scientific evidence on the toxicity of PFAS and is more protective of public health than the summed approach used previously in CT.
Assessed in Appendix D?		No, no health basis provided.

B.4.6 DOH (2017)

Agency Report Reference: DOH (2017). Health-based Guidance Values for PFAS. 2017. Department of Health (DOH), Australian Government.		
General Information	Date of data extraction	02 August 2023
	Authors	Department of Health (DOH), Australian Government.
	Publication date	Undated. Known to have been released in 2017.
	Literature search timeframe	Not stated
	Publication type	Agency Guideline. Summary Document.
	Peer reviewed?	FSANZ's report and recommended health-based guidance values have been nationally and internationally peer reviewed.
	Country of origin	Australia
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Health-based guidance values (HBGV) including: • Tolerable daily intake (TDI) • Drinking water quality guideline value (DWG)
	Exposure timeframe	Lifetime
	Critical human health endpoint	Not stated (refer to FSANZ 2017b). The tolerable daily intake for PFOS and PFOA are derived from the results of toxicity studies in laboratory animals. FSANZ concluded that the current available epidemiological data on human health is not suitable to support the derivation of tolerable daily intake levels for PFOS and PFOA.
	Justification provided by agency for critical endpoint	Not stated (refer to FSANZ 2017b)
	Critical study(ies) underpinning point of departure	Not stated (refer to FSANZ 2017b)

Agency Report Reference: DOH (2017). Health-based Guidance Values for PFAS. 2017. Department of Health (DOH), Australian Government.		
	Species for critical study(ies)	Not stated (refer to FSANZ 2017b)
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Not stated (refer to FSANZ 2017b)
	Point of departure value (include units)	Not stated (refer to FSANZ 2017b)
	Uncertainty factor(s) & rationale	Not stated (refer to FSANZ 2017b)
	Guideline value (include units)	• TDI: 160 ng/kg.bw/day • DWG: 560 ng/L
	Mode of action for critical health endpoint	Not stated (refer to FSANZ 2017b)
	Genotoxic carcinogen?	Not stated (refer to FSANZ 2017b)
	Identified sensitive sub-populations	Not stated (refer to FSANZ 2017b). The tolerable daily intakes include conservative assumptions to ensure the protection of public health.
	Any non-health-based considerations?	Not stated (refer to FSANZ 2017b)
Exposure considerations	Principal routes of exposure in general population	Not stated (refer to FSANZ 2017b)
	Levels in drinking water supplies (include location)	Not stated (refer to FSANZ 2017b)
	Any special considerations to exposure levels (e.g. higher in drought?)	Not stated (refer to FSANZ 2017b)
	Typical exposure in general population (include units for intakes & location)	Not stated (refer to FSANZ 2017b)
Risk Summary	Any risks to human health from drinking water identified in agency document?	Not stated (refer to FSANZ 2017b)
	Any emerging risks identified?	Not stated (refer to FSANZ 2017b)
Any other relevant information that should be captured?		The health-based guidance values are protective of human health; are a precautionary measure for use when conducting site investigations; and are to assist in providing advice to affected communities on how to minimise exposure to PFAS.
Assessed in Appendix D?		No, adopted from FSANZ (2017b), which is assessed separately.

B.4.7 EU (2020), EC (2022)

Agency Report Reference: EC (2022). Final Opinion on Groundwater quality standards for proposed additional pollutants in the annexes to the Groundwater Directive (2006/118/EC) Scientific Co **Agency Report Reference:** EU (2020). Directives. Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the Quality of Water Intended for Human Consumption (recast) (Text with EEA relevance). L 435/2, 23.12.2020. European Union (EU). **Supporting Documentation:** EC (2022). Final Opinion on Groundwater quality standards for proposed additional pollutants in the annexes to the Groundwater Directive (2006/118/EC) Scientific Committee on Health, Environmental and Emerging Risks SCHEER. 18 July 2022. DG Health and Food Safety. European Commission (EC).mmittee on Health, Environmental and Emerging Risks SCHEER. 18 July 2022. DG Health and Food Safety. European Commission (EC).		
Refer to the data extraction table for PFOS: **Section B.1.7** noting the value is for Sum of PFAS or Total PFAS.		
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Quality Standard for surface water - drinking water and human health ($EQS_{dw,hh}$)
	Guideline value (include units)	Technical Guidelines: 100 ng/L (EU 2020 only) Technical Guidelines and $EQS_{dw,hh}$: PFAS Total: 500 ng/L (EU 2020, EC 2022) NB: 'Total PFAS' as the totality of per- and polyfluoroalkyl substances detected with available analytical methods and monitoring guidelines (EU 2020, EC 2022). 'Sum of PFAS' means the sum of per- and polyfluoroalkyl substances considered a concern as regards to water intended for human consumption listed in point 3 of Part B of Annex III. This is a subset of 'PFAS Total' substances that contain a perfluoroalkyl moiety with three or more carbons (i.e. $–C_nF_{2n}–$, n ≥ 3) or a perfluoroalkylether moiety with two or more carbons (i. e. $C_nF_{2n}OC_mF_{2m}–$, n and m ≥ 1) (EU 2020).
Assessed in Appendix D?		No, no basis provided.

B.4.8 EFSA (2020)

Agency Report Reference: EFSA (2020). Risk to human health related to the presence of perfluoroalkyl substances in food. Adopted: 9 July 2020. European Food Safety Authority (EFSA)		
Refer to the data extraction table for PFOS: **Section B.1.8** as the TWI from EFSA (2020a) is for the sum of four PFAS, i.e. ∑PFOA, PFNA, PFHxS and PFOS.		
Health considerations	Guideline value (include units)	Daily intake for ∑PFOA, PFNA, PFHxS and PFOS: 0.63 ng/kg bw/day (TWI = 4.4 ng/kg bw per week)
Assessed in Appendix D?		Yes.

B.4.9 FSANZ (2017)

Agency Report Reference: FSANZ (2017). Hazard assessment report – Perfluorooctane Sulfonate (PFOS), Perfluorooctanoic Acid (PFOA), Perfluorohexane Sulfonate (PFHxS). Food Standards Australia New Zealand (FSANZ)		
General Information	Date of data extraction	02 August 2023
	Authors	Food Standards Australia New Zealand (FSANZ)
	Publication date	Undated. Known to have been released in 2018.
	Literature search timeframe	Five years. Search strategy in PubMed, with results retrieved for the final search on 15 December, 2016
	Publication type	Agency Guideline Document
	Peer reviewed?	Not stated.
	Country of origin	Australia
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Health-based guidance values (HBGV) • Tolerable daily intake (TDI)
	Exposure timeframe	Lifetime
	Critical human health endpoint	The NOAEL for fetotoxicity was 1 mg/kg bw/day, based on decreased body weight gain at doses of ≥ 3 mg/kg bw/day in the study by Lau et al. (2006, as quoted in FSANZ 2017b). Critical endpoints for other studies included: • Decreased body weight gain (maternal toxicity) (Lau et al. 2006, as quoted in FSANZ 2017b). • Clinical signs, decreased body weight and hepatic toxicity at the high dose (Butenhoff et al. 2002, as quoted in FSANZ 2017b). • Decreased mean body weight (Perkins et al. 2004, as quoted in FSANZ 2017b)
	Justification provided by agency for critical endpoint	Four NOAELs from three studies were chosen for a range of health endpoints and converted to a HBGV. HBGVs were calculated with the lowest HBGV selected based on the lowest NOAEL from the study by Lau et al. (2006, as quoted in FSANZ 2017b). PFOA is a PPARα agonist; that is, it induces peroxisome proliferation. PPARα agonists typically cause hepatocellular hypertrophy and markedly increased liver weight in rodents, although primates are refractory to this response. Increased liver weight in rodents in response to a PPARα agonist, in the absence of hepatocellular degeneration or necrosis, is usually regarded as an adaptive response and not predictive of human toxicity (Hall et al. 2012). FSANZ has not

Agency Report Reference: FSANZ (2017). Hazard assessment report – Perfluorooctane Sulfonate (PFOS), Perfluorooctanoic Acid (PFOA), Perfluorohexane Sulfonate (PFHxS). Food Standards Australia New Zealand (FSANZ)		
		interpreted increase in absolute and/or relative liver weight in rodents, in the absence of hepatocellular degeneration or necrosis, as an adverse effect for the purpose of identifying a NOAEL or LOAEL. Similarly, FSANZ has not interpreted increased absolute liver weight in a small number of monkeys (Butenhoff et al. 2002) as an adverse effect because there was no significant effect on relative liver weight, and no histological evidence of hepatocellular hypertrophy or liver lesions. Consequently, the NOAELs and LOAELs identified by FSANZ for some studies differ from those of regulatory agencies that identify increased liver weight as an adverse effect. Currently available epidemiology data are insufficient to establish a cause and effect relationship between PFOA exposure and clinically relevant immunomodulatory effects in humans.
	Critical study(ies) underpinning point of departure	Developmental and female reproductive study in mice (Lau et al. 2006, as quoted in FSANZ 2017b). NB: Candidate HBGV were also calculated using data from these studies: • subchronic toxicity study in nonhuman primates (Butenhoff et al. 2002, as quoted in FSANZ 2017b) • subchronic toxicity study in rats (Perkins et al. 2004, as quoted in FSANZ 2017b)
	Species for critical study(ies)	Mice NB: Species in other studies included the monkey and rat
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Human Equivalent Dose (HED). HEDs were derived from modelled animal average PFOS serum concentrations using PBPK modelling based on four established NOAELs from three animal studies.
	Point of departure value (include units)	Lowest HED: 0.0049 mg/kg/day (NB: Four HEDs from three studies selected as a POD: 0.014, 0.013, 0.0049, and 0.0276 mg/kg/day)
	Uncertainty factor(s) & rationale	A UFH of 10 for intraspecies variability within the human population was applied in all cases, as was a UFA of 3 for interspecies variability between animals and humans.
	Guideline value (include units)	Lowest TDI: 160 ng/kg/day (Four TDI from three studies calculated and the lowest value selected as the TDI: 470, 430, 160, 92 ng/kg/day)

Agency Report Reference: FSANZ (2017). Hazard assessment report – Perfluorooctane Sulfonate (PFOS), Perfluorooctanoic Acid (PFOA), Perfluorohexane Sulfonate (PFHxS). Food Standards Australia New Zealand (FSANZ)		
	Mode of action for critical health endpoint	Toxic mechanism(s) in humans are unclear.
	Genotoxic carcinogen?	IARC concluded that there is strong evidence that direct genotoxicity is not a mechanism of PFOA carcinogenesis.
	Identified sensitive sub-populations	-
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		-
Assessed in Appendix D?		Yes.

B.4.10 HC (2018b)

Agency Report Reference: HC (2018b). Guidelines for Canadian Drinking Water Quality Guideline Technical Document Perfluorooctanoic Acid (PFOA). December 2018. Health Canada (HC). Government of Canada.		
General Information	Date of data extraction	03 August 2023
	Authors	Health Canada (HC). Government of Canada.
	Publication date	December 2018.
	Literature search timeframe	Not stated
	Publication type	Agency Guidance
	Peer reviewed?	This document was endorsed by the Federal-Provincial-Territorial Committee on Drinking Water of the Federal-Provincial-Territorial Committee on Health and the Environment.
	Country of origin	Canada

Agency Report Reference: HC (2018b). Guidelines for Canadian Drinking Water Quality Guideline Technical Document Perfluorooctanoic Acid (PFOA). December 2018. Health Canada (HC). Government of Canada.		
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Tolerable Daily Intake (TDI), Health-based Value (HBV) or Maximum acceptable concentration (MAC)
	Exposure timeframe	Lifetime
	Critical human health endpoint	Hepatocellular hypertrophy for male rats (Perkins et al., 2004)
	Justification provided by agency for critical endpoint	Chronic exposure to PFOA has been associated with both cancer and non-cancer effects in animals and humans. HBVs for both endpoints have been calculated, with the non-cancer effects resulting in a lower, more conservative value. Liver effects in rats was used to calculate a MAC that is protective of human health from both cancer and non-cancer effects. In animals, non-cancer effects observed at the lowest levels of exposure include reproductive and developmental effects, liver effects and changes in serum lipid levels. For various reasons described in section 10.2, the most appropriate endpoint to derive a HBV for PFOA is hepatocellular hypertrophy (liver effects) in rats, occurring at the same levels as the changes in serum lipid levels. Epidemiological studies have shown associations between exposure to PFOA and multiple non-cancer health outcomes, such as dysfunctions of the immunological system and alterations in birth weight and lipid levels. However, these studies cannot be used to derive the non-cancer HBV for PFOA due to limitations in terms of design, bias, confounding, and possibility of chance findings. This HBV is considered to be sufficiently protective of both cancer and non-cancer effects of PFOA.
	Critical study(ies) underpinning point of departure	13-Week dietary toxicity study in rats (Perkins et al. 2004 as quoted in HC 2019b). • Perkins, R., Butenhoff, J., Kennedy, G. and Palazzolo, M. (2004). 13-Week dietary toxicity study of ammonium perfluorooctanoate (APFO) in male rats. Drug Chem. Toxicol., 27: 361–378. (as quoted in HC 2019a).
	Species for critical study(ies)	Rats
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	NOAEL, POD_{HEQ}, BMD_{10}, $BMDL_{10}$
	Point of departure value (include units)	NOAEL: 0.06 mg/kg/day BMD_{10}: 0.13 mg/kg/day. $BMDL_{10}$: 0.05 mg/kg/day.

Agency Report Reference: HC (2018b). Guidelines for Canadian Drinking Water Quality Guideline Technical Document Perfluorooctanoic Acid (PFOA). December 2018. Health Canada (HC). Government of Canada.		
		POD_{HEQ}: 0.000521 mg/kg/day [0.05 mg/kg/day ÷ 96] Where 96 is the ratio of the steady-state plasma PFOA prediction in humans (86.1 µg/mL) vs. rats (0.9 µg/mL) at an oral dose of 0.01 mg/kg bw/day.
	Uncertainty factor(s) & rationale	25 An interspecies uncertainty factor of 2.5 was used to reflect only the toxicodynamic component of the default interspecies uncertainty factor, because the toxicokinetic differences between animals and humans were already incorporated when calculating the POD_{HEQ}. Likewise, default values of 10 were applied for the intraspecies uncertainty factor. The default value was assumed to be sufficient in the absence of data on intraspecies differences.
	Guideline value (include units)	TDI: 21 ng/kg/day HBV or MAC: 200 ng/L (HBV = TDI x body weight of an adult x default allocation factor ÷ daily volume of water consumed by an adult = 0.000021 mg/kg/day × 70 kg × 0.2 ÷ 1.5 L/day)
	Mode of action for critical health endpoint	Based on the MOA analysis, no endpoints were considered to be irrelevant to humans, and the results suggest that the TDI approach is the most appropriate method for cancer risk assessment. The weight of evidence for non-mutagenic MOAs of tumours is stronger than for direct-acting mutagenicity, which suggests that low-dose linear extrapolation is not appropriate for PFOA-induced tumours. Three main key events in the peroxisome proliferation MOA are considered to lead to liver histological effects and hepatocellular tumours. These key events are 1) the activation of hepatic PPARα receptors, which leads to 2) altered cell growth pathways that inhibit apoptosis and/or promote cell replication, eventually leading to 3) hepatocyte proliferation (Corton et al., 2014).
	Genotoxic carcinogen?	Neither PFOS nor PFOA are considered to be direct-acting genotoxic chemicals
	Identified sensitive sub-populations	-
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	Exposure is mainly from food and consumer products, however, the proportion of exposure from drinking water can increase in individuals living in areas with contaminated drinking water.

Agency Report Reference: HC (2018b). Guidelines for Canadian Drinking Water Quality Guideline Technical Document Perfluorooctanoic Acid (PFOA). December 2018. Health Canada (HC). Government of Canada.		
	Levels in drinking water supplies (include location)	PFOA is not regularly monitored at water treatment plants in Canada, the analysis has been performed for a few locations. When detected in drinking water, it is usually found below 3 ng/L. • Calgary: <0.51 ng/L (from 2 Water Treatment Plants, WTPs) • Quebec: 2.5 ng/L (median), 98 ng/L (max) (n = 84). • Ontario: 2.1 mg/L (n = 5). • Calgary and Vancouver: 0.2 ng/L
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	The estimated total daily intake of PFAS (estimates not provided for individual PFAS) in Canadians was reported to be 410 ng/day for the general population of Canada (Tittlemier et al., 2007). Drinking water ingestion, estimated at 0.3 ng/day, contributed only a minor amount to the overall estimated exposure.
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		In keeping with a precautionary approach, the currently available data support the implementation of an additive approach for PFOS and PFOA when evaluating situations where PFOS and PFOA co-occur in drinking water. Given that PFOS and PFOA are the predominant PFAS detected in Canadian water samples and the lack of toxicological data on PFAS besides PFOS and PFOA, the additive approach was not extended to other PFAS. Of the existing additivity approaches for risk assessment (i.e, hazard index, point of departure index, combined margin of exposure index, toxic unit summation, and relative potency factors/toxic equivalency factors; (Meek et al., 2011; SCHER, 2012; WHO, 2017), the hazard index approach was deemed to be the best choice for PFOS and PFOA that is health protective. The health effects of PFOS and PFOA are similar and well documented. Recent scientific evidence shows that PFOS and PFOA affect the same organ in similar ways. Thus, when PFOA and PFOS are found together in drinking water, the best approach to protect human health is to consider both chemicals together when comparing to the guideline values. This is done by adding the ratio of the observed concentration for PFOS to its

Agency Report Reference: HC (2018b). Guidelines for Canadian Drinking Water Quality Guideline Technical Document Perfluorooctanoic Acid (PFOA). December 2018. Health Canada (HC). Government of Canada.	
	MAC with the ratio of the observed concentration for PFOA to its MAC; if the result is below or equal to one, then the water is considered safe for drinking. Science currently does not justify the use of this approach for other PFAS.
Assessed in Appendix D?	Yes.

B.4.11 Maine DHHS (2021a)

Agency Report Reference: Maine DHHS (2021a). PFOS, PFOA and other PFAS Questions and Answers. Updated 7/07/2021. Maine Department of Health and Human Services (Maine DHHS).		
Refer to the data extraction table for PFOS: **Section B.1.11** as the Interim State drinking water standard from Maine DHHS (2021a) is for the combined sum of six different PFAS: PFOA, PFOS, PFHpA, PFNA, PFDA, and PFHxS.		
Health considerations	Guideline value (include units)	20 ng/L For the combined sum of six different PFAS: PFOA, PFOS, PFHpA, PFNA, PFDA, and PFHxS
Assessed in Appendix D?		No, no basis provided.

B.4.12 Mass DEP (2022a)

Agency Report Reference: Mass DEP (2022a). Important Information. EPA's New Health Advisories for Some PFAS. August 11, 2022. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP). **Supporting Documentation:** Mass DEP (2023a). EPA Proposed Maximum Contaminant Level (MCL) for PFAS. April 12, 2023. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP).		
Refer to the data extraction table for PFOS: **Section B.1.12**.		
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	• EPA's Health Advisories • Maximum Contaminant Level (MCL) • Maximum Contaminant Level Goals (MCLGs) (Mass DPH 2023a)
	Guideline value (include units)	• MCL (PFAS6): 20 ng/L for the sum of six PFAS (PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA) (established an enforceable in Massachusetts) The two EPA Interim Health Advisories and two Final Health Advisories are: • Interim Health Advisory for PFOA: 0.004 ng/L • Interim Health Advisory for PFOS: 0.02 ng/L • Final Health Advisory for GenX: 10 ng/L • Final Health Advisory for PFBS: 2,000 ng/L MCLGs from Mass DPH (2023a):

Agency Report Reference: Mass DEP (2022a). Important Information. EPA's New Health Advisories for Some PFAS. August 11, 2022. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP). **Supporting Documentation:** Mass DEP (2023a). EPA Proposed Maximum Contaminant Level (MCL) for PFAS. April 12, 2023. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP).		
		• PFOS: 4 ng/L • PFOA: 4 ng/L • PFNA, PFHxS, PFBS, & GenX: Hazard Index of 1. NB: Massachusetts will adopt PFAS drinking water regulations that are at least as stringent as the federal standards (Mass DEP 2023a). NB: Mass DEP (2023a) is proposing to address four additional PFAS (GenX, PFBS, PFNA, and PFHxS) as a mixture using a Hazard Index. A Hazard Index accounts for the increased risk from mixtures of PFAS (Mass DEP 2023a). SLR note that it is not clear how the Hazard Index will be calculated, i.e. which MCLG, HA or MCL will be used for the calculation.
Assessed in Appendix D?		No, adopted from other agency, no basis provided.

B.4.13 MDH (2022f, 2022d)

Agency Report Reference: MDH (2022f). Toxicological Summary for: Perfluorooctanoate. March 2022. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH) **Supporting Documentation:** MDH (2022d). PFOA and Water. April 2022. Minnesota Department of Health (MDH).		
General Information	Date of data extraction	04 August 2023
	Authors	Minnesota Department of Health (MDH)
	Publication date	March 2022
	Literature search timeframe	Not stated
	Publication type	Agency Guideline
	Peer reviewed?	Not stated
	Country of origin	US (Minnesota)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Reference Dose (RfD) Non-Cancer Health-Based Value (nHBV)
	Exposure timeframe	Short-term, subchronic, and chronic durations
	Critical human health endpoint	Delayed ossification, accelerated preputial separation (PPS) in male mice offspring, trend for decreased pup body weight, and increased maternal liver weight

Agency Report Reference: MDH (2022f). Toxicological Summary for: Perfluorooctanoate. March 2022. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH) **Supporting Documentation:** MDH (2022d). PFOA and Water. April 2022. Minnesota Department of Health (MDH).		
	Justification provided by agency for critical endpoint	Among the animal studies, decreased postnatal growth leading to developmental effects (e.g. lower pup body weight, delayed eye opening, delayed vaginal opening, and accelerated preputial separation) have been observed. These effects form the basis of the RfD. SLR note the most sensitive effect was not chosen due to limitations in the testing (see discussion from MDH 2022f below under "Any other relevant information that should be captured?")
	Critical study(ies) underpinning point of departure	Lau et al 2006 (as quoted in MDH 2022f). • Lau, C., JR Thibodeaux, RG Hanson, MG Narotsky, JM Rogers, AB Lindstrom, MJ Strynar. (2006). "Effects of Perfluorooctanoic Acid Exposure during Pregnancy in the Mouse." Toxicological Sciences 90(2): 510-51
	Species for critical study(ies)	Mice
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Predicted average serum concentration for maternal animals, HED
	Point of departure value (include units)	Predicted average serum concentration for maternal animals = 38 µg/mL HED = 0.0053 mg/kg/day [38 µg/mL x (0.17 L/kg x 0.693/840 days)]
	Uncertainty factor(s) & rationale	300 3 for interspecies differences (for toxicodynamics); 10 for intraspecies variability. With the exception of accelerated preputial separation (PPS), the effects observed at the LOAEL were mild. A LOAEL-to-NOAEL uncertainty factor of 3 was used, along with a database uncertainty factor of 3 for the lack of an acceptable 2-generation study.
	Guideline value (include units)	• RfD: 18 ng/kg/day • nHBV: 35 ng/L NB: Refer to News Release from MDH (2023a) for MCLs and Hazard index approach for assessing PFOS, PFOA, PFHxS, PFBS and GenX. NB: EPA derived a slope factor of 0.07 $(mg/kg\text{-}d)^{-1}$, however, this slope factor cannot be used to derive quantitative guidance because it was based on body weight scaling rather than established chemical-specific toxicokinetic differences. NB: Based on currently available data, MDH considers the noncancer-based water guidance

Agency Report Reference: MDH (2022f). Toxicological Summary for: Perfluorooctanoate. March 2022. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH) **Supporting Documentation:** MDH (2022d). PFOA and Water. April 2022. Minnesota Department of Health (MDH).		
		value of 0.035 µg/L to be protective for potential cancer effects.
	Mode of action for critical health endpoint	Not stated for the critical effect. NB: Three cancer bioassays have been conducted to date. Increased incidence of Leydig cell tumors, liver tumors and pancreatic tumors were not consistently observed across the three bioassays. No specific mode of action(s) (MOAs) has been identified. PFOA is not genotoxic, and a variety of key events have been suggested, including cellular hyperplasia and hormonal changes. These mechanisms would have a threshold. The current RfD protects against hepatic and acinar hyperplasia as well as changes in hormone levels, which are considered potential key events in tumor formation.
	Genotoxic carcinogen?	PFOA is not genotoxic
	Identified sensitive sub-populations	-
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	Almost everyone is exposed to small amounts of PFOA, but this does not necessarily indicate a risk to your health. Large-scale biomonitoring programs show that PFOA levels in people's blood are declining. For most people, the main route of exposure to PFOA is through the foods they eat. PFOA can be present on food crops due to environmental exposures and some food packaging may transfer PFOA to packaged food items. Ingestion of household dust can also be a significant route of exposure, especially for infants and young children (MDH 2022d). For people living in areas affected by PFAS releases or disposal, drinking water may be a major source of exposure to PFOA (MDH 2022d). In addition to exposure from drinking formula mixed with contaminated water, PFOA can pass from a mother to infant during pregnancy and to an infant through breastmilk. Breastfeeding is important for the short and long term health of both a mother and infant (MDH 2022d).
	Levels in drinking water supplies (include location)	PFOA has been detected in private drinking water wells and public drinking water systems in several parts of Minnesota. PFOA has been detected in sources of public drinking water at levels up to 1,000 ng/L (MDH 2022d).

Agency Report Reference: MDH (2022f). Toxicological Summary for: Perfluorooctanoate. March 2022. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH) **Supporting Documentation:** MDH (2022d). PFOA and Water. April 2022. Minnesota Department of Health (MDH).		
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		Co-critical effect(s): In offspring exposed during development: decreased pup body weight; changes in liver weight, histology, and triglycerides; and delayed mammary gland development. In adult animals: liver weight changes accompanied by changes in liver enzyme levels, changes in triglyceride and cholesterol levels, microscopic evidence of cellular damage and bile duct hyperplasia; decreased spleen weight and spleen lymphocytes; decreased IgM response; kidney weight changes and papilla urothelium hyperplasia; increased pancreatic acinar cell hyperplasia; and decreased serum thyroid hormone levels. An RSC of 0.5 (50%) was selected for the peak serum concentration during infancy. The RSC of 0.5 during infancy resulted in chronic (steady-state) serum concentrations at approximately 0.2 of the 'reference' serum concentration. **Endocrine Toxicity testing**: Three large epidemiological studies provide support for an association between PFOA exposure and incidence or prevalence of thyroid disease in female adults or children, but not in males. In addition, associations between PFOA and Thyroid Stimulating Hormone (TSH) have also been reported in some populations of pregnant females. However, no significant associations were found between PFOA and TSH or thyroid hormones (T4 or T3) in people who have not been diagnosed with thyroid disease. Effects of PFOA on thyroid hormones in animals are generally not as well characterized as those of PFOS. Reduced total and free T4 were reported in adult male rats and monkeys at serum levels 400-fold or more than the serum level corresponding to the RfD. However, these doses were the lowest doses tested within the study and the dose-response relationship of serum total T4 with PFOA exposure has yet to be fully evaluated. As a result,

Agency Report Reference: MDH (2022f). Toxicological Summary for: Perfluorooctanoate. March 2022. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH) **Supporting Documentation:** MDH (2022d). PFOA and Water. April 2022. Minnesota Department of Health (MDH).	
	the lowest effective dose remains unknown. Thyroid hormone effects are listed as a co-critical effect and are identified as an Additivity Endpoint. Additional thyroid effects (e.g. follicular cell hypertrophy) were observed at doses that were approximately 500-fold higher than the serum level corresponding to the RfD. Other endocrine effects beyond thyroid have not been well-studied, and study results are not entirely consistent. A few studies reported sperm abnormalities, decreased testosterone, and increased estradiol in male rats and mice at PFOA levels similar to those which form the basis of the RfD, whereas other studies only reported these effects at higher doses. **Immunotoxicity**: Associations between prenatal, childhood, or adult PFOA exposure and risk of infectious diseases (as a marker of immune suppression) have not been consistently seen in epidemiological studies, although there was some indication of effect modification by gender (i.e. associations seen in female children but not in male children). Three studies examined associations between maternal and/or child serum PFOA levels and vaccine response (measured by antibody levels) in children and adults. The study in adults reported that a reduction in antibody response to one of the three influenza strains tested after receiving the flu vaccine was associated with increasing levels of serum PFOA. While decreased vaccine response was associated with PFOA levels in these studies, similar results were also observed with other perfluorinated chemicals and, therefore, could not be attributed specifically to PFOA. Several animal studies demonstrate effects on the spleen and on thymus weights as well as decreased immune response. These effects were observed at serum concentrations similar to the critical study LOAEL. The immune system is listed as one of the co-critical effects and Additivity Endpoints. **Developmental toxicity**: There have been numerous human epidemiological studies examining PFOA exposure and developmental effects. Some studies reported an association between PFOA and birth weight, while others have not. Two epidemiological studies examined development of puberty in females in relation to prenatal exposure to PFOA, however, the results of these two studies are conflicting.

Agency Report Reference: MDH (2022f). Toxicological Summary for: Perfluorooctanoate. March 2022. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH) **Supporting Documentation:** MDH (2022d). PFOA and Water. April 2022. Minnesota Department of Health (MDH).	
	Among the animal studies, decreased postnatal growth leading to developmental effects (e.g. lower pup body weight, delayed eye opening, delayed vaginal opening, and accelerated preputial separation) have been observed. These effects form the basis of the RfD. Delayed mammary gland development in female mice exposed in utero has been reported. Qualitative and quantitative scoring assessments have identified different thresholds for this effect. MDH had more confidence in using quantitative measurements of mammary gland development and these measures were used in identifying mammary gland development as a co-critical effect. An additional study evaluated the correlation between mammary duct branching patterns and the ability to support pup growth through lactation. No significant impacts were found. Doses resulting in serum concentrations >700-fold higher than the serum concentration corresponding to the RfD resulted in decreased neonatal survival. **Reproductive toxicity**: A series of studies in a high-exposure study population reported associations between PFOA exposure and pregnancy-induced hypertension or preeclampsia. Limited data suggest a correlation between higher PFOA levels in females and decreases in fecundity and fertility, however, loss of body burden via birth and lactation could impact this correlation. No clear effects of PFOA on male fertility endpoints have been identified. Among the animal studies, there was no effect of PFOA on reproductive or fertility parameters in female rats. However, it should be noted that female rats have a very high elimination rate compared to male rats or other species. Increased full litter resorptions and increased stillbirths were observed in pregnant mice exposed at serum concentrations >700-fold higher than the serum concentration corresponding to the RfD. No evidence of altered testicular and sperm structure or function was reported in adult male rats exposed to doses producing serum concentrations >350-fold higher than the serum concentration corresponding to the RfD. Increased sperm abnormalities and decreased testosterone have been reported, but typically at serum concentrations 100-fold higher than the serum concentration corresponding to the RfD.

Agency Report Reference: MDH (2022f). Toxicological Summary for: Perfluorooctanoate. March 2022. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH) **Supporting Documentation:** MDH (2022d). PFOA and Water. April 2022. Minnesota Department of Health (MDH).	
	Neurotoxicity: The human data pertaining to neurotoxicity (including neurodevelopmental effects) of PFOA are limited, but do not indicate the presence of associations between PFOA and a variety of outcomes. Epidemiology studies of children found a weak statistical association between serum PFOA and parental reports of ADHD. Information from animal studies is also quite limited. The offspring of mice fed PFOA throughout gestation had detectable levels of PFOA in their brains at birth. Locomotor activity, anxiety-related or depression-like behavior, or muscle strength were not altered. Circadian activity tests revealed gender-related differences in exploratory behavior patterns. These data suggest a need for additional studies to fully understand the neurological effects of PFOA.
Assessed in Appendix D?	Yes.

B.4.14 MDH (2023a)

Agency Report Reference: MDH (2023a). News Release. Joint agency statement on draft federal limits on PFAS in drinking water. March 14, 2023. Minnesota Department of Health (MDH)		
General Information	Date of data extraction	04 August 2023
	Authors	Minnesota Department of Health (MDH)
	Publication date	March 14, 2023
	Literature search timeframe	Not stated
	Publication type	News Release. Agency Joint Statement
	Peer reviewed?	Not stated
	Country of origin	US (Minnesota)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Maximum Contaminant Levels (MCLs)
	Exposure timeframe	Not stated
	Critical human health endpoint	Not applicable (MCL based on non-health-based considerations)
	Justification provided by agency for critical endpoint	The EPA is proposing Maximum Contaminant Levels (MCLs) for two per- and polyfluoroalkyl substances (PFAS) - PFOA and PFOS - in drinking water.

Agency Report Reference: MDH (2023a). News Release. Joint agency statement on draft federal limits on PFAS in drinking water. March 14, 2023. Minnesota Department of Health (MDH)		
	Critical study(ies) underpinning point of departure	Not applicable (MCL based on non-health-based considerations)
	Species for critical study(ies)	Not applicable (MCL based on non-health-based considerations)
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Not applicable (MCL based on non-health-based considerations)
	Point of departure value (include units)	Not applicable (MCL based on non-health-based considerations)
	Uncertainty factor(s) & rationale	Not applicable (MCL based on non-health-based considerations)
	Guideline value (include units)	MCL = 4 ng/L
	Mode of action for critical health endpoint	Not applicable (MCL based on non-health-based considerations)
	Genotoxic carcinogen?	Not applicable (MCL based on non-health-based considerations)
	Identified sensitive sub-populations	Not applicable (MCL based on non-health-based considerations)
	Any non-health-based considerations?	Not stated. NB: The MCLs adopted by MDH (2023a) are equivalent to the MCLG from USEPA (2022d, 2022e) of 4 ng/L for PFOA and PFOS which is based on a minimum reporting level (MRL).
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		NB: EPA is also proposing that four PFAS (PFBS, PFHxS, GenX and PFNA) be evaluated in combination with each other, using an approach called a Hazard Index. A hazard index is calculated by comparing a measured drinking water value with a standard.
Assessed in Appendix D?		No, adopted from other agency, no health basis.

B.4.15 MPART (2019a)

Agency Report Reference: MPART (2019a). Health-Based Drinking Water Value Recommendations for PFAS in Michigan. June 27, 2019. Michigan Science Advisory Workgroup. Michigan's PFAS Action Response Team (MPART).		
General Information	Date of data extraction	08 August 2023
	Authors	Michigan's PFAS Action Response Team (MPART).
	Publication date	June 27, 2019
	Literature search timeframe	Not stated.
	Publication type	Agency Guidance
	Peer reviewed?	Not stated.
	Country of origin	US (Michigan)
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Toxicity value Drinking water Health-based value (HBV)
	Exposure timeframe	Not stated
	Critical human health endpoint	Developmental delays (decreased number of inactive periods, altered novelty induced activity and skeletal alteration such as bone morphology and bone cell differentiation in the femurs and tibias) of mice.
	Justification provided by agency for critical endpoint	For all of the PFAS examined, points of departure were selected from studies with laboratory animal models. This approach does not negate findings associated with epidemiological studies, but reflects that humans experience uncontrolled and imperfectly documented rather than controlled, precisely measured exposures. Additionally, these points of departure reflect adverse health effects that occur at low doses and that are supported by the weight-of-evidence across endpoints and between findings in humans and laboratory animal models.
	Critical study(ies) underpinning point of departure	2 developmental reproductive toxicity studies in mice. • Onishchenko N, Fischer C, Wan Ibrahim WN, Negri S, Spulber S, Cottica D, Ceccatelli S. 2011. Prenatal exposure to PFOS or PFOA alters motor function in mice in a sex-related manner. Neurotox. Res. 19(3):452-61. • Koskela A, Finnilä MA, Korkalainen M, Spulber S, Koponen J, Håkansson H, Tuukkanen J, Viluksela M. 2016. Effects of developmental exposure to perfluorooctanoic acid (PFOA) on

Agency Report Reference: MPART (2019a). Health-Based Drinking Water Value Recommendations for PFAS in Michigan. June 27, 2019. Michigan Science Advisory Workgroup. Michigan's PFAS Action Response Team (MPART).		
		long bone morphology and bone cell differentiation. Toxicol. Appl. Pharmacol. 301:14-21.
	Species for critical study(ies)	Mice
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	LOAEL, $LOAEL_{HED}$
	Point of departure value (include units)	LOAEL: 0.3 mg/kg/day Serum based Point of Departure: 8.29 mg/L $LOAEL_{HED}$ = 0.001163 mg/kg/day [The serum TWA of 8.29 mg/L was converted to a HED as follows: TWA serum x ke x Vd = 8.29 mg/L x 8.2 x 10^{-4} x 0.17 L/kg].
	Uncertainty factor(s) & rationale	300 3 ($10^{0.5}$) for LOAEL to NOAEL, 10 for human variability, 3 ($10^{0.5}$) for animal to human variability, 1 for subchronic to chronic, 3 ($10^{0.5}$) for database deficiencies (endocrine effects). The Workgroup discussed the use of an uncertainty factor of 3 for use of a LOAEL. They noted that a NOAEL for immune effects was similar to the LOAEL selected and that the selected LOAEL represented less severe effects. The Workgroup concluded that use of the 3 ($10^{0.5}$) would be sufficiently protective. The Workgroup added a database uncertainty factor of 3 ($10^{0.5}$) for deficiencies the database regarding endocrine effects. The Workgroup noted that the mammary gland effects may signal a concern for other low dose endocrine effects.
	Guideline value (include units)	Toxicity Value: 3.9 ng/kg/day Drinking water HBV: 8 ng/L
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Not stated
	Identified sensitive sub-populations	Not clearly stated.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-

Agency Report Reference: MPART (2019a). Health-Based Drinking Water Value Recommendations for PFAS in Michigan. June 27, 2019. Michigan Science Advisory Workgroup. Michigan's PFAS Action Response Team (MPART).		
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		The mammary gland effects may be representative of endocrine effects at doses below the selected POD.
Assessed in Appendix D?		Yes.

B.4.16 NJDEP (2019a)

Agency Report Reference: NJDEP (2019a). Technical Support Document: Interim Specific Ground Water Criterion for Perfluorooctanoic Acid (PFOA, C8) (CAS #: 335-67-1; Chemical Structure: CF3(CF2)6COOH)*. March 6, 2019. New Jersey Department of Environmental Protection (NJDEP).		
General Information	Date of data extraction	08 August 2023
	Authors	Department of Environmental Protection. State of New Jersey (NJDEP)
	Publication date	March 6, 2019
	Literature search timeframe	Through April 2015
	Publication type	Agency Guidance
	Peer reviewed?	Not stated
	Country of origin	US (State of New Jersey)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Reference Dose (RfD) Health-based water concentration or Interim Specific Ground Water Criterion (ISGWQC)
	Exposure timeframe	Chronic (lifetime) drinking water exposure
	Critical human health endpoint	Increased liver weight in male mice
	Justification provided by agency for critical endpoint	Increased relative liver weight is a well-established effect of PFOA that is more sensitive than most other toxicological effects such as immune system toxicity and most reproductive/developmental effects
	Critical study(ies) underpinning point of departure	2-week toxicity study in mice/rats (Loveless et al., 2006)

Agency Report Reference: NJDEP (2019a). Technical Support Document: Interim Specific Ground Water Criterion for Perfluorooctanoic Acid (PFOA, C8) (CAS #: 335-67-1; Chemical Structure: CF3(CF2)6COOH)*. March 6, 2019. New Jersey Department of Environmental Protection (NJDEP).		
		• Loveless, S.E., Finlay, C., Everds, N.E., Frame, S.R., Gillies, P.J., O'Connor, J.C., Powley, C.R., Kennedy, G.L. (2006). Comparative responses of rats and mice exposed to linear/branched, linear, or branched ammonium perfluorooctanoate (APFO). Toxicology 220: 203–217.
	Species for critical study(ies)	Mice
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	$BMDL_{10}$, Target Human Serum Level.
	Point of departure value (include units)	$BMDL_{10}$: 4,351 ng/mL Target Human Serum Level: 14.5 ng/mL (=$BMDL_{10}$ ÷ UF x 0.001 mL/L = 4,351 ÷ 300 x 0.001) or 14,500 ng/L
	Uncertainty factor(s) & rationale	300 10 - UF for human variation, to account for variation in susceptibility across the human population and the possibility that the available data may not be representative of individuals who are most sensitive to the effect. 3 - UF for animal-to-human extrapolation, to account for toxicodynamic differences between humans and mice. 1 - UF for LOAEL to NOAEL. The point of departure is a BMDL, not a LOAEL. Therefore, an adjustment for use of a LOAEL is not necessary. 1 - UF for duration of exposure. Increased liver weight, usually associated with hepatocellular hypertrophy, is an early manifestation of PFOA's hepatic toxicity. 10 - UF for more sensitive effects that are not otherwise considered (e.g. incomplete database).
	Guideline value (include units)	RfD = 2 ng/kg/day (14,500 ng/L x 1.4 x 10^{-4}); Clearance factor from US EPA (2016a). Health-based water concentration (ISGWQC): 10 ng/L (rounded to one significant figure). [(2 ng/kg/day x 70 kg x 0.2) ÷ 2 L/day].
	Mode of action for critical health endpoint	Data from both the standard strain and PPAR-alpha null strains of mice demonstrate that increased liver weight and other types of hepatic toxicity occur through both PPAR-alpha dependent and independent modes of action in mice, and these effects are considered relevant to humans.
	Genotoxic carcinogen?	It is considered unlikely to be genotoxic.
	Identified sensitive sub-populations	These elevated exposures during early life are of special concern because effects from neonatal

Agency Report Reference: NJDEP (2019a). Technical Support Document: Interim Specific Ground Water Criterion for Perfluorooctanoic Acid (PFOA, C8) (CAS #: 335-67-1; Chemical Structure: CF3(CF2)6COOH)*. March 6, 2019. New Jersey Department of Environmental Protection (NJDEP).		
		exposure are sensitive endpoints for the toxicity of PFOA.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	Most of these studies predict that diet is the predominant exposure source. It is well established that serum PFOA concentrations are greatly elevated in communities with highly contaminated drinking water resulting from environmental discharges.
	Levels in drinking water supplies (include location)	• Cape Fear River (North Carolina): 12.6 ng/L (median), 287 ng/L max) • Upper Mississippi River drainage basin: 2.07 ng/L (median), 125 ng/L (max) • Tennessee River (Alabama): 395+128 ng/L • Moehne River Germany: 519 ng/L • New Jersey PWS: up to 190 ng/L in a groundwater source and up to 64 ng/L in tap water
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	Typical adult total exposures of about 2-3 ng/kg/day in Europe or North American were estimated in several studies. NB: Such dietary exposure estimates, in general, are highly uncertain because there are relatively few data on PFOA levels in food, analytical methods for food lack sufficient sensitivity, detection limits vary greatly among food types, and PFOA levels differ greatly in samples of the same foods obtained from different sources and/or locations.
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	The potential for prenatal and early life exposures to environmental contaminants to cause adverse health effects later in life is currently a focus of high interest in both epidemiology and toxicology.
Any other relevant information that should be captured?		ISGWQC based on carcinogenicity of 14 ng/L calculated using a cancer slope factor of 0.021 $(mg/kg/day)^{-1}$ from testicular tumour data. This value is identical to the health-based water concentration based on non-cancer endpoints developed above.
Assessed in Appendix D?		Yes.

B.4.17 OEHHA (2019a)

Agency Report Reference: OEHHA (2019a). Notification Level Recommendations. Perfluorooctanoic Acid and Perfluorooctane Sulfonate in Drinking Water. August 2019. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency		
General Information	Date of data extraction	02 August 2023.
	Authors	Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.
	Publication date	August 2019.
	Literature search timeframe	Unrestricted.
	Publication type	Agency Guidance Document.
	Peer reviewed?	Yes.
	Country of origin	US (California)
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	• Cancer Slope Factor (CSF). • Acceptable Daily Dose (ADD) • Reference Levels (RL) for cancer and non-cancer endpoints. • Notification Levels (NLs)
	Exposure timeframe	Lifetime
	Critical human health endpoint	• Non-cancer endpoint: Liver toxicity (and oxidative DNA damage, changes in mitochondrial membrane potential) in female mice (Li et al. 2017 as quoted in OEHHA 2019a). • Cancer endpoint: Pancreatic and liver tumours in male rats (NTP, 2018c as quoted in OEHHA 2019a).
	Justification provided by agency for critical endpoint	• Non-cancer endpoint: Li et al. (2017 as quoted in OEHHA 2019a) generated a LOAEL of 0.05 mg/kg-day (administered dose) for changes in mitochondrial membrane potential, increases in biomarkers of apoptosis, and increased oxidative DNA damage in the liver of female mice. This LOAEL corresponds to a serum concentration of 0.97 mg/L, which is lower than the POD of 4.35 mg/L based on increased relative liver weight in male mice (Loveless et al., 2006 as quoted in OEHHA 2019a) that formed the basis for the interim NL. The NOAELs/LOAELs (based on administered dose) determined from the recent

Agency Report Reference: OEHHA (2019a). Notification Level Recommendations. Perfluorooctanoic Acid and Perfluorooctane Sulfonate in Drinking Water. August 2019. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency		
		immunotoxicity studies are substantially higher than the LOAEL of 0.05 mg/kg-day for liver toxicity from the Li et al. (2017) study, which is selected as a critical study for development of a noncancer RL. Therefore, these studies are not considered for POD derivation in support of a final recommendation on the PFOA NL. • Cancer endpoint: Significant increases in hepatocellular adenomas/carcinomas and pancreatic acinar cell adenomas/carcinomas were observed in male rat. Hepatocellular adenoma/carcinoma and pancreatic acinar cell adenoma/carcinoma in male rats were evaluated for RL derivation.
	Critical study(ies) underpinning point of departure	• Non-cancer endpoint: Hepatotoxicity study in mice (Li et al., 2017 as quoted in OEHHA 2019a). • Cancer endpoint: Chronic 107-week dietary bioassay (NTP, 2018c as quoted in OEHHA 2019a as quoted in OEHHA 2019a).
	Species for critical study(ies)	Non-cancer endpoint: Female mice. Cancer endpoint: Male rats.
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Various: LOAEL, $BMDL_{05}$, HED
	Point of departure value (include units)	Cancer endpoint: • $BMDL_{05}$: 0.00648 mg/kg/day. • $BMDL_{05}$ HED: 0.00035 mg/kg/day. Non-cancer endpoint: • LOAEL: 0.05 mg/kg/day, or 0.97 mg/L
	Uncertainty factor(s) & rationale	Non-cancer endpoint: A total uncertainty factor (UF) of 300 is applied in calculating the ADD for PFOA: 3 for interspecies extrapolation, 10 for intraspecies variability, 3 for LOAEL to NOAEL extrapolation, and 3 for the potential for developmental toxicity at the point of departure. Because the critical endpoints here are upstream physiological changes that can lead to adverse effects in a known target organ of PFOA toxicity, the liver, OEHHA is applying a LOAEL to NOAEL UF of 3 rather than 10. OEHHA also is applying a subchronic to chronic extrapolation UF of 1. Since PFOA is not known to be metabolised in animals or humans, and because PFOA serum concentration is the dose metric used in the dose-response analysis, the pharmacokinetic components of the interspecies and intraspecies uncertainty factors are reduced. An intraspecies pharmacokinetics UF of √10 (rather than 10) is

Agency Report Reference: OEHHA (2019a). Notification Level Recommendations. Perfluorooctanoic Acid and Perfluorooctane Sulfonate in Drinking Water. August 2019. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency		
		kept to account for potential PK differences in infants and children. Cancer endpoint: Early-life exposures to PFOA do not substantially increase the likelihood of tumour formation later in life. Therefore, OEHHA is not applying ASFs for derivation of the cancer RL.
	Guideline value (include units)	Cancer endpoint: • CSF: 143 $(mg/kg\text{-}day)^{-1}$. • RL: 0.1 ng/L. NB: RL = R ÷ (CSF × DWI) = 10^{-6} ÷ (143 $(mg/kg\text{-}day)^{-1}$ × 0.053 L/kg-day), (where R = default excess cancer risk level of one in one million and DWI = drinking water intake rate, RL rounded to 0.4 ng/L). Non-cancer endpoint: • ADD: 0.0032 mg/L (Target human serum concentration) • ADD: 0.45 ng/kg-day. [0.0032 mg/L x 1.4 x 10^{-4} L/kg/day x 10^{6} ng/mg] • RL: 2 ng/L. NB: RL = ADD x RSC ÷DWI = 0.45 ng/kg/day × 0.2÷ 0.053 L/kg/day (where RSC = relative source contribution, RL rounded to 2 ng/L). The State Water Resources Control Board (SWRCB) set the NLs at the lowest levels at which PFOA and PFOS can be reliably detected in drinking water.
	Mode of action for critical health endpoint	Non-cancer endpoint: It has been established that PFOA can induce toxicity via activation of the nuclear receptor peroxisome proliferator-activated receptor alpha (PPARα). However, PPARα activation does not explain all of the observed toxicity, and studies in PPARα knockout mice clearly demonstrate PPARα-independent toxicity. Furthermore, there is evidence that PFOA activates other nuclear receptors, including constitutive androstane receptor (CAR), pregnane X receptor (PXR), and oestrogen receptor alpha (ERα) (New Jersey DWQI, 2017). Recently, it was demonstrated that PFOA indirectly activates CAR, differently from the prototypical CAR activator phenobarbital. Cancer endpoint: Not discussed.
	Genotoxic carcinogen?	Not stated
	Identified sensitive sub-populations	-
	Any non-health-based considerations?	-

Agency Report Reference: OEHHA (2019a). Notification Level Recommendations. Perfluorooctanoic Acid and Perfluorooctane Sulfonate in Drinking Water. August 2019. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency		
Exposure considerations	Principal routes of exposure in general population	Oral ingestion is the primary route of exposure to PFOS in drinking water, and inhalation and dermal exposures are considered negligible. NB: Refer to the draft document, OEHHA (2023a) in **Section B.4.18**.
	Levels in drinking water supplies (include location)	- NB: Refer to the draft document, OEHHA (2023a) in **Section B.4.18**.
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	- NB: Refer to the draft document, OEHHA (2023a) in **Section B.4.18**.
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		The cancer RLs cited above are lower than the levels of PFOA and PFOS that can be reliably detected in drinking water using currently available technologies. In light of this, OEHHA recommends that the State Water Resources Control Board (SWRCB) set the NLs at the lowest levels at which PFOA and PFOS can be reliably detected in drinking water using available and appropriate technologies.
Assessed in Appendix D?		Yes.

B.4.18 OEHHA (2023a)

Agency Report Reference: OEHHA (2023a). Public Health Goals. Second Public Review Draft. Perfluorooctanoic Acid and Perfluorooctane Sulfonic Acid in Drinking Water. July 2023. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency		
General Information	Date of data extraction	02 August 2023.
	Authors	Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency.
	Publication date	July 2023.
	Literature search timeframe	Unrestricted.
	Publication type	Agency Guidance Document.

Agency Report Reference: OEHHA (2023a). Public Health Goals. Second Public Review Draft. Perfluorooctanoic Acid and Perfluorooctane Sulfonic Acid in Drinking Water. July 2023. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency		
	Peer reviewed?	Yes.
	Country of origin	US (California)
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Cancer endpoint: • Cancer Slope Factor (CSF). • Public Health Goal (PHG) Non-cancer endpoint • Acceptable Daily Dose (ADD) • Health-Protective Concentration (HPC) (also referred to as 'C' in OEHHA 2023a).
	Exposure timeframe	Lifetime
	Critical human health endpoint	• PHG: Kidney cancer in humans (Vieira et al., 2013; Shearer et al., 2021, as quoted in OEHHA 2023d). • HPC: Increased risk of elevated alanine aminotransferase (ALT) in humans (Gallo et al. 2012, as quoted in OEHHA 2023d)
	Justification provided by agency for critical endpoint	• PHG (cancer): Four human studies (Steenland and Woskie, 2012; Barry et al., 2013; Vieira et al., 2013; Shearer et al., 2021, as quoted in OEHHA 2023a) with adequate data to evaluate an association between PFOA and kidney cancer all reported strong evidence supporting a true causal association between PFOA and this cancer type. Evaluations of chance, bias, confounding, dose-response, consistency, and biologic plausibility all support these findings. There are a number of potential reasons why a fifth study, the Raleigh et al. (2014) study, could have missed a true effect. Overall, based on these analyses, OEHHA concludes that the positive associations identified in most of the studies of PFOA and kidney cancer are real, and that PFOA is a cause of kidney cancer in humans. • HPC (non-cancer): OEHHA selected the NOAEC of 9.8 ng/mL for elevated ALT from the Gallo et al. (2012) study as the POD for its PFOA ADD calculations. While this study does not provide the lowest POD, it does offer the following advantages for dose-response and risk assessment calculations. o Very large sample size (N=46,452) o Valid method for assessing exposure. o Clinically relevant outcome.

Agency Report Reference: OEHHA (2023a). Public Health Goals. Second Public Review Draft. Perfluorooctanoic Acid and Perfluorooctane Sulfonic Acid in Drinking Water. July 2023. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency		
		o Consistency of findings.
	Critical study(ies) underpinning point of departure	• PHG: Case-control studies (Vieira et al., 2013, and Shearer et al., 2021 as quoted in OEHHA 2023d). • HPC: Cross-sectional study (Gallo et al. 2012 as quoted in OEHHA 2023d)
	Species for critical study(ies)	PHG and HPC: Humans.
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	NOAEC
	Point of departure value (include units)	Cancer endpoint: • PODs not discernible. Non-cancer endpoint: • Serum NOAEC: 9.8 ng/mL.
	Uncertainty factor(s) & rationale	Non-cancer endpoint: a UF of √10 for intraspecies variation. A UF of √10 for intraspecies variation rather than 1 was applied because the C8 study population was not diverse in terms of race or ethnicity. In addition, it did not examine other potential susceptibility factors such as obesity or genetics. Some data suggest that obesity or certain genetic polymorphisms might increase susceptibility to PFAS. Cancer endpoint: Uncertainty factors are not used for CSF derivation.
	Guideline value (include units)	Cancer endpoint: • CSF: 0.0026 $(ng/kg/day)^{-1}$.(Geometric mean from two studies) • PHG: 0.007 ng/L. NB: PHG = R ÷ (CSF × DWI) = 10^{-6} ÷ (0.0026 $(ng/kg\text{-}day)^{-1}$ × 0.053 L/kg-day), (where R = default excess cancer risk level of one in one million and DWI = drinking water intake rate, PHG rounded to 0.007 ng/L). Non-cancer endpoint: • ADD: 0.87 ng/kg/day [9.8 ng/mL x 0.28 mL/kg-day]. • HPC: 3 ng/L. NB: HPC = ADD x RSC ÷DWI = 0.87 ng/kg/day × 0.2÷ 0.053 L/kg/day (where RSC = relative source contribution, HPC rounded to 3 ng/L).
	Mode of action for critical health endpoint	Cancer endpoint: PPARα activation by PFOA and PFOS has been previously proposed as a key event in the induction of carcinogenesis observed in mice and rats.

Agency Report Reference: OEHHA (2023a). Public Health Goals. Second Public Review Draft. Perfluorooctanoic Acid and Perfluorooctane Sulfonic Acid in Drinking Water. July 2023. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency		
		The key events identified in the proposed tumour progression pathway are 1) activation of PPARα, 2) perturbation of cell proliferation and apoptosis, and 3) selective clonal expansion. NB: It is suggested that the liver tumour induction observed from exposure to some PPARα activators in rats and mice is not relevant to human cancer risk assessment. It is likely that carcinogenesis occurs through multiple MOAs. PFOA has been shown to disrupt lipid metabolism in the liver. One way PFOA does this is by changing the expression and activity of enzymes involved in fatty acid metabolism. Changes in fatty acid metabolism have been linked to liver disease. PFOA increases acyl-CoA oxidase activity in rat liver, and carboxylesterase mRNA and protein levels in male mice. Carboxylesterases play a role in lipid metabolism and homeostasis.
	Genotoxic carcinogen?	There is some positive evidence of genotoxicity for PFOA and PFOS. For PFOA, the evidence of mutagenicity is limited, but chromosomal effects and DNA damage have been observed both *in vivo* and *in vitro*. Therefore, genotoxicity cannot be dismissed as a possible mode of action for PFOA.
	Identified sensitive sub-populations	-
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	The major exposure contribution in adults is food (71-87%), followed by drinking water (7.5-23%). Contaminated drinking water can also become the main source of exposure.
	Levels in drinking water supplies (include location)	• US: Several UCMR3-tested areas in California had 20-70 ng/L PFOA in drinking water (UCMR3 = US EPA's Third Unregulated Contaminant Monitoring Rule). • In the subset of UCMR3 results for California with average PFOS concentration of 28 ng/L. • More recent drinking water monitoring program carried out by State Water Resources Control Board (SWRCB). Arithmetic means excluding non-detects: o 14.4 ng/L (n=570, 40% detect) o 12.4 ng/L (n=653, 43% detect) o 14.5 ng/L (n = 920, 33% detect) o 13.9 ng/L (n=772, 38% detect)

Agency Report Reference: OEHHA (2023a). Public Health Goals. Second Public Review Draft. Perfluorooctanoic Acid and Perfluorooctane Sulfonic Acid in Drinking Water. July 2023. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency		
	Any special considerations to exposure levels (e.g. higher in drought?)	Studies point to the potential for immunotoxicity to occur below the NOAEC for elevated ALT in adults.
	Typical exposure in general population (include units for intakes & location)	For PFOA, exposure levels for an intermediate exposure scenario for infants, children and adults were at 9.8, 7.6 and 2.5 ng/kg-day, respectively.
Risk Summary	Any risks to human health from drinking water identified in agency document?	SLR note that the PHG (0.007 ng/L) and HPC (3 ng/L) are lower than PFOA concentration reported in drinking water (12.4 to 14.5 ng/L). SLR note that the ADD (0.87 ng/kg/day) is lower than PFOA intake modelled from foods (2.5 to 9.8 ng/kg/day).
	Any emerging risks identified?	-
Any other relevant information that should be captured?		-
Assessed in Appendix D?		Yes.

B.4.19 RIVM (2021a)

Agency Report Reference: RIVM (2021a). Revised Risk Assessment of GenX and PFOA in Food. Part 1: Toxicity of GenX and PFOA and intake through contaminated Dairy products, eggs and fish. 01-09-2021 (final version). Rijksinstituut voor Volksgezondheid en Milieu (RIVM). **Supporting Documentation:** RIVM (2018a). Mixture exposure to PFAS: A Relative Potency Factor approach. RIVM Report 2018-0070. Rijksinstituut voor Volksgezondheid en Milieu (RIVM).		
Refer to the data extraction table for PFOS: **Section B.1.19** as the Tolerable Weekly Intake (TWI) and Daily Intake from RIVM (2021a) were established by EFSA for the EFSA-4 (PFOA, PFOS, PFNA and PFHxS) as a sum together with relative potency factors (RPFs) for PFAS for the risk assessment of this group of compounds (including GenX and PFBS).		
Health considerations	Guideline value (include units)	• TWI (for EFSA-4): 4.4 ng/kg/wk. • Daily Intake (for EFSA-4): 0.63 ng/kg/day • RPF for GenX: 0.06 (unitless) • RPF for PFBS: 0.001 (unitless) (refer to RIVM 2018a).
Exposure considerations	Levels in drinking water supplies (include location)	Netherlands (Dordrecht, 37 locations) • PFBS: 3.0 ng/L (2015), 3.4 (2017) • GenX: No data • PFOS: <0.6 ng/L, 0.41 (2017) • PFOA: 4.5 ng/L, 2.2 (2017) • PFHxS: <0.6 ng/L, 0.43 (2017) • Sum of PFAS: 23.8 to 27.4 ng/L, 19.3- 21.3 ng/L (2017).
Assessed in Appendix D?		No, because TRV was adopted from EFSA (2020a).

B.4.20 USEPA (2022d, 2021a, 2022c)

Agency Report Reference: USEPA (2022d). Interim Drinking Water Health Advisory: Perfluorooctanoic Acid (PFOA) CASRN 335-67-1. EPA Publication # EPA/822/R-22/003. June 2022. United States Environmental Protection Agency (USEPA). **Supported Documentation :** USEPA (2021a). External Peer Review Draft. Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctanoic Acid (PFOA) (CASRN 335-67-1) in Drinking Water. EPA Document No. 822D21001. December 2021. DRAFT. DO NOT CITE OR QUOTE. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).		
General Information	Date of data extraction	01 August 2023
	Authors	U.S. Environmental Protection Agency, Office of Water (4304T). Office of Science and Technology. Health and Ecological Criteria Division, Washington, DC 20460.
	Publication date	June 2022
	Literature search timeframe	No date restrictions identified by SLR in the Literature Search Strategy.
	Publication type	Agency Guideline
	Peer reviewed?	The document underwent a technical edit by the contractor Tetra Tech (contract number 68HERC20D0016). This Health Advisory document was provided for review by staff in the following EPA program Offices: Office of Water, Office of Chemical Safety and Pollution Prevention, Office of Pollution Prevention and Toxics, Office of Land and Emergency Management, Office of Policy, Office of Children's Health Protection, Office of Research and Development
	Country of origin	US
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	• Interim Health Advisory (iHA) • draft chronic reference dose (RfD) • Maximum Contaminant Level Goals (MCLG)
	Exposure timeframe	Lifetime. NB: iHA is for 0- to < 5-year-old children because PFOA exposure was measured in 5-year-old children in the critical study, and it is reasonable to expect that PFOA exposure levels were similar from birth through age 5

Agency Report Reference: USEPA (2022d). Interim Drinking Water Health Advisory: Perfluorooctanoic Acid (PFOA) CASRN 335-67-1. EPA Publication # EPA/822/R-22/003. June 2022. United States Environmental Protection Agency (USEPA). **Supported Documentation :** USEPA (2021a). External Peer Review Draft. Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctanoic Acid (PFOA) (CASRN 335-67-1) in Drinking Water. EPA Document No. 822D21001. December 2021. DRAFT. DO NOT CITE OR QUOTE. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).		
	Critical human health endpoint	Developmental immune health outcome (suppression of tetanus vaccine response in 7-year-old children)
	Justification provided by agency for critical endpoint	Decreased immune response to vaccination was observed after exposure during a sensitive developmental life stage, and it yields the lowest point of departure (POD) human equivalent dose (POD_{HED}) among the candidate $PODs_{HED}$. Other candidate RfDs were derived based on other health effects (e.g. development/growth) observed in epidemiology studies; all of the candidate RfDs are associated with low daily oral exposure doses, ranging from 1 to 0.001 ng/kg.bw-day
	Critical study(ies) underpinning point of departure	Epidemiological study (Grandjean et al., 2012; Budtz-Jorgensen and Grandjean, 2018). • Grandjean, P., E.W. Andersen, E. Budtz-Jørgensen, F. Nielsen, K. Mølbak, P. Weihe, and C. Heilmann. 2012. Serum vaccine antibody concentrations in children exposed to perfluorinated compounds. JAMA 307:391–397 (as quoted in USEPA 2021d) • Budtz-Jørgensen, E., and P. Grandjean. 2018. Application of benchmark analysis for mixed contaminant exposures: mutual adjustment of perfluoroalkylate substances associated with immunotoxicity. PLoS One 13(10):e0205388. doi:10.1371/journal.pone.0205388 (as quoted in USEPA 2021d).
	Species for critical study(ies)	Epidemiological studies in children
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Point of departure human equivalent dose (POD_{HED}) Note - refer to USEPA 2021a for details: The PODs from human epidemiological studies (immune, developmental and serum lipid endpoints) were derived using benchmark dose modelling (see Appendix B.1) and included. • A POD based on a BMR of 5% and a $BMDL_5$ of 0.72 ng/mL (USEPA 2021a). • A POD Internal Dose/Internal Dose Metric: 7.2×10^{-4} mg/L (USEPA 2021a). • The internal dose POD was then converted to a POD_{HED} (USEPA 2021a).

Agency Report Reference: USEPA (2022d). Interim Drinking Water Health Advisory: Perfluorooctanoic Acid (PFOA) CASRN 335-67-1. EPA Publication # EPA/822/R-22/003. June 2022. United States Environmental Protection Agency (USEPA). **Supported Documentation :** USEPA (2021a). External Peer Review Draft. Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctanoic Acid (PFOA) (CASRN 335-67-1) in Drinking Water. EPA Document No. 822D21001. December 2021. DRAFT. DO NOT CITE OR QUOTE. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).		
	Point of departure value (include units)	0.0149 ng/kg/day (POD_{HED}) (USEPA 2021a)
	Uncertainty factor(s) & rationale	From USEPA (2021a): The total or composite UF (UFC) used to derive the PFOA RfD was 10. • UFA = 1: A UFA of 1 is applied to developmental and immunological effects observed in epidemiological studies. • UFH = 10 No information was available relative to variability in the human population that supports a factor other than 10. • UFS = 1: The developmental period is recognised as a susceptible life stage when exposure during a time window of development is more relevant to the induction of developmental effects than lifetime exposure (U.S. EPA, 1991, 732120).
	Guideline value (include units)	• RfD: 0.0015 ng/kg/day • iHA: 0.004 ng/L (= RfD * RSC ÷ DWI-BW) where o Relative source contribution (RSC) = 0.2 o DWI-BW = 0.0701 L/kg/bw/day (the 90th percentile drinking water intake for the selected population) • MCLG: 4 ng/L, i.e. minimum reporting level, MRL)
	Mode of action for critical health endpoint	-
	Genotoxic carcinogen?	EPA previously concluded that the induction of tumours is likely due to nongenotoxic mechanisms involving membrane receptor activation, perturbations of the endocrine system, and/or the process of DNA replication and cell division (USEPA 2021a). An updated MOA analysis incorporating literature identified since 2016 is ongoing. Notably, other agencies have since published conclusions about the available evidence related to the MOA of PFOA. CalEPA's Office of Environmental Health Hazard Assessment concluded in their recent Proposed Public Health Goals for PFOA and PFOS in Drinking Water that PFOA "*possesses several of the key characteristics of carcinogens, including the ability to induce oxidative stress, inflammation,*

Agency Report Reference: USEPA (2022d). Interim Drinking Water Health Advisory: Perfluorooctanoic Acid (PFOA) CASRN 335-67-1. EPA Publication # EPA/822/R-22/003. June 2022. United States Environmental Protection Agency (USEPA).

Supported Documentation : USEPA (2021a). External Peer Review Draft. Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctanoic Acid (PFOA) (CASRN 335-67-1) in Drinking Water. EPA Document No. 822D21001. December 2021. DRAFT. DO NOT CITE OR QUOTE. United States Environmental Protection Agency (USEPA).

Supporting Documentation: USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).

		and modulate receptor-mediated effects. Additionally, there is suggestive evidence that PFOA and PFOS are genotoxic, thus a genotoxic MOA for cancer remains plausible" {CalEPA, 2021, 9416932}. Moreover, IARC (2016, 3982387) concluded that there is moderate evidence for many potential mechanisms for PFOA-induced toxicity (including PPARα). (NB: Classified as likely to be carcinogenic to humans).
	Identified sensitive sub-populations	EPA considered the sensitive life stage of exposure associated with the critical effect on which the draft chronic RfD was based.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	Ingestion of food is a potentially significant source of exposure to PFOA and is often claimed to be the dominant source of exposure based on early studies that modelled the relative contributions of various sources among the general populations of North America and Europe (USEPA 2021a). Ingestion of drinking water is a potentially significant source of exposure to PFOA (USEPA 2021a).
	• Levels in drinking water supplies (include location)	• US public water systems (PWSs): detections ranged from 20 ng/L to 349 ng/L with median = 30 ng/L and 90th percentile concentration = 70 ng/L (n = 36,792, PWSs = 4,920) • Bottled water (domestic and imported): <4 ng/L (n = 30) (USEPA 2021a). • US: Median = 4.15 ng/L, maximum = 104 ng/L (from 29 drinking water treatment plants) (USEPA 2021a).
	Any special considerations to exposure levels (e.g. higher in drought?)	The dominance of the food ingestion pathway is attributed to bioaccumulation in food from environmental emissions, relatively large amounts of foods being consumed, and high gastrointestinal uptake (USEPA 2021a). However, the estimates are highly uncertain due to analytical methods with poor sensitivity, relatively few food items with detectable levels, and levels that can vary greatly depending on sources or location (USEPA 2021a).

Agency Report Reference: USEPA (2022d). Interim Drinking Water Health Advisory: Perfluorooctanoic Acid (PFOA) CASRN 335-67-1. EPA Publication # EPA/822/R-22/003. June 2022. United States Environmental Protection Agency (USEPA). **Supported Documentation :** USEPA (2021a). External Peer Review Draft. Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctanoic Acid (PFOA) (CASRN 335-67-1) in Drinking Water. EPA Document No. 822D21001. December 2021. DRAFT. DO NOT CITE OR QUOTE. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).		
	Typical exposure in general population (include units for intakes & location)	The exposure among adults (from foods) is typically estimated to be about 2-3 ng/kg/day (USEPA 2021a).
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	Candidate draft CSFs from human and animal studies were identified in the draft PFOA document, but one was not selected as the preferred draft CSF for derivation of a 10^{-6} cancer risk concentration. The selection of a CSF is ongoing.
Any other relevant information that should be captured?		Cumulative exposures (from USEPA 2022c): Use the Hazard Index (HI) approach to assess the potential noncancer risk of a mixture of PFOA, PFOS, GenX chemicals, and PFBS (USEPA 2022c), i.e. HI = ($Conc._{PFOA}$ ÷HA_{PFOA}) + ($Conc._{PFOS}$÷HA_{PFOS}) + ($Conc._{PFBS}$ ÷ HA_{PFBS}) +($Conc._{GenX}$ ÷HA_{GenX}). The Unregulated Contaminant Monitoring Rule (UCMR) 5-derived and promulgated minimum reporting level (MRL) for PFOA is 4 ng/L. Sorption-based treatment processes such as granular activated carbon (GAC), powdered activated carbon (PAC), and anion exchange (AIX), as well as high-pressure membrane processes such as nanofiltration (NF) and reverse osmosis (RO), have been shown to successfully remove PFOA from drinking water to below the 0.004 µg/L MRL for UCMR 5
Assessed in Appendix D?		Yes.

B.4.21 WHO (2022)

Agency Report Reference: WHO (2022). PFOS and PFOA in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality. 29 September 2022. Version for public review. WHO/SDE/WSH/XXXXXX. World Health Organisation (WHO).		
General Information	Date of data extraction	01 August 2023
	Authors	World Health Organisation (WHO)
	Publication date	29 September 2022

Agency Report Reference: WHO (2022). PFOS and PFOA in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality. 29 September 2022. Version for public review. WHO/SDE/WSH/XXXXXX. World Health Organisation (WHO).		
	Literature search timeframe	Not stated. Contains references from 2022.
	Publication type	Agency Guideline Document
	Peer reviewed?	Not stated
	Country of origin	Not stated
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Oral Tolerable Daily Intake provisional guideline values (pGVs)
	Exposure timeframe	Not relevant
	Critical human health endpoint	Acknowledging the significant uncertainties and absence of consensus with identifying the critical health endpoint to calculate a HBGV and the rapidly evolving science, a pragmatic solution is therefore proposed for the derivation of provisional guideline values (pGVs).
	Justification provided by agency for critical endpoint	Not relevant.
	Critical study(ies) underpinning point of departure	Not relevant.
	Species for critical study(ies)	Not relevant.
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10,}$ etc.)	Not relevant.
	Point of departure value (include units)	Not relevant.
	Uncertainty factor(s) & rationale	Not relevant.
	Guideline value (include units)	100 ng/L NB: 500 ng/L for Total PFAS
	Mode of action for critical health endpoint	Not relevant.
	Genotoxic carcinogen?	Not relevant.
	Identified sensitive sub-populations	Not relevant.
	Any non-health-based considerations?	The pGVs are derived with the objective of reducing human exposure and therefore risk. In deriving the pGVs, global data on occurrence including co-occurrence of PFAS, available analytical methods and treatment achievability were considered. A pGV of 100 ng/L for PFOA is proposed based on the following considerations:

Agency Report Reference: WHO (2022). PFOS and PFOA in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality. 29 September 2022. Version for public review. WHO/SDE/WSH/XXXXXX. World Health Organisation (WHO).		
		• This value corresponds to greater than 90% removal achievability with high pressure membrane filtration (NF and RO), activated carbon adsorption or ion-exchange (section 9.4), considering that upper-bound concentrations detected in drinking water sources have mostly been in the low µg/L range. • The pGV for PFOA should therefore be achievable, where these technologies are available and have been optimised for PFAS removal. • Although the pGV was not derived based on adverse health effects studies, the value falls within the range of most health-based values derived through national risk assessments.
Exposure considerations	Principal routes of exposure in general population	Human exposure to PFAS, including PFOS and PFOA, occurs through multiple media and routes; dietary exposure, dust and drinking water are key exposure routes for which quantitative exposure data are available. Other studies support food as being the major source (>70%) of exposure to PFOS and PFOA in the general population living in areas not characterised by heavy contamination by PFAS.
	PFOS Levels in drinking water supplies (include location)	• China: 0.75 ng/L (Median, LOQ = 0.03 ng/L). Tap water sampled from the household kitchen from 79 cities. • Japan: up to 44 ng/L PFOS (not detected in 11 samples). Water sampled from 39 water treatment plants between January and March 2020. • Philippines: 3.01 ng/L (maximum, n = 7): and Thailand 7.89 ng/L (n = 16). • Australia: 9.7 ng/L (maximum, n=62, 34 locations across Australia) • US: ∑PFOS and PFOA: ranged from 0.02 to 7.22 µg/L. • US: 4.15 ng/L (median) and 104 ng/L (maximum) (25 drinking water treatment plants across the USA) • EU: 1 ng/L (lower bound mean) to 3.0 ng/L (upper 7 bound mean) • Turkey: 2.37 ng/L (n=94 samples, 33 provinces) • Netherlands, Germany, France and Spain: High variability. 0.63 ng/L (Utrecht, Netherlands) to 519 ng/L (Rhine, Ruhr and Moehne area). • Italy: Maximums ranged from 7 ng/L to 1,475 ng/L.

Agency Report Reference: WHO (2022). PFOS and PFOA in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality. 29 September 2022. Version for public review. WHO/SDE/WSH/XXXXXX. World Health Organisation (WHO).		
	Any special considerations to exposure levels (e.g. higher in drought?)	Living in areas characterised by heavy contamination by PFAS. Bioaccumulation of PFOS and PFOA is possible in aquatic organisms, in land-based food chains (i.e. plants) and mammals, including farm animals, and humans (EFSA, 2020). The partitioning to albumins in blood, liver and eggs is a key bioaccumulation mechanism for PFAS, in contrast to lipid accumulation that is typical of other POPs.
	Typical exposure in general population (include units for intakes & location)	In the evaluation carried out by EFSA (2020), the contribution of drinking water to overall PFOS and PFOA intake (as lower bound mean exposure) in the general population was found to be highest in the infant age group, with a maximum of 10% and 60% respectively. Trudel et al. (2008) reported that comparable levels of PFAS uptake would be expected in North America and Europe from food and water. Intakes from food: • US: 1 – 130 ng/kg bw/day • Canada: 250 ng/day (PFOS and PFOA) in adults • Germany: 2.9 ng/kg bw/day (median)
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		Although the reduced antibody response following vaccination has been considered by some agencies as the most robust end point based on epidemiological data, it is unclear whether this correlation results in increased rates of infection and hence the clinical implications are uncertain. Although animal data would generally be utilised in the absence of adequate human data for risk assessment purposes, there are also areas of uncertainty around the suitability of animal studies for assessing the effects to human health for PFOS and PFOA as discussed earlier, including interspecies differences in kinetic parameters such as elimination half-life and clearance rate. Additionally, diverging estimates of the human half-life of PFOA may also add uncertainty to animal-to-human dosimetric adjustments, as well as PBPK-based conversions of human plasma PFAS concentrations to external doses. Finally, the uncertainty and lack of consensus in the critical health end point to derive a HBGV is evident from the diverse range of endpoints utilised by other agencies to derive tolerable daily intakes or similar values, and the resulting range in proposed drinking water values described in Table A.1 (see appendix). Although the values derived by several different organisations vary

Agency Report Reference: WHO (2022). PFOS and PFOA in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality. 29 September 2022. Version for public review. WHO/SDE/WSH/XXXXXX. World Health Organisation (WHO).	
	significantly, all have margins of safety. Data analysis also shows that science on PFAS is evolving very rapidly in various areas
Assessed in Appendix D?	No, as the DWG is not health-based.

B.4.22 WSDH (2019a, 2023a, 2022b)

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (SWDH). **Supporting Documentation:** WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (SWDH). **Supporting Documentation:** WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (SWDH).		
General Information	Date of data extraction	04 August 2023
	Authors	Washington State Department of Health (SWDH).
	Publication date	November 2019
	Literature search timeframe	Not applicable
	Publication type	Agency Guidance and Fact Sheets
	Peer reviewed?	Yes
	Country of origin	US (Washington)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	For the SAL: Reference Dose (RfD) or Allowable daily intake (ADI) (WSDH 2022b) WA State Action Level (SAL) EPA Health Advisory Levels (WSDH 2023a) EPA Proposed Maximum contamination levels (MCLs) (WSDH 2023a)
	Exposure timeframe	Chronic
	Critical human health endpoint	SAL: Neurodevelopmental and skeletal effects in mouse offspring (WSDH 2022b).
	Justification provided by agency for critical endpoint	SAL: We selected the ATSDR's MRL of 3 ng/kg–day based on developmental effects in mice as the best basis for drinking water state action levels. In both the EPA and ATSDR evaluations, developmental endpoints yielded health protective values that were as low as or lower than liver injury and immunotoxicity endpoints. There are sufficient supporting toxicity data demonstrating PFOA's developmental toxicity in fish, rats, mice, and monkeys.

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (SWDH). **Supporting Documentation:** WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (SWDH). **Supporting Documentation:** WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (SWDH).		
		The proposed EPA standards for PFOA and PFOS are lower than the Washington SALs adopted by the State Board of Health (SBOH) in 2021. EPA established stricter goals based on evidence that these PFAS contribute to cancer risk (WSDH 2023a).
	Critical study(ies) underpinning point of departure	SAL: Developmental study in mice (Koskela et al. 2016; Onishchenko et al. 2011 as quoted in WSDH 2019a). • Koskela, A., et al., Effects of developmental exposure to perfluorooctanoic acid (PFOA) on long bone morphology and bone cell differentiation. Toxicol Appl Pharmacol, 2016. 301: p. 14-21. • Onishchenko, N., et al., Prenatal exposure to PFOS or PFOA alters motor function in mice in a sex-related manner. Neurotox Res, 2011. 19(3): p. 452-61.
	Species for critical study(ies)	SAL: Mouse
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	SAL: LOAEL, HED, Predicted time-weighted average maternal serum level
	Point of departure value (include units)	SAL: • LOAEL: 0.3 mg/kg/day • Predicted time-weighted average maternal serum level: 8.29 mg/L. • HED: 0.000821 mg/kg/day [The LOAEL of 8.29 mg/L was multiplied by the Dose Adjustment Factor of 0.000099 L/kg-day].
	Uncertainty factor(s) & rationale	SAL: 300 UFH: 10 - UFH, 3 -UFA: 3, UFL: 10 SLR notes the basis for the UF is not provided in WSDH 2019a. Refer above in **Section B.4.3** to ATSDR data extraction (ATSDR 2021a), "*10 for use of a LOAEL, 3 for extrapolation from animals to humans with dosimetric adjustments, and 10 for human variability*".
	Guideline value (include units)	• SAL: RfD or ADI: 3 ng/kg/day (ADI in WSDH 2022b) • USEPA RfD: 20 ng/kg/day (WSDH 2022b) • SAL: 10 ng/L

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (SWDH). **Supporting Documentation:** WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (SWDH). **Supporting Documentation:** WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (SWDH).		
		• Health Advisory Level: 0.004 ng/kg/day (refer to data extraction for USEPA 2022d for derivation) (WSDH 2022b) • MCL: 4 ng/L (WSDH 2023a)
	Mode of action for critical health endpoint	Not stated.
	Genotoxic carcinogen?	PFOA is not considered genotoxic or mutagenic but studies in laboratory animals have reported increased incidence of tumours in liver, testicular, and pancreatic tissues as well as ovarian tubular hyperplasia. From WSDH (2022b): PFOA is not considered genotoxic or mutagenic, but studies in laboratory animals have reported increased incidence of tumours in liver, testicular, and pancreatic tissues as well as ovarian tubular hyperplasia (Biegel et al., 2001; Butenhoff et al., 2012; EPA, 2016a; NTP, 2020). PFOA exposure has been positively associated with increased incidence of kidney and/or testicular cancers in some epidemiological studies (Barry et al., 2013; Shearer et al., 2020; Vieira et al., 2013). Studies of the general population have looked for but not found associations between serum PFOA levels and a range of human cancers (Bonefeld-Jorgensen et al., 2014; Eriksen et al., 2009; Hardell et al., 2014; Innes et al., 2014). The following cancer classifications have been applied to PFOA: • "Suggestive evidence" of carcinogenic potential in humans (EPA, 2016c). • Group 2B, possibly carcinogenic to humans
	Identified sensitive sub-populations	Sensitive subpopulations. While most studies of developmental toxicity in animals administered PFOA during gestation, some studies have demonstrated that postnatal exposure alone resulted in decreased postnatal growth and altered behaviour in adulthood mature mice. Overall, toxicity studies available for PFOA demonstrate that early life stages are sensitive to PFOA-induced toxicity. Infant and later childhood developmental periods could also be sensitive as these are periods of rapid growth and development.
	Any non-health-based considerations?	The MCL (4 ng/L) is the lowest concentration of PFOA and PFOS that can be reliably measured by

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (SWDH). **Supporting Documentation:** WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (SWDH). **Supporting Documentation:** WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (SWDH).		
		the lab methods required by EPA (drinking water testing methods 533 and 537.1).
Exposure considerations	Principal routes of exposure in general population	PFAS exposure in the home occurs during product use and exposure to house dust containing PFAS. The greatest portion of the chronic exposure to PFAS for the general public, specifically to PFOS and PFOA, results from the intake of contaminated drinking water and foods (WSDH 2022b)
	Levels in drinking water supplies (include location)	Results of PFAS testing of drinking water in Washington state for PFAS (PFOS + PFOA concentration) (data from WSDH 2022b): • Issaquah Water System – Well #4: 490 ng/L then LOD (after GAC filter installed) • Issaquah Water System – Well #5: Up to 40 ng/L. • Sammamish Plateau Water and Sewer District: Up to 40 ng/L. • City of DuPont Water System (2 wells): 30ng/L • City of DuPont Water System (4 wells): 14 – 60 ng/L • JBLM - Lewis (two wells): 51 ng/L. • Ft. Lewis (five wells): 15 – 71 ng/L • McChord Field (four wells): 216-250 ng/L • Lakewood Water District (6 wells): 17 – 63 ng/L. • Parkland Light and Water Well #9: 7 – 42 ng/L • Town of Coupeville, Evergreen Mobile Home Park, Group B wells, and 20 private wells: 6 – 7,740 ng/L. • Town of Coupeville water system (one well): 22 – 61 ng/L. • City of Airway Heights (two wells): 1,400 – 1,500 ng/L. • Fairchild AFB (88 wells): 73 – 5,700 ng/L • Fairchild AFB (78 wells): LOD – 70 ng/L • Naval Base Kitsap- Bangor 2 wells: >70 ng/L Naval Base Kitsap- Bangor 93 wells: LOD – 70 ng/L
	Any special considerations to exposure levels (e.g. higher in drought?)	-

Agency Report Reference: WSDH (2019a). Group A Public Water Supplies • Chapter 246-290 WAC. Draft Recommended State Action Levels for Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water: Approach, Methods and Supporting Information. November 2019. Washington State Department of Health (SWDH).

Supporting Documentation: WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (SWDH).

Supporting Documentation: WSDH (2022b). Per- and Polyfluoroalkyl Substances Chemical Action Plan. Publication 21-04-048. Revised September 2022. Washington State Department of Ecology. Washington State Department of Health (SWDH).

	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	
Any other relevant information that should be captured?		Any change to a SAL or adopting a state MCL requires rulemaking (WSDH 2023a). In the meantime, we will continue to implement our requirements under our existing SALs (WSDH 2023a). PFNA is comparable to our SAL, PFHxS is lower than our SAL, and PFBS is higher than our SAL. We'll read EPA's support documentation to understand why they differ (WSDH 2023a). SLR Note: Also refer to compilation of Health-based value for subchronic/ chronic oral intake (ng/kg-day) in **Section B.1.22**.

Compilation of Health-based value for subchronic/ chronic oral intake (ng/kg-day)

Type of PFAA Chem.	Authoritative body responsible for value (year)	Health-based value for subchronic/ chronic oral intake (ng/kg-day)
PFOA	EPA RfD (2016)	20
PFOA	ATSDR MRL (2021)	2
PFOA	NJ DWQI RfD (2017)	2
PFOA	NH DES RfD (2019)	6.1
PFOA	MI SAW TV (2019)	3.9
PFOA	CA OEHHA ADD (2019)	0.45

Assessed in Appendix D?	No, as the TRV is adopted from another agency (ATSDR 2021a).

B.5 GenX Chemicals Existing Health-based Guidance

B.5.1 CDPH (2023a)

Agency Report Reference: CDPH (2023a). Per- and polyfluoroalkyl Substances (PFAS). 2023. Connecticut State Department of Public Health (CDPH)		
General Information	Date of data extraction	07 August 2023
	Authors	Connecticut State Department of Public Health (CDPH)
	Publication date	2023
	Literature search timeframe	Not stated
	Publication type	Agency webpage.
	Peer reviewed?	Not stated.
	Country of origin	US (Connecticut)
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	CT Drinking Water Action Level
	Exposure timeframe	Not stated.
	Critical human health endpoint	Liver effects.
	Justification provided by agency for critical endpoint	CT DPH develops its drinking water Action Levels by considering health impacts to the most sensitive and most exposed populations across all stages of human development.
	Critical study(ies) underpinning point of departure	Not stated.
	Species for critical study(ies)	Animal studies
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10,}$ etc.)	Not stated.
	Point of departure value (include units)	Not stated.
	Uncertainty factor(s) & rationale	Not stated.
	Guideline value (include units)	19 ng/L
	Mode of action for critical health endpoint	Not stated.
	Genotoxic carcinogen?	Not stated.
	Identified sensitive sub-populations	Pregnant people, infants and children are at higher risk because of PFAS effects on pregnancy

Agency Report Reference: CDPH (2023a). Per- and polyfluoroalkyl Substances (PFAS). 2023. Connecticut State Department of Public Health (CDPH)		
		outcomes and foetal, infant and child growth and development.
	Any non-health-based considerations?	Not stated.
Exposure considerations	Principal routes of exposure in general population	Not stated.
	Levels in drinking water supplies (include location)	Not stated.
	Any special considerations to exposure levels (e.g. higher in drought?)	Not stated.
	Typical exposure in general population (include units for intakes & location)	Not stated.
Risk Summary	Any risks to human health from drinking water identified in agency document?	Not stated.
	Any emerging risks identified?	Not stated.
Any other relevant information that should be captured?		The chemical-specific approach reflects the evolving scientific evidence on the toxicity of PFAS and is more protective of public health than the summed approach used previously in CT.
Assessed in Appendix D?		No, no health basis provided.

B.5.2 EU (2020), EC (2022)

Agency Report Reference: EC (2022). Final Opinion on Groundwater quality standards for proposed additional pollutants in the annexes to the Groundwater Directive (2006/118/EC) Scientific Co **Agency Report Reference:** EU (2020). Directives. Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the Quality of Water Intended for Human Consumption (recast) (Text with EEA relevance). L 435/2, 23.12.2020. European Union (EU). **Supporting Documentation:** EC (2022). Final Opinion on Groundwater quality standards for proposed additional pollutants in the annexes to the Groundwater Directive (2006/118/EC) Scientific Committee on Health, Environmental and Emerging Risks SCHEER. 18 July 2022. DG Health and Food Safety. European Commission (EC).mmittee on Health, Environmental and Emerging Risks SCHEER. 18 July 2022. DG Health and Food Safety. European Commission (EC).		
Refer to the data extraction table for PFOS: **Section B.1.7** noting the value is for Sum of PFAS or Total PFAS.		
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Quality Standard for surface water - drinking water and human health ($EQS_{dw,hh}$)
	Guideline value (include units)	Technical Guidelines: 100 ng/L (EU 2020 only) Technical Guidelines and $EQS_{dw,hh}$: PFAS Total: 500 ng/L (EU 2020, EC 2022) NB: 'Total PFAS' as the totality of per- and polyfluoroalkyl substances detected with available

Agency Report Reference: EC (2022). Final Opinion on Groundwater quality standards for proposed additional pollutants in the annexes to the Groundwater Directive (2006/118/EC) Scientific Co **Agency Report Reference:** EU (2020). Directives. Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the Quality of Water Intended for Human Consumption (recast) (Text with EEA relevance). L 435/2, 23.12.2020. European Union (EU). **Supporting Documentation:** EC (2022). Final Opinion on Groundwater quality standards for proposed additional pollutants in the annexes to the Groundwater Directive (2006/118/EC) Scientific Committee on Health, Environmental and Emerging Risks SCHEER. 18 July 2022. DG Health and Food Safety. European Commission (EC).mmittee on Health, Environmental and Emerging Risks SCHEER. 18 July 2022. DG Health and Food Safety. European Commission (EC).		
		analytical methods and monitoring guidelines (EU 2020, EC 2022). 'Sum of PFAS' means the sum of per- and polyfluoroalkyl substances considered a concern as regards to water intended for human consumption listed in point 3 of Part B of Annex III. This is a subset of 'PFAS Total' substances that contain a perfluoroalkyl moiety with three or more carbons (i.e. $–C_nF_{2n}–$, n ≥ 3) or a perfluoroalkylether moiety with two or more carbons (i. e. $C_nF_{2n}OC_mF_{2m}–$, n and m ≥ 1) (EU 2020).
Assessed in Appendix D?		No, no basis provided.

B.5.3 Mass DEP (2022a)

Agency Report Reference: Mass DEP (2022a). Important Information. EPA's New Health Advisories for Some PFAS. August 11, 2022. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP). **Supporting Documentation:** Mass DEP (2023a). EPA Proposed Maximum Contaminant Level (MCL) for PFAS. April 12, 2023. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP).		
Refer to the data extraction table for PFOS: **Section B.1.12**.		
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	• EPA's Health Advisories • Maximum Contaminant Level (MCL) • Maximum Contaminant Level Goals (MCLGs) (Mass DPH 2023a)
	Guideline value (include units)	• MCL (PFAS6): 20 ng/L for the sum of six PFAS (PFOS, PFOA, PFHxS, PFNA, PFHpA, and PFDA) (established as enforceable in Massachusetts) The two EPA Interim Health Advisories and two Final Health Advisories are: • Interim Health Advisory for PFOA: 0.004 ng/L • Interim Health Advisory for PFOS: 0.02 ng/L • Final Health Advisory for GenX: 10 ng/L • Final Health Advisory for PFBS: 2,000 ng/L MCLGs from Mass DPH (2023a): • PFOS: 4 ng/L

Agency Report Reference: Mass DEP (2022a). Important Information. EPA's New Health Advisories for Some PFAS. August 11, 2022. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP). **Supporting Documentation:** Mass DEP (2023a). EPA Proposed Maximum Contaminant Level (MCL) for PFAS. April 12, 2023. Department of Environment Protection. Commonwealth of Massachusetts (Mass DEP).		
		• PFOA: 4 ng/L • PFNA, PFHxS, PFBS, & GenX: Hazard Index of 1. NB: Massachusetts will adopt PFAS drinking water regulations that are at least as stringent as the federal standards (Mass DEP 2023a). NB: Mass DEP (2023a) is proposing to address four additional PFAS (GenX, PFBS, PFNA, and PFHxS) as a mixture using a Hazard Index. A Hazard Index accounts for the increased risk from mixtures of PFAS (Mass DEP 2023a). SLR note that it is not clear how the Hazard Index will be calculated, i.e. which MCLG, HA or MCL will be used for the calculation.
Assessed in Appendix D?		No, adopted from other agencies. No basis provided.

B.5.4 MDH (2023a)

Agency Report Reference: MDH (2023a). News Release. Joint agency statement on draft federal limits on PFAS in drinking water. March 14, 2023. Minnesota Department of Health (MDH)		
Refer to the data extraction table for PFOS: **Section B.1.14** for further information.		
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Hazard Index Approach
	Guideline value (include units)	EPA is also proposing that four PFAS (PFBS, PFHxS, GenX and PFNA) be evaluated in combination with each other, using an approach called a Hazard Index. A hazard index is calculated by comparing a measured drinking water value with a standard. SLR presumes the standard is the MCL of 4 ng/L for PFOS and PFOA.
	Any non-health-based considerations?	Not stated. NB: The MCLs adopted by MDH (2023a) are equivalent to the MCLG from USEPA (2022d, 2022e) of 4 ng/L for PFOA and PFOS which is based on a minimum reporting level (MRL).
Assessed in Appendix D?		No, adopted from another agency (no health basis provided).

B.5.5 MPART (2019a)

Agency Report Reference: MPART (2019a). Health-Based Drinking Water Value Recommendations for PFAS in Michigan. June 27, 2019. Michigan Science Advisory Workgroup. Michigan's PFAS Action Response Team (MPART).		
General Information	Date of data extraction	08 August 2023
	Authors	Michigan's PFAS Action Response Team (MPART).
	Publication date	June 27, 2019
	Literature search timeframe	Not stated.
	Publication type	Agency Guidance
	Peer reviewed?	Not stated.
	Country of origin	US (Michigan)
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Toxicity value Drinking water Health-based value (HBV)
	Exposure timeframe	Not stated
	Critical human health endpoint	Liver effects (increased absolute and relative weight and histopathologic findings, i.e. liver single cell necrosis in parental male mice)
	Justification provided by agency for critical endpoint	For all of the PFAS examined, points of departure were selected from studies with laboratory animal models. This approach does not negate findings associated with epidemiological studies, but reflects that humans experience uncontrolled and imperfectly documented rather than controlled, precisely measured exposures. Additionally, these points of departure reflect adverse health effects that occur at low doses and that are supported by the weight-of-evidence across endpoints and between findings in humans and laboratory animal models. The Workgroup noted that while primarily industry-funded studies are the only ones available, they followed recognised testing guidelines and/or were published following external peer-review. These studies appear to be sufficient for developing values.
	Critical study(ies) underpinning point of departure	Reproduction/ Developmental Toxicity Study in Mice (DuPont-18405-1037 2010). • Oral (Gavage) Reproduction/ Developmental Toxicity Study in Mice (OECD TG 421; modified according to the Consent Order) DuPont-18405-1037 (2010)
	Species for critical study(ies)	Mice
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	NOAEL, $BMDL_{10}$, POD_{HED}

Agency Report Reference: MPART (2019a). Health-Based Drinking Water Value Recommendations for PFAS in Michigan. June 27, 2019. Michigan Science Advisory Workgroup. Michigan's PFAS Action Response Team (MPART).		
	Point of departure value (include units)	NOAEL: 0.1 mg/kg/day $BMDL_{10}$ = 0.15 mg/kg/day $BMDL_{10}$-POD_{HED} = 0.023 mg/kg/day [$BMDL_{10}$ x (0.0372 kg in male mice/80 kg in humans)$^{3/4}$]
	Uncertainty factor(s) & rationale	300 1 for use of a LOAEL to NOAEL, 10 for human variability, 3 ($10^{0.5}$) for animal to human variability, 3 ($10^{0.5}$) for subchronic-to-chronic, 3 ($10^{0.5}$) for database deficiencies, including lack of epidemiological, and developmental and immunotoxicological studies in laboratory animals. The Workgroup evaluated the uncertainty factors selected by USEPA (2018). Given the deficiencies in the database, including a lack of epidemiological studies and developmental and immunotoxicological in laboratory animals, a database uncertainty factor of 3 was retained. In conjunction with the deficiencies covered by the database uncertainty factor, the subchronic to chronic uncertainty factor of 3 was identified as sufficient.
	Guideline value (include units)	Toxicity Value: 77 ng/kg/day Drinking water HBV: 370 ng/L [(RSC of 0.2 x 77 ng/kg/day x 80 kg) ÷ 3.353 L/day]
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Not stated
	Identified sensitive sub-populations	Not clearly stated although an UF was applied for the lack of information on early-life sensitivity.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-

Agency Report Reference: MPART (2019a). Health-Based Drinking Water Value Recommendations for PFAS in Michigan. June 27, 2019. Michigan Science Advisory Workgroup. Michigan's PFAS Action Response Team (MPART).	
Any other relevant information that should be captured?	-
Assessed in Appendix D?	Yes.

B.5.6 N.C. DHHS (2017)

Agency Report Reference: NC DHHS (2017). Gen X Health Information. 2017. State of North Carolina. Department of Health and Human Services (NC DHHS).		
General Information	Date of data extraction	08 August 2023
	Authors	State of North Carolina. Department of Health and Human Services (NC DHHS).
	Publication date	2017
	Literature search timeframe	Not stated
	Publication type	Agency Letter
	Peer reviewed?	Not stated
	Country of origin	US (North Carolina)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Health goal
	Exposure timeframe	Not stated
	Critical human health endpoint	Not stated
	Justification provided by agency for critical endpoint	Not stated
	Critical study(ies) underpinning point of departure	Not stated
	Species for critical study(ies)	Not stated
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Not stated
	Point of departure value (include units)	Not stated
	Uncertainty factor(s) & rationale	Not stated
	Guideline value (include units)	Health goal: 140 ng/L
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Not stated

Agency Report Reference: NC DHHS (2017). Gen X Health Information. 2017. State of North Carolina. Department of Health and Human Services (NC DHHS).		
	Identified sensitive sub-populations	Not stated
	Any non-health-based considerations?	Not stated
Exposure considerations	Principal routes of exposure in general population	If this water is used as a drinking water source, people could be exposed to these compounds through drinking water. There is not enough information about GenX to know if people in North Carolina are likely to be exposed through sources other than drinking water. People can be exposed to other types of PFAS in multiple ways, including through food, indoor dust, consumer products, and workplaces such as manufacturing facilities.
	Levels in drinking water supplies (include location)	-
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		A health goal is a non-regulatory, non-enforceable level of contamination below which no adverse health effects would be expected over a lifetime of exposure. This health goal may change as new information becomes available. There is not enough information to develop health goals for many other new or emerging PFAS at this time.
Assessed in Appendix D?		No, no basis provided.

B.5.7 NJDEP (2023a)

Agency Report Reference: NJDEP (2023a). Interim Specific Ground Water Quality Criterion (ISGWQC) for hexafluoropropylene oxide dimer acid (HFPO-DA) and its ammonium salt (GenX). May 24, 2023. Department of Environmental Protection. State of New Jersey (NJDEP).		
General Information	Date of data extraction	07 August 2023
	Authors	Department of Environmental Protection. State of New Jersey (NJDEP)
	Publication date	May 24, 2023
	Literature search timeframe	Not stated

Agency Report Reference: NJDEP (2023a). Interim Specific Ground Water Quality Criterion (ISGWQC) for hexafluoropropylene oxide dimer acid (HFPO-DA) and its ammonium salt (GenX). May 24, 2023. Department of Environmental Protection. State of New Jersey (NJDEP).		
	Publication type	Agency Technical Memorandum
	Peer reviewed?	Yes
	Country of origin	US (State of New Jersey)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Interim Specific Ground Water Quality Criterion (ISGWQC) Reference Dose (RfD)
	Exposure timeframe	Chronic (lifetime) exposure
	Critical human health endpoint	Histopathological changes in the livers of parental female mice
	Justification provided by agency for critical endpoint	As discussed in the January 25, 2022 memorandum from DSR to DAQ (Attachment 1), DSR reviewed the basis of the USEPA (2021) RfD of 3 ng/kg/day and concluded that it is scientifically justified and health protective.
	Critical study(ies) underpinning point of departure	Reproductive/developmental study (DuPont18405-1037, 2010) • DuPont-18405-1037. (2010). An Oral (Gavage) Reproduction/Developmental Toxicity Screening Study of H-28548 in Mice. U.S. EPA OPPTS 870.3550; OECD Test Guideline 421. E.I. du Pont de Nemours and Company. Study conducted by WIL Research Laboratories, LLC (Study Completed: December 29, 2010), Ashland, OH.
	Species for critical study(ies)	Mice
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	$BMDL_{10}$, POD_{HED}
	Point of departure value (include units)	$BMDL_{10}$: 0.09 mg/kg/day POD_{HED}: 0.01 mg/kg/day
	Uncertainty factor(s) & rationale	A total uncertainty factor (UF) of 3000 (10 for intraspecies variability, 3 for interspecies extrapolation, 10 for subchronic-to-chronic exposure duration, and 10 for database uncertainties [for potentially more sensitive effects])
	Guideline value (include units)	RfD: 3 ng/kg/day ISGWQC: 20 ng/L
	Mode of action for critical health endpoint	Not stated
	Genotoxic carcinogen?	Not stated.

Agency Report Reference: NJDEP (2023a). Interim Specific Ground Water Quality Criterion (ISGWQC) for hexafluoropropylene oxide dimer acid (HFPO-DA) and its ammonium salt (GenX). May 24, 2023. Department of Environmental Protection. State of New Jersey (NJDEP).		
		The mode of action of the tumours caused by GenX is unknown (USEPA, 2021), the non-threshold assumption is applicable to GenX. NB: Suggestive Evidence of Carcinogenic Potential
	Identified sensitive sub-populations	Not stated
	Any non-health-based considerations?	Not stated
Exposure considerations	Principal routes of exposure in general population	Not stated
	Levels in drinking water supplies (include location)	Not stated
	Any special considerations to exposure levels (e.g. higher in drought?)	Not stated
	Typical exposure in general population (include units for intakes & location)	Not stated
Risk Summary	Any risks to human health from drinking water identified in agency document?	Not stated
	Any emerging risks identified?	Not stated
Any other relevant information that should be captured?		As discussed in the January 25, 2022 memorandum from DSR to DAQ (Attachment 1), DSR reviewed the basis of the USEPA (2021) RfD of 3 ng/kg/day and concluded that it is scientifically justified and health protective. DSR therefore recommended that NJDEP use the USEPA (2021) RfD of 3 ng/kg/day for GenX.
Assessed in Appendix D?		No, adopted from US EPA (2021).

B.5.8 RIVM (2018a)

Agency Report Reference: RIVM (2018a). Mixture exposure to PFAS: A Relative Potency Factor approach. RIVM Report 2018-0070. Rijksinstituut voor Volksgezondheid en Milieu (RIVM).		
General Information	Date of data extraction	03 August 2023
	Authors	Rijksinstituut voor Volksgezondheid en Milieu (RIVM)
	Publication date	2018
	Literature search timeframe	Not stated.
	Publication type	Agency Guidance
	Peer reviewed?	Not stated.

Agency Report Reference: RIVM (2018a). Mixture exposure to PFAS: A Relative Potency Factor approach. RIVM Report 2018-0070. Rijksinstituut voor Volksgezondheid en Milieu (RIVM).		
	Country of origin	Netherlands
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Relative Potency Factor (RPF)
	Exposure timeframe	Chronic
	Critical human health endpoint	Relative liver weight (for all PFAS)
	Justification provided by agency for critical endpoint	In general, the RPFs based on absolute and relative liver weight are similar, and the RPFs based on hypertrophy are below those based on liver weight. Since the set of RPFs derived from relative liver weight is the most complete set, the use of the RPFs derived from this endpoint is suggested. Due to the uncertainties in the RPFs, it is considered appropriate to round them off to one significant digit.
	Critical study(ies) underpinning point of departure	GenX (FRD-902): 28-day chronic Toxicity study in rats (Haas, 2009 as quoted in RIVM 2018a) • Haas, M.C., A 90-day Oral (Gavage) Toxicity Study of H-28548 in Rats with a 28-day Recovery (Study No. Wil-189216), WIL Research Laboratories, LLC, Ashland, OH, 2009 PFOA: 13-Week dietary toxicity study in rats (Perkins, 2004 as quoted in RIVM 2018a) • Perkins, R., Butenhoff, J., Kennedy, G. and Palazzolo, M. (2004). 13-Week dietary toxicity study of ammonium perfluorooctanoate (APFO) in male rats. Drug and Chemical Toxicology 27: 361-378 (as cited in SIAR, 2006).
	Species for critical study(ies)	Rats
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	BMD_{05}
	Point of departure value (include units)	**Derived BMD in mg/kg bw/day for two models (Table A7).** **PFAS** / **Exp** / **Hill** GenX (FRD-902) / 4.968 / 5.008 PFOA / 0.288 / 0.2938
	Uncertainty factor(s) & rationale	Not applicable.
	Guideline value (include units)	0.06 (unitless)

Agency Report Reference: RIVM (2018a). Mixture exposure to PFAS: A Relative Potency Factor approach. RIVM Report 2018-0070. Rijksinstituut voor Volksgezondheid en Milieu (RIVM).		
	Mode of action for critical health endpoint	PFAS are known to cause effects on the liver (though the mode of action remains unknown).
	Genotoxic carcinogen?	Not stated
	Identified sensitive sub-populations	-
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	Netherlands (Dordrecht, 37 locations) • PFBS: 3.0 ng/L (2015), 3.4 (2017) • GenX: No data • PFOS: <0.6 ng/L, 0.41 (2017) • PFOA: 4.5 ng/L, 2.2 (2017) • PFHxS: <0.6 ng/L, 0.43 (2017) • Sum of PFAS: 23.8 to 27.4 ng/L, 19.3- 21.3 ng/L (2017).
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	PFOA equivalents are calculated for a mixture of PFAS congeners, while neglecting the conversion of environmental PFAS precursors to these congeners. The extent to which this introduces uncertainty in the calculation of PFOA equivalents depends on the occurrence of the precursors in the media of interest.
Any other relevant information that should be captured?		The RPF approach taken rests on the assumption of dose-addition, i.e. the absence of any interaction between mixture congeners in inducing liver toxicity. Verifying this assumption requires the availability of toxicity studies in which mixture toxicity is directly compared with that of its constituting congeners. Unfortunately, such studies are not available for PFAS. Therefore, for the time being, the assumption made concerning the dose addition of PFAS congeners still needs to be verified.
Assessed in Appendix D?		No, as no guidance value or guideline value were derived specifically for GenX. Only a potency factor relative to PFOA is provided.

B.5.9 USEPA (2021e, 2022c)

Agency Report Reference: USEPA (2021e). Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (CASRN 13252-13-6 and CASRN 62037-80-3). Also Known as "GenX Chemicals". EPA-Final. EPA Document Number: 822R-21-010. October 2021. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).		
General Information	Date of data extraction	01 August 2023
	Authors	U.S. Environmental Protection Agency, Office of Water (4304T). Health and Ecological Criteria Division, Washington, DC 20460.
	Publication date	October 2021
	Literature search timeframe	No date restrictions identified by SLR in the Literature Search Strategy. The initial literature searches for these GenX chemicals were conducted in July 2017 (acid) and January/February 2018 (ammonium salt). Subsequent literature searches were conducted from 2018 to March 2020.
	Publication type	Agency Guideline
	Peer reviewed?	This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication.
	Country of origin	US
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	Reference Dose (RfD)
	Exposure timeframe	Chronic NB: A sub-chronic RfD was also calculated.
	Critical human health endpoint	Liver effects (a constellation of lesions, including cytoplasmic alteration, hepatocellular single-cell and focal necrosis, and hepatocellular apoptosis) in female mice.
	Justification provided by agency for critical endpoint	Overall, the available toxicity studies demonstrate that the liver is particularly sensitive to HFPO dimer acid- and HFPO dimer acid ammonium salt-induced toxicity. EPA determined that the constellation of liver lesions observed in the rodent are relevant to human health and not a result of PPARα-induced cell proliferation unique to rodents.

Agency Report Reference:

USEPA (2021e). Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (CASRN 13252-13-6 and CASRN 62037-80-3). Also Known as "GenX Chemicals". EPA-Final. EPA Document Number: 822R-21-010. October 2021. United States Environmental Protection Agency (USEPA).

Supporting Documentation: USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).

	Critical study(ies) underpinning point of departure	The critical study chosen for determining the subchronic and chronic RfDs for HFPO dimer acid and/or its ammonium salt was the oral reproductive/developmental toxicity study in mice.
	Species for critical study(ies)	Mice
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	POD Human Equivalent Dose (HED). NB: The POD_{HED} was derived using a NOAEL of 0.1 mg/kg/day and EPA's Benchmark Dose Technical Guidance Document (EPA, 2012). EPA conducted benchmark dose modelling to empirically model the dose-response relationship in the range of observed data. Additionally, EPA's Recommended Use of Body Weight$^{3/4}$ as the Default Method in Derivation of the Oral Reference Dose (EPA, 2011b) was used to allometrically scale a toxicologically equivalent dose of orally administered agents from adult laboratory animals to adult humans. Allometric scaling addresses some aspects of cross-species extrapolation of toxicokinetic and toxicodynamic processes (i.e. interspecies UF). A benchmark response (BMR) of 10% extra risk was chosen.
	Point of departure value (include units)	0.01 mg/kg/day
	Uncertainty factor(s) & rationale	3,000 10 for intraspecies variability, 3 for interspecies differences, and 10 for database deficiencies, including immune effects and additional developmental studies. A UF of 10 was also applied for extrapolation from a subchronic to a chronic duration
	Guideline value (include units)	RfD = 3 ng/kg/day (chronic)
	Mode of action for critical health endpoint	The available data indicate that multiple MOAs could be involved in the liver effects observed after GenX chemical exposure. The available studies provide support for a role for PPARα, cytotoxicity, mitochondrial dysfunction, and PPARγ. The potential MOA(s) for the observed reproductive and developmental effects (e.g. changes in GWG and placental lesions) are unknown. Additionally, no data support identification of a potential carcinogenic MOA for tumours in the pancreas and testes as being related to any of the proposed MOAs for the tumour development in either organ.

Agency Report Reference: USEPA (2021e). Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (CASRN 13252-13-6 and CASRN 62037-80-3). Also Known as "GenX Chemicals". EPA-Final. EPA Document Number: 822R-21-010. October 2021. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).		
		Although there is evidence for a PPARα MOA in the liver, particularly in the high-dose groups in the available studies, data indicate that liver toxicity extends beyond a single PPARα-based MOA. The available data for HFPO dimer acid support cytotoxicity as a potential MOA.
	Genotoxic carcinogen?	No. There is Suggestive Evidence of Carcinogenic Potential of oral exposure to GenX Chemicals in humans, based on the female hepatocellular adenomas and hepatocellular carcinomas and male combined pancreatic acinar adenomas and carcinomas observed in the chronic 2-year study in rats.
	Identified sensitive sub-populations	Not specifically stated.
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	• North Carolina Cape Fear drinking water treatment plants (DWTPs): One of 3 DTWPS = 631 ng/L (mean HFPO dimer acid in DWTP C). Note: subsequent testing found GenX Chemicals at concentrations of 400 - 500 ng/L at all steps of the treatment process, indicating that the concentrations of HFPO dimer acid were only slightly decreased by the conventional and advanced water treatment processes used at this DWTP. • Delaware River: 3–4 ng/L HFPO dimer acid • Kentucky DWTPs 1.32 ng/L to 29.7 ng/L • Globally, GenX Chemical occurrence has been reported in Germany, China, the Netherlands, the United Kingdom, South Korea, and Sweden (concentrations not shown). • Arctic surface water: 0.03 ng/L
	Any special considerations to exposure levels (e.g. higher in drought?)	-

Agency Report Reference: USEPA (2021e). Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (CASRN 13252-13-6 and CASRN 62037-80-3). Also Known as "GenX Chemicals". EPA-Final. EPA Document Number: 822R-21-010. October 2021. United States Environmental Protection Agency (USEPA). **Supporting Documentation:** USEPA (2022c). Technical Fact Sheet: Drinking Water Health Advisories for Four PFAS (PFOA, PFOS, GenX chemicals, and PFBS). EPA Document No. EPA 822-F-22-002. June 2022. United States Environmental Protection Agency (USEPA).		
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		Cumulative exposures (from USEPA 2022c): Use the Hazard Index (HI) approach to assess the potential noncancer risk of a mixture of PFOA, PFOS, GenX Chemicals, and PFBS (USEPA 2022c), i.e. HI = (Conc.$_{PFOA}$ ÷HA$_{PFOA}$) + (Conc.$_{PFOS}$÷HA$_{PFOS}$) + (Conc.$_{PFBS}$ ÷ HA$_{PFBS}$) +(Conc.$_{GenX}$ ÷HA$_{GenX}$). There are data available that demonstrate that the toxicokinetic profile for GenX chemicals is different than PFOA in that GenX chemicals are more rapidly excreted than PFOA and appear not to bioaccumulate like PFOA.
Assessed in Appendix D?		Yes.

B.5.10 USEPA (2022j)

Agency Report Reference: USEPA (2022j). Drinking Water Health Advisory: Hexafluoropropylene Oxide (HFPO) Dimer Acid (CASRN 13252-13-6) and HFPO Dimer Acid Ammonium Salt (CASRN 62037-80-3), Also Known as "GenX Chemicals". EPA-Final. EPA Document Number: EPA/822/R-22/005. June 2022. United States Environmental Protection Agency (USEPA).		
General Information	Date of data extraction	01 August 2023
	Authors	U.S. Environmental Protection Agency, Office of Water (4304T). Office of Science and Technology. Health and Ecological Criteria Division, Washington, DC 20460.
	Publication date	June 2022
	Literature search timeframe	Unlimited.
	Publication type	Agency Guideline
	Peer reviewed?	This Health Advisory document was provided for review by staff in the following EPA program Offices: Office of Water, Office of Chemical Safety and Pollution Prevention, Office of Pollution Prevention and Toxics, Office of Land and

Agency Report Reference: USEPA (2022j). Drinking Water Health Advisory: Hexafluoropropylene Oxide (HFPO) Dimer Acid (CASRN 13252-13-6) and HFPO Dimer Acid Ammonium Salt (CASRN 62037-80-3), Also Known as "GenX Chemicals". EPA-Final. EPA Document Number: EPA/822/R-22/005. June 2022. United States Environmental Protection Agency (USEPA).		
		Emergency Management, Office of Policy, Office of Children's Health Protection, Office of Research and Development
	Country of origin	US
	Source of funding	Not stated.
	Possible conflicts of interest	Not stated.
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	• Health Advisory (HA) • Chronic reference dose (RfD)
	Exposure timeframe	Not stated.
	Critical human health endpoint	Constellation of liver lesions (i.e. cytoplasmic alteration, hepatocellular single-cell and focal necrosis, and hepatocellular apoptosis)
	Justification provided by agency for critical endpoint	This endpoint was selected because the available health effects studies indicate that the liver is the most sensitive target of toxicity from exposure to GenX Chemicals.
	Critical study(ies) underpinning point of departure	The critical study selected for deriving the noncancer subchronic and chronic RfDs for HFPO dimer acid and/or its ammonium salt was the oral reproductive/developmental toxicity study in mice that reported a NOAEL of 0.1 milligrams per kilogram body weight per day (mg/kg bw-day) based on liver effects (a constellation of lesions, including cytoplasmic alteration, hepatocellular single-cell and focal necrosis, and hepatocellular apoptosis) in females (DuPont-18405-1037, 2010; NTP, 2019). • DuPont-18405-1037: E.I. du Pont de Nemours and Company. 2010. An Oral (Gavage) Reproduction/Developmental Toxicity Screening Study of H-28548 in Mice. EPA OPPTS 870.3550; OECD Test Guideline 421. Study conducted by WIL Research LaboratoriesLLC (Study Completion Date: December 29, 2010), Ashland, OH. (As quoted in USEPA 2022j). • NTP (National Toxicology Program). 2019. Pathology Peer Review of Liver Findings for H28548: Subchronic Toxicity 90 Day Gavage Study in Mice (DuPont-18405-1307). Study Number WIL-189225. National Institute of Environmental Health Sciences, NTP Pathology Working Group, Research Triangle Park, NC. (As quoted in USEPA 2022j)
	Species for critical study(ies)	Female mice

Agency Report Reference: USEPA (2022j). Drinking Water Health Advisory: Hexafluoropropylene Oxide (HFPO) Dimer Acid (CASRN 13252-13-6) and HFPO Dimer Acid Ammonium Salt (CASRN 62037-80-3), Also Known as "GenX Chemicals". EPA-Final. EPA Document Number: EPA/822/R-22/005. June 2022. United States Environmental Protection Agency (USEPA).		
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	POD Human Equivalent Dose (HED). NB: The POD_{HED} was derived using a NOAEL of 0.1 mg/kg/day and EPA's Benchmark Dose Technical Guidance Document (EPA, 2012). EPA conducted benchmark dose modelling to empirically model the dose-response relationship in the range of observed data. Additionally, EPA's Recommended Use of Body Weight$^{3/4}$ as the Default Method in Derivation of the Oral Reference Dose (EPA, 2011b) was used to allometrically scale a toxicologically equivalent dose of orally administered agents from adult laboratory animals to adult humans. Allometric scaling addresses some aspects of cross-species extrapolation of toxicokinetic and toxicodynamic processes (i.e. interspecies UF). A benchmark response (BMR) of 10% extra risk was chosen.
	Point of departure value (include units)	0.01 mg/kg/day
	Uncertainty factor(s) & rationale	3,000 10 for intraspecies variability, 3 for interspecies differences, and 10 for database deficiencies, including immune effects and additional developmental studies. A UF of 10 was also applied for extrapolation from a subchronic to a chronic duration
	Guideline value (include units)	• RfD: 3 ng/kg/day • HA: 10 ng/L (rounded) (= RfD * RSC ÷ DWI-BW) where o Relative source contribution (RSC) = 0.2 o DWI-BW = 0.0469 L/kg/bw/day (the 90th percentile drinking water intake for the selected population, lactating women)
	Mode of action for critical health endpoint	- (refer to data extraction for USEPA 2021e)
	Genotoxic carcinogen?	- (refer to data extraction for USEPA 2021e)
	Identified sensitive sub-populations	Lactating women
	Any non-health-based considerations?	-
Exposure considerations	Principal routes of exposure in general population	-
	Levels in drinking water supplies (include location)	• North Carolina Cape Fear drinking water treatment plant (DWTP): downstream of a fluorochemical manufacturer: ~500 ng/L.

Agency Report Reference: USEPA (2022j). Drinking Water Health Advisory: Hexafluoropropylene Oxide (HFPO) Dimer Acid (CASRN 13252-13-6) and HFPO Dimer Acid Ammonium Salt (CASRN 62037-80-3), Also Known as "GenX Chemicals". EPA-Final. EPA Document Number: EPA/822/R-22/005. June 2022. United States Environmental Protection Agency (USEPA).		
		• Netherlands: 0.25, 0.48, and 11 ng/L in the vicinity of the fluorochemical plant but not detected upstream at two locations. • Netherlands: 1.4 to 8.1 ng/L in tap water from residential homes (6 municipalities) in vicinity of fluorochemical plant above. • Belgium: Mean = 2.9 ng/L and maximum = 28 ng/L (11 water suppliers, concentrations above 4 ng/L were measured in drinking water from suppliers that sourced surface water in the vicinity of the fluoropolymer manufacturing plant in the Netherlands). • Delaware River: median = 2.02, max = 8.75 ng/L for HFPO dimer acid (n=12) • Kentucky DWTPs 1.32 ng/L to 29.7 ng/L (n=12) • Globally, GenX Chemical occurrence has been reported in Germany, China, the Netherlands, the United Kingdom, South Korea, and Sweden (concentrations not shown). • Arctic surface water: 0.03 ng/L
	Any special considerations to exposure levels (e.g. higher in drought?)	-
	Typical exposure in general population (include units for intakes & location)	-
Risk Summary	Any risks to human health from drinking water identified in agency document?	-
	Any emerging risks identified?	-
Any other relevant information that should be captured?		- (refer to data extraction for USEPA 2021e)
Assessed in Appendix D?		No, TRV derivation already described in USEPA (2021e).

B.5.11 WSDH (2023a)

Agency Report Reference: WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (SWDH).		
General Information	Date of data extraction	04 August 2023
	Authors	Washington State Department of Health (SWDH).
	Publication date	3/15/2023

Agency Report Reference: WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (SWDH).		
	Literature search timeframe	Not applicable
	Publication type	Agency Frequently Asked Questions Sheet
	Peer reviewed?	Not stated
	Country of origin	US (Washington)
	Source of funding	Not stated
	Possible conflicts of interest	Not stated
Health considerations	Guideline value type (e.g. oral TRV, drinking water guideline)	EPA Health Advisory Levels Health-based water concentration (HBWC)
	Exposure timeframe	EPA will regulate PFAS as chronic contaminants.
	Critical human health endpoint	Not stated.
	Justification provided by agency for critical endpoint	-
	Critical study(ies) underpinning point of departure	Not stated.
	Species for critical study(ies)	Not stated.
	Point of departure type (e.g. NOAEL, LOAEL, $BMDL_{10}$, etc.)	Not stated.
	Point of departure value (include units)	Not stated.
	Uncertainty factor(s) & rationale	Not stated.
	Guideline value (include units)	• EPA Health Advisory Levels: 10 ng/L • HBWC: 10 ng/L NB: For both the EPA Health Advisory Levels and HBWC refer to the data extraction for USEPA (2022j) for derivation of this value (a HA). Health-based water concentration (HBWC) are the "acceptable" values used to create a ratio of observed/acceptable for each of 4 PFAS (PFNA, PFHxS, PFBS and GenX). If the ratios add up to more than 1.0, action must be taken to lower PFAS in the drinking water.
	Mode of action for critical health endpoint	Not stated.
	Genotoxic carcinogen?	Not stated.
	Identified sensitive sub-populations	Not stated.
	Any non-health-based considerations?	For PFOS and PFOA only. The MCL (4 ng/L) is the lowest concentration of PFOA and PFOS that can be reliably measured by the lab methods

<table>
<tr><td colspan="3">Agency Report Reference: WSDH (2023a). 2023 EPA Proposal to Regulate PFAS in Drinking Water. 331-718. 3/15/2023. Washington State Department of Health (SWDH).</td></tr>
<tr><td></td><td></td><td>required by EPA (drinking water testing methods 533 and 537.1).</td></tr>
<tr><td rowspan="4">Exposure considerations</td><td>Principal routes of exposure in general population</td><td>-</td></tr>
<tr><td>Levels in drinking water supplies (include location)</td><td>-</td></tr>
<tr><td>Any special considerations to exposure levels (e.g. higher in drought?)</td><td>-</td></tr>
<tr><td>Typical exposure in general population (include units for intakes & location)</td><td>-</td></tr>
<tr><td rowspan="2">Risk Summary</td><td>Any risks to human health from drinking water identified in agency document?</td><td>-</td></tr>
<tr><td>Any emerging risks identified?</td><td></td></tr>
<tr><td colspan="2">Any other relevant information that should be captured?</td><td>Any change to a SAL or adopting a state MCL requires rulemaking (WSDH 2023a).
In the meantime, we will continue to implement our requirements under our existing SALs (WSDH 2023a).
PFNA is comparable to our SAL, PFHxS is lower than our SAL, and PFBS is higher than our SAL. We'll read EPA's support documentation to understand why they differ (WSDH 2023a).
SLR Note: Also refer to compilation of Health-based value for subchronic/ chronic oral intake (ng/kg-day) in Section B.1.22.</td></tr>
<tr><td colspan="3">Compilation of Health-based value for subchronic/ chronic oral intake (ng/kg-day)
Type of PFAA Chem. | Authoritative body responsible for value (year) | Health-based value for subchronic/ chronic oral intake (ng/kg-day)
GenX | MI SAW TV (2019) | 77
GenX | EPA (2018) | 80</td></tr>
<tr><td colspan="2">Assessed in Appendix D?</td><td>No, adopted from other agency (US EPA 2021e).</td></tr>
</table>

Appendix C Data Extraction Tables – Supporting Information for Fact Sheet

Evidence Evaluations for Australian Drinking Water Guidelines Chemical Fact Sheets – PFOS, PFHxS, PFOA, PFBS, and GenX Chemicals

PFOS, PFHxS, PFOA, PFBS, and GenX Chemicals Technical Report

National Health and Medical Research Council

SLR Project No.: 640.V30693.20000

17 October 2024

C.1 Supporting Information for Fact Sheets

C.1.1 Abusallout et al. (2021)

Reference: Abusallout, I., Wang, J., & Hanigan, D. (2021). Emerging investigator series: rapid defluorination of 22 per- and polyfluoroalkyl substances in water using sulfite irradiated by medium-pressure UV. Environmental science water research & technology, 7(9), 1552-1562. https://doi.org/10.1039/d1ew00221j.		
General Description	Uses	-
	Sources in drinking water	-
	Other	We investigated rapid defluorination of 22 PFAS species using a high-photon-flux medium-pressure UV/sulfite process.
Treatment of drinking water	Treatment technology	High-photon-flux medium-pressure UV/sulfite process
	Effectiveness	• GenX was the most rapidly defluorinated PFAS with a half-life of 4.3 min at pH 12 and 10 mM sulfite. • Perfluorocarboxylic acids (PFCAs) also exhibited appreciable defluorination with half-lives between 7.8 and 577.6 min. • PFCA defluorination rates increased with decreasing fluoroalkyl chain length. • Perfluorooctanoic acid and perfluorooctanesulfonic acid, the most commonly detected PFAS in water, were rapidly defluorinated with half-lives of 11.3 and 22.1 min, respectively. • PFOA and PFOS defluorination at neutral pH (7.0) after 30 min were 39 and 22%, respectively, and at pH 9, 71 and 48%, respectively.
	Any special conditions?	-
	Other	Many treatment methods have been examined for PFAS removal from water including sorption, filtration, chemical oxidation, electrochemical oxidation/ reduction, sonolysis and biodegradation. However, disadvantages surrounding these methods have hindered their applicability including poor selectivity, formation of toxic byproducts, and complex operation. Reduction via irradiation of sulfite and production of hydrated electrons (eaq−) has been shown to defluorinate PFAS at bench-scale but at relatively slow degradation rates.
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-

Reference: Abusallout, I., Wang, J., & Hanigan, D. (2021). Emerging investigator series: rapid defluorination of 22 per- and polyfluoroalkyl substances in water using sulfite irradiated by medium-pressure UV. Environmental science water research & technology, 7(9), 1552-1562. https://doi.org/10.1039/d1ew00221j.		
Additional information	Any additional non-health related information considered important?	-

C.1.2 Abunada et al. (2020)

Reference: Abunada, Z., Alazaiza, M., & Bashir, M. (2020). An Overview of Per-and Polyfluoroalkyl Substances (PFAS) in the Environment: Source, Fate, Risk and Regulations. Water, 12, 3590. https://doi.org/10.3390/w12123590.		
General Description	Uses	They are considered as highly fluorinated surfactants that have been applied in numerous industrial applications and manufactured goods including food packaging, firefighting foams, clothes and protective coatings for fabrics and carpets, electronics and fluoropolymer manufacturing.
	Sources in drinking water	-
	Other	The current article reviews the state of art of the perfluoroalkyl and polyfluoroalkyl substances (PFAS) compounds and provides an overview of PFAS occurrence in the environment, wildlife, and humans.
Treatment of drinking water	Treatment technology	Immobilization and plasma arc destruction are among the recommended methods to irreversibly transform PFAS waste. Conventional processes of wastewater treatment were found to be ineffective in removing of PFOA. Destructive Treatment: Advance oxidation processes, Electrochemical oxidation, Incinerations, Sono-chemical, Biodegradation, Photolysis. Non-Destructive treatment: Adsorption, Ion exchange, Fractionation. Adsorption via activated carbon and ion exchange resins have been widely employed.
	Effectiveness	• Removal efficiency of polyfluoroalkyl substances by granular activated carbon was >90%. There is a risk that shorted-chained PFAS are more likely than their longer chain counterparts to split through a GAC medium. • UV-Fenton (oxidation): >95% PFOA destruction (defluorination efficiency of 53.2%). • Oxidation (H_2O_2, Fe, UV, pH 3): 100% (PFOA 559 mg/L). • Oxidation (Light-activated persulfate & radiation): PFOS 73%. • Sonolysis: PFOS 73%. • Oxidation (ozonation): 55-98% for different PFAS. • Adsorption: adsorption capacity 41.3 mg/g PFOA and 72mg/g PFOS.

Reference: Abunada, Z., Alazaiza, M., & Bashir, M. (2020). An Overview of Per-and Polyfluoroalkyl Substances (PFAS) in the Environment: Source, Fate, Risk and Regulations. Water, 12, 3590. https://doi.org/10.3390/w12123590.		
		• Adsorption: adsorption capacity 510 mg/g PFOA. • Ion exchange (IRA 67): adsorption capacity 166 mg/g PFHxA. • Ion exchange (IRA 67): adsorption capacity 2,390 mg/g PFOS.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.3 (Baldaguez) Medina et al. (2021)

Reference: Baldaguez Medina, P., Cotty, S., Kim, K., Elbert, J., & Su, X. (2021). Emerging investigator series: electrochemically-mediated remediation of GenX using redox-copolymers. Environmental science water research & technology, 7(12), 2231-2224. https://doi.org/10.1039/d1ew00544h.		
General Description	Uses	PFAS contain oleophobic and hydrophobic characteristics that are attractive for a range of commercially available products such as firefighting foams, non-stick cookware, food packaging, cosmetics, and many more.
	Sources in drinking water	-
	Other	Here, we evaluate a redox-copolymer, poly(4-methacryloyloxy-2,2,6,6-tetramethylpiperidin-1-oxyl-co-4-methacryloyloxy-2,2,6,6-tetramethylpiperidine) (PTMA-co-PTMPMA), for the selective electrochemical removal of GenX.
Treatment of drinking water	Treatment technology	Combined asymmetric redox-copolymer/boron-doped diamond (BDD) counter electrode.
	Effectiveness	the enhancement of adsorption kinetics under electrochemical conditions, which showed >95% of GenX removal in 9 minutes versus 30 minutes for >95% removal at O.C. Redox-electrodes from a batch to flow-by cell configuration, showing successful adsorption and release of GenX under flow and electrochemical control. Finally, prolonged exposure of GenX at reduction potentials generated smaller PFAS fragments at the redox-electrodes. To fully defluorinate GenX,

Reference: Baldaguez Medina, P., Cotty, S., Kim, K., Elbert, J., & Su, X. (2021). Emerging investigator series: electrochemically-mediated remediation of GenX using redox-copolymers. Environmental science water research & technology, 7(12), 2231-2224. https://doi.org/10.1039/d1ew00544h.		
		the copolymer-functionalized electrodes were coupled with a boron-doped diamond (BDD) counter electrode for integrating separation and defluorination within the same device. The combined system demonstrated close to 100% defluorination efficiency.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	UPLC LC/MS
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.4 Bao et al (2020)

Reference: Bao, Y., Cagnetta, G., Huang, J., & Yu, G. (2020). Degradation of hexafluoropropylene oxide oligomer acids as PFOA alternatives in simulated nanofiltration concentrate: Effect of molecular structure. Chemical Engineering Journal, 382, 122866. https://doi.org/https://doi.org/10.1016/j.cej.2019.122866.		
General Description	Uses	Per- and polyfluoroalkyl substances (PFAS) are stable and high-efficient surfactants, which are widely used in various industrial and consumer applications.
	Sources in drinking water	-
	Other	In the present study, we propose two possible approaches to treat nanofiltration (NF) retentate; that is, advanced oxidation by UV-activated persulfate (UV/PS) and advanced reduction by UV-activated sulfite (UV/sulfite), which have been found to be effective in degrading several PFAS. To understand the degradation potential of hexafluoropropylene oxide trimer acid (HFPO-TA) and its homologue, hexafluoropropylene oxide tetramer acid (HFPO-TeA), the degradability of HFPO-TA and HFPO-TeA was investigated for the first time in this study.
Treatment of drinking water	Treatment technology	UV-activated persulfate (UV/PS). UV-activated sulfite (UV/sulfite).

Reference: Bao, Y., Cagnetta, G., Huang, J., & Yu, G. (2020). Degradation of hexafluoropropylene oxide oligomer acids as PFOA alternatives in simulated nanofiltration concentrate: Effect of molecular structure. Chemical Engineering Journal, 382, 122866. https://doi.org/https://doi.org/10.1016/j.cej.2019.122866.		
	Effectiveness	Although HFPO-TA and HFPO-TeA were both oxidizable (by UV/PS), HFPO-DA was found as an end product during their degradation. Consequently, the risks could not be eliminated. In contrast, high-concentration HFPO-TA and HFPO-TeA were degraded by the strong reductive process (UV/sulfite). Moreover, the same products in the UV/ sulfite system compared with those in the UV/PS system (i.e. HFPO-DA, PFA and TFA) were defluorinated efficiently, thus demonstrating the feasibility of UV/sulfite for treating effluent from fluoropolymer production plants with high levels of PFAS.
	Any special conditions?	-
	Other	Although HFPO-TA and HFPO-TeA were both oxidizable (by UV/PS), HFPO-DA was found as an end product during their degradation. Granular activated carbon, ion-exchange resins, and reverse osmosis (RO) or nanofiltration (NF) can remove many PFAS from drinking water. However, both RO and NF are more reliable and effective in the elimination of short-chain PFAS, while the other two adsorption technologies have demonstrated poor removal rates with respect to these chemicals.
Measurement	Analytical method	High performance liquid chromatography (HPLC) equipped with a conductivity detector (CDD) or HPLC equipped with a tandem mass spectrometer (MS/MS) operated in negative electrospray ionization (ESI^-) and MRM mode.
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.5 Belkouteb et al. (2020)

Reference: Belkouteb, N., Franke, V., McCleaf, P., Köhler, S., & Ahrens, L. (2020). Removal of per- and polyfluoroalkyl substances (PFASs) in a full-scale drinking water treatment plant: Long-term performance of granular activated carbon (GAC) and influence of flow-rate. Water Res, 182, 115913. https://doi.org/10.1016/j.watres.2020.115913.		
General Description	Uses	PFAS have a wide range of applications and are for instance used in food packaging materials, textiles and in aqueous film forming foams (AFFFs) for firefighting.

Reference: Belkouteb, N., Franke, V., McCleaf, P., Köhler, S., & Ahrens, L. (2020). Removal of per- and polyfluoroalkyl substances (PFASs) in a full-scale drinking water treatment plant: Long-term performance of granular activated carbon (GAC) and influence of flow-rate. Water Res, 182, 115913. https://doi.org/10.1016/j.watres.2020.115913.		
	Sources in drinking water	-
	Other	In this study, the treatment efficiency for the removal of 15 PFAS was examined in a full-scale drinking water treatment plant (DWTP) in the City of Uppsala, Sweden, over a period of two years (2015-2017). Removal of the five frequently detected PFAS was influenced by the total operation time of granular activated carbon (GAC) filters, GAC type and surface loading rate.
Treatment of drinking water	Treatment technology	Granular activated carbon (GAC) filters.
	Effectiveness	The average removal efficiency of PFAS ranged from 92 to 100% for “young” GAC filters and decreased to 7.0 - 100% for “old” GAC filters (up to 357 operation days, 29 300 bed volumes (BV) treated).
	Any special conditions?	-
	Other	-
Measurement	Analytical method	Water samples sent to the commercial laboratory. High performance liquid chromatography (HPLC) coupled to a triple quadrupole and an electrospray ionisation interface in negative-ion mode ((-)ESI-MS/MS.
	Limit of determination/ Limit of Reporting (LOR)	The method detection limit (MDL) ranged between 0.05 and 15 ng/L.
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.6 Boone et al. 2019

Reference: Boone, J. S., Vigo, C., Boone, T., Byrne, C., Ferrario, J., Benson, R., Donohue, J., Simmons, J. E., Kolpin, D. W., Furlong, E. T., & Glassmeyer, S. T. (2019). Per- and polyfluoroalkyl substances in source and treated drinking waters of the United States. Sci Total Environ, 653, 359-369. https://doi.org/10.1016/j.scitotenv.2018.10.245.		
General Description	Uses	-
	Sources in drinking water	One of the downsides of PFAS use is that they end up in the water cycle, either directly through nonpoint sources such as runoff and groundwater infiltration, or through point sources such as firefighting training grounds, industrial facilities, and

Reference: Boone, J. S., Vigo, C., Boone, T., Byrne, C., Ferrario, J., Benson, R., Donohue, J., Simmons, J. E., Kolpin, D. W., Furlong, E. T., & Glassmeyer, S. T. (2019). Per- and polyfluoroalkyl substances in source and treated drinking waters of the United States. Sci Total Environ, 653, 359-369. https://doi.org/10.1016/j.scitotenv.2018.10.245.		
		municipal and industrial wastewater treatment plant effluent, or even through atmospheric deposition.
	Other	This study measured 17 PFAS in source and treated water from 25 drinking water treatment plants (DWTPs) as part of a broader study of contaminants of emerging concern in drinking water across the United States.
Treatment of drinking water	Treatment technology	Water Treatment Plant
	Effectiveness	Comparing the total PFAS concentration in source and treated water at each location, only five locations demonstrated statistically significant differences (i.e. $P < 0.05$) between the source and treated water.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	Liquid chromatography, tandem mass spectrometry (LC/MS-MS).
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	PFAS were quantitatively detected in all 50 samples, with summed concentrations of the 17 PFAS ranging from <1 ng/L to 1102 ng/L. The median total PFAS concentration was 21.4 ng/L in the source water and 19.5 ng/L in the treated drinking water.
Additional information	Any additional non-health related information considered important?	-

C.1.7 Boyer et al. (2021)

Reference: Boyer, T. H., Fang, Y., Ellis, A., Dietz, R., Choi, Y. J., Schaefer, C. E., Higgins, C. P., & Strathmann, T. J. (2021). Anion exchange resin removal of per- and polyfluoroalkyl substances (PFAS) from impacted water: A critical review. Water Res, 200, 117244. https://doi.org/10.1016/j.watres.2021.117244.		
General Description	Uses	Consumer products, fire-fighting foams, and other applications.
	Sources in drinking water	-
	Other	The goal of this paper was to critically review the available peer-reviewed literature on PFAS removal from water by anion exchange resin (AER) treatment.

Reference: Boyer, T. H., Fang, Y., Ellis, A., Dietz, R., Choi, Y. J., Schaefer, C. E., Higgins, C. P., & Strathmann, T. J. (2021). Anion exchange resin removal of per- and polyfluoroalkyl substances (PFAS) from impacted water: A critical review. Water Res, 200, 117244. https://doi.org/10.1016/j.watres.2021.117244.		
Treatment of drinking water	Treatment technology	PFAS removal by AERs follows ion exchange stoichiometry and is influenced by PFAS structure and resin properties, which manifests itself as a combination of electrostatic and non-electrostatic (van der Waals, hydrophobic) interactions.
	Effectiveness	At high PFAS concentrations (mg/L to g/L), the capacity of AERs for PFAS equals the chloride exchange capacity of the resin. As PFAS concentration decreases, PFAS loading on AER decreases following the linear region of the isotherm. Batch and continuous-flow adsorption experiments agree on AER selectivity for PFAS with the general order of increasing selectivity as PFBA < PFHxA < GenX < PFBS < PFOA ≈ PFHxS ≈ FOSA < PFOS. PFAS can be desorbed from AERs using salt aqueous solution with organic cosolvent, typically methanol.
	Any special conditions?	In general, water composition has a minor impact on PFAS removal by AER. pH and the presence of inorganic anions results in minor change in PFAS removal by SB-AER and slightly greater impact of WB-AER. The presence of Natural Organic Matter (NOM) can reduce PFAS removal by AER with greater impact of high molecular weight NOM, such as humic acid, and polyacrylic resin.
	Other	-
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.8 Brun et al. (2023)

Reference: Brunn, H., Arnold, G., Körner, W., Rippen, G., Steinhäuser, K. G., & Valentin, I. (2023). PFAS: forever chemicals—persistent, bioaccumulative and mobile. Reviewing the status and the need for their phase out and remediation of contaminated sites. Environmental Sciences Europe, 35(1), 20. https://doi.org/10.1186/s12302-023-00721-8.		
General Description	Uses	Several thousand commercially produced compounds are used in numerous products and technical processes.
	Sources in drinking water	-

Reference: Brunn, H., Arnold, G., Körner, W., Rippen, G., Steinhäuser, K. G., & Valentin, I. (2023). PFAS: forever chemicals—persistent, bioaccumulative and mobile. Reviewing the status and the need for their phase out and remediation of contaminated sites. Environmental Sciences Europe, 35(1), 20. https://doi.org/10.1186/s12302-023-00721-8.		
	Other	-
Treatment of drinking water	Treatment technology	-
	Effectiveness	-
	Any special conditions?	-
	Other	• The purification of PFAS-contaminated water is complex, only effective to a limited extent and expensive. • Treatment of short-chain PFAS is usually even less effective than for long-chain homologues. • Activated charcoal is primarily used as an adsorbent. • Ion exchange resins are more effective for short-chain anionic compounds. • Membrane processes such as nanofiltration and reverse osmosis are being tested as alternatives. • For the treatment of concentrates from the membrane processes, from regeneration of ion exchange media, and from ozofractionation, electrochemical oxidation can be considered, which is still under development. • Lab-scale processes: Ionic liquids [342], reductive defluorination with UV, sulfite, and iodide [343] or UV and hydrogen [344], and the use of zeolites as sorbent media in combination with activated peroxodisulfate. • Electrocoagulation and electrosorption are also still at an experimental stage.
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	Currently, good laboratories routinely achieve an LOQ of about 1 ng/L.
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.9 Chen et al. (2019)

Reference: Chen, R., Li, G., Yu, Y., Ma, X., Zhuang, Y., Tao, H., & Shi, B. (2019). Occurrence and transport behaviors of perfluoroalkyl acids in drinking water distribution systems. Sci Total Environ, 697, 134162. https://doi.org/10.1016/j.scitotenv.2019.134162.		
General Description	Uses	Perfluoroalkyl acids (PFAAs) are primarily used in industrial and household products, such as fire-fighting foams, surfactants, food packaging, nonstick cookware, and carpets.
	Sources in drinking water	-
	Other	This investigation profiled the occurrence of 17 kinds of PFAAs in tap water of some Chinese cities, and the transport behaviours of PFAAs in DWDS were observed in eastern China.
Treatment of drinking water	Treatment technology	-
	Effectiveness	-
	Any special conditions?	-
	Other	-
Measurement	Analytical method	HPLC System coupled to a Triple Quadrupole LC/MS System operated in the negative electrospray ionization (ESI-) mode.
	Limit of determination/ Limit of Reporting (LOR)	The LODs and LOQs ranged from 0.01 to 0.1 ng/L and 0.05 to 0.5 ng/L for water.
	Other	The results showed that perfluorooctanoic acid (PFOA) and perfluorobutanoic acid (PFBA) widely existed in tap water samples, and were the predominant PFAAs in eastern China areas. The mean concentration of the 17 PFAAs was 77.49 ng/L (ranging from 9.29 ng/L to 266.68 ng/L). Short-chain PFAAs (mainly PFBA) concentrations were relatively stable from water treatment plant to consumer taps, while long-chain PFAAs (mainly PFOA) exhibited a significant decrease in concentration, which could be attributed to their accumulation by the loose deposits in the DWDSs.
Additional information	Any additional non-health related information considered important?	-

C.1.10 Chiriac et al. (2023)

Reference: Chiriac, F. L., Pirvu, F., Paun, I., & Petre, V. A. (2023). Perfluoroalkyl substances in Romanian wastewater treatment plants: Transfer to surface waters, environmental and human risk assessment. Sci Total Environ, 892, 164576. https://doi.org/10.1016/j.scitotenv.2023.164576.		
	Uses	They are adequate for various applications, such as floor repellents, surfactants in textile coatings, cleaning products,

Reference: Chiriac, F. L., Pirvu, F., Paun, I., & Petre, V. A. (2023). Perfluoroalkyl substances in Romanian wastewater treatment plants: Transfer to surface waters, environmental and human risk assessment. Sci Total Environ, 892, 164576. https://doi.org/10.1016/j.scitotenv.2023.164576.		
General Description		cosmetics, food packaging, pesticides, medical devices, and fire-fighting foams.
	Sources in drinking water	-
	Other	The current study aimed to determine the concentration levels of nine perfluoroalkyl substances (PFAS) in the five most significant Romanian wastewater treatment plants (WWTPs) and their transfer to natural receivers.
Treatment of drinking water	Treatment technology	Wastewater treatment plants
	Effectiveness	In most of the wastewater samples investigated, the dominant compounds were perfluoropentanoic acid (PFPeA), perfluorooctanoic acid (PFOA), and perfluorooctansulfonate acid (PFOS), with the maximum concentration range between 105 and 316 ng/L in influents, 14.8–31.3 ng/L in effluents and removal efficiencies higher than 80 % for all selected PFAS compounds. For most compounds, removal efficiencies were >50 %. Removal capacities below 50 % were observed for the Targoviste (for PFPeA), Bucharest (for PFBA, PFPeA, and PFHxA), and Rm Valcea (for PFBA and PFHxA) WWTPs. However, evaluating the total removal efficiencies, a higher efficiency of ∑PFAS removal was observed at over 80 %, with the maximum efficiencies being up to 85 %.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	Liquid chromatography–tandem mass spectrometry (LC–MS/MS) using electrospray ionization.
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.11 Choi et al. (2021)

Reference: Choi, P. J., Lao, J. Y., Lam, P. K. S., Im, S. J., Jang, A., & An, A. K. (2021). Low-pressure volume retarded osmosis for removal of per- and polyfluoroalkyl substances. Water Res, 194, 116929. https://doi.org/10.1016/j.watres.2021.116929.		
	Uses	-

Reference: Choi, P. J., Lao, J. Y., Lam, P. K. S., Im, S. J., Jang, A., & An, A. K. (2021). Low-pressure volume retarded osmosis for removal of per- and polyfluoroalkyl substances. Water Res, 194, 116929. https://doi.org/10.1016/j.watres.2021.116929.		
General Description	Sources in drinking water	-
	Other	Herein, we developed and optimized a one-step process that does not require additional treatment for the draw solution (DS).
Treatment of drinking water	Treatment technology	Pressure assisted-volume retarded osmosis (PA-VRO).
	Effectiveness	The rejection rates for PFOA/PFOS were observed to exceed 98%, after 24 h and 99%, after 48 h. There were no traceable amounts of PFOA/PFOS in the DS.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.12 Conte et al. (2015)

Reference: Conte, L., Falletti, L., Zaggia, A., & Milan, M. (2015). Polyfluorinated Organic Micropollutants Removal from Water by Ion Exchange and Adsorption. Chemical Engineering Transactions, 43, 2257-2262. https://doi.org/10.3303/CET1543377.		
General Description	Uses	-
	Sources in drinking water	-
	Other	In this research work an alternative solution based on ion exchange resins and/or polystyrenic adsorbents was tested both in laboratory with batch tests and on pilot-scale with a continuously fed plan.
Treatment of drinking water	Treatment technology	Ion exchange resins and/or polystyrenic adsorbents.
	Effectiveness	• Sorption isotherms showed a progressively decreasing adsorption capacity following the order PFOS>PFOA>PFBS> PFBA.

Reference: Conte, L., Falletti, L., Zaggia, A., & Milan, M. (2015). Polyfluorinated Organic Micropollutants Removal from Water by Ion Exchange and Adsorption. Chemical Engineering Transactions, 43, 2257-2262. https://doi.org/10.3303/CET1543377.		
		• Resin PAD500 (figure 3) removed almost 100 % of PFOA and PFOS, but it showed no efficiency for PFBA since the beginning of experiments. • Results encountered with PAD428 were very similar to the ones obtained with PAD50. • Resin MN102 (figure 4) removed almost 100 % of PFOA, PFOS and PFBS without significant variations, but PFBA removal efficiency decreased rapidly after 48 h working. • Resin A600E (Figure 5) removed and still removes almost 100 % of PFOA and PFOS after 800 h working (that correspond to a total treated water volume which is ca. 4,500 times the volume of material), and removal efficiency for PFBA was high for ca. 250 h working. • Results of first 800 h working (that correspond to a total treated water volume which is ca. 4,500 times the volume of material in each column) were excellent for PFOA and PFOS removal, but a rapid decrease in PFBA and PFBS removal efficiency was encountered with PAD500 and PAD428.
	Any special conditions?	-
	Other	These compounds can be removed by adsorption on activated carbon with high efficiency, but frequent regeneration is requested especially because of polyfluorobutylic acid (PFBA) and polyfluorobutyl sulfonate (PFBS) that saturate activated carbon much more quickly than heavier molecules as polyfluoro-octanoic acid (PFOA) and polyfluoroctyl sulfonate (PFOS).
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.13 Cornelson et al. (2021)

Reference: Cornelsen, M., Weber, R., & Panglisch, S. (2021). Minimizing the environmental impact of PFAS by using specialized coagulants for the treatment of PFAS polluted waters and for the decontamination of firefighting equipment. Emerging Contaminants, 7, 63-76. https://doi.org/https://doi.org/10.1016/j.emcon.2021.02.001.		
General Description	Uses	Per- and polyfluoroalkyl substances (PFAS) in a wide range of industrial applications and consumer products.

Reference: Cornelsen, M., Weber, R., & Panglisch, S. (2021). Minimizing the environmental impact of PFAS by using specialized coagulants for the treatment of PFAS polluted waters and for the decontamination of firefighting equipment. Emerging Contaminants, 7, 63-76. https://doi.org/https://doi.org/10.1016/j.emcon.2021.02.001.		
	Sources in drinking water	-
	Other	Therefore, in this paper we want to: • Give some relevant information on the risk of (future) PFAS pollution from firefighting foam use. • Give an insight into specific remediation and adsorption methods of PFAS pollution and their optimisation. • Describe the largely unknown pollution from the cleaning of firefighting vehicles and equipment and how this can be avoided.
Treatment of drinking water	Treatment technology	A combination of a pre-precipitation with the application of specialized precipitants and a subsequent adsorption or ion exchange.
	Effectiveness	High PFAS loads and a complex organic background load of the medium to be treated, the application of adsorption or ion exchange processes lead to early or immediate filter breakthroughs. Precipitants specialized in PFAS can also be used for the decontamination of fire extinguishing systems when PFAS containing foam is substituted by fluorine free foams.
	Any special conditions?	-
	Other	The current study shows that well-known methods of water treatment, especially the use of materials for adsorption and ion exchange, can often neither guarantee satisfactory cleaning results nor economically justifiable filter running times at high PFAS concentrations and complex matrix conditions. Their combination with a pre-precipitation stage using specialized precipitants can significantly optimize treatment successes.
Measurement	Analytical method	High-performance liquid chromatography and mass spectrometric detection (HPLC-MS/MS). Analyses by a commercial lab.
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.14 Dasu et al. (2017)

Reference: Dasu, K., Nakayama, S. F., Yoshikane, M., Mills, M. A., Wright, J. M., & Ehrlich, S. (2017). An ultra-sensitive method for the analysis of perfluorinated alkyl acids in drinking water using a column switching high-performance liquid chromatography tandem mass spectrometry. J Chromatogr A, 1494, 46-54. https://doi.org/10.1016/j.chroma.2017.03.006.		
General Description	Uses	-
	Sources in drinking water	-
	Other	A novel method was developed for the determination of 14 perfluorinated alkyl acids (PFAAs) in small volumes (10 mL) of drinking water.
Treatment of drinking water	Treatment technology	-
	Effectiveness	-
	Any special conditions?	-
	Other	-
Measurement	Analytical method	In-line pre-concentration on a WAX column before analysis on column-switching high performance liquid chromatography tandem mass spectrometry (HPLC–MS/MS).
	Limit of determination/ Limit of Reporting (LOR)	The lowest concentration minimum reporting levels (LCMRL) for the 14 PFAAs ranged from 0.59 to 3.4 ng/L.
	Other	The current method requires approximately 10 mL of drinking water (not 100-1,000 mL).
Additional information	Any additional non-health related information considered important?	-

C.1.15 Dixit et al. (2019)

Reference: Dixit, F., Mohseni, M., Barbeau, B., & Mostafavi, S. (2019). PFOA and PFOS removal by ion exchange for water reuse and drinking applications: Role of organic matter characteristics. Environmental Science: Water Research & Technology, 5. https://doi.org/10.1039/C9EW00409B.		
General Description	Uses	This research aimed to investigate the efficiency of strongly basic ion exchange resins (Purolite® A860) for the removal of PFOA and PFOS from drinking and recycled water sources (i.e. effluents of secondary treated municipal wastewaters, further-treated with MF/UF before IX).
	Sources in drinking water	-
	Other	In the present study, a strongly basic anion exchange resin was used to remove two of the most persistent PFAS, namely

Reference: Dixit, F., Mohseni, M., Barbeau, B., & Mostafavi, S. (2019). PFOA and PFOS removal by ion exchange for water reuse and drinking applications: Role of organic matter characteristics. Environmental Science: Water Research & Technology, 5. https://doi.org/10.1039/C9EW00409B.		
		perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS).
Treatment of drinking water	Treatment technology	A strongly basic anion exchange resin (IX).
	Effectiveness	IX was able to achieve complete PFAS removal with simultaneous >60% dissolved organic carbon (DOC) removal.
	Any special conditions?	-
	Other	Conventional water treatment technologies have limited ability to eliminate PFAS from water. Advanced water treatment processes such as low-pressure membrane filtration (MF/UF) and ozonation are considered ineffective for PFAS removal. The effectiveness of advanced oxidation processes is also deemed low. Reverse osmosis, although highly effective, requires additional pretreatment steps to prevent membrane fouling. Numerous carbon based adsorbent materials for PFAs removal: problems with high Organic Matter (OM) competition, adsorbent regeneration and design of adsorbents. Under pH relevant to water treatment, PFOA and PFOS are negatively charged and can therefore be simultaneously removed by IX resins. However, effluent OM (EfOM) in recycled waters and natural organic matter (NOM) in surface and ground water sources are usually present at concentrations (mg/L), much higher than those of PFAS (ng/L), which result in competition for uptake sites via IX.
Measurement	Analytical method	HPLC-MS in negative electro-spray ionization and multiple reaction monitoring (MRM) modes.
	Limit of determination/ Limit of Reporting (LOR)	Lower detection limit for PFOA and PFOS: 10 ng/L
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.16 Dixit et al (2020)

Reference: Dixit, F., Barbeau, B., Mostafavi, S. G., & Mohseni, M. (2020). Efficient removal of GenX (HFPO-DA) and other perfluorinated ether acids from drinking and recycled waters using anion exchange resins. J Hazard Mater, 384, 121261..		
General Description	Uses	Broad use of PFAS in several industries such as painting, clothing, fire-fighting and polytetrafluoroethylene coatings for many decades.
	Sources in drinking water	-
	Other	A strongly basic anion exchange (IX) resin was used to remove GenX and two other perfluorinated ether acids (PFEAS) from natural surface and recycled water sources.
Treatment of drinking water	Treatment technology	Anion exchange (IX) resins
	Effectiveness	IX was able to achieve complete PFEAS removal (Cfinal < 10 ng/L) with simultaneous removal of > 60% NOM and > 80% inorganic ions. At commercial IX dosage (~20 mL/L, or ~4000 mg/L, details in SI) IX was able to achieve complete GenX (C0≤5 mg C/L to < 70 ng/L) removal along with simultaneous NOM removal of > 70% within 10 min of contact time, indicating great potential for commercial applications.
	Any special conditions?	-
	Other	Factors influencing the uptake behaviour included the PFEAS concentrations, resin dosage, and background anion characteristics.
Measurement	Analytical method	HPLC Mass spectrometric analysis in negative electro-spray ionization and multiple reaction monitoring (MRM) modes.
	Limit of determination/ Limit of Reporting (LOR)	Lower detection limit of 10 ng/L.
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.17 Eke et al. (2020)

Reference: Eke, J., Banks, L., Mottaleb, M. A., Morris, A. J., Tsyusko, O. V., & Escobar, I. C. (2020). Dual-Functional Phosphorene Nanocomposite Membranes for the Treatment of Perfluorinated Water: An Investigation of Perfluorooctanoic Acid Removal via Filtration Combined with Ultraviolet Irradiation or Oxygenation. Membranes (Basel), 11(1). https://doi.org/10.3390/membranes11010018.		
General Description	Uses	PFAS can be found in many consumer products including food packaging, household cleaners and fire-fighting foams.
	Sources in drinking water	-
	Other	The purpose of this research was to develop and validate environmentally safe nanomaterial-based approach for treatment of drinking water including removal and degradation of per- and polyfluorinated chemicals (PFAS).
Treatment of drinking water	Treatment technology	Nanocomposite membranes composed of sulfonated poly ether ether ketone (SPEEK) and two-dimensional phosphorene.
	Effectiveness	99% rejection of perfluorooctanoic acid (PFOA) alongside with a 99% removal from the PFOA that accumulated on surface of the membrane. The removal of PFOA accumulated on the membrane surface achieved 99% after the membranes were treated with ultraviolet (UV) photolysis and liquid aerobic oxidation.
	Any special conditions?	-
	Other	Traditional drinking water treatment technologies are usually ineffective for the removal of PFAS from contaminated waters, because they are normally present in exiguous concentrations and have unique properties that make them persistent.
Measurement	Analytical method	Liquid chromatography-tandem mass spectrometry (LC-MS/MS)
	Limit of determination/ Limit of Reporting (LOR)	PFOA: 0.25 ng/mL (250 ng/L)
	Other	100 mg/L PFOA solution filtered
Additional information	Any additional non-health related information considered important?	-

C.1.18 Eschauzier et al. (2012)

Reference: Eschauzier, C., Beerendonk, E., Scholte-Veenendaal, P., & De Voogt, P. (2012). Impact of Treatment Processes on the Removal of Perfluoroalkyl Acids from the Drinking Water Production Chain. Environmental Science & Technology, 46(3), 1708-1715. https://doi.org/10.1021/es201662b.		
General Description	Uses	-
	Sources in drinking water	-
	Other	Perfluoroalkyl substances have been detected in drinking water at concentrations typically in the low ng/L range, with occasionally higher concentrations (lower µg/L level) in some contaminated areas. The present work aims at evaluating the efficacy of removing PFAAs from raw source water by the various treatment steps operating in a full-scale drinking water production site. Apart from PFOA and PFOS, this study focuses on the behaviour of other PFAA, in particular short-chained PFAAs for which little information exists other than that they are difficult to remove by common treatment techniques including GAC.
Treatment of drinking water	Treatment technology	Standard water treatment: intake, coagulation, rapid sand filtration, dune passage, aeration, rapid sand filtration, ozonation, pellet softening, granular activated carbon (GAC) filtration, slow sand filtration.
	Effectiveness	• During treatment, longer chain PFAA such as PFNA (perfluorononanoic acid) and PFOS were readily removed by the GAC treatment step and their GAC effluent concentrations were reduced to levels below the limits of quantitation (LOQ). • However, more hydrophilic shorter chain PFAA (especially PFBA and PFBS) were not removed by GAC and their concentrations remained constant through treatment. • A decreasing removal capacity of the GAC was observed with increasing carbon loading and with decreasing carbon chain length of the PFAAs. • This study shows that none of the treatment steps, including softening processes, are effective for PFAA removal, except for GAC filtration.
	Any special conditions?	-
	Other	These findings suggest that PFAAs are not or poorly removed during drinking water treatment.
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	PFBA (9.5 ng/L), PFPeA, PFHxA, & PFOA (0.8 ng/L), PFNA, PFBS, & PFOS (0.2 ng/L), PFDA (0.1 ng/L), and PFHxS (0.6 ng/L)
	Other	-
Additional information	Any additional non-health related information	-

Reference: Eschauzier, C., Beerendonk, E., Scholte-Veenendaal, P., & De Voogt, P. (2012). Impact of Treatment Processes on the Removal of Perfluoroalkyl Acids from the Drinking Water Production Chain. Environmental Science & Technology, 46(3), 1708-1715. https://doi.org/10.1021/es201662b.		
	considered important?	

C.1.19 Gobelius et al. (2019)

Reference: Gobelius, L., Persson, C., Wiberg, K., & Ahrens, L. (2019). Calibration and application of passive sampling for per- and polyfluoroalkyl substances in a drinking water treatment plant. J Hazard Mater, 362, 230-237. https://doi.org/10.1016/j.jhazmat.2018.09.005.		
General Description	Uses	Their unique properties make them eligible for applications such as surface coatings of cookware, furniture, clothing, and packaging material, and as an active ingredient in aqueous firefighting foams (AFFFs).
	Sources in drinking water	Common point sources of PFAS to the environment are discharges from industrial and municipal sewage treatment plants (STPs), fire training sites, and landfills.
	Other	The aim of this study was to calibrate and apply polar organic chemical integrative samplers (POCIS) to examine 26 per- and polyfluoroalkyl substances (PFAS) in a drinking water treatment plant (DWTP). Diffuse sources include atmospheric deposition and sources related to urban environments.
Treatment of drinking water	Treatment technology	-
	Effectiveness	In the full-scale DWTP, the mean removal efficiency of ∑26PFAS was -4.6%, based on TWA concentrations derived from POCIS-WAX comparing RW and DW (-29% for POCIS-HLB and -2.5% for water composite sampling). Low removal efficiency of PFAS in full-scale DWTPs has been reported in previous studies. The GAC filter in the full-scale DWTP led to a general increase in PFAS in drinking water (mean 12% for the three sampling techniques). This can be explained by desorption of PFAS from the GAC filter due to aging (4 years). In contrast to the full-scale DWTP, the pilot plant achieved 100% removal of all PFAS after GAC filtration or a combination of NF and GAC filtration, based on the TWA concentrations from POCIS-WAX. Unlike the full-scale DWTP, the pilot-scale plant was equipped with two relatively new GAC filters.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	Polar organic chemical integrative samplers (POCIS)

Reference: Gobelius, L., Persson, C., Wiberg, K., & Ahrens, L. (2019). Calibration and application of passive sampling for per- and polyfluoroalkyl substances in a drinking water treatment plant. J Hazard Mater, 362, 230-237. https://doi.org/10.1016/j.jhazmat.2018.09.005.		
	Limit of determination/ Limit of Reporting (LOR)	< 100 ng/L Overall, the ∑26PFAS concentrations detected in the finished drinking water using POCIS-WAX (14 ng L−1), POCIS-HLB (7.1 ng L−1), and composite water samples (8.7 ng L−1) were all well below the drinking water guidelines for PFAS set by the Swedish National Food Agency (∑11PFAS < 90 ng L−1). • PFOS: 0.44 ng/L • PFHxS: 0.64 ng/L • PFBS: 0.86 ng/L • PFOA: 0.85 ng/L • GenX: not included.
	Other	Use of POCIS-WAX and POCIS-HLB in the DWTP showed good agreement with composite water sampling. Passive sampling has the advantage of providing time-weighted-average (TWA) concentrations without an external power supply, maintenance, or supervision.
Additional information	Any additional non-health related information considered important?	-

C.1.20 Hara-Yamamura et al. (2022)

Reference: Hara-Yamamura, H., Inoue, K., Matsumoto, T., Honda, R., Ninomiya, K., & Yamamura, H. (2022). Rejection of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) by severely chlorine damaged RO membranes with different salt rejection ratios. Chemical Engineering Journal, 446, 137398. https://doi.org/https://doi.org/10.1016/j.cej.2022.137398.		
General Description	Uses	Industrial applications such as stain- and water-resistant fabrics and carpeting, grease-proof, food-contact paper, cleaning products, paints, and fire-fighting foams.
	Sources in drinking water	-
	Other	In this study, we aimed to develop an economically sustainable membrane process for PFAS removal, by upgrading the used membranes.
Treatment of drinking water	Treatment technology	-
	Effectiveness	The filtration tests demonstrated that the efficient PFAS removal over 85% was achieved even by highly damaged membranes with 39 ~ 66% salt rejection ratios (SRR).
	Any special conditions?	-
	Other	-

Reference: Hara-Yamamura, H., Inoue, K., Matsumoto, T., Honda, R., Ninomiya, K., & Yamamura, H. (2022). Rejection of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) by severely chlorine damaged RO membranes with different salt rejection ratios. Chemical Engineering Journal, 446, 137398. https://doi.org/https://doi.org/10.1016/j.cej.2022.137398.		
Measurement	Analytical method	HPLC coupled with a triple quadruple spectrometer in negative electrospray ionization mode (ESI).
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.21 Harris et al. (2022)

Reference: Harris, J. T., de la Garza, G. D., Devlin, A. M., & McNeil, A. J. (2022). Rapid Removal of Poly- and Perfluoroalkyl Substances with Quaternized Wood Pulp. ACS ES&T Water, 2(2), 349-356. https://doi.org/10.1021/acsestwater.1c00396.		
General Description	Uses	-
	Sources in drinking water	-
	Other	To overcome this limitation, authors developed materials that rapidly adsorb anionic PFAS from water within seconds.
Treatment of drinking water	Treatment technology	Cellulose fibers functionalized with cationic amines (quaternized wood pulp (QWP)).
	Effectiveness	QWP removed more than 80% of the most prevalent PFAS (perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA)) within seconds at environmentally relevant concentrations (~2.5 µg/L). QWPs were less efficient at adsorbing shorter chain PFAS (<30%). At environmentally relevant concentrations (~2.5 µg/L), PFOS and PFOA were adsorbed in under 30 s, making QWPs advantageous compared to other adsorbents that require long adsorption times (>15 min).
	Any special conditions?	Although adsorption was impacted by natural organic matter, it was unaffected by solution pH and low salt concentrations.
	Other	Conventional adsorbents usually require long contact times (minutes to days) to achieve high removal efficiencies. Researchers are developing adsorbents to overcome the limitations of AC and IX resins. For example. ionic fluorogel: high removal efficiencies (>95%) were observed for most PFAS after 2 h using spiked water samples from a local treatment plant.
Measurement	Analytical method	-

Reference: Harris, J. T., de la Garza, G. D., Devlin, A. M., & McNeil, A. J. (2022). Rapid Removal of Poly- and Perfluoroalkyl Substances with Quaternized Wood Pulp. ACS ES&T Water, 2(2), 349-356. https://doi.org/10.1021/acsestwater.1c00396.		
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.22 HEPA (2022, 2020)

Reference: HEPA (2020). PFAS National Environmental Management Plan. Version 2.0 – January 2020. National Chemicals Working Group of the Heads of EPAs Australia and New Zealand (HEPA). ***Supporting Documentation****:* HEPA (2022). Draft PFAS National Environmental Management Plan. Version 3.0 – Draft Prepared for Public Consultation. 2022. National Chemicals Working Group of the Heads of EPAs Australia and New Zealand (HEPA).		
General Description	Uses	In Australia, PFAS have been used for a long time in a wide range of consumer products and industrial applications, including certain firefighting foams.
	Sources in drinking water	-
	Other	For humans, the main sources of PFAS are via ingestion of food and drinking water.
Treatment of drinking water	Treatment technology	-
	Effectiveness	-
	Any special conditions?	-
	Other	-
Measurement	Analytical method	• Liquid chromatography tandem mass spectrometry (LC-MS/MS). • Total Oxidisable Precursor Assay (TOP Assay). • Total Organic Fluorine Assay (TOF Assay) as combustion ion chromatography. • Liquid chromatography quadrupole time of flight mass spectroscopy (LC-QToF-MS). • Particle-induced gamma emission (PIGE) spectroscopy.
	Limit of determination/ Limit of Reporting (LOR)	0.01-0.05 µg/L. Ultratrace method available from some laboratories.

Reference: HEPA (2020). PFAS National Environmental Management Plan. Version 2.0 – January 2020. National Chemicals Working Group of the Heads of EPAs Australia and New Zealand (HEPA). ***Supporting Documentation****:* HEPA (2022). Draft PFAS National Environmental Management Plan. Version 3.0 – Draft Prepared for Public Consultation. 2022. National Chemicals Working Group of the Heads of EPAs Australia and New Zealand (HEPA).		
	Other	Commercially available analytical techniques generally measure up to 33 of the more than 4,700 PFAS compounds known to exist.
Additional information	Any additional non-health related information considered important?	The TOP Assay and TOF Assay can provide a more complete indication of the amount of PFAS present in a sample. TOF Assay analysis is useful when there is uncertainty as to whether the USEPA methods adequately measure all the PFAS likely to be present. High resolution accurate mass LC-QToF-MS. This technique can further reduce uncertainty by providing information on the structures of unidentified PFAS compounds. A more recent overseas approach proposed is a drinking water guidance value for total PFAS (EU 1356 2020), where 'PFAS Total' means the totality of per- and polyfluoroalkyl substances and is defined as 1357 substances that contain a perfluoroalkyl moiety with three or more carbons (i.e. $–C_nF_{2n}–$, $n \geq 3$) or a 1358 perfluoroalkylether moiety with two or more carbons (HEPA 2022).

C.1.23 Hyman et al. (2023)

Reference: Hayman, N. T., Carilli, Jessica E., Liu, Y., Shields, M. R., Hsu, L., & George, R. (2023). Water quality impacts on sorbent efficacy for per- and polyfluoroalkyl substances treatment of groundwater. Remediation Journal, 33(2), 89-100. https://doi.org/https://doi.org/10.1002/rem.21747.		
General Description	Uses	-
	Sources in drinking water	-
	Other	A series of evaluations using a rapid small-scale column test approach was conducted with two sorbent materials (a granulated activated carbon [GAC] and an AIX), individually and combined, under conditions where conductivity, pH, and organic carbon concentrations were varied in a semifactorial approach.
Treatment of drinking water	Treatment technology	Granulated activated carbon (GAC) and an Anion exchange resin (AIX).
	Effectiveness	• IX was found to be more effective than GAC at removing the tested perfluoroalkyl sulfonic acids (PFBS, PFHxS, and PFOS). • GAC was similarly or more effective than AIX at removing perfluorocarboxylic acids (PFBA, PFHxA, and PFOA) under high conductivity conditions.

Reference: Hayman, N. T., Carilli, Jessica E., Liu, Y., Shields, M. R., Hsu, L., & George, R. (2023). Water quality impacts on sorbent efficacy for per- and polyfluoroalkyl substances treatment of groundwater. Remediation Journal, 33(2), 89-100. https://doi.org/https://doi.org/10.1002/rem.21747.		
		• Overall, the efficacy of AIX at removing PFAS was more strongly impacted by organic carbon and conductivity than GAC. • pH had less of an effect on either sorbent's efficacy compared to the other test conditions.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	Samples sent to Geochemical and Environmental Research Group (GERG) analytical laboratory at Texas A&M University (TAMU) for analysis.
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.24 Heidari et al. (2021)

Reference: Heidari, H., Abbas, T., Ok, Y. S., Tsang, D. C. W., Bhatnagar, A., & Khan, E. (2021). GenX is not always a better fluorinated organic compound than PFOA: A critical review on aqueous phase treatability by adsorption and its associated cost. Water Res, 205, 117683. https://doi.org/10.1016/j.watres.2021.117683.		
General Description	Uses	Per- and polyfluoroalkyl substances (PFAS) have been used as water and stain repellents for containers, leather, and fabrics, as well as the main ingredients for firefighting foams and photographic emulsifiers.
	Sources in drinking water	-
	Other	In this paper, comparisons of GenX and PFOA adsorption are evaluated, including adsorption potential, adsorption mechanisms, and associated costs.
Treatment of drinking water	Treatment technology	• Granular activated carbon and powdered activated carbon. • Anion exchange resins. • Unconventional adsorbents (Ionic fluorogel resin, Modified poly (ethylene glycol) diacrylate (PEGDA)), Covalent organic frameworks, Poly (N-[3-(dimethylamino)propyl] acrylamide, methyl chloride quaternary) (DMAPAA-Q), β-cyclodextrin polymers.

Reference: Heidari, H., Abbas, T., Ok, Y. S., Tsang, D. C. W., Bhatnagar, A., & Khan, E. (2021). GenX is not always a better fluorinated organic compound than PFOA: A critical review on aqueous phase treatability by adsorption and its associated cost. Water Res, 205, 117683. https://doi.org/10.1016/j.watres.2021.117683.		
	Effectiveness	Based on the literature review: • Both AC and AEs can treat GenX and PFOA, but AEs are a more promising choice with higher removal efficiency. • GenX removal efficiency through activated carbon (30%) is lower than that of PFOA (80–95%), while GenX and PFOA removal efficiencies by anion exchange resins are similar (99%). • Ionic fluorogel resin: The ionic fluorogel (100 mg/L) removed 98–100% of GenX, PFOA, and PFHxA in 21 h at an initial concentration of 50 µg.L−1. At a lower adsorbent dose (10 mg/L) and an initial concentration of each PFAS (1 µg/L), better PFOA removal (97%) was achieved than those of GenX (80–88%) and PFHxA (76–82%) in 21 h. • PEGDA: No GenX (100 mg/L) removal was observed using fluoridated PEGDA hydrogel (10 mg/5 mL) in 12 h. • Covalent organic frameworks: At an initial concentration of 200 µg.L−1 of GenX, COFs with no and maximum loadings of azide were able to remove small amounts of GenX (5% efficiency). • DMAPAA-Q: high removal efficiency (85%) and high selectivity (> 80%). • β-cyclodextrin polymers: CDPs removed GenX (>93%) after 4 h of contact time.
	Any special conditions?	-
	Other	• A detailed literature review suggests that anion-exchange resins are more effective in removing GenX than activated carbon. • GenX removal efficiency through activated carbon (30%) is lower than that of PFOA (80–95%), while GenX and PFOA removal efficiencies by anion exchange resins are similar (99%). • Unconventional adsorbents, such as ionic fluorogels and covalent organic frameworks can effectively remove GenX from water. • The review reveals that GenX adsorption is more challenging, requiring almost 4 times the treatment cost of its predecessor, PFOA.
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information	-

Reference: Heidari, H., Abbas, T., Ok, Y. S., Tsang, D. C. W., Bhatnagar, A., & Khan, E. (2021). GenX is not always a better fluorinated organic compound than PFOA: A critical review on aqueous phase treatability by adsorption and its associated cost. Water Res, 205, 117683. https://doi.org/10.1016/j.watres.2021.117683.		
	considered important?	

C.1.25 Hopkins et al. (2018)

Reference: Hopkins, Z. R., Sun, M., DeWitt, J. C., & Knappe, D. R. U. (2018). Recently Detected Drinking Water Contaminants: GenX and Other Per- and Polyfluoroalkyl Ether Acids. Journal AWWA, 110(7), 13-28. https://doi.org/https://doi.org/10.1002/awwa.1073.		
General Description	Uses	GenX serves as a replacement for ammonium perfluorooctanoate, the ammonium salt of PFOA, and it is used as a processing aid in the production of fluoropolymers such as polytetrafluoroethylene (PTFE). While GenX is produced for commercial purposes, the acid form of GenX is also generated as a byproduct during the production of fluoromonomers.
	Sources in drinking water	-
	Other	This article is divided into five parts: (1) sources of GenX and other PFEAs, (2) toxicity of GenX and development of North Carolina's health goal, (3) analytical methods for GenX and other PFEAs, (4) occurrence, and (5) treatment options.
Treatment of drinking water	Treatment technology	-
	Effectiveness	-
	Any special conditions?	-
	Other	From Table 4: Effectiveness of drinking water treatment processes for PFAS removal • Coagulation/sedimentation/filtration: Not effective. • Chlorination/chloramination: Not effective. • Ozonation: Not effective. • UV/H_2O_2: Not effective. • PAC adsorption: Not effective for short chain PFAS, moderately effective for long-chain PFAS and PFEA (incl. GenX). Desorption can diminish with PFAS load. • GAC adsorption: Moderately effective for short chain PFAS and PFEAs, very effective long chain PFAS. Desorption can diminish with PFAS load. • Anion exchange: Moderately to very effective. • High-pressure membranes (nanofiltration, reverse osmosis): Effective for all PFAS. High energy requirements.

Reference: Hopkins, Z. R., Sun, M., DeWitt, J. C., & Knappe, D. R. U. (2018). Recently Detected Drinking Water Contaminants: GenX and Other Per- and Polyfluoroalkyl Ether Acids. Journal AWWA, 110(7), 13-28. https://doi.org/https://doi.org/10.1002/awwa.1073.		
Measurement	Analytical method	Ultraperformance liquid chromatograph (UPLC) interfaced with a triple quadrupole mass spectrometer.
	Limit of determination/ Limit of Reporting (LOR)	GenX 5 ng/L
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.26 Huang et al. (2018)

Reference: Huang, P. J., Hwangbo, M., Chen, Z., Liu, Y., Kameoka, J., & Chu, K. H. (2018). Reusable Functionalized Hydrogel Sorbents for Removing Long- and Short-Chain Perfluoroalkyl Acids (PFAAs) and GenX from Aqueous Solution. ACS Omega, 3(12), 17447-17455. https://doi.org/10.1021/acsomega.8b02279.		
General Description	Uses	PFAS are broadly used in various industries, including paintings, clothing, electrical conductors, and polytetrafluoroethylene coatings for many decades.
	Sources in drinking water	-
	Other	We developed reusable hydrogel sorbents to remove long- and short-chain perfluoroalkyl acids and GenX.
Treatment of drinking water	Treatment technology	Fluoridation and amination of poly(ethylene glycol) diacrylate (PEGDA).
	Effectiveness	• The newly synthesized sorbents can sorb the five targeted PFAS (PFOA, PFOS, PFBS, PFBA and GenX) to different degrees from aqueous solution. • Aminated PEGDA showed the highest sorption capacity for all five PFAS, particularly for PFBA and PFBS. • The bifunctionalized PEGDA showed higher capacities for PFOA and PFOS, suggesting that both hydrophobic interactions and charges contribute to the sorption. • Both aminated and bifunctionalized sorbents can remove GenX from water. • Sorbent A can sorb low levels of PFOA, PFOS, and PFBA in 6 h (less than 10%), sorbent A was unable to sorb PFBS and GenX. • Within 6 h, sorbent B was able to completely (100%) sorb PFOA and PFBS, and 91 and 78% for PFOS and PFBA, respectively.

Reference: Huang, P. J., Hwangbo, M., Chen, Z., Liu, Y., Kameoka, J., & Chu, K. H. (2018). Reusable Functionalized Hydrogel Sorbents for Removing Long- and Short-Chain Perfluoroalkyl Acids (PFAAs) and GenX from Aqueous Solution. ACS Omega, 3(12), 17447-17455. https://doi.org/10.1021/acsomega.8b02279.		
		• Sorbent C also showed excellent removal toward PFOA and PFBS. However, sorbent C showed a less removal for PFBA (62%) than those observed for sorbent B. • Both sorbents B and C showed greater than 95% of removal toward GenX. • The spent sorbents were reusable after readily regenerated with 70% methanol contained 1% NaCl.
	Any special conditions?	-
	Other	Sorption processes have shown better PFAS removals from water than other treatment processes such as coagulation/flocculation/sedimentation, filtration, and advanced oxidation. Activated carbons and ion-exchange resins are two commonly used sorbents for removing long-chain PFAS from water. High costs are common associated with the applications of these sorbents.
Measurement	Analytical method	High-performance liquid chromatography (HPLC)/triple quadrupole mass spectrometer.
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.27 Inyang and Dickenson (2017)

Reference: Inyang, M., & Dickenson, E. R. V. (2017). The use of carbon adsorbents for the removal of perfluoroalkyl acids from potable reuse systems. Chemosphere, 184, 168-175. https://doi.org/https://doi.org/10.1016/j.chemosphere.2017.05.161.		
General Description	Uses	-
	Sources in drinking water	-
	Other	Bench- and pilot-scale sorption tests were used to probe the performance of several biochars at removing perfluoroalkyl acids (PFAA) from field waters, compared to granular activated carbon (GAC).
Treatment of drinking water	Treatment technology	GAC, anthracite, and HWC (hardwood) biochar
	Effectiveness	• Pilot adsorbers most effective towards PFOA and PFOS removal were: GAC >biochar.

Reference: Inyang, M., & Dickenson, E. R. V. (2017). The use of carbon adsorbents for the removal of perfluoroalkyl acids from potable reuse systems. Chemosphere, 184, 168-175. https://doi.org/https://doi.org/10.1016/j.chemosphere.2017.05.161.		
		• GAC was the most effective in mitigating perfluoropentanoic acid (PFPnA), perfluorohexanoic acid (PHxA), PFOA, perfluorooctane sulfonic acid (PFOS), and DOC (45 - 67% removed at 4354 bed volumes) followed by HWC, and then anthracite. • Biochar affinity to PFOA was higher in surface water than in treated wastewater. • Shorter-chain PFAA [perfluorobutanoic acid (PFBA), PFPnA, or PFHxA] were more difficult to remove with both biochar and GAC than the longer-chain, PFOS and PFOA.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	Isotope-dilution liquid chromatography with tandem mass spectrometry (LC/MS-MS) using a triple-quadrupole mass spectrometer.
	Limit of determination/ Limit of Reporting (LOR)	MRL for the nine PFAA were: 5 ng/L (PFBA and PFOA), 2 ng/L (PFPnA), 1 ng/L (PFHxA, PFHxS, PFOS, PFNA, and PFDA), and 0.5 ng/L (PFHpA).
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.28 Iwabuchi and Sato (2021)

Reference: Iwabuchi, K., & Sato, I. (2021). Effectiveness of household water purifiers in removing perfluoroalkyl substances from drinking water. Environ Sci Pollut Res Int, 28(9), 11665-11671. https://doi.org/10.1007/s11356-020-11757-1		
General Description	Uses	Perfluoroalkyl substances (PFAS) typified by perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) had been widely used as raw materials or as ingredients in antifouling agents, water/oil repellents, surfactants, lubricants, fire extinguishers, and polymers since the 1950s (Schultz et al. 2003). PFAS were also found in a wide range of consumer products that people use daily such as cookware, food boxes, fibre products, and cosmetics.
	Sources in drinking water	In general, PFAS concentrations in drinking water are at the nanogram per litre level or lower, but extraordinary concentrations exceeding 100 ng/L are sometimes detected in urban areas or around airports.

Reference: Iwabuchi, K., & Sato, I. (2021). Effectiveness of household water purifiers in removing perfluoroalkyl substances from drinking water. Environ Sci Pollut Res Int, 28(9), 11665-11671. https://doi.org/10.1007/s11356-020-11757-1		
	Other	In the present study, four models of pitcher-type water purifiers (A-D) were tested to evaluate their removal effect on six PFAS including PFOS and PFOA.
Treatment of drinking water	Treatment technology	• Model A: Hollow fibre membrane and ceramics. • Model B: Hollow fibre membrane and ceramics. • Model C: Ion exchange. • Model D: Ion exchange.
	Effectiveness	This study clearly demonstrates that household water purifiers are effective in removing PFAS from drinking water. All of the water purifiers removed PFAS, but the efficiency was dependent on the models. Model C was most effective; more than 90% of all PFAS were removed through the recommended life of the filter cartridge. Model D was least effective; its removal efficiency declined below 50% by the end of the cartridge's life. When compared by the carbon chain length of PFAS, the removal efficiency was "C12 > C10 > C8 > C6" in all models.
	Any special conditions?	-
	Other	These chemicals are scarcely removed by the conventional process in water purification plants. 50 ng/L PFAS solution (PFOA, PFOS, PFHxS, Perfluorohexanoic acid (PFHxA), perfluorodecanoic acid (PFDA) and perfluorododecanoic acid (PFDoA)).
Measurement	Analytical method	LC-QTOF-MS analysis
	Limit of determination/ Limit of Reporting (LOR)	LOQ: PFHxA 0.10 ng/L, PFOA 0.05 ng/L, PFDA 0.06 ng/L, PFDoA 0.02 ng/L, PFHxS 0.09 ng/L, PFOS 0.17 ng/L
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.29 Jiao et al. (2022)

Reference: Jiao, E., Zhu, Z., Yin, D., Qiu, Y., Kärrman, A., & Yeung, L. W. Y. (2022). A pilot study on extractable organofluorine and per- and polyfluoroalkyl substances (PFAS) in water from drinking water treatment plants around Taihu Lake, China: what is missed by target PFAS analysis? Environ Sci Process Impacts, 24(7), 1060-1070. https://doi.org/10.1039/d2em00073c		
General Description	Uses	Per- and polyfluoroalkyl substances (PFAS) are man-made substances which have been manufactured and used extensively as additives in consumer products since the 1950s.

Reference: Jiao, E., Zhu, Z., Yin, D., Qiu, Y., Kärrman, A., & Yeung, L. W. Y. (2022). A pilot study on extractable organofluorine and per- and polyfluoroalkyl substances (PFAS) in water from drinking water treatment plants around Taihu Lake, China: what is missed by target PFAS analysis? Environ Sci Process Impacts, 24(7), 1060-1070. https://doi.org/10.1039/d2em00073c		
	Sources in drinking water	Releases of PFAS have resulted in their detections in various environmental media, especially in drinking water which was identified as one of the major exposure pathways to humans.
	Other	-
Treatment of drinking water	Treatment technology	The overall treatment process includes pre-ozonation, coagulation, sedimentation, sand filtration, post-ozonation, bio-activated carbon and disinfection, although there are some differences between drinking water treatment plants (DWTPs).
	Effectiveness	Total concentrations (PPFAS) ranged from 25.8 to 187 ng/L in the raw water and 29.4 to 188 ng/L in the treated water. The concentrations of PFAS showed little differences between raw and treated water, indicating limited removal efficiency.
	Any special conditions?	Activated carbon was already in use in these DWTPs.
	Other	-
Measurement	Analytical method	• Acquity UPLC system coupled with the Xevo TQ-S tandem mass spectrometer (Waters Corporation, Milford, USA) that was operated in the electrospray negative ionization mode. • NB: Ultra-short analytes: Acquity Ultra Performance Convergence Chromatography (UPC2) system coupled with a tandem mass spectrometer.
	Limit of determination/ Limit of Reporting (LOR)	• The method detection limit (MDL) of PFAS was determined as average concentrations in procedural blanks plus three times the standard deviation. The method quantification limit (MQL) was determined as average concentrations in procedure blanks plus ten times the standard deviation. • PFOS: 0.054 – 0.181 ng/L • PFHxS: 0.020 – 0.057 ng/L • PFBS: 0.023 – 0.086 ng/L • PFOA: 0.038 – 0.103 ng/L • GenX: 0.05 ng/L
	Other	• PFOA, PFOS and PFHxS were the abundant compounds. • Mass balance analysis of organofluorine revealed that at least 68% of EOF could not be explained by target PFAS. • Suspect screening analysis identified 10 emerging PFAS (e.g. H-PFAAs, H-PFESAs and OBS).
Additional information	Any additional non-health related information considered important?	• Eight pairs of raw and treated water were collected from drinking water treatment plants (DWTPs) around Taihu Lake in China (5 cities). • Extractable organofluorine (EOF) and 34 target PFAS. • The ratios PFBA/PFOA and PFBS/PFOS between previous and current studies showed significant replacements of short-chain to long-chain PFAS.

Reference: Jiao, E., Zhu, Z., Yin, D., Qiu, Y., Kärrman, A., & Yeung, L. W. Y. (2022). A pilot study on extractable organofluorine and per- and polyfluoroalkyl substances (PFAS) in water from drinking water treatment plants around Taihu Lake, China: what is missed by target PFAS analysis? Environ Sci Process Impacts, 24(7), 1060-1070. https://doi.org/10.1039/d2em00073c		
		• The ratios of the measured PFAS concentrations to the guideline values showed that some of the treated drinking water exceeds guideline values, appealing for efforts on drinking water safety guarantee. • ultra-short PFAS (C2 and C3) also attract increasing attention due to their mobile properties, and among them, trifluoroacetate (TFA) has already been widely reported in surface water, rainwater, the atmosphere, and sediments.

C.1.30 Jian et al. (2017)

Reference: Jian, J. M., Guo, Y., Zeng, L., Liang-Ying, L., Lu, X., Wang, F., & Zeng, E. Y. (2017). Global distribution of perfluorochemicals (PFCs) in potential human exposure source-A review. Environ Int, 108, 51-62. https://doi.org/10.1016/j.envint.2017.07.024		
General Description	Uses	-
	Sources in drinking water	-
	Other	PFOS, PFHxA, PFHpA, PFNA, PFDA, and PFOA appeared to be the main perfluorinated chemicals (PFCs) with the highest concentrations and detection frequencies in drinking water. In this study, we reviewed recent studies on PFCs in potential sources (e.g. air, food and drinking water) related to human exposure. We outlined the occurrences of different PFC congeners/isomers in indoor air and dust, foodstuffs (e.g. vegetables, dairy products, beverages, eggs, meat and meat products, fish, and shellfish), and drinking water.
Treatment of drinking water	Treatment technology	-
	Effectiveness	-
	Any special conditions?	-
	Other	• PFC levels varied in an order of well water > tap water > bottled water > drinking water > raw water. • The highest PFC contamination in well water indicated that point sources could be the main cause. • The greater PFC concentrations in tap and drinking water than in raw water indicated the role of drinking water treatment processes in PFC contamination.
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-

Reference: Jian, J. M., Guo, Y., Zeng, L., Liang-Ying, L., Lu, X., Wang, F., & Zeng, E. Y. (2017). Global distribution of perfluorochemicals (PFCs) in potential human exposure source-A review. Environ Int, 108, 51-62. https://doi.org/10.1016/j.envint.2017.07.024		
Additional information	Any additional non-health related information considered important?	-

C.1.31 Karatas et al. (2022)

Reference: Karataş, O., Kobya, M., Khataee, A., & Yoon, Y. (2022). Perfluorooctanoic acid (PFOA) removal from real landfill leachate wastewater and simulated soil leachate by electrochemical oxidation process. Environmental Technology & Innovation, 28, 102954. https://doi.org/10.1016/j.eti.2022.102954		
General Description	Uses	They are widely used in several products, such as paints, non-stick cookware, firefighting, foams, carpets, floor polishes, semiconductors, pesticide formulations, and food packaging.
	Sources in drinking water	-
	Other	In this study, we investigated the efficiency of electrooxidation (EO) in PFOA removal, optimization of EO parameters, and groundwater simulation in a realistic scenario. The EO optimization experiments were performed with a boron-doped diamond (BDD) anode for different values of pH, current density, and inlet concentration, and the effects of different anode materials were investigated for comparison.
Treatment of drinking water	Treatment technology	BDD EO treatment
	Effectiveness	Under optimum conditions, total organic carbon (TOC) removal of up to 90% was achieved. In the groundwater simulation, we applied optimized EO parameters after obtaining leachates from the soil. A TOC removal of up to 86% was obtained in the EO of simulated groundwater contaminated with PFOA.
	Any special conditions?	-
	Other	TOC reduction and F− ion release values were used to investigate the PFOA degradation.
Measurement	Analytical method	LC/MS QTOF
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information	-

Reference: Karataş, O., Kobya, M., Khataee, A., & Yoon, Y. (2022). Perfluorooctanoic acid (PFOA) removal from real landfill leachate wastewater and simulated soil leachate by electrochemical oxidation process. Environmental Technology & Innovation, 28, 102954. https://doi.org/10.1016/j.eti.2022.102954		
	considered important?	

C.1.32 Li et al. (2023)

Reference: Li, Z., Lu, Y., Chen, T., He, A., Huang, Y., Li, L., Pan, W., Li, J., Zhu, N., Wang, Y., & Jiang, G. (2023). Generation Mechanism of Perfluorohexanesulfonic Acid from Polyfluoroalkyl Sulfonamide Derivatives During Chloramination in Drinking Water. Environmental Science & Technology. https://doi.org/10.1021/acs.est.2c07881		
General Description	Uses	Widely used as surfactants for water- and stain-protective coatings for carpets, paper, leather, and textile.
	Sources in drinking water	-
	Other	The potential precursors and formation mechanisms of PFHxS were explored during drinking water disinfection. Herein, we suspect four PFHxS-related compounds may undergo the generation of PFHxS during two conventional drinking water oxidative disinfection processes (chlorination and chloramination). The selected four PFHxS-related compounds including FHxSA (CAS No. 41997-13-1), N-MeFHxSA (CAS No. 68259-15-4), N-AP-FHxSA (CAS No. 50598-28-2), and N-TAmP-FHxSA (CSA No. 38850-51-0).
Treatment of drinking water	Treatment technology	-
	Effectiveness	-
	Any special conditions?	-
	Other	• PFHxS has been widely detected in drinking water and is difficult to remove or degrade via conventional drinking water treatments. • Previous studies showed a higher concentration of PFHxS in finished water than in influent water during wastewater and drinking water treatments. • PFHxS could be generated from polyfluoroalkyl sulfonamide derivatives during chlorination and chloramination. • Several perfluoroalkyl oxidation products and decarboxylation intermediates were detected and identified in the chloraminated samples using Fourier-transform ion cyclotron resonance mass spectrometry. • The process could be highly affected by the monochloramine dose, pH, and temperature.
Measurement	Analytical method	UHPLC system coupled with an electrospray-ionization triple quadrupole mass spectrometer.

Reference: Li, Z., Lu, Y., Chen, T., He, A., Huang, Y., Li, L., Pan, W., Li, J., Zhu, N., Wang, Y., & Jiang, G. (2023). Generation Mechanism of Perfluorohexanesulfonic Acid from Polyfluoroalkyl Sulfonamide Derivatives During Chloramination in Drinking Water. Environmental Science & Technology. https://doi.org/10.1021/acs.est.2c07881		
	Limit of determination/ Limit of Reporting (LOR)	• PFHxS: 0.3 ng/L • PFHxA: 0.03 ng/L • FHxSA, N-MeFHxSA, N-AP-FHxSA, N-TAmP-FHxSA: 0.05 ng/L
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.33 Li et al. (2020)

Reference: Li, F., Duan, J., Tian, S., Ji, H., Zhu, Y., Wei, Z., & Zhao, D. (2020). Short-chain per- and polyfluoroalkyl substances in aquatic systems: Occurrence, impacts and treatment. Chemical Engineering Journal, 380, 122506. https://doi.org/https://doi.org/10.1016/j.cej.2019.122506		
General Description	Uses	PFAS have been used in a variety of industries around the globe and widely distributed in our daily consumer products such as food packaging, pesticide formulations, waterproof fabrics, carpets, non-stick cookware, fume suppressants, photographic films, masking tape, firefighting foams, etc. Short-chain PFAS have been widely used as substitutes for long-chain PFAS.
	Sources in drinking water	-
	Other	Treatment of short-chain PFAS
Treatment of drinking water	Treatment technology	• Adsorption of short-chain PFAS: AC, anion exchange resin, fluorinated clay, modified biomass, and β-cyclodextrin polymer. • Oxidation and reduction of short-chain PFAS: Direct photolysis, Free radical processes, Zero-valent iron reduction. • Photocatalytic degradation of short-chain PFAS: TiO2 and its modifications, Non-TiO_2 catalysts. • Electrochemical oxidation of short-chain PFAS. • Thermolytic and sonochemical degradation of short-chain PFAS. • Short-chain PFAS removal by membrane filtration. • Microbial degradation of short-chain PFAS.
	Effectiveness	Conventional adsorption, ion-exchange, and membrane filtration can remove short-chain PFAS, but are less effective than the long-chain homologues, and are challenged with poor material regeneration efficiency and disposal of process waste residual.

Reference: Li, F., Duan, J., Tian, S., Ji, H., Zhu, Y., Wei, Z., & Zhao, D. (2020). Short-chain per- and polyfluoroalkyl substances in aquatic systems: Occurrence, impacts and treatment. Chemical Engineering Journal, 380, 122506. https://doi.org/https://doi.org/10.1016/j.cej.2019.122506		
		Advanced oxidation such as thermolysis and sonolysis can achieve complete mineralisation, but come with a high process cost. Direct photolysis, oxidation/reduction, photocatalysis, and electrochemical reaction may degrade short-chain PFAS following similar degradation pathways as long-chain PFAS, but at a slower rate. Photocatalytic processes appear most promising.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.34 Liu et al. (2020a)

Reference: Liu, S., Junaid, M., Zhong, W., Zhu, Y., & Xu, N. (2020a). A sensitive method for simultaneous determination of 12 classes of per- and polyfluoroalkyl substances (PFASs) in groundwater by ultrahigh performance liquid chromatography coupled with quadrupole orbitrap high resolution mass spectrometry. Chemosphere, 251, 126327. https://doi.org/10.1016/j.chemosphere.2020.126327		
General Description	Uses	PFAS are a large group of synthetic compounds extensively used in industrial and consumer products since 1950s.
	Sources in drinking water	-
	Other	A trace analytical method based on ultrahigh performance liquid chromatography-quadrupole Orbitrap high resolution mass spectrometry (UHPLC-Q-Orbitrap HRMS) was developed for simultaneous determination of 54 PFAS belonging to 12 classes in groundwater, including 24 perfluorocarbons and 30 precursors.
Treatment of drinking water	Treatment technology	-
	Effectiveness	-
	Any special conditions?	-

Reference: Liu, S., Junaid, M., Zhong, W., Zhu, Y., & Xu, N. (2020a). A sensitive method for simultaneous determination of 12 classes of per- and polyfluoroalkyl substances (PFASs) in groundwater by ultrahigh performance liquid chromatography coupled with quadrupole orbitrap high resolution mass spectrometry. Chemosphere, 251, 126327. https://doi.org/10.1016/j.chemosphere.2020.126327		
	Other	-
Measurement	Analytical method	UHPLC-Q-Orbitrap HRMS
	Limit of determination/ Limit of Reporting (LOR)	Method limits of quantification (MLOQs) (0.5 - 250 pg/L)PFOS, PFOA (0.025 ng/L), PFHxS, PFBS (0.0005 ng/L)GenX not included.
	Other	In most of the previous studies, the liquid chromatography triple quadrupole mass spectrometry (LC-QQQ-MS) was commonly used to measure PFAS concentration, which resulted in the following method limits of quantification (MLOQs): 13 - 89 ng/L, 0.35 - 26 ng/L (53 PFAS), and 0.3 - 199 ng/L (52 PFAS). HRMS could achieve high precision, and low detection limits at the level of pg/L, orders of magnitude lower than QQQ-MS such as 14 - 170 pg/L (15 PFAS) with high performance liquid chromatography-quadrupole time of flight-HRMS (HPLC-Q-Tof-HRMS), 7.1 - 62 pg/L (8 PFASs) with LC-Orbitrap Tribrid HRMS, and 8 - 150 pg/L (36 PFAS) with LC-Orbitrap HRMS.
Additional information	Any additional non-health related information considered important?	-

C.1.35 Liu et al. (2020b)

Reference: Liu, C., Hatton, J., Arnold, W. A., Simcik, M. F., & Pennell, K. D. (2020b). In Situ Sequestration of Perfluoroalkyl Substances Using Polymer-Stabilized Powdered Activated Carbon. Environ Sci Technol, 54(11), 6929-6936. https://doi.org/10.1021/acs.est.0c00155		
General Description	Uses	PFAS have been widely used in products such as firefighting foams, mineral extraction surfactants, floor polishes, photographic film, waterproof clothing, and nonstick coatings for cookware.
	Sources in drinking water	-
	Other	The objective of this study was to evaluate the in situ delivery and sorptive capacity of an aqueous suspension containing powdered activated carbon (PAC) stabilized with polydiallyldimethylammonium chloride (polyDADMAC).
Treatment of drinking water	Treatment technology	polyDADMAC-stabilized PAC
	Effectiveness	Batch reactor studies demonstrated substantial adsorption of PFOA and PFOS by polyDADMAC-stabilized PAC. increased subsequent PFOA and PFOS retention by 3 orders of magnitude relative to untreated control columns.

Reference: Liu, C., Hatton, J., Arnold, W. A., Simcik, M. F., & Pennell, K. D. (2020b). In Situ Sequestration of Perfluoroalkyl Substances Using Polymer-Stabilized Powdered Activated Carbon. Environ Sci Technol, 54(11), 6929-6936. https://doi.org/10.1021/acs.est.0c00155		
	Any special conditions?	
	Other	Previous studies have shown that activated carbon is an effective sorbent for removal of perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) in conventional water treatment systems. An alternative to chemical or biological destruction that could be applied in situ is the injection of particulate materials into the subsurface to create an in situ permeable adsorptive barrier (PAB) that sequesters PFAS, with the intent of concentrating and containing mass from dilute groundwater plumes.
Measurement	Analytical method	Ultra performance liquid chromatograph coupled with a triple quadrupole mass spectrometer (UPLC−MS). The mass spectrometer was operated in negative electrospray ionization (ESI-) and multiple reaction monitoring (MRM) modes.
	Limit of determination/ Limit of Reporting (LOR)	Method detection limits for PFOA and PFOS were 5.16 and 33.2 ng/L, respectively.
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.36 Liu et al. (2021)

Reference: Liu, N., Wu, C., Lyu, G., & Li, M. (2021). Efficient adsorptive removal of short-chain perfluoroalkyl acids using reed straw-derived biochar (RESCA). Science of The Total Environment, 798, 149191. https://doi.org/https://doi.org/10.1016/j.scitotenv.2021.149191.		
General Description	Uses	-
	Sources in drinking water	-
	Other	-
Treatment of drinking water	Treatment technology	Reed straw-derived biochar (RESCA)
	Effectiveness	RESCA exhibiting exceptional removal efficiencies (>92%) toward short-chain PFAAs at environment-relevant concentrations (e.g. 1 µg/L). Dissolved organic matter (DOC) of >8 mg/L can negatively affect the removal of short-chain PFAAs by RESCA.
	Any special conditions?	-

Reference: Liu, N., Wu, C., Lyu, G., & Li, M. (2021). Efficient adsorptive removal of short-chain perfluoroalkyl acids using reed straw-derived biochar (RESCA). Science of The Total Environment, 798, 149191. https://doi.org/https://doi.org/10.1016/j.scitotenv.2021.149191.		
	Other	Granular activated carbon (GAC) and resin are effective in removing PFOS, PFOA, and many other long-chain PFAAs. Application of GAC is restricted by its inefficiency to remove short-chain PFAAs that have prevalently emerged as substitutes and/or metabolites of long-chain polyfluoroalkyl and perfluoroalkyl substances (PFAS).
Measurement	Analytical method	HPLC system in tandem with a triple quadrupoles mass spectrometer (LC/MS/MS).
	Limit of determination/ Limit of Reporting (LOR)	The method detection limits (MDLs) were estimated as PFBA (80 ng/L), PFBS (40 ng/L), PFHxA (80 ng/L), PFHxS (50 ng/L), PFOA (30 ng/L), PFOS (60 ng/L), respectively.
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.37 Liu et al. (2022)

Reference: Liu, Z., Solliec, M., Papineau, I., Lompe, K. M., Mohseni, M., Bérubé, P. R., Sauvé, S., & Barbeau, B. (2022). Elucidating the removal of organic micropollutants on biological ion exchange resins. Sci Total Environ, 808, 152137. https://doi.org/10.1016/j.scitotenv.2021.152137		
General Description	Uses	-
	Sources in drinking water	-
	Other	The objective of the present study was to evaluate the performance of Biological ion exchange (BIEX) resins for the removal of organic micropollutants and thereby validate the occurrence of biodegradation. The removals of biodegradable micropollutants (neutral: caffeine and estradiol; negative: ibuprofen and naproxen) and nonbiodegradable micropollutants with different charges (neutral: atrazine and thiamethoxam; negative: PFOA and PFOS) were respectively monitored during batch tests with biotic and abiotic BIEX resins.
Treatment of drinking water	Treatment technology	Biological ion exchange (BIEX)
	Effectiveness	The removal of naproxen, PFOS, and PFOA were attributable to ion exchange with previously retained natural organic matter on BIEX resins. SLR comment: From Figure 1, it appears PFOA reduced from 1µg/L to 0.6µg/L and PFOS from 0.9µg/L to 0.2µg/L.
	Any special conditions?	-

Reference: Liu, Z., Solliec, M., Papineau, I., Lompe, K. M., Mohseni, M., Bérubé, P. R., Sauvé, S., & Barbeau, B. (2022). Elucidating the removal of organic micropollutants on biological ion exchange resins. Sci Total Environ, 808, 152137. https://doi.org/10.1016/j.scitotenv.2021.152137		
	Other	-
Measurement	Analytical method	Ultra-high-performance liquid chromatography coupled to high-resolution mass spectrometry (UHPLC-HRMS)
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.38 Liu et al. (2022b)

Reference: Liu, C., Chu, J., Cápiro, N. L., Fortner, J. D., & Pennell, K. D. (2022). In-situ sequestration of perfluoroalkyl substances using polymer-stabilized ion exchange resin. J Hazard Mater, 422, 126960. https://doi.org/10.1016/j.jhazmat.2021.126960		
General Description	Uses	-
	Sources in drinking water	-
	Other	Previous studies have shown that ion exchange resins can serve as effective sorbents for the removal of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) in conventional water treatment systems. The objectives of this study were to evaluate the in situ delivery and PFAS sorption capacity of a polymer-stabilized ion exchange resin (S-IXR) consisting of Amberlite® IRA910 beads and Pluronic® F-127 in a quartz sand.
Treatment of drinking water	Treatment technology	Polymer-stabilized ion exchange resin (S-IXR)
	Effectiveness	These findings indicate that injectable ion exchange resins could provide an effective in situ remediation strategy for PFAS-impacted groundwater plumes. At environmentally relevant applied concentrations (< 100 ug/L total) that are typical of most groundwater contamination scenarios, competitive adsorption of PFAS was not observed. However, at higher concentrations (60 mg/L total) preferential adsorption of longer-chain length PFAS, especially PFOS, was evident in both batch reactor and column studies.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	-

Reference: Liu, C., Chu, J., Cápiro, N. L., Fortner, J. D., & Pennell, K. D. (2022). In-situ sequestration of perfluoroalkyl substances using polymer-stabilized ion exchange resin. J Hazard Mater, 422, 126960. https://doi.org/10.1016/j.jhazmat.2021.126960		
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.39 Liu et al. (2022c)

Reference: Liu, F., Guan, X., & Xiao, F. (2022c). Photodegradation of per- and polyfluoroalkyl substances in water: A review of fundamentals and applications. J Hazard Mater, 439, 129580. https://doi.org/10.1016/j.jhazmat.2022.129580		
General Description	Uses	Application since the 1940 s in a wide range of industrial and consumer products, including cosmetics, lubricants, paper packaging, textiles, fabric finishing agents, and aqueous film-forming foams (AFFFs).
	Sources in drinking water	-
	Other	Degradation mechanisms of PFAS by photo-oxidation and photo-reduction processes are discussed in detail.
Treatment of drinking water	Treatment technology	• Photooxidation: TiO_2-based photocatalysts, In_2O_3-based photocatalysts, Ga_2O_3-based photocatalysts, Bi- or BiOX-based photocatalysts. • Photo-reduction: Photo-induced hydrated electrons.
	Effectiveness	It is evident from the literature that certain photo-oxidation and photo-reduction processes are effective to mineralize long-chain PFAS (e.g. PFOA and PFOS). However, there is a critical lack of knowledge on the photocatalysis of short-chain PFAS. The intermediate and end degradation products of PFAS generated in photodegradation processes need to be further identified. The performance of photodegradation may be unsatisfactory for PFAS treatment at environmentally realistic concentrations. The literature review indicates that PFAS photodegradation experiments were mostly conducted in an ideal environment with synthetic water. However, the successes in removal and degradation of PFAS achieved in the laboratory have not occurred equally in the treatment of PFAS in natural water and wastewater.
	Any special conditions?	-

Reference: Liu, F., Guan, X., & Xiao, F. (2022c). Photodegradation of per- and polyfluoroalkyl substances in water: A review of fundamentals and applications. J Hazard Mater, 439, 129580. https://doi.org/10.1016/j.jhazmat.2022.129580		
	Other	These substances cannot be effectively removed during conventional drinking water treatment. Photocatalytic treatment is promising for PFAS degradation and mineralization in the aqueous solution.
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.40 McBeath and Graham (2021)

Reference: McBeath, S. T., & Graham, N. J. D. (2021). Degradation of perfluorooctane sulfonate via in situ electro-generated ferrate and permanganate oxidants in NOM-rich source waters [10.1039/D1EW00399B]. Environmental Science: Water Research & Technology, 7(10), 1778-1790. https://doi.org/10.1039/D1EW00399B		
General Description	Uses	Perfluorooctane sulfonate (PFOS) is used in a number of applications including as a mist suppressant agent for carcinogenic aerosols, aqueous film-forming foams, surfactants and lubricants, as well as various household products such as carpet, clothing and non-stick cookware.
	Sources in drinking water	The prevalence of PFOS in natural waters varies largely and is dependent on contaminant source location. In a worldwide survey conducted in 15 countries and 41 cities during 2004–2010, in both industrialised and non-industrialised areas, PFOS levels ranged from trace to 70.1 ng/L. A United States Environmental Protection Agency (US EPA) survey found PFOS contamination ranging from 40–43 ng/L as an average in 50 US states in contaminated waters, with individual levels ranging from trace to over 1800 ng/L.
	Other	The present study investigated the efficacy of both electro-oxidation (EO), and the simultaneous EO and ferrate/permanganate generation and oxidation, of PFOS as a potential drinking water treatment technology.
Treatment of drinking water	Treatment technology	• EO • Simultaneous EO and ferrate/permanganate generation and oxidation
	Effectiveness	Permanganate was shown to have little effect on PFOS removal, significantly increased degradation was observed when EO was coupled with ferrate generation and oxidation, significantly exceeding that of solely EO.

Reference: McBeath, S. T., & Graham, N. J. D. (2021). Degradation of perfluorooctane sulfonate via in situ electro-generated ferrate and permanganate oxidants in NOM-rich source waters [10.1039/D1EW00399B]. Environmental Science: Water Research & Technology, 7(10), 1778-1790. https://doi.org/10.1039/D1EW00399B		
	Any special conditions?	-
	Other	-
Measurement	Analytical method	Ultra-high performance liquid chromatography-tandem mass spectrometry (UPLC-MS/MS), using negative electrospray ionization with the multiple reaction monitoring (MRM).
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.41 McCLeaf et al. (2017)

Reference: McCleaf, P., Englund, S., Östlund, A., Lindegren, K., Wiberg, K., & Ahrens, L. (2017). Removal efficiency of multiple poly- and perfluoroalkyl substances (PFASs) in drinking water using granular activated carbon (GAC) and anion exchange (AE) column tests. Water Res, 120, 77-87. https://doi.org/10.1016/j.watres.2017.04.057.		
General Description	Uses	PFAS are used in a variety of products such as water repellents, food packaging and several industrial processes.
	Sources in drinking water	-
	Other	The present study investigated the effects of perfluorocarbon chain length, functional group and isomer structure (branched or linear) on removal of multiple PFAS using granular activated carbon (GAC, Filtrasorb® 400) and anion exchange (AE, Purolite® A600) column experiments. The removal of 14 different PFAS, i.e. the C3-C11, C14 perfluoroalkyl carboxylic acids (PFCAs) (PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTeDA), perfluorooctane sulfonamide (FOSA), and the C4, C6, C8 perfluoroalkyl sulfonic acids (PFSAs) (PFBS, PFHxS, PFOS), was monitored for a 217 day period.
Treatment of drinking water	Treatment technology	Granular activated carbon (GAC) and anion exchange (AE)
	Effectiveness	• The AE and GAC adsorbent columns successfully removed the 14 PFAS in this study with an average removal efficiency 66% for the AE column and 62% for the GAC.

Reference: McCleaf, P., Englund, S., Östlund, A., Lindegren, K., Wiberg, K., & Ahrens, L. (2017). Removal efficiency of multiple poly- and perfluoroalkyl substances (PFASs) in drinking water using granular activated carbon (GAC) and anion exchange (AE) column tests. Water Res, 120, 77-87. https://doi.org/10.1016/j.watres.2017.04.057.		
		• The results indicate the selective nature of PFAS removal as the absorbents are loaded with PFAS and dissolved organic carbon (DOC). • A clear relationship between perfluorocarbon chain length and removal efficiency of PFAS using GAC and AE was found while PFAS with sulfonate functional groups displayed greater removal efficiency than those with carboxylate groups. • Similarly, time to column breakthrough increased with increasing perfluorocarbon chain length and was greater for the PFSAs than the PFCAs for both GAC and AE. • Shorter carbon chained PFAS such as PFBA, PFPeA, PFHxA showed desorption behavior and long-chained PFAS showed increased removal towards the end of the experiment indicating agglomeration or micelle development. • Linear isomers of PFOS, PFHxS, and perfluorooctane sulfonamide (FOSA) had greater column removal efficiencies using GAC (and also for AE at greater bed volume throughput) than the branched and this difference increased at greater bed volume throughputs. • The GAC and AE columns showed a poor correlation between DOC and PFAS removal efficiency.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	High performance liquid chromatography-mass spectrophotometry (HPLC-MS/MS)
	Limit of determination/ Limit of Reporting (LOR)	The method detection limits (MDLs) ranged between 0.05 and 0.86 ng/L.
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.42 McCleaf et al. (2023)

Reference: McCleaf, P., Stefansson, W., & Ahrens, L. (2023). Drinking water nanofiltration with concentrate foam fractionation—A novel approach for removal of per- and polyfluoroalkyl substances (PFAS). Water Research, 232, 119688. https://doi.org/https://doi.org/10.1016/j.watres.2023.119688		
	Uses	-

Reference: McCleaf, P., Stefansson, W., & Ahrens, L. (2023). Drinking water nanofiltration with concentrate foam fractionation—A novel approach for removal of per- and polyfluoroalkyl substances (PFAS). Water Research, 232, 119688. https://doi.org/https://doi.org/10.1016/j.watres.2023.119688		
General Description	Sources in drinking water	-
	Other	Semi-permeable membrane treatment processes such as reverse osmosis and nanofiltration (NF) have been shown effective at removing PFAS, however, disposal of PFAS laden concentrate is problematic. The present work examined a novel PFAS removal scheme for drinking water using NF filtration with treatment of the resulting NF concentrate via foam fractionation (FF) with and without co-surfactants.
Treatment of drinking water	Treatment technology	Nanofiltration (NF) (and treatment of PFAS laden concentrate with FF)
	Effectiveness	The novel combination of NF for drinking water treatment coupled with FF for concentrate treatment was able to reduce total detectable PFAS in the permeate from approximately 77 ng/L to approximately 1.4±0.4 and $\sum PFAS_4$ from 56 ng/L to 1.0 ±0.2 ng/L. The NF-pilot removed 98% of PFAS from AFFF contaminated groundwater producing permeate with 1.4 ng/L total PFAS. Using FF resulted in ∑PFAS removal efficiency of 90% from the NF concentrate and with improved removal of 94% with addition of cationic co-surfactant. Addition of the cationic cosurfactant to the FF process resulted in increased removal efficiency of the shorter chain PFAS, specifically 37% for PFPeA, 9% for PFHxA, and 34% for PFBS thus attaining 59%, 99% and 96% removal efficiency, respectively.
	Any special conditions?	-
	Other	Fortunately, reverse osmosis (RO) and nanofiltration (NF) have been shown effective at reducing PFAS concentrations by 90–99%. FF has been shown to be effective at removing PFAS from landfill leachate, wastewater, and contaminated groundwater. FF is not typically efficient unless applied on waters with higher concentrations of PFAS.
Measurement	Analytical method	Liquid chromatography – tandem mass spectrometry (LC-MS/MS)
	Limit of determination/ Limit of Reporting (LOR)	PFBS, PFHxS, PFOS and PFOA: 0.3 ng/L. GenX: not in analytical schedule.
	Other	-
Additional information	Any additional non-health related information	-

Reference: McCleaf, P., Stefansson, W., & Ahrens, L. (2023). Drinking water nanofiltration with concentrate foam fractionation—A novel approach for removal of per- and polyfluoroalkyl substances (PFAS). Water Research, 232, 119688. https://doi.org/https://doi.org/10.1016/j.watres.2023.119688		
	considered important?	

C.1.43 McNamara et al (2018)

Reference: McNamara, J. D., Franco, R., Mimna, R., & Zappa, L. (2018). Comparison of Activated Carbons for Removal of Perfluorinated Compounds From Drinking Water. Journal AWWA, 110(1), E2-E14. https://doi.org/https://doi.org/10.5942/jawwa.2018.110.0003		
General Description	Uses	These compounds, as well as the fluoropolymers made from them, have been used in stain-resistant fabrics, nonstick cookware, firefighting foams, and other applications.
	Sources in drinking water	Given their stability and solubility in water, PFCs have now become widely distributed throughout the environment, particularly in water systems.
	Other	This article describes the challenge of treating drinking waters contaminated by perfluorinated compounds, especially perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS).
Treatment of drinking water	Treatment technology	Granular activated carbons (GACs): bituminous coal-based re-agglomerated GAC and coconut-based direct activated GAC.
	Effectiveness	The effectiveness of GACs in removing PFOA and PFOS to nondetectable levels is demonstrated through the use of rapid small-scale column testing. Results demonstrate that bituminous coal-based re-agglomerated carbons provide considerably greater removal capacity of the targeted compounds compared with the coconut-based direct activated carbon. All four GACs tested performed better at removing PFOS than PFOA. Comparatively, the re-agglomerated bituminous coal-based carbons greatly outperformed the coconut-based carbons for removal of both PFOA and PFOS. Coconut-based GACs could not effectively remove PFCs for any reasonable treatment period. These GACs experienced rapid initial breakthrough and reached loading saturation much more quickly than the coal-based GACs.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-

Reference: McNamara, J. D., Franco, R., Mimna, R., & Zappa, L. (2018). Comparison of Activated Carbons for Removal of Perfluorinated Compounds From Drinking Water. Journal AWWA, 110(1), E2-E14. https://doi.org/https://doi.org/10.5942/jawwa.2018.110.0003		
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.44 Mohammadi et al. (2022)

Reference: Mohammadi, A., Dobaradaran, S., Schmidt, T. C., Malakootian, M., & Spitz, J. (2022). Emerging contaminants migration from pipes used in drinking water distribution systems: a review of the scientific literature. Environ Sci Pollut Res Int, 29(50), 75134-75160. https://doi.org/10.1007/s11356-022-23085-7		
General Description	Uses	They are widely utilized in cookware, paper products, surfactants, fire-fighting foams, and textiles. Furthermore, PFAS are applied in the aviation and automotive industries, electronics, and semiconductor production.
	Sources in drinking water	Migration of PFAS from pipes in to drinking water
	Other	This paper reviews, the reported occurrence migration of emerging contaminants (Ecs) from pipes into water distribution systems in the world.
Treatment of drinking water	Treatment technology	-
	Effectiveness	-
	Any special conditions?	-
	Other	-
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	Pipes type used had an important role on levels of Ecs migration in water during transport and storage of water. Based on the current knowledge, sources of PFAS in water distribution systems due to pipe types are not known yet.

C.1.45 Najm et al. (2021)

Reference: Najm, I., Gallagher, B., Vishwanath, N., Blute, N., Gorzalski, A., Feffer, A., & Richardson, S. (2021). Per- and polyfluoroalkyl substances removal with granular activated carbon and a specialty adsorbent: A case study. AWWA Water Science, 3(5), e1245. https://doi.org/https://doi.org/10.1002/aws2.1245		
General Description	Uses	They are found in many consumer and industrial products.
	Sources in drinking water	-
	Other	Three granular activated carbons (GACs) and a clay-based adsorbent, Fluoro-sorb® 200 (FS200), were tested using rapid small scale column tests (RSSCTs) to compare relative performance of the media for PFAS removal.
Treatment of drinking water	Treatment technology	Adsorbents: GAC and clay-based adsorbent.
	Effectiveness	FS200 effluent was below detection for all PFAS except PFHxA at 300,000 bed volumes (BVs). The three GACs performed similarly except for PFBS and PFHxA. FS200 showed higher BVs to breakthrough, required a significantly shorter empty bed contact time, and had higher hydraulic loading rate, translating into a smaller footprint than GAC.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	Minimum Reporting Limit (MRL) of 2 ng/L
	Other	The PFAS samples collected were stored at 4^{o}C until they were transported to a commercial laboratory for analysis. The RSSCT method was used to evaluate the BV to breakthrough of each adsorbent for all seven PFAS chemicals present in the source water, four of which (PFOS, PFHxS, PFBS, and PFNA) were present at concentrations ranging from 2.4 to 8.5 ng/L, while three (PFHpA, PFOA, and PFHxA) were present at estimated levels between the MDL of 0.39 ng/L and the MRL.
Additional information	Any additional non-health related information considered important?	-

C.1.46 Opoku-Duah and Johnson (2020)

Reference: Opoku-Duah, S., & Johnson, D. (2020). Removal of Perfluorooctanoic Acid and Microcystins from Drinking Water by Electrocoagulation. Journal of Chemistry, 2020, 1836264. https://doi.org/10.1155/2020/1836264		
General Description	Uses	-
	Sources in drinking water	-
	Other	In the present study, two innovative aspects of electrocoagulation techniques were tested, (a) cheap and easy-to-operate field-unit instead of hi-tech electrocoagulation and (b) reverse-polarity instead of conventional polarity, and applied to remove PFOA and microcystins from drinking water sources.
Treatment of drinking water	Treatment technology	Electrocoagulation techniques
	Effectiveness	The method presented here outperformed commercial activated-carbon filtration by nearly 40%. When the efficiency of electrocoagulation was examined in terms of voltage discharge, pH, and reverse polarity, the results averaged 80% decontamination for individual treatment, while their combined effects produced 100% detoxification in 10–40 minutes.
	Any special conditions?	-
	Other	Electrocoagulation reverse polarity (this study): 100%. Traditional electrocoagulation (Bao et al. [35]): 80–90%. 60Co c-irradiation: UV-A (Zhang et al. [40]): 100%. N-TiO_2 (Triantis et al. [41]): 100%. Activated carbon filtration (Meng et al. [18]): 70–80%.
Measurement	Analytical method	Tandem High Performance Liquid Chromatography-Mass Spectrometer (HPLC-MS)
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.47 Pan et al. (2016)

Reference: Pan, C. G., Liu, Y. S., & Ying, G. G. (2016). Perfluoroalkyl substances (PFASs) in wastewater treatment plants and drinking water treatment plants: Removal efficiency and exposure risk. Water Res, 106, 562-570. https://doi.org/10.1016/j.watres.2016.10.045		
General Description	Uses	Used in a wide range of industrial and commercial applications, including insecticide formulations, paper, textiles, fire retardants, pesticides, food packaging and other applications.
	Sources in drinking water	-
	Other	This study aimed to investigate the occurrence and removal efficiency of eighteen PFAS in wastewater treatment plants (WWTPs) and drinking water plants (DWTPs) with different treatment processes.
Treatment of drinking water	Treatment technology	Drinking water plants (DWTPs)
	Effectiveness	The results showed that both perfluorobutane sulfonic acid (PFBS) and perfluorooctane sulfonic acid (PFOS) were the predominantcompounds in the water phase of DWTPs. The average total PFAS concentrations in the two selected DWTPs were detected at 4.74 - 14.3 ng/L in the influent and 3.34 - 13.9 ng/L in the effluent. In DWTPs, only granular activated carbon (GAC) and powder activated carbon (PAC) showed significant removal of PFAS.
	Any special conditions?	-
	Other	In DWTPs, previous studies showed that coagulation, sand filtration, ozonation, chlorination, and ultraviolet (UV) irradiation are unlikely to be effective for PFAS removal). But granular activated carbon (GAC) and reverse osmosis (RO) can remove PFAS completely when GAC is new.
Measurement	Analytical method	Liquid chromatograph coupled to a Triple Quadrupole mass spectrometer under electrospray negative ionisation mode.
	Limit of determination/ Limit of Reporting (LOR)	
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.48 Park et al. (2021a)

Reference: Park, J., Noh, J. H., Yoon, S., Samiya, Choi, B., Kim, G.-B., Oh, H., & Maeng, S. K. (2021a). Removal of short- and long-chain perfluorinated compounds from surface water by coagulation. Membrane Water Treatment, 12, 187-194. https://doi.org/10.12989/mwt.2021.12.4.187		
General Description	Uses	Perfluorinated compounds (PFCs) are manufactured chemicals used in numerous industries to produce alkaline cleaners, paints, non-stick cookware coatings, textiles, soaps, shampoos, floor polishes, denture cleaners, fume suppressants, firefighting foams, semiconductors, packaging, and others.
	Sources in drinking water	-
	Other	In this study, we investigated the effect of coagulation on the removal of short- and long-chain PFCs.
Treatment of drinking water	Treatment technology	Coagulation
	Effectiveness	The PFCs mixture (C5–C10) resulted in a lower removal efficacy via coagulation treatment, and the average removals of selected PFCs were found to be below 5%. Only long-chain perfluorodecanoic acid (PFDA) (C10) and perfluorooctanesulfonic acid (PFOS) were significantly removed via coagulation. We concluded that coagulation was not effective in removing selected PFCs.
	Any special conditions?	-
	Other	Coagulation treatment process possibly mitigates PFC levels for the following granular activated carbon filters, often used in advanced drinking water treatment processes.
Measurement	Analytical method	Triple quadrupole LC/MS with a high-performance LC system run in negative ionization mode.
	Limit of determination/ Limit of Reporting (LOR)	Individual PFC concentrations were calculated based on calibration curves, with the method detection limit being below 0.5 ng/L.
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.49 Park et al. (2021b)

Reference: Park, Y.-G., Lee, W., & Kim, K. (2021). Different Adsorption Behavior between Perfluorohexane Sulfonate (PFHxS) and Perfluorooctanoic Acid (PFOA) on Granular Activated Carbon in Full-Scale Drinking Water Treatment Plants. Processes, 9, 571. https://doi.org/10.3390/pr9040571		
General Description	Uses	It has been widely used in industrial and commercial applications, such as cookware coatings, refrigerants, surfactants, polymers, pharmaceutical compounds, firefighting foams, paints, lubricants, adhesives, cosmetics, paper coatings, and insecticides.
	Sources in drinking water	-
	Other	In this study, the changes in PFC concentration were monitored and analysed in raw and final water of two large-scale water treatment plants for eight months. Additionally, the correlation of the GAC replacement cycle with the removal efficiency of PFHxS and PFOA was investigated in a total of 30 GAC basins of two drinking water treatment plants. The changes in their concentrations during each treatment process were investigated, including pre-ozonation, coagulation/flocculation, filtration, post-ozonation, and GAC adsorption.
Treatment of drinking water	Treatment technology	Granular activated carbon (GAC) adsorption (Coal-Based and coconut shell based).
	Effectiveness	Prior to GAC regeneration: The PFHxS concentration in the treated water for both DWTPs was higher than that in raw water, indicating that there would be a source of PFHxS in water treatment processes for both M1 and M2. In contrast, the water treatment processes in M1 and M2 removed PFOA at 43% and 37.8%, respectively. Post GAC regeneration: For both PFHxS and PFOA, the GAC operation for less than 6 months showed 100% removal of the compounds. At 3 years, PFHxS concentrations for each GAC basin for both M1 and M2 were significantly different up to 0.175 µg/L, which is 7.6 times higher than the raw intake water (i.e. 0.023 µg/L) for both M1 and M2. However, the PFOA concentrations were relatively consistent at 0.020 and 0.009 µg/L for M1 and M2, respectively, which were not significantly different from those of raw water. Thus, it was determined that a GAC replacement cycle of less than one year would improve the PFC removal efficiency, although the actual operation of the GAC regeneration and replacement cycle primarily depends on the receiving water characteristics of water utilities. GAC replacement will be required within less than one year if the PFC concentrations in raw water are high.
	Any special conditions?	-
	Other	The removal rate of these compounds by conventional water treatment processes is low.

Reference: Park, Y.-G., Lee, W., & Kim, K. (2021). Different Adsorption Behavior between Perfluorohexane Sulfonate (PFHxS) and Perfluorooctanoic Acid (PFOA) on Granular Activated Carbon in Full-Scale Drinking Water Treatment Plants. Processes, 9, 571. https://doi.org/10.3390/pr9040571		
		As reported in various studies, conventional water treatment methods, such as coagulation/flocculation/sedimentation, sand filtration, and oxidation, are not suitable for removing PFCs effectively. GAC, nanofiltration, reverse osmosis, and ion exchange, are significantly effective in managing these concentrations in the final product water of drinking water treatment plants (DWTPs). Considering the capital and operational costs of advanced methods, GAC has generally been used to remove PFCs in many DWTPs. GAC adsorption process has been used in drinking water treatment plants to maintain concentrations of PFCs, perfluorohexyl sulfonate (PFHxS), and perfluorooctanoic acid (PFOA), below 70 ng/L. However, it was found that these concentrations in the final product water in local water utilities unexpectedly increased because of inappropriate operation and maintenance methods of GAC, such as its inefficient regeneration and replacement cycle.
Measurement	Analytical method	Liquid chromatography-tandem mass spectrometry (LC-MS/MS) with multiple reaction monitoring (MRM) conditions
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.50 Pillai et al. (2022)

Reference: Pillai, S.D., Kowald, C., Lassalle, J., and Staack, D. (2022). Chapter 13. Remediation of Poly- and Perfluorinated Chemical Substances (PFAS) in the Environment by Ionizing Technology. Ionizing Radiation Technologies: Managing and Extracting Value from Wastes, First Edition. Published 2022 by John Wiley & Sons Ltd.		
General Description	Uses	-
	Sources in drinking water	-
	Other	-
Treatment of drinking water	Treatment technology	-
	Effectiveness	• eBeam technology: Technology summary

Reference: Pillai, S.D., Kowald, C., Lassalle, J., and Staack, D. (2022). Chapter 13. Remediation of Poly- and Perfluorinated Chemical Substances (PFAS) in the Environment by Ionizing Technology. Ionizing Radiation Technologies: Managing and Extracting Value from Wastes, First Edition. Published 2022 by John Wiley & Sons Ltd.		
		• In situ chemical oxidation (ISCO): Unlikely to degrade PFCs in groundwater. • Bioaugmentation using vault proteins: Novel in situ bioremediation technology: neither whole cells nor free enzymes could transform PFOA in laboratory studies. • Electrocatalytic technologies: In situ electrocatalytic and catalytic processes for PFAS remediation. • PFC-coagulant: In situ remediation by coagulation-enhanced sorption of PFAS. • In situ chemical reductive defluorination: Use of clay-encased zero-valent metals and bimetals. • Titanate nanotubes: Titanate nanotubes did not enhance PFOA decomposition as compared to direct UV photolysis. • Photochemical approaches: Direct photolysis was slow; H_2O_2 combined with UV-visible light irradiation was ineffective. • Electro-microfiltration: Demonstrated to remove ~ 70%–80% of PFOS/PFOA in industrial wastewater. • Photo reductive defluorination: UV (254 nm) at pH 9.0 and under anaerobic conditions achieved ~ 98% PFOA defluorination. • Sonochemical decomposition: Ultrasound (150 W; 40 kHz) combined with carbonate radicals and N2 saturated conditions. • Cobalt-60 γ irradiation: Mineralization of PFOA in aqueous solution. • Electron beam (eBeam) irradiation technology: eBeam achieved 100% PFOA defluorination in aqueous solution at 10 kilo-grays (kGy).
	Any special conditions?	-
	Other	-
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.51 Pontius (2019)

Reference: Pontius, F. (2019). Regulation of Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonic Acid (PFOS) in Drinking Water: A Comprehensive Review. Water, 11(10), 2003. https://www.mdpi.com/2073-4441/11/10/2003		
General Description	Uses	-
	Sources in drinking water	-
	Other	This review synthesizes current knowledge providing a publicly available, comprehensive point of reference for researchers, water utilities, industry, and regulatory agencies to better understand and address cross-cutting issues associated with regulation of PFOA and PFOS contamination of drinking water.
Treatment of drinking water	Treatment technology	Conventional treatment, Oxidation processes, Adsorption, Anion exchange, Membrane Processes
	Effectiveness	• Conventional treatment: Conventional coagulation, flocculation, sedimentation, and filtration are relatively ineffective for removing PFOA and PFOS. • Oxidation processes: Chlorine and ozone-based oxidation processes at a typical water treatment plant doses and contact times have not been effective of removing PFOA, PFOS, and other PFAS. • Adsorption: Granular activated carbon (GAC) adsorption is one of the few treatment processes demonstrating significant PFAS removal from water. Once the GAC in a column has been exhausted it must be replaced and disposed of or be reactivated and reused. GAC filters can be costly to operate and maintain. • Anion exchange: Studies have found anion exchange to be effective for removing PFOA, PFOS, and other PFAS. • Membrane Processes: RO is a proven technology for removing PFOA and PFOS, achieving up to >99% removal. NF also rejects PFOA and PFOS, with about 95% rejection achieved for PFAS with molecular weights >300 g/mol.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	Liquid-liquid extraction, ion-pair extraction, or solid-phase extraction followed by HPLC-MS/MS or GC/MS.
	Limit of determination/ Limit of Reporting (LOR)	Minimum Reporting Limit (MRL): HFPO-DA 4.3 ng/L, NEtFOSAA 4.8 ng/L, NMeFOSAA 4.3 ng/L, PFBS 6.3 ng/L, PFDA 3.3 ng/L, PFDoA 1.3 ng/L, PFHpA 0.63 ng/L, PFHxS 2.4 ng/L, PFHxA 1.7 ng/L, PFNA 0.83 ng/L, PFOS 2.7 ng/L, PFOA 0.82 ng/L, PFTA 1.2 ng/L, PFTrDA 0.53 ng/L, PFUnA 5.2 ng/L, 11Cl-PF3OUdS 1.5 ng/L, 9Cl-PF3ONS 1.8 ng/L, ADONA 0.55 ng/L.
	Other	-

Reference: Pontius, F. (2019). Regulation of Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonic Acid (PFOS) in Drinking Water: A Comprehensive Review. Water, 11(10), 2003. https://www.mdpi.com/2073-4441/11/10/2003		
Additional information	Any additional non-health related information considered important?	-

C.1.52 Ryu et al. (2021)

Reference: Ryu, H., Li, B., De Guise, S., McCutcheon, J., & Lei, Y. (2021). Recent progress in the detection of emerging contaminants PFASs. *J Hazard Mater*, *408*, 124437. https://doi.org/10.1016/j.jhazmat.2020.124437.		
General Description	Uses	The products containing PFAS include carpet protectant, non-stick cookware, fire- fighting foam, medical devices, and electronics.
	Sources in drinking water	-
	Other	The purpose of this review is to provide recent progress in alternative detection platforms relying on non-MS based techniques for PFAS analysis.
Treatment of drinking water	Treatment technology	-
	Effectiveness	-
	Any special conditions?	-
	Other	-
Measurement	Analytical method	Optical (fluorescence, absorbance, Raman scattering, resonance light scattering or refractive index, colorimetric) and electrochemical techniques (amperometry/voltammetry, potentiometry, impedimetric sensors, electrochemiluminescence and HPLC technique coupled with non-MS detectors.
	Limit of determination/ Limit of Reporting (LOR)	• Fluorescence: 4 – 11 ppb • Absorbance (bioassay): 2.5, 5 ppt • molecularly imprinted polymer (MIP): 65 ppq and 85 ppq of PFOS in serum and urine sample, respectively
	Other	In general, the gold standard for PFAS detection was chromatographic based techniques coupling with mass spectroscopy. Method 533, solid phase extraction (SPE) enabled liquid chromatography-tandem mass spectrometry (LC-MS/MS) that utilizes isotope Dilution Anion Exchange Solid Phase Extraction and MS/MS in Multiple Reaction Monitoring (MRM). In terms of real time and on-site monitoring application, this method was not suitable because it required expensive instrumentations, professional operators, and complicated and lengthy sample preparation.

Reference: Ryu, H., Li, B., De Guise, S., McCutcheon, J., & Lei, Y. (2021). Recent progress in the detection of emerging contaminants PFASs. *J Hazard Mater*, *408*, 124437. https://doi.org/10.1016/j.jhazmat.2020.124437.		
		The optical based detection techniques demonstrated the feasibility as alternative detection methods for PFAS detection owing to its superior accessibility, low cost as well as acceptable sensitivity. • novel lab-on-a-chip sensor for PFOS analysis • molecularly imprinted polymer (MIP):
Additional information	Any additional non-health related information considered important?	-

C.1.53 Sahu (2023)

Reference: Sahu, O. (2023). Remediation of perfluorooctanoic acid (PFOA) with nano ceramic clay: Synthesis, characterization, scale-up and regenerations. Environ Pollut, 322, 121241. https://doi.org/10.1016/j.envpol.2023.121241		
General Description	Uses	PFAS offers a wide range of industrial and commercial uses (fire-fighting foams, polymer additives, surfactants, and cleaning agents) due to its remarkable chemical and biological reliabilities.
	Sources in drinking water	-
	Other	In this research work, Perfluorooctanoic Acid was treated from drinking water sources with nano-ceramic clay.
Treatment of drinking water	Treatment technology	Nano ceramic clay
	Effectiveness	The outcomes of batch experiment confirm a maximum of 99.15% (1.18 mg/g) of PFOA reduction at 82 ± 12 nm ceramic clay particle size; 3.0 initial pH; 210 rpm agitation 1.2 mg/L PFOA concentration; 100 mg/L clay dosage. The experimental data is well fitted with kinetics, isotherms, and thermodynamics calculated data. In fixed bed, continuous column study 10 h treatment time, 10 cm of bed height, and 2 mL/min were adsorbed 99.99% of PFOA. Overall nano ceramic clay was found to potential adsorbent for Perfluorooctanoic acid removal.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	HPLC-MS/MS
	Limit of determination/ Limit of Reporting (LOR)	-

Reference: Sahu, O. (2023). Remediation of perfluorooctanoic acid (PFOA) with nano ceramic clay: Synthesis, characterization, scale-up and regenerations. Environ Pollut, 322, 121241. https://doi.org/10.1016/j.envpol.2023.121241		
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.54 Saleh et al. (2018)

Reference: Saleh, N., Khalid, A., Tian, Y., Ayres, C., Sabaraya, I., Pietari, J., Chowdhury, I., Apul, O., & Hanigan, D. (2018). Removal of poly- and per-fluoroalkyl substances from aqueous systems by nano-enabled water treatment technologies. Environmental Science: Water Research & Technology, 5. https://doi.org/10.1039/C8EW00621K		
General Description	Uses	Applications ranging from stain and water repellents to fire suppressants.
	Sources in drinking water	-
	Other	This perspective aims to present a critical review on reported PFAS removal/destruction techniques, provide molecular-level insights into possible removal/destruction pathways, and propose potential nano-enabled remediation options for these persistent contaminants.
Treatment of drinking water	Treatment technology	Nanomaterials using Electrochemical oxidation Photocatalytic decomposition, Reductive degradation, or Microwave enhanced Fenton process.
	Effectiveness	Electrochemical oxidation: • Carbon nanotube: PFOA 0.1 mg/L, >90%, 3 hours. • SnO_2–Sb/carbon aerogel: PFOA 100 mg/L, 91%, 5 hours. • Zr-doped nanocrystalline PbO2 (Zr–PbO_2): PFOA 20 mg/L, 81.8 % at pH 4.8 1.5 hours. • Nano-ZnO: 12 PFCs (0.03-6.37 mg/L, 39-66%, pH7 40m. • Ce-doped modified porous nanocrystalline PbO_2: PFBA, PFPeA, PFHxA, PFHpA, PFOA 100 mg/L, 49-95%, 1.5hr. Photocatalytic decomposition: • Nanoporous In_2O_3: PFOA 30mg/L 71%, 3 hours. • Titanate nanotubes: PFOA 50 mg/L, 55 to 91%. • Titanium dioxide with multiple wall carbon nanotubes (TiO_2-MWCNT): PFOA 30 mg/L, 100% in acid, 8 hours. • Graphene quantum dots (GQDs) attached to SiC nanoparticles (SiC/GQDs): PFOS 0.019mM, 88.5% at pH7 20 hours. • Nano-structured In_2O_3: PFOA 30 mg/L, ~100%, pH3.9 40-120m. • Transition-metal modified TiO_2 nanoparticle (Fe–TiO_2 and Cu–TiO_2): PFOA 50 mg/L, 91% pH 5, 12 hours.

Reference: Saleh, N., Khalid, A., Tian, Y., Ayres, C., Sabaraya, I., Pietari, J., Chowdhury, I., Apul, O., & Hanigan, D. (2018). Removal of poly- and per-fluoroalkyl substances from aqueous systems by nano-enabled water treatment technologies. Environmental Science: Water Research & Technology, 5. https://doi.org/10.1039/C8EW00621K		
		• Nanostructured gallium oxide (Ga_2O_3): PFOA 0.5 mg/L, ~100% pH 4.7 <1hour. • Noble metallic nanoparticle modified TiO_2 (M-TiO_2, M = Pt, Pd, Ag): PFOA 60 mg/L, 57.7 -100% pH3 7hours. • In_2O_3-graphene composite: PFOA 30 mg/L, 90% 3 hours. • BiOCl nanosheets: PFOA 0.02mM, ~100% pH 4.8 12 hours. • Platinum modified indium oxide nanorods (Pt/IONRs): PFOA 200 mg/L, 98% pH 1.85 – 5% pH 9.3 1 hour. • SiC/graphene: PFOA 0.12 mM, 40.5-58.5 pH7 8 hours. • CeO_2-doped indium oxide (CeO_2/In_2O_3): PFOA 100 mg/L, >90% pH 4.6, 1 hour. Reductive degradation: • Nanoscale zero-valent iron (nZVI): PFOA PFOS PFNA PFDA 0.2 mg/L, 38-96% pH3 1 hour. Microwave enhanced Fenton process • Pb-doped $BiFeO_3$ nanoparticles on reduced graphene oxide sheets (Pb–$BFeO_3$/rGO): PFOA 50 mg/L, ~90% pH5 1hour, 90°C.
	Any special conditions?	-
	Other	Remediation of PFAS contaminated water is generally achieved by physical removal processes of adsorption and membrane filtration.
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.55 Sim et al. (2021)

Reference: Sim, W., Choi, S., Choo, G., Yang, M., Park, J. H., & Oh, J. E. (2021). Organophosphate Flame Retardants and Perfluoroalkyl Substances in Drinking Water Treatment Plants from Korea: Occurrence and Human Exposure. Int J Environ Res Public Health, 18(5). https://doi.org/10.3390/ijerph18052645		
General Description	Uses	PFAS can offer resistance against water, oil, and soil owing to their structures with both hydrophobic and hydrophilic functional groups [5]. Therefore, they are used as surface

Reference: Sim, W., Choi, S., Choo, G., Yang, M., Park, J. H., & Oh, J. E. (2021). Organophosphate Flame Retardants and Perfluoroalkyl Substances in Drinking Water Treatment Plants from Korea: Occurrence and Human Exposure. Int J Environ Res Public Health, 18(5). https://doi.org/10.3390/ijerph18052645		
		protectors and surfactants of carpets, leathers, textiles, papers, and fire extinguishing agents.
	Sources in drinking water	These chemicals have often been detected in water resources because of their widespread use.
	Other	In this study, the concentrations of organophosphate flame retardants (OPFR) and perfluoroalkyl substances (PFAS) were investigated in raw water and treated water samples obtained from 18 drinking water treatment plants (DWTPs).
Treatment of drinking water	Treatment technology	Water Treatment Plant
	Effectiveness	The removal efficiencies of ∑27PFAS in the DWTPs ranged from −200% to 50%, with the ∑27PFAS concentrations in the raw water (4.15–154 ng/L; median 32.0 ng/L) being similar to or lower than those in the treated water (4.74–116 ng/L; median 42.2 ng/L). The dominant PFAS (perfluorooctanoic acid (PFOA) and perfluorohexanoic acid (PFHxA)) in the raw water samples were slightly different from those in the treated water samples (PFOA, L-perfluorohexane sulfonate (L-PFHxS), and PFHxA).
	Any special conditions?	-
	Other	PFAS were not effectively removed by ozonation and chlorination processes, whereas the GAC processes had high removal efficiencies for PFAS than those in the other water treatment processes [20,28,41]. However, the removal rates of PFAS may decrease because breakthrough is frequently caused by the low sorption capacity of PFAS in GAC processes [20,28]. Therefore, the PFAS removal rates in DWTPs have been reported to vary from negative to positive in several surveys, including in this study.
Measurement	Analytical method	High-performance liquid chromatography (HPLC) system coupled with an electrospray triple- quadruple mass spectrometer (ESI-MS-MS).
	Limit of determination/ Limit of Reporting (LOR)	The MDLs were defined as three times the standard deviation of the measured concentration in seven replicated water samples spiked target compounds, which ranged from 0.20–1.09 ng/L for PFAS.
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.56 Singh and Singh (2017)

Reference: Singh, R., & Singh, T. S. (2017). Resilient water treatment technologies and challenges for the removal of emerging contaminants – Perfluorinated compounds.		
General Description	Uses	-
	Sources in drinking water	-
	Other	This paper outlines major treatment technologies that can be incorporated in existing water infrastructure. Two major such technologies are adsorption (granulated and powdered activated carbon) and membrane filtration (reverse osmosis, nanofiltration etc.).
Treatment of drinking water	Treatment technology	adsorption (granulated and powdered activated carbon) and membrane filtration (reverse osmosis, nanofiltration etc.).
	Effectiveness	• Adsorption using activated carbon has proved to be effective in removing these perfluorinated compounds. • Presence of such GAC/PAC systems in existing drinking water treatment trains make these technologies more attractive. • New advances in carbon materials has further improved the removal efficiencies of PFOA and PFOS. • However, disposal of spent media (carbon) may pose a greater threat as incinerating such material requires energy. • To make such process energy efficient, more research is required to develop novel sorbents for PFOA and PFOS removal.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.57 Siriwardena et al. (2021)

Reference: Siriwardena, D. P., James, R., Dasu, K., Thorn, J., Iery, R. D., Pala, F., Schumitz, D., Eastwood, S., & Burkitt, N. (2021). Regeneration of per- and polyfluoroalkyl substance-laden granular activated carbon using a solvent based technology. J Environ Manage, 289, 112439. https://doi.org/10.1016/j.jenvman.2021.112439		
General Description	Uses	PFAS have been widely used globally for many applications such as lubricants, adhesives, stain and soil repellents, paper coatings, pharmaceuticals, insecticides, cosmetics, food packaging, and fire-fighting foams.
	Sources in drinking water	-
	Other	This research focused on development and demonstration of an effective GAC regeneration technology using a solvent-based method for PFAS-laden GAC used in water treatment.
Treatment of drinking water	Treatment technology	-
	Effectiveness	Based on column tests using laboratory-contaminated GAC with perfluorooctanoic acid (PFOA) and perfluorooctanoic sulfonate (PFOS), the solvent-base mix (SBM) of ethanol with 0.5% NH_4OH was found to be the optimum performing regenerant solution. The GAC life span assessment showed that solvent-regenerated GAC performed similar to virgin GAC without losing its optimal performance of PFAS sorption. Average percent removal in laboratory-contaminated GAC using the optimum solvent-base mix (SBM) was 65% and 93% for PFOS and PFOA, respectively. Percent removal from four field-spent GAC samples was found to be in range of 55%–68%.
	Any special conditions?	-
	Other	Most conventional remediation techniques are reportedly ineffective in destroying PFAS. Sorption by carbon is found to be an effective ex situ technique to remove various PFAS from water matrices. Challenges attributed to thermally reactivating PFAS-spent GAC have led to solvent regeneration of GAC being investigated as a possible alternative.
Measurement	Analytical method	Liquid chromatography tandem mass spectrometry (LC-MS/MS) in the multiple reaction monitoring (MRM) in negative electrospray mode and the analytes quantified using the isotope dilution method.
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information	-

Reference: Siriwardena, D. P., James, R., Dasu, K., Thorn, J., Iery, R. D., Pala, F., Schumitz, D., Eastwood, S., & Burkitt, N. (2021). Regeneration of per- and polyfluoroalkyl substance-laden granular activated carbon using a solvent based technology. J Environ Manage, 289, 112439. https://doi.org/10.1016/j.jenvman.2021.112439		
	considered important?	

C.1.58 Sorengard et al. 2020

Reference: Sörengård, M., Östblom, E., Köhler, S., & Ahrens, L. (2020). Adsorption behavior of per- and polyfluoralkyl substances (PFASs) to 44 inorganic and organic sorbents and use of dyes as proxies for PFAS sorption. Journal of Environmental Chemical Engineering, 8(3), 103744. https://doi.org/https://doi.org/10.1016/j.jece.2020.103744		
General Description	Uses	PFAS have been used in numerous consumer and industrial products, e.g. firefighting foams, electronics, clothing, cookware, and lubricants.
	Sources in drinking water	-
	Other	This study investigated the sorption behaviour of 17 PFAS of varying chain lengths and functional groups to 44 conventional and novel inorganic and organic sorbents with potential in treatment of PFAS-contaminated water or soil.
Treatment of drinking water	Treatment technology	Adsorbent materials were selected, covering organic sorbents such as activated carbon (AC) (5 replicas (n)), biochar (n = 5), sorbents with high organic content (n = 6), and organic waste products (n = 5), and inorganic sorbents such as soil minerals (n = 6), inorganic filter materials (n = 4), inorganic phosphorus filters (n = 5), and inorganic waste products (n = 2).
	Effectiveness	• PFAS sorbed best (mean > 99.9 %) to activated carbons (granulated and pulverized (n = 5)). • Sorption of PFAS to magnesium chloride-fortified biochar, Moringa seed, and pyrolytic carbon waste was 17- to 25-fold higher than to sand. • Sorption generally increased with increasing perfluorocarbon chain length and based as follows on functional group: fluorotelomer sulfonic acids (FTSAs) < perfluoroalkyl carboxylates (PFCAs) < perfluoroalkane sulfonates (PFSAs) < perfluorooctanesulfonamide (FOSA).
	Any special conditions?	-
	Other	-
Measurement	Analytical method	Ultra-high performance liquid chromatography (UHPLC) system coupled to a triple quadrupole mass spectrometer (MS/MS).
	Limit of determination/ Limit of Reporting (LOR)	The LOQ ranged from 0.01 to 1.0 ng/mL (10 – 1,000 ng/L). PFOS (0.1 ng/mL, 100 ng/L), PFHxS (0.05 ng/mL, 50 ng/L), PFBS (0.05 ng/mL, 50 ng/L), & PFOA (0.1 ng/mL, 100 ng/L).

Reference: Sörengård, M., Östblom, E., Köhler, S., & Ahrens, L. (2020). Adsorption behavior of per- and polyfluoralkyl substances (PFASs) to 44 inorganic and organic sorbents and use of dyes as proxies for PFAS sorption. Journal of Environmental Chemical Engineering, 8(3), 103744. https://doi.org/https://doi.org/10.1016/j.jece.2020.103744		
		GenX not included.
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.59 Soriano et al. (2023)

Reference: Soriano, A., Schaefer, C., & Urtiaga, A. (2020). Enhanced treatment of perfluoroalkyl acids in groundwater by membrane separation and electrochemical oxidation. Chemical Engineering Journal Advances, 4, 100042. https://doi.org/https://doi.org/10.1016/j.ceja.2020.100042		
General Description	Uses	-
	Sources in drinking water	Contamination of water bodies (e.g. surface water, groundwater) by AFFF has been associated with fire-training sites located in military bases and airports, or as a result of the extinction of catastrophic fires.
	Other	This work explores the treatment of poly- and perfluoroalkyl acids (PFAAs) in groundwater by coupling membrane separation and electrochemical oxidation (ELOX). In this work, we explore the integration of pressure-driven membrane processes with electrochemical oxidation for the treatment of PFAAs in concentrations relevant to AFFF-impacted groundwater. Initial testing focused on nanofiltration (NF) and reverse osmosis (RO) treatment of a perfluorinated carboxylic acid (PFCA) mixture, followed by ELOX of the PFCA concentrate (amended with perfluorooctane sulfonic acid (PFOS) and 6:2 FTSA) using BDD anodes, at several current densities.
Treatment of drinking water	Treatment technology	Membrane separation and electrochemical oxidation (ELOX).
	Effectiveness	For 99.9% PFAAs removal, the total specific cost of treatment was minimized using a cascade of four RO stages and ELOX treatment of the concentrate. • BW30 membrane (RO), PFCA rejection ranged from 84% to 95.9%. • The NF90 membrane provided lower rejections compared to the BW30 membrane, as maximum rejection in the NF90 membrane reached 88%. • Treatment of a mixture of perfluorocarboxylic acids, perfluorooctane sulfonic acid and 6:2 fluorotelomer sulfonic acid, the optimal integration of membrane preconcentration and BDD electrochemical oxidation enables mineralisation of long alkyl chain compounds (PFOA, PFOS and 6:2 FTSA) and their most recalcitrant

Reference: Soriano, A., Schaefer, C., & Urtiaga, A. (2020). Enhanced treatment of perfluoroalkyl acids in groundwater by membrane separation and electrochemical oxidation. Chemical Engineering Journal Advances, 4, 100042. https://doi.org/https://doi.org/10.1016/j.ceja.2020.100042		
		degradation products (PFHpA, PFHxA, PFPeA and PFBA), at a much lower energy consumption and total process costs than the electrochemical treatment alone. • the RO membrane studied in this work was preferred over the NF membrane.
	Any special conditions?	-
	Other	Conventional wastewater treatment methods have proven to be ineffective to remove PFAAs from impacted water bodies. Granular activated carbon (GAC), powder activated carbon (PAC) and anion exchange resins are the most extensively studied adsorbents for PFAA removal from water. However, adsorption techniques have several disadvantages, such as the decline of the sorption efficiency for short-chain PFAAs, their low regeneration efficiency, and when applicable, the generation of large amounts of waste organic solvents used as regenerants. Alternative attempts to regenerate anion exchange resins rely on the use of cosolvents, which provides additional complexity to the overall treatment process. Alternatively, the adsorption media must be incinerated at high temperatures (>1000 °C). A disadvantage of membrane processes is that the PFAAs retained in the concentrate typically require further treatment. The electrochemical oxidation (ELOX) of PFAAs has shown very promising results. Specifically, the use of ELOX by means of boron doped diamond (BDD) anodes can satisfactorily mineralize PFAAs, as well as PFAAs precursors, to CO2 and fluoride anions. However, widescale application of ELOX for treatment of PFAA-impacted waters remains challenging due to the associated high energy consumption and the high capital costs of BDD electrochemical cells.
Measurement	Analytical method	Liquid chromatography system coupled to a triple-quadrupole mass spectrometer with an electrospray ionization (ESI) interface operated in the negative ionisation mode.
	Limit of determination/ Limit of Reporting (LOR)	Values of LOQ for every PFAA are the following: PFBA (0.14 µg/L), PFPeA (0.44 µg/L), PFHxA (0.38 µg/L), PFHpA (0.43 µg/L), PFOA (0.04 µg/L), PFOS (0.44 µg/L), 6:2 FTSA (0.70 µg/L).
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.60 Sun et al. (2017)

Reference: Sun, M., Zhou, H., Xu, B., & Bao, J. (2018). Distribution of perfluorinated compounds in drinking water treatment plant and reductive degradation by UV/SO(3)(2-) process. Environ Sci Pollut Res Int, 25(8), 7443-7453. https://doi.org/10.1007/s11356-017-1024-9		
General Description	Uses	-
	Sources in drinking water	-
	Other	This study investigated the removal efficiency of five PFCs in a drinking water treatment plant.
Treatment of drinking water	Treatment technology	Flocculator, Sedimentation Tank, Sand filtration, Ozonation and activated carbon, Disinfection.
	Effectiveness	Among all of the treatment processes, coagulation sedimentation process had the highest removal ratio of PFCs (36.12%), and removal ratio was the least in the sand filtration process (13.28%). The ozonation/activated carbon and disinfection processes increased the concentration of PFCs. The degradation ratio and degradation rate of PFOA and PFOS increased upon addition of potassium dihydrogen phosphate buffer; the degradation ratio of PFOA was 90%, and pH increased by 0.16 in the absence of buffer. Likewise, the degradation ratio of PFOS was 50%, and pH increased by 0.22.
	Any special conditions?	-
	Other	In this study, we proposed a method using UV irradiation of SO32− at 365 nm to degrade PFCs. The SO32− concentration, pH, and initial concentration had profound impacts on the degradation of PFCs. During the degradation of PFCs, short-chain PFCs and hydrofluorinated carboxylic acid were generated. Conventional water treatment technologies, including physicochemical and biological processes, have been proven to be ineffective in the degradation of PFCs; generally, removal rates of these technologies are 5–20%.
Measurement	Analytical method	HPLC–MS in electrospray negative ionization mode
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.61 Sundaram and Pagilla (2019)

Reference: Sundaram, V., & Pagilla, K. (2020). Trace and bulk organics removal during ozone–biofiltration treatment for potable reuse applications. Water Environment Research, 92(3), 430-440. https://doi.org/https://doi.org/10.1002/wer.1202		
General Description	Uses	-
	Sources in drinking water	-
	Other	This study investigated impact of ozone/biological activated carbon (BAC) filtration design and operational parameters on contaminants of emerging concern and bulk organics removal over 450 days of operation.
Treatment of drinking water	Treatment technology	Ozone/biological activated carbon (BAC)
	Effectiveness	• Biofilter with lower empty bed contact time (EBCT) (10 min) and exhausted media resulted in poor removals of PFOA. • Biofilter with higher EBCT (20 min) and remaining adsorptive effects resulted in significant (84% or more). • Increasing both ozone dose and BAC EBCT resulted in increased removal of UV absorbance (UVA254).
	Any special conditions?	-
	Other	-
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.62 Tang et al. (2020)

Reference: Tang, J., Liu, Y., Su, P., Quan, J., Hu, Y., Wang, W., & Zhang, C. (2020). Removal of COD, NH4-N, and perfluorinated compounds from wastewater treatment plant effluent using ZnO-coated activated carbon. Water Science and Technology, 81(11), 2459-2470. https://doi.org/10.2166/wst.2020.308		
General Description	Uses	Perfluorinated compounds (PFCs) are a class of fluorine-containing chemicals that have been used worldwide in plastic, rubber, leather, and other consumer and industrial products.
	Sources in drinking water	-

Reference: Tang, J., Liu, Y., Su, P., Quan, J., Hu, Y., Wang, W., & Zhang, C. (2020). Removal of COD, NH4-N, and perfluorinated compounds from wastewater treatment plant effluent using ZnO-coated activated carbon. Water Science and Technology, 81(11), 2459-2470. https://doi.org/10.2166/wst.2020.308		
	Other	This study investigated the removal of chemical oxygen demand (COD), NH_4-N, and perfluorinated compounds (PFCs) in the effluent from a wastewater treatment plant (WWTP) using ZnO coated activated carbon (ZnO/AC).
Treatment of drinking water	Treatment technology	ZnO coated activated carbon (ZnO/AC).
	Effectiveness	The removal efficiencies of PFOA and PFOS reached 86.5% and 82.1%. In comparison, the removal efficiencies of PFBA, and PFBS were lower, at approximately 44.0%, and 55.4%, respectively. The saturated ZnO/AC was finally regenerated using ultrasound for 3 h and retained excellent performance, which proved it could be considered as an effective and alternative technology.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	HPLC coupled to electrospray ionization tandem mass spectrometry.
	Limit of determination/ Limit of Reporting (LOR)	PFBA (3.5 ng/L), PFBS, PFHxA, PFHpA (5ng/L), PFOA (2.1 ng/L), PFOS (0.9 ng/L), PFNA (3.2 ng/L), PFDA (6.9 ng/L)
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.63 Tang et al. (2022)

Reference: Tang, W., Meng, Y., Yang, B., He, D., Li, Y., Li, B., Shi, Z., & Zhao, C. (2022). Preparation of hollow-fiber nanofiltration membranes of high performance for effective removal of PFOA and high resistance to BSA fouling. J Environ Sci (China), 122, 14-24. https://doi.org/10.1016/j.jes.2021.10.004.		
General Description	Uses	PFOA with unique water and oil-repelling abilities was frequently added to various consumer and industrial products, including emulsifying agents, surface treatment agents, fire retardants, and food packaging, etc.
	Sources in drinking water	-
	Other	In this work, hydrophilic SiO_2 nanoparticles with various contents blended with carboxylic multiwalled carbon nanotube

Reference: Tang, W., Meng, Y., Yang, B., He, D., Li, Y., Li, B., Shi, Z., & Zhao, C. (2022). Preparation of hollow-fiber nanofiltration membranes of high performance for effective removal of PFOA and high resistance to BSA fouling. J Environ Sci (China), 122, 14-24. https://doi.org/10.1016/j.jes.2021.10.004.		
		were used to modify poly (m-phenylene isophthal amide) (SiO_2 /CMWCNT/PMIA) hollow fiber NF membrane.
Treatment of drinking water	Treatment technology	SiO_2 /CMWCNT/PMIA hollow fiber NF membrane
	Effectiveness	The modified membrane with 0.1 wt% SiO_2 doping exhibits way better fouling resistance with irreversible fouling ratio decreased dramatically from 18.7% to 2.3%, and the recovery rate of water flux increases significantly from 81.2% to 97.7%. The separation experiment results had confirmed that the modified membrane could improve the rejection from 97.2% to 98.6% for perfluorooctanoic acid (PFOA) and its combined pollution with bovine serum albumin (BSA).
	Any special conditions?	-
	Other	-
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.64 Teymourian et al. (2021)

Reference: Teymourian, T., Teymoorian, T., Kowsari, E., & Ramakrishna, S. (2021). A review of emerging PFAS contaminants: sources, fate, health risks, and a comprehensive assortment of recent sorbents for PFAS treatment by evaluating their mechanism. Research on Chemical Intermediates, 47(12), 4879-4914. https://doi.org/10.1007/s11164-021-04603-7		
General Description	Uses	Textiles and leather, Paper- and food-packaging, Cosmetic products, Household products, Electronic components and equipment, Fire-fighting foam.
	Sources in drinking water	--
	Other	Urban water cycles such as drinking water, surface water, groundwater, and wastewater have been faced with the occurrence of PFAS, and PFOS and PFOA are the most detected PFAS.
Treatment of drinking water	Treatment technology	Various methods have been applied to remove PFAS which are divided into two main categories: separation and destruction.

Reference: Teymourian, T., Teymoorian, T., Kowsari, E., & Ramakrishna, S. (2021). A review of emerging PFAS contaminants: sources, fate, health risks, and a comprehensive assortment of recent sorbents for PFAS treatment by evaluating their mechanism. Research on Chemical Intermediates, 47(12), 4879-4914. https://doi.org/10.1007/s11164-021-04603-7		
		• Coagulation-flocculation • Adsorption • Membrane filtration • Destruction technologies (photochemical and electrochemical oxidation, Sonochemical treatment, ultraviolet radiation, thermal treatment, and plasma treatment) Sorption is an eco-friendly and cost-effective technique with high efficacy that is commonly applied to eliminate PFAS from wastewater. Most important: powdered or granular activated carbons, carbon nanotubes, biochar, polysaccharide-based adsorbents, ion exchange resins, and minerals.
	Effectiveness	PFAS concentration is higher in the finished water in treatment plants in comparison to sources of raw water that are less impacted by wastewater discharge or are pristine. Regeneration or Recovery Percentage (%) for adsorbents • PACFs (Ethanol): ~85% PFOS • BAC (50% ethanol): ~60% PFOS • IRA67 Resin: ~70% PFOA • MWCNTs@MIPs: 85% PFOA • DFB-CDP: ~100 PFOA • PS-β-CDs: 100% PFOA, 100% PFHxA, 26% PFOS • HMB: 65% PFOA • Organic scavenger resin (A860): ~100% GenX • PMCAs: 85% PFOS, PFHxS, and FBuS • DMAPAA-Q Polymer: <95% GenX, PFBA, PFOA • CuMgFe-LDH: <85% PFOS • Fe3O4-CDI-IL MNPs: <95% PFOA, PFOS
	Any special conditions?	-
	Other	-
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

Reference: Teymourian, T., Teymoorian, T., Kowsari, E., & Ramakrishna, S. (2021). A review of emerging PFAS contaminants: sources, fate, health risks, and a comprehensive assortment of recent sorbents for PFAS treatment by evaluating their mechanism. Research on Chemical Intermediates, 47(12), 4879-4914. https://doi.org/10.1007/s11164-021-04603-7
DMAPAA-Q Polymer Poly (N-[3-(dimethylamino) propyl] acrylamide, methyl chloride quaternary, DMAPAA-Q) hydrogel matrix; CuMgFe-LDH Layered double hydrox-ide (LDH) with the metal composition of Cu (II) Mg (II) Fe (III); PS-β-CDs Surface-tethered β-cyclodextrins (β-CD content: 36%) on the surface of polystyrene; Fe3O4-CDI-IL MNPs β-cyclodextrin-ionic liquid polyurethane-modified magnetic; DFB-CDP β-Cyclodextrin polymer cross-linked with decafluorobiphenyl, MWCNTs@MIPs Molecularly imprinted polymer applying MWCNT as the supporting substance; DFB-CDP β-Cyclodextrin polymer cross-linked with decafluorobiphenyl; Permanently confined micelle arrays (PCMAs), Hierarchically microporous biochar (HMB); Polyacrylonitrile fiber-derived activated carbon fibers (PACFs)

C.1.65 Tian and Sun (2019)

Reference: Tian, Q., & Sun, M. (2019). Chapter 14 - Analysis of GenX and Other Per- and Polyfluoroalkyl Substances in Environmental Water Samples. In S. Ahuja (Ed.), Separation Science and Technology (Vol. 11, pp. 355-370). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-815730-5.00014-4		
General Description	Uses	Until the year 2000, long-chain PFAS, especially perfluoroalkyl carboxylic and sulfonic acids (PFCA and PFSA) were predominantly used in the production of fluoroplastics, firefighting foams, water/stain repellents, and commercial products treated with water/stain repellent coatings.
	Sources in drinking water	-
	Other	-
Treatment of drinking water	Treatment technology	-
	Effectiveness	-
	Any special conditions?	-
	Other	-
Measurement	Analytical method	High-resolution mass spectrometry (HRMS) - Ion trap, orbitrap, triple quadrupole, and time-of-flight MS have all been used in a large number of studies LC–MS and LC–MS/MS.
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.66 Wang et al. (2021a)

Reference: Wang, X., Chen, Z., Wang, Y., & Sun, W. (2021). A review on degradation of perfluorinated compounds based on ultraviolet advanced oxidation. Environmental Pollution, 291, 118014. https://doi.org/https://doi.org/10.1016/j.envpol.2021.118014		
General Description	Uses	Used in industrially manufactured products such as paints, fabrics, pigments, and foam fire extinguishers.
	Sources in drinking water	-
	Other	-
Treatment of drinking water	Treatment technology	Advanced oxidation processes (AOP) based on ultraviolet (UV) light.
	Effectiveness	Traditional processes, including coagulation, biological filtration, chlorination, ozonolysis, and ultraviolet light have ineffective removal efficiency on PFCs. However, advanced oxidation processes (AOP) based on ultraviolet (UV) light have good application prospects for the removal of PFCs. PFCs can be degraded by generating •OH, SO4•-, and other free radicals, and the degradation (defluorination) rate ranges from 5% (10%) to 100% (82%)
	Any special conditions?	-
	Other	By-products are observed following the advanced oxidation of PFCs (mainly short-chain perfluorocarboxylic acids containing 2 to 6 carbon atoms. PFHpA, PFHeA, PFPeA, PFBA, and PFPrA). Fluorotelomer sulfonate (6:2 FTS) acid and salt are an alternative product of PFOA or PFOS.
Measurement	Analytical method	Liquid chromatograph-ion trap mass spectrometry (LC- MS) in the full scan mode.
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.67 Wang et al. (2021b)

Reference: Wang, M., Orr, A. A., Jakubowski, J. M., Bird, K. E., Casey, C. M., Hearon, S. E., Tamamis, P., & Phillips, T. D. (2021b). Enhanced adsorption of per- and polyfluoroalkyl substances (PFAS) by edible, nutrient-amended montmorillonite clays. Water Res, 188, 116534. https://doi.org/10.1016/j.watres.2020.116534		
General Description	Uses	Extensively used in numerous consumer and industrial products, such as firefighting foams, stain preventives, electronics, clothing, cookware, and lubricants, due to their high thermal stability and water, dust and oil repellency.

Reference: Wang, M., Orr, A. A., Jakubowski, J. M., Bird, K. E., Casey, C. M., Hearon, S. E., Tamamis, P., & Phillips, T. D. (2021b). Enhanced adsorption of per- and polyfluoroalkyl substances (PFAS) by edible, nutrient-amended montmorillonite clays. Water Res, 188, 116534. https://doi.org/10.1016/j.watres.2020.116534		
	Sources in drinking water	
	Other	The overall objective of this study was to investigate the binding of 4 common PFAS to the active surfaces of carnitine- and choline-amended montmorillonite clays versus the parent clay.
Treatment of drinking water	Treatment technology	Edible sorbents: Montmorillonites amended with the common nutrients, carnitine and choline.
	Effectiveness	PFOA and PFOS had enhanced binding to amended clays compared to GenX and PFBS. The inclusion of edible, nutrient-amended clays with optimal affinity, capacity, and enthalpy can be used to decrease the bioavailability of PFAS from contaminated drinking water and diets. Using simulated conditions found in the stomach and intestine, amended montmorillonite clays showed high binding efficacy for PFOA, PFOS and a mixture of the two based on high binding percentage, capacity, affinity, correlation coefficient, enthalpy, and tightness.
	Any special conditions?	-
	Other	Powdered activated carbon (AC) has been shown to have the highest adsorption ability, and as early as 2005, the 3M company reported 99% removal of PFOS using AC.
Measurement	Analytical method	ultraperformance liquid chromatography/tandem mass spectrometer (LC/MS-MS) equipped with triple quadrupole. The mass spectrometer was used with an electrospray ionization interface (ESI) and operated in a negative ion mode. The mass spectrometer was operated under multiple reaction monitoring (MRM) mode.
	Limit of determination/ Limit of Reporting (LOR)	10 ppb (10 µg/L)
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.68 Wang et al. (2023a)

Reference: Wang, Z., Alinezhad, A., Sun, R., Xiao, F., & Pignatello, J. (2023a). Pre- and Postapplication Thermal Treatment Strategies for Sorption Enhancement and Reactivation of Biochars for Removal of Per- and Polyfluoroalkyl Substances from Water. ACS ES&T Engineering, 3. https://doi.org/10.1021/acsestengg.2c00271.		
General Description	Uses	-
	Sources in drinking water	-
	Other	The two most important properties of PCS, surface chemistry and pore structure, were tailored in this study to understand their importance in the sorption of various anionic shorter-chain and longer-chain PFAS. Brief thermal oxidation (post-pyrolysis air oxidation, PPAO) of PCS, including biochars, at a moderate temperature (400 ˚C) was used to increase specific surface area and nanoporosity.
Treatment of drinking water	Treatment technology	Pyrogenic carbonaceous sorbents (PCS)
	Effectiveness	• Modifications can improve the performance of biochars for sorption of PFAS from water. • Thermal oxidation in air, or PPAO, can open nanoscale pores of biochars that generally benefit longer-chain more than shorter-chain PFAS. • The sorption distribution ratio, KD, of individual PFAS after PPAO treatment increased by as much as three orders of magnitude compared to the unmodified PCS—more effectively so for longer-chain than shorter-chain compounds. • Coating with a quaternary ammonium cationic polymer, poly(dimethyldiallylammonium) chloride (pDADMAC)increased PFAS sorption by a factor of 10–3000 predominantly by an anion-exchange mechanism. • Sorption enhancement was more effective for the sulfonate than the carboxylate with the same perfluoro chain length. • After regenerating SW600-PPAO in air at 500 ˚C, it sorbed more PFAS than before regeneration.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	high performance liquid chromatography coupled with high-resolution mass spectrometry (LC-HRMS)
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-

Reference: Wang, Z., Alinezhad, A., Sun, R., Xiao, F., & Pignatello, J. (2023a). Pre- and Postapplication Thermal Treatment Strategies for Sorption Enhancement and Reactivation of Biochars for Removal of Per- and Polyfluoroalkyl Substances from Water. ACS ES&T Engineering, 3. https://doi.org/10.1021/acsestengg.2c00271.		
Additional information	Any additional non-health related information considered important?	-

C.1.69 Wang et al. (2023b)

Reference: Wang, Z., Alinezhad, A., Nason, S., Xiao, F., & Pignatello, J. J. (2023b). Enhancement of per- and polyfluoroalkyl substances removal from water by pyrogenic carbons: Tailoring carbon surface chemistry and pore properties. Water Research, 229, 119467. https://doi.org/https://doi.org/10.1016/j.watres.2022.119467		
General Description	Uses	-
	Sources in drinking water	-
	Other	Here, we report a strategy for employing biochar for PFAS removal that combines post-pyrolysis modification, which greatly improves performance, with a reactivation step that enables its reuse.
Treatment of drinking water	Treatment technology	Raw Biochars and Enhancement by PPAO. Thermal Reactivation of PFAS-Laden Biochars.
	Effectiveness	Sorption is greatly enhanced by PPAO treatment, by as much as 10^3. In cases where confident comparison was possible, sorption of PFAS with longer chains was more effectively enhanced by PPAO treatment than PFAS with shorter chains within each class.
	Any special conditions?	-
	Other	Commercial granular activated carbon (GAC) has been used for the sorptive removal of PFAS in practical applications. Biochar is a possible cheaper alternative to GAC for small-scale water treatment systems. A limitation of thermal reactivation is the generation of potentially hazardous volatile substances during treatment, which could include smaller nonpolar fluorinated compounds and reactive F species including HF.
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-

Reference: Wang, Z., Alinezhad, A., Nason, S., Xiao, F., & Pignatello, J. J. (2023b). Enhancement of per- and polyfluoroalkyl substances removal from water by pyrogenic carbons: Tailoring carbon surface chemistry and pore properties. Water Research, 229, 119467. https://doi.org/https://doi.org/10.1016/j.watres.2022.119467		
Additional information	Any additional non-health related information considered important?	-

C.1.70 Wagner et al. (2013)

Reference: Wagner, A., Raue, B., Brauch, H. J., Worch, E., & Lange, F. T. (2013). Determination of adsorbable organic fluorine from aqueous environmental samples by adsorption to polystyrene-divinylbenzene based activated carbon and combustion ion chromatography. J Chromatogr A, 1295, 82-89. https://doi.org/10.1016/j.chroma.2013.04.051		
General Description	Uses	-
	Sources in drinking water	The known raw and drinking water contaminations usually originate from local hot spots, such as application of fire-fighting foams, contaminated fertilizers or emissions from fluorochemical production sites.
	Other	While target compound analysis comprises a limited number of chemicals, a large number of unknown fluorinated chemicals of other compound classes, unknown precursors, transformation products, homologues, and isomers might be present at certain sites as well. The aim of this study was to develop an improved and validated protocol for the determination of the surrogate parameter adsorbable organic fluorine (AOF) from aqueous environmental samples this new method of analysis should be sensitive enough to measure the low expected organofluorine contents even in weakly contaminated samples, such as municipal wastewater treatment plant (WWTP) effluents, surface, ground-, and drinking waters.
Treatment of drinking water	Treatment technology	-
	Effectiveness	-
	Any special conditions?	-
	Other	-
Measurement	Analytical method	Combustion ion chromatography after solid phase extraction (SPE-CIC).
	Limit of determination/ Limit of Reporting (LOR)	The new developed AOF method is two orders of magnitude more sensitive than a former German draft standard.
	Other	The second positive feature of this method is the possibility to determine the surrogate parameter extractable organic fluorine (EOF) and individual PFC or other fluorinated target compounds from the same extracts of an aqueous sample,

Reference: Wagner, A., Raue, B., Brauch, H. J., Worch, E., & Lange, F. T. (2013). Determination of adsorbable organic fluorine from aqueous environmental samples by adsorption to polystyrene-divinylbenzene based activated carbon and combustion ion chromatography. J Chromatogr A, 1295, 82-89. https://doi.org/10.1016/j.chroma.2013.04.051		
		which allows fluorine mass balance calculations for the produced extracts.
Additional information	Any additional non-health related information considered important?	-

C.1.71 Xiao et al. (2017)

Reference: Xiao, X., Ulrich, B. A., Chen, B., & Higgins, C. P. (2017). Sorption of Poly- and Perfluoroalkyl Substances (PFASs) Relevant to Aqueous Film-Forming Foam (AFFF)-Impacted Groundwater by Biochars and Activated Carbon. Environ Sci Technol, 51(11), 6342-6351. https://doi.org/10.1021/acs.est.7b00970		
General Description	Uses	-
	Sources in drinking water	-
	Other	While these other PFAS may also be present in AFFF-impacted drinking water, their removal by conventional drinking water treatment is poorly understood. This study compared the removal of 30 PFAS, including 13 recently discovered PFAS, from an AFFF-impacted drinking water using carbonaceous sorbents (i.e. granular activated carbon, GAC).
Treatment of drinking water	Treatment technology	GAC
	Effectiveness	GAC systems for the treatment of AFFF-impacted sources of water for PFOA and PFOS likely achieve poor removal, when operated only for the treatment of PFOS and PFOA, of many unmonitored PFAS.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	Liquid chromatography tandem mass spectrometry (LC−MS/MS) and LC−quadrupole time-of-flight MS (LC-QToF-MS.
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information	-

Reference: Xiao, X., Ulrich, B. A., Chen, B., & Higgins, C. P. (2017). Sorption of Poly- and Perfluoroalkyl Substances (PFASs) Relevant to Aqueous Film-Forming Foam (AFFF)-Impacted Groundwater by Biochars and Activated Carbon. Environ Sci Technol, 51(11), 6342-6351. https://doi.org/10.1021/acs.est.7b00970		
	considered important?	

C.1.72 Xiao (2022)

Reference: Xiao, F. (2022). An Overview of the Formation of PFOA and PFOS in Drinking-Water and Wastewater Treatment Processes. Journal of Environmental Engineering, 148(4), 01822001. https://doi.org/doi:10.1061/(ASCE)EE.1943-7870.0001986		
General Description	Uses	-
	Sources in drinking water	Once released to the environment, PFAS distribute themselves among different environmental compartments, and are transported to drinking water sources.
	Other	The generation of PFOA and PFOS has also been observed in the drinking water disinfection processes. 18%–77% of the mass of PFCAs after disinfection was caused by the transformation of unidentified precursors in surface water (France) other than legacy precursor compounds such as 8:2 FTOH. In a survey of 15 US water treatment plants, Appleman et al. found that the concentration of PFOA and PFOS in water was consistently higher after chemical disinfection treatments. Similarly, negative removals of PFOA and PFOS in drinking water treatment processes have been reported in Japan, which was attributed to the transformation of precursor compounds.
Treatment of drinking water	Treatment technology	-
	Effectiveness	They are not readily removed by conventional drinking water treatment processes and are stable against physical and chemical degradation at circumneutral pH (6–9). GAC adsorption is a frequently used approach for treatment of PFAS-contaminated water at pilot- and full-scale operations. Some studies have shown that bituminous coal-based reagglomerated GAC is better than coconut-based direct GAC for removing anionic PFAS species (e.g. PFOA and PFOS) from water. Spent or exhausted GAC can be thermally reactivated or regenerated, where the carbon is heated with inert gases (e.g. N_2), CO_2, or steam. Heating PFAS-laden GAC at high temperatures (≥500°C) is highly effective for decomposition of PFAS, including PFOA and PFOS. However, at low temperature conditions (< 400°C), PFAS can transform to shorter-chained homologues or other PFAS species.
	Any special conditions?	High temperatures (≥500°C) for decomposition of PFAS on PFAS-laden GAC.

Reference: Xiao, F. (2022). An Overview of the Formation of PFOA and PFOS in Drinking-Water and Wastewater Treatment Processes. Journal of Environmental Engineering, 148(4), 01822001. https://doi.org/doi:10.1061/(ASCE)EE.1943-7870.0001986		
	Other	-
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.73 Yin et al. (2023)

Reference: Yin, S., López, J. F., Solís, J. J. C., Wong, M. S., & Villagrán, D. (2023). Enhanced adsorption of PFOA with nano MgAl2O4@CNTs: influence of pH and dosage, and environmental conditions. Journal of Hazardous Materials Advances, 9, 100252. https://doi.org/https://doi.org/10.1016/j.hazadv.2023.100252		
General Description	Uses	Per- and polyfluoroalkyl substances (PFAS) are a group of man- made chemicals that have been widely used in daily life, including uses in paints, food packaging, floor polishes, and firefighting foams.
	Sources in drinking water	-
	Other	Nano-$MgAl_2O_4$ modified carbon nanotubes (CNTs) were synthesized, characterized, and used as nanoadsorbents to remove ppb (μg/L)-levels of PFOA from drinking water and brackish groundwater.
Treatment of drinking water	Treatment technology	Modified carbon nanotubes (CNTs).
	Effectiveness	Composite nano-$MgAl_2O_4$ @CNTs remove over 99% of PFOA (100 ppb) from water in 3 hours, and completely (100%) in 3.5 hours. More complex water matrices, such as simulated brackish groundwater, slightly hinder PFOA adsorption under similar timescales, suggesting that interfering species can affect the adsorption process. Regeneration studies show that these composite nano-$MgAl_2O_4$@CNTs can be regenerated under thermolysis and be reused for more than four cycles with a drop in efficiency of less than 5%.
	Any special conditions?	The optimal pH range is under mild alkaline conditions (pH = 7.5-9.0).
	Other	Various PFOA removal technologies have been reported, including adsorption, advanced oxidation and reduction

Reference: Yin, S., López, J. F., Solís, J. J. C., Wong, M. S., & Villagrán, D. (2023). Enhanced adsorption of PFOA with nano MgAl2O4@CNTs: influence of pH and dosage, and environmental conditions. Journal of Hazardous Materials Advances, 9, 100252. https://doi.org/https://doi.org/10.1016/j.hazadv.2023.100252		
		(chemical, electro-, and photo- chemical), and biological remediation). Many current studies concerning PFAS adsorbents have limited relevance for in-field applications due to several issues. For instance, (a) reported adsorption studies are typically performed at unrealistically high levels of PFAS concentrations (usually in ppm or mg/L), which are far higher than the actual concentrations observed in-ground or drinking waters; (b) many reported materials have an optimal working pH range of 3-4, which does not apply to real water conditions; (c) most common adsorbents have long adsorption times ranging from 12 h to days. Therefore, materials that are better suited for real-life applications (i.e. those that are more efficient at low PFAS concentrations, those that can work in real water conditions (such as the pH 6.5-8.5), and those that have fast kinetics) are needed for in-field use.
Measurement	Analytical method	-
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.74 Yuan et al. (2022)

Reference: Yuan, J., Mortazavian, S., Passeport, E., & Hofmann, R. (2022). Evaluating perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) removal across granular activated carbon (GAC) filter-adsorbers in drinking water treatment plants. Sci Total Environ, 838(Pt 3), 156406. https://doi.org/10.1016/j.scitotenv.2022.156406		
General Description	Uses	
	Sources in drinking water	
	Other	To examine the removal of PFAS compounds across existing GAC filter adsorbers in several drinking water treatment plants, instead of simulating it using rapid small-scale column tests (RSSCTs).
Treatment of drinking water	Treatment technology	Granular activated carbon (GAC)

Reference: Yuan, J., Mortazavian, S., Passeport, E., & Hofmann, R. (2022). Evaluating perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) removal across granular activated carbon (GAC) filter-adsorbers in drinking water treatment plants. Sci Total Environ, 838(Pt 3), 156406. https://doi.org/10.1016/j.scitotenv.2022.156406		
	Effectiveness	It was observed that the GAC could achieve approximately 20% to 55% of PFOA and PFOS removal even after a long period of GAC operation (e.g. 6 years). In one location, there was evidence suggesting both removal and formation of PFOS and PFOA across the GAC, with the formation presumably due to the biotransformation of pre-existing precursors in the source water. GAC was harvested from six GAC filter-adsorbers in three drinking water treatment plants in Ontario, Canada, and evaluated for the removal of two representative legacy PFAS, PFOA and PFOS.
	Any special conditions?	-
	Other	Drinking water treatment plants that have installed GAC filter-adsorbers for other reasons, such as taste and odour control, or the removal of disinfection byproduct precursors or other micropollutants.
Measurement	Analytical method	Liquid chromatography-mass spectrometer (LCMS) with a Triple Quadrupole mass spectrometer system.
	Limit of determination/ Limit of Reporting (LOR)	The limits of quantification for both PFOA and PFOS were 2 ng/L.
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.75 Zaggia et al. (2016)

Reference: Zaggia, A., Conte, L., Falletti, L., Fant, M., & Chiorboli, A. (2016). Use of strong anion exchange resins for the removal of perfluoroalkylated substances from contaminated drinking water in batch and continuous pilot plants. Water Res, 91, 137-146. https://doi.org/10.1016/j.watres.2015.12.039		
General Description	Uses	In the last six decades these substances have been incorporated into a wide range of industrial and commercial products used in more than 200 applications: surfactants, medical applications, surface protecting agents, fire fighting foams, mist suppressor.
	Sources in drinking water	Widespread use, PFAS are ubiquitous micro pollutants found both in underground and surface water with concentration ranging from detection limits (<1 ng/L) to several tens of ng/L.
	Other	This work focuses on the application of three strong anion exchange resins (Purolite® A520E, A600E and A532E) for the

Reference: Zaggia, A., Conte, L., Falletti, L., Fant, M., & Chiorboli, A. (2016). Use of strong anion exchange resins for the removal of perfluoroalkylated substances from contaminated drinking water in batch and continuous pilot plants. Water Res, 91, 137-146. https://doi.org/10.1016/j.watres.2015.12.039		
		removal of traces of PFOA, PFOS, PFBA and PFBS (concentration of hundreds of ng/L) from drinking water. This technology is attractive for the possibility of reusing resins after an in situ regeneration step.
Treatment of drinking water	Treatment technology	Ion exchange resins
	Effectiveness	• Adsorption on GAC is poorly effective in removing traces of PFAS from groundwater. The extremely premature breakthrough of PFBA makes this emergency solution not practicable for routine applications. • A600E (non hydrophobic) and A520E (fairly hydrophobic) show a reduced sorption capacity compared to A532E (highly hydrophobic). • While A600E and A520E can be regenerated with solvent-less dilute solutions of non-toxic NH_4Cl and NH_4OH, A532E requires concentrated solutions of methanol or ethanol and 1% NH_4Cl and for the sake of this work it was regarded as non-regenerable. • The volume of regeneration effluents requiring incineration can be efficiently reduced by more than 96.5% by using reverse osmosis coupled with under-vacuum evaporation.
	Any special conditions?	-
	Other	Adsorption on granular activated carbon is an emergency measure which is poorly effective requiring frequent replacement.
Measurement	Analytical method	UPLC tandem quadrupole MS with MRM acquisition and electrospray ionization (ESI) operating in negative-ion mode.
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.76 Zeng et al. (2020)

Reference: Zeng, C., Atkinson, A., Sharma, N., Ashani, H., Hjelmstad, A., Venkatesh, K., & Westerhoff, P. (2020). Removing per- and polyfluoroalkyl substances from groundwaters using activated carbon and ion exchange resin packed columns. AWWA Water Science, 2(1), e1172. https://doi.org/https://doi.org/10.1002/aws2.1172		
General Description	Uses	Industrial processes and consumer products, including surfactants, surface-protecting agents, and processing aids to produce polymers.
	Sources in drinking water	-
	Other	In this study, rapid small-scale column tests (RSSCTs) were used to investigate the effects of PFAS type and chain length on adsorption by GAC and IX resin for six groundwaters used as drinking water supplies.
Treatment of drinking water	Treatment technology	Granular activated carbon (GAC) or ion exchange (IX) resin.
	Effectiveness	• Coal-based GACs had higher adsorption capacity compared with coconutshell-based GAC, which was likely due to higher mesopore and macropore volumes. • IX resins performed better than GAC in removing PFAS, but they were not effective in treating short-chain perfluorocarboxylic acids (PFCAs). • Perfluorosulfonic acids (PFSAs) broke through later than PFCAs with the same chain length. • Within PFSA or PFCA classes, shorter-chain PFAS species always broke through before longer-chain PFAS.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	Measured by a commercial laboratory.
	Limit of determination/ Limit of Reporting (LOR)	Method detection limit (MDL) of 2.0 ng/L.
	Other	Seven PFAS substances with chain lengths of C4–C9 were detected in the groundwaters with the sum of their concentrations (ΣPFAS) ranging from 156 to 7,044 ng/L.
Additional information	Any additional non-health related information considered important?	-

C.1.77 Zhang et al. (2021a)

Reference: Zhang, Z., Sarkar, D., Datta, R., & Deng, Y. (2021a). Adsorption of perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) by aluminum-based drinking water treatment residuals. Journal of Hazardous Materials Letters, 2, 100034. https://doi.org/https://doi.org/10.1016/j.hazl.2021.100034.		
General Description	Uses	PFAS have been widely and substantially applied to industrial and commercial manufacturing since the mid-20th century.
	Sources in drinking water	-
	Other	This study reports the removal of two representative PFAS species, perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), from water by adsorption using aluminium-based water treatment residuals (Al-WTR), a non-hazardous waste generated during the process of drinking water treatment by alum salts.
Treatment of drinking water	Treatment technology	The chemical or biochemical degradation of PFAS is exceptionally challenging due to their high stability. In contrast, adsorption provides a potentially promising remediation approach. Various adsorbent materials for immobilization of PFAS have been reported, such as alumina, boehmite, activated carbon, biochar, hematite, clays, resins, and kaolinite.
	Effectiveness	At pH 3.0 and an initial concentration of 1.0 mg/L, 97.4 % of PFOA and 99.5 % of PFOS were adsorbed onto Al-WTR. Desorption tests indicated that the adsorption by Al-WTR was irreversible. This paper reports for the first time, the rapid and effective adsorption of PFOA and PFOS by Al-WTR, a non-hazardous industrial solid waste.
	Any special conditions?	-
	Other	-
Measurement	Analytical method	Waters Quattro Ultima Mass Spectrometer at selected ion monitoring mode.
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.1.78 Zhang et al (2021b)

Reference: Zhang, K., Kujawski, D., Spurrell, C., Wang, D., Yan, J., & Crittenden, J. C. (2021). Extraction of PFOA from dilute wastewater using ionic liquids that are dissolved in N-octanol. J Hazard Mater, 404(Pt B), 124091. https://doi.org/10.1016/j.jhazmat.2020.124091.		
General Description	Uses	Fluorinated compounds are widely applied in semiconductor, polymer, and energy industry.
	Sources in drinking water	-
	Other	We design and develop an efficient liquid-liquid extraction method for PFOA separation from the diluted aqueous solution containing a ppm-level concentration of PFOA.
Treatment of drinking water	Treatment technology	Liquid phase extraction method using ionic liquid (IL): octanolmethyltrioctylammonium bis(trifluoromethylsulfonyl)imide ([A336] [NTf2] and hexadecyl trimethyl ammonium bromide (CTAB).
	Effectiveness	• CTAB as an extractant caused severe and stable emulsion. • [A336] [NTf2] could suppress the emulsification with high extraction efficiency. • The results showed that the extraction efficiency was strongly dependent on the concentration of IL and aqueous pH. • The extraction efficiency of PFOA from water could be up to 88.21 wt% for the optimized condition.
	Any special conditions?	The pH of the aqueous solution was found to be critical for the PFOA extraction.
	Other	• Liquid-liquid extraction processes can remove them from water; however, the hydrophobic and oleophobic properties of PFOA lead to the low extraction efficiency and severe emulsification, especially for the ppm-levels concentration of PFOA. • The traditional low-cost methods like coagulation–sedimentation and activated sludge process, are not effective enough in removing PFAS. • Ion exchange, granular activated carbon, and electrocoagulation are efficient for PFAS removal. However, they are costly and produce sludges that need further treatment.
Measurement	Analytical method	HPLC and electrospray ionization mass spectrometer (ESI-MS) n the negative ion detection modes.
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information	-

Reference: Zhang, K., Kujawski, D., Spurrell, C., Wang, D., Yan, J., & Crittenden, J. C. (2021). Extraction of PFOA from dilute wastewater using ionic liquids that are dissolved in N-octanol. J Hazard Mater, 404(Pt B), 124091. https://doi.org/10.1016/j.jhazmat.2020.124091.		
	considered important?	

C.1.79 Zhao et al. (2018)

Reference: Zhao, C., Hu, G., Hou, D., Yu, L., Zhao, Y., Wang, J., Cao, A., & Zhai, Y. (2018). Study on the effects of cations and anions on the removal of perfluorooctane sulphonate by nanofiltration membrane. Separation and Purification Technology, 202, 385-396. https://doi.org/https://doi.org/10.1016/j.seppur.2018.03.046		
General Description	Uses	-
	Sources in drinking water	-
	Other	In this study, a commercial NF membrane (ESNA1-K1) was utilized to separate PFOS compounds in the existence of three cations including Na^+, Ca^{2+} and Fe^{3+}, as well as three anions including Cl^-, SO_4^{2-} and PO_4^{3-}.
Treatment of drinking water	Treatment technology	Nanofiltration (NF) membrane
	Effectiveness	The PFOS rejection increased from 92.65% to 94.74%, 97.14%, and 97.94%, respectively, with 2 mM Na^+, Ca^{2+} and Fe^{3+}, respectively. As the concentrations of anions including SO_4^{2-} and PO_4^{3-} increased to 2 mM, the PFOS rejection increased to 94.74% and 97.60%, respectively.
	Any special conditions?	-
	Other	Nanofiltration is an effective method to remove organic contaminants and it is widely used in water treatment. The NF membrane could effectively remove trace amount of PFOS in drinking water comparing to traditional methods.
Measurement	Analytical method	Ultra-performance liquid chromatography coupled with tandem quadrupole mass spectrometry (UPLC-MS/MS).
	Limit of determination/ Limit of Reporting (LOR)	-
	Other	-
Additional information	Any additional non-health related information considered important?	-

C.2 Supporting Information for Fact Sheets – PFAS in Australian Drinking Water

C.2.1 QAEHS (2018a, 2018b)

Water Association Report Reference: QAEHS (2018a). Catchment and Drinking Water Quality Micro Pollutant Monitoring Program – Passive Sampling. Report 8 – Summer 2018. Queensland Alliance for Environmental Health Sciences (QAEHS). QAEHS (2018b). Catchment and Drinking Water Quality Micro Pollutant Monitoring Program – Passive Sampling. Report 9 – Winter 2018. Queensland Alliance for Environmental Health Sciences (QAEHS).		
General Information	Date of data extraction	22 August 2023
	Authors	Not stated.
	Publication date	Report 8 – Summer 2018 (Seqwater 2018) (37 sites) Report 9 – Winter 2018 (Seqwater 2018a) (3 sites)
	Publication type	Drinking Water Corporation report.
	Description	Per- and poly-fluoroalkyl substances (PFAS) accumulated in PE passive samplers across Leslie Harrison Dam (SEQ24, SEQ41 and SEQ42) and the range of mass accumulated over 28-30 days (ng/L).
	∑PFAS	24 – 37 ng/L
	PFOS Findings (1)	Australian Drinking Water Guideline (Health): 70 ng/L (PFOS + PFHxS) Summer Minimum detect: 0.06 ng/PE (~0.24 ng/L) (2) Summer Maximum detect: 1.1 ng/PE (~4.4 ng/L) (2) Summer detection rate: 73% (27 of 37 sites) Winter Minimum detect: 3.4 ng/L Winter Maximum detect: 5.9 ng/L Average (mean) values not reported (refer to figures)
	PFHxS Findings (1)	Australian Drinking Water Guideline (Health): 70 ng/L (PFOS + PFHxS) Summer Minimum detect: 0.06 ng/PE (~0.24 ng/L) (2) Summer Maximum detect: 0.74 ng/PE (~3 ng/L) (2) Summer detection rate: 41% (15 of 37 sites) Winter Minimum detect: 2.5 ng/L Winter Maximum detect: 4.6 ng/L Average (mean) values not reported (refer to figures)
	PFBS Findings (1)	Australian Drinking Water Guideline (Health): Not applicable Summer Minimum detect: 0.08 ng/PE (~0.32 ng/L) (2) Summer Maximum detect: 0.26 ng/PE (~1 ng/L) (2) Summer detection rate: 30% (11 of 37 sites) Winter Minimum detect: 1 ng/L Winter Maximum detect: 2.2 ng/L Average (mean) values not reported (refer to figures)

Water Association Report Reference: QAEHS (2018a). Catchment and Drinking Water Quality Micro Pollutant Monitoring Program – Passive Sampling. Report 8 – Summer 2018. Queensland Alliance for Environmental Health Sciences (QAEHS). QAEHS (2018b). Catchment and Drinking Water Quality Micro Pollutant Monitoring Program – Passive Sampling. Report 9 – Winter 2018. Queensland Alliance for Environmental Health Sciences (QAEHS).		
	PFOA Findings (1)	Australian Drinking Water Guideline (Health): 560 ng/L Summer Minimum detect: 0.05 ng/PE (~0.2 ng/L) (2) Summer Maximum detect: 0.77 ng/PE (~3 ng/L) (2) Summer detection rate: 76% (28 of 37 sites) Winter Minimum detect: 2.9 ng/L Winter Maximum detect: 4.6 ng/L Average (mean) values not reported (refer to figures)
	GenX Findings (1)	Australian Drinking Water Guideline (Health): Not applicable Winter Minimum detect: not reported Winter Maximum detect: not reported
(1) Summary data for raw water (2) Seqwater (2018) did not publish absolute values for PFAS in ng/L. Instead, they published values in ng/PE (with a PE being a sampler). Based on the axis and concentrations shown in Figure 13 (ng/PE) and Figure 14 (ng/L) of Seqwater (2018) it appears to SLR that concentrations for ng/L are higher than ng/PE by a factor of 4, i.e. ~4ng/L = 1ng/PE.		

C.2.2 Sydney Water 2023

Water Association Report Reference: Sydney Water (2023). PFAS and Drinking Water. Sydney Water. Last accessed on 06 September 2023 at this location: https://www.sydneywater.com.au/water-the-environment/how-we-manage-sydneys-water/safe-drinking-water/water-analysis/pfas-and-drinking-water.html		
General Information	Date of data extraction	22 August 2023
	Authors	Not stated.
	Publication date	2023
	Publication type	Drinking Water Corporation report.
	Description	The raw water inlet to North Richmond Water Filtration Plant (WFP) is about 13 kilometres upstream of where water draining from the Richmond RAAF Base enters the river. There were community concerns about the potential for PFAS from the RAAF Base to contaminate the drinking water.
	∑PFAS	24 – 37 ng/L
	PFOS Findings (1)	Australian Drinking Water Guideline (Health): 70 ng/L (PFOS + PFHxS) • 22–23 Jan 2019 (wet weather): High tide: 5.5 ng/L, Low tide: 5.7 ng/L • 18 Feb 2019: 3.6 • 5 March 2019: 4.3

Water Association Report Reference: Sydney Water (2023). PFAS and Drinking Water. Sydney Water. Last accessed on 06 September 2023 at this location: https://www.sydneywater.com.au/water-the-environment/how-we-manage-sydneys-water/safe-drinking-water/water-analysis/pfas-and-drinking-water.html		
		• 15 Mar 2019 – Wet weather #2: 1.9 • 19 Mar 2019 – Wet weather #3: 2.0 • 21 Mar 2019: 2.8 • 4 Apr 2019: 4.3 • 15 Apr 2019: 4.1 • 29 Apr 2019: 3.9 • Jan – Mar 2019: 1.9 – 4.3 (SLR summary) • 2011: 1.46-3.32
	PFHxS Findings (1)	Australian Drinking Water Guideline (Health): 70 ng/L (PFOS + PFHxS) • 22–23 Jan 2019 (wet weather): High tide: 4.2 ng/L, Low tide: 4.2 ng/L • 18 Feb 2019: 3.8 • 5 March 2019: 3.7 • 15 Mar 2019 – Wet weather #2: 2.5 • 19 Mar 2019 – Wet weather #3: 2.8 • 21 Mar 2019: 2.7 • 4 Apr 2019: 3.1 • 15 Apr 2019: 3.9 • 29 Apr 2019: 3.6 • Jan – Mar 2019: 2.5 – 4.2 (SLR summary) • 2011: 4.21 – 8.24
	PFBS Findings (1)	Australian Drinking Water Guideline (Health): Not applicable No data
	PFOA Findings (1)	Australian Drinking Water Guideline (Health): 560 ng/L • 22–23 Jan 2019 (wet weather): High tide: 3.6 ng/L, Low tide: 3.8 ng/L • 18 Feb 2019: 2.9 • 5 March 2019: 3.0 • 15 Mar 2019 – Wet weather #2: 1.9 • 19 Mar 2019 – Wet weather #3: 2.0 • 21 Mar 2019: 1.7 • 4 Apr 2019: 3.1 • 15 Apr 2019: 3.7 • 29 Apr 2019: 3.7 • Jan – Mar 2019: 1.7 – 3.8 (SLR summary) • 2011: 5.17 – 9.16
	GenX Findings (1)	Australian Drinking Water Guideline (Health): Not applicable No data

Water Association Report Reference: Sydney Water (2023). PFAS and Drinking Water. Sydney Water. Last accessed on 06 September 2023 at this location: https://www.sydneywater.com.au/water-the-environment/how-we-manage-sydneys-water/safe-drinking-water/water-analysis/pfas-and-drinking-water.html		
	Other	PFAS is a low risk to Sydney's drinking water supply. Sydney's drinking water complies with the Australian Drinking Water Guidelines and is safe to drink. Since 2015, we've been working with WaterNSW and NSW Health to review the risks from PFAS in the water it supplies. While the understanding of these chemicals is still developing, the risk to drinking water in Sydney is considered low.
(1) Summary data for raw water		

C.2.3 Water Corporation of Western Australia (undated)

Water Association Report Reference: WCWA (2023). Advice Article. PFAS & Esperance Town Water Supply Scheme. 2023. Water Corporation of Western Australia (WCWA). Last accessed online on 06 September 2023 at this location: https://www.watercorporation.com.au/Help-and-advice/Water-issues/Water-quality/Known-water-issues/PFAS-and-Esperance-Town-Water-Supply-Scheme#:~:text=The%20sample%20results%20show%20PFAS,supply%20is%20safe%20for%20use.		
General Information	Date of data extraction	22 August 2023
	Authors	Not stated.
	Publication date	Undated
	Publication type	Advice Article.
	Description	We have tested groundwater bores and sample points in the drinking water supply scheme in Esperance for per and poly-fluoroalkyl substances (PFAS) as part of a new targeted statewide monitoring program.
	PFOS + PFHxS	Australian Drinking Water Guideline (Health): 70 ng/L • Water Treatment Plant 1 – (Paine Road): <2 – 21ng/L • Hammersley Street Bore 2: 62 – 130 ng/L • Bore 3: 3 to 4 ng/L • Bore 4: < 2 ng/L • Bore 6: 2 – 4 ng/L • Bore 12: < 2 ng/L • Bore 15: <2 – 5 ng/L • Water Treatment Plant 2 (Thompson Street): <2 • Reticulation 1: <2 – 3 ng/L • Reticulation 2: <2 – 3 ng/L • Reticulation 3: <2 ng/L • Reticulation 4: <2 ng/L
	PFOS Findings (1)	Australian Drinking Water Guideline (Health): 70 ng/L (PFOS + PFHxS) • No individual data. See PFOS+PFHxS.

Water Association Report Reference: WCWA (2023). Advice Article. PFAS & Esperance Town Water Supply Scheme. 2023. Water Corporation of Western Australia (WCWA). Last accessed online on 06 September 2023 at this location: https://www.watercorporation.com.au/Help-and-advice/Water-issues/Water-quality/Known-water-issues/PFAS-and-Esperance-Town-Water-Supply-Scheme#:~:text=The%20sample%20results%20show%20PFAS,supply%20is%20safe%20for%20use.		
	PFHxS Findings (1)	Australian Drinking Water Guideline (Health): 70 ng/L (PFOS + PFHxS) • No individual data. See PFOS+PFHxS.
	PFBS Findings (1)	Australian Drinking Water Guideline (Health): Not applicable No data
	PFOA Findings (1)	Australian Drinking Water Guideline (Health): 560 ng/L • Water Treatment Plant 1 – (Paine Road): <1 – 1ng/L • Hammersley Street Bore 2: <1 – 5 ng/L • Bore 3: <1 to 1 ng/L • Bore 4: <1 ng/L • Bore 6: <1 – 2 ng/L • Bore 12: <1 ng/L • Bore 15: <1 ng/L • Water Treatment Plant 2 (Thompson Street): <1 • Reticulation 1: <1 ng/L • Reticulation 2: <1 ng/L • Reticulation 3: <1 ng/L • Reticulation 4: <1 ng/L
	GenX Findings (1)	Australian Drinking Water Guideline (Health): Not applicable No data
(1) Summary data for raw water		

C.2.4 Water Corporation of Western Australia (2019, 2020, 2021, 2022b)

Water Association Report Reference: WCWA (2019). Drinking Water Quality. Annual Report 2018-19. 2019. Water Corporation of Western Australia (WCWA). WCWA (2020). Drinking Water Quality. Annual Report 2019-20. 2020. Water Corporation of Western Australia (WCWA). WCWA (2021). Drinking Water Quality. Annual Report 2020-21. 2021. Water Corporation of Western Australia (WCWA). WCWA (2022b). Drinking Water Quality. Annual Report 2021-22. 2022. Water Corporation of Western Australia (WCWA).		
General Information	Date of data extraction	22 August 2023
	Authors	Not stated.
	Publication date	2019: Annual Report 2018-19 (WCWA 2019) 2020: Annual Report 2019 – 20 (WCWA 2020) 2021: Annual Report 2020 – 21 (WCWA 2021)

Water Association Report Reference: WCWA (2019). Drinking Water Quality. Annual Report 2018-19. 2019. Water Corporation of Western Australia (WCWA). WCWA (2020). Drinking Water Quality. Annual Report 2019-20. 2020. Water Corporation of Western Australia (WCWA). WCWA (2021). Drinking Water Quality. Annual Report 2020-21. 2021. Water Corporation of Western Australia (WCWA). WCWA (2022b). Drinking Water Quality. Annual Report 2021-22. 2022. Water Corporation of Western Australia (WCWA).		
		2022: Annual Report 2021 – 22 (WCWA 2022b)
	Publication type	Drinking Water Corporation Annual reports.
	Description	Water Corporation's 2021-22 Wastewater Quality Annual Report is a review of performance for the financial year ending 30 June 2022.
	PFOS Findings (1)	Australian Drinking Water Guideline (Health): 70 ng/L (PFOS + PFHxS) • 2018 – 19: PFOS + PFHxS = 90% of ADWG in one bore in Esperance. • 2019-20: PFOS + PFHxS = 90% of ADWG in one bore in Esperance • 2020 – 21: <50 ng/L (n = 1). • 2021-22: Not stated.
	PFHxS Findings (1)	Australian Drinking Water Guideline (Health): 70 ng/L (PFOS + PFHxS) No data
	PFBS Findings (1)	Australian Drinking Water Guideline (Health): Not applicable No data
	PFOA Findings (1)	Australian Drinking Water Guideline (Health): 560 ng/L • 2018 – 19: not stated. • 2019-20: not stated. • 2020 – 21: <50 ng/L (n = 1). • 2021-22: Not stated.
	GenX Findings (1)	Australian Drinking Water Guideline (Health): Not applicable No data
(1) Summary data for raw water		

Appendix D Existing Guidance/Gudeline Assessment Tables

Evidence Evaluations for Australian Drinking Water Guidelines Chemical Fact Sheets – PFOS, PFHxS, PFOA, PFBS, and GenX Chemicals

PFOS, PFHxS, PFOA, PFBS, and GenX Chemicals Technical Report

National Health and Medical Research Council

SLR Project No.: 640.V30693.20000

17 October 2024

D.1 Criteria for assessing existing guidance or guidelines

Administrative and technical criteria for assessing existing guidance or guidelines

Criteria have been colour-coded to assess minimum requirements as follows: 'Must have', 'Should have' or 'May have'

D.1.1 ATSDR 2021a

Agency Report Reference: *ATSDR (2021a). Toxicological Profile for Perfluoroalkyls. Released May 2021. Agency for Toxic Substances and Disease Registry (ATSDR).*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	Y	
	Are the administrative processes documented and publicly available?	Y	
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	Y	Yes, proposed minimal risk levels (MRLs) are reviewed by the Health Effects/MRL Workgroup within the Division of Toxicology and Human Health Sciences; an expert panel of external peer reviewers; the agency wide MRL Workgroup, with participation from other federal agencies, including EPA; and are submitted for public comment. Regarding potential conflicts of interest, this was not stated in the document reviewed. However, ATSDR (2021a) states that non-peer-reviewed studies considered relevant to the health effects of a substance undergo peer review by at least three ATSDR-selected experts who have been screened for conflict of interest. This statement suggests such screening may be commonplace for selection of experts to sit on the relevant committees.
	Are funding sources declared?	Y	Although funding sources are not declared in the tox profile, the profiles are produced by congressional mandate, indicating they are likely government-funded.

Criteria		Y/N/?/NA	Notes
	Was there public consultation on this work? If so, provide details.	Y	Yes, there were three previous drafts released for public comment in May 2009, August 2015, and June 2018.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	Y	Independent peer review panel provided comments. Scientists from the ATSDR have reviewed the peer reviewers' comments and determined which comments to include in the profile, with a brief explanation of the rationale for their exclusion; this exists as part of the administrative record.
	Was the guidance/advice developed or updated recently? Provide details.	Y	The profile reflects ATSDR's assessment of all relevant toxicologic testing and information that has been peer-reviewed through September 2018. New studies were added in 2019 following public comment, and NHANES data were updated.
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	Y	
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	Y	Yes, quality or shortcomings of individual studies is discussed in the text. However, for the meta-analysis underpinning guideline value development no attempt was made by ATSDR to weight selected studies for quality.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	N	ATSDR has recently begun incorporating systematic review methodology into profile development. However, it is unclear from the PFAS toxicity profile whether systematic or methodical review approaches have been utilised for production of this document.
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	NA	All cited literature in the profile bibliography appears to be publicly available.
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	Y	
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	NA	

Criteria		Y/N/?/NA	Notes
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	Y	
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	Y	
	Is it specified what date range the literature search covers? Is there a justification?	Y	
	Are search terms and/or search strings specified?	Y	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	N/A	
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	N	No information given regarding whether risk of bias assessment was undertaken for individual studies. However, the shortcomings of some studies (where identified by the authors) have been provided in the text.
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	Y	ATSDR summarises health endpoint information in the form of figures organised by route of exposure. This allows the reader to quickly assimilate the most sensitive health effects associated with PFAS exposure.
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	N	
	Derivation of health-based guideline values		

Criteria		Y/N/?/NA	Notes
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	NA	
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	N	Guidance documentation is not cited.
	What processes are used when expert judgement is required and applied? Is the process documented and published?	Y	ATSDR only derives MRLs if quantitative or qualitative information is available for all potential systemic, neurological and developmental effects. If insufficient data are judged to be available, an MRL is not derived (ATSDR 2018).
	Is dose response modelling (e.g. BMDL) routinely used?	Y	
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	Y	ATSDR only derives MRLs for non-cancer health endpoints.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	NA	

Summary:

Total # of 'Must-Have' criteria met (or not applicable): 18/20 = 90%

Total # of 'Should-Have' criteria met (or not applicable): 8/10 = 80%

Total # of 'May-Have' criteria met (or not applicable): 2/2 = 100%

Criteria	Y/N/?/NA	Notes
References: ATSDR (2018). DRAFT guidance on the preparation of toxicological profiles. Agency for Toxic Substances and Disease Registry. April 2018. https://www.atsdr.cdc.gov/toxprofiles/guidance/profile_development_guidance.pdf		

D.1.2 EFSA 2020a

Agency Report Reference: *EFSA (2020). Risk to human health related to the presence of perfluoroalkyl substances in food. Adopted: 9 July 2020. European Food Safety Authority (EFSA)*

	Criteria	Y/N/?/NA	Notes
	Overall guidance/advice development process		
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	Y	
	Are the administrative processes documented and publicly available?	Y	
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	Y	
	Are funding sources declared?	Y	Although funding sources are not declared in the report, EFSA is funded by the European Union that operates independently of the European legislative and executive institutions and EU Member states.
	Was there public consultation on this work? If so, provide details.	Y	Yes, the draft opinion was open for public consultation from 24 February until 20 April 2020 (https://www.efsa.europa.eu/en/consultations/call/public-consultation-draft-scientific-opinion-risks-human-health)

Criteria		Y/N/?/NA	Notes
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	?	Not stated in document, however in 2007 a proposal document was published for various levels of peer review (EFSA 2007). This indicates the document was likely peer reviewed.
	Was the guidance/advice developed or updated recently? Provide details.	Y	A previous opinion was drafted and released in 2018 where two TWIs were set, one for PFOS and one for PFOA. In the new opinion, the CONTAM Panel reassessed the two TWIs and applied EFSA's 'MixTox' guidance, published in 2019 to assess combined exposure to multiple chemicals. This resulted in a single group TWI being set for PFOA, PFNA, PFHxS and PFOS. The 2018 opinion based its TWIs on increased cholesterol as the critical effect for adults due to its link to cardiovascular disease. However, new data about the effects of PFAS in animals and humans have become available and new scientific studies were published which question the direct link between exposure to PFAS and increased cholesterol.
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	Y	The document provides information on these aspects in a general sense.
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	?	Unclear. The EFSA publication does not provide information on this aspect.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	N	Potentially for specific purposes, but this does not appear to have been undertaken for this review.
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	Y	Unpublished information is described.
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	½	Although a statement is made that selection of scientific papers for inclusion or exclusion was based on consideration of the extent to which the study was relevant to the assessment and general study quality considerations, details of inclusion/exclusion criteria are not provided in the publication.

Criteria		Y/N/?/NA	Notes
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	NA	
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	Y	
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	Y	Yes, Web of Science and PubMed as well as government reviews.
	Is it specified what date range the literature search covers? Is there a justification?	Y	
	Are search terms and/or search strings specified?	Y	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	N/A	
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	N	No information given regarding whether risk of bias assessment was undertaken for individual studies.
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	N	

Criteria		Y/N/?/NA	Notes
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	N	
	Derivation of health-based guideline values		
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	NA	
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	N	Guidance documentation is not cited.
	What processes are used when expert judgement is required and applied? Is the process documented and published?	½	Unclear from the documentation consulted. However, the Panels consist of a group of experts which discuss and agree on the contents of the reports.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	Y	Yes (EFSA 2012). Until 2005, the advice given by EFSA was to reduce exposures to such substances to a level that is as low as reasonably achievable (ALARA principle). Since then, EFSA has employed a margin of exposure (MOE) approach using a BMDL10 for cancer incidence in animals or humans. However this was not undertaken for PFAS due to the available studies providing insufficient support for carcinogenicity of PFOS and PFOA in humans.

Criteria		Y/N/?/NA	Notes
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	NA	
Summary: Total # of 'Must-Have' criteria met (or not applicable): 16.5/20 = 82.5% Total # of 'Should-Have' criteria met (or not applicable): 5.5/10 = 55% Total # of 'May-Have' criteria met (or not applicable): 2/2 = 100%			
References: EFSA (2007). Scientific advice by the Scientific Committee (Question No EFSA-Q-2007-060) adopted by written procedure on 3 August 2007. Proposal for a review system for EFSA's scientific activities. European Food Safety Authority. The EFSA Journal 2007. 526: 1-15. EFSA (2012). Scientific opinion. Statement on the applicability of the Margin of Exposure approach for the safety assessment of impurities which are both genotoxic and carcinogenic in substances added to food/feed. EFSA Scientific Committee, European Food Safety Authority. The EFSA Journal 2012. 10(3): 2578.			

D.1.3 FSANZ 2017b

Agency Report Reference: *FSANZ (2017). Hazard assessment report – Perfluorooctane Sulfonate (PFOS), Perfluorooctanoic Acid (PFOA), Perfluorohexane Sulfonate (PFHxS). Food Standards Australia New Zealand (FSANZ)*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	Y	
	Are the administrative processes documented and publicly available?	Y	

Criteria		Y/N/?/NA	Notes
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	?	Unclear from the report.
	Are funding sources declared?	Y	Funded / commissioned by the Commonwealth Department of Health.
	Was there public consultation on this work? If so, provide details.	?	No, does not appear to have been undertaken from the information in the report or on the FSANZ website.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	?	Not stated in document.
	Was the guidance/advice developed or updated recently? Provide details.	NA	
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	Y	The document provides information on these aspects in a general sense.
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	?	Unclear. The publication does not provide information on this aspect.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	Y	It appears data has been based on a previous systematic review, and literature searches updated to identify additional sources.
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	Y	Unpublished information is described.
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	Y	Inclusion / exclusion criteria were as per the systematic reviews that FSANZ (2017b) decided to update (i.e. Johnson et al. 2014, Bach et al. 2015 as cited in FSANZ 2017b).
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	Y	FSANZ (2017b) has used other systematic reviews and updated the information from those using the same criteria. Risk of bias was undertaken for systematic reviews and overall confidence in the reviews assessed.

Criteria		Y/N/?/NA	Notes
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	Y	
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	Y	
	Is it specified what date range the literature search covers? Is there a justification?	Y	
	Are search terms and/or search strings specified?	Y	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	N/A	
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	Y	Risk of bias assessment was undertaken for the systematic reviews and for studies added to the meta-analyses.
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	Y	Meta-analyses of effects were undertaken where possible, selecting studies that would not lead to multiple inclusions of the same results in its consideration.
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	Y	Yes, in an informal sense by looking at the weight of evidence and examining the meta-analyses and potential influencing factors on the overall conclusion.
	Derivation of health-based guideline values		

Criteria		Y/N/?/NA	Notes
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	NA	
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	N	Guidance documentation is not cited.
	What processes are used when expert judgement is required and applied? Is the process documented and published?	½	Unclear from the documentation consulted. However, the authors consist of a group of experts which discuss and agree on the contents of the reports.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	Yes where possible, but not necessarily for the endpoint investigated.
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	Y	As per Australian risk assessment guidance on genotoxic carcinogens. However this was not undertaken for PFAS due to the available studies providing insufficient support for carcinogenicity of PFOS and PFOA in humans.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	NA	

Summary:

Total # of 'Must-Have' criteria met (or not applicable): 18/20 = 90%

Total # of 'Should-Have' criteria met (or not applicable): 6.5/10 = 65%

Total # of 'May-Have' criteria met (or not applicable): 2/2 = 100%

D.1.4 HC 2018a

Agency Report Reference: *HC (2018a). Guidelines for Canadian Drinking Water Quality Guideline Technical Document Perfluorooctane Sulfonate (PFOS). December 2018. Health Canada (HC). Government of Canada.*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	Y	
	Are the administrative processes documented and publicly available?	?	Unclear / could not be readily located.
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	?	Unclear from the report.
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Canadian Government.
	Was there public consultation on this work? If so, provide details.	?	Unclear from the report or website.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	?	Not stated in document.
	Was the guidance/advice developed or updated recently? Provide details.	NA	
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	Y	The document provides information on these aspects in a general sense.
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	?	Unclear. The publication does not provide information on this aspect.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	N	Previous systematic reviews are cited, but there is no indication in the report that systematic review methods have been followed to undertake the review.

Criteria		Y/N/?/NA	Notes
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	NA	Only one mention of an unpublished study, and the results are briefly stated (no detailed description provided).
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	N	No mention of inclusion / exclusion criteria.
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	½	Other agencies are cited as sources of information, but the process for critically assessing the findings is not described.
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	½	Databases are not specified but all references are provided in a bibliographical list in the report.
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	?	No details on literature search provided.
	Is it specified what date range the literature search covers? Is there a justification?	N	
	Are search terms and/or search strings specified?	N	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	N/A	
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	½	Risk of bias assessment was discussed in the text of the report, but not in a formal manner.

Criteria		Y/N/?/NA	Notes
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	N	
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	½	Yes, in an informal sense by looking at the weight of evidence and examining the potential influencing factors on the overall conclusion.
	Derivation of health-based guideline values		
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	NA	
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	Y	Mode of action (MOA) analysis was considered for effects occurring at the lowest PFOS levels (i.e. immune effects in mice, lipid effects in monkeys and mice, liver weight increase in rats and mice, liver histological changes in rats, hepatocellular tumours in rats, and thyroid hormone changes in monkeys, rats, and mice). Based on the MOA analysis, no endpoints were considered to be irrelevant to humans.
	What processes are used when expert judgement is required and applied? Is the process documented and published?	½	Unclear from the documentation consulted. However, the authors consist of a group of experts which discuss and agree on the contents of the reports.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	Yes where possible, but not necessarily for the endpoint investigated.

Criteria		Y/N/?/NA	Notes
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	Y	Cancer risk for genotoxic carcinogens done using linear low-dose extrapolation. However, this was not undertaken for PFOS as the weight of evidence indicates it is not a genotoxic compound.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	NA	
Summary: Total # of 'Must-Have' criteria met (or not applicable): 11.5/20 = 58% Total # of 'Should-Have' criteria met (or not applicable): 5/10 = 50% Total # of 'May-Have' criteria met (or not applicable): 2/2 = 100%			

D.1.5 MDH 2020a

Agency Report Reference: *MDH (2020a). Toxicological Summary for: Perfluorooctane sulfonate. August 2020. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH)*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	Y	
	Are the administrative processes documented and publicly available?	?	Unclear / could not be readily located.
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	?	Unclear from the report.
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Government of Minnesota.

Criteria		Y/N/?/NA	Notes
	Was there public consultation on this work? If so, provide details.	?	Unclear from the report or website.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	?	Not stated in document.
	Was the guidance/advice developed or updated recently? Provide details.	Y	MDH (2023) released additional guidance on application of the hazard index approach based on proposed MCLs from US EPA. EPA will collect public comments on the MCLs and consider revisions before they are finalised into a new federal drinking water rule in late 2023 or early 2024. The rule may require changes in the way that certain drinking water supplies in Minnesota are managed to address PFAS.
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	N	
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	?	Unclear. The publication does not provide information on this aspect.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	N	There is no indication in the report that systematic review methods have been followed to undertake the review.
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	NA	No mention of unpublished studies.
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	N	No mention of inclusion / exclusion criteria.
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	½	Other agencies are cited as sources of information, but the process for critically assessing the findings is not described.
	Can grey literature such as government reports and policy documents be included?	Y	

Criteria		Y/N/?/NA	Notes
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	½	Databases are not specified but all references are provided in a bibliographical list in the report.
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	?	No details on literature search provided.
	Is it specified what date range the literature search covers? Is there a justification?	N	
	Are search terms and/or search strings specified?	N	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	N/A	
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	N	No mention of risk of bias.
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	N	
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	½	Yes, in an informal sense by looking at the weight of evidence and examining the potential influencing factors on the overall conclusion.
	Derivation of health-based guideline values		
	Is there justification for the choice of uncertainty and safety factors?	Y	

Criteria		Y/N/?/NA	Notes
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	½	Although mathematical workings are clearly documented for derivation of the RfD, derivation of the DWG is not as clearly articulated as it was done using toxicokinetic modelling and limited details are supplied.
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	Y	Limit of reporting is taken into consideration.
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	?	Unclear from the documentation reviewed.
	What processes are used when expert judgement is required and applied? Is the process documented and published?	?	Unclear from the documentation consulted.
	Is dose response modelling (e.g. BMDL) routinely used?	?	Unclear from the documentation consulted.
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	Y	Cancer risk estimated using linear low-dose extrapolation. However, this was not undertaken for PFOS; it simply stated cancer health-based value is not available.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	NA	

Summary:

Total # of 'Must-Have' criteria met (or not applicable): 8.5/20 = 42.5%

Total # of 'Should-Have' criteria met (or not applicable): 3.5/10 = 35%

Total # of 'May-Have' criteria met (or not applicable): ½ = 50%

D.1.6 HC 2018a

Agency Report Reference: *HC (2018a). Guidelines for Canadian Drinking Water Quality Guideline Technical Document Perfluorooctane Sulfonate (PFOS). December 2018. Health Canada (HC). Government of Canada.*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	Y	
	Are the administrative processes documented and publicly available?	?	Unclear / could not be readily located.
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	?	Unclear from the report.
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Canadian Government.
	Was there public consultation on this work? If so, provide details.	?	Unclear from the report or website.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	?	Not stated in document.
	Was the guidance/advice developed or updated recently? Provide details.	NA	
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	Y	The document provides information on these aspects in a general sense.
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	?	Unclear. The publication does not provide information on this aspect.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	N	Previous systematic reviews are cited, but there is no indication in the report that systematic review methods have been followed to undertake the review.

Criteria		Y/N/?/NA	Notes
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	NA	Only one mention of an unpublished study, and the results are briefly stated (no detailed description provided).
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	N	No mention of inclusion / exclusion criteria.
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	½	Other agencies are cited as sources of information, but the process for critically assessing the findings is not described.
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	½	Databases are not specified but all references are provided in a bibliographical list in the report.
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	?	No details on literature search provided.
	Is it specified what date range the literature search covers? Is there a justification?	N	
	Are search terms and/or search strings specified?	N	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	N/A	
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	½	Risk of bias assessment was discussed in the text of the report, but not in a formal manner.

Criteria		Y/N/?/NA	Notes
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	N	
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	½	Yes, in an informal sense by looking at the weight of evidence and examining the potential influencing factors on the overall conclusion.
	Derivation of health-based guideline values		
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	NA	
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	Y	Mode of action (MOA) analysis was considered for effects occurring at the lowest PFOS levels (i.e. immune effects in mice, lipid effects in monkeys and mice, liver weight increase in rats and mice, liver histological changes in rats, hepatocellular tumours in rats, and thyroid hormone changes in monkeys, rats, and mice). Based on the MOA analysis, no endpoints were considered to be irrelevant to humans.
	What processes are used when expert judgement is required and applied? Is the process documented and published?	½	Unclear from the documentation consulted. However, the authors consist of a group of experts which discuss and agree on the contents of the reports.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	Yes where possible, but not necessarily for the endpoint investigated.

Criteria		Y/N/?/NA	Notes
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	Y	Cancer risk for genotoxic carcinogens done using linear low-dose extrapolation. However, this was not undertaken for PFOS as the weight of evidence indicates it is not a genotoxic compound.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	NA	
Summary: Total # of 'Must-Have' criteria met (or not applicable): 11.5/20 = 58% Total # of 'Should-Have' criteria met (or not applicable): 5/10 = 50% Total # of 'May-Have' criteria met (or not applicable): 2/2 = 100%			

D.1.7 MPART 2019a

Agency Report Reference: *MPART (2019a). Health-Based Drinking Water Value Recommendations for PFAS in Michigan. June 27, 2019. Michigan Science Advisory Workgroup. Michigan's PFAS Action Response Team (MPART).*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	Y	
	Are the administrative processes documented and publicly available?	Y	
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	Y	Work was overseen / undertaken by a Science Advisory Workgroup.
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Government of Michigan.

Criteria		Y/N/?/NA	Notes
	Was there public consultation on this work? If so, provide details.	?	Unclear from the report or website.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	?	Not exactly, it was a piece of work put together by the Science Advisory Workgroup.
	Was the guidance/advice developed or updated recently? Provide details.	NA	
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	½	The document provides information on these aspects in a general sense.
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	Y	There is a mention in one of the tables about studies following recommended test guidelines.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	N	There is no indication in the report that systematic review methods have been followed to undertake the review.
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	NA	No mention of unpublished studies.
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	N	No mention of inclusion / exclusion criteria.
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	Y	Other agency reports were relied upon for the literature reviews. For each of the selected PFAS analytes, the Workgroup evaluated the identified points of departure (defined as the point on a toxicological dose-response curve corresponding to an estimated low effect level or no effect level) and rationale from published risk assessments and assessed the underlying key studies that served as the basis for the published values. From this review, the merits of each available point of departure was discussed among the Workgroup and critical studies and points of departures for each of the seven identified PFAS analytes were identified to form the basis of public health toxicity values described further in the report.

Criteria		Y/N/?/NA	Notes
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	½	Databases are not specified but all references are provided in a bibliographical list in the report.
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	?	No details on literature search provided. Relied on other agency reviews.
	Is it specified what date range the literature search covers? Is there a justification?	N	
	Are search terms and/or search strings specified?	N	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	N/A	
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	N	No mention of risk of bias.
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	N	
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	N	
	Derivation of health-based guideline values		

Criteria		Y/N/?/NA	Notes
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	½	Although mathematical workings are clearly documented for derivation of the RfD, derivation of the DWG is not as clearly articulated as it was done using toxicokinetic modelling. The outputs and the workings of the modelling are not provided.
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	NA	
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	?	Unclear from the documentation reviewed.
	What processes are used when expert judgement is required and applied? Is the process documented and published?	?	Unclear from the documentation consulted.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	Yes, where possible.
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	NA	Not stated in document. No mention of a cancer-based value available for PFAS.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	NA	

Summary:

Total # of 'Must-Have' criteria met (or not applicable): 13.5/20 = 67.5%

Total # of 'Should-Have' criteria met (or not applicable): 3/10 = 30%

Total # of 'May-Have' criteria met (or not applicable): 2/2 = 100%

D.1.8 NJDEP 2019b

Agency Report Reference: *NJDEP (2019b). Technical Support Document: Interim Specific Ground Water Criterion for Perfluorooctane Sulfonate (PFOS) (CAS #: 1763-23-1; Chemical Formula: C8HF17O3S). March 6, 2019. New Jersey Department of Environmental Protection (NJDEP).*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	Y	
	Are the administrative processes documented and publicly available?	Y	
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	Y	Based primarily on an evaluation by the Health Effects Subcommittee of the New Jersey Drinking Water Quality Institute (DWQI). The information in this document is very similar to that in the DWQI Health-Based Maximum Contaminant Level Support Document: Perfluorooctane Sulfonate (DWQI, 2018). The text has been revised by the New Jersey Department of Environmental Protection to describe the development of the ISGWQC.
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Government of New Jersey.
	Was there public consultation on this work? If so, provide details.	?	Unclear from the report or website.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	?	Not exactly, it was a piece of work put together by the Health Effects Subcommittee.
	Was the guidance/advice developed or updated recently? Provide details.	NA	
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	½	The document provides information on these aspects in a general sense.

Criteria		Y/N/?/NA	Notes
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	?	Unclear.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	Y	
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	Y	Where unpublished data are mentioned (on two occasions), this was described briefly.
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	Y	
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	Y	Yes other reviews are cited but not necessarily adopted.
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	Y	
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	Y	
	Is it specified what date range the literature search covers? Is there a justification?	Y	
	Are search terms and/or search strings specified?	Y	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	Y	Yes, all exclusion criteria listed in Appendix 1.

Criteria		Y/N/?/NA	Notes
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	Y	Risk of bias mentioned in individual study reviews.
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	Y	Overall summary tables are provided.
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	N	
	Derivation of health-based guideline values		
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	NA	
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	Y	Mode of action state of knowledge is explained in document.
	What processes are used when expert judgement is required and applied? Is the process documented and published?	?	Unclear from the documentation consulted.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	Yes, where possible.

Criteria		Y/N/?/NA	Notes
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	Y	Low-dose linear extrapolation is used for any chemicals causing cancer. But authors concluded that a ISGWQC for PFOS based on carcinogenicity would be much more uncertain than one based on the non-cancer endpoint, decreased immune response as assessed by plaque forming cell response in mice.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	Y	Typically 1 in a million.
Summary: Total # of 'Must-Have' criteria met (or not applicable): 18.5/20 = 92.5% Total # of 'Should-Have' criteria met (or not applicable): 6/10 = 60% Total # of 'May-Have' criteria met (or not applicable): 2/2 = 100%			

D.1.9 OEHHA 2019a

Agency Report Reference: *OEHHA (2019a). Notification Level Recommendations. Perfluorooctanoic Acid and Perfluorooctane Sulfonate in Drinking Water. August 2019. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	½	Yes, apart from the fact that a cancer-based DWG is derived by OEHHA, regardless of whether the chemical acts via a genotoxic mode of action. Since PFAS are understood not to act via a genotoxic mode of action for eliciting cancer, this part of the methodology is not consistent with Australian science policy.
	Are the administrative processes documented and publicly available?	?	Administrative processes are not documented in the review and could not be readily found from a search of the OEHHA website.

Criteria		Y/N/?/NA	Notes
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	?	Unclear. Document lists authors and reviewers but no mention of expert advisory committee or conflict of interest management.
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Government of California.
	Was there public consultation on this work? If so, provide details.	?	Unclear from the report or website.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	½	Reviewers are listed on the front cover, but outcome of peer review does not appear to be documented.
	Was the guidance/advice developed or updated recently? Provide details.	Y	The advice is an update to previous advice, in which the New Jersey values were simply adopted.
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	½	The document provides information on these aspects in a general sense.
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	?	Unclear.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	?	Unclear.
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	Y	Where unpublished data are mentioned (on one occasion), this was described briefly.
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	N	
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	Y	Yes, other reviews are cited and previously adopted. But an updated literature search was undertaken to update the data from previous reviews.
	Can grey literature such as government reports and policy documents be included?	Y	

Criteria		Y/N/?/NA	Notes
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	N	
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	?	
	Is it specified what date range the literature search covers? Is there a justification?	N	
	Are search terms and/or search strings specified?	N	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	?	
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	N	No mention of risk of bias.
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	N	Does not appear to have been undertaken.
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	N	
	Derivation of health-based guideline values		
	Is there justification for the choice of uncertainty and safety factors?	Y	

Criteria		Y/N/?/NA	Notes
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	Y	Recommended health-based values are lower than the limit of reporting, hence OEHHA (2019a) recommended the notification levels in drinking water be set at the LoR.
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	Y	Mode of action state of knowledge is explained in document.
	What processes are used when expert judgement is required and applied? Is the process documented and published?	?	Unclear from the documentation consulted.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	Yes, where possible.
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	½	Low-dose linear extrapolation is used for any chemicals causing cancer. A cancer-based DWG is derived by OEHHA, regardless of whether the chemical acts via a genotoxic mode of action. Since PFAS are understood not to act via a genotoxic mode of action for eliciting cancer, this part of the methodology is not consistent with Australian science policy. Therefore this criterion has been assigned a '1/2'.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	Y	Typically 1 in a million.

Summary:

Total # of 'Must-Have' criteria met (or not applicable): 9.5/20 = 47.5%

Total # of 'Should-Have' criteria met (or not applicable): 4.5/10 = 45%

Total # of 'May-Have' criteria met (or not applicable): ½ = 50%

D.1.10 OEHHA 2023a

Agency Report Reference: *OEHHA (2023a). Public Health Goals. Second Public Review Draft. Perfluorooctanoic Acid and Perfluorooctane Sulfonic Acid in Drinking Water. July 2023. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	½	Yes, apart from the fact that a cancer-based DWG is derived by OEHHA, regardless of whether the chemical acts via a genotoxic mode of action. Since PFAS are understood not to act via a genotoxic mode of action for eliciting cancer, this part of the methodology is not consistent with Australian science policy.
	Are the administrative processes documented and publicly available?	Y	To a certain degree. For example, the document does provide indication that it has been peer reviewed.
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	?	Unclear.
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Government of California.
	Was there public consultation on this work? If so, provide details.	Y	This document is the second public review draft document.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	Y	Preface indicates a previous draft was externally peer reviewed. Website provides outcome of peer review comments: https://oehha.ca.gov/water/report/perfluorooctanoic-acid-pfoa-and-perfluorooctane-sulfonic-acid-pfos-drinking-water
	Was the guidance/advice developed or updated recently? Provide details.	Y	The advice is a draft update to previous advice.
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	½	The document provides information on these aspects in a general sense.

Criteria		Y/N/?/NA	Notes
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	?	Unclear
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	Y	
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	Y	Where unpublished data are mentioned, this was described briefly.
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	Y	
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	NA	Although other reviews are cited, OEHHA used their own independent assessment to come to conclusions.
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	Y	
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	Y	
	Is it specified what date range the literature search covers? Is there a justification?	Y	
	Are search terms and/or search strings specified?	Y	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	Y	Exclusions included case reports (because of lack of a comparison group), abstracts and studies without original data.

Criteria		Y/N/?/NA	Notes
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	Y	Yes, a number of factors in the human studies were evaluated when assessing study quality and causal inference. These factors are based on an updated version of the Hill criteria and are similar to those described in the NTP Risk of Bias (RoB) tool.
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	Y	Yes, full details provided in report.
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	N	
	Derivation of health-based guideline values		
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	NA	
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	Y	Mode of action state of knowledge is explained in document.
	What processes are used when expert judgement is required and applied? Is the process documented and published?	?	Unclear from the documentation consulted.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	Yes, where possible.

Criteria		Y/N/?/NA	Notes
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	½	Low-dose linear extrapolation is used for any chemicals causing cancer. A cancer-based DWG is derived by OEHHA, regardless of whether the chemical acts via a genotoxic mode of action. Since PFAS are understood not to act via a genotoxic mode of action for eliciting cancer, this part of the methodology is not consistent with Australian science policy. Therefore this criterion has been assigned a '1/2'.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	Y	Typically 1 in a million.
Summary: Total # of 'Must-Have' criteria met (or not applicable): 16.5/20 = 82.5% Total # of 'Should-Have' criteria met (or not applicable): 8/10 = 80% Total # of 'May-Have' criteria met (or not applicable): 2/2 = 100%			

D.1.11 US EPA 2021b

Agency Report Reference: *USEPA (2021b). External Peer Review Draft. Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctane Sulfonic Acid (PFOS) (CASRN 1763-23-1) in Drinking Water. EPA Document No. 822D21002. December 2021. DRAFT. DO NOT CITE OR QUOTE. United States Environmental Protection Agency (USEPA).*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	Y	
	Are the administrative processes documented and publicly available?	½	To a certain degree.

Criteria		Y/N/?/NA	Notes
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	Y	Yes, EPA seeks comments from the Science Advisory Board (SAB).
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Federal Government of USA.
	Was there public consultation on this work? If so, provide details.	Y	This document is a draft for public comment.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	Y	Previous drafts of this document appear to have been peer reviewed.
	Was the guidance/advice developed or updated recently? Provide details.	Y	The advice is a draft update to previous advice.
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	Y	
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	?	Unclear.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	Y	
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	?	Unpublished data do not seem to be mentioned, although the literature search indicates that various agency websites were reviewed for published as well as unpublished or interim research reports.
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	Y	
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	NA	Although other reviews are cited, US EPA used their own independent assessment to come to conclusions.

Criteria		Y/N/?/NA	Notes
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	Y	
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	Y	
	Is it specified what date range the literature search covers? Is there a justification?	Y	
	Are search terms and/or search strings specified?	Y	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	?	Unclear.
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	Y	Yes, this was determined as an overall confidence rating for each study by study reviewers and checked by a QA reviewer.
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	Y	Yes, full details provided in report.
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	Y	Yes, confidence is assigned to the levels of evidence and an overall weight of evidence is examined to describe certainty in the evidence. Formal certainty ratings do not appear to be derived.
	Derivation of health-based guideline values		

Criteria		Y/N/?/NA	Notes
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	Y	Yes, for derivation of a MCLG but not for a lifetime iHA.
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	?	Very little information on mechanistic/mode of action studies in document.
	What processes are used when expert judgement is required and applied? Is the process documented and published?	½	Under the 2005 guidelines, a descriptive weight of evidence expert judgment is made, based on all available animal, human, and mechanistic data, as to the likelihood that an agent is a human carcinogen and the conditions under which the carcinogenic effects may be expressed.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	Yes, where possible.
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	½	Low-dose linear extrapolation is used for any chemicals causing cancer. No cancer-based values have been derived by US EPA, citing the lack of appropriate dose response data rather than the fact the chemical does not act via a genotoxic mode of action. Since PFAS are understood not to act via a genotoxic mode of action for eliciting cancer, this part of the methodology is not consistent with Australian science policy. Therefore, this criterion has been assigned a '1/2'.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	Y	Typically 1 in a million.

Criteria	Y/N/?/NA	Notes
Summary: Total # of 'Must-Have' criteria met (or not applicable): 17/20 = 85% Total # of 'Should-Have' criteria met (or not applicable): 8.5/10 = 85% Total # of 'May-Have' criteria met (or not applicable): ½ = 50%		

D.1.12 MDH 2020b

Agency Report Reference: *MDH (2020b). Toxicological Summary for: Perfluorohexane sulfonate. August 2020. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH)*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	Y	
	Are the administrative processes documented and publicly available?	?	Unclear / could not be readily located.
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	?	Unclear from the report.
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Government of Minnesota.
	Was there public consultation on this work? If so, provide details.	?	Unclear from the report or website.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	?	Not stated in document.

Criteria		Y/N/?/NA	Notes
	Was the guidance/advice developed or updated recently? Provide details.	Y	MDH (2023) released additional guidance on application of the hazard index approach based on proposed MCLs from US EPA. EPA will collect public comments on the MCLs and consider revisions before they are finalised into a new federal drinking water rule in late 2023 or early 2024. The rule may require changes in the way that certain drinking water supplies in Minnesota are managed to address PFAS.
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	N	
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	?	Unclear. The publication does not provide information on this aspect.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	N	There is no indication in the report that systematic review methods have been followed to undertake the review.
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	NA	No mention of unpublished studies.
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	N	No mention of inclusion / exclusion criteria.
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	½	Other agencies are cited as sources of information, but the process for critically assessing the findings is not described.
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		

Criteria		Y/N/?/NA	Notes
	Are databases and other sources of evidence specified?	½	Databases are not specified but all references are provided in a bibliographical list in the report.
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	?	No details on literature search provided.
	Is it specified what date range the literature search covers? Is there a justification?	N	
	Are search terms and/or search strings specified?	N	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	N/A	
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	N	No mention of risk of bias.
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	N	
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	½	Yes, in an informal sense by looking at the weight of evidence and examining the potential influencing factors on the overall conclusion.
	Derivation of health-based guideline values		
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	

Criteria		Y/N/?/NA	Notes
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	NA	
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	?	Unclear from the documentation reviewed.
	What processes are used when expert judgement is required and applied? Is the process documented and published?	?	Unclear from the documentation consulted.
	Is dose response modelling (e.g. BMDL) routinely used?	?	Unclear from the documentation consulted.
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	NA	Cancer risk estimated using linear low-dose extrapolation. However, this was not undertaken for PFHxS; cancer health-based value is not applicable.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	NA	
Summary: Total # of 'Must-Have' criteria met (or not applicable): 10/20 = 50% Total # of 'Should-Have' criteria met (or not applicable): 3.5/10 = 35% Total # of 'May-Have' criteria met (or not applicable): ½ = 50%			

D.1.13 OEHHA 2022a

Agency Report Reference: *OEHHA (2022a). Notification Level Recommendation. Perfluorohexane Sulfonic Acid in Drinking Water. March 2022. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		

Criteria		Y/N/?/NA	Notes
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	½	Yes, apart from the fact that a cancer-based DWG is derived by OEHHA, regardless of whether the chemical acts via a genotoxic mode of action. Since PFAS are understood not to act via a genotoxic mode of action for eliciting cancer, this part of the methodology is not consistent with Australian science policy.
	Are the administrative processes documented and publicly available?	?	Administrative processes are not documented in the review and could not be readily found from a search of the OEHHA website.
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	?	Unclear. Document lists authors and reviewers but no mention of expert advisory committee or conflict of interest management.
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Government of California.
	Was there public consultation on this work? If so, provide details.	?	Unclear from the report or website.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	½	Reviewers are listed on the front cover, but outcome of peer review does not appear to be documented.
	Was the guidance/advice developed or updated recently? Provide details.	NA	
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	½	The document provides information on these aspects in a general sense.
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	?	Unclear.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	Y	OEHHA performed a systematic literature search for epidemiological studies on the human health effects of PFHxS.
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	NA	No unpublished data mentioned in the report.

Criteria		Y/N/?/NA	Notes
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	Y	
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	NA	
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	Y	
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	Y	
	Is it specified what date range the literature search covers? Is there a justification?	Y	
	Are search terms and/or search strings specified?	Y	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	Y	Case-reports were excluded because of the lack of a comparison group. Ecological and cross-sectional studies were considered, although the potential for ecological fallacy or reverse causation was examined. Abstracts and studies without original data (e.g. editorials) were excluded.
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	Y	Qualitative considerations listed for risk of bias and overall evaluation of quality of papers. No specific tools mentioned.

Criteria		Y/N/?/NA	Notes
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	Y	Study quality, and causal inference of the epidemiological studies of PFHxS and non-Developmental and Reproductive Toxicity outcomes was undertaken.
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	N	
	Derivation of health-based guideline values		
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	Y	OEHHA recommends that the Water Board establish the NL for PFHxS in drinking water at the HPC of 2 ppt, or at the lowest level at which PFHxS can be reliably detected in drinking water using available and appropriate technologies.
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	½	Some mentions of mechanisms made in document.
	What processes are used when expert judgement is required and applied? Is the process documented and published?	?	Unclear from the documentation consulted.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	Yes, where possible.

Criteria		Y/N/?/NA	Notes
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	½	Low-dose linear extrapolation is used for any chemicals causing cancer. A cancer-based DWG is derived by OEHHA, regardless of whether the chemical acts via a genotoxic mode of action. Since PFAS are understood not to act via a genotoxic mode of action for eliciting cancer, this part of the methodology is not consistent with Australian science policy. Therefore, this criterion has been assigned a '1/2'.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	Y	Typically 1 in a million.
Summary: Total # of 'Must-Have' criteria met (or not applicable): 15.5/20 = 77.5% Total # of 'Should-Have' criteria met (or not applicable): 6/10 = 60% Total # of 'May-Have' criteria met (or not applicable): 2/2 = 100%			

D.1.14 MDH 2022g

Agency Report Reference: *MDH (2022g). Toxicological Summary for: Perfluorobutane sulfonate. March 2022. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH)*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	Y	
	Are the administrative processes documented and publicly available?	?	Unclear / could not be readily located.
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	?	Unclear from the report.

Criteria		Y/N/?/NA	Notes
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Government of Minnesota.
	Was there public consultation on this work? If so, provide details.	?	Unclear from the report or website.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	?	Not stated in document.
	Was the guidance/advice developed or updated recently? Provide details.	Y	MDH (2023) released additional guidance on application of the hazard index approach based on proposed MCLs from US EPA. EPA will collect public comments on the MCLs and consider revisions before they are finalised into a new federal drinking water rule in late 2023 or early 2024. The rule may require changes in the way that certain drinking water supplies in Minnesota are managed to address PFAS.
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	N	
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	?	Unclear. The publication does not provide information on this aspect.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	N	There is no indication in the report that systematic review methods have been followed to undertake the review.
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	NA	No mention of unpublished studies.
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	N	No mention of inclusion / exclusion criteria.
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	½	Other agencies are cited as sources of information, but the process for critically assessing the findings is not described.

Criteria		Y/N/?/NA	Notes
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	½	Databases are not specified but all references are provided in a bibliographical list in the report.
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	?	No details on literature search provided.
	Is it specified what date range the literature search covers? Is there a justification?	N	
	Are search terms and/or search strings specified?	N	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	N/A	
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	N	No mention of risk of bias.
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	N	
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	½	Yes, in an informal sense by looking at the weight of evidence and examining the potential influencing factors on the overall conclusion.
	Derivation of health-based guideline values		

Criteria		Y/N/?/NA	Notes
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	NA	
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	?	Unclear from the documentation reviewed.
	What processes are used when expert judgement is required and applied? Is the process documented and published?	?	Unclear from the documentation consulted.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	NA	Cancer risk estimated using linear low-dose extrapolation. However, this was not undertaken for PFBS; cancer health-based value is not derived (due to insufficient data).
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	NA	

Summary:

Total # of 'Must-Have' criteria met (or not applicable): 10/20 = 50%

Total # of 'Should-Have' criteria met (or not applicable): 3.5/10 = 35%

Total # of 'May-Have' criteria met (or not applicable): 2/2 = 100%

D.1.15 OEHHA 2021d

Agency Report Reference: *OEHHA (2021d). Notification Level Recommendation. Perfluorobutane Sulfonic Acid in Drinking Water. January 2021. Pesticide and Environmental Toxicology Branch. Office of Environmental Health Hazard Assessment (OEHHA). California Environmental Protection Agency*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	½	Yes, apart from the fact that a cancer-based DWG is derived by OEHHA, regardless of whether the chemical acts via a genotoxic mode of action. Since PFAS are understood not to act via a genotoxic mode of action for eliciting cancer, this part of the methodology is not consistent with Australian science policy.
	Are the administrative processes documented and publicly available?	?	Administrative processes are not documented in the review and could not be readily found from a search of the OEHHA website.
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	?	Unclear. Document lists authors and reviewers but no mention of expert advisory committee or conflict of interest management.
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Government of California.
	Was there public consultation on this work? If so, provide details.	?	Unclear from the report or website.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	½	Reviewers are listed on the front cover, but outcome of peer review does not appear to be documented.
	Was the guidance/advice developed or updated recently? Provide details.	NA	
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	½	The document provides information on these aspects in a general sense.

Criteria		Y/N/?/NA	Notes
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	?	Unclear.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	Y	OEHHA conducted an initial systematic literature search in December 2019 of multiple open literature databases (PubMed, Embase, Scopus, and Toxnet) using a search string intended to identify all studies that mention PFBS in the title or abstract.
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	NA	Only one mention of unpublished data in report which was cited from another agency report.
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	Y	OEHHA uploaded the identified references into DistillerSR systematic review software and conducted inclusion/exclusion screening for relevant toxicological data against a PECO (populations, exposures, comparators, and outcomes) statement designed to capture relevant toxicological data (Appendix I).
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	NA	
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	Y	
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	Y	
	Is it specified what date range the literature search covers? Is there a justification?	Y	

Criteria		Y/N/?/NA	Notes
	Are search terms and/or search strings specified?	Y	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	Y	Ecological studies, animal biomonitoring studies, and reviews were excluded.
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	N	Risk of bias not mentioned.
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	N	
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	½	This was done in a qualitative manner considering the overall quality of information available.
	Derivation of health-based guideline values		
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	NA	
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	½	Some mentions of mechanisms made in document.

Criteria		Y/N/?/NA	Notes
	What processes are used when expert judgement is required and applied? Is the process documented and published?	?	Unclear from the documentation consulted.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	Yes, where possible.
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	½	Low-dose linear extrapolation is used for any chemicals causing cancer. A cancer-based DWG is derived by OEHHA, regardless of whether the chemical acts via a genotoxic mode of action. Since PFAS are understood not to act via a genotoxic mode of action for eliciting cancer, this part of the methodology is not consistent with Australian science policy. Therefore, this criterion has been assigned a '1/2'.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	Y	Typically 1 in a million.
Summary: Total # of 'Must-Have' criteria met (or not applicable): 14.5/20 = 72.5% Total # of 'Should-Have' criteria met (or not applicable): 5.5/10 = 55% Total # of 'May-Have' criteria met (or not applicable): 2/2 = 100%			

D.1.16 US EPA 2021c

Agency Report Reference: *USEPA (2021c). Human Health Toxicity Values for Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-49-3). EPA/600/R-20/345F. April 2021. United States Environmental Protection Agency (USEPA).*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		

Criteria		Y/N/?/NA	Notes
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	Y	
	Are the administrative processes documented and publicly available?	Y	
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	N	
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Federal Government of USA.
	Was there public consultation on this work? If so, provide details.	Y	Yes, draft was released for public comment.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	Y	
	Was the guidance/advice developed or updated recently? Provide details.	NA	
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	Y	
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	Y	In the rationale for reporting quality of individual studies, reviewers indicated whether the study adhered to GLP, OECD, or other testing guidelines.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	Y	
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	?	Unpublished data do not seem to be mentioned.
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	Y	

Criteria		Y/N/?/NA	Notes
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	NA	Although other reviews are cited, US EPA used their own independent assessment to come to conclusions.
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	Y	
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	Y	
	Is it specified what date range the literature search covers? Is there a justification?	Y	
	Are search terms and/or search strings specified?	Y	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	Y	In addition to the PECO criteria, the following additional exclusion criteria were applied, although these study types were tracked as supplemental material as described following the exclusion criteria: • Records that do not contain original data such as other agency assessments, scientific; • literature reviews, editorials, and commentaries; • Abstract only (e.g. conference abstracts); and • Retracted studies.

Criteria		Y/N/?/NA	Notes
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	Y	Yes, for animal studies, the evaluation process focused on assessing aspects of the study design and conduct through three broad types of evaluations: reporting quality, risk of bias, and study sensitivity. A set of domains with accompanying core questions fall under each evaluation type and directed individual reviewers to evaluate specific study characteristics. For each domain evaluated for experimental animal studies (reporting quality, selection or performance bias, confounding/variable control, reporting or attrition bias, exposure methods sensitivity, and outcome measures and results display), basic considerations provided additional guidance on how a reviewer might evaluate and judge a study for that domain. Core and prompting questions used to guide the criteria and judgment for each domain are presented in Appendix C.
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	Y	Yes, full details provided in report.
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	Y	Yes, confidence is assigned to the levels of evidence and an overall weight of evidence is examined to describe certainty in the evidence. Formal certainty ratings do not appear to be derived.
	Derivation of health-based guideline values		
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	NA	

Criteria		Y/N/?/NA	Notes
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	?	Very little information on mechanistic/mode of action studies in document.
	What processes are used when expert judgement is required and applied? Is the process documented and published?	?	Unclear.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	Yes, where possible.
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	1/2	Low-dose linear extrapolation is used for any chemicals causing cancer. No cancer-based values have been derived by US EPA, citing there are no known studies evaluating potential cancer effects of PFBS. Since PFAS are understood not to act via a genotoxic mode of action for eliciting cancer, this part of the methodology is not consistent with Australian science policy. Therefore, this criterion has been assigned a '1/2'.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	Y	Typically 1 in a million.
Summary: Total # of 'Must-Have' criteria met (or not applicable): 17.5/20 = 87.5% Total # of 'Should-Have' criteria met (or not applicable): 8/10 = 80% Total # of 'May-Have' criteria met (or not applicable): 2/2 = 100%			

D.1.17 HC 2018b

Agency Report Reference: *HC (2018b). Guidelines for Canadian Drinking Water Quality Guideline Technical Document Perfluorooctanoic Acid (PFOA). December 2018. Health Canada (HC). Government of Canada.*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		

Criteria		Y/N/?/NA	Notes
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	Y	
	Are the administrative processes documented and publicly available?	?	Unclear / could not be readily located.
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	?	Unclear from the report.
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Canadian Government.
	Was there public consultation on this work? If so, provide details.	?	Unclear from the report or website.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	?	Not stated in document.
	Was the guidance/advice developed or updated recently? Provide details.	NA	
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	Y	The document provides information on these aspects in a general sense.
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	?	Unclear. The publication does not provide information on this aspect.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	N	Previous systematic reviews are cited, but there is no indication in the report that systematic review methods have been followed to undertake the review.
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	NA	A few mentions made to unpublished studies, and the results are briefly stated (no detailed description provided).
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	N	No mention of inclusion / exclusion criteria.

Criteria		Y/N/?/NA	Notes
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	½	Other agencies are cited as sources of information, but the process for critically assessing the findings is not described.
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	1/2	Databases are not specified but all references are provided in a bibliographical list in the report.
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	?	No details on literature search provided.
	Is it specified what date range the literature search covers? Is there a justification?	N	
	Are search terms and/or search strings specified?	N	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	N/A	
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	1/2	Risk of bias assessment was discussed in the text of the report, but not in a formal manner.
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	N	

Criteria		Y/N/?/NA	Notes
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	1/2	Yes, in an informal sense by looking at the weight of evidence and examining the potential influencing factors on the overall conclusion.
	Derivation of health-based guideline values		
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	NA	
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	Y	Mode of action (MOA) analysis was considered for effects occurring at the lowest PFOA levels (i.e. Leydig cell tumours, hepatocellular hypertrophy, and changes in serum lipids in rats, and liver weight increases, hepatocellular hypertrophy, obesity, developmental delays, and delayed mammary gland development in mice). Based on the MOA analysis, no endpoints were considered to be irrelevant to humans.
	What processes are used when expert judgement is required and applied? Is the process documented and published?	1/2	Unclear from the documentation consulted. However, the authors consist of a group of experts which discuss and agree on the contents of the reports.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	Yes where possible.
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	Y	Cancer risk for genotoxic carcinogens done using linear low-dose extrapolation. However, this was not undertaken for PFOA as the weight of evidence indicates it is not a genotoxic compound.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	NA	

Criteria	Y/N/?/NA	Notes
Summary: Total # of 'Must-Have' criteria met (or not applicable): 11.5/20 = 58% Total # of 'Should-Have' criteria met (or not applicable): 5/10 = 50% Total # of 'May-Have' criteria met (or not applicable): 2/2 = 100%		

D.1.18 MDH 2022f

Agency Report Reference: *MDH (2022f). Toxicological Summary for: Perfluorooctanoate. March 2022. Health-Based Guidance for Water. Health Risk Assessment Unit, Environmental Health Division. Minnesota Department of Health (MDH)*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	Y	
	Are the administrative processes documented and publicly available?	?	Unclear / could not be readily located.
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	?	Unclear from the report.
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Government of Minnesota.
	Was there public consultation on this work? If so, provide details.	?	Unclear from the report or website.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	?	Not stated in document.

Criteria		Y/N/?/NA	Notes
	Was the guidance/advice developed or updated recently? Provide details.	Y	MDH (2023) released additional guidance on application of the hazard index approach based on proposed MCLs from US EPA. EPA will collect public comments on the MCLs and consider revisions before they are finalised into a new federal drinking water rule in late 2023 or early 2024. The rule may require changes in the way that certain drinking water supplies in Minnesota are managed to address PFAS.
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	N	
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	?	Unclear. The publication does not provide information on this aspect.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	N	There is no indication in the report that systematic review methods have been followed to undertake the review.
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	NA	No mention of unpublished studies.
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	N	No mention of inclusion / exclusion criteria.
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	½	Other agencies are cited as sources of information, but the process for critically assessing the findings is not described.
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		

Criteria		Y/N/?/NA	Notes
	Are databases and other sources of evidence specified?	1/2	Databases are not specified but all references are provided in a bibliographical list in the report.
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	?	No details on literature search provided.
	Is it specified what date range the literature search covers? Is there a justification?	N	
	Are search terms and/or search strings specified?	N	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	N/A	
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	N	No mention of risk of bias.
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	N	
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	1/2	Yes, in an informal sense by looking at the weight of evidence and examining the potential influencing factors on the overall conclusion.
	Derivation of health-based guideline values		
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	

Criteria		Y/N/?/NA	Notes
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	NA	
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	?	Unclear from the documentation reviewed.
	What processes are used when expert judgement is required and applied? Is the process documented and published?	?	Unclear from the documentation consulted.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	NA	Cancer risk estimated using linear low-dose extrapolation. However, this was not undertaken for PFOA; cancer health-based value is not derived. The current RfD protects against hepatic and acinar hyperplasia as well as changes in hormone levels, which are considered potential key events in tumour formation. Based on currently available data, MDH considers the noncancer-based water guidance value of 0.035 µg/L to be protective for potential cancer effects.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	NA	

Summary:

Total # of 'Must-Have' criteria met (or not applicable): 10/20 = 50%

Total # of 'Should-Have' criteria met (or not applicable): 3.5/10 = 35%

Total # of 'May-Have' criteria met (or not applicable): 2/2 = 100%

D.1.19 NJDEP 2019a

Agency Report Reference: *NJDEP (2019a). Technical Support Document: Interim Specific Ground Water Criterion for Perfluorooctanoic Acid (PFOA, C8) (CAS #: 335-67-1; Chemical Structure: CF3(CF2)6COOH)*. March 6, 2019. New Jersey Department of Environmental Protection (NJDEP).*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	Y	
	Are the administrative processes documented and publicly available?	Y	
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	Y	Based primarily on an evaluation by the Health Effects Subcommittee of the New Jersey Drinking Water Quality Institute (DWQI). The information in this document is very similar to that in the DWQI Health-Based Maximum Contaminant Level Support Document: Perfluorooctanoic Acid (DWQI, 2017). The text has been revised by the New Jersey Department of Environmental Protection to describe the development of the ISGWQC.
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Government of New Jersey.
	Was there public consultation on this work? If so, provide details.	?	Unclear from the report or website.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	?	Not exactly, it was a piece of work put together by the Health Effects Subcommittee.
	Was the guidance/advice developed or updated recently? Provide details.	NA	
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	1/2	The document provides information on these aspects in a general sense.

Criteria		Y/N/?/NA	Notes
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	?	Unclear.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	Y	
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	Y	Where unpublished data are mentioned (on two occasions), this was described briefly.
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	Y	
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	Y	Yes, other reviews are cited but not necessarily adopted.
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	Y	Presumably. Literature search details are said to be included in Appendix 1, but Appendix 1 could not be sourced in the report or on website. However, based on a similar report published for PFOS, these aspects are likely described.
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	Y	Presumably. Literature search details are said to be included in Appendix 1, but Appendix 1 could not be sourced in the report or on website. However, based on a similar report published for PFOS, these aspects are likely described.

Criteria		Y/N/?/NA	Notes
	Is it specified what date range the literature search covers? Is there a justification?	Y	Presumably. Literature search details are said to be included in Appendix 1, but Appendix 1 could not be sourced in the report or on website. However, based on a similar report published for PFOS, these aspects are likely described.
	Are search terms and/or search strings specified?	Y	Presumably. Literature search details are said to be included in Appendix 1, but Appendix 1 could not be sourced in the report or on website. However, based on a similar report published for PFOS, these aspects are likely described.
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	NA	Presumably. Literature search details are said to be included in Appendix 1, but Appendix 1 could not be sourced in the report or on website. However, based on a similar report published for PFOS, these aspects are likely described.
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	Y	Yes, risk of bias evaluated for each study and quality and strength of evidence across all studies was rated.
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	Y	Overall summary tables are provided.
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	N	
	Derivation of health-based guideline values		
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	

Criteria		Y/N/?/NA	Notes
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	NA	
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	Y	Mode of action state of knowledge is explained in document.
	What processes are used when expert judgement is required and applied? Is the process documented and published?	?	Unclear from the documentation consulted.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	Yes, where possible.
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	1/2	Low-dose linear extrapolation is used for any chemicals causing cancer. A cancer slope factor, 0.021 $(mg/kg/day)^{-1}$, was developed based on increased incidence of testicular tumours in a chronic rat study. This slope factor was used to develop a health-based water concentration protective for cancer effects at the 1×10^{-6} (one in one million) lifetime cancer risk level of 14 ng/L, identical to the health-based water concentration based on non-cancer endpoints. Since ISGWQC are rounded to one significant figure, the ISGWQC is therefore 10 ng/L. As the policy is not consistent with Australian science policy on non-genotoxic carcinogens, a '1/2' score has been allocated to this criterion.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	Y	Typically 1 in a million.

Summary:
Total # of 'Must-Have' criteria met (or not applicable): 18/20 = 90%
Total # of 'Should-Have' criteria met (or not applicable): 6/10 = 60%
Total # of 'May-Have' criteria met (or not applicable): 2/2 = 100%

D.1.20 US EPA 2021a

Agency Report Reference: *USEPA (2021a). External Peer Review Draft. Proposed Approaches to the Derivation of a Draft Maximum Contaminant Level Goal for Perfluorooctanoic Acid (PFOA) (CASRN 335-67-1) in Drinking Water. EPA Document No. 822D21001. December 2021. DRAFT. DO NOT CITE OR QUOTE. United States Environmental Protection Agency (USEPA).*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	Y	
	Are the administrative processes documented and publicly available?	Y	
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	N	
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Federal Government of USA.
	Was there public consultation on this work? If so, provide details.	Y	Yes, draft was released for public comment.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	Y	
	Was the guidance/advice developed or updated recently? Provide details.	NA	Guidance (US EPA 2021a) is still in draft form.
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	Y	
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	?	Not stated.

Criteria		Y/N/?/NA	Notes
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	Y	
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	?	Unpublished data do not seem to be mentioned.
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	Y	
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	NA	Although other reviews are cited, US EPA used their own independent assessment to come to conclusions.
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	Y	
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	Y	
	Is it specified what date range the literature search covers? Is there a justification?	Y	
	Are search terms and/or search strings specified?	Y	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	NA	

Criteria		Y/N/?/NA	Notes
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	Y	Yes, reviewers evaluated epidemiological and animal toxicological studies for potential risk of bias (systematic error or deviations from the truth related to internal validity that affect the magnitude or direction of an effect in either direction) or insensitivity (factors that limit the ability of a study to detect a true effect; low sensitivity is a bias toward the null when an effect exists). This was done using the Health Assessment Workplace Collaborative (HAWC) platform and conflict resolution was undertaken by an additional reviewer, as needed.
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	Y	Yes, full details provided in report in Section 2.6.
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	Y	Yes, confidence is assigned to the levels of evidence and an overall weight of evidence is examined to describe certainty in the evidence. Formal certainty ratings do not appear to be derived.
	Derivation of health-based guideline values		
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	Y	The interim health advisory DWG is set at the limit of reporting, rather than at the derived health-based value.
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	Y	

Criteria		Y/N/?/NA	Notes
	What processes are used when expert judgement is required and applied? Is the process documented and published?	?	Unclear.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	Yes, where possible.
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	1/2	Low-dose linear extrapolation is used for any chemicals causing cancer. A cancer-based value was derived by US EPA but ultimately was so low that an interim health advisory value at the limit of reporting was recommended in drinking water instead. Since PFAS are understood not to act via a genotoxic mode of action for eliciting cancer, this part of the methodology is not consistent with Australian science policy. Therefore, this criterion has been assigned a '1/2'.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	Y	Typically 1 in a million.
Summary: Total # of 'Must-Have' criteria met (or not applicable): 16.5/20 = 82.5% Total # of 'Should-Have' criteria met (or not applicable): 9/10 = 90% Total # of 'May-Have' criteria met (or not applicable): 2/2 = 100%			

D.1.21 US EPA 2021e

Agency Report Reference: *USEPA (2021e). Human Health Toxicity Values for Hexafluoropropylene Oxide (HFPO) Dimer Acid and Its Ammonium Salt (CASRN 13252-13-6 and CASRN 62037-80-3). Also Known as "GenX Chemicals". EPA-Final. EPA Document Number: 822R-21-010. October 2021. United States Environmental Protection Agency (USEPA).*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		

Criteria		Y/N/?/NA	Notes
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	Y	
	Are the administrative processes documented and publicly available?	Y	
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	N	
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Federal Government of USA.
	Was there public consultation on this work? If so, provide details.	Y	Yes, draft was released for public comment.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	Y	
	Was the guidance/advice developed or updated recently? Provide details.	NA	
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	Y	
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	Y	The unpublished confidential studies forming the basis of the GenX guidance value were conducted in accordance with standardised testing guidelines.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	Y	
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	Y	
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	Y	

Criteria		Y/N/?/NA	Notes
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	NA	Although other reviews are cited, US EPA used their own independent assessment to come to conclusions.
	Can grey literature such as government reports and policy documents be included?	Y	
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	
	Evidence search		
	Are databases and other sources of evidence specified?	Y	
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	Y	
	Is it specified what date range the literature search covers? Is there a justification?	Y	
	Are search terms and/or search strings specified?	Y	
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	Y	Studies excluded included the following: • Ecological species. • Study population is not exposed to HFPO dimer acid and/or its ammonium salt. • Exposure is a mixture only without evaluating HFPO dimer acid and/or its ammonium salt individually. • Not on topic (details listed in Appendix A of US EPA 2021e).

Criteria		Y/N/?/NA	Notes
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	Y	Yes, study quality was determined by two independent reviewers who assessed risk of bias and sensitivity for the following domains: reporting quality, risk of bias (selection or performance bias, confounding/variable control, and reporting or attrition bias), and study sensitivity (exposure methods sensitivity, and outcome measures and results display) using EPA's version of HAWC. A third reviewer made the final decision on the quality ratings based on the primary ratings. The results of the study quality evaluation are provided as an interactive version of the heatmap.
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	Y	Yes, full details provided in report in Section 3.3.
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	Y	Yes, confidence is assigned to the levels of evidence and an overall weight of evidence is examined to describe certainty in the evidence. Formal certainty ratings do not appear to be derived.
	Derivation of health-based guideline values		
	Is there justification for the choice of uncertainty and safety factors?	Y	
	Are the parameter value assumptions documented and explained?	Y	
	Are the mathematical workings/algorithms clearly documented and explained?	Y	
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	NA	
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	Y	

Criteria		Y/N/?/NA	Notes
	What processes are used when expert judgement is required and applied? Is the process documented and published?	Y	See previous response on risk of bias & use of third reviewer to make a final decision.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	Yes, where possible.
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	1/2	Low-dose linear extrapolation is used for any chemicals causing cancer. A cancer-based value was not derived by US EPA due to insufficient information for GenX. Since PFAS are understood not to act via a genotoxic mode of action for eliciting cancer, this part of the methodology is not consistent with Australian science policy. Therefore, this criterion has been assigned a '1/2'.
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	Y	Typically 1 in a million.
Summary: Total # of 'Must-Have' criteria met (or not applicable): 18.5/21 = 92.5% Total # of 'Should-Have' criteria met (or not applicable): 10/10 = 100% Total # of 'May-Have' criteria met (or not applicable): 2/2 = 100%			

D.1.22 US EPA 2023

Agency Report Reference: *USEPA (2023). IRIS Toxicological Review of Perfluorohexanesulfonic Acid (PFHxS, CASRN 335-46-4) and Related Salts. EPA Publication # EPA/635/R-23/148a. External Review Draft. July 2023. United States Environmental Protection Agency (USEPA).*

Criteria		Y/N/?/NA	Notes
	Overall guidance/advice development process		
	Are the key stages of the organisation's advice development processes compatible with Australian processes?	Y	-

Criteria		Y/N/?/NA	Notes
	Are the administrative processes documented and publicly available?	Y	-
	Was the work overseen by an expert advisory committee? Are potential conflicts of interest of committee members declared, managed and/or reported?	N	
	Are funding sources declared?	Y	Funding sources not provided in report, but likely funded by the Federal Government of USA.
	Was there public consultation on this work? If so, provide details.	Y	Yes, draft was released for public comment.
	Is the advice peer reviewed? If so, is the peer review outcome documented and/or published?	Y	-
	Was the guidance/advice developed or updated recently? Provide details.	Y	This guidance was release in 2023 and is draft for public comment.
	Evidence review parameters		
	Are decisions about scope, definitions and evidence review parameters documented and publicly available?	Y	
	Is there a preference for data from studies that follow agreed international protocols or meet appropriate industry standards?	Y	In the rationale for reporting quality of individual studies, reviewers indicated whether the study adhered to OECD or other testing guidelines.
	Does the organisation use or undertake systematic literature review methods to identify and select data underpinning the advice? Are the methods used documented clearly?	Y	-
	If proprietary/confidential studies or data are considered by the agency, are these appropriately described/recorded?	Y	-
	Are inclusion/exclusion criteria used to select or exclude certain studies from the review? If so, is justification provided?	Y	-

Criteria		Y/N/?/NA	Notes
	Does the organisation use or adopt review findings or risk assessments from other organisations? What process was used to critically assess these external findings?	NA	Although other reviews are cited, US EPA used their own independent assessment to come to conclusions.
	Can grey literature such as government reports and policy documents be included?	Y	-
	Is there documentation and justification on the selection of a toxicological endpoint for use as point of departure for health-based guideline derivation?	Y	-
	Evidence search		
	Are databases and other sources of evidence specified?	Y	-
	Does the literature search cover at least more than one scientific database as well as additional sources (which may include government reports and grey literature)?	Y	-
	Is it specified what date range the literature search covers? Is there a justification?	N	The search date range appears unlimited.
	Are search terms and/or search strings specified?	Y	-
	Are there any other exclusion criteria for literature (e.g. publication language, publication dates)? If so, what are they and are they appropriate?	Y	Studies excluded did not meet the populations, exposures, comparators, and outcomes (PECO) eligibility criteria:
	Is risk of bias of individual studies taken into consideration to assess internal validity? If so, what tools are used? If not, was any method used to assess study quality?	Y	Yes, study quality was determined by two independent reviewers who assessed risk of bias and sensitivity for the following domains: reporting quality, risk of bias (selection or performance bias, confounding/variable control, and reporting or attrition bias), and study sensitivity (exposure methods sensitivity, and outcome measures and results display) using EPA's version of HAWC. A third reviewer made the final decision on the quality ratings based on the primary ratings. The results of the study quality evaluation are provided as an interactive version of the heatmap.

Criteria		Y/N/?/NA	Notes
	Does the organisation use a systematic or some other methodological approach to synthesise the evidence (i.e. to assess and summarise the information provided in the studies)? If so, provide details.	Y	Yes, full details provided in report in Section 3.
	Does the organisation assess the overall certainty of the evidence and reach recommendations? If so, provide details.	Y	Yes, confidence is assigned to the levels of evidence and an overall weight of evidence is examined to describe certainty in the evidence. Formal certainty ratings do not appear to be derived.
	Derivation of health-based guideline values		
	Is there justification for the choice of uncertainty and safety factors?	Y	-
	Are the parameter value assumptions documented and explained?	Y	-
	Are the mathematical workings/algorithms clearly documented and explained?	Y	-
	Does the organisation take into consideration non-health related matters to account for feasibility of implementing the guideline values (e.g. measurement attainability)?	NA	-
	Is there documentation directing use of mechanistic, mode of action, or key events in adverse outcome pathways in deriving health-based guideline values?	Y	-
	What processes are used when expert judgement is required and applied? Is the process documented and published?	Y	See previous response on risk of bias & use of third reviewer to make a final decision.
	Is dose response modelling (e.g. BMDL) routinely used?	Y	Yes, where possible.
	What is the organisation's policy for dealing with substances for which a non-threshold mode of action may be applicable in humans? Has the policy been articulated and recorded?	1/2	Low-dose linear extrapolation is used for any chemicals causing cancer. A cancer-based value was not derived by US EPA due to insufficient information for PFHxS. Since PFAS are understood not to act via a genotoxic mode of action for eliciting cancer, this part of the methodology is not consistent with Australian science policy. Therefore, this criterion has been assigned a '1/2'.

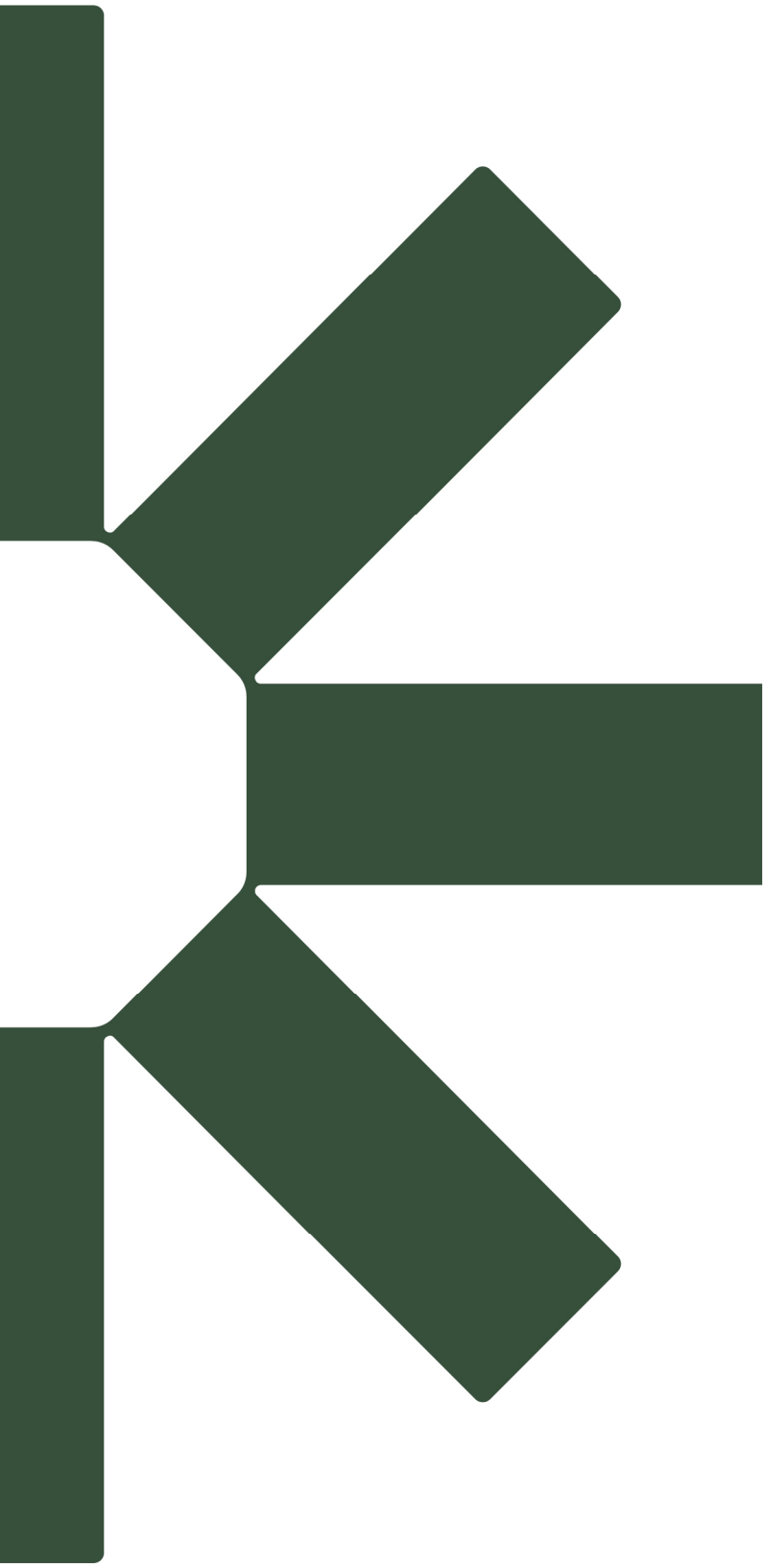
Criteria		Y/N/?/NA	Notes
	If applicable: For carcinogens, what is the level of cancer risk used by the organisation to set the health-based guideline value?	Y	Typically 1 in a million.

Summary:

Total # of 'Must-Have' criteria met (or not applicable): 17.5/20 = 87.5%

Total # of 'Should-Have' criteria met (or not applicable): 10/10 = 100%

Total # of 'May-Have' criteria met (or not applicable): 2/2 = 100%



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