PFAS National Environmental Management Plan

CONSULTATION DRAFT | AUGUST 2017

HEPA

Foreword

There is increasing concern worldwide about the environmental and human health impacts from the use of a group of manufactured chemicals known as PFAS (per-and poly-fluoroalkyl substances). Since the mid-1900s, PFAS have been used in industrial and commercial applications, such as in firefighting foams, mist suppressants and coatings. PFAS are highly resistant to heat, chemical and biological attack. Consequently, they persist in the environment and occur in many places, including soil, surface water and groundwater.

In Australia, we have many sites affected by PFAS contamination. This is a legacy issue that we need to deal with and represents a challenge for us as regulators. It is a challenge best dealt with collectively, noting that each jurisdiction has its own responsibilities and obligations for managing these chemicals.

The Heads of EPAs Australia and New Zealand (HEPA) and the Australian Government Department of the Environment and Energy (DoEE) are collaborating in developing a nationally consistent approach to the environmental regulation of PFAS and progressing it at the request of Environment Ministers around Australia. HEPA is well placed to tackle emerging issues such as PFAS, where scientific advances are outpacing our current regulatory frameworks. Through HEPA, the regulators will work together to develop this PFAS National Environmental Management Plan to achieve clear, effective and coherent approaches to environmental regulation and management.

Consultation is an indispensable component of the development of a sound PFAS National Environmental Management Plan. Thank you for your time and consideration of this plan. Your involvement in the process to develop the PFAS National Environmental Management Plan will ensure that we build on activities already underway, implement best practice approaches and manage PFAS in a manner that aims to match your expectations.

Acknowledgments

The Heads of EPAs Australia and New Zealand (HEPA) acknowledge the contributions to this plan of Commonwealth, State and Territory agencies.

Contents

Preface

The per-and poly-fluoroalkyl substances (PFAS) National Environmental Management Plan (NEMP) aims to provide governments with a consistent, practical, risk-based framework for the environmental regulation of PFAS-contaminated materials and sites. The PFAS NEMP is being developed as an adaptive plan, able to respond to emerging research and knowledge.

The National Chemicals Working Group of the Heads of EPAs Australia and New Zealand (HEPA) is developing the plan in consultation with relevant Australian Government and State and Territory agencies. The PFAS NEMP seeks to build a nationally collaborative approach and national consistency in priority areas, allowing for the implementation of actions in a way that becomes 'business as usual'. The plan is being developed by all jurisdictions and recognises the need for implementation of best practice regulation through individual jurisdictional mechanisms.

The PFAS NEMP is expected to be a reference on the state of knowledge related to the environmental regulation of PFAS. The plan will also represent a how-to guide for the investigation and management of PFAS contamination and waste management, including best practice approaches, which will be called upon to inform actions by EPAs. It is important to recognise that a practical balance will be required between the desire for perfect understanding and moving forward with management actions.

This PFAS NEMP Consultation Draft provides some background on the state of knowledge of environmental regulation of PFAS and seeks feedback on experiences and views.

Comments on the questions in this Consultation Paper are requested by Monday, 25 September 2017. Your feedback will inform the development of the PFAS National Environmental Management Plan, which is expected to be provided to HEPA late in 2017.

If you wish to make a written submission, you may like to use the template provided on the website. Written submissions can be sent to email: PFASNEMP@epa.vic.gov.au

Mail: PFAS NEMP Consultation Feedback
c/o- Applied Science Directorate, EPA Victoria
GPO Box 4395 Melbourne VIC 3001

If you would like to receive email updates on the PFAS NEMP, including details of opportunities for further participation in its development, please email us at PFASNEMP@epa.vic.gov.au

Your comments will help the development of the PFAS NEMP. Please clearly state if you would like your contribution to remain confidential. Note that Freedom of Information access requirements will apply to all comments, even those marked and treated as confidential. Accordingly, your comments may be released to the public.

Abbreviations

AELERT	Australasian Environmental Law Enforcement and Regulators network
ASC NEPM	National Environment Protection (Assessment of Site Contamination) Measure
bw	body weight
CRC CARE	Cooperative Research Centre for Contamination Assessment and Remediation of the Environment
DoEE	Commonwealth Department of the Environment and Energy
DW	drinking water
enHealth	Standing Committee on Environmental Health
EPA	Environmental Protection Agency
FSANZ	Food Standards Australia New Zealand
HEPA	Heads of EPAs Australia and New Zealand
kg	kilogram
L	litre
LCMS	liquid chromatography–mass spectrometry
mg	milligrams (10−3g)
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
ng	nanograms (10−9g)
NHMRC	National Health and Medical Research Council
NMI	National Measurement Institute
NEMP	National Environmental Management Plan
NWQMS	National Water Quality Management Strategy
PCB	polychlorinated biphenyl
PFAS	per- and poly-fluoroalkyl substances
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexane sulfonate
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PFOSA	perfluorooctane sulfonamide
RWQ	recreational water quality
TDI	tolerable daily intake
TOF	total organic fluorine
TOPA	total oxidisable precursor assay
µg	micrograms (10−6g)
Water Quality Guidelines	Australian and New Zealand Guidelines for Fresh and Marine Water Quality

Executive summary

This PFAS National Environmental Management Plan (NEMP) Consultation Draft arises from an April 2017 regulators summit at which jurisdictions agreed to develop a nationally consistent approach to the environmental regulation of PFAS. This Consultation Draft serves as the basis for feedback on experiences and views on the environmental regulation of PFAS.

The consultation process will inform the development of the PFAS NEMP (the plan), which will provide a consistent, practical, risk-based framework for the assessment and management of PFAS contamination. Development and implementation of the plan will build trust and confidence in the way in which PFAS are managed and ensure that people enjoy the benefit of equivalent protection from PFAS contamination wherever they live in Australia.

The National Chemicals Working Group of the Heads of EPAs Australia and New Zealand (HEPA) is developing the plan in consultation with relevant Australian Government, State and Territory agencies. The plan will represent the state of knowledge on environmental regulation of PFAS and will present information on the investigation and management of contamination and waste, and on treatment and remediation. The plan will be periodically reviewed and updated as new information becomes available.

Guiding principles include a focus on protection of human health and the environment. The precautionary principle states that where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.

This document introduces PFAS, their applications and their persistence in the environment and a recognition that sound environmental management is important for protecting human health. Health-based guidance values for PFAS have been agreed by authorities in Australia and are listed in this document for ease of reference. There is information on the value of a national stocktake of stockpiles and contamination and criteria for determining priority areas for assessment. Examples of environment and health criteria used to inform site investigations are also provided, again for ease of reference.

There is information on site assessment and management, which should include determining the risk to receptors associated with land and resource uses and off-site movement. Further discussion is provided on management of contaminated sites, containment, remediation and treatment, landfill disposal, performance standards for treatment and destruction facilities, and storage and transport.

There are many PFAS compounds and only a few available analytical methods. The preferred approach is to use commercially available methods for the main compounds, including PFOS, PFOA and PFHxS. Subsequently, techniques such as Total Oxidisable Precursor Assay (TOPA) and the determination of Total Organic Fluorine (TOF) can indicate the amount of other PFAS present. This can provide regulators with information on the total PFAS burden and potential risks associated with the other PFAS present.

The document acknowledges the importance of effective stakeholder engagement, communication and of data sharing between jurisdictions. The PFAS NEMP needs to recognise the considerable uncertainty associated with establishing guidelines and standards, be flexible and adaptable and subject to regular evaluation and review.

Introduction

Manufactured chemicals called per- and poly-fluoroalkyl substances (PFAS) and their derivatives have many applications. These chemicals provide resistance to heat, other chemicals or to abrasion, and can be used as dispersion, wetting or surface-treatment agents.

PFAS and their derivatives have been used for many decades in industrial processes and consumer products, including in aqueous film forming foams for firefighting, chromium plating (in plastic etching and as a mist suppressant to protect workers from toxic hexavalent chromium fumes), medical imaging (e.g. x-ray films), various fabric and cooking applications, paper treatments, and in aviation hydraulic fluid.

There are at least 3,000 PFAS (see Appendix A: PFAS sub-classes), with about 200 to 600 estimated to occur in, or result from, firefighting foams. The PFAS of greatest concern are PFOS (perfluorooctane sulfonate) and PFOA (perfluorooctanoic acid). These two chemical families have been manufactured and used since the mid-20th century and are the most commonly found in the environment. There are also increasing concerns about PFHxS (perfluorohexane sulfonate), PFOS and PFOA homologues, precursors and transformation compounds.

Due to their widespread application and persistence in the environment, PFAS occur in Australia at low concentrations in soil, sediment, surface water, groundwater, biota and waste including solid waste (such as construction debris and biosolids) and waste water (effluent from sewage treatment plants). PFAS are rapidly dispersed into the environment through surface water run-off and leaching to groundwater.

There is some certainty on PFAS persistence, bioaccumulation and ecological toxicity, particularly PFOS, PFOA and PFHxS; but uncertainty on human toxicity. Effective management requires that all significant environmental risks be recognised and managed and that exposure is limited, noting that the chemicals can readily find their way into the environment beyond the original source.

PFAS regulators Summit

In April 2017, EPA Victoria, on behalf of HEPA and the Australian Government Department of the Environment and Energy, hosted a summit of national and international regulators of PFAS-related issues. The summit outcomes, after being provided to HEPA for consideration, have been used to support the development of this PFAS NEMP Consultation Draft, which outlines a nationally consistent approach to the environmental regulation of PFAS.

Summit participants agreed on the application of the 'precautionary principle' to the environmental regulation of PFAS. The precautionary principle means that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. Additionally, decision-making should be guided by a careful evaluation to avoid serious or irreversible damage to the environment wherever practicable, and an assessment of the risk-weighted consequences of various options.[2]

Summit participants also agreed on the need for a nationally consistent approach. Such an approach would help ensure that sound environmental practices are applied to the environmental regulation of PFAS across Australia. Components of this approach to nationally consistent regulation include an agreed approach to management and data sharing, collaboration of national technical and policy experts and a nationally coordinated and funded research program.

1 Wang Z, DeWitt J, Higgins C, Cousins I (2017). A Never-Ending Story of Per- and Polyfluoroalkyl Substances (PFAS)? Environ. Sci. Technol., 51 (5): 2508–2518.

2 http://www.epa.vic.gov.au/~/media/Publications/1554.pdf

Purpose and scope

The aim of the PFAS NEMP will be to present a nationally consistent and collaborative approach to the environmental regulation of PFAS. The plan will give confidence to decision-makers and recognise limitations on the management of PFAS imposed by international conventions, such as the Stockholm Convention.

Given PFAS contamination concerns and the number of affected stakeholders, timely and pragmatic decisions are required. The PFAS NEMP is expected to guide decision making, including presenting details of best practice approaches and processes in PFAS investigation, contaminated material and site management, and treatment and remediation. The PFAS NEMP is not expected to deal with the use of PFAS compounds, noting that this may be addressed through State and Territory policies and regulations or through Stockholm Convention ratification decisions and domestic regulation or policies to implement those decisions.

It is expected that the PFAS NEMP will initially focus on a smaller list of PFAS compounds for quantitative assessment: PFOS, PFOA and PFHxS, but that comprehensive consideration of other PFAS compounds will inform uncertainty and risk management decisions. The plan will provide clarity on analytical standards and methods for establishing quantitative environmental levels and qualitative considerations.

This initial focus on PFOS, PFOA and PFHxS is supported by other environmental quality protection standards and guidelines that are being introduced within Australia. At this time, the Water Quality Guidelines have considered only PFOS and PFOA and the human health criteria PFOS, PFOA and PFHxS.

Importantly, international approaches are considering the potential need to manage impacts associated with a much larger number of PFAS compounds as well as total organic fluorine. Additionally, data collected at contaminated sites around Australia is starting to show that the percentage of other PFAS collectively can be considerably higher than those of PFOS, PFOA and PFHxS. Some jurisdictions are already requiring information on a broader range of compounds.

A commitment to the PFAS NEMP being an adaptive document will mean that as information and data become available on other PFAS compounds and analytical techniques, they will be considered for incorporation. Given different legislative frameworks between jurisdictions, the PFAS NEMP will be flexible in its approach to enable implementation by individual jurisdictions while also seeking to establish, where appropriate, a nationally consistent approach.

The complexity concerning cross-boundary environmental considerations of PFAS management, including the roles of Local, State and Territory governments, and the Australian Government is also acknowledged. The PFAS NEMP will seek to provide a commonly agreed approach, which will facilitate the resolution of differences that may arise between governments and their agencies.

QUESTION 1: Is the proposed purpose and scope, including the initial focus on PFOS, PFOA and PFHxS of the PFAS NEMP appropriate to address legacy PFAS contamination issues. What else would be required to enable a nationally consistent approach that enables decision making? Why do you think this? What are the priority areas where national consistency would be desirable?

Guiding principles

The following principles are expected to underpin the PFAS NEMP:

1. A focus on protection of human health and the environment.
2. The precautionary principle such that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
3. The best practice approaches and processes included will be informed by existing national guidelines, including the National Environment Protection (Assessment of Site Contamination) Measure, Water Quality Guidelines and applicable research.
4. Best practice approaches shall be applied to the management of legacy PFAS contamination.[3]
5. The document should draw on accepted current scientific understanding from both domestic and international sources, noting that it will be adapted and improved as research progresses.
6. The approach to PFAS assessment is to be based on soundly evaluated and nationally agreed analytical methods and analytical standards.
7. Consistency between State/Territory and Commonwealth approaches will be supported by protocols, standard procedures, and consideration of accountability.
8. Actions should be proportionate to risks, include identification and management of exposure pathways, be informed by scientific evidence, and reflect national and international obligations.
9. Where existing guidelines/approaches do not adequately foresee or address an identified environment risk, responses should be guided by available scientific approaches and the precautionary principle.
10. Addressing cross boundary issues should be coordinated and consistent with any relevant environmental laws.
11. Management, while being protective, needs to consider economic and social matters and acknowledge the limited options currently available for remediation.
12. Intergenerational equity, conservation of biological diversity and ecological integrity should be considered in all decision making.

Managing uncertainty

There are commercially available analytical techniques to measure fewer than 30 of the thousands of known PFAS. Some of the remaining compounds can be identified through advanced analytical techniques. However, there are still thousands of chemicals that cannot be measured.

The approach of measuring individual chemicals or families of chemicals (e.g. PFOS and PFOA) is important for setting environment quality guidelines and objectives (water, sediment and soil quality guidelines, leaching guidelines etc.) and monitoring progress towards meeting those objectives.

Toxicological and ecotoxicological data are usually generated for individual chemicals. Of the PFAS compounds that have been identified, comprehensive toxicological data is available for only a few. Moreover, PFAS compounds are always found as complex mixtures. For any mixture of PFAS compounds, it is unclear whether the toxicity of the compounds will act in an additive, synergistic or antagonistic manner. Also, the amount and variety of PFAS compounds may be influenced by the nature of the PFAS source, the amount of time the PFAS have been present in the environment, movement and dispersion from the source and the characteristics of the environment. Despite these uncertainties, the community, industry and other agencies expect regulators to manage PFAS-contaminated materials and sites.

Some analytical approaches have emerged to provide an indication of the total amount of PFAS present in a sample. The Total Oxidisable Precursor Assay (TOPA) can provide an indication of the presence of chemical compounds that are likely to transform into PFAS compounds (precursors). The determination of Total Organic Fluorine (TOF) can estimate the total amount of organic fluorine in compounds including all PFAS and precursor compounds. These analyses can be used to inform management options. When such an estimate is compared to the mass of the standard suite of analytes, the difference will indicate the amount of other PFAS compounds present. If the percentage of other PFAS compounds is low, this provides more certainty about the specific PFAS compounds present. Conversely, if the percentage of other PFAS compounds is high, the regulator has more uncertainty with a greater potential risk to manage.

[3] A best practice is a method that has been generally accepted as superior to alternatives because it produces results better than those achieved by other means or because it has become a standard way of doing things.

Other relevant plans and guidelines

The PFAS NEMP will provide an overarching framework that recognises existing national instruments, including the Australian and New Zealand Guidelines for Fresh and Marine Water Quality, the National Environment Protection (Assessment of Site Contamination) Measure 1999 (ASC NEPM) and the National Environment Protection (Movement of Controlled Waste between States and Territories) Measure 1998.

Human health reference values are best determined by health authorities. Hence, the plan will include material from the Commonwealth Department of Health document, *Health Based Guidance Values for PFAS*, and the associated standards (2017).

Some jurisdictions have interim guidelines and other support materials for the management of PFAS. It is expected that these will be reviewed either during the development of the PFAS NEMP or once it has been established. It is a goal that the plan will include investigation levels that would be nationally accepted (e.g. investigation, remediation and waste management related criteria).

Importantly, consideration must be given to requirements that will be established through current and future Stockholm Convention ratification processes including that currently underway for PFOS. Outcomes from this process may require changes to the PFAS NEMP and consideration of activities that have been taken to address PFAS-contaminated materials and sites.

Australia's response to the Stockholm Convention for Persistent Organic Pollutants

Work is already underway to consider the use of PFOS, its salts and PFOA-related chemicals as part of the ratification process for its listing in the Stockholm Convention for Persistent Organic Pollutants.

The objective of the Stockholm Convention is to protect human health and the environment from the impacts of persistent organic pollutants. PFOS was listed on Annex B (restriction) of the Stockholm Convention in 2009. The Australian Government Department of the Environment and Energy has prioritised the treaty-making process to inform an Australian Government decision on ratification of the listing of PFOS. The treaty-making process includes analytical, consultative and parliamentary steps. These steps are critical to ensure any management measures deliver the desired environmental outcomes, and that potential impacts (such as economic impacts on industry) are manageable. A Regulation Impact Statement on options for the national phase-out of PFOS in the context of the Stockholm Convention is expected to be released for public consultation in mid-2017.

PFOA, its salts and PFOA-related compounds were nominated in 2015 for listing on the Stockholm Convention. The earliest date for the Convention's decision-making body to decide on the listing of PFOA to the Convention will be in 2019. Australia will continue to participate in the Convention's processes and in addressing any domestic implementation requirements that may result.

Australian ratification of the listing of PFOS or the potential future listing of PFOA in the Stockholm Convention, would mean acceptance of international standards, including requirements in regards to waste that has PFOS or PFOA (or related chemicals) above agreed limits.

1 Human health

1.1 Protection of the environment and human health is intimately linked. Sound environmental management is important for protecting human health.

1.2 The PFAS NEMP does not seek to duplicate the guidance provided on human health by public health agencies in Australia, nor does it aim to specify Australian-derived health-based guidance values for the protection of human health.

1.3 Health based guidance values for PFAS were released in April 2017. See Appendix B: Australian interim/ draft criteria and standards for PFAS for a listing of the health based guidance values as well as the drinking and recreational water quality values.

1.4 The Australian Government Department of Health advises that there is no consistent evidence that exposure to PFAS causes adverse health effects in humans. However, as these chemicals persist in humans and the environment, it is recommended that people in affected communities minimise their exposure and, where possible, avoid prolonged exposure. (The health based guidance values recommended by FSANZ are a precautionary measure while further research is conducted into potential health effects of PFAS.)

1.5 TDIs developed by FSANZ, where available, should be used for human health risk assessment. For any other PFAS encountered, advice should be sought from health authorities and consideration given to current research and any relevant international approaches.

1.6 For further information, please refer to the Australian Government Department of Health factsheet.[4]

[4] http://www.health.gov.au/internet/main/publishing.nsf/Content/44CB8059934695D6CA25802800245F06/$File/Health-effects-exposure-pathways.pdf

2 PFAS occurrence

2.1 Some PFAS, including PFOS and PFOA and their precursors (e.g. perfluorooctane sulfonamide) and various homologues (e.g. PFHxS), have been globally identified as chemicals of high concern due to their environmental persistence and bioaccumulation potential.

Australian occurrence

2.2 Accurate estimates of the volume of PFAS-contaminated waste, soils and water are not available. There have been national and individual jurisdiction studies, including desktop assessment of stockpiles and historical contamination. Several jurisdictions are undertaking detailed stocktakes and have legacy site management programs that include PFAS-contaminated sites.

2.3 A PFAS stocktake would gather information on the volume of PFAS materials, or PFAS-containing wastes, and a survey would determine the known extent of PFAS contamination in the environment. Surveys should also include current usage and management practices so that risks of incidents can be estimated and proactive actions prioritised to areas of highest risk. Ideally, information should be collected in a nationally consistent manner or agreement developed on how to make any disparate data at least partially comparable.

2.4 It is proposed that the PFAS NEMP would provide best practice approaches for the study of PFAS-contaminated materials and wastes. The plan may focus on:

- PFAS-containing wastes (e.g. waste firefighting foam, contaminated solid wastes, liquid wastes and concentrates from remediation works)
- PFAS-impacted soil stockpiles
- In-situ PFAS-contaminated soils
- PFAS-contaminated sites including groundwater plumes and impacted surface water.

2.5 Ambient concentrations of PFAS in the environment, not affected by contaminated sites, are poorly understood. Governments and research groups have started to assess the presence of PFAS compounds in different segments of the environment around Australia. Assessment of ambient PFAS concentrations should also be a goal of the NEMP.

2.6 As governments have different legislative powers for the collection of information (some collect data themselves and some require this of polluters), the PFAS NEMP is expected to facilitate the sharing of data on sources, pathways and receptors to build a national understanding of PFAS in the environment. It is expected that the PFAS NEMP will aim to establish a nationally consistent approach to the collection of prioritised data, such as situations where contamination is likely to have moved off site. The plan may include information on stockpiles and contaminated sites, including waste and contaminated soil, and identify potential industry sources as well as legacy sources.

QUESTION 2: What information would further inform the Australian occurrence of PFAS-contaminated materials and sites? Can you contribute to this information? What might limit your ability to provide this information?

Notifiable quantity

2.7 It is expected that the PFAS NEMP will include a best practice approach to notification as this will help in generating a more complete understanding of the extent of stockpiles and contaminated materials.

2.8 Given different jurisdictional legislative systems, the best practice approach will have to be established by individual jurisdictions for implementation. Notification could be included in national implementation arrangements if the listing of PFOS under the Stockholm Convention is ratified.

Priority areas for assessment

2.9 When prioritising sites for assessment, the following factors are relevant:

- scale of prior and current PFAS use on site
- did use disperse PFAS widely or was it captured and managed
- likelihood of off-site migration
- proximity to agriculture, animal husbandry and aquaculture
- proximity and sensitivity of human receptors and aquatic and terrestrial ecosystems
- presence of exposure pathways
- use of soil, groundwater and surface water.

2.10 Social and community needs, such as maintaining operations at airports, bulk fuel storage facilities and ports, should also be considered as part of site assessments.

2.11 Prioritisation of sites for assessment of PFAS contamination and approaches to risk management, including remediation, should be proportionate to risks, and consistent with sound environmental practices and national and international obligations (See Section 4: Contaminated sites assessment). Potential economic and social implications of management actions will need to be considered and well communicated.

2.12 Some jurisdictions already have comprehensive frameworks for assessing PFAS-contaminated sites. Consistent with the ASC NEPM, a pragmatic approach may be to provide minimum criteria that would provide equivalent levels of environment and human health protection.

3 Environmental and health criteria

Introduction

3.1 The aim of the PFAS NEMP is to establish a nationally agreed suite of criteria that would be used to inform site investigations at sites contaminated with PFAS. The following are some examples of criteria (e.g. standards or guidelines) that may be included, noting that jurisdictions may have additional requirements:

- soil and sediment investigation levels
- surface water, groundwater, marine water, recycled water and wastewater criteria
- waste disposal guidance (including guidance for disposal to sewerage and landfills)
- biosolid land application guidelines
- acceptable soil and waste re-use criteria including where reuse may not be suitable.

3.2 Some jurisdictions have released interim or draft criteria. It is expected that these will form the basis for the development of the PFAS NEMP criteria. There are some criteria that will not be able to be set until information gaps are filled. For example, there are currently no data to support ecological criteria for sediments. (See Appendix B: Australian interim/ draft criteria and standards for PFAS for a summary, including references to relevant documents.)

QUESTION 3: What priority environment and human health criteria should be included in the PFAS NEMP. Can you provide any resources, such as technical reports or reviews, that should be considered?

Health-based guidance values

3.3 As human health reference values are best determined by health authorities, the Commonwealth Department of Health document, *Health Based Guidance Values for PFAS*, in particular, the Tolerable Daily Intake values, are expected to be used to inform criteria values established in the PFAS NEMP.

3.4 These values, as provided in Section 1. Human health, have been developed based on the April 2017, Food Standards Australia New Zealand (FSANZ) tolerable daily intake values for perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS).

Ecological protection values for fresh and marine water

3.5 Draft freshwater quality guideline values for ecological protection for PFOS and PFOA have been developed under the National Water Quality Management Strategy, which sets out a framework for water quality management and recognises that water quality objectives can be set for a catchment or be site-specific. The PFOS and PFOA values have been calculated according to the agreed methodology, which has also been used for all other guideline values in use around Australia. Noting that because of the persistence and bioaccumulative nature of PFOS and PFOA, studies with multigenerational endpoints are important considerations. See Appendix B: Australian interim/draft criteria and standards for PFAS.

3.6 Proposed marine water quality guideline values for ecological protection for PFOS and PFOA have been suggested by CRC CARE and, while published as drafts in 2017, have not been submitted under the National Water Quality Management Strategy third party nomination process.

3.7 The Water Quality Guidelines (Volume 2 Section 8.3.4.4) advise that for estuarine waters, in the absence of specifically estuarine toxicity data, users should adopt the lower of the two values (marine or estuarine) and whatever salinity corrections are available, using the risk-based decision tree approach outlined in Section 3.4.3 of the document.

3.8 In incident investigations, the product released will often be known and samples available. Given that these are likely to be complex mixtures with potential for additive and synergistic effects, direct toxicity tests carried out using the spilled product should be considered where there is inadequate information to evaluate toxicity. Bioaccumulation could also be considered by measuring PFAS in key receptor species.

Soils

3.9 As mentioned above, it is expected that the PFAS NEMP will include a set of criteria for soils based on the most recent health and environmental guidance values.

3.10 Some jurisdictions have undertaken determination of environmental criteria for soils using standard calculation methods described in the National Environment Protection (Assessment of Site Contamination) Measure (ASC NEPM). However, some of these values were determined before the introduction of the most recent health based guidance values so will need to be reconsidered. See Appendix B: Australian interim/draft criteria and standards for PFAS for a listing of these soil criteria.

3.11 Many jurisdictions require that these values should be used only in conjunction with a specific site assessment, as consideration must be given to leaching potential, off-site transport, bioaccumulation and secondary exposure. Further work will be undertaken in the development of the PFAS NEMP to determine the appropriateness of soil screening values and requirements for site specific risk assessment.

3.12 **Investigation levels for soils**
Adapted from the ASC NEPM

What investigation levels do:

- provide a guide on when more detailed investigation might be appropriate

What investigation levels are not:

- mandatory
- levels up to which contamination may be allowed to occur
- trigger levels for remediation
- clean-up or response levels
- default values for regulating specific emissions and/or application of wastes to soils.

QUESTION 4: What resources (e.g. Explanatory notes or guidelines) would be useful to accompany criteria values to explain how and why these values are set and what they mean for assessment of a contaminated site? How should the plan include or reference these resources?

4 Contaminated sites assessment

4.1 Due to the complexity of most PFAS-contaminated sites, site assessment and management should include a site-specific risk assessment to determine the risk to receptors associated with land and resource uses. Off-site movement and multiple sources of contamination need to be considered.

4.2 The interplay between surface water and groundwater transport can be complex. PFAS can be rapidly carried a long way from the source in stormwater run-off. Surface water receptors have seasonally-variable interactions with groundwater. These factors mean that the development of a conceptual site model is more complex than for most other contaminants. PFAS site contamination may also move large distances in ground water or bioaccumulate in seafood some distance from sources due to ground and surface water interactions.

QUESTION 5: What are your observations of site assessment and management for PFAS-contaminated sites? Can you provide brief examples or case studies where a site assessment and management approach worked well and led to a good outcome on the site? Why do you think this worked well?

Site assessment and risk-based frameworks

4.3 The *National Environment Protection (Assessment of Site Contamination) Measure 1999* (ASC NEPM) provides a nationally consistent approach to the assessment of site contamination, including risk assessment. The ASC NEPM is broad-based and provides detailed guidance, which can be applied to a wide range of contaminants.

4.4 The ASC NEPM contains sufficient flexibility to incorporate assessment of PFAS. However, it is expected that the PFAS NEMP will include the development of additional PFAS-specific site assessment objectives, guidance and/or tools because of the chemicals' unique properties. For example, consideration of bioaccumulation and biota sampling when assessing a site is important for PFAS: this is not covered in the ASC NEPM. The interactions of PFAS with soils, and the mechanisms for bioaccumulation of PFAS, are different from those of other persistent organic pollutants. Hence, assessment approaches commonly applied to other persistent organic pollutants often do not work for PFAS, presenting further justification for including PFAS-specific guidance.

4.5 The following are expected to be considered for further development as part of the ongoing revision and updating of the plan:

- Additional site assessment guidance for PFAS that considers their unique physical and chemical properties, including the potential for significant movement from the source. Such guidance is expected to be retained and referred in the ASC NEPM toolbox and considered in future ASC NEPM amendments.
- Bioaccumulation and secondary exposure pathways in the management of soil and groundwater
- Surface drainage as a pathway to receptors
- Multiple sources of PFAS affecting a single receptor
- Leachability and mobility in soils and groundwater
- Protection of environmental values.

4.6 Duty holders or regulators may be required to prioritise sites for investigation. In some jurisdictions, there may be specific legislative requirements for these investigations. Determination of prioritisation factors, such as proximity to sensitive ecosystems, and the presence of exposure pathways, will enable the identification of key receptors and timely sampling to determine plausible exposure pathways.

QUESTION 6: What other PFAS specific resources are needed to accompany the ASC NEPM? What should these resources include? Are the important site investigation prioritisation factors identified?

5 Contaminated site management, including containment, remediation, treatment and disposal

5.1 The assessment and management of PFAS-contaminated sites have commenced at some Australian sites. These activities have demonstrated that given the persistence of PFAS in the environment and their ability to migrate through the water column, there should be early consideration of water flows and potential exposure pathways offsite from the contamination.

5.2 Early engagement with the local community is needed to assist with identifying potential exposure pathways. Depending on the exposure pathways, early preliminary advice may be required while further assessment occurs.

Contaminated site management

5.3 When considering the management of PFAS-contaminated sites, it will be important to use the information gathered during the site assessment to determine whether certain activities may be acceptable, including:

- agricultural land use and residential crop production
- water use for drinking and cooking, showering, swimming pools, and cleaning
- water use for irrigation and stock watering
- use of wastewater treatment plant biosolids.

5.4 It is expected that the plan will provide guidance associated with on- and off-site use of PFAS containing waters (e.g. irrigation and groundwater recharge) and solid waste (e.g. biosolids, sediments, soils and debris – including fill material). This may include the development of standards or guidance for

- low level PFAS-contaminated soil criteria
- biosolids land application values and guidance
- irrigation waters and groundwater recharge.

5.5 Each site is unique, but factors that should be considered in determining site management activities include the sensitivity of the local environment, the remobilisation risk associated with rainfall and flood, future land use, and agricultural applications. While remediation of some contaminated sites may be required, it may be necessary to manage some sites by controlling exposure pathways in the short to long term (e.g. through regulatory controls), rather than removing the contamination. Authorities will need to balance remediation costs with environmental, social and economic impacts and costs. Some sites that may have a greater potential impact on communities could require more significant intervention.

5.6 An important decision is whether to leave material in situ and implement measures to reduce mobility or remobilisation, or stockpile the material for future remediation rather than sending it to landfill. For many large-scale impact sites, management of the contamination in-situ is the only practicable option. Transport to landfill may result in further release of the PFAS compounds into the environment. For example, disposal of PFAS-containing landfill leachate to waste water treatment plants may introduce or add to existing PFAS into the effluent or biosolids. If site disturbance has the potential to lead to higher risk, disposal or destruction may be the best options.

5.7 Where possible, contaminated material should be managed on site, with transport off-site for treatment or disposal only being undertaken if necessary. Treatment to destroy or remove the PFAS contamination will reduce ongoing management requirements at the site. However, this approach may not be technologically or economically feasible.

5.8 Where PFAS contaminants are left on site, it may be necessary to evaluate risks by considering PFAS compounds other than PFOS, PFOA and PFHxS. For example, shorter chain PFAS are more amendable to transfer to plants whereas longer chain PFAS are more bioaccumulative in animals.

International guidance

5.9 The Australian Government Department of the Environment and Energy is managing Australia's consideration of ratification of the listing of PFOS its salts under the Stockholm Convention on Persistent Organic Pollutants. If the Government decides to ratify the listing and hence accept management responsibilities consistent with the agreed international approaches, implementation would include requirements that waste material containing above 50 mg/kg PFOS be treated using a technique that will destroy or irreversibly transform the chemicals. Requirements are set out in Section IV.G.3 of the Basel Convention's General technical guidelines on the environmentally sound management of waste consisting of, containing or contaminated with persistent organic pollutants.

5.10 Where destruction or irreversible transformation does not represent the environmentally preferable option for managing waste containing PFOS above this limit (because of other environmental or human health impacts), the PFOS in the contaminated soil or sediment could:

- be either immobilised or its mobility substantially reduced, for example by using emerging treatment/immobilisation technologies; or
- be disposed of in highly secure specially engineered landfill or, when commercially available in Australia, permanent storage in underground mines and formations, consistent with Section IV.G.3 of the Basel Convention's guidelines referred to above.

5.11 It is expected that the form of secure containment would need to be negotiated with the relevant State or Territory regulator.

Containment

5.12 In the short-term, containment of the source should focus on reducing risks to receptors. This may include capping or covering or may require more significantly engineered containment facilities. In the medium to long-term, the contained sources can be removed for destruction, particularly where ongoing containment presents unacceptable risks. Site-based and, where appropriate, catchment-based assessments of ongoing containment and management actions should be undertaken.

5.13 The mobility and bioaccumulating nature of PFAS, particularly through water, means that the design and management of contained sources needs to account for secondary contamination pathways such as plant uptake and uptake by animals.

5.14 It is expected that the plan will support the use of best practice environmental management or best available technologies for the containment of PFAS-contaminated materials and soils.

QUESTION 7: What experience have you had with the effective or ineffective containment of PFAS-contaminated materials and soils? Do you have examples or case studies that you can provide?

Remediation and treatment

5.15 The remediation and treatment of PFAS-contaminated materials, including solid and liquid wastes and soils, is hindered by limited knowledge of the extent of contamination across Australia; the likely quantities of materials and soils needing management on or off site; a shortage of reliable, proven treatment techniques; and limited management, treatment and disposal guidelines, policies and regulations. Clear policies, requirements and regulations could provide clarity to the market, thus facilitating planning, development or delivery of remediation and treatment options.

5.16 Remediation or treatment is impeded by the resistance of PFAS to common physical, chemical, and biological processes; their solubility and mobility in the environment; and the production of other PFAS compounds from precursors. Moreover, treating PFAS can create additional contaminated by-products and wastes.

5.17 The plan is expected to include a PFAS-specific hierarchy of options for management, including remediation and treatment. Presented below is an example of the ASC NEPM hierarchy of options for site clean-up.

QUESTION 8: What principles may be applicable to treatment and remediation of PFAS-contaminated materials. Why do you consider these principles important?

Preferred hierarchy of options for site clean-up

Adapted from the ASC NEPM

5.18 ***Most preferred:***

- on-site treatment of the contamination so that it is destroyed or the associated risk is reduced to an acceptable level; and
- off-site treatment of excavated soil (or contaminated waters), so that the contamination is destroyed or the associated risk is reduced to an acceptable level, after which soil is returned to the site or waters discharged.

5.19 ***If the above is not practicable:***

- consolidation and isolation of the soil (or contaminated waters) on site by containment with a properly designed barrier; and
- removal of contaminated material to an approved site or facility followed, where necessary, by replacement with appropriate material.

5.20 Where the assessment indicates that remediation would have no net environmental benefit or would have a net adverse environmental effect:

- implementation of an appropriate management strategy.

5.21 When deciding which option to choose, the sustainability (environmental, economic, social) of each option should be considered in terms of achieving an appropriate compromise between the benefits and effects of undertaking each option.

5.22 In cases where no readily available or economically feasible option is available for remediation, it may be possible to adopt appropriate regulatory controls or develop other forms of remediation.

5.23 The appropriateness of any option will vary depending on a range of local factors. Acceptance of any specific option or mix of options is therefore a matter for the responsible decision-maker/regulator.

5.24 Remediation is being hampered in Australia by the limited number of current, commercially available treatment facilities and technology options available for destroying PFAS. Many technologies are available or emerging for removal or immobilisation, but there are few options for destruction.

5.25 Granular activated carbon and resin-based technologies are the most advanced for separation of PFAS from water, and other remediation and treatment technologies, such as soil washing are being tested. Treatment options, such as those that immobilise PFAS in soils, are commercially available. However, there is limited information on the long-term stability of large volumes of treated soils.

5.26 High temperature destruction of some types of PFAS waste, for example concentrated liquid waste and some solid wastes, is used overseas and represents a promising option. A small number of Australian facilities, such as those for treating medical waste, soil treatment and cement kilns, are trialling or seeking approval for thermal destruction.

5.27 Appendix C: Treatment technologies available in Australia provides a list of treatment technologies that are understood to be currently available commercially and/or undertaking trials in Australia.

QUESTION 9: What treatment criteria and remediation objectives should be considered for inclusion in the PFAS NEMP? Please provide details explaining the nature and basis for these criteria and objectives.

Landfill disposal and off-site containment

5.28 The safe landfill disposal and off-site containment of PFAS-contaminated waste, including contaminated soil, represent a significant challenge for responsible parties, affected communities, waste operators, consultants and regulators.

5.29 Landfills and off-site containment facilities may require different approaches to their management when they are accepting PFAS-contaminated wastes and soils. There will need to be assessment of any nearby sensitive receptors, including consideration of bioaccumulation and impacts, for example, on air-breathing animals. Where a landfill is located close to a farm or market gardens, it is important to consider off-site impacts through surface and groundwater, particularly if the farm or market garden is using the groundwater.

5.30 Operational and post-closure management of landfills and off-site containment facilities must ensure that PFAS are contained. Consideration must be given to leachate management, particularly where it may be managed at a wastewater or sewage treatment plant. Resulting sewage treatment plant effluent and biosolids or water treatment residues will contain the PFAS, requiring a chain of treatment or control to prevent release of PFAS into the environment.

Landfill disposal criteria

5.31 Landfill disposal criteria generally provide total concentration and leachable concentration limits for specific contaminants within a waste. Typically, the criteria are based on the type of landfill liner and the expected migration of contaminants in order to protect surrounding groundwater and soils. The unique characteristics of PFAS (mobility, bioaccumulation and persistence) are expected to require additional consideration beyond groundwater and soil protection in the derivation of appropriate landfill disposal criteria.

5.32 Some jurisdictions have available interim/draft landfill disposal criteria for certain landfills in their jurisdiction. As such, these criteria may not be directly comparable, nor may they be acceptable for a different landfill in a different location. Appendix B: Australian interim/draft criteria and standards for PFAS provides information on these criteria.

QUESTION 10: While noting that jurisdictions have individual approaches for setting specific landfill disposal criteria, what is your experience with the development of PFAS disposal criteria? Should the PFAS NEMP provide levels below which a material is non-contaminated or levels above which the PFAS content must be destroyed? Can you provide examples of applicable criteria, including how they were developed?

Performance standards

5.33 Treatment technologies should be able to irreversibly transform PFAS into benign compounds either by destruction or stabilisation (e.g. that reduces the transportability in water).

It is expected that the PFAS NEMP will include performance standards for treatment and destruction facilities, and will include capacity to evaluate treatment efficiency and undertake post-treatment validation assessment.

5.34 Inclusion of guidance regarding the application or implementation of best practice/best technologies and publication of collated information on contaminated stocktakes will encourage the development of treatment and remediation solutions and capacity in Australia. These performance standards would be expected to be used to strengthen existing regulatory approaches, including consideration of whether proof of performance assessments should be required prior to approval of the use of new technologies in PFAS treatment. These may include standards or expectations for facilities used for the management of PFAS-contaminated solid waste, wastewater or for PFAS waste containment facilities. These performance standards would support jurisdictions as they continue to approve trials and ongoing treatment technologies for PFAS affected wastes and soils.

QUESTION 11: What performance standards would be most helpful to provide clarity for industry and the community for the establishment of new treatment and remediation technologies?

6 Storage and transport

Storage of PFAS-contaminated wastes and soils

6.1 Long-term storage and containment on or off-site may be important management options but they may be problematic given the large volumes of material involved and the ongoing accumulation of PFAS-contaminated waste. Current best practice for tackling large-scale contamination involves source management or containment and immobilisation combined with a multi-stage approach to decreasing PFAS concentration.

6.2 It is expected that the PFAS NEMP will include a best practice approach to the storage of PFAS-contaminated wastes, including soils and water. This would include bunding (construction of a retaining wall around storage) and protection from weather, particularly the prevention of water movement through stored wastes and soils.

Transport of controlled wastes within and between jurisdictions

6.3 The transport of PFAS-contaminated wastes and soils within and between jurisdictions will be best managed through a single waste code under the National Environment Protection (Movement of Controlled Waste) Measure (Movement of Controlled Wastes NEPM). This will provide clarity for waste transport and disposal through inclusion of the code in specific licences or other regulatory tools, where it has been determined that the facility is suitable for the management of these wastes.

6.4 As the Movement of Controlled Wastes NEPM is reviewed, a single PFAS specific waste code could be considered for inclusion. In the interim, jurisdictions would adopt this waste code under appropriate legislative arrangements.

QUESTION 12: What are your views on the introduction of a PFAS specific waste code? For example: PFAS compounds or any material containing PFAS compounds.

7 Environmental monitoring and analysis

Environmental monitoring and assessment

7.1 Environmental monitoring for PFAS (including baseline monitoring: in catchments; of landfill leachate; groundwater and surface water near landfills; in receiving waters; effluents and biosolids from sewage treatment plants; and of media in and close to contaminated sites) is an important consideration for regulators that licence such facilities or regulate sites.

7.2 Many jurisdictions now require environmental monitoring at regulated landfills and sewage treatment plants. This data will provide evidence on whether current technologies and regulatory controls are appropriate to protect the environment and human health from exposure to PFAS.

7.3 Ambient or baseline monitoring is also important to inform regulatory and policy decisions and for evaluating the effectiveness of regulatory actions. An environmental assessment program can provide valuable information, both qualitative to inform of the presence or absence of PFAS in a location, and quantitative data on its concentration.

PFAS analysis

7.4 As mentioned above, there are many PFAS compounds, with analytical methods and chemical standards available only for limited individual compounds. Analytical methods are available in commercial, government and research laboratories for the main PFAS compounds, including PFOS, PFOA and PFHxS.

7.5 Techniques such as Total Oxidisable Precursor Assay (TOPA) and the determination of Total Organic Fluorine (TOF) can be used to inform site managers and regulators of the amount of other PFAS compounds that may be present in a sample. However, the techniques are available at only a few laboratories and have not yet been well validated. TOPA and TOF analyses can inform the uncertainty associated with a management option for a PFAS-contaminated site or waste. Where there is a large portion of other PFAS compounds present, this may lead to more uncertainty, thus impacting on the final decisions for the management of the site or the wastes. Where the portion of other PFAS compounds are low, this will provide greater certainty about the PFAS compounds present and thus the proposed management option.

7.6 There are benefits in obtaining standardised data during site specific sampling programs. Assessing the environmental conditions for factors such as pH, electrical conductivity, redox potential and biological activity can can provide information on processes that may be affecting PFAS and precursors.

7.7 Although useful to determine the type of PFAS-containing product that may have led to a contamination, product formulations (e.g. Safety Data Sheets) can be of little value, as single precursor compounds can create 10 to 20 intermediate transformation compounds with functional groups quite unlike the initial compound, and with multiple final end-point compounds.

7.8 Analytical variability may be improved through the introduction of standard methods for the analysis of PFAS compounds, particularly those of primary focus (PFOS, PFOA and PFHxS). Further work will be needed to establish standard methods and undertake proficiency trials, such as those recently completed by the National Measurement Institute (NMI) in collaboration with EPA Victoria with funding from CRC CARE.[5] Standardisation of analytical results reporting is required, including consideration in the plan for the establishment of an acceptable upper and lower bound for recoveries, which may vary depending on the individual PFAS.

Laboratory analysis methods

7.9 The following is adapted from Government of Western Australia, Department of Environment Regulation, Interim Guideline on the Assessment and Management of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS), Contaminated Sites Guideline, v.2.1, January 2017. It is provided to give an indication of the type of considerations that need to be addressed in finalising the PFAS NEMP.

7.10 Schedule B3 of the ASC NEPM states that comparable established standard methods from recognised sources such as Standards Australia, the US EPA, the American Public Health Association (APHA), the American Society for Testing and Materials (ASTM) and the International Standards Organisation (ISO) should be used when analysis is required for contaminants not included in the ASC NEPM.

7.11 The available standard methods from these sources include:

- **US EPA Method 537** – *Determination of selected perfluorinated alkyl acids in drinking water by solid phase extraction and liquid chromatography/tandem mass spectrometry (LC/MS/MS) (applicable to drinking water)*
- **ISO 25101** – Water quality – *Determination of perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) – Method for unfiltered samples using solid phase extraction and liquid chromatography/mass spectrometry (applicable to drinking water, ground water and surface water)*
- **ASTM D7968** – *Standard Test Method for Determination of Perfluorinated Compounds in Soil by Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS)*
- **ASTM D7979** – *Standard Test Method for Determination of Perfluorinated Compounds in Water, Sludge, Influent, Effluent and Wastewater by Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS).*

7.12 Practitioners should ensure that the proposed analytical laboratories (primary and secondary):

- provide details as to whether a linear only or a mixed linear/branched standard has been used for calibration purposes
- report analytical results representing the concentration of summed linear and branched isomers
- use an isotopically labelled internal standard for each compound analysed; and
- report results corrected for internal standard recoveries, including when the internal standards are added, together with a statement of the recovery.

7.13 Practitioners should confirm the target analyte suite of PFAS and that the required method reporting limits can be achieved. Some commercial laboratories offer an extended PFAS suite comprising 20 or more different compounds but need to explicitly state whether internal standards were used for each target compound.

QUESTION 13: What other analysis methods are required (e.g. biota)? Are you able to provide suitable methods from recognised sources?

5 http://www.measurement.gov.au/Publications/ProficiencyStudyReports/Documents/AQA15-03.pdf

8 Stakeholder engagement, communication and data sharing

Stakeholder engagement and communication

8.1 Consistent advice on stakeholder engagement and communication relating to PFAS-contamination benefits everyone. Effective communication and stakeholder engagement need national coordination, an agreed engagement plan and an engagement toolkit that includes materials (such as consistent messaging, fact sheets, support and guidance). Plans, processes and protocols for emergency management communication could also be included.

8.2 The development of an accessible and comprehensive web portal that presents data and management approaches clearly and accessibly could contribute to transparent and accessible communication of information and advice.

8.3 The way in which information is conveyed is a critical part of building trust. Such trust helps engender greater community engagement and understanding. Failure to properly communicate leads to distrust, which compounds the difficulties in managing contaminated sites and other sources of PFAS exposure.

8.4 If a PFAS contamination incident occurs, those responsible including industries and governments as well as government regulators should accurately and swiftly communicate what is known and unknown, presenting all relevant information and data, including

8.5 the risks. Government regulators should communicate any procedures to follow to minimise exposure, and the ways in which the government is seeking to help.

8.6 The PFAS NEMP is expected to include a variety of resources to be used by jurisdictions, including best practice approaches to community and stakeholder engagement.

8.7 The PFAS NEMP will include plain English descriptions of best practice approaches, including best practice approaches to community and stakeholder engagement. These best practice approaches will focus on actions required by environmental regulatory agencies and the most common issues that they address. Further guidance topics are likely to be identified, for example, the coordinated management of PFAS contamination at a whole of catchment (and aquifer) level.

QUESTION 14: The PFAS NEMP is expected to include a number of best practice approaches to community and stakeholder engagement resources to be used by the jurisdictions. Based on your experience, what has worked well when engaging on PFAS-related issues?

Data sharing

8.8 Jurisdictions and the Australian Government are working together to develop this plan. There is ongoing work to identify options for the establishment of data sharing arrangements.

9 Research, review and evaluation

9.1 The PFAS NEMP needs to be flexible and adaptable to emerging knowledge and technologies, transparent regarding the evidence and acknowledge the considerable uncertainties.

Limitations and caveats

9.2 While there is high certainty on PFAS persistence and bioaccumulation, there is still much that we do not know about these chemicals and their impacts. PFOS, PFOA and PFHxS have been more widely studied than other PFAS compounds with several thousand studies now available. However, there is still a lack of clarity on human toxicity and the long-term impacts of many PFAS on the environment. There are thousands of these compounds and precursors, most of which have no toxicity data. As more information becomes available on the PFAS compounds of concern, we will need to establish whether environmental criteria for a wider range of compounds are required.

Current knowledge and research

9.3 Research will support the development of nationally consistent, best practice environmental guidance. For example, we have already heard that industry is seeking advice on monitoring and analysis techniques – including guidance or a 'how to' guide for consultants. The efficacy of treatment and remediation technologies needs to be determined prior to the granting of approvals at waste treatment facilities. Performance standards for thermal treatment must be rigorously enforced, to avoid the production of non-PFAS fluorinated chemicals or other chemical compounds. Regulators and landfill managers will need information that will enable them to better understand the behaviour of PFAS materials in landfills and the interaction between PFAS and landfill liners.

9.5 A national research and data sharing program could include exchange of data and information from jurisdictional stocktakes and contamination audits for potential or licenced remediation technologies, sector-specific work (e.g. airports, defence establishments and fire training facilities) on ecotoxicology and occurrence including species data, and data on transport and fate of PFAS. Such a program would be expected to drive the national research agenda on important PFAS topics, including:

- determining priorities in analysis methods,
- enhancing risk-based investigation and remediation levels
- undertaking in-situ remediation,
- waste disposal,
- informing recycled water use, and
- strengthening our understanding of ecotoxicology.

9.6 The program would facilitate collaboration between regulators and researchers.

QUESTION 15: HEPA is expected to consider research programs in priority areas. What areas would you recommend? Why would these be important research priorities? As research is completed, do you have suggestions on the best way to make this information available?

Review process and cycle

9.7 A formal review of the PFAS NEMP will be undertaken every two years, with more frequent informal reviews as needed. Through HEPA, the Working Groups, including the National Chemical Working Group, the National Contaminated Environments Network and the National Waste Working Group would be suitable co-ordinating bodies to provide technical input, evaluation and review and advise the Meeting of Environment Ministers on any findings or proposed updates. The PFAS NEMP will draw on existing mechanisms for information sharing and collaboration, such as HEPA, HEPA Working Groups, and the Australasian Environmental Law Enforcement and Regulators network (AELERT).

9.8 The use of other PFAS compounds including short-chain compounds, fluorotelomers and fluorinated alkyl ethers in industrial and domestic products will continue to grow as the more hazardous PFAS are phased out. This will result in an increasing list of chemicals for potential inclusion in the PFAS NEMP.

9.9 The group appointed by HEPA to undertake the plan reviews will scan and assess chemicals for future inclusion, providing HEPA with recommendations, as well as responding to international developments and obligations and coordinating activities with agencies such as enHealth. Moreover, limitations on use of particular PFAS may be considered through other mechanisms. For example, jurisdictions may act in response to incidents or as a result of environmental or human health impact investigations.

Evaluation

9.10 Regular evaluation of the PFAS NEMP should report on criteria including uptake of the NEMP and consistent application by jurisdictions (including the Australian Government and its agencies), understanding of the extent of contamination nationally (including the number of sites), appropriate management of those sites, and development of capacity for treating and disposing of PFAS contaminated wastes, including soils, and approaches to addressing catchment level contamination.

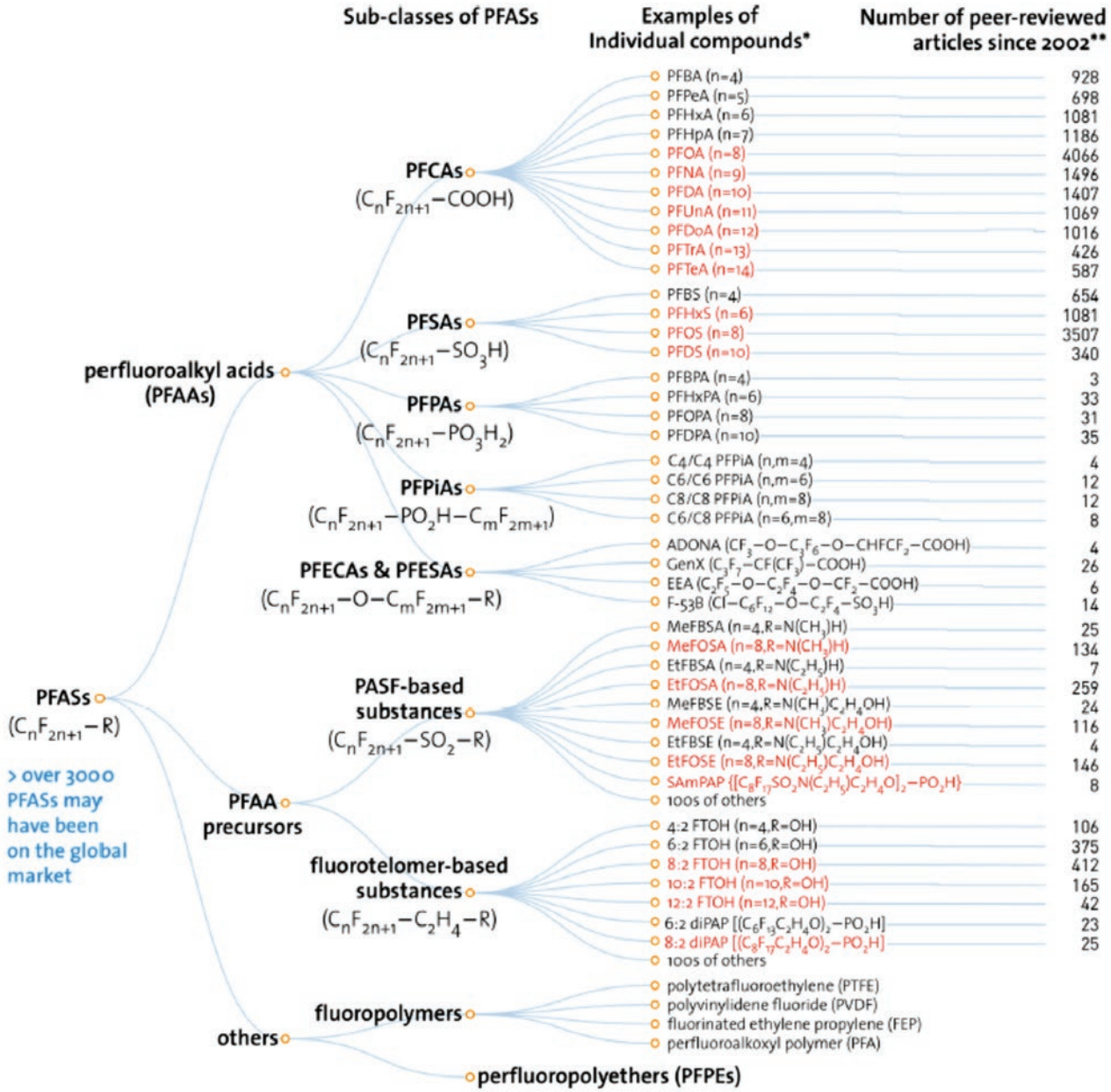
9.11 An additional measure of success for the PFAS NEMP would be stakeholder – including public and industry – satisfaction. Part of this measure would be the extent to which the community is engaged and their level of trust in the approach.

QUESTION 16: What does success of the PFAS NEMP look like to you? How would you evaluate the success of the PFAS NEMP in meeting your expectations? What is your expectation on timing for the delivery of various components of the PFAS NEMP as well as the achievement of outcomes? How often should the outcomes be assessed?

Appendices

Appendix A: PFAS sub-classes

Taken from: Wang Z, DeWitt J, Higgins C, Cousins I (2017). A Never-Ending Story of Per- and Polyfluoroalkyl Substances (PFAS)? Environ. Sci. Technol., 51 (5): 2508–2518



Appendix B: Australian interim/draft criteria and standards for PFAS

The following tables provide a consolidated reference for Australian criteria and standards. Health based guidance values are included for easy reference. These tables have been adapted from:

1. Australian Government, Department of Environment and Energy, Commonwealth Environmental Management Guidance on Perfluorooctane Sulfonic Acid (PFOS) and Perfluorooctanoic Acid (PFOA), Draft, October 2016 (CEMG)
2. Government of Western Australia, Department of Environment Regulation, Interim Guideline on the Assessment and Management of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS), Contaminated Sites Guideline, v.2.1, January 2017 (WA DER)
3. PFAS Screening Criteria, Prepared by OEH Science, May 2017. (OEH/NSW)

Table 1: Australian interim and draft ecological criteria

Exposure Scenario	PFOS	PFOA	Land Use/ Environment Value	Comments and Source
Ecological - freshwater	0.00023µg/L	19 µg/L	High conservation value systems (99% species protection)	Australian and New Zealand Guidelines for Fresh and Marine Water Quality – technical draft default guideline values Note: These investigation levels are protective of environmental values only and are not to be used in setting drinking water guideline values which are derived according to different methods – human health effects can differ from effects observed in aquatic ecosystems.
	0.13 µg/L	220 µg/L	Slightly to moderately disturbed systems (95% species protection)	
	2 µg/L	632 µg/L	Highly disturbed systems (90% species protection)	
	31 µg/L	1824 µg/L	Highly disturbed systems (80% species protection	

Table 2: Australian interim and draft health based criteria by exposure scenario

Exposure Scenario	PFOS/ PFHxS	PFOA	Land Use/ Environment Value	Comments and Source
Health based guidance values	0.02 µg/ kgbw/d	0.16 µg/ kgbw/d	Tolerable Daily Intake (TDI)	FSANZ 2017a
	0.07 µg/L	0.56 µg/L	Drinking water	Health 2017
	0.7 µg/L	5.6 µg/L	Recreational water	

For all soil screening values from OEH/NSW: these values should only be used in conjunction with other investigation to account for potential leaching, off-site transport, bioaccumulation and secondary exposure.

Exposure Scenario	PFOS/ PFHxS	PFOA	Land Use/ Environment Value	Comments and Source
Soil – Health based screening levels	0.009 mg/kg	0.1 mg/kg	Residential	Based on 20% of FSANZ TDI, i.e. up to 80% of exposure is assumed to come from other pathways. ASC NEMP HIL-A assumptions with home grown produce included. OEH/NSW
	2 mg/kg	20 mg/kg	High density residential	Based on 20% of FSANZ TDI, i.e. up to 80% of exposure is assumed to come from other pathways. ASC NEPM HIL-B assumptions OEH/NSW
	20 mg/kg	100 mg.kg	Industrial/ commercial	Based on 20% of FSANZ TDI, i.e. up to 80% of exposure is assumed to come from other pathways. ASC NEPM HIL-D assumptions including 8 hrs time spent indoors and 1 hr spent outdoors at an industrial/commercial site
	4 mg/kg (sum of PFOS + PFHxS)	40 mg/kg	Residential	Based on previous TDI of 0.15 µg/kg/d for PFOS/PFHxS and 1.5 µg/kg/d for PFOA Government of Western Australia (WA DER)
	100 mg/kg (sum of PFOS + PFHxS)	1000 mg/kg	Commercial and industrial	
	6.6 mg/kg (PFOS only)	1 mg/kg	National parks / areas with high ecological values	Draft default guideline values prepared for CRC CARE, version as at July 2016. Not taking into account water transport and to be used only if hydrogeology of the site assessed and levels in pore water, groundwater or nearby surface water sustaining aquatic life (i.e. Within 10 km) are also tested if present. Note: waste soil containing above 50 mg/kg of PFOS and PFOA must be managed in accordance with Stockholm Convention requirements. Department of Environment and Energy (CEMG).
	32 mg/kg (PFOS only)	29 mg/kg	Urban residential/ public open spaces	
	60 mg/kg	81 mg/kg	Commercial and industrial spaces	

Appendix C: Treatment technologies available in Australia

The following table provides a summary of technologies available in Australia. This table has been adapted from the following documents:

1. Australian Government, Department of Environment and Energy, Commonwealth Environmental Management Guidance on Perfluorooctane Sulfonic Acid (PFOS) and Perfluorooctanoic Acid (PFOA), Draft, October 2016 (CEMG)
2. Government of Western Australia, Department of Environment Regulation, Interim Guideline on the Assessment and Management of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS), Contaminated Sites Guideline, v.2.1, January 2017 (WA DER)

Process	Definition	Australian Example	Media
Adsorption (stabilisation/ immobilisation)	Adhesion of the PFAS compounds to the surface of an adsorbant	Activated carbon (powdered (PAC) or granular (GAC)), resins, ion exchange polymers.	Water and wastewater
Reverse osmosis and nanofiltration	Semi-permeable membranes are used to remove the PFAS from water	Various systems available	Water and wastewater
Pyrolysis and oxidative thermal destruction	High temperature in the absence or presence of oxygen to change the chemical composition	High temperature plasma arc, cement kilns and medical waste treatment facilities – current and proposed trials	Soil, aqueous film forming foam concentrates, solid concentrates from adsorption, liquid concentrates from reverse osmosis
Thermal desorption	High temperatures increase volatility of PFAS so that it can be separated from the solid	In-direct and direct-fired thermal desorption	Soil and waste
Solidification	Mixing a binding agent with affected soil to bind the compounds in a solid block, potentially trapping it in place	Various proprietary binding agents available in Australia	Soil and waste
In-situ oxidation or reduction	Applying chemicals and often heat to break down the PFAS into more environmentally friendly forms	Current trial	Soils and groundwater
Foam fractionation/ separation	A method to generate a foam containing the PFAS from affected groundwater.	Current trial	Surface, groundwater and wastewater
Ultrasonication/ sonochemistry	Intense ultrasonic-wave energy to change the compounds into more environmentally friendly forms.	Current trial	Water and wastewater

Appendix D: Interim/draft landfill disposal criteria

The following tables provide an easy reference for interim/draft landfill disposal criteria. These criteria are applicable to certain landfill designs and would not be directly transferrable to landfills with a different design or in a different location.

Addendum to the Waste Classification Guidelines (2014) – Part 1: classifying waste, October 2016 (NSW EPA) ** noting these values have been based on the enHealth TDI values

Contaminant[1]	Maximum values for leachable concentration and specific contaminant concentration when used together			
	General solid waste[2]		Restricted solid waste	
	Leachable concentration	Specific contaminant concentration	Leachable concentration	Specific contaminant concentration
	TCLP1 (mg.L)	SCC1 (mg/kg)	TCLP2 (mg.L)	SCC2 (mg/kg)
PFOS + PFHxS	0.05	1.8	0.2	7.2
PFOA	0.50	18.0	2.0	72.0

1. PFOS and PFHxS are to be summed for comparison against the TCLP and SCC values.
2. Values are the same for general solid waste (putrescible) and general solid waste (non-putrescible).

Government of Western Australia, Department of Environment Regulation, Interim Guideline on the Assessment and Management of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS), Contaminated Sites Guideline, v.2.1, January 2017.

Table 6: Interim leachable concentration (ASLP) and concentration limit (CL) values for waste classification*

Contaminant	Leachable Concentration ASLP (µg/L)	Concentration Limit CL (mg/kg)	Leachable Concentration ASLP (µg/L)	Concentration Limit CL (mg/kg)	Leachable Concentration ASLP (µg/L)	Concentration Limit CL (mg/kg)	Leachable Concentration ASLP (µg/L)	Concentration Limit CL (mg/kg)
	Unlined Class I and II		Lined Class II		Lined Class III		Lined Class IV	
PFOS + PFHxS	<0.001	<0.02	1.3	5	1.3	5	13	50
PFOA	20	<0.02	2,200	50	2,200	50	22,000	500

Notes to Table 6

*Waste concentrations must be less than both the relevant leachable concentration (ASLP conducted at both pH 5 and pH 7 (approximating 'worst cast' for leaching conditions) and the concentration limit values for the relevant class of landfill to enable consideration for disposal at a specific landfill.

Landfills accepting waste containing PFOS/ PFHxS or PFOA must not be located:

- on very high[1] or high[2] vulnerability aquifers;
- within 1,000 m of a surface water body that supports an aquatic environment (including groundwater dependent ecosystems); or
- within 1,000 m of a surface water drain that is connected to groundwater and/or discharges directly into an aquatic environment (including groundwater dependent ecosystems) or a water body that supports fish species that may be caught and consumed.

[1] Very high vulnerability aquifers; limestone with known karst features; and sand, peat and clay deposits (wetland areas) with a shallow water table (≤3 m).

[2] High vulnerability aquifers; sand and limestone with a shallow to intermediate water table (≤30 m); and fractured rocks with a high permeability (≥40 m/d) and a shallow to intermediate water table (≤30 m).

Definitions of high and very high aquifer vulnerability are adapted from Appleyard (1993) Explanatory notes for the groundwater vulnerability to contamination maps of the Perth Basin, Record 1993/6 Geological Survey of Western Australia, Department of Minerals and Energy.