

Operational Policy Environmental Management of Firefighting Foam

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Operational Policy
Environmental Management of Firefighting Foam

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This Policy provides direction for government and industry on the environmental protection requirements of the Department of Environment and Science when making decisions on activities with the potential to impact on the environment.

1 Objective

The objective of this Operational Policy (the Policy) is to outline the Department of Environment and Science's (the Department's) requirements and expectations for the handling, transport, storage, use, release, waste treatment, disposal and environmental protection measures relevant to the use of firefighting foam. Particular regard is given to foam management for the prevention of the potential adverse impacts from acute effects such as toxicity and oxygen depletion, as well as persistence, bioaccumulation, toxicity, long-range transport and any other chronic effects from some components. The provisions of the Policy should be read in conjunction with the Definitions in [Appendix A](#).

2 Scope

This Policy applies to any person, organisation or corporation that handles, transports, stores, uses, releases, treats wastes or disposes of any products, compounds, water, soils, wastes or other materials associated with or contaminated by firefighting foams at any concentration at any place in the state of Queensland and its waters.

This Policy does not consider the range of other possible contaminants that may co-occur within firewater runoff that may have significant environmental impacts, including hydrocarbons, chemicals, combustion products, heavy metals and sediments.

3 Legislation

The *Environmental Protection Act 1994* (EP Act) requires that all persons undertaking any activity that impacts, or has the potential to impact, the environment in Queensland take all reasonable and practical measures to prevent such harm from occurring (GED, EP Act s319). This includes having regard for the nature of the harm or potential harm, the sensitivity of the receiving environment and the current state of technical knowledge for the activity.

This Policy has as its objective the prevention of short-term and long-term environmental harm considering the *Precautionary Principle* as set out in the Intergovernmental Agreement on the Environment (IGAE) and best practice environmental management (BPEM). The application of the *Precautionary Principle* regarding the use of firefighting foam has been detailed by the Hon. Chief Justice Brian Preston ([Preston, 2017](#)).

In Queensland section 440ZG of the EP Act requires that a person must not unlawfully deposit a prescribed water contaminant into any waters; or in a roadside gutter or any stormwater drainage; or at another place, and in a way, so that the contaminant could reasonably be expected to wash, blow, fall or otherwise move into waters, a roadside gutter or stormwater drainage.

All PFAS including precursors are prescribed water contaminants for section 440ZG under item 1 (Schedule 10) of the *Environmental Protection Regulation 2019*. Item 1 of the Regulation is "a chemical, or chemical waste containing a chemical", with the listed examples of chemicals including PFAS.

The precautionary approach adopted in this guidance is consistent with the National PFAS Position Statement that Australian governments (Commonwealth, state and territory), as

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represented by Environment Ministers, are signatories to through the *Intergovernmental Agreement on a National Framework for Responding to PFAS Contamination* ([Council of Australian Governments \(COAG\), 2018](#)).

In regard to responses to emergency incidents, disaster management and health provisions, other legislative provisions may apply, and where specified may take precedence during the emergency (e.g., *Fire and Emergency Services Act 1990*, *Public Safety Preservation Act 1986* and the *Work Health and Safety Act 2011*). However, those provisions primarily apply to the powers and actions of the emergency services personnel and do not negate the obligation of the facility owner/operator or site manager to have considered and proactively put into place all the necessary plans, measures and controls to deal with an incident and the wastes generated including for those containing PFAS.

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The Department is committed to managing the health of Queensland's environment by protecting the state's unique ecosystems, including its landscapes and waterways, as well as its native plants, animals and biodiversity through strong environmental regulation that supports sustainable long-term economic development.

Foams are acknowledged as an essential firefighting tool for protection of life and property with a prime consideration being safety and the protection of life. Nonetheless, the consequences of the highly dispersive use of foam on environment, human health, socio-economic values and amenity must be considered in contingency planning as well as during the incident response with consideration of all likely adjacent and downstream adverse effects. These can include public and economic use of resources such as recreational activities, public amenity, water supply, industry, livestock, crops, aquaculture and fisheries.

All firefighting foams pose a range of hazards to the environment when released during activities such as training, maintenance, testing, incident response, fires and waste disposal. The combination of chemicals used in firefighting foams can have direct and indirect acute and chronic impacts on biota, soils and waterways through their persistence, bioaccumulation, toxicity, mobility and BOD when they are released and as they degrade.

Of particular concern in regard to firefighting foams is the significant body of existing and growing evidence that persistent organic compounds including fluorinated organic compounds (PFAS) which have been and are commonly used in some Class B firefighting foams, pose significant risks to socio-economic values, human health and the environment through their extreme persistence, increasing exposure, mobility, bioaccumulation potential and toxicity.

Most historical major environmental pollution events with fluorochemicals have been the result of firefighting foam use, either operationally or during training. While only 33% of global fluorotelomer production is used for firefighting foam production, foam use is unavoidably the greatest environmentally dispersive use of all applications.

When choosing and procuring firefighting foam the user must consider in their risk assessment and contingency planning, its suitability for a particular application, its firefighting performance, its potential to cause adverse effects and any necessary management measures with regard to the following issues:

- **composition** of the foam and appropriate effectiveness for the intended application
- **concentrate types** and quantities to be held on site
- **volume of firewater** that could potentially be generated during an incident
- **ability to manage** and contain spills and firewater on site and off site
- **measures to prevent release** to soils, groundwater, waterways and the atmosphere

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- **facility location** and proximity to environmentally sensitive areas
- **circumstances** under which an intended or unintended release might occur
- **pathways** whereby foam and other contaminants could be released to the environment
- **potential for PBT and BOD impacts** on the local and wider environmental values
- **on-site and off-site treatment** and disposal of wastewater and contaminated materials
- **remediation** of contaminated soils, waterways and groundwater
- **training, maintenance and testing** needs and requirements.

This Policy also recognises that a prime consideration when choosing and procuring firefighting foam is the effectiveness of the foam for the intended application in providing adequate levels of firefighting performance, safety and property protection. The foams available that meet the appropriate independently verified performance standards and approvals must then be compared in terms of a net environmental benefit analysis (NEBA), (Deacon, Goddard, & Eury, 2010) to select the optimal product that also addresses the relevant environmental protection standards and overall best practice.

All firefighting foams must be assessed for their potential to cause environmental harm prior to use or disposal of wastes. The need for management and containment, as well as protective measures and procedures must be assessed in terms of the foam's properties relative to:

- **Environmental persistence** of the compounds in the formulation and any potential intermediate transformation and endpoint products.
- **Biopersistence**, bioaccumulation, bioconcentration and biomagnification potential.
- **Toxicity** (both acute and chronic effects).
- **Mobility** in soils, surface waters and groundwaters.
- **Biochemical oxygen demand** and biodegradability.

4.1 Non-Persistent Firefighting Foams

In choosing and using a non-persistent (fluorine-free Class-B or Class-A) foam the potential for causing environmental harm and the need for management, containment and protective measures and procedures must be fully considered. Particular regard should be paid to potential impacts from biochemical oxygen demand, acute toxicity and the biodegradability characteristics of the foam.

Non-persistent (fluorine-free) foams must not contain any deliberately added persistent organic compounds such as PFAS. Where a firefighting system has previously contained PFAS firefighting foam, all reasonable and practicable measures must be taken to clean out the PFAS residues. It is recognised that non-persistent foam concentrates may nonetheless have low levels of contamination from:

- PFAS residues in existing systems that have previously held PFAS foams and have been cleaned out as far as is practicable.
- PFAS traces in new foam concentrate from sources such as contaminated water, production feedstocks or cross-contamination from other foam products.

Accordingly, allowance is made for possible low levels of contamination in new foam concentrate or concentrate introduced into an existing system that has residual PFAS contamination. For new non-persistent foam placed into an existing system, contamination by residual PFAS or PFAS from another source must not exceed the limits in [Table 4.1A](#) for PFASs and PFCAs including their precursors.

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The level of PFAS contamination can be established by:

- Analyses of a representative sample of the new foam after one-month residence time in the existing system.
- Where there are parts of a system that has parts that are not practical to clean out or replace, calculations should be made of the probable contamination, or contribution to contamination, based on known, or reasonably inferred quantities and concentrations of PFAS residues in the system, the total should equate to half or less of the limits in [Table 4.1A](#).

Table 4.1A – PFAS limits in non-persistent (fluorine-free) foam concentrates

PFAS or fluorine content	Limit (mg/kg)
Perfluoroalkyl sulfonates and precursors ≥C4 to C12 , the sum of the compounds. (PFBS+PFPeS+PFHxS+PFHpS+PFOS+PFNS+PFDS+PFDoS+precursors)	10 (sum)
Perfluoroalkyl carboxylates ≥C4 and higher homologues as the sum of the TOP-A analyses results for C4 to C14 compounds (TOP-A C4-C14).	50 (as fluorine)

Consideration should also be given to the EU revision 2021/1297, ([European Union Commission, 2021](#)) to restrict/prohibit C9-C14 PFCAs and their related substances, which are regarded as PBT or vPvB substances, with the result that foam feedstocks and concentrates should contain less than 25 ppb C9-C14 PFCAs and less than 260 ppb C9-C14 related substances.

Where a supplier or end-user wishes to confirm that a non-persistent (fluorine-free) foam concentrate does not contain significant levels of PFAS arising from manufacture or contamination or from introduction to an existing system, a simpler alternative to the TOP-A is a basic total organic fluorine (TOF) analysis against the limit in [Table 4.1B](#). This would be sufficient to demonstrate that the foam would be regarded as fluorine-free or has acceptable levels of contamination for the purposes of the Policy.

Table 4.1B – Non-persistent foam (fluorine-free) concentrates and cross-contamination, simplified certification

Fluorine content	Limit (mg/kg)
Total organic fluorine (by combustion ion chromatography, TOF-CIC).	6.4 (as fluorine)

The application of the limit in [Table 4.1B](#) to a TOF analysis to certify a foam concentrate as fluorine-free or minimally contaminated is based on the unlikely but worst-case scenario that PFAS contamination may be from perfluoroalkyl sulfonates (PFSAs) such as PFOS and PFHxS that are of greatest health and environmental concern and have the more stringent PFAS limit of (10mg/kg). The limit for TOF is derived from the PFSAs limit in [Table 4.1A](#) expressed as fluorine based on an assumed mean fluorine proportion of 0.64 for the most likely C6-C8 sulfonates in legacy foams.

Advice from industry sources suggests that the contribution of PFAS contamination from external sources in new foam concentrates, such as from contaminated water supplies in manufacturing, should be lower than 1 mg/kg (<1 ppm). Some manufacturers are now using ultra-pure water in formulations to ensure PFAS contamination in formulations during manufacture is unlikely.

Where non-persistent (fluorine-free) firefighting foam is used, the site manager must take all reasonable and practical measures to adequately manage, contain, treat or properly dispose of the foam, firewater, wastewater, runoff from activities or after incidents on the site such that any unavoidable release of foam or other contaminants to the environment is not likely to cause significant environmental harm.

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The site manager is the person or entity, or their agent, with normal management or control of the site. The responsibilities of this role do not pass to the emergency services incident controller, personnel or agency during the incident emergency response. Where practicable the emergency services incident controller may facilitate initial pollution control measures such as bunding to contain runoff, however, the site manager is nonetheless responsible for prevention of any releases to the environment, management of wastes and any adverse effects. This may include having to seek approval for and facilitate off-site containment measures such as bunding of adjacent drains or waterways during an incident.

Where a small volume of non-persistent (fluorine-free) foam is used such as for vapour and spark suppression at an incident and is contained on site with the only significant contaminant being the firefighting foam this may be disposed of by:

- **Irrigation onto adjacent land** to soak in and degrade *in situ* provided it is unlikely to migrate to groundwater or a waterway.
- **Holding of larger quantities in ponds** or drains for 28 days or longer according to its BOD profile to allow it to fully biodegrade.
- **Covering with sand, soil or other absorbent** to prevent or limit subsequent movement to a waterway in runoff.
- **Soaking into soil** to degrade *in situ* (clear of any drain or waterway).
- **Pumping out and disposal** to sewer or wastewater treatment plant subject to acceptance by the relevant water treatment authority.

The disposal of firewater runoff that also contains significant levels of other contaminants, such as hydrocarbons, chemicals or fire combustion products, in addition to containing non-persistent firefighting foam, needs to be considered on a case-by-case basis.

4.1.1 Direct releases to land of non-persistent foam

Release of fully-biodegradable, non-persistent firefighting foam to land away from waterways, is acceptable in circumstances such as:

- **Rural firefighting** for ignition prevention, fire control, extinguishment, damping-down, fuel reduction and training on vegetation fires (Class-A foam). It is expected that no adverse effects will occur from the application of small amounts of foam at low concentrations (e.g., 0.5% to 1%). For the normal application of foam across a wide area of fire front away from waterways the foam is expected to rapidly soak into the soil and biodegrade *in-situ*. Significant releases of foam or concentrate directly to, or within 50 metres of a waterway during rural firefighting should be avoided where possible.
- **Fuel and chemical spills** for vapour suppression, static spark prevention and fire extinguishment, typically at roadside incidents where 3% or 6% Class-B foam is used. Foam can be left to soak into soils or be irrigated to adjacent land to soak in. Where there is the potential for foam to drain to a waterway it should be contained and removed for treatment elsewhere. Any other contaminants also need to be considered.
- **Carbonaceous fire response** (e.g., paper, tyres, wood chips, recyclables, wooden structures) foam use is similar to rural firefighting in that 0.5% to 1% Class-A foam may be used. However, consideration must be given to firefighting runoff containing combustion products, low dissolved oxygen, leachate and other contaminants in the firewater.
- **Foam equipment testing** such as small-volume releases to grassed or vegetated areas. Foam can be left to soak into soils to biodegrade *in-situ* provided that the area is not used to the extent that the soils remain saturated.
- **Bare-earth training areas with containment** where there may be concentrated and repeated applications of non-persistent foam, provided there are firewater and runoff control

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measures in place to prevent immediate releases to adjacent waterways. Where a volume of firewater is generated, beyond that which can readily soak into the soil or be irrigated to adjacent land to soak in, control measures such as bunding or ponds should be used to hold the water to allow it to biodegrade (about 28 days) until it is suitable for release and/or to evaporate. The potential for contamination of underlying groundwater by infiltration should also be considered.

4.1.2 Direct releases to waterways of non-persistent foam

When selecting a non-persistent (fluorine-free) foam type for use where a discharge directly to the environment may be unavoidable, such as directly to a waterway, or to a drain or place where contaminants may then travel to a waterway, the management measures for the foam should include consideration of the potential extent of impacts from the combined effects of acute toxicity and oxygen depletion (from BOD) in the affected waterway (e.g., for marina firefighting, foam from a firefighting tug, vessel systems, shipping berth or wharf where hydrocarbons are transferred).

Testing, training, certification and maintenance activities are recognised as essential and necessary to maintain fire protection standards and proficiency and may result in unavoidable releases of non-persistent foam directly to the environment. These activities are acceptable but should be undertaken and managed in such a way as to minimise the potential for causing pollution or environmental harm, for example, through measures to:

- avoid discharging to environmentally sensitive areas (for mobile firefighting appliances)
- avoid or minimise discharges to confined waterways where water turnover is limited
- block drains and pump out wastewater to adjacent land where it can soak in and biodegrade
- limit the quantity of foam used in testing
- test systems in segments spread over a period to allow dispersion of foam
- wash down of vessel decks and hardstands with large volumes of water to dilute discharges
- use only water for testing or lower concentrations of foam
- schedule activities to coincide with large outgoing tidal flows to dilute and disperse foam.

4.2 Persistent Firefighting Foams

A persistent firefighting foam is any foam that has in its composition any deliberately added persistent organic compounds or has or may have contamination levels or persistent organic compounds that exceed those in this Policy. The most common persistent firefighting foams are those that contain PFAS in their formulations including those branded as AFFF (aqueous film-forming foam), FP (fluoro-protein), FFFP (film-forming fluoro-protein) and associated -AR or ATC (alcohol resistant) variants.

If any foam is known to contain or may contain PFAS then the user must be aware of its composition in terms of persistent organic compounds including:

- The presence and concentrations of PFCAs (carboxylates) and their precursors for carbon-chain lengths of C4 to C14, e.g., PFBA, PFPeA, PFHxA, PFHpA, PFOA, etc.
- The presence and concentration of PFSA (sulfonates) and their precursors for carbon-chain lengths of C4 to C12, e.g., PFBS, PFPeS, PFHxS, PFHpS, PFOS etc.
- The presence of any other persistent, mobile, toxic or bioaccumulative organic compounds, e.g., persistent siloxanes.

Subject to the limited uses allowable for PFAS foams under this Policy, where there is any potential for a spill or release from a site of firefighting foam containing PFAS or other persistent, mobile, toxic, organic compounds, the user must be able to demonstrate that they are able to fully and completely contain, manage and properly dispose of the concentrate, foam solution, produced foam, firewater, wastewater, runoff, contaminated soils and other materials. This

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includes accidental spills or releases during the testing and maintenance of fixed or mobile equipment, or otherwise.

The person or entity, or their agent, normally managing or having control of the site has principal responsibility for foam, firewater and waste management and their effects. This responsibility does not pass to the emergency services agency, incident controller or personnel during an incident emergency response. Where practicable the emergency services incident controller may facilitate the use of initial pollution control measures such as bunding to contain runoff. However, the site owner and/or manager is at all times responsible for ongoing prevention of releases to the environment and any adverse effects.

Of particular concern are foams containing long-chain PFAS including PFOS, PFHxS, PFOA, their precursors and higher homologues and any other persistent organic compounds. Long-chain PFAS are defined in the *Intergovernmental Agreement on a National Framework for Responding to PFAS Contamination as perfluoroalkyl sulfonates [PFASs] with six or more carbons, perfluoroalkyl carboxylic acids [PFCAs] with seven or more carbons*, including the precursors of these compounds. ([Council of Australian Governments \(COAG\), 2018](#)), ([OECD/UNEP Global PFC Group, 2013](#)).

Firefighting foams based on long-chain (>C6) PFAS are not permitted to be used except for facilities that hold a relevant authorization issued by the Administering Authority under the *Environmental Protection Act 1994*. The limits for long-chain PFAS compounds in persistent foams whether from production or contamination are in [Table 4.2A](#) with their application detailed in the following relevant sections.

4.2.1 Use of foams containing short-chain PFAS (so-called C6-pure)

Foam containing short-chain PFAS such as fluorotelomers (with C6 or shorter perfluoroalkyl moieties) are permitted to be used, but only if it is found and demonstrated to the satisfaction of the Administering Authority to be the only viable option including consideration of firefighting effectiveness, short and long-term health, safety and environmental risks and property protection, however, the following requirements must be met including:

- The foam must be *C6 purity compliant* foam with contamination or impurities less than the limits in [Table 4.2A](#).
- No releases are permitted directly to the environment (e.g., to unsealed ground, sewers, soakage pits, waterways or uncontrolled drains).
- All releases must be fully contained on site.
- Containment measures such as bunds and ponds must be controlled, impervious and must not allow firewater, wastewater, runoff and other wastes to be released to the environment (e.g., releases to soils, groundwater, waterways stormwater, sewer, unlined ponds, etc.).

All firewater, wastewater, runoff and other wastes must be disposed of as regulated waste to a facility authorised to accept wastes containing PFAS and any other contaminants as relevant.

Table 4.2A – PFAS (long-chain) limits in persistent short-chain (C6-pure) foam concentrates

Compounds	Limit (mg/kg)
Perfluoroalkyl sulfonates and precursors ≥C4 to C12 , the sum of the compounds. (PFBS+PFPeS+PFHxS+PFHpS+PFOS+PFNS+PFDS+PFDoS+precursors)	10 (sum)
Perfluoroalkyl carboxylates ≥C7 and higher homologues as the sum of the TOP-A analyses results for C7 to C14 compounds (TOP-A C7-C14).	50 (as fluorine)

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4.2.2 Foams containing perfluoroalkyl sulfonates (PFSA) \geq C4 and precursors

Use of foams that contain PFSA such as C4 PFBS, C6 PFHxS, C8 PFOS and their higher homologues as well as their salts or any compound that degrades or transforms to PFSA \geq C4 at greater than the concentrations sum listed in [Table 4.2A](#) in foam concentrate must not to be used, held in a system or in circumstance where it might be used. Any stocks being held pending proper disposal must be held securely and clearly marked as a regulated waste and not for use. These materials are to be managed and disposed of as regulated waste (*Environmental Protection Regulation 2019*, Schedule 9). For the purpose of determining compliance with the PFSA (total sulfonates) limit in [Table 4.2A](#), the analysis results for C4 to C12 PFSA compounds and their precursors are to be summed together.

4.2.3 Foams containing long-chain perfluoroalkyl carboxylates (PFCAs) and precursors

Firefighting foams containing PFCAs \geq C7, including PFOA, its precursor compounds or higher homologues, where the total organic fluorine content in the foam concentrate exceeds that listed in [Table 4.2A](#), must be withdrawn from service as soon as practicable and any stocks held (and any other related wastes) must be secured and not be available for use pending disposal. These materials are to be managed and disposed of as regulated waste (*Environmental Protection Regulation 2019*, Schedule 9).

PFCAs and their precursor compounds \geq C7 include any compounds that potentially degrade or convert to PFCAs \geq C7, for example 8:2 fluorotelomer derivatives, or higher homologs in the range of C7 to C14 perfluoroalkyl carbon chain-lengths.

Foams containing \geq C7 PFCAs and their precursors can only remain in service where it can be demonstrated to the satisfaction of the Administering Authority that there is no other viable fluorine-free or short-chain 'C6-pure' alternative after firefighting effectiveness, short and long-term health, safety and environmental risks and property protection characteristics have all been appropriately considered (primarily pertaining to very large fuel and crude oil storage tank fires). A plan for transition must be put in place with appropriate milestones and timelines approved under the relevant provisions of the EP Act.

4.2.4 Disposal of PFAS wastes including foam concentrate and wastewater

Foam concentrate that contains deliberately added PFAS, whether regarded by the user as a waste or not, must not be donated, sold, traded, exported or otherwise provided to any person other than for the purposes of proper and approved disposal. The waste generator is responsible and liable for any handling or effects of the waste until its final disposal or destruction.

Foam concentrate waste and wastewater containing PFAS contaminants from system testing or cleaning of equipment and pipework are regulated waste and must be fully contained and removed for transport to and disposal at an approved facility.

In Queensland new regulated waste classification and waste-related activity regulations came into force on 1 September 2019 as part of the *Environmental Protection Regulation 2019 (EP Regulation)*. This included provisions for classification of wastes. These are used to identify and appropriately manage the risks associated with various wastes and associated waste management activities (<https://environment.des.qld.gov.au/management/waste/business/classification>). The information sheet *Overview of regulated waste categorisation* (available from the link above) specifically addresses the issues pertaining to wastes containing PFAS.

A disposal plan for waste fluorinated foam concentrate containing PFAS of any type must be drawn up as soon as is practical but nonetheless within 3 months of the foam becoming a waste by being taken out of service or by being surplus to requirements (a guide for the plan format and content is available from the Department). This plan must include management measures to secure and prevent release of the material until arrangements are put into place for eventual

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disposal. Foam wastes must not be used in training, maintenance, testing or other activities that may result in their release to the environment on or off the user's site.

4.2.5 Portable extinguishers and mobile plant extinguishers

Some existing portable and hand-held extinguishers used in commercial applications as well as fixed systems mounted on very large earthmoving vehicles such as used in the mining and extractive industries may still contain PFAS foams such as AFFF. While the quantities of foam in these extinguishers and systems are individually small there are very large numbers in use, involving a large total volume of foam, with a significant potential for cumulative health and environmental impacts if the discharges and wastes are not managed properly.

There is a high probability that foam from these small-quantity extinguishers will be discharged directly into the environment by users with limited knowledge or through poor waste disposal practices during testing and servicing resulting in no control of dispersal and creation of PFAS contaminated sites.

There are now non-persistent (fluorine-free) foams available for hand-held extinguishers and mobile plant systems that meet Australian fire performance standards. Hand-held and mobile plant extinguishers containing PFAS foam must not be used unless it has been clearly demonstrated to the Administering Authority that there are no viable non-persistent alternatives. These are subject to the following restrictions:

- Foam concentrate used in the extinguisher must meet C6-purity as per the limits in [Table 4.2A](#).
- All discharges of foam containing PFAS, along with the associated contaminated water, soils and other materials must be collected and contained for proper disposal as regulated waste whether discharges are from operational use or from testing and maintenance activities.
- Foams and wastewater containing PFAS must not be disposed of by discharge to the ground, drains or waterways.
- Foams and wastewater containing PFAS must not be disposed to sewers or general wastewater treatment facilities. Disposal must only be to facilities licensed and capable of properly disposing of such wastes with the facility operator being made aware that the wastes contain PFAS.

4.2.6 Shipping – Special considerations

Regulations pertaining to safety systems and foam which off-shore facilities, and international and domestic shipping are required to comply with and procedures to contain and deal with on-board firewater will have an effect as to what mitigation measures can be practically achieved and how much a facility, vessel or port operator may be able to influence how risks from potential incidents are managed. However, the Master of a vessel, the ship's owner, the vessel's insurer and the offshore facility operator are ultimately responsible for making good any short-term or long-term damage that their vessel/facility causes in Australian waters and to the port, shipping and/or offshore facility including any long-term adverse effects to health, environmental and socio-economic values.

Port Authorities and berth managers will have limited powers with respect to activities on board foreign-registered vessels. However, they should still endeavour to raise awareness of PFAS foam issues and influence the potential releases of foam to the environment within their area of responsibility.

In terms of practical management of the current carriage and use of firefighting foam by vessels the risks of short or long-term adverse environmental effects could be reduced while still addressing the priority of maintaining safety at sea by:

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- **Forward planning** – Contingency planning and relevant facilities to manage and prevent as far as practicable the release to the environment of firewater containing persistent pollutants, e.g., procedures to capture and hold firewater on board.
- **Incident management** – Taking all reasonable and practicable measures during and after the incident to prevent discharge of firefighting foam or related wastewater containing a persistent pollutant to the sea or any waterway unless it is unavoidable to secure the safety of a ship or to save life at sea.
- **Waste disposal** – Wastes or firewater containing persistent pollutants must be disposed of to an appropriately licenced onshore facility capable of treating and disposing of the wastes in accordance with legislative requirements. For example, a vessel should not be allowed to depart the port carrying PFAS waste that is expected to be disposed of at sea.

The large number, diversity of types and nationalities of ships operating in Australian waters limits the consistent and adequate application of on-board risk reduction practices for PFAS foam. Accordingly, port managers may need to consider what practical measures could be implemented locally in the case of an incident to assist vessels to prevent releases and minimise the risk to their local environment where the environmental sensitivities are highest.

4.2.7 Training and testing foams

For the purposes of this Policy “training foams” are regarded as the same as operational firefighting foams for all intents and purposes as they all contain chemicals that can have adverse environmental effects. Foams used for training, testing or maintenance purposes must not contain any persistent organic compounds including PFAS with the exceptions where testing with a PFAS operational foam is mandatory or unavoidable. Any firewater, wastewater, runoff and other wastes containing persistent organic compounds such as PFAS must not be released to the environment, must be able to be fully contained and must be disposed of as regulated waste.

Where a non-persistent, fully biodegradable training foam may be released to the environment, for example to soils to biodegrade, its release must be in a controlled manner and managed in such a way so as not to cause environmental harm by adverse toxicity, BOD or physical effects in water bodies or groundwater.

5.3 Environmental Acceptability

In the assessment of the suitability of a foam product for firefighting or vapour and spark suppression, the environmental acceptability must be considered in addition to performance and other aspects such as initial and lifetime costs, operational constraints, etc.

Accurate information and statements regarding environmental effects and acceptability must be included in the product SDS with sufficient information that enables the end user to determine the potential effects and need for management measures. It is not sufficient for the SDS to have statements such as “Not available” or “Not tested” for critical characteristics information.

The environmental acceptability of any foam being considered or used must be assessed by the user for their particular circumstances in terms of the potential impacts upon the adjacent and downstream environment based on SDS information, values or statements in regard of all of the following critical characteristics:

- persistence in the environment
- biopersistence, bioconcentration, bioaccumulation and biomagnification potential
- toxicity (both short-term acute and long-term chronic impact potential)
- mobility in soils and groundwater
- biochemical oxygen demand (acute oxygen stress potential for waterways)
- biodegradability and fate in the environment.

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Environmental acceptability related tests should be conducted against recognised standards and methodologies, such as those accepted and recognised in Australia, the USA, Canada, New Zealand and the OECD, and carried out by an independent certified laboratory or organisation.

The assessment of the foam characteristics must be undertaken for the combined formulation of all the ingredients, that is, the concentrate after formulation as marketed, sold and used. It is meaningless and misleading to only cite the effects of the principal or selected ingredients in isolation. Accurate concentrations of components are rarely given and synergistic effects of chemicals in complex mixtures can be very different to an individual chemical. For example, a surfactant can amplify the adverse effects of biocides and/or solvents by facilitating entry into plant or animal cells.

Products that do not have accurate and adequate information relevant to environmental acceptability should be avoided by end users unless information deficiencies are rectified. Inadequate or inaccurate product information by the manufacturer or supplier does not absolve the end user of responsibility and liability for any failure to put in appropriate mitigation measures or for any harm caused by their use or management of their chosen product.

5.3.1 Citing of environmental acceptability

As an alternative to full characterisation of persistence, bioaccumulation and mobility and reporting of the results, where a foam formulation is known to contain persistent organic compounds, such as PFAS, it will be sufficient for the manufacturer to clearly state in the SDS (section 12 and section 3) that the product contains chemicals that are persistent and potentially bioaccumulative in the environment and must not be released. For example, for a C6-pure foam, in Section 12 of the SDS a statement that would provide general identification of a persistent PFAS component and relevant cautions as to its release and would be:

- *“This product contains PFAS that are highly persistent, mobile and potentially bioaccumulative and must not be released to the environment or disposed of to sewer”.*

Where the firefighting foam is non-persistent and fully biodegradable, and that is clearly stated in the SDS, its environmental acceptability can be defined in terms of:

- acute toxicity (short-term acute values for fish, invertebrates and micro algae)
- biochemical oxygen demand profile/values to 95%/99% biodegradation
- a general statement about mobility in soils and groundwater.

Note that the generic description of “readily biodegradable” ([OECD Method 301, 1992](#)) relates to single fully degradable organic compounds, not complex mixtures such as foam, and has very lenient pass-thresholds of 70% removal of dissolved organic carbon and 60% of theoretical oxygen demand. These pass thresholds are not relevant to environmental acceptability of any product that contains persistent organic compounds including PFAS firefighting foam.

It is the manufacturer’s and/or supplier’s responsibility to undertake such testing and assessment as necessary and provide the results for the product to the user in written form in the SDS (section 12) in compliance with the GHS, Australian and Queensland SDS guidelines. The Administering Authority considers that it is the end user’s responsibility to ensure that the product that they intend to hold, or use is provided with an SDS that is adequate and is readily available for inspection on that site. Where there is missing or inadequate information the end user must seek it from the foam supplier in written form and include it with the SDS.

5.3.2 Persistence, mobility and bioaccumulation

Persistence, mobility and bioaccumulation information must be provided for any foam containing any persistent organic substances. End users should obtain written assurances from manufacturers or suppliers as to what persistent organic substances are in the products and obtain adequate information on their environmental characteristics.

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Where a firefighting foam product contains any PFAS compound it is sufficient to identify in the SDS Sections 3 and 12 that it is highly persistent, mobile in soils and groundwater, potentially toxic and bioaccumulative.

Where the foam contains potentially persistent organic compounds for which there is no established information on their persistence, toxicity, bioaccumulation and mobility, the foam is to be subject to the same restrictions as PFAS foam. Otherwise, data relevant to its proper management should be derived from accepted and recognised best practice, i.e., using Australian, United States Environmental Protection Agency (USEPA) or OECD methods or tests. For example but not limited to:

- **Persistence** – OECD (2008), *Test No. 314: Simulation Tests to Assess the Biodegradability of Chemicals Discharged in Wastewater*, OECD Guidelines for the Testing of Chemicals, Section 3.
- **Bioaccumulation aquatic** – OECD (2012), *Test No. 305: Bioaccumulation in Fish: Aqueous and Dietary Exposure*, OECD Guidelines for the Testing of Chemicals, Section 3.
- **Bioaccumulation terrestrial** – OECD (2010), *Test No. 317: Bioaccumulation in Terrestrial Oligochaetes*, OECD Guidelines for the Testing of Chemicals, Section 3.
- **Mobility** – Persistent or very persistent organic substances that are also mobile or highly mobile in soils and groundwater under PMT/vPvM criteria ([Arp & Hale, UBA 126/2019](#)).

The tests must be conducted by an internationally certified laboratory accredited for the relevant tests in order to demonstrate what the firefighting foam ALARP bioaccumulation and persistence risks to the environment are. The potential for highly persistent degradation or transformation products must also be identified together with relevant PBT data.

Whether a substance is considered persistent (P) or very persistent (vP) is assessed against the REACH Annex XIII criteria for PBT substances (see definitions).

5.3.3 Acute toxicity testing

Acute toxicity testing applies for all foams and should be conducted in accordance with standards and methodologies, such as those accepted and recognised in Australia, the USA, Canada, New Zealand and the OECD, by an independent laboratory or organisation. Australian or equivalent test species should include freshwater and marine species, for example but not limited only to:

- **48-hour acute (immobilisation) test** using a freshwater species, e.g., the daphnid *Ceriodaphnia dubia* (using USEPA 2002 method) or Australian or equivalent test species.
- **72-hour micro-algal growth inhibition** (cell yield) tests using, e.g., freshwater alga *Selenastrum capricornutum* (using USEPA Method 1003.0) or Australian or equivalent test species.
- **96-hour fish imbalance tests** using a freshwater fish species, e.g., Rainbow fish *Melanotaenia splendida splendida* (based on OECD Method 203) or Australian or equivalent test species.
- **72-hour micro-algal growth inhibition tests** using *Isochrysis aff. galbana* or *Nitzschia closterium* (based on USEPA Method 1003.0 and Stauber *et. al.* 1996 for the National Pulp Mills Research Program) or Australian or equivalent test species.
- **96-hour acute toxicity tests** using juvenile tiger prawn *Penaeus monodon* (based on USEPA OPPTS 850.1045), or the amphipod *Melita plumulosa* if tiger prawns or another Australian or equivalent test species are not available.

Acute toxicity results must be cited for the foam concentrate as sold, not for its individual components, but can additionally be cited for the usual produced foam concentrations such as 1%, 3% and 6%. The acute toxicity results can be compared against the U.S. Fish and Wildlife

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Service freshwater acute toxicity (EC/LC₅₀) rating scale (El-Harbawi, 2014) to provide the end user with a non-technical assessment benchmark.

It should be noted that short-term toxicity test results are not relevant to assessing long-term chronic PFAS toxicity. Research into the effects of PFAS on organisms, such as potential multigenerational effects on aquatic wildlife, is ongoing.

Relative acute toxicity	Aquatic LC50 range (mg/L)
Super toxic	<0.01
Extremely toxic	0.01–0.1
Highly toxic	0.1–1
Moderately toxic	1–10
Slightly toxic	10–100
Practically nontoxic	100–1,000
Relatively harmless	>1,000

After US Fish and Wildlife Service (El-Harbawi, 2014)

5.3.4 Chronic toxicity testing

For foams containing persistent organic substances (see “environmental persistence” in the Definitions) that are not PFAS and not indefinitely persistent, chronic toxicity information must be provided in the SDS. Chronic toxicity data should be derived from accepted and recognised best practice such as Australian, USEPA or OECD methods or tests, for example but not limited to the OECD (1992), *Test No. 210: Fish, Early-Life Stage Toxicity Test*, OECD Guidelines for the Testing of Chemicals, Section 2.

Non-persistent (fluorine-free) foams can be assessed by the manufacturer as to their persistence and chronic toxicity characteristics based on their knowledge of the chemicals used in the formulation (without having to reveal the confidential components) provided that there is sufficient information on which to make that judgement and that the manufacturer certifies clearly in the SDS that there they have assessed the formulation components and there are none that are persistent or have chronic environmental toxicity effects.

5.3.5 Biochemical oxygen demand and biodegradability

Biochemical oxygen demand (BOD) has the potential to cause severe depletion of oxygen levels in enclosed waterways. The SDS for any foam held for use or stored on a site must include information on its BOD, COD (chemical oxygen demand) and biodegradability. BOD for all foams is high to very high due to the degradable organic components necessary for effective firefighting performance. As such there is no high or low environmental acceptability threshold for BOD but rather the BOD profile of a foam is needed to plan mitigation and waste management measures for day-to-day use, training and incidents.

Under some circumstances it may be acceptable, or may be necessary, to release a non-persistent foam to a waterway in which case the BOD characteristics are important for managing the release and assessing potential impacts. Note that for PFAS foams including AFFF, FP, FFFP, (-AR) etc., they must be fully contained, and it is not acceptable for them to be released to sewer, drains or waterways regardless of the BOD characteristics.

The BOD must be expressed as biochemical oxygen demand in milligrams O₂ per litre measured at least for 5, 10, 15, 28-day periods and to 95% / 99% completion where that is >28 days - i.e., BOD₅ to BOD₂₈ and to BOD_{95%/99%} as mg O₂/L. The values cited for BOD must be reported in the SDS relative to foam concentrate as sold. Additionally, BOD can be cited for the normal concentrations recommended by the manufacturer for the finished foam, e.g., at 1%, 3% and/or 6% to assist the end user with contingency planning. A value for COD must also be reported in milligrams O₂ per litre for the foam concentrate against which to assess overall biodegradability.

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Where BOD progression to completion departs substantially from that normally expected in terms of the steepness of the initial degradation curve through 5 day and 7 day BOD and/or the length of time to achieve 95% to 99% degradation (e.g., where “ $BOD_{95\%} = 45 \text{ days}$ ”) additional values for BOD, or a representation of the BOD as a graphed curve, must be reported to assist users and responders in planning for potential impacts in the early stages of a release and to indicate likely timelines for waste management by biodegradation.

5.4 Disposal of PFAS Wastes

All solid and liquid wastes that contain PFAS (e.g., concentrates, firewater, wash-water, run-off, absorbents, etc.), including those from *C6 purity-compliant foam*, are regarded as regulated wastes and must only be disposed of through a facility that is licensed to take PFAS regulated wastes. Further guidance on waste management is included in the PFAS NEMP.

Waste materials not containing PFAS or any other persistent or hazardous materials may be disposed of by the appropriate lawful means according to the contaminants present.

5.4.1 PFAS contaminated sites and soil disposal

Where investigation of a site suspected of being contaminated by PFAS finds significant concentrations in environmental media such that there is the potential to cause pollution or environmental harm, a detailed site investigation must be carried out in accordance with the PFAS NEMP ([HEPA, 2020](#)) Australian guidance for the investigation of sites potentially impacted by PFAS including *the National Environmental Protection Council, National Environmental Protection (Assessment of Site Contamination) Measure 1999 (amended to 2013)* and relevant Queensland legislation and guidelines. Assessment criteria for contaminated soils assessment and disposal are considered separately from this Policy.

5.4.2 Waste foam concentrate and contaminated water disposal

PFAS waste must only be disposed of to a facility that is specifically licensed to accept PFAS wastes. Firefighting foam concentrate, foam solution, firewater or other wastewater containing PFAS or other persistent toxic compounds must not be discharged to sewer or similar standard waste treatment facilities, and must not be irrigated to land or provided for composting.

Standard sewage and wastewater treatment facilities have been shown to be ineffective at removing PFAS, which pass through in effluent and biosolids resulting in their eventual release to the environment via contaminated bio-solids applied to land as soil conditioner or treated effluent discharges onto land, crops or into waterways.

It is not acceptable to artificially dilute PFAS contaminated water with water, soil, other media or waste to make it suitable for reuse or release into the environment nor to disperse it into the atmosphere as vapour. Contaminated water must be treated in a way that prevents PFAS release to the air, waterways, soils or groundwater. For example, by treatment to extract or capture the fluorinated organics and/or by high temperature destruction with neutralisation or scrubbing of hydrogen fluoride from the flue gasses. Wastewaters may be treated to separate or concentrate the PFAS compounds from the water to reduce the volume of PFAS waste for final disposal.

In Queensland PFAS liquid wastes can be disposed of by high temperature incineration at licensed facilities such as by plasma-arc destruction or by co-processing in a cement kiln. Limited quantities of PFAS solid wastes, such as contaminated filter media, can also be co-processed in a cement kiln.

Further guidance on how to manage PFAS contaminants is provided in the PFAS NEMP. Consultation with the Department on specific issues is recommended.

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6 Implementation and Full Compliance

It is expected that since the Foam Policy was released in 2016 to guide compliance with the requirements of the *Environmental Protection Act 1994* firefighting foam users would have already achieved substantial or full compliance with this Policy, excepting where users are still transitioning to full compliance under an approved Transitional Environmental Program under the EP Act.

6.1 Effective Date

Notwithstanding that the requirements of the *Environmental Protection Act 1994* and the *Environmental Protection Regulation 2019* are already in force; this Policy has been in effect from its initial date of approval on 7 July 2016 and the amendments to it from the dates of signing.

6.2 Full Compliance

Firefighting foam users who find that they are not in compliance with the provisions of the Policy must advise the Administering Authority as soon as practicable, immediately put in place measures to minimise the risk of release of firefighting foam to the environment and seek approval under relevant provisions of the *Environmental Protection Act 1994* for a plan to come into compliance with specific milestones and timelines.


7 Review

This Policy may be reviewed and amended on the basis of any significant new information or changes in technology or best practice that become evident. This Policy will be reviewed three years after the date of the most recent version of this Policy.

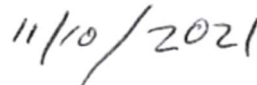
8 Further Information

For further information please contact the Environmental Services and Regulation Branch of the Department.

Approved by:



Signature



Date

Rob Lawrence
Deputy Director-General
Environmental Services and Regulation

Operational Policy Environmental Management of Firefighting Foam

Appendix A – Definitions

The following definitions and requirements apply for the purposes of this Policy and provide background and explanation for Policy provisions:

As low as reasonably practical (ALARP)

The risks from the activity must be averted unless there is a gross disproportion between the costs and benefits of doing so.

Best practice environmental management (BPEM)

The management of the activity to achieve an ongoing minimisation of the activity's environmental harm through cost-effective measures assessed against the measures currently used nationally and internationally for the activity.

Biochemical oxygen demand (BOD)

BOD is a measure of the amount of oxygen consumed, primarily by bacteria, in breaking down organic matter in a water body (algal respiration, sediment and chemical uptake can also contribute to BOD). The terms *biochemical* oxygen demand and *biological* oxygen demand are interchangeable for the purposes of this Policy. Elevated BOD will result in depletion of dissolved oxygen from the water column that can cause harm to aquatic life (i.e., from the decay of the organic compounds in foam). BOD for most foams is very high, typically 100,000s mg O₂/L and therefore of considerable environmental concern.

BOD is reported relative to periods such as 5, 10, 15, 20 and 28 days expressed in milligrams of oxygen per litre consumed for each period. When BOD is plotted, the initial slope of the degradation curve, i.e., to ~BOD₅, usually represents the acute oxygen stress to which a receiving body of water will be exposed ([ANZECC, 2000](#)). Rapid degradation kinetics imply high acute oxygen stress, with low acute oxygen stress being associated necessarily with longer degradation times. For firefighting foams the 5-day BOD (BOD₅), is commonly the time by which 50% to 70% of the organics have degraded.

The environmental degradation of most organics usually goes to near completion after about 28 days (typically to >95%) with no further significant BOD occurring. However, for complex mixtures of organics such as in firefighting foams the time for 95-99% degradation can be more than 28 days and this needs to be determined as the BOD-95% or BOD-99% period.

The standard method for determining BOD₅ and dissolved oxygen in Australia is in accordance with the APHA section 5210B and Section 4500-O, respectively (American Public Health Association, 1998).

While the BOD for most foams is high to very high due to the degradable organic components some solvent-free, i.e., glycol derivative free, foams are now available offering reduced overall BOD/COD values.

Bioaccumulation

A general term for the progressive increase of a substance in an organism or part of an organism that occurs because the rate of intake exceeds the organism's ability to remove the substance from the body. Intake can be directly from environmental exposure, i.e., by absorption through the skin or from the air through inhalation, or from food and water ingestion. See also the related terms *Bioconcentration* and *Biomagnification* ([International Union of Pure and Applied Chemistry \(IUPAC\), 2007](#)).

Bioconcentration

The process leading to a higher steady-state concentration of a substance in an organism or specific organ, such as the thyroid or liver, higher than the concentration in the environmental media to which it is exposed. For example, the net uptake, against a concentration gradient, of a

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contaminant directly from the environment by plants or animals (from food, water or soil) until an equilibrium (higher) concentration of the contaminant is reached in one or more tissues.

Biodegradability (value)

The degradability of the product or waste under environmental or biological treatment conditions, determined as the ratio of the BOD_n value (~95-99% degraded) to the total chemical oxygen demand (COD) for the oxidisable organics, expressed as a percentage ($BOD_{95\%/99\%}/COD \times 100$).

While the biodegradability of readily degradable organic materials is generally expressed as the ratio of the 28-day BOD to the COD, the biodegradation of firefighting foams often exceeds 28 days due to the complex formulations. For any complex mixture biodegradability should be determined as the ratio of the BOD of 95%-99% degradation to the COD.

Note: The Organisation for Economic Co-operation and Development (OECD) threshold of “60%” for “readily biodegradable” (Test 301 A-F) relates to the degradation of single organic compounds that are expected to rapidly and fully biodegrade. This term and measure is not directly applicable to complex mixtures such as in firefighting foam where biodegradability to 95%-99% needs to be established and cannot be inferred from an arbitrary “60%”. Additionally, assurance needs to be provided that the mixture does not contain any persistent organic compounds. Any description of “biodegradability” for PFAS foams is inappropriate, misleading and must not be applied for any mixture containing persistent organic compounds such as per- and poly-fluoroalkyl substances (PFAS) or persistent siloxanes.

Biodegradable

For the purposes of classifying and stating the biodegradability of a firefighting foam, all the organic compounds in its composition must degrade under normal environmental conditions within 28 days or over another period from the time of its release to the environment (see BOD) and be stated in the form:

- Readily biodegradable (>95% in 28 days).
- Fully biodegradable (>99% in 28 days). OR
- Readily biodegradable (>95%) in ## days.
- Fully biodegradable (>99%) in ## days (e.g., “Fully biodegradable (>99%) in 45 days”).

Foams that contain persistent organic compounds or that break down or transform to produce further persistent organic compounds such as PFCAs or PFSA that do not fully degrade under normal environmental conditions, cannot be classed as fully or readily biodegradable. In particular, if transformation or end-point products with persistence, bioaccumulation and toxicity (PBT) properties are being generated, the substances themselves must be regarded as PBT substances ([European Chemicals Association \(ECHA\), 2015](#)).

Biopersistence

The persistence of a chemical compound in plant or animal tissues unaltered or altered in a way that results in a chemical with similar characteristics or effects. Biopersistence is significant if the chemical compound is toxic and persists in the plant or animal tissues for long enough to have a potentially detrimental effect (beyond that of acute toxicity) or for the chemical to be passed on to further individuals via the food chain, or across the placenta to the foetus in mammals. Steady-state exposure where the chemical persists in the plant or animal due to the intake being the same as elimination has the same effect as biopersistence.

Biomagnification

Also termed *ecological* or *trophic magnification*. The sequence of processes in an ecosystem by which higher *concentrations* are attained in organisms at higher trophic levels (at higher levels in the food web); at its simplest, a process leading to a higher concentration of a substance in an organism than in its food.

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Chemical oxygen demand (COD)

COD, expressed as milligrams of oxygen per litre, is a measure of the theoretical maximum amount of oxygen required to oxidise all the chemically oxidisable organics in a sample, as usually determined using acid dichromate. When BOD₂₈ (or BOD_n) is subtracted from COD the remaining amounts represent the oxidisable organic components that are not readily biodegradable over that 28-day (or “n” other) period. PFAS compounds in foam are a component of the total organic material present. However, because of their chemical stability, PFAS do not contribute to the COD value, as normally measured, and are considered non-oxidisable, even by acid dichromate, and are non-biodegradable organics.

Contaminant/contamination

Contamination of the environment is the release to the environment (whether by act or omission) of a contaminant that is of concern or could cause adverse effects to socio-economic, human health or environmental values. This includes concerns that might arise from the application of the *Precautionary Principle* (Preston, 2017).

C6 purity-compliant foam

For the purposes of this Policy, a foam product that is *C6 purity compliant* must be based on fluorotelomer technology and not exceed the PFAS limits in Table 4.2A for PFCA and PFSA, precursors and related compounds.

For long-chain PFAS carboxylates and their precursors the limit is ≤50 mg/kg (as F) in C6-pure foam concentrate for any compounds where the *perfluorinated* part of the carbon chain is longer than 6 carbon atoms. For example, perfluoro-heptanoic acid (C7 PFHpA) its higher homologues and precursors, including 7:3, 8:2, 10:2 fluorotelomers, fluoropolymers with ≥C7 side-chains, etc.

For PFAS sulfonates there is an impurity limit of a total of 10 mg/kg (sum) for ≥C4 to C12 PFASs and their precursors. This includes perfluorooctane sulphonic acid (C8 PFOS) and perfluorohexane sulphonic acid (C6 PFHxS).

Environmental persistence

The long-term persistence of chemicals, including their degradation products with similar characteristics or effects, in the environment under normal environmental conditions, with resistance to degradation by factors such as oxidation, hydrolysis, reduction, exposure to ultraviolet light and aerobic or anaerobic metabolic breakdown by microbes. Environmental persistence increases the exposure of organisms to the chemicals, and is of particular concern for chemicals that bioaccumulate (as well as bioconcentrate or biomagnify) thereby increasing the risks of adverse effects.

An organic compound is considered environmentally *persistent* or *very persistent* under the EU Commission REACH (Annex XIII) Regulation (European Union, 2011) when its half-life, including that of its degradation products with similar characteristics or effects, is greater than the value shown in the table below for each environmental compartment.

REACH ANNEX XIII: Criteria for the identification of persistent and very persistent substances.
<p>Persistent (P) – A substance fulfils the ‘persistence criterion’ where the degradation half-life in:</p> <ul style="list-style-type: none">a) marine water is higher than 60 daysb) fresh or estuarine water is higher than 40 daysc) marine sediment is higher than 180 daysd) fresh or estuarine water sediment is higher than 120 dayse) soil is higher than 120 days.

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REACH ANNEX XIII: Criteria for the identification of persistent and very persistent substances.

Very Persistent (vP) – A substance fulfils the ‘very persistent’ criterion where the degradation half-life in:

- f) **marine, fresh or estuarine water** is higher than 60 days;
- g) **marine, fresh or estuarine water sediment** is higher than 180 days;
- h) **soil** is higher than 180 days.

ECHA, 2017. Guidance on Information Requirements and Chemical Safety Assessment. Part C: PBT/vPvB Assessment

Firefighting foam

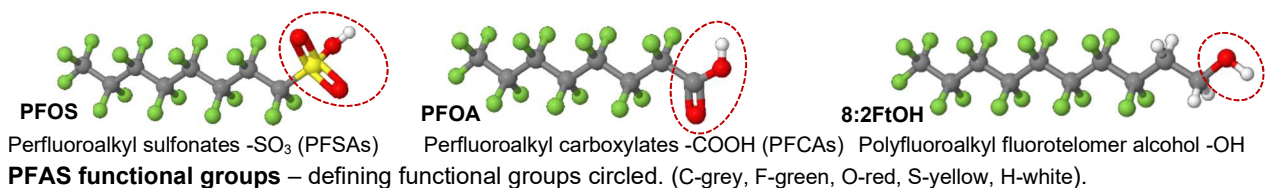
Firefighting foam refers to concentrates and their aqueous solutions that are used in the production of streams or blankets of air/gas-filled bubbles to suppress flammable vapours, increase water penetration, reduce static spark generation, control or extinguish fires, and prevent re-ignition by excluding air and cooling the fuel. For the purposes of this Policy firefighting foams are referred to as Class A and Class B foams. Class A foams are used on carbonaceous combustible materials, such as vegetation, wood, paper, fabric, plastics and rubber. Class B foams are used on flammable and combustible liquids or spills such as liquid hydrocarbon fuels and polar solvents where the fire and vapours are on the surface of the liquid.

Firewater, wastewater or runoff

Any contaminated water generated where water sprays, jets, mists, deluge, monitors or foam generators have been used to extinguish a fire, dilute a contaminant, cool a container or stockpile, blanket a spill with foam, disperse or dissolve a gas or vapour release or wash down a contaminated area. This includes firewater, wastewater or runoff produced during testing, training, maintenance, accidental release, or an incident whether or not a fire was involved.

Fluorinated organic compounds (PFAS)

Fluorinated organic compounds commonly found in or associated with firefighting foam have come to be generally referred to as “PFAS”, an acronym derived from *per- and polyfluoroalkyl substances*. PFAS are organic compounds with one or more carbon atoms having one or more hydrogen atoms replaced by fluorine atoms in the straight or branched organic carbon chains, and which contain a perfluoroalkyl moiety. This includes both perfluorinated and polyfluorinated PFAS (as illustrated below) in the original foam formulation and any resulting transformation products. All PFAS include a linear or branched fluorinated carbon chain with a *functional group* usually on one end. Fluoropolymers can also have multiple fluorinated carbon chains attached to a non-fluorinated backbone.



All organic fluorochemicals, or any other fluorine-carbon compounds, fall within the general classification ‘*organohalogen*s’ under the Queensland *Environmental Protection Regulation 2019* and Annex VIII(1) of the EU Water Framework Directive 2000/60/EC.

Fluorinated organic compounds (PFAS) analyses

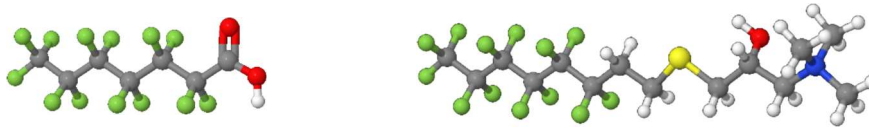
PFAS analyses must be representative of the compounds present for contamination and risk assessments to be meaningful and relevant to the environmental risk and the end user’s liability. When used alone the standard analyses suite falls well short of revealing the real extent of the PFAS present in most cases. There is also the possibility of the inclusion of novel persistent siloxane and fluorinated-siloxane compounds under consideration for active ingredients. Where

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other persistent organic compounds are known or likely to be present, such as siloxanes (Hetzer, Kummerlen, Wirz, & Blunk, 2014), other relevant analytical methods will be necessary.

The determination of the PFAS content of foams and other matrixes is made difficult by the very diverse range of PFAS that are known to occur in fluorinated firefighting foams and in their associated wastes.

Current generation firefighting foams are primarily based on even-numbered straight-chain fluorotelomers with fluorinated carbon chain lengths in the range of C4 to C14. The wide diversity of complex PFAS in foam formulations (Field & Sedlak, 2017) relates to the wide range of functional groups attached to the perfluorinated carbon chains that are the common feature of all PFAS, including fluorotelomers, in the form $CF_3-(CF_2)_n$, where $n+1$ is the length of the perfluoroalkyl chain.



C7 PFHpA contains the same perfluoro chain as the complex 6:2 fluorotelomer thiohydroxy ammonium (6:2 FtTHA).

The presence of a wide range of complex fluorotelomers in PFAS foams results in an even wider range of transformation compounds in the environment generated by partial and progressive transformation of the parent compounds. All transformation products and precursors are nonetheless PFAS having the persistent perfluoroalkyl carbon chain common to all with the potential to cause adverse effects.

In order to meaningfully assess the levels of PFAS present in samples and to assess the probable associated risk it is not sufficient to only analyse for the limited standard suite of about 20 to 40 PFAS because many of the complex PFAS compounds present will remain undetected against the PFAS analytical standards used. Similarly, to only consider legacy compounds such as PFOS, PFHxS and PFOA in risk assessments is not sufficient, is out-of-date and a failure to understand the real scope of the PFAS 'universe'. PFOS, PFOA and PFHxS are not relevant to the risks posed by current generation fluorotelomer PFAS foams that have been in common use since about 2000. For example, a site that has been heavily contaminated by only fluorotelomer PFAS foam use will not have any PFOS and PFHxS in analyses results and may only exhibit traces of PFOA present from C8 fluorotelomer breakdown.

It is not practical to carry out analyses for all the individual complex PFAS compounds present, nor is it meaningful as there is very little information available on the effects of each compound or the complex combinations of transformation compounds that could occur. The most practical approach is to use the total oxidisable precursor assay (TOP-A) method that is available to reveal the extent of the many C4-C14 chain length PFAS hidden from the standard analyses.

However, for the TOP-A method to produce meaningful results the method needs to be applied carefully considering the factors and refinements outlined below.

The TOP-A method (Houtz & Sedlak, 2012) transforms the diversity of PFAS not detected by the standard suite through oxidative transformation of the complex functional groups to the simpler end-point perfluorinated carboxylic acids (PFCAs) and sulfonates (PFSAs) that are measurable.

While the PFAS functional groups are very diverse and probably have a significant influence on their behaviour and effects, for practical PFAS content determination and assessment purposes for firefighting foam, the TOP-A method will give an indication of the range of PFAS chain lengths present revealing the presence of complex PFAS not detectable by the standard analysis.

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The perfluoroalkyl chain lengths of the PFCAs in TOP-A results are generally indicative of the chain lengths and proportions of their precursors in wastes and firefighting foam (Field & Sedlak, 2017). The chain-lengths also relate generally to PFAS toxicity, dispersibility, mobility in soils and groundwater, uptake in crops and bioaccumulation potential.

The TOP-A method is available through commercial laboratories with important refinements to the original method to compensate for interference from high oxidisable organic content in firefighting foam samples and has been verified as reliable (Ventia/ALGA, 2019).

TOP-A analyses of matrixes with high organic content, including firefighting foams, may also benefit from advanced precursor digestion (APD) using peroxide to reduce the organic content that can interfere in the TOP-A method (Hutchinson, Rieck, & Wu, 2020).

The high organic content of firefighting foam (and some other matrixes such as biosolids) poses two main problems for the TOP-A method:

- The TOP-A digest persulfate oxidant can become exhausted by the high general organic content of the sample such that there is incomplete transformation of complex PFAS to the end-point PFAS that are measurable, thereby resulting in under-reporting of the PFAS content.
- An excess of TOP-A aggressive persulfate oxidant or too many cycles of digestion used to overcome the high organic content interference can result in significant perfluoroalkyl chain shortening resulting in mis-assignment of PFAS as shorter chain-lengths than the parent compounds as well as some very short-chain PFAS content failing to be reported due to chain-shortening to below the C4 detection threshold.

Advanced precursor digestion uses peroxide pre-treatment to target and remove the non-fluorinated organic content while leaving the perfluoroalkyl chains intact. This avoids the need to use persulfate more aggressively in the TOP-A digestion process.

Fluorotelomers used in foams have even perfluorinated carbon chains (e.g., 4:2, 6:2, 8:2, etc.). However, odd chain-length end-point PFAS appear in TOP-A results, this is due to some chain shortening of the parent perfluoroalkyl chain in the aggressive TOP-A digest. The odd-chains in TOP-A results should be ascribed to the next longer even chain for their source. For example, the sum of C5 PFPeA + C6 PFHxA in TOP-A results is probably an indicator of the content of 6:2 fluorotelomer parent compound(s) in the sample.

Where there is likely to be a preponderance of short-chain PFAS ($\leq C4$) in material the use of laboratories that offer detection of PFPrA (C3 PFCA) is desirable. Similarly, to assess whether a significant amount of ultra-short chain PFAS are not being detected or where PFAS may be difficult to separate from matrixes, the analysis for total organic fluorine by combustion ion chromatography (TOF-CIC) of the original sample can be used and the result compared to the sum of the PFAS (fluorine) results from the TOP-A method.

For the purposes of determining compliance with this policy and reporting the presence of PFAS in water, foam solutions, wastes, foam concentrate or any matrix relevant to the Policy, sample analyses shall be carried out for:

- **The PFAS standard analyses suite** including at least:
 - a) Perfluoroalkyl carboxylic acids (PFCAs) at least C4 to C14.
 - b) Perfluoroalkyl sulfonic acids (PFSAs) at least C4 to C10.
 - c) PFOS precursors – PFOSA, N-MeFOSA, N-EtFOSA, N-MeFOSA-ethanol, N-EtFOSA-ethanol, MeFOSA-acetic acid, EtFOSA-acetic acid.
 - d) N:2 Fluorotelomer sulfonic acids (N= 4, 6, 8, 10 - e.g., 6:2 FtS).

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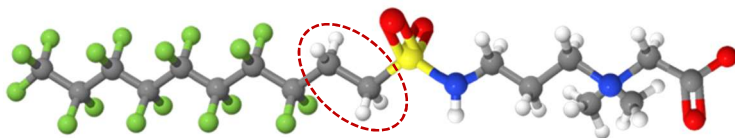
- **TOP-Assay**, quality assured, reported for:
 - e) the suite in a) as the sum of the fluorine content for C4 to C14 (PFBA to PFTeDA).
 - f) the suite in b) as the sum of the compounds for C4 to C10 (PFBS to PFDA).
- **Total Organic Fluorine (TOF)** Adsorbable fluorine for liquids, extractable fluorine for solids.

Note: The TOP Assay analysis must be quality assured using the recommendations in the *PFAS NEMP 2020* section 19.2.3 and the associated conclusions and recommendations in the ALGA funded TOPA Assay reliability study ([Ventia/ALGA, 2019](#)) with consideration of advanced precursor digestion (APD) to reduce the organic content that can interfere in the TOP-A method ([Hutchinson, Rieck, & Wu, 2020](#)).

If a total organic fluorine analysis is unavailable, or the TOF limit of reporting (LOR) is inadequate to determine its significance under an environmental authority or other EP Act waste evaluation requirement, the results of quality assured TOP-A analyses may be substituted. If the waste can be practicably analysed using TOP-A the results are reported as the sum of the fluorine content for the C4 to C14 PFAS using the lowest achievable limit of reporting as a surrogate for the approximate TOF. Use of TOP-A results as a substitute for TOF is only applicable where the waste or contamination source is related to firefighting foam or a source with a likely perfluoroalkyl chain-length range of C4 to C14.

Fluorotelomer PFAS

Fluorotelomer PFAS are poly-fluoroalkyl substances where the carbon chain has one or more carbon atoms that are not fully fluorinated, usually having two non-fluorinated carbon atoms between the perfluoroalkyl chain and the functional group. For current generation firefighting foams, the most common fluorotelomers in use follow the form “n:2” where “n” is the length of the perfluoroalkyl moiety (always an even number for fluorotelomers) The “:2” represents a non-fluorinated di-methylene spacer group (-CH₂-CH₂-). For example, the telomer spacer is circled in the 8:2 fluorotelomer thioamido alkyl betaine (8:2FtTAB) illustrated below, between the perfluoroalkyl chain and the complex functional group.



Complex fluorotelomer - 8:2 fluorotelomer thioamido propyl betaine (8:2FtTAB) The -CH₂-CH₂- spacer is circled.

Fluorotelomer PFAS are a very diverse group of compounds, not only in terms of the variety of complex compounds used in foam formulations but also in the large number of complex intermediate degradation or transformation products possible on release to the environment ([Washington, Jenkins, & Weber, 2015](#)), ([Liu & Avendaño, 2013](#)), ([Kim, Wang, & Chu, 2013](#)).

For example, the simple 8:2 fluorotelomer alcohol has about 16 intermediate transformation compounds and 5 end-point PFCA compounds. All PFAS are of concern, including parent fluorotelomers, their intermediate transformation products and their end-point carboxylate PFAS such as PFOA and PFHxA.

Some intermediate fluorotelomer transformation products have been found to be significantly more toxic by up to 10,000 times to aquatic organisms than their parent PFAS or some of their end-point perfluoroalkyl carboxylic acids ([Phillips, Dinglasan-Panlilio, Mabury, Solomon, & Sibley, 2010](#)). They have also been found to bioaccumulate in marine invertebrates ([Langberg, et al., 2019](#)). Therefore, it is not sufficient to refer only to the characteristics of end-point compounds such as C6 PFHxA for risk assessment.

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General environmental duty (GED)

Under the Queensland *Environmental Protection Act 1994* the GED requires that a person must not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to prevent or minimise the harm having regard to the current state of technical knowledge for the activity and other relevant matters (Section 319, *Environmental Protection Act, 1994*).

Intergovernmental Agreement on the Environment (IGAE)

The IGAE was made on 1 May 1992 between the Commonwealth, the States, the Australian Capital Territory, the Northern Territory, and the Australian Local Government Association. This includes the commitment to ecologically sustainable development (ESD) and the obligation to apply the *Precautionary Principle*.

The IGAE also incorporates the PFAS *National Environmental Management Plan May 2020* and the *Intergovernmental Agreement on a National Framework for Responding to PFAS Contamination*.

Mobility in the environment

Substances that are persistent and mobile are potential substances of very high concern (SVHC) and can be considered of equivalent concern to bioaccumulative substances. This arises from their potential to migrate into, accumulate and cycle in sources of drinking water to levels that may cause adverse effects through chronic exposure or adversely affect other human-use environmental values reliant on uncontaminated water sources, e.g., industry, food production, fisheries, aquaculture and agriculture. The German environment agency (UBA) has proposed two classes of concern, *persistent* and *mobile* (PM) and persistent and very mobile (PvM) to protect drinking water under European REACH regulations ([Neumann & Schliebner, 2019](#)):

- A substance fulfils the "mobility" criterion when the lowest organic carbon-water coefficient $\log K_{oc}$ over the pH range of 4-9 is less than 4.0.
- A substance fulfils the "very mobile" criterion when the lowest organic carbon-water coefficient $\log K_{oc}$ is less than 3.0, over the pH range of 4-9.

The same intrinsic PFAS properties that lead to persistence in the environment and mobility in the aquatic environment give rise to breakthrough in water treatment facilities ([Hale, Arp, Schliebner, & Neumann, 2020](#)). If emissions are continuous or increasing, the concentration of such persistent and mobile substances in the wastewater-water reuse cycle and the environment may increase over time, potentially becoming irreversible and practically untreatable through remediation.

PFAS of C6 and shorter are of concern as they are highly mobile, difficult to treat, and have been observed to be taken up to a greater extent in edible plants than longer chain PFAS, indicating a commensurately greater risk of contamination by uptake into the food chain ([Blaine, et al., 2014](#)), ([Felizeter, McLachlan, & Voogt, 2012](#)) ([European Commission, 2020](#)). Where there is steady-state PFAS uptake into foodstuffs from the application of PFAS in irrigation water, biosolids and effluent the exposure is analogous to bioaccumulation, countering the argument that short-chain PFAS are of lesser concern because of fairly rapid bioelimination in humans.

Very persistent, very mobile (vPvM) and toxic substances, including short-chain PFAS, have been demonstrated to have an equivalent level of concern (ELoC) for human health, environmental and other values to substances that are very persistent and very bioaccumulative (vPvB), as is the case for long-chain PFAS ([Hale, Arp, Schliebner, & Neumann, 2020](#)). While the exposure pathways differ temporally and spatially the effects are comparable. The PMT/vPvMT short-chain substances circulate in drinking water and food crop cycles while the PBT/vPvB substances accumulate more statically in humans and the food chain.

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Perfluoroalkyl carboxylates (PFCAs)

A class of persistent PFAS compounds with the formula $\text{CF}_3\text{-(CF}_2\text{)}_{n-1}\text{-COOH}$ as the carboxylic acid or, $\text{CF}_3\text{-(CF}_2\text{)}_{n-1}\text{-COO}^-$ as the carboxylate anion (where “n” is from 1 to 14). For example, C8 perfluorooctanoic acid (PFOA, CAS 335-67-1) or C6 perfluoro hexanoic acid (PFHxA, CAS 307-24-4). For the purposes of the Policy and PFAS management, all PFCAs, their precursors and related substances that transform biotically or abiotically to PFCAs are regarded in the same way as the end-point PFCA of the same carbon chain length, except where there are indications directly or by read-across to a similar compound to suggest greater adverse effects. For example, 8:2 fluorotelomers and higher homologues are regarded in the same way as PFOA while some odd-chain acids such as 5:3 and 7:3 fluorotelomers are regarded as more toxic or bioaccumulative.

Perfluoroalkyl sulfonates (PFSAs)

A class of persistent PFAS compounds with the formula $\text{CF}_3\text{-(CF}_2\text{)}_n\text{-SO}_3\text{H}$ as the unionised sulfonic acid or, $\text{CF}_3\text{-(CF}_2\text{)}_n\text{-SO}_3^-$ as the sulfonate anion (where “n” is from 1 to 14). For example, C8 perfluorooctane sulfonic acid (PFOS, CAS 1763-23-1) or C6 perfluorohexane sulfonic acid (PFHxS, CAS 355-46-4). For the purposes of the Policy and PFAS management, PFSAs with carbon chain lengths of C6 and greater are regarded as long-chain PFSAs due to their similar, toxicity, bioaccumulation and long elimination half-lives. This includes related substances such as $\geq\text{C6}$ perfluoroalkyl sulfonamides and other PFSA end-point precursors.

Safety data sheet (SDS)

SDS, previously referred to as a material safety data sheet (MSDS), in the form described by the Safe Work Australia Code of Practice *Preparation of safety data sheets for hazardous chemicals* (2020). Information relevant to the characteristic of the product and its potential environmental impacts as required by the Policy should be placed in *Section 12–Ecological Information* of the SDS.

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