Senate Inquiry

Part B:

Contamination at Commonwealth, state and territory sites in Australia where fire fighting foams containing Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA) were used

Airservices Australia Submission

February 2016

connecting australian aviation

Contents

Glossary

AFFF	Aqueous film forming foams
ARFF	Aviation rescue fire fighting
Class A and Class B	These are references to different standards of fire fighting foams under the CASR
Current Sites	Sites where ARFF services are still provided
Historical Sites	Sites where ARFF services were previously provided, either by Airservices or earlier providers, but are no longer provided
NICNAS	National Industrial Chemicals Notification and Assessment Scheme
PFCs	Perfluorinated compounds
PFHxS	Perfluorohexanesulfonic acid – a PFC
PFOA	Perfluorooctanoic acid – a PFC
PFOS	Perfluorooctanesulfonic acid or perfluorooctane sulfonate – a PFC
Solberg RF6	A PFC-free Class B fire fighting foam

References to Legislation

Air Services Act	*Air Services Act 1995* (Cth)
Airports Act	*Airports Act 1996* (Cth)
CASR	*Civil Aviation Safety Regulations 1998* (Cth)
Environment Protection Regulations	*Airports (Environment Protection) Regulations 1997* (Cth)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)

Executive Summary

Airservices has been actively and responsibly managing issues arising from the use of fire fighting foams now known to have contained perfluorinated compounds (PFCs) since it became aware of concerns about PFCs in the early 2000s.

International civil aviation regulations adopted by Australia specify performance, training and operational requirements for aviation rescue fire fighting (ARFF) services, including for fire fighting foams. Since the 1950s, various types of foams have been used by rescue fire fighting services at airports around Australia. Fire training grounds at airports have generally been used for necessary training activities, including the use of fire fighting foam.

From the early 1980s until the early 2000s, a fire fighting foam called 3M Lightwater was used. This product contained perfluorooctane sulfonate (PFOS) as an active ingredient and other PFCs such as perfluorooctanoic acid (PFOA). Following increasing concerns about the possible environmental and health impacts of PFOS, in 2003 Airservices changed to another approved fire fighting foam called Ansulite that was understood to not contain PFOS or PFOA. It was later found to contain trace amounts of both of these chemicals. In 2010, Airservices transitioned to a PFC free foam, Solberg RF6, at all airports where Airservices provides ARFF services with the exception of the joint civil-military airports of Darwin and Townsville[1].

Airservices initiated investigations which have identified 56 sites where rescue fire fighting services at airports were provided and:

- at 20 sites, aqueous film forming foams (AFFFs) have not been used (although there may have been some extremely low levels of residues in equipment or materials transferred from other locations); and
- 36 sites (both Current and Historical Sites) have, or are suspected of having, PFC residues as a result of AFFF use (further details are provided at **Appendix D)**.

The science as to the risks posed by PFCs is not settled. However, scientists have found that:

- PFCs do not readily break down;
- PFCs are highly persistent in the environment; and
- PFCs are capable of accumulating in the bodies of some animals and humans.

Research is still being undertaken both within Australia and internationally to establish any causation between human health impacts and PFOS or PFOA exposure (see parts 3.4 and 3.6).

In Australia, there is no specific regulatory standard or generally accepted risk-based screening criteria for PFC concentrations in soil or water (see part 4). This has posed challenges for Airservices' response to PFC impacted locations. Airservices has sought to take a proactive and responsible approach underpinned by developing a better understanding of the issues through site assessments, implementing a research and development program, and open and transparent stakeholder engagement and communication. Key actions taken include:

- Since 2009, Airservices has worked with Commonwealth, State and Territory health and environment experts, regulators, policy agencies, airport owners and operators, and research institutions to inform development of appropriate national standards and guidelines including screening levels for soil and water. This work is ongoing.
- In 2010, Airservices engaged an expert to undertake a voluntary health study on ARFF staff's exposure to PFCs.
- Airservices has undertaken soil, surface water and groundwater sampling at current fire training grounds where PFCs were used between the 1980s and 2003.
- Airservices is undertaking risk assessments of airport sites where fire fighting foams containing PFCs have been used to determine if any migration of PFC residues from fire stations and training grounds has occurred which may have impacted beneficial users. Further site testing may commence following the outcomes of the risk assessment and will be based on a range of factors developed in consultation with regulators and experts.
- Airservices is undertaking a number of research and development activities to better characterise and develop solutions to the PFC issue as it applies to our sites.

[1] This is due to Department of Defence requirements to use Ansulite. However, Airservices has not used foam for training or in response to an incident at these locations since 2010.

- In 2014, Airservices and the Department of Infrastructure and Regional Development (DIRD) engaged GHD Pty Ltd to develop a risk-based framework, 'Managing PFC Contamination at Airports', to guide decision-making when dealing with contamination issues on airport sites. The framework was finalised in June 2015.
    - GHD reviewed international screening levels and other guidance to develop screening levels that could be used in this management framework. Airservices has adopted this framework in its operations nationally.
    - The framework has been provided by Airservices to DIRD, and it has subsequently been distributed to the airport lessee companies and DIRD's Airport Environment Officers as well as the Department of the Environment and the Department of Health. The draft interim framework and screening levels have no regulatory authority.

Airservices will continue to take a proactive approach to managing risks as a result of past use of fire fighting foams that contained PFCs and, for this purpose, is continuing engagement with regulators to assist in the identification and development of practicable responses.

1. Structure of Submission

With respect to the terms of reference of the Senate Inquiry, the submission responds as follows:

By 30 April 2016 on PFOS and PFOA contamination on other Commonwealth, state and territory sites in Australia where firefighting foams containing PFOS and PFOA were used, with reference to:	
• what Commonwealth, state and territory facilities have been identified as having PFOS/PFOA contamination, and what facilities may potentially still be identified as being contaminated,	See parts 5.3 and 5.4 and Appendix D
• the response of, and coordination between, the Commonwealth, state and territory governments, local governments, commercial entities and affected local communities,	See part 5
• what measures have been taken by the Commonwealth and state and territory governments, to ensure the health, wellbeing and safety of people in close proximity to known affected sites	See parts 3.6, 5 and Appendix C
• the adequacy of public disclosure of information about PFOS/PFOA contamination,	See part 5.4
• what consideration has been undertaken of financial impacts on affected businesses and individuals,	Airservices has not made specific comments that relate to measures taken by governments to ensure the health, wellbeing and safety of people nor the financial impacts on third parties. These issues are currently under consideration by both Commonwealth and State and Territory agencies and will require a national, cooperative approach across all governments
• the adequacy of Commonwealth and state and territory government environmental and human health standards and legislation, with specific reference to PFOS/PFOA contamination,	See parts 4, 5 and Appendix B
• what progress has been made on the remediation and the adequacy of measures to control further PFOS/PFOA contamination at affected Commonwealth, state and territory sites,	See part 5 and Appendix E
• what investigation and assessment of contaminated sites and surrounding areas has occurred	See part 5 and Appendix D
• any other related matters	The functions and responsibilities of Airservices are discussed in parts 2 and 4.3. The CASRs relevant to ARFF and AFFF are discussed in parts 2.2 and 4.3 and Appendix A

2. Background

2.1 Airservices Australia

Airservices is a corporate Commonwealth entity constituted in 1995 under the Air Services Act for the provision of air traffic management, air navigation support (communications infrastructure, radar and navigation aids) and ARFF services to the aviation industry.

In providing these services, the Air Services Act requires Airservices to regard the safety of air navigation as the most important consideration. Section 9 of the Air Services Act provides:

> **Manner in which Airservices must perform its functions**
>
> ***(1)*** *In exercising its powers and performing its functions, AA must regard the safety of air navigation as the most important consideration.*
>
> ***(2)*** *Subject to subsection (1), AA must exercise its powers and perform its functions in a manner that ensures that, as far as is practicable, the environment is protected from:*
>
> *(a) the effects of the operation and use of aircraft; and*
>
> *(b) the effects associated with the operation and use of aircraft.*
>
> ***(3)*** *AA must perform its functions in a manner that is consistent with Australia's obligations under:*
>
> *(a) the Chicago Convention; and*
>
> *(b) any other agreement between Australia and any other country or countries relating to the safety of air navigation.*

2.2 ARFF services

The ARFF service's primary function is to rescue people from an aircraft crash or fire, and from other fires, at an airport. Prior to Airservices being established, the ARFF function was performed by the Civil Aviation Authority (CAA) from 1988 to 1995, and prior to that by the Commonwealth Department of Civil Aviation.

Since 1995, Airservices has provided ARFF services and currently provides ARFF services at 26 of Australia's busiest airports.

Airservices is one of the world's largest emergency service providers dedicated to aviation with more than 900 operational and support personnel based around Australia. Last year, Airservices responded to 6,753 emergencies, including 378 aircraft incidents and 3,670 first aid requests, saving 10 lives in the process.

ARFF services are provided under Civil Aviation Safety Regulations (CASR) part 139H which covers aspects such as incident response times, fire fighting agent discharge rates and training requirements. Requirements include that Airservices fire fighters must be able to respond to an aircraft incident on any part of the runway within three minutes from the initial call and be able to apply fire fighting agent at 50 per cent of the maximum discharge rate.

ARFF services provided range from Category 6 to 10 services. The categories dictate the required amount of water and foam that is needed to be carried, the response times and water discharge rates. In summary:

- a Category 6 service is delivered by one officer and four fire fighters operating two ultra-large fire vehicles; and
- a Category 10 service is delivered by three officers and eleven fire fighters operating four ultra-large fire vehicles (see **Appendix A** for further information on Fire Extinguishing Agents and Performance Criteria).

Airservices owns, operates and maintains a fleet of over 100 specialised, high-performance aviation fire fighting vehicles, aerial rescue vehicles, water rescue boats, difficult terrain vehicles and domestic response vehicles. This allows Airservices to respond to a broad range of aviation and airport emergencies, including aircraft incidents, structural fires, medical assistance requests, water rescues and fire alarms.

Airservices costs are recovered through charges paid by airlines.

3. Perfluorinated Compounds

3.1 What are they?

PFCs are a group of manufactured chemical compounds that are used in a wide range of products including common household products such as non-stick cookware, food packaging and stain resistant textiles. They are also used in fire fighting foams - specifically AFFF, which have the ability to spread over the surface of hydrocarbon-based liquids. AFFF is used for fire suppression in many industries including the petrochemical industry, and aviation and public fire services.

Two common PFCs are PFOS and PFOA. PFOS and PFOA have unique surfactant properties and many specialty applications including heat, chemical and abrasion resistance and as dispersion, wetting and surface treatments. They are extremely heat stable and resistant to breakdown. These compounds may be released into the environment from both their production and use. They may also enter the environment from landfill sites where products and materials that contain these chemicals are sent for disposal.

3.2 PFC use in AFFF

While serious aircraft incidents are rare, it is important that fire fighters use the most effective product available in order to save lives. Fire fighting foams are currently classified as Class A and Class B. Class B fire fighting foam is a higher performing foam than Class A and is effective for use on fires involving liquid fuels such as petroleum, diesel or aviation fuels. Class B foams create a barrier that prevents oxygen reaching the fuel, therefore smothering, cooling and extinguishing the fire.

Since the 1950s, various types of foams were used in ARFF services around Australia. In the 1960s, the 3M Company and the United States Navy developed an AFFF specifically for fighting fuel fires. The foam was called 3M Lightwater. It was designed to spread rapidly across the surface of fuels and create a water film beneath the foam to cool the liquid fuel and stop the formation of flammable vapours. This AFFF had superior fire knockdown capability which was particularly effective for fire fighting operations and began to be used by many fire services around the world.

Airservices understands that the following AFFFs have been used over time:

- from the early 1980s to 1995, 3M Lightwater was used by the CAA and the Department of Civil Aviation;
- from 1995 to 2003, Airservices used 3M Lightwater; and
- from 2003 to 2010 Airservices used Ansulite[2].

3.3 PFCs are prevalent in the environment

PFCs are often referred to as ubiquitous contaminants with international studies reporting detections in widespread environments and receptors, including polar bears, the mid Pacific Ocean and rainfall. In Australia, this is supported by a study undertaken by the University of Queensland in 2012 which examined contaminant loads in the Brisbane river catchment following flooding[3]. The study tested for PFCs along the entire length of the catchment (from Wivenhoe Dam to Moreton Bay) including side branches. PFCs were detected in Wivenhoe Dam but significant sources were detected in the side branches consistent with the urban catchment being a significant contributor to the load of PFCs received in Moreton Bay.

Due to their chemical structure, PFOS and PFOA are chemically and biologically stable in the environment, resisting typical degradation processes. Their widespread use, environmental persistence and the ability to accumulate through food chains has resulted in the detection of trace levels of these PFCs in the blood of animals and the general human population globally when studied. Studies have shown that exposure to low levels of PFOS and PFOA is widespread and commonplace in the general population worldwide. People may be exposed to these compounds through the air, dust, food, water and various consumer products.

[2] Except for at Darwin and Townsville, where Ansulite continues to be used. See footnote 1.
[3] See Christie Gallen et al, 'Spatio-temporal assessment of perfluorinated compounds in the Brisbane River system, Australia: Impact of a major flood event' (2014) 85 *Marine Pollution Bulletin*, 597-605 <http://www.sciencedirect.com/science/article/pii/S0025326X14001106

3.4 Concerns

In the early 2000s, concerns started to emerge about PFCs including PFOS and PFOA.

- The Organisation for Economic Co-operation and Development's (OECD) hazard assessment report on PFOS and its salts, concluded that the persistence of PFOS in the environment—as well as its toxicity and bioaccumulation potential—indicate a cause for concern for the environment and human health[4].
- In 2003, the Australian Government Department of Health, through NICNAS, issued an alert relating to PFOS in response to environmental and health concerns over PFCs. The alert recommended that 'PFOS and related PFC based chemicals be restricted to only essential uses, for which no suitable and less hazardous alternatives were available such as certain Class B fire fighting foams'[5]. It also recommended that PFOS-based fire fighting foam not be used for fire training purposes in order to limit its release to the environment.
- PFOS and PFOA have been classified by international bodies as 'chemicals of emerging concern' or 'emerging contaminants'. The US Environment Protection Agency (EPA) defines emerging contaminants as:

  > a chemical or material that is characterized by a perceived, potential, or real threat to human health or the environment or by a lack of published health standards[6].

- PFOA was classified in Group 2B at the June 2014 meeting of the International Agency for Research on Cancer (IARC). PFOS, the active ingredient in 3M Lightwater, was not considered by IARC. Airservices understands that this classification was made on the basis of limited evidence of testicular and renal cancer in workers in a fluoropolymer production plant and in the highest exposed nearby residents[7]. The IARC classifies the carcinogenicity of agents to humans in the following groups[8]:
  - Group 1 – the agent is carcinogenic to humans: this category is used when there is sufficient evidence of carcinogenicity in humans. Examples include: ethanol in alcoholic beverages; radioactive elements (uranium, radium, plutonium etc); shale oils; therapeutic drugs (oral contraceptives, some anti-cancer drugs) and asbestos.
  - Group 2A – the agent is probably carcinogenic to humans: this category is used when there is inadequate evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals. Examples include: anabolic steroids; acrylamide; and glyphosate (a common household weedkiller).
  - Group 2B – the agent is possibly carcinogenic to humans: this category is used for agents for which there is limited evidence of carcinogenicity in humans and less than sufficient evidence of carcinogenicity in experimental animals. Examples include: some heavy metals (e.g. lead, nickel); some chlorinated solvents (e.g. chloroform); some therapeutic drugs (phenobarbital, phenytoin, hydrochlorothiazide); the plasticiser di-ethylhexylphthalate; carbon black powder; and coffee.
  - Group 3 – the agent is not classifiable as to its carcinogenicity to humans: this category is used most commonly for agents for which the evidence of carcinogenicity is inadequate in humans and inadequate or limited in experimental animals. Examples include: some oxidative hair dyes; some artificial sweeteners (e.g. saccharin); some colouring agents/dyes; and toluene.

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[4] See <http://www.oecd.org/chemicalsafety/>
[5] https://www.nicnas.gov.au/communications/publications/information-sheets/existing-chemical-info-sheets/pfc-derivatives-and-chemicals-on-which-they-are-based-alert-factsheet
[6] See <http://www.epa.gov/fedfac/emerging-contaminants-perfluorooctane-sulfonate-pfos-and-perfluorooctanoic-acid-pfoa>
[7] See Kyle Steenland and Susan Woskie, 'Cohort Mortality Study of Workers Exposed to Perfluorooctanoic Acid' (2012) 176 *American Journal of Epidemiology,* 909 (http://aje.oxfordjournals.org/content/176/10/909.full.pdf+html); Verónica M. Vieira et al, 'Perfluorooctanoic Acid Exposure and Cancer Outcomes in a Contaminated Community: A Geographical Analysis' (2013) 121 *Environmental Health Perspectives*, 318 (http://ehp.niehs.nih.gov/wp-content/uploads/121/3/ehp.1205829.pdf); Vaughn Barry, Andrea Winquist, and Kyle Steenland, 'Perfluorooctanoic Acid (PFOA) Exposures and Incident Cancers among Adults Living Near a Chemical Plant' (2013) 121 *Environmental Health Perspectives*,1313 (http://ehp.niehs.nih.gov/wp-content/uploads/121/11-12/ehp.1306615.pdf).
[8] See <http://monographs.iarc.fr/ENG/Preamble/CurrentPreamble.pdf> [22].

- Group 4 – the agent is probably not carcinogenic to humans: this category is used for agents for which there is evidence suggesting lack of carcinogenicity in humans and in experimental animals.

3.5 Current manufacture and use in Australia

NICNAS has reported that PFOS is no longer manufactured in Australia, however, it is imported for use as mist suppressants in the metal plating industry, hydraulic fluid in the aviation industry, surfactants in the photography industry and as fire fighting foams. Airservices understands that PFOA is not manufactured in Australia or imported as the base chemical.[9]

3.6 Uncertainty as to health impacts

Whether PFOS or PFOA cause adverse health effects in humans is currently unknown. Overall, at this time, studies do not clearly establish a causal relationship between PFC exposure and adverse health effects in humans, even where there has been occupational exposure in orders of magnitude higher than the general population. More information on health impacts from PFC exposure can be found in a factsheet prepared by Professor Brian Priestly, Australian Centre for Human Health Risk Assessment, Monash University, at **Appendix C**.

Airservices has commissioned independent expert advice to determine whether there are any potential health risks to ARFF staff from exposure to PFCs through the past use of AFFF. The advice received indicated that there are no specific health concerns likely to be associated with exposure to PFCs through the use of AFFFs.

Despite this, Airservices offered ARFF staff the option of participating in a voluntary study to measure their exposure levels to PFCs[10]. The focus of the study was on the evaluation of the blood serum levels of the three most prevalent PFCs found in AFFF, being PFOS, PFOA and PFHxS. The findings of the study included:

- Participants were found to have levels of PFOA similar to those found in the general Australian population, but higher levels of PFOS and PFHxS.
- The concentrations of PFOS and PFHxS were found to be positively associated with years of service involving AFFF contact.
- Study participants who had worked ten years or less had levels of PFOS that were similar to or only slightly above those of the general population. This coincides with the phase out of 3M Lightwater from ARFF training facilities in 2003, and suggests that the exposures to PFOS and PFHxS in AFFF have declined in recent years.

Airservices continues to seek advice from experts to ensure we understand the latest research globally on potential health and safety impacts of PFC exposure.

4. Regulation of PFCs

4.1 Relevant international examples

- The United Nations (UN) Stockholm Convention, of which Australia is a signatory, is a global treaty that aims to protect human health and the environment from the effects of Persistent Organic Pollutants. PFOS was added to the list of convention annexes in 2009. Australia is yet to ratify this addition.
- In May 2008, Canada listed PFOS as a toxic substance, but expressly permitted use of AFFF containing PFOS until 29 May 2013.
- Similarly, in December 2006, the European Union allowed the use of fire fighting foams that contained PFOS to continue until 27 June 2011.

[9] See <www.nicnas.gov.au/communications/publications/information-sheets/existing-chemical-info-sheets/perfluorinated-chemicals-pfcs-factsheet>

[10] See Anna Rotander et al, Report prepared for Airservices Australia, 'Final Report Evaluation of perfluoroalkyl acids (PFAAs) in Airservices Australia's Aviation Rescue and Fire Fighting (ARFF) staff' (June 2014), *National Research Centre for Environmental Toxicology (Entox)*

4.2 Domestic legislation

There is no Australian legislation that prescribes particular actions or standards specifically in respect of PFCs. However, where PFCs are used, legislation which relates more generally to the protection of the environment, health and contamination may be relevant.

In respect of airports:

- the Airports Act applies to certain Commonwealth owned airports;
- the Environment Protection Regulations set out the details of the system of regulation of environmental standards at airports governed by the Airports Act;
- PFCs are not specifically mentioned in the Airports Act or Environment Protection Regulations;
- part 6 of the Airports Act and the Environment Protection Regulations impose general duties in relation to pollution and contamination; and
- the EPBC Act is not relevant for the purposes of this submission as it primarily regulates the assessment and approval of actions having impacts on matters of national environmental significance.

4.3 Legislation relating to ARFF services

As noted in part 2.2 above, ARFF services are provided under the CASR. CASR 139H covers aspects such as incident response times, fire fighting agent discharge rates and training requirements.

4.4 Screening levels relevant to PFC contamination

In order to determine what action is implied or required by a contamination investigation, it is necessary to have investigation levels or screening levels for the particular contaminant of concern. There are no generally accepted screening levels for concentrations of PFCs in soil, groundwater or surface water in Australia.

Airservices partnered with DIRD in 2014 and engaged GHD Pty Ltd to research and develop a draft interim PFC decision-making guide. The risk-based guide employs a series of decision steps, references and proposed interim contamination screening levels for soil, surface and groundwater. This draft interim guide was provided to the Department of the Environment in 2015 for reference and consideration. It has also been provided to DIRD, Airport Environment Officers, airport lessee companies and the Department of Health.

A copy of the interim screening levels adopted by Airservices is set out in **Appendix B**.

5. Airservices response to PFC concerns

5.1 Overview

Airservices response has focused on three key areas of work:

- phasing out PFC use including cleaning and upgrade of equipment;
- understanding PFC contamination issues - identifying affected sites and undertaking a research and development program to inform potential solutions; and
- managing the PFC contamination issues - developing and implementing a management plan, trialling treatment and management technologies and undertaking stakeholder engagement.

5.2 Phasing out of PFC usage

As noted at part 3.4, in 2003 the Australian Government Department of Health, through NICNAS, issued an alert recommending that PFOS and related PFC based chemicals be restricted to only essential uses.

Airservices followed the recommendations and in 2003, completed transition to a fire fighting foam called Ansulite on the understanding that it did not contain PFOS or PFOA.

However, in 2010 Ansulite was found to contain trace elements of PFOS and PFOA. As a result of these findings, Airservices transitioned to a fire fighting foam called Solberg RF6 from 2010. The transition from Ansulite to Solberg RF6 was a complex process and involved Airservices undertaking activities including:

- investigations and trials related to the cleaning of aviation fire fighting vehicles;
- waste management;
- chemical analysis of Solberg RF6;
- engineering assessment of impact to operations and equipment; and
- operational trials of the foams effectiveness.

Airservices currently uses Solberg RF6 at civilian airports which meets the ICAO Class B fire fighting foam standard. This product is PFC-free and continues to be used today.

5.3 Understanding the PFC issue

Identification of sites of concern
Initial investigations have identified 56 sites where ARFF services were provided using fire fighting foam. These sites comprise of 30 Historical Sites and 26 Current Sites. Of those 56 sites:

- 16 are Historical Sites where only protein-based foam was used and so there will be no impacts from PFCs from ARFF operations;
- four are sites where only Solberg RF6 (PFC-free) foam has been used so impacts from PFCs from ARFF operations are not expected, although there may be some potential for some PFCs to be present due to extremely low levels of residues being present in equipment and materials as well as other past uses of the sites prior to there being an ARFF presence; and
- 36 sites (both Current and Historical Sites) are known to contain or are suspected to contain PFCs.

See **Appendix D** for a breakdown of the 36 sites.

Site assessments
In 2008, Airservices embarked on a program of preliminary site assessment work of fire fighting training grounds and at that time focussed on the detection of PFCs in both soil and groundwater. PFOS and PFOA were the target chemicals which were identified to varying degrees in the analysis.

Due to the absence of regulatory screening or investigation levels in Australia for PFCs, the results of the site assessments were compared against the limited number of international screening levels that could be found at the time. Airservices decided to adopt the Minnesota Department of Health guidelines because:

- the screening levels covered both water and soil; and
- due to the presence of 3M manufacturing sites within Minnesota, the guidelines were developed by a Department which had a reasonable amount of experience in dealing with PFOS and PFOA related issues.

The US EPA had not produced any guidance at that time.

In the absence of regulatory PFC threshold levels in Australia for benchmarking the analysis results, Airservices recognised the need for further site investigation work to gain a better understanding of an issue of growing concern, both domestically and internationally. To this end, a program of detailed site assessments was initiated following a priority risk ranking based on limited information available at the time. Detailed investigations were undertaken at ARFF sites at Brisbane, Sydney, Rockhampton and Perth Airports. Results from these initial investigations were provided to airport owners and regulators and have informed further studies and assisted in refining Airservices priority site ranking.

Airservices site investigations, in combination with its research and development (R&D) program on PFCs (see below), has significantly enhanced understanding of the PFC issue and contributed to our ability to develop conceptual site models for PFC impacted sites. These models provide an important tool to explain and characterise issues requiring consideration and assist in properly targeting management decision-making.

Other initiatives Airservices has recently commenced to gain a better understanding of the impact from historical fire fighting foam containing PFCs include:

- an assessment to identify potential water extraction sources (e.g. groundwater bores, surface water extraction sites) in the vicinity of current and former airports where Airservices and its predecessors provided ARFF services using fire fighting foams containing PFCs; and
- working with relevant stakeholders and state regulators to progress investigative sampling off-airport to assess possible impacts and risks to beneficial uses.

Research and development program

Airservices is implementing a R&D program with industry to better understand PFC issues and develop solutions to the challenges we face. The R&D program includes initiatives that range from gaining a better understanding of the behaviour of PFCs in the environment, to supporting initiatives to establish screening criteria (ecological, human health, waste management etc) and developing treatments to remove PFCs from impacted materials.

In support of the R&D program, Airservices has engaged expertise from a number of organisations, including the University of Queensland, the Cooperative Research Centre for Contamination and Remediation of the Environment (CRC CARE), and specialist consultants in contamination assessment and waste management. Published studies have included those relating to the human health of ARFF personnel and the quantification of PFC impacts within ARFF training pad infrastructure.

Initiatives were initially focused on the technical aspects of PFC analysis, such as ensuring reporting levels for environmental media could be undertaken by commercial laboratories to relevant adopted screening levels, and dealing with the complexity of the analysis of PFCs in fire fighting foam concentrates or other complex matrices. As more information was gathered, subsequent focus was given to waste management strategies and trialling technologies to determine their suitability for removing PFCs from sources such as training ground wastewater streams. Although initial trials of such technologies were of limited success, recent trials using purpose designed products such as MyCelx, MatCARE™ and RemBind™ have been extremely positive. Field trials are now underway to assist in undertaking a cost benefit analysis of these technologies.

By way of example, Airservices has in recent years undertaken trials of the RemBind™ product as an immobilising agent for PFCs in impacted soils. Initial laboratory trials of PFC impacted soil from ARFF sites were undertaken by an independent consultancy firm in co-operation with Ziltek, the manufacturer of RemBind™. These trials were highly successful, with immobilisation levels attained up to 99%. Airservices has subsequently used this technology in its operations, with over 700 cubic metres of PFC impacted soil from one site treated and sent to landfill for disposal, and similar uses elsewhere intended in the near future. Further investigations are underway in collaboration with the University of Queensland, to assess the application of RemBind™ as an in-situ treatment for PFC impacted soils.

In 2015, Airservices has offered its support to the University of Queensland's Australian Research Council (ARC) Linkage Grant proposal to investigate the fate of fluorinated surfactants and hydrocarbons at coastal airports. This support stems from previous collaboration with the University on studies relating to PFCs in the environment.

In addition, Airservices is currently in discussion with private sector representatives on the use of PFC soil immobilisation technology (e.g. RemBindTM) as a permeable reactive barrier (PRB). PRBs are a widely used, cost-effective technology for removing other contaminants from impacted groundwater but are not known to have yet been used for PFCs. In essence, PRBs are barriers which allow some—but not all—materials to pass through. PRBs present the possibility of being a cost-effective solution for in situ (at the site) groundwater remediation. Airservices intends to undertake 'proof of concept' investigations of the PRB technology in 2016.

Research and development is a valuable tool to improving understanding which can lead to new and improved products to address PFC concerns. Airservices is committed to its R&D program but also recognises is can take time to produce the necessary results and findings which may lead to innovative solutions.

Investigation levels

Due to the lack of PFC human health or ecological regulatory threshold or investigation levels, Airservices initiated a project in 2012 to develop guidance levels for PFOS and PFOA. The aim of the initiative was to improve Airservices confidence that the contamination levels at ARFF sites were not of concern to beneficial uses. A detailed project plan was prepared incorporating toxicity studies.

However, it was recognised that, should Airservices develop its own threshold levels, these would be of limited benefit if the results and methodology for their derivation were not agreed by regulatory agencies. Consequently, through the Commonwealth Department of Environment, Airservices proposal and draft plan was provided to all environmental regulatory agencies in Australia. Given the challenges of coordinating across nine jurisdictions (including the Commonwealth), it proved difficult to generate agreement across the jurisdictions.

Other initiatives where Airservices is making a contribution includes a project to develop Australian human health and ecological screening levels for PFOS and PFOA which was funded by CRC CARE in 2014. Airservices is represented on the project's Technical Working Group and has contributed to the development of a final report making recommendations, which is expected to be available in the first quarter of 2016.

5.4 Managing the PFC Issue

Operational considerations
In the early 2000s when Airservices transitioned from 3M Lightwater to another AFFF product called Ansulite, it was Airservices' understanding that Ansulite did not contain PFOS or PFOA.

In 2009, Airservices commissioned a chemical analysis on a selection of new containers of Ansulite product. The analysis identified the presence of trace amounts of PFOS and PFOA (albeit at significantly lower levels than those found in 3M Lightwater), which was contrary to Airservices understanding of the foam's constituents.

In 2010, Airservices decided to transition to a non-fluorinated ICAO-rated Class B fire fighting foam for both operational and training purposes[11]. The transition was in recognition of the PFC-related environmental issues at ARFF sites, and the objective was to cease adding to a potential problem without compromising ARFF's operational capability. Only two potential foams were identified at the time, and only Solberg RF6 was deemed appropriate for Airservices' use.

Transitioning to Solberg RF6 at all ARFF Stations took approximately one year and was completed by the end of 2010. As noted in part 5.2, the transition was complex, requiring AFFF to be removed from aviation fire fighting vehicles and associated foam storage equipment, and replacing it with Solberg RF6. It also required trials to determine the nature of cleaning required of the aviation fire fighting vehicles' internal foam production systems to ensure the removal of PFC contamination to an acceptable standard.

Prior to beginning the transition to Solberg RF6, Airservices instigated a policy to cease all training using AFFF. At the start of 2010, this was extended to include the cessation of routine foam training using the operational foam.

In conjunction with the decision to transition to Solberg RF6, Airservices instigated a major project to build a centralised national ARFF training facility at Melbourne Airport designed to operate with only PFC-free training foam. The facility was commissioned in 2013 and is used all year round for ab initio training, career development training courses and operational refresher training (based on a rolling three yearly cycle).

<u>Risk-based approach</u>
Airservices partnered with DIRD in 2014 and engaged GHD Pty Ltd to research and develop a draft interim PFC decision-making guide. The risk-based guide employs a series of decision steps, references and proposed interim contamination screening levels for soil, surface and groundwater. This draft interim guide was provided to the Department of the Environment in 2015 for reference and consideration. The draft interim framework and screening levels have no regulatory authority.

<u>Construction workers on PFC impacted sites</u>
Although at this time the studies do not clearly establish a causal relationship between PFC exposure and any adverse health effects in humans, Airservices has, in addition to conducting the human health study for ARFF staff, engaged the University of Queensland to provide advice on any risks to construction personnel operating on PFC impacted sites.

The advice assessed different exposure pathways, exposure scenarios and provided some practical guidance on how to limit exposure. The report recommended the proper use of personal protective equipment while working on all sites, regardless of whether contamination is known to be present or not. Based on an assessment of estimated possible exposure levels and pathways, the report concluded that the risk to workers was acceptable provided that general workplace safety best practices were followed.

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[11] Apart from at Darwin and Townsville. See footnote 1.

Enhanced Governance
In recognition of the ongoing concerns and need for further PFC related work, Airservices strengthened its governance arrangements and established a PFC Contamination Strategic Environmental Management Plan (SEMP) in 2010. The SEMP provides the overarching management strategy for Airservices to manage the environmental and associated business risks in relation to PFCs on sites and outlines initiatives to be developed and implemented.

The SEMP objectives are to:

- ensure Airservices is environmentally responsible with respect to management of PFC contamination;
- achieve and maintain legal compliance with respect to PFC contamination;
- reduce, as far as practicable, the environmental impact and related business risks associated with the presence of PFCs in the environment resulting from Airservices and its predecessors use of AFFFs; and
- give effect to the direction set by the Airservices Board.

The SEMP and its relevant initiatives have been reviewed on a regular basis by GHD Pty Ltd to assess Airservices' progress against the SEMP and to consider whether any revisions to the SEMP need to be made.

Stakeholder Engagement

Government
Since 2009, Airservices has been working closely with Commonwealth, State and Territory government health and environment regulators, policy agencies, airport owners and operators, and research institutions on various initiatives in response to PFC concerns.

In 2009/2010, Airservices wrote to Commonwealth and State environmental regulators advising them of its PFC concerns in relation to its current and former ARFF facilities. Relevant Commonwealth departments, airports, and waste service providers were also notified. Face to face meeting were arranged with these organisations to discuss the issue, and to outline Airservices' proposed PFC management approach.

In recognition of Airservices' proactive approach and expertise in PFC management, Airservices has been invited to present at forums and provide comment and advice on a range of PFC-related technical matters. Recent examples include: the Western Australian Department of Environmental Regulation paper on Fire Fighting Foams with Perfluorochemicals – Environmental Review; and the Queensland Department of Environment and Heritage Protection draft Policy on Management of Firefighting Foam and associated Explanatory Notes.

Airservices also participates in a Commonwealth interdepartmental committee, chaired by the Department of Environment, which has been established to inform the Commonwealth Government position on PFC management and provide advice on how to respond to PFC concerns. This work is ongoing.

Industry
Following Airservices' correspondence to airports in 2009/10 informing them of our PFC concerns and proposed management strategy, Airservices has twice been invited to present at the Inter-Airport Forum (in 2010 and 2015).

The forum is run by the environmental managers of airports for the benefit of sharing information relevant to all airports. At these events, Airservices has been able to explain to airport stakeholders what activities are being undertaken by Airservices in relation to PFCs, and respond to questions.

In January 2016, Airservices also convened an Airport industry information session in Canberra to provide airport stakeholders with an update on its response to PFC concerns and stakeholder engagement approach.

5.5 Conclusion

Airservices acknowledges the concerns related to PFC residues found at its sites as a result of historic use of fire fighting foams containing PFCs (see **Appendix E** for a timeline of key activities).

Airservices has and continues to take a scientific, fact-based approach in managing its response to these concerns in the absence of any specific Australian regulatory standards or guidance relating to PFCs, and has made a significant investment in R & D activities to better understand PFC related issues. Airservices has engaged health and environmental experts to provide advice and develop guidance material to assist Airservices and its stakeholders manage PFCs at airports. Airservices continues to work with relevant Commonwealth, State and Territory regulatory authorities and agencies to assist them establish adequate regulatory guidance to manage this issue at sites.

Airservices remains actively involved in engaging its stakeholders and outlining its understanding and management of the PFC issue through discussions with regulatory agencies and attending contamination and aviation related industry forums and workshops, particularly in relation to its R&D projects. This approach is in recognition of the importance of sharing knowledge on the PFC issue to inform a nationally strategic approach, as opposed to the largely local and piecemeal approaches that are presently confounding this issue in Australia.

Due to the widespread occurrence of PFCs in the environment, the multiple sources from which they are able to enter the environment, and the uncertainty of their impact, Airservices strongly believes the PFC issue must not be treated solely as an aviation issue. Any potential solution should include a cross-industry approach and be nationally consistent. It must be driven by an understanding of the health and ecological impacts and be risk-based, giving due consideration to cost-benefit analysis of remediation works versus natural attenuation where appropriate.

Appendix A: Extract from the Manual of Standards Part 139H - Standards Applicable to the Provision of Aerodrome Rescue and Fire Fighting Services

Section 7.1: General

7.1.1 Standard: Fire Extinguishing Agent Performance Criteria

7.1.1.1 Having determined the category of the aerodrome, the category figure is then applied to the Table below which determines the minimum amount of water and discharge rate of produced foam required as well as the mandatory amount of complementary agent.

MINIMUM USABLE AMOUNTS OF EXTINGUISHING AGENTS					
Aerodrome Category	Foam Meeting Performance Level A		Foam Meeting Performance Level B		Complementary Agent
	Discharge rate foam solution		Discharge rate foam solution		Dry chemical powder
	Water litres	Discharge rate l/m	Water litres	Discharge rate l/m	DCP kg
1	350	350	230	230	45
2	1000	800	670	550	90
3	1800	1300	1200	900	135
4	3600	2600	2400	1800	135
5	8100	4500	5400	3000	180
6	11800	6000	7900	4000	225
7	18200	7900	12100	5300	225
8	27300	10800	18200	7200	450
9	36400	13500	24300	9000	450
10	48200	16600	32300	11200	450

7.1.1.2 The required quantities of extinguishing agent must be available for discharge from operational fire vehicles within the response times detailed in Chapter 6 of this Manual.

7.1.1.3 The quantity of foam concentrate separately provided on vehicles for foam production must be in proportion to the quantity of water provided and the foam concentration selected. The amount of foam concentrate should be sufficient to supply at least two full tank loads of water.

7.1.1.4 Foam concentrate of different types or from a different manufacturer must not be mixed except where it has been established that they are interchangeable and compatible.

7.1.1.5 The ARFFS provider may, with CASA approval, substitute extra complementary agent in place of water capacity in accordance with the ICAO formula in Annex 14, Chapter 9.

7.1.1.6 For aerodrome categories 1 and 2 up to 100% of water may be replaced by a complementary agent.

7.1.2 Fire Extinguisher Agent Performance Criteria

7.1.2.1 For aerodromes with categories ranging from 3 to 10, a maximum of 30% of specified water capacity for foam production meeting performance "Level A" listed in the Table, for each category may be replaced by a complementary agent. For the purpose of substitution, 1kg of foam compatible DCP, equals 1 litre of water for production of foam meeting performance level A, or 1 kg of foam compatible DCP equals 0.66 litres of water for production of foam meeting performance level B.

7.1.2.2 CASA must be advised of the performance level foam to be used as well as providing a manufacturers certificate verifying that the foam achieves the Standard specified. Ref: ICAO Airport Service Manual, Part 1, Rescue and Fire Fighting, Extinguishing Agent Characteristics, Chapter 8, para, 8.1.5 and Table 8-1.

7.1.2.3 The foam discharge monitors must be aspirated and have an effective discharge range at least equal to the length of the longest aircraft normally used in determining the aerodrome ARFFS category and have the capability to deliver foam in a dispersed pattern.

7.1.2.4 Vehicles may employ mobile monitor mode operations and /or extendible monitors to assist in or to meet these requirements, subject to a satisfactory demonstration of its ability to CASA.

7.1.2.5 Further information for level of protection and categorisation can be found in ICAO, Airport Services Manual, Part 1, Chapter 2.

Extract from the Airport Services Manual

Part 1: Rescue and Fire Fighting (Fourth Edition — 2014)

2.2 TYPES OF EXTINGUISHING AGENTS

2.2.1 Both principal and complementary agents should normally be provided at an airport. Principal agents produce a permanent control, i.e. for a period of several minutes or longer. Complementary agents have rapid fire suppression capability but offer a "transient" control which is usually only available during application.

2.2.2 The principal extinguishing agent should be:

a) a foam meeting the minimum performance level A; or

b) a foam meeting the minimum performance level B; or

c) a foam meeting the minimum performance level C; or

d) a combination of these agents.

The principal extinguishing agent for airports in categories 1 to 3 should preferably meet the minimum performance levels B or C foam.

2.2.3 The complementary extinguishing agent should be:

a) dry chemical powders (classes B and C powders); or

b) other extinguishing agents with at least the same firefighting capability.

When selecting dry chemical powder for use with foam, care must be exercised to ensure compatibility.

2.2.4 Characteristics of the recommended extinguishing agents may be found in Chapter 8.

8.1.6 *Foam Performance Acceptance Test*

It is essential that the foam produced by an RFF vehicle, or other such appliance, is of an acceptable quality and the delivery parameters such as monitor jet range and pattern meet and are maintained to the appropriate operational requirement.

In order to ensure that foam production by an RFF vehicle is of an acceptable standard a Foam Production Performance Test (i.e. an “Acceptance Test”) should be carried out:

a) When a RFF vehicle is first acquired by the licence holder for operational use at an aerodrome. Acquisition may mean the new or second-hand purchase, leasing or hire of a RFF Vehicle.

b) When significant maintenance, refurbishment or component replacement has been undertaken on a RFF vehicle that could affect a change in the foam quality or production performance of the foam-making system. This includes a change of foam-making branches, nozzles or monitors. Only those parts of the system that could have been affected by the work undertaken or the component change need to be tested.

The Foam Production Performance Test should confirm the following:

a) The induction percentage for all foam-making devices. (If the foam production system is fitted with an Induction Monitoring System, the test results obtained from analysis of the foam sample should correspond with those provided with the monitoring system, i.e. check for correct calibration and accuracy of induction monitoring system.) Induction can be checked using water instead of foam.

b) The expansion ratio from all foam making devices.

c) The quarter drainage time from all foam making devices.

d) The jet range of the main monitor.

e) The spray pattern of the main monitor.

For vehicles equipped with foam monitors capable of producing foam whilst on the move, the tests shall include an assessment of this capability. Where both a high and low discharge capability has been provided on larger monitors, this provision should be tested in line with manufacturer’s guidance.

Induction systems should induce with a tolerance of +/- 10% of the desired induction percentage at optimum working conditions. Pre-mixed foam systems shall have foam concentrate introduced to within a tolerance of 1.0 to 1.1 times the manufacturer’s desired induction rate. Care should be taken in the use of freeze point depressants where pre-mixed foam systems are exposed to low temperatures, since excessive amounts of additives may have adverse effects on fire extinguishing performance. The foam performance acceptance test should be carried out as described in Section 8.1.8.

Appendix B: Extract from GHD report for Airservices Australia-Managing PFC Contamination at Airports

Table 1 Interim screening levels (ISLs)

Exposure Scenario	PFOS	PFOA / 8:2FtS	6:2FtS	Source	Comments
SOIL					
Human health interim screening levels (HISLs) – residential (direct contact only)	6 mg/kg	16 mg/kg	60 mg/kg	USEPA Region 4 2009 (in US EPA 2014) Jarman et al 2014	US EPA Region 4 provides a residential soil screening level of 6 mg/kg for PFOS and 16 mg/kg for PFOA (US EPA 2014). This guideline is protective of human health via direct contact exposure (i.e. ingestion, dermal, dust inhalation) for a residential scenario. The US EPA does not provide a screening level for 6:2FtS. Jarman et al (2014) have carried out a toxicological assessment of 6:2FtS for drinking water and conclude that intakes of more than 10 fold over that for PFOS may be acceptable. On this basis, an interim screening value for 6:2FtS of 10 fold the PFOS value is proposed. It should be noted these screening levels do not protect against leaching into groundwater.
HISLs – industrial (direct contact only)	90 mg/kg	240 mg/kg	900 mg/kg		Criteria have not been published for commercial and industrial land use, and for this document a scaling factor has been applied to the residential criteria to derive screening levels for commercial/industrial land. The scaling factor allows for the differences in adult worker body weight, exposure time and duration of exposure compared with those that apply for residential exposure, which include children. The scaling factor varies with the contaminant, and depends on the contribution of risk from different pathways, i.e. oral, dermal and dust inhalation. Lipophilic chemicals such as DDT tend to absorb more through skin and the scaling factor is generally found to be in the order of 15. For PFCs a scaling factor of 15 is proposed. Note that these screening levels do not protect against leaching into groundwater; leachability is considered further in Section 4.
Ecological interim screening levels (EISLs) (terrestrial)	0.373 mg/kg (95% protection) 0.91 mg/kg (residential, 80% protection, low reliability) 4.71 mg/kg (commercial/industrial, 60% protection, low reliability)	3.73 mg/kg	NA	UK Environmental Agency 2009	Due to the lack of terrestrial data, the low reliability 'predicted no effect concentration' (PNEC) for soil calculated at 0.373 mg/L, which has been derived from a single earthworm bioassay using an application factor of 100 by the UK Environmental Agency (2009), has been selected as a conservative interim screening level for PFOS. The selection of this screening level is supported by the calculation of a PNEC of 0.22 mg/kg recommended for application to marine sediments in Norway (Bakke et al 2010). It would be expected that marine sediments would have a lower PNEC due to the lower amounts of organic carbon in the system when compared to terrestrial systems or freshwater sediments. The selected screening level for PFOS is shown to be conservative as the no effect concentration for sub-lethal endpoints in plants (shoot height and emergence) ranges from 3.91 mg/kg to 62.5 mg/kg (UK Environment Agency 2009). There are currently no terrestrial toxicity data to calculate screening levels for the protection of terrestrial ecosystems for PFOA and 6:2FtS. However, as the toxicity of PFOA and 6:2FtS have been shown to be lower than PFOS (Yang et al 2014), it would be expected that the ecological screening levels would be >0.373 mg/kg. Yang et al (2014) have calculated PNECs for PFOS and PFOA and reported a 12 to 14 fold difference between the PNECs. Therefore, to calculate a conservative PNEC for PFOA, a conservative interim screening value using 10 fold the PFOS PNEC is proposed. The low reliability PNEC for soil of 0.373 mg/kg is based on 95% protection of species. Based on the limited terrestrial ecotox data (only 4 data points with an additional professional judgement data point to get the five required to meet ANZECC 2000 requirements), using Burrlioz species sensitivity distribution software low reliability values were calculated for 80% species protection (urban residential in accordance with the NEPM, 0.91 mg/kg) and 60% species protection (commercial/industrial land use, 4.71 mg/kg). Using the data presented in the UK Environment Agency report the 95% species protection level was found to be 0.36 mg/kg. The appropriate interim screening level should be selected based on the current and future site land use (i.e. commercial/industrial – 60%, residential – 80%, or areas of ecological significance - note the NEPM defines the criteria for these areas as 99% species protection).
GROUNDWATER					
HISLs (drinking water only)	0.2 µg/L	0.4 µg/L	5.0 µg/L	USEPA Region 4 2009a (PFOS/PFOA) Jarman et al 2014 (6:2 FTS)	***Drinking water*** The US EPA has published a provisional guideline of 0.2 µg/L for PFOS and 0.4 µg/L for PFOA for drinking water (US EPA 2009a). A study on monkeys (Seacat et al 2002) was used to derive the PFOS/PFOA no-observed-adverse-effect level (NOAEL) of 0.03 mg/kg/d based on lower body weights, increased liver weight and other effects. The derivation allowed for 80% background contribution. Half-life clearance rates (bio-elimination) were measured (from rat studies) for PFOS and PFOA. It was found the PFOS half-life is higher than PFOA (i.e. more persistent in the body) and therefore the intake allowed dose is lower for PFOS resulting in the lower criterion. The State of Minnesota has established a health based drinking water guideline of 0.3 µg/L for PFOS and PFOA. These are based on the Seacat et al 2002 study of monkeys, but do not include the half-life studies in rats used by US EPA. While the derived values are similar, the US EPA's values include a wider range of toxicological considerations and have been selected for this document. Jarman et al (2014) proposed drinking water guidelines for 6:2FtS: below 5 µg/L requires no further action, 5 – 290 µg/L requires monitoring, above 290 µg/L requires management/remediation. The various values given are based on a drinking water endpoint protective of human health, and do not include allowance for other exposures or effects that might arise from use or disposal of water after use. ***Other beneficial uses*** Published criteria for other beneficial uses, such as primary contact recreation and industrial water use have not been identified, and are generally not likely to be limiting. Consequently, other beneficial uses of groundwater should be considered on a case by case basis. Protection of human health would also protect other, less sensitive beneficial uses. There are no criteria for human health for direct contact exposure to groundwater. Adopting the drinking water criteria would be an acceptable, conservative approach.
EISLs	In most cases the assessment of ecological impact will relate to the discharge of groundwater to a surface water, and impact on the aquatic ecosystems of the surface water (see below). In assessing risk to surface waters, consideration should be given to the flux of the chemical in groundwater, the resulting dilution that will occur in the surface water and the existing PFC levels in the surface water. This can then be compared to the surface water screening values below.				

Exposure Scenario	PFOS	PFOA / 8:2FtS	6:2FtS	Source	Comments
SURFACE WATER					
EISLs (toxicity effects on aquatic organisms)	6.66 µg/L	2900 µg/L	NA	Qi et al 2011 Giesy et al 2010	Qi et al (2011) have calculated a PNEC (95% species protection) of 6.66 µg/L following the same methodology as used in Australia, based on species sensitivity distribution. The UK Environmental Agency requires an annual average PFOS concentration of 1 µg/L in fresh surface waters and an annual average in marine systems of 2.5 µg/L (Seow 2013). The RIVM maximum acceptable concentration (MAC) for ecosystems for freshwater was calculated as 36 µg/L and a serious risk concentration (SRC) of 930 µg/L. The MAC for marine systems is 7.2 µg/L and the SRC is 930 µg/L (RIVM 2010). Environment Canada (2013) provided a draft guideline for PFOS in water of 6 µg/L, similar to Qi et al (2011). The methodology and input parameters for this guideline have not been reviewed in detail. Giesy et al (2010) propose an ecological toxicity criterion for PFOA, which appears to have been developed on a similar basis to ANZECC aquatic protection (species effect levels). There is insufficient information to determine a screening level for 6:2FtS; this is currently under review. Given the lower toxicity of 6:2FtS, it can be expected that PFOS and PFOA will be the limiting contaminants with respect to ecological toxicity.
HISLs (consumption of fish)	0.65 ng/L	300 ng/L	6.5 ng/L	RIVM 2010	RIVM (2010) presents a PFOS Maximum Permissible Concentration (MPC) of 0.65 ng/L based on protection of human health via consumption of seafood (i.e. the bioaccumulation in food chain), rather than a direct toxicological effect. As such, the RIVM MPC number should not be used for protection of aquatic species, but should be used in surface water where seafood is caught for consumption (e.g. fish, crabs, oysters, etc.). The criterion applies in the receiving water after dilution, and can apply to situations where there is groundwater discharge, rainfall run off from contaminated areas, and treated effluent discharging to a receiving water. Studies have found that PFOA is not as bioaccumulative as PFOS in fish; US EPA 2014 indicates that PFOS is the only PFC that has been identified as bioaccumulating to levels of concern in fish tissue. RIVM (2010) does not provide a criterion for PFOA. The RIVM PFOS criterion is based on a bioaccumulation factor of 14,000 L/kg, whereas BCF and BMF values for PFOA (27 L/kg and 2.7 respectively) reported by Environment Canada (2012) indicate a bioaccumulation factor of 72.9. On this basis PFOS is around 200 times more bioaccumulative than PFOA in fish. Allowing for a further factor of 2.6 to account for the differences in toxicity and pharmokinetics (as per the residential soil criteria) results in a total factor of around 500. Therefore a PFOA criterion of 300 ng/L is proposed. There are no readily available published guideline values for 6:2FtS for protection of human health via consumption of fish, therefore an interim screening level of 10 x PFOS screening level is proposed, based on the lower toxicity of 6:2FtS documented by Jarman et al 2014.
HISL (drinking water)	There are no specific guidelines for surface water use as drinking water; in this instance the groundwater drinking water ISLs would apply.				
<u>NOTES</u>: NA – not available					

Appendix C:

Health effects of perfluorinated compounds (PFCS)

FREQUENTLY ASKED QUESTIONS

Professor Brian Priestly MPharm, PhD, FACTRA
December 2015

What are perfluorinated compounds (PFCs)?

PFCs are similar to fatty acids found normally in the body, but where the hydrocarbon chains have been fully substituted with fluorine atoms. They have surfactant (detergent) and stain resistant properties, and have been extensively used in stain resistant coatings for fabrics and furniture, paper sizing coatings, non-stick cookware and in semi-conductor production.

Their widespread use, environmental persistence and the ability to accumulate through food chains has resulted in the detection of trace levels in the blood of most people when studied.

Are PFCs used in fire fighting foams?

Prior to 2002, an aqueous film forming foam (AFFF) known as 3M Lightwater was commonly used by fire fighting agencies. It contained two PFCs:

- Perfluorooctanesulfonate (PFOS) which was used to stabilise the fire fighting foams; and
- Perfluorooctanoic acid (PFOA) which was a minor component in AFFF.

The use of PFOS and PFOA in AFFF was phased out from around 2002 because of these chemicals' persistence in the environment and resistance to degradation.

Are there any overseas and Australian studies about the health risks of both short-term and long-term exposure to PFCs?

There are now many studies focussed on whether there are any health impacts resulting from short and long term exposure to PFCs including:

- conventional controlled exposure studies in rats, mice and monkeys that are used to identify potential toxic effects and to derive estimates of exposures in humans that are unlikely to be dangerous; and
- epidemiological studies in humans who have been exposed to PFCs in situations including: working in production factories (the most highly exposed groups); contact with drinking water near a specific factory that was polluted by PFOA (but where PFOS exposure was low); and exposure of 'normal' populations with low levels of PFOS exposure through food, water and house dusts.

What have the studies shown? Is my health in danger from exposure to PFCs?

Overall, at this time, the studies do not clearly establish a causal relationship between PFC exposure and any adverse health effects in humans, even where there have been occupational exposures orders of magnitude higher than those of the general population. The types of exposures in people living near airports is very unlikely to result in any immediate adverse health effects. You would likely need to receive long-term exposure (for example, exposure every day over an entire lifetime) in order to experience any adverse health effects.

In recent years, there have been studies which have compared the disease incidence of people who have both high and low PFC blood levels. Some of these studies suggest an 'association' between exposure to some PFCs and certain health effects such as hormonal disturbances, effects on the immune system, effects on blood lipids and effects on normal reproduction. However, 'associations' are not necessarily causal. That is, these health effects have not necessarily resulted from PFC exposure. Furthermore, some studies cannot rule out the possibility of 'reverse causation', where the higher PFC blood levels are the result of the disease, but not the cause.

I've heard you can get cancer from exposure to PFCs – is that true?

The U.S. Agency for Toxic Substances and Disease Registry (ATSDR 2015) said in August 2015:

> *There is no conclusive evidence that perfluoroalkyls cause cancer in humans.*[1]

Other studies have reached a similar conclusion. For example, in 2014 a study done by E.T. Chang and others reviewed 18 epidemiological studies of cancer incidence and reached the conclusion that the evidence does not support an 'association' between cancer and either PFOS or PFOA.[2]

PFOA (but not PFOS) has recently been classified as 'possibly carcinogenic to humans' by the International Agency for Research on Cancer (IARC). However, this IARC classification is based on limited evidence of bladder cancer from studies in factory workers exposed to PFOA. Further, because of confounding factors, it cannot be concluded that PFOA alone had a causal role. For example, most studies did not take into account other potential factors in causing disease such as smoking. There are two higher IARC classifications that could be applied if the evidence is stronger, but these have not been applied to PFOA, PFOS or any other PFC at this time.

To add some further context to the IARC classification, a number of common and everyday products have received higher or similar ratings. For example, coffee has been given the same classification as PFOA ('possibly carcinogenic'), and the oral contraceptive pill has been given the highest classification ('carcinogenic to humans').

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Expert in toxicology and environmental health risk assessment.

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1 http://www.atsdr.cdc.gov/Toxfaqs/TF.asp?id=1116&tid=237

2 Chang E. T, Adami H-0. , Boretta P. , Cole P. , Starr TB. and Mandel J. S. (2014) A critical review of perfluorooctanoat and perfluorooctanesulfonate exposure and cancer risk in humans. Crit. Rev. Toxicol.44 pages 1-81.

Appendix D: List of ARFF Current and Historical Sites

Table 1: Current ARFF Sites

Green represents locations where only PFC-free fire fighting foam has been used

ARFF Site	Years of Operation	Fluorine-based Foam Used	Non Fluorine-based Foam Used
Adelaide	1950 - now	3M Lightwater, Ansulite	Protein, Solberg RF6
Alice Springs	1964 - now	3M Lightwater, Ansulite	Protein, Solberg RF6
Avalon	<1959 - 1992	3M Lightwater	Protein
Avalon	2005 - now	Ansulite	Solberg RF6
Ballina	2014 - now		Solberg RF6
Brisbane	1988 - now	3M Lightwater, Ansulite	Solberg RF6
Broome	2008 - now	Ansulite	Solberg RF6
Cairns	1950 - now	3M Lightwater, Ansulite	Protein, Solberg RF6
Canberra	<1959 - now	3M Lightwater, Ansulite	Protein, Solberg RF6
Coffs Harbour	2014 - now		Solberg RF6
Coolangatta	1950 - now	3M Lightwater, Ansulite	Protein, Solberg RF6
Darwin	1950 - now	3M Lightwater, Ansulite	Protein
Gladstone	2014 - now		Solberg RF6
Hamilton Island	2005 - now	Ansulite	Solberg RF6
Hobart	1950 - now	3M Lightwater, Ansulite	Protein, Solberg RF6
Karratha	1988 - 2003	3M Lightwater, Ansulite	Protein
Karratha	2010 - now		Solberg RF6

Table 1: Current ARFF Sites

Green represents locations where only PFC-free fire fighting foam has been used

ARFF Site	Years of Operation	Fluorine-based Foam Used	Non Fluorine-based Foam Used
Launceston	<1959 - now	3M Lightwater, Ansulite	Protein, Solberg RF6
Mackay	<1964 - now	3M Lightwater, Ansulite	Protein, Solberg RF6
Maroochydore	2004 - now	Ansulite	Solberg RF6
Melbourne	1950 - now	3M Lightwater, Ansulite	Protein, Solberg RF6
Newman	2014-now		Solberg RF6
Perth	1950 - now	3M Lightwater, Ansulite	Protein, Solberg RF6
Port Hedland	1968 - 2003	3M Lightwater	Protein
Port Hedland	2013 - now		Solberg RF6
Rockhampton	1950 - now	3M Lightwater, Ansulite	Protein, Solberg RF6
Sydney	1950 - now	3M Lightwater, Ansulite	Protein, Solberg RF6
Townsville	2005 - now	Ansulite	
Yulara (Ayers Rock)	2005 - now	Ansulite	Solberg RF6

Historical ARFF Sites *Green represents locations where only PFC-free fire fighting foam has been used.*			
ARFF Site	**Years of Operation**	**Fluorine-based Foam Used**	**Non Fluorine-based Foam Used**
Archerfield	1950 - 1991	3M Lightwater	Protein
Bankstown	1950 - 1991	3M Lightwater	Protein
Broken Hill	<1959 - 1974		Protein
Bundaberg	1964 - 1984	3M Lightwater	Protein
Camden	1966 - 1977		Protein
Cloncurry	<1959 - 1966		Protein
Cocos Island	<1959 - 1967		Protein
Cooma	1964 - 1977		Protein
Derby	1966 - 1973		Protein
Devonport	<1964 - 1991	3M Lightwater	Protein
Dubbo	<1959 - 1974		Protein
Eagle Farm	1945 - 1988	3M Lightwater	Protein
Essendon	1956 - 1990	3M Lightwater	Protein
Geraldton	1966 - 1975		Protein
Jandakot	1964 -1991	3M Lightwater	Protein
Kalgoorlie	<1959 - 1966		Protein
Longreach	1964 - 1972		Protein
Mangalore	<1959 - 1974		Protein
Maryborough	<1964 - 1978		Protein
Mildura	<1959 - 1966		Protein
Moorabbin	1950 - 1990	3M Lightwater	Protein
Mt Isa	1964 - 1990	3M Lightwater	Protein
Narromine	<1959 - 1973		Protein
Norfolk Island	<1959 - 1991	3M Lightwater	Protein
Parafield	<1964 - 1991	3M Lightwater	Protein
Proserpine	1980 - 1986	3M Lightwater	

Historical ARFF Sites *Green represents locations where only PFC-free fire fighting foam has been used.*			
ARFF Site	**Years of Operation**	**Fluorine-based Foam Used**	**Non Fluorine-based Foam Used**
Tamworth	<1959 - 1991	3M Lightwater	Protein
Tennant Creek	<1959 - <1962		Protein
Wagga Wagga	<1959 - 1979		Protein
Wynyard	1950 - 1988	3M Lightwater	Protein

Appendix E: Timeline of key activities

1950s	Since this time, various types of fire fighting foams have been used by Airservices and its predecessors where an aviation rescue fire fighting service has been provided at airports around Australia.
1980 – 2003	A product called 3M Lightwater is used by ARFF. The product is later identified as containing PFCs.
1995	Airservices is established under the *Air Services Act 1995* (Cth). The Aviation Rescue Fire Fighting (ARFF) function is taken over from the Civil Aviation Authority (CAA).
1997	Most of the civilian airports at which Airservices operates become subject to the *Airports (Environment Protection) Regulations 1997* (Cth) (Environment Protection Regulations) which are made under the *Airports Act 1996* (Cth). The Regulations aim to establish a Commonwealth system of regulation of, and accountability for, activities at airports that generate or have the potential to generate pollution; and improve environmental management practices for activities carried out at airport sites.
1998	The *Civil Aviation Safety Regulations 1998* (Cth), made under the *Civil Aviation Act 1988* (Cth), require Airservices to ensure that an ARFF service is available at airports at which it operates. Functions are to be carried out in accordance with a Manual of Standards issued by CASA which prescribe among other things, fire extinguisher agent performance criteria.
2001	Airservices becomes aware of international environmental concerns regarding PFOS which was known to be an active ingredient in 3M Lightwater.
2003	The Australian Government Department of Health, through the National Industrial Chemicals Notification and Assessment Scheme (NICNAS), issues an alert relating to PFOS in response to growing environmental and health concerns.
	Airservices ceases using 3M Lightwater and transitioned to Ansulite. It was Airservices' understanding that Ansulite did not contain PFOS or PFOA. (Ansulite would later be found to contain trace amounts of PFOS and PFOA at significantly lower levels than those found in 3M Lightwater).
2007/2008	Airservices embarks on a program of preliminary site assessment work of its fire fighting training grounds focussing on the detection of PFCs in both soil and groundwater. The focus of the testing is on sites considered to have had the greatest exposure, namely sites where 3M Lightwater has been used for training. PFOS and PFOA are the target chemicals and are identified to varying degrees in the analysis results. In the absence of regulatory PFC threshold levels in Australia for benchmarking, the analysis results are compared against the limited number of international screening levels that could be found at the time.
2008	Canada lists PFOS as a toxic substance, but expressly permits use of AFFF containing PFOS until 29 May 2013. Similarly, the European Union allowed the use of fire fighting foams that contained PFOS to continue until 27 June 2011.
2009	Airservices begins working closely with Commonwealth, State and Territory government health experts, environment regulators and policy agencies, airport owners and operators and research institutions to inform the development of appropriate national standards and guidelines.
	PFOS is added to Annex B of the Stockholm Convention as a Persistent Organic Pollutant in 2009. The Stockholm Convention restricts the production and uses of chemicals listed in Annex B. However, Annex B states that the production and use of PFOS for the purposes of fire-fighting foam is an 'acceptable purpose'. Australia is yet to ratify the amendments made to Annex B in 2009.
	Airservices undertakes risk assessments for airport sites where fire fighting foams containing PFCs have been used.
	Airservices commissions a chemical analysis on a selection of new containers of Ansulite product. The analysis identifies the presence of trace amounts of PFOS and PFOA, which is contrary to Airservices understanding of the foam's constituents.
	Airservices instigates a policy to cease all training using AFFF. At the start of 2010, this is extended to include the ceasing of routine foam training employing the operational foam.
	Airservices establishes its PFOS Environmental Management Plan.
	Analysis of wastewater as part of treatment system trail identifies high levels of PFOA which lead to testing of Ansulite. This finding expands Airservices locations of concern from 14 to 36, with potentially multiple sites at each location.

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2009/2010	Airservices writes to Commonwealth and State environmental regulators advising them of its PFC concerns in relation to its ARFF facilities. Relevant Commonwealth departments, airports, and waste service providers are also notified. Face to face meetings are held with these organisations to discuss the issue, and to outline Airservices' proposed PFC management approach.
2010	Airservices ceases using Ansulite and switches to a fire fighting foam called Solberg RF6 which is PFC-free and continues to be used today. Airservices continues to carry Ansulite where required under contract with the Department of Defence at Townsville and Darwin but has not used the foam for training or in response to an incident at these locations since 2010. The transition to Solberg involved investigations and trials of aviation rescue fire fighting vehicle cleaning, waste management, analysis of Solberg RF6 and consultation with specialist consultants to ensure the transition was successful.
	Airservices is invited to present at the Inter-Airport Forum. The forum is run by the environmental managers of airports for the benefit of sharing information relevant to all airports. At this event, Airservices explains to airport stakeholders what activities are being undertaken by Airservices in relation to PFCs, and responds to questions.
	Airservices engages Professor Jochen Mueller from the National Research Centre for Environmental Toxicology to develop a voluntary health study to measure aviation rescue fire fighters' exposure to PFCs.
	In recognition of the ongoing concerns and need for further PFC related work, Airservices strengthens its governance arrangements and establishes a broader PFC Contamination Strategic Environmental Management Plan (SEMP). A dedicated team of subject matter experts is established to implement the PFC SEMP.
	A desktop risk ranking is undertaken to assist prioritisations of sites for further investigation.
	ARFF takes action to minimised local foam training – branch line training as per CASA requirements at local fire training grounds with most local training being conducted with water only. In addition, ARFF personal protection equipment is replaced to minimise exposure to PFC residues.
	Detailed site assessments and human health and ecological risk assessments are commenced for Brisbane, Rockhampton and Sydney.
2011	A site assessment is undertaken at Perth former fire station and workshop due to handback of site.
	Airservices conducts a trial of plasma arc technology to destroy PFC impacted soil/sludge. The trials were successful but costly.
	An independent review of Airservices PFC SEMP is conducted to ensure Airservices management is appropriate and aligned with industry practice. A further independent review is conducted in 2014.
2012	Airservices initiates a project to develop guidance levels for PFOS and PFOA. The project fails to gain sufficient momentum with other Commonwealth stakeholders and is postponed until consensus on a national approach can be reached.
	Sydney and Brisbane site contamination assessment and human health and ecological risk assessments are completed with reports provided to airports and regulators.
	Research trials commence on treatments of PFC impacted waste water and concrete fire training ground pad sealants with mixed success.
2013	A centralised national ARFF training facility is opened at Melbourne Airport. The facility is used all year round for recruit and diploma training, with only non-fluorinated training foam used.
	Trials of RemBind™ as an immobilising agent for PFCs in impacted soils commence in December 2013. Initial trials of PFC impacted soil from ARFF sites were undertaken by an independent consultancy firm in co-operation with Ziltek, the manufacturer of RemBind™. The final report presented in August 2014 found that these trials were highly successful, with immobilisation levels attained up to 99%. Further investigations are underway in collaboration with the University of Queensland, to assess the application of RemBind™ as an in-situ treatment for PFC impacted soils.
	Investigation and trials commence into options for destroying excess AFFF stocks and storage tanks impacted by PFCs.
	Works commence to review and update appropriate trade waste agreements at PFC impacted sites.
2014	CRC CARE funds a project to develop Australian human health and ecological screening levels for PFOS and PFOA. Airservices is represented on the project's Technical Working Group and contributes to the development of a final report making recommendations expected to be available in the first quarter of 2016.
	PFOA is classified in Group 2B 'possibly carcinogenic to humans' by the International Agency for Research on Cancer in June 2014. It was classified in Group 2B on the basis of limited

	evidence of testicular and renal cancer in workers in a fluoropolymer production plant and in the highest exposed nearby residents.
	Works continue to dispose of excess AFFF stocks.
	Rockhampton site contamination assessment and human health and ecological risk assessment completed and report provided to airport and regulator.
	Airservices partnered with DIRD in 2014 and engaged GHD Pty Ltd to research and develop a draft interim PFC decision-making guide.
2015	GHD Pty Ltd finalises the interim PFC decision-making framework for construction projects at airports. The risk-based guide employs a series of decision steps, references and proposed interim contamination screening levels for soil, surface and groundwater. This draft interim guide was provided to the Department of the Environment in 2015 for reference and consideration.
	Airservices engages the University of Queensland to provide advice on any risks to construction personnel operating on PFC impacted sites. The report, delivered in September 2015, recommends the proper use of personal protective equipment while working on all sites, regardless of whether contamination is present or not. Based on an assessment of estimated possible exposure levels and pathways, the report concludes that the risk to workers is acceptable provided that general workplace safety best practices are followed.
	Airservices continues to progress a further round of risk assessments for airport sites where fire fighting foams containing PFCs have been used to determine if any migration of PFC residues from fire stations and training grounds has occurred. Further site testing will commence following the outcomes of the risk assessment and will be based on a range of factors developed in consultation with regulators and experts.
	Airservices participates in a Commonwealth interdepartmental committee, chaired by the Department of Environment, which has been established to inform the Commonwealth Government position on PFC management and provide advice on how to respond to PFC concerns. This work is ongoing.
	Airservices commences an assessment to identify potential water extraction sources (e.g. groundwater bores, surface water extraction sites) in the vicinity of airports and former airports where Airservices and its predecessors provided ARFF services using fire fighting foams containing PFCs.
	Airservices is again invited to present at the Inter-Airport Forum. The forum is run by the environmental managers of airports for the benefit of sharing information relevant to all airports. At the event Airservices explains to airport stakeholders what activities are being undertaken by Airservices in relation to PFCs, and responds to questions.
	Airservices PFC SEMP and strategic stakeholder engagement plan is reviewed and updated to ensure ongoing adequacy of Airservices management approach.
	Works to dispose of residual waste of stored PFC impacted waste water and containers from truck and pad cleaning activities are completed.
	Airservices is granted regulatory approval to send PFC impacted soil treated with RemBind™ to landfill in Tasmania.
2016	Airservices holds an airport industry information session in Canberra to provide airport stakeholders with an update on its response to PFC concerns and stakeholder engagement approach for 2016.