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Evaluation of Per- and Poly-Fluoroalkyl Substances (PFAS) in Airservices Australia’s Aviation ARFFS/EVT Employees Over Time (2025-2028)

Report 1: Sample Collection 1 (2025-26)

Contents

Appendices

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Abbreviations

AFFF	Aqueous Film Forming Foam
ARFFS	Aviation Rescue Fire Fighting Service
EVT	Emergency Vehicle Technicians
NHMRC	National Health and Medical Research Council
PFAS	Per- and Poly- fluoroalkyl substances
PFOA	Perfluorooctanoic acid
PFNA	Perfluorononanoic acid
PFDA	Perfluorodecanoic acid
PFHxS	Perfluorohexanesulfonic acid
PFHpS	Perfluoroheptanesulfonic acid
PFOS	Perfluorooctanesulfonic acid
QAEHS	Queensland Alliance For Environmental Health Sciences
QC/QA	Quality Control and Quality Assurance
UQ	The University of Queensland

Executive Summary

This report presents findings from the first blood collection round (2025/26) of the 2025-2028 Airservices PFAS Exposure Study, conducted by the Queensland Alliance for Environmental Health Sciences at The University of Queensland (QAEHS). The study continues previous investigations into occupational exposure to per- and poly-fluoroalkyl substances (PFAS) among current and former Airservices Australia Aviation Rescue Fire Fighting Services (ARFFS) and Emergency Vehicle Technician (EVT) employees.

Historically, Airservices used PFAS-containing firefighting foams, including 3M Light Water and Ansulite, until transitioning to PFAS-free foam in 2010. While the replacement of these foams has significantly reduced occupational exposure, PFAS are highly persistent and remain detectable in the blood serum of many employees due to their long elimination half-lives and historical exposure.

A total of 566 participants provided blood samples between March 2025 and April 2026, with approximately 90% having participated in previous exposure studies. Results show that serum concentrations of PFHxS, PFHpS and PFOS remain elevated in many participants compared with the Australian population, particularly among employees who commenced work before 2005 during the period when 3M Light Water was in use. PFOA concentrations were generally comparable to the Australian population.

Among employees who commenced service after 2005, longer employment duration and earlier commencement were associated with higher serum PFHxS, PFHpS and PFOS concentrations. This may reflect greater historical exposure opportunities during the transition from 3M Light Water, including potential exposure to residual PFAS, rather than ongoing occupational exposure after 2010. This interpretation is supported by the finding that PFAS concentrations among participants who commenced service after 2010 were comparable to those observed in the Australian population. This suggests limited ongoing occupational PFAS exposure, but this finding should be interpreted with caution due to the small number of participants in this group.

Overall, PFAS concentrations continued to decline over time across the cohort. No statistically significant differences in the rate of decline were identified between current and former employees, indicating no clear evidence of widespread ongoing occupational exposure during this period. However, large variability in individual temporal trends may have limited the ability to detect small differences between the groups.

Station-specific assessments did not identify consistent differences between most locations. Avalon Airport remained a notable exception due to the previously identified contaminated mains water exposure event, although follow-up testing indicates PFAS concentrations are now decreasing following implementation of exposure control measures.

The study highlights the importance of continued monitoring due to the slow rate of decline in serum concentrations, the persistence of PFAS, and the potential for new or secondary exposure pathways from historical contamination. Ongoing longitudinal monitoring will improve statistical power and the ability to detect trends, support assessment of health-related biomarkers, and assist Airservices in refining exposure control strategies to ensure PFAS exposure risks remain as low as reasonably achievable. Continued and new participation, particularly among current employees and those without a history of 3M Light Water AFFF exposure, will be important for strengthening the ability to identify and assess any emerging or ongoing low-level occupational PFAS exposure.

1. Introduction

Airservices Australia (Airservices) and its predecessors have been using various types of Aqueous Film Forming Foam (AFFF) for firefighting purposes on airfields since the 1980's. Historically, Aviation Rescue Fire Fighting Services (ARFFS) staff have also been required to regularly train with these products to maintain their competency levels, while routine maintenance activities have likewise resulted in Emergency Vehicle Technician (EVT) employees having regular contact with AFFF. The products that were used at Airservices stations included 3M Light Water AFFF ('3M Light Water'), containing per- and poly- fluoroalkyl substances (PFAS) such as perfluorooctanesulfonic acid (PFOS), perfluorohexanesulfonic acid (PFHxS), and perfluoroheptanesulfonic acid (PFHpS) and Ansul Ansulite 6% AFFF ('Ansulite') containing fluorotelomer precursors to the PFAS perfluorooctanoic acid (PFOA) and other shorter chain perfluorocarboxylate species. In 2010, Airservices transitioned to Solberg RF6, a fluorine-free foam (PFAS free), for operational and training purposes at all civilian airports[1].

PFAS are a group of fluorinated organic compounds, some that are very persistent and can accumulate in the blood serum of individuals who are exposed. The historical use of PFAS containing AFFF has been the main source of PFAS contamination at facilities for the provision of fire services, including stations, workshops and firefighting training grounds, which now act as a secondary source of PFAS (the primary source being the AFFF). This historical environmental contamination (including to infrastructure) may result in potential new exposure routes, such as contaminated water sources. In other words, Airservices firefighters could be exposed through secondary contamination or its consequent impacts.

The University of Queensland's (UQ) Queensland Alliance for Environmental Health Sciences (QAEHS) have assessed PFAS exposure among current and former ARFFS/EVT employees in studies commissioned by Airservices as well as a recent study funded by the National Health and Medical Research Council (NHMRC). These studies investigated blood serum concentrations of PFAS among current and former Airservices ARFFS/EVT employees and collected survey data including work history information. In summary, the findings of these studies show that ARFFS/EVT employees who worked with 3M Light Water in the past had experienced occupational PFAS exposure, but the replacement of this foam, which commenced in the early 2000s, was effective in reducing this occupational PFAS exposure. Although PFAS serum concentrations have been observed to decrease since the replacement of 3M Light Water, many current and former ARFFS/EVT employees who had worked with this foam still have elevated serum concentrations of some PFAS compared to the general Australian population, due to the persistence and slow elimination half-lives of PFAS. Furthermore, these studies have highlighted the risk of new exposure for ARFFS/EVT employees. For example, following detection of PFAS contamination in the mains water at Avalon Airport in late 2022, blood testing revealed that Avalon employees had experienced elevated PFAS exposure. Follow up blood tests showed that PFAS serum concentrations were decreasing again, suggesting that exposure control implementations (provision of alternative drinking water and a deep clean of the Avalon station) were successful.

The previous studies have provided information of PFAS exposure among current and former ARFFS/EVT employees to Airservices and to the study participants as well as contributed to the scientific literature. The studies have further highlighted the importance of continued monitoring of PFAS exposure over time to be able to ensure that PFAS serum concentrations are continuing to

[1] Operations at joint civil-military facilities at Darwin and Townsville airports were required to use Ansulite firefighting foam under contract with Department of Defence until 2019.

decrease among Airservices ARFFS/EVT employees who have experienced exposure in the past and determine whether there is any evidence of new (or potentially ongoing) exposure for ARFFS.

Accordingly, in 2024, Airservices commissioned QAEHS to conduct the current study, which follows on from previous work and aims to continue to monitor and further evaluate changes of PFAS serum concentrations over time to assess whether ongoing/new elevated exposures to PFAS are being experienced by Airservices ARFFS/EVT employees. The current study is a longitudinal study, conducted between 2025-2028.

Specific aims of the study are to:

- Assess if PFAS serum concentrations are changing among ARFFS/EVT participants differently compared to the general population (i.e. assess if there is ongoing or new occupational exposure),
- Assess if there are any work-related factors (e.g. station, job/position) associated with observed trends in PFAS serum concentrations among ARFFS/EVT participants (note that this assessment may be limited by low statistical power)
- Assess associations between changes in PFAS relevant biochemical markers and/or confounders associated with changes in PFAS serum concentrations, and
- Provide ongoing advice to Airservices to assess and minimise exposure risks to PFAS.

1.1 The Current Report

The current report outlines updates and main findings from the first blood collection period, conducted between 2025 to early 2026. These updates include participation numbers and the following PFAS serum concentration trends:

- PFAS concentration in serum among participants who provided a blood sample as part of the first blood collection, including:
    - Work history trends (year of service commencement and work duration)
    - How the PFAS serum concentrations compare to the general population
    - How the PFAS serum concentrations compare to previous study cohorts
    - Trends in PFAS concentration in serum over time.

The purpose of assessing change is to understand if participants have experienced recent or current ongoing PFAS exposure. Thus, the report will predominantly focus on the PFAS serum concentration trends between the most recent Airservices Exposure Study (2018/19) and the current collection (2025/26). These trends include:

- Annual change in PFAS concentration and elimination half-lives
- Factors associated with the rate of change; age, blood/plasma donation and current employment status
- Station specific changes

Improved statistical power is expected by the end of the study (2028). Thus, additional and more comprehensive assessments will be conducted and included in the final report. The final report will also include an assessment of changes in PFAS relevant biochemical markers and additional confounders associated with changes in PFAS concentrations.

1.2 Background PFAS Information

PFAS is a collective term used for several classes of chemicals which have been used in consumer products and industrial applications since the 1950s [1]. Many PFAS are biologically persistent and can accumulate in the blood serum of individuals who are exposed. PFOA, PFHxS, PFHpS and PFOS (**Appendix A, Figure A-1**) have been the dominant PFAS in the blood in previous exposure studies.

The general population is exposed to PFAS through multiple different routes, including the use of consumer products and ingestion of contaminated food and drinking water [2]. As a result, PFAS are detected in serum samples taken from members of the public. Since 2002, QAEHS has conducted approximately biennial evaluations of the blood serum concentrations of PFAS in pooled surplus pathology samples from the Australian population [3-5]. The data demonstrate a decline in the concentrations of the most prominent PFAS (i.e., PFOA, PFHpS, PFHxS and PFOS) in the Australian population over the last two decades, with an apparent slowing in the rate of decline in recent years, suggesting that concentrations are increasingly being influenced by low-level ongoing exposures and persistent background sources (**Figure 1**, PFOS is shown as an example). These datasets present important baseline values for the evaluation of PFAS in exposed populations and hence serve as a reference in the current report (**Appendix A, A-1-2**).

Firefighters are at risk of occupational exposure to PFAS through the direct or indirect use of PFAS containing AFFFs, as well as inhalation of PFAS present in smoke, air and dust during firefighting or at firefighting stations. Elevated serum PFAS concentrations, in comparison to a reference population, have been reported in firefighters from different parts of the world [6-11], as well as in current and former Airservices ARFFS/EVT employees previously (Section **1.3)**.

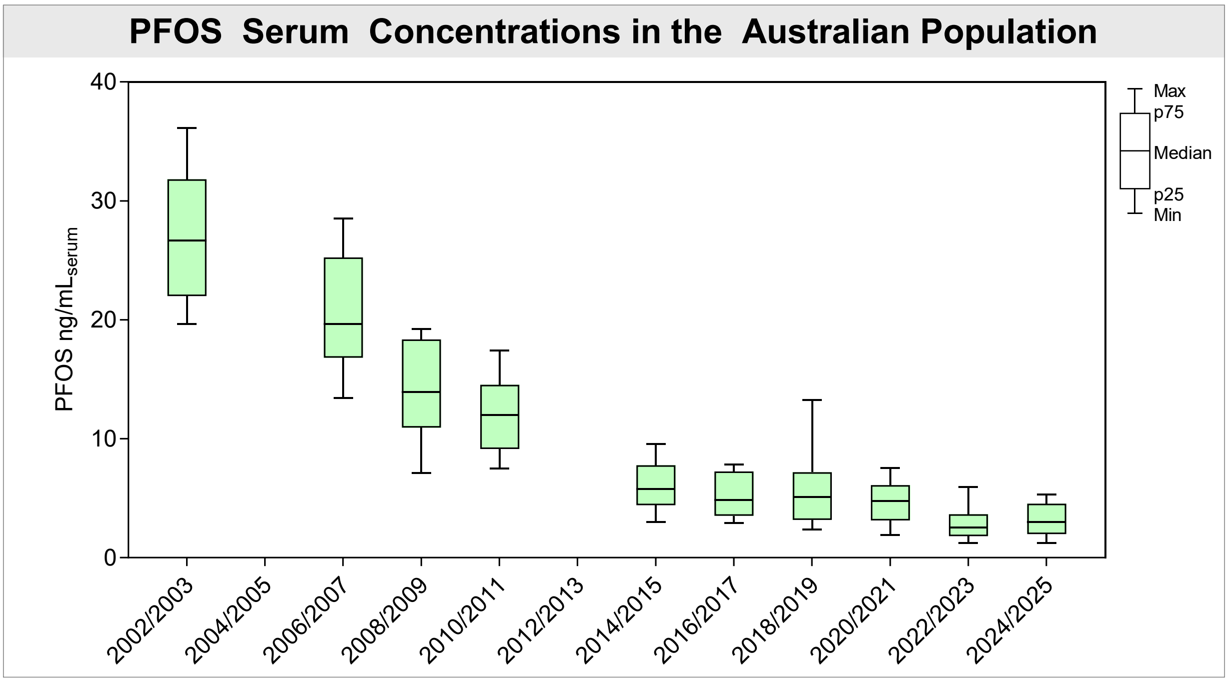

Figure 1 *Time-trend of PFOS serum concentrations in pooled samples from adults (>16 years) of the general Australian population. The lines in the boxes indicate median concentrations.*

1.3 Overview of Previous Exposure Studies

1.3.1 2013/14 and 2018/19 Airservices Exposure Studies

Airservices have commissioned QAEHS to evaluate PFAS exposure among Airservices ARFFS/EVT employees, by conducting two major "PFAS Exposure Studies" (Airservices Exposure Studies), in which Airservices current and former ARFFS/EVT employees have had their blood serum samples measured for PFAS and selected health biomarkers. The study participants also completed surveys to capture their work history and other lifestyle factors.

QAEHS conducted the first Airservices exposure study in 2013/14, in which approximately 150 ARFFS/EVT employees participated. PFOS and PFHxS serum concentrations among the participants were found to be higher than the general Australian population, while PFOA serum concentrations among the ARFFS employees were found to be similar to those found in the general Australian population. No associations between PFAS serum concentrations and health biomarkers were observed, but this assessment was limited by the small sample size.

A follow-up study was conducted in 2018/19, approximately 800 current and former ARFFS/EVT employees participated. Of these participants, a total of 130 participants had also taken part in the 2013/14 Exposure Study, allowing for a longitudinal assessment of PFAS serum concentrations in this sub cohort. Samples archived in the 2013/2014 Airservices Exposure Study were re-analysed as part of a quality control/quality assurance (QA/QC) procedure. The re-analysis showed good agreement. Furthermore, PFHpS, which was originally not included in the 2013/14 analysis, was detected in the samples, and thus allowed for temporal assessment for this compound as well.

Compared to the concentrations measured in the 2013/14 Exposure Study, average concentrations of PFOA, PFHxS, PFHpS and PFOS were 55 – 65% lower in participants of the 2018/19 Exposure study (**Figure 2 a**, only PFOS shown). A similar decrease was also observed on an individual level among the 130 individuals who took part in both studies.

Although the concentrations had decreased in current and former ARFFS/EVT employees over the five years between these two studies, the mean serum concentrations of PFHxS, PFHpS and PFOS in the 2018/19 cohort were still elevated, compared to the general Australian population at the time. PFOA concentrations remained similar to those found in the general Australian population. Elevated PFHxS, PFHpS and PFOS concentrations were associated with past use of 3M Light Water AFFF. Mean concentrations of these three PFAS were not elevated in those participants who had started working for Airservices after 2005, when 3M Light Water AFFF had been substituted at all stations (**Figure 2 b**, only PFOS shown). These findings suggest that the substitution of 3M Light Water AFFF reduced occupational PFAS exposure to ARFFS employees.

An assessment of differences in PFAS serum concentrations across fire stations did not show major differences in exposure. However, these analyses were limited by many Airservices employees having worked at more than one location throughout their career and the small number of participants from some fire stations.

Participants who reported that they were blood donors were found to have lower mean concentrations of PFOA, PFHxS, PFHpS and PFOS and their PFAS concentrations declined more rapidly across time points compared to those who did not report to be blood donors.

Higher levels of PFOA, PFHxS, PFHpS and PFOS were all associated with higher levels of biochemical markers for cardiovascular health (Total Cholesterol, LDL-Cholesterol). Despite PFOA not being elevated among the participants, PFOA was additionally associated with higher levels of the kidney function marker, urate, and the thyroid function marker TSH. These findings should be interpreted as associations only and do not imply causality, as the cross-sectional study design precludes establishing temporal relationships and the observed associations may be influenced by residual or unmeasured confounding factors. No significant association was observed when assessing the change of PFAS serum concentrations and biomarker concentrations over time in the longitudinal sub-cohort.

The 2013/14 and 2018/19 exposure studies have been published in two reports for Airservices as well as in a series of publications in peer-reviewed journals [12-18]. The full report of the 2018/19 study can be found on the QAEHS website [19].

Summary Study Findings:
2013/14 and 2018/19 Airservices Exposure Studies

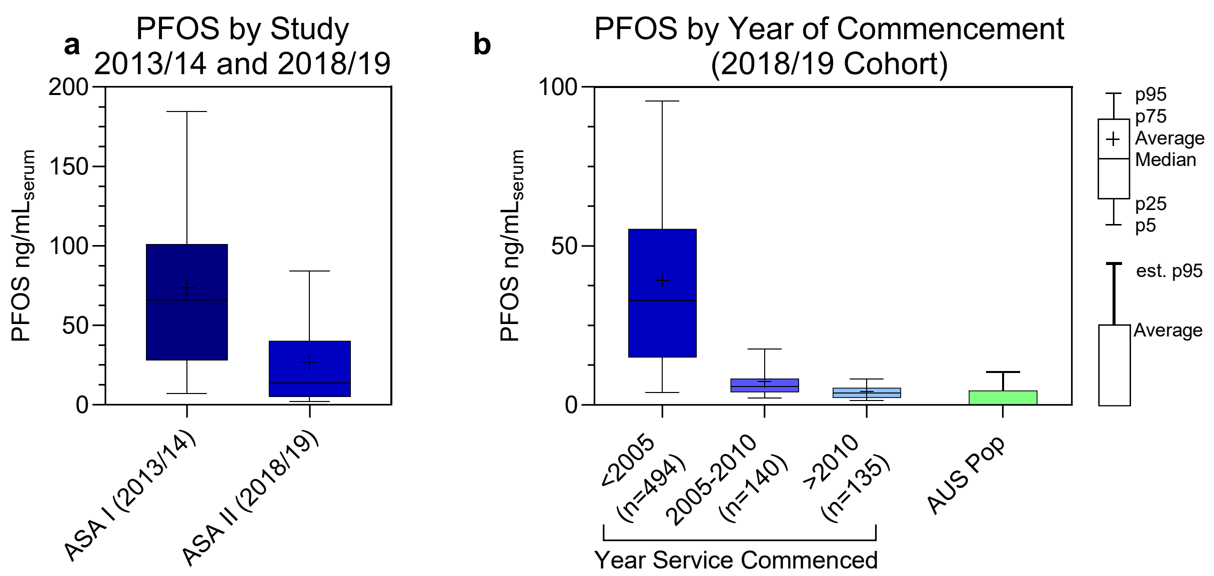

***Figure 2** Main findings from the Airservices Exposure Studies in 2013/14 and 2018/19, with PFOS as an example; a) PFOS Concentrations in the 2013/14 Airservices cohort and the 2018/19 Airservices cohort and b) PFOS concentrations grouped by category when employees commenced working for Airservices (2018/19 Airservices cohort), compared to the general Australian population at the time and at a comparable age group (2018/19, 46–60-year-olds). **Note:** Blue box-and-whisker plots show the distribution of individual-level PFAS concentrations in the ARFFS/EVT cohort. Australian population data are based on pooled samples and are therefore shown as the average and estimated p95 only. For comparison of average concentrations, the average indicated by "+" in each blue box plot should be compared with the Australian population average (green bar). The box-and-whisker plots additionally illustrate the distribution of individual cohort concentrations.*

1.3.2 The 2020-2025 NHMRC Study

An NHMRC-funded study (referred to as "the NHMRC study" from hereon), led by QAEHS, was conducted between 2020 and 2025 to assess the effectiveness of exposure control measures among exposed communities and firefighters. The study aimed to investigate changes over time in PFAS concentrations in the blood serum of individuals known to have experienced elevated PFAS exposure, including current and former Airservices ARFFS employees.

Current and former ARFFS/EVT employees who had previously provided blood samples for PFAS analysis were invited to participate in the NHMRC study by completing a questionnaire and providing two additional blood samples for analysis of PFAS and selected health biomarkers. The first blood sample and survey data were collected in 2021/22, with participants invited to provide a second blood sample and complete a follow-up survey approximately two years later (2023/24).

In total, 516 current and former Airservices ARFFS/EVT provided a blood sample in 2021/22, and 469 participants provided a follow-up sample in 2023/24. PFAS serum concentrations decreased over time for most participants.

Data collected through the NHMRC study will be integrated with data from all the previous and ongoing Airservices exposure studies to support more comprehensive analysis.

Further information about the study can be found on the QAEHS website [19].

1.3.3 2022-2024 Avalon Exposure Study

In October 2022, PFAS was detected in the mains water at Avalon Airport. As a response, Airservices commissioned QAEHS to provide blood testing services for Airservices employees who were concerned about their exposure at Avalon. QAEHS also used existing information from the PFAS database, available from previous and ongoing studies (2018/19 Airservices Exposure Studies and the NHMRC study), to help to identify when the exposure to PFAS-impacted mains water began at Avalon Airport.

A total of 65 individuals, including 40 ARFFS, provided a blood sample for analysis between October 2022 and January 2023. Of these, 25 ARFFS, consented to the use of their data for further data analysis which enabled assessments of the PFAS exposure trends. The findings of this study confirmed that exposure of Avalon ARFFS employees to PFAS contaminated mains water resulted in an elevation of their PFOS, PFHpS and PFHxS blood serum concentrations.

With information from the PFAS data base, QAEHS identified a subset of Avalon ARFFS (n=7), who had previous PFAS concentrations in serum measured as part of our previous studies in 2021/22 and 2018/19. The retrospective analysis of the blood sample results of this small cohort at Avalon provided information on the temporal trend of the exposure to the contamination that was discovered by accident during site investigations (**Figure 3 a**). This illustrates the utility of the longitudinal study when assessing potential workplace exposures.

Eight to 11 months following the initial testing at Avalon, follow up blood testing was offered to determine how PFAS blood concentrations have changed over time in Airservices ARFFS employees (including contractors) at Avalon following exposure control that was implemented after the identification of PFAS contamination of the mains water and to assess the efficacy of blood or plasma donations in accelerating the elimination of PFAS. In total, 29 participants provided a blood sample at both the initial and follow up testing, completed a questionnaire where they provided information about work history and blood/plasma donation, and consented for the use of their data for this assessment.

The PFAS concentration decreased in all participants who confirmed that they worked at the Avalon station between the two blood tests. Overall, PFAS concentrations in serum decreased for both those who were blood/plasma donors and those who were not, suggesting that PFAS exposure had been reduced at Avalon station. However, only five participants who currently worked at Avalon had not donated any blood/plasma and this limits any definite conclusion regarding any potential ongoing exposure.

The decrease of PFAS serum concentration was associated with the number of blood/plasma donations, where a greater number of donations was found to result in a greater decrease in PFAS serum concentration (**Figure 3 b**). This provides evidence that the elimination of PFAS can be increased, and that blood/plasma donation can be effective for reducing PFAS serum concentrations. The study findings have provided important information to individuals who wish to reduce their PFAS levels.

The Avalon exposure investigations have been documented in two reports for Airservices. The follow up blood testing report can be found on the QAEHS website [19]. The study findings have also been summarised in a factsheet and 'frequently asked questions' document which can be found on the same website.

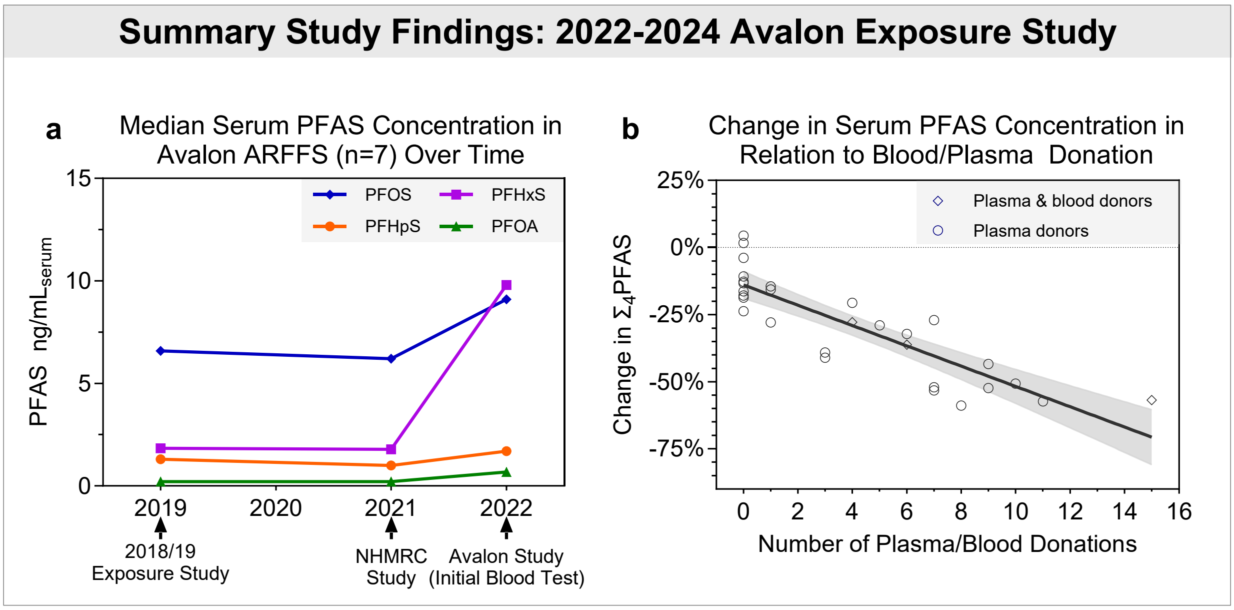

Figure 3 *Main findings from the Avalon Station Case Studies; a) Initial Avalon testing: Median concentrations of PFOS, PFHpS, PFHxS and PFOA among Avalon ARFFS employees (n=7) between 2018/19 and 2022/23. The ARFFS employees were assumed to have been employed at the Avalon station during the period assessed. b) Follow up Avalon testing: Percent change in the sum of PFOA, PFHxS, PFHpS and PFOS serum concentration ($\sum_4$PFAS) in 29 study participants who donated plasma or both blood and plasma between 0-15 times over the course of 8-11 months. The line shows the unadjusted trend and the highlighted area represent the 95% confidence interval.*

1.3.4 Station Specific Exposure Assessment (2023)

Concurrent with the Avalon Exposure Study, Airservices commissioned QAEHS to investigate whether there was evidence of new or potentially ongoing PFAS exposure among ARFFS/EVT employees at other Airservices stations. This assessment reviewed serum PFAS concentration trends among 500 ARFFS/EVT employees using existing Airservices and NHMRC study data. Individual annual changes in PFAS concentrations between the 2018/19 - 021/22 period were compared between stations based on reported employment locations in 2018/19. While there was no evidence of an Avalon-style exposure event occurring at other stations (i.e. an increase in serum PFAS levels for most staff at a location), participants from Alice Springs/Ayers Rock stations demonstrated consistently slower declines in PFHxS, PFHpS, and PFOS (the PFAS compounds historically associated with 3M Light Water AFFF exposure) compared with the overall cohort. However, these findings should be interpreted cautiously due to limitations including small station-specific sample sizes, no information on employee movements during the assessment period, and analytical uncertainty associated with the relatively short follow-up period. The findings provided supporting evidence for consideration alongside other site-specific information, including Airservices' facility water testing results. Further details of this assessment are provided in **Appendix A, A-1-3.**

2. Methods

2.1 Study Design

The current study was designed by adopting the study design and logistics of the previous Airservices Exposure studies as a longitudinal study with repeat blood sampling over the course of four and a half years (2025-2028) for the purpose of continuing research and providing additional data in respect of past and current employees' exposure.

A workshop was held in November 2024 which included attendees from the research team (UQ and associated research organisations) and Airservices staff representing different areas of the company, including a Local Operations Manager, a Fire Commander, a Station Officer, a Leading Fire Fighter, an Emergency Vehicle Technician, a staff representative of Airservices Health and Safety committee, representatives of Airservices PFAS and communications teams, as well as a representative from the United Firefighters Union. The workshop aimed to discuss the study design and welcome any suggestions to improve the design, logistics and make sure expectations on research questions will be met. Outcomes of the discussions resulted in a refined questionnaire, with improvements of questions related to capturing health and work history information.

The project was designed to measure both PFAS and biochemical markers over time in as many personnel as are willing to participate, including both current and former Airservices ARFFS/EVT employees. Both new participants and participants from any of the previous exposure studies are recruited. As per previous studies, the study includes informed consent, protection of identity of individuals, confidentiality of individual results, and is carried out under strictest ethical standards. Participants are asked to provide a blood sample and complete a questionnaire in 2025/26, and then again in 2027/28. By collecting blood two years apart, a significant change in PFAS concentration can be assessed with confidence, taking the long elimination half-lives and analytical uncertainties into consideration. Participants who are donating blood or plasma regularly, have a faster elimination of PFAS. Thus, participants who are donating blood/plasma have the opportunity for yearly PFAS testing during this study to confirm that their levels are decreasing as expected. Participants will be provided with their individual results in the form of individual letters. A report will be provided to Airservices at the end of each collection round. At the end of the study, there will be an option for an online information session (**Figure 4**).

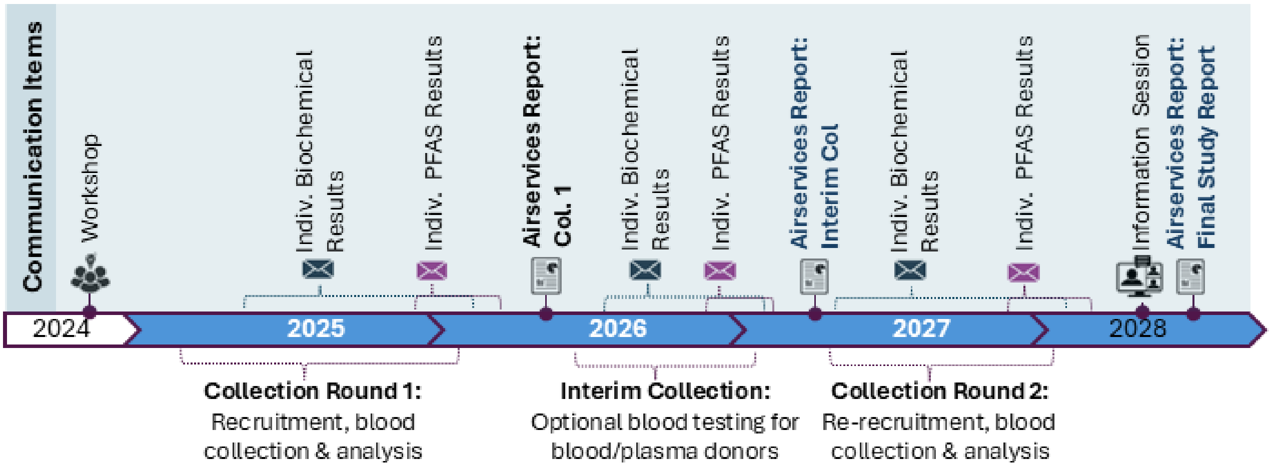

***Figure 4** Airservices 2025-2028 Exposure study design and timeline*

2.2 Ethical Clearance

All data and material generated in the provision of this investigation are kept secure and confidential. Ethical approval was provided by the UQ Human Research Ethics Committee (2024/HE002577).

2.3 Participant Recruitment

All participant recruitment was handled by the research team at UQ. Airservices involvement in the recruitment process was to send out memos to current staff outlining the study commencement and invite any new potential participants to register directly with the Research Team. The research team at UQ also made contact with the Aviation branch of the United Firefighters Union of Australia and with social media groups affiliated with aviation firefighting for assistance in contacting retired or ex-staff. Participants can join at any time during the 2025-2028 timeframe of the current study. Recruitment and data collection numbers as part of the first sample collection round are presented in **Table 1**.

Each participant was contacted individually, and consent to participate in the study was obtained via an online form or written consent form. Participants were provided details of the closest collection clinic to provide their blood sample. The study coordinator called participants at two weekly/monthly intervals to follow up on outstanding questionnaires and blood samples.

Each participant was requested to complete a detailed questionnaire, designed to capture demographic, lifestyle and work history information. Data from the questionnaire was used to integrate the results and investigate factors that could be associated with PFAS. All participants were given the choice to complete the questionnaire online or in paper format. The full questionnaire can be found in **Table 1.**

Table 1 *Recruitment and data collection information as part of the current study's first sample collection round March 2025-April 2026 (as of 30/04/2026)*

Cohort Groups		Contacted but no response[1]	Consented but not completed[2]	Partly completed[3]	Fully completed[4]	No. of Samples provided	No. of Surveys completed
Current Staff	Existing Participants	-	61	60	245	278	273
	New Participants	-	5	4	30	31	33
Subtotal			66	64	275	309	306
Former Staff	Existing Participants	-	26	18	244	258	250
	New Participants	-	0	1	12	13	12
Subtotal		-	26	19	256	271	262
Overall totals		44	92	83	531	580	568

1. Participants for whom we have contact information and we have had recent contact with, but who have been unresponsive. For this category we are unable to give further breakdown (current/former staff) as we do not know.
2. Participants who have consented but not commenced.
3. Have either completed their survey or provided their blood sample.
4. Have completed survey and provided their blood sample and finalised their participation in the first phase of the study.

2.4 Blood Testing

Blood samples (3 SST tubes per participant) were collected by state specific pathology clinics under the Sonic Healthcare Pathology banner (e.g. Sullivan Nicolaides in Qld, NT; Douglass Hanly Moir in NSW). All samples were sent to Sullivan Nicolaides in Brisbane, where biochemical analyses were performed on one of three collected SST tubes. More information about the biochemical analysis is available in **Appendix A, A-2-1.**

PFAS analysis was conducted at QAEHS laboratories with blood serum samples analysed for 53 different PFAS (**Appendix A**, **A-2-2**) This report focusses on the four dominant PFAS; PFOA, PFHxS, PFHpS and PFOS. The analysis showed good reproducibility of replicate analysis within the QAEHS laboratory, and accurate measurements of standard reference materials. Furthermore, the QAEHS laboratory participates in an international inter-laboratory comparison study (AMAP) three times per year and consistently passes acceptable criteria (**Appendix A, A-2-2**).

A total of 20 randomly selected samples were sent to two different laboratories. The laboratory comparison is shown in **Appendix A, Figure A-3** with some further discussion of the results. In short, PFOA, PFHxS and PFHpS all showed acceptable variation between the laboratories. However, it was noted that each laboratory quantified PFOS using different analytical methodologies, resulting in different quantified concentrations which was especially apparent for samples with higher PFOS concentrations. Specifically, QAEHS laboratory reported higher PFOS concentrations compared to other laboratories. QAEHS is currently investigating these differences by evaluating and refining its PFOS analytical methodology. As this work progresses, the reported PFOS results may be updated if warranted. However, any such revisions are not expected to alter the overall conclusions of the results presented in the current report.

Individual biochemical results were provided to each participant approximately two weeks after the blood test was collected. Individual PFAS results were provided to each participant at the end of the sample collection, between December 2025 and March 2026, together with summary study trends.

2.5 Data Analysis

Participant data summarised in this report include those who provided a blood sample by 13/03/2026. Participants who have provided blood samples after this date will only be included in the final report at the end of the study (2028). In addition to the data collected in the current study, PFAS measures from previous studies are integrated to assess temporal trends.

Both current and former employees were included in this study. Where appropriate, these groups are presented separately or compared throughout the report. This distinction is particularly important when assessing evidence of ongoing or recent occupational exposure.

When assessing the relationship between current PFAS concentrations and work history (e.g. duration of employment, year of commencement, or station history), current and former employees are analysed together in the primary analyses. PFAS are persistent compounds that accumulate over time and have long biological half-lives. As a result, current serum concentrations reflect cumulative historical occupational exposure, regardless of current employment status, making both groups informative for evaluating past occupational exposure.

When assessing recent or ongoing occupational exposure, current and former employees are analysed as separate groups to be compared. Former employees are not expected to experience ongoing occupational exposure because they are no longer working at Airservices stations. Consequently, they provide a useful comparison group in the temporal analyses, allowing changes in PFAS concentrations over time among current employees to be interpreted in the context of expected background elimination of PFAS from the body in the absence of continued occupational exposure. Comparisons between current and former employees must account for differences in age and historical exposure patterns between these groups, as these factors may influence PFAS concentrations and temporal trends.

To determine if serum PFAS concentrations among the study participants were elevated compared to the ‘background concentrations’ observed in the Australian population, comparisons were made with PFAS data obtained from age and sex stratified pooled serum pathology samples collected in Australia biennually as part of the QAEHS human biomonitoring program (40). The most recent data was obtained in 2024/25. Comparison of individual results with the Australian population were always made between matching age groups. Individuals were considered as having elevated concentrations of PFASs if they fell above the estimated 95th percentile (p95) concentration in the general population (that is, the estimated level that 95% of the population is at or below). For consistency with previous studies, the estimated p95 for the population was derived for PFOA, PFHxS and PFOS mean:p95 ratios according to the method described in Toms et al. (2019) [20], while the p95 for PFHpS was estimated by using the average of the mean:p95 ratio for PFOA, PFHxS and PFOS. The mean:p95 ratios agree well with the ratios published by the Australian Bureau of Statistics summarising the National Health Measures Survey (2022-24) [21]. Further information about the QAEHS human biomonitoring program and the p95 values used for comparison in this report is presented in **Appendix A, A-1-2.**

Cross sectional trends in PFAS serum concentrations among all participants were assessed using multiple linear regression models.

Changes in PFAS serum concentrations over time were initially estimated using all samples collected since, and including, the 2018/19 PFAS Exposure Study to capture any potential ongoing or new occupational exposure occurring after this period. For each participant, a simple linear regression was fitted between log-transformed PFAS serum concentration and elapsed time (years since the first sample), using all available measurements (2–6 samples per participant). The slope of the regression line was used to estimate the annual percentage change in PFAS concentration. This participant-specific approach provides a simple and intuitive summary of individual temporal trends; however, it does not account for the unbalanced longitudinal design, as participants contributed different numbers of samples and therefore regression slopes were estimated with differing precision. In addition, these analyses were not adjusted for participant characteristics or other factors that may influence PFAS elimination and should therefore be interpreted as descriptive summaries of the observed trends.

To formally assess whether the data provided evidence of potential ongoing occupational exposure, linear mixed-effects models were fitted to evaluate differences in temporal trends between current and former employees and between Airservices stations. Mixed-effects models are better suited to longitudinal data because they account for the correlation between repeated measurements within individuals, accommodate differences in the number and timing of observations, account for between-participant variability in baseline PFAS concentrations, and allow direct assessment of whether rates of change over time differ between groups while adjusting for relevant covariates. As participants who had worked at Avalon station were already known to have experienced a recent PFAS exposure event, they were excluded from the primary analysis comparing temporal trends between current and former employees to avoid biasing the assessment of ongoing occupational exposure. However, participants who had worked at Avalon were retained in the station-specific analyses, which included all individuals who reported working at an Airservices station between the 2018/19 and 2025/26 sampling rounds.

All statistical models were adjusted for potential confounders that could influence the PFAS concentrations or rate of PFAS elimination (e.g. initial PFAS concentration, age and blood donation). PFAS measurements <MDL (Method Detection Limit) were included as MDL/√2. All statistical analysis were conducted using IBM SPSS (Version 31.0.1.0) software. A p-value of <0.05 was considered statistically significant. Detailed description of statistical terms, the statistical models and their outcomes are included in **Appendix C.**

3. Results and Discussion

3.1 Participation Figures and Cohort Demographics

A total of 566 participants provided a blood sample between 16/05/2025 and 13/03/2026 and are summarised in this report. Cohort demographics are presented in (**Appendix C, C-2**) Among the participants 98% were male and 2% female. The median age of the cohort was 60 years, ranging from 26-87 years. A total of 295 (52%) were currently employed by Airservices, while 271 (48%) were former employees at the time consent was given. The median age among current employees was lower compared to former employees (51 vs 68 years). Approximately 90% (517/566) completed the questionnaire (**Table 2**). A total of 514 (91%) had participated and provided a blood sample in one or more of the previous studies.

Among participants who were currently employed, the study cohort represented 29% of the total Airservices current workforce (**Table 3**). The sex distribution was broadly comparable between the study cohort and eligible employees (4% female among participants versus 5% of Airservices current workforce). The study cohort was skewed toward older age groups: for example, approximately one third (34%) of study participants were aged 55 years or older, compared with only about one tenth (11%) of the overall Airservices workforce.

Approximately half (48%) of the participants reported that they held several different roles during their employment with Airservices. In the following, participants who held multiple positions were included in multiple job categories; 83% stated that they have worked as Firefighters, 43% as Officers, 28% as Senior Officers, 10% as Instructors and 6% as Emergency Vehicle Technicians (EVT). Approximately 11% did not report what position they had worked at.

Table 2 *Number of participants who provided a blood sample during the first collection period[1] of the current Airservices study*

Cohort Groups		Samples provided	Corresponding surveys
Employment Status	Current Staff	295	260
	Former Staff	271	256
Overall totals		**566**	**517**

1. Provided a sample between 16/05/2025 to 13/03/2026 and filled in the survey by 28/04/2026.

***Table 3** Numbers and proportions of study participants (currently employed) compared with the total Airservices employee workforce population*

		Airservices Employee Numbers [1]	Study Cohort (Currently Employed[2])	
		n (% of total employee numbers)	n (% of total participants)	Number of participants/ Airservices employee numbers (%)
Age group	<35	217 (21%)	12 (4%)	12/217 (6%)
	35-<45	394 (39%)	74 (25%)	74/394 (19%)
	45-<55	286 (28%)	109 (37%)	109/286 (38%)
	>55	115 (11%)	100 (34%)	100/115 (87%)
Gender	Male	957 (95%)	284 (96%)	284/957 (30%)
	Female	55 (5%)	11 (4%)	11/55 (20%)
Overall Totals		**1012**	**295**	**295/1012 (29%)**

1. Total number of employees as of July 2026.
2. Participants who confirmed they were currently employed at the time of consent (May 2025-March 2026).

3.2 Self-Reported Impacts Related to Possible or Actual Occupational Exposure to PFAS

Participants were asked in the questionnaire if and how they had been impacted by possible or actual exposure to PFAS (**Figure 5**)[2]. Among 505 answers, 53% reported that their health had been impacted in some way. Among those, the most frequently reported impact was on physical health (66%), including but not limited to the need for additional or more frequent health checks and belief that their exposure had caused their health problems. Mental health impact, such as anxiety, stress, depression, anger, worry, were also frequently reported (61%).

Participants who started working while AFFF (3M Light Water or Ansulite) was still in use[3] were more likely to report that possible or actual occupational exposure to PFAS had impacted their health (56%, 235/421), compared to participants who commenced service after AFFF had been replaced[4] (38%, 26/69) (**Appendix C, Figure A-4**). Among participants who commenced service after AFFF replacement, reported health impacts likely reflect concerns about residual environmental contamination rather than direct occupational AFFF exposure. This suggests that perceptions of risk persist even in the absence of direct AFFF exposure, potentially driven by awareness of PFAS persistence and uncertainty about legacy contamination at affected sites.

Participants were asked if they currently receive any support for managing possible or actual work-related exposures to PFAS. The questionnaire did not assess whether participants had attempted to obtain support or whether support had been offered but not taken up. Among those participants who reported that possible or actual PFAS exposure had impacted their health, 70% reported participation in blood testing programs/studies and/or external health checks with their usual health provider. A total of 13% reported receiving support through Airservices (i.e. through participation in the regular yearly health screening, support via Airservices ARFFs leaders or Airservices ARFFs Health and Safety Committees). As the questionnaire did not capture whether participants who did not report receiving Airservices support had sought or been offered such report, these findings cannot be used to assess the availability, accessibility or adequacy of organisational support. Further

[2] Questionnaire questions 26-28, Appendix B
[3] Participants who commenced service prior to 2011 or worked at Darwin or Townsville before 2019 or 2020 respectively were considered as “Participants who started working while AFFF was still in use”.
[4] Participants who commenced service after 2010 (excluding participants who worked at Darwin or Townsville prior to 2019 or 2020 respectively), were considered as “Participants who started working after AFFF was in use.

consideration of how the availability and adequacy of organisational support could be assessed may be undertaken through follow-up working group discussions and/or a future questionnaire.

Among those who specified possible or actual PFAS exposure had impacted on their work, approximately 21% reported this impact to their work negatively, such as reduced motivation, engagement, productivity and/or early retirement. A similar proportion (24%) reported that they had an increased desire to support Airservices in risk management.

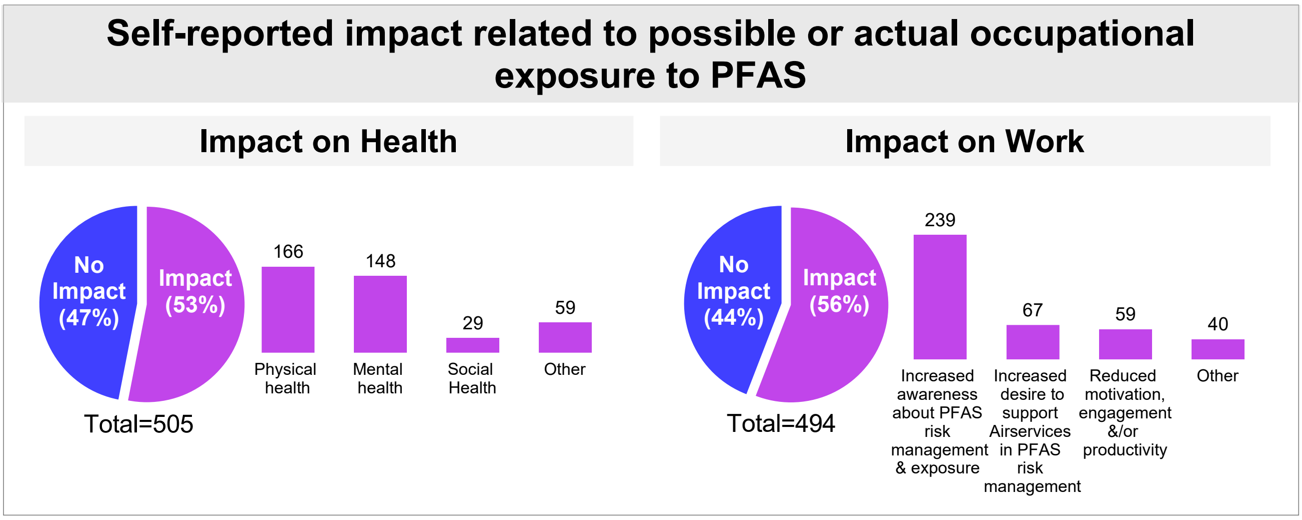

Figure 5** Answers related to the questionnaire question 'How has possible or actual, work-related exposure to PFAS impacted you?" Each participant could provide multiple reasons each. Answers stratified by AFFF use history is shown in **Appendix C, Figure A-4

3.3 PFAS Concentration in Blood Serum: Cross Sectional Trends

3.3.1 PFAS Blood Concentration and Comparisons to the Australian Population

Among the 53 PFAS analysed, only 6 PFAS were detected in more than 15% of the cohort; PFOA, perfluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA), PFHxS, PFHpS and PFOS. PFOS, PFOA and PFHxS were detected in 99% of the participants. PFHpS was detected in 86%, PFNA in 82% and PFDA in 41% of the participants. The measured concentrations of these PFAS, and how they compare to the Australian population is shown in **Figure 6** (overall sturdy cohort) and **Figure 7** (by age and current employment status). As per trends observed in the general population, older age was associated with higher PFAS concentrations. No statistically significant difference in PFAS concentrations between participants that are currently employed, compared to those who are former employees was found, when accounting for age and blood donation (**Appendix C**, **Table A-10)**

Serum concentrations of PFOA, PFNA and PFDA among Airservices ARFFS/EVT participants were similar to those observed in the Australian population, indicating no evidence of elevated exposure to these PFAS at the group level. In contrast, PFHxS, PFHpS and PFOS concentrations were higher than Australian population levels, with 66% of participants exceeding the estimated 95th percentile of the Australian population (**Table A-11, Appendix C**). Strong significant positive correlation (**Table A-12, Appendix C**) between PFHxS, PFHpS and PFOS suggest that they come from a common exposure source, consistent with their historical use as components of 3M Light Water [22, 23]. As per trends observed in the previous Airservices studies, as well as the current study (discussed further in the next section (**Section 3.3.2**)), participants who commenced service during the time 3M Light Water was still in use had the highest concentrations of the three PFAS. Due to the slow elimination of these PFAS, elevated past exposure can still be evident decades after exposure [17].

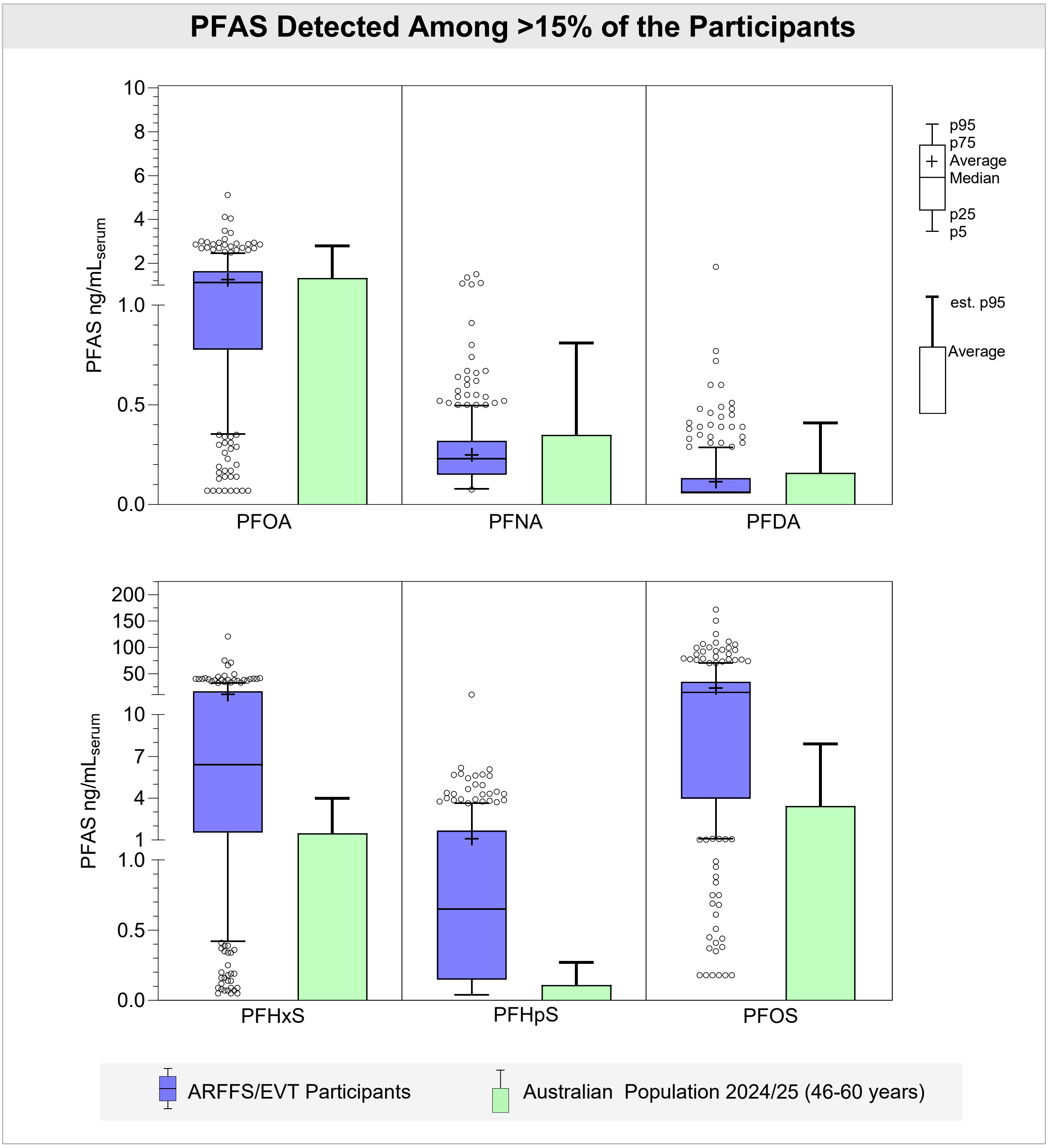

Figure 6 *Concentration of PFAS in serum of 566 Airservices ARFFS/EVT participants (blue, average age 59), and how these concentrations compare to the Australian population (green), estimated from pooled pathology samples collected from the 46–60-year-olds in 2024-2025.* ***Note 1:*** *Blue box-and-whisker plots show the distribution of individual-level PFAS concentrations in the ARFFS/EVT cohort. Australian population data are based on pooled samples and are therefore shown as the average and estimated p95 only. For comparison of average concentrations, the average indicated by "+" in each blue box plot should be compared with the Australian population average (green bar). The box-and-whisker plots additionally illustrate the distribution of individual cohort concentrations.* ***Note 2;*** *y-axis is broken to fit the full range of PFAS concentrations.*

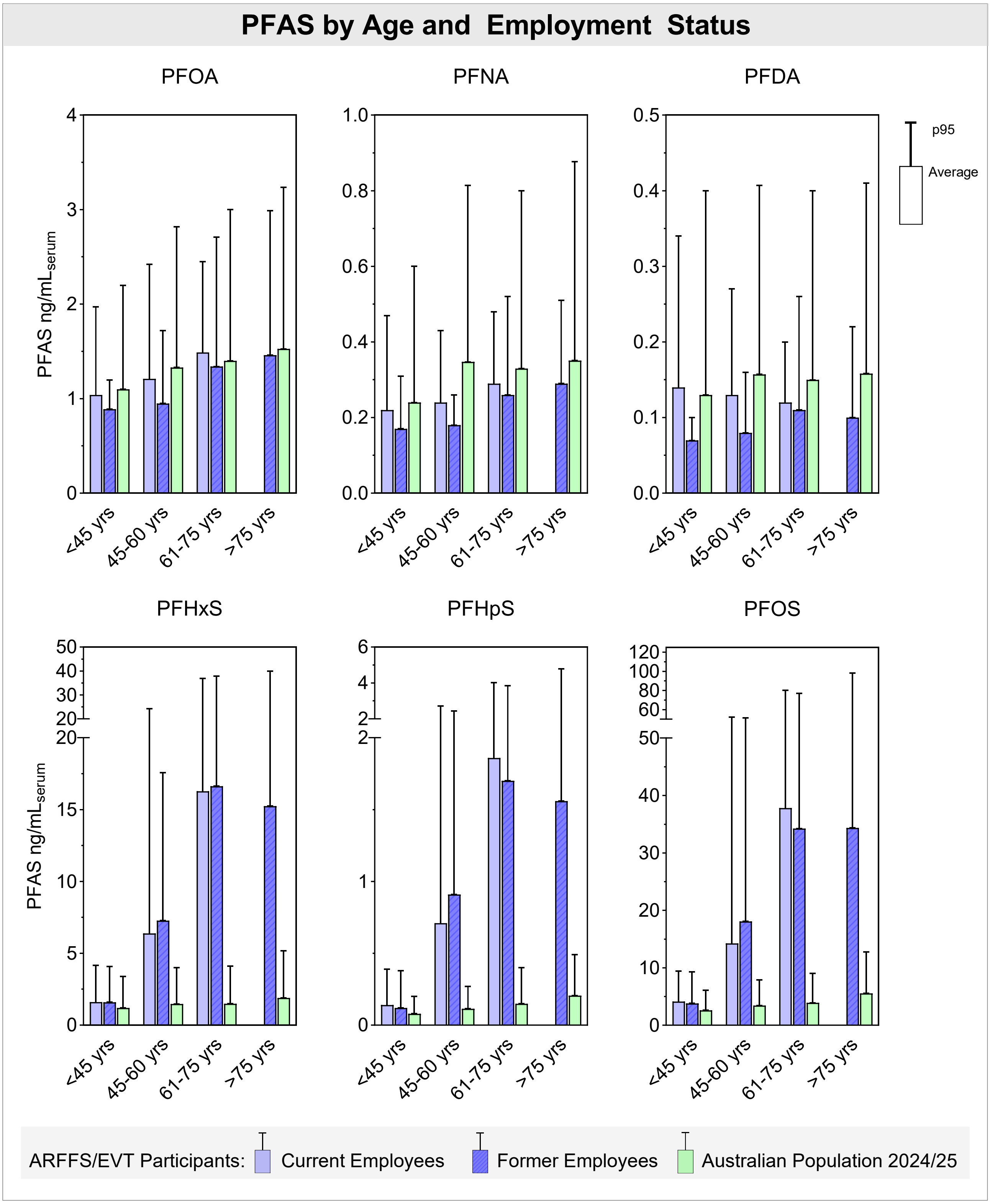

Figure 7 *Concentration of PFAS in serum of Airservices ARFFS/EVT participants by age group and employment status; current employees (light blue) and former employees (darker blue), and how these concentrations compare to the Australian population (green), estimated from pooled pathology samples collected in 2024-2025. Only PFASs detected in more than 15% of the participants are presented. Note the broken y axis for PFHxS, PFHpS and PFOS.*

3.3.2 PFAS Concentration in Blood Serum in Relation to Work History

From here on, the report focuses on PFOA, PFHxS, PFHpS and PFOS, as these were the dominant PFAS in both concentration and detection frequency.

Participants were grouped according to their work history to identify past exposure trends in the current study cohort. PFAS concentrations trends were assessed according to year of commencement and total number of years worked.

Both current and former employees were included in these assessments because serum PFAS concentrations reflect historical exposure and PFAS persistence in the body. Inclusion of former employees allowed assessment of a broader range of occupational histories, including individuals who commenced employment during earlier periods of PFAS use.

3.3.2.1 PFAS Concentration by Likely Foam Exposure

Airservices employees could have been exposed to PFAS from the 3M Light Water between approximately 1980 and 2005, and Ansulite between 2005 and 2010; since 2010 the PFAS-free Solberg RF6 has been used at all locations except Darwin and Townsville. These airports are operated jointly with the Royal Australian Air Force (RAAF) and the ARFF services agreement with Defence required the use of Ansulite to continue for a longer period. Darwin was transitioned to Solberg RF6 in 2019 and Townsville in 2020. Accordingly, participants were grouped according to likely foam exposure based on the foam in use at the time they commenced employment: pre-2005 starters were assigned to the “3M Light Water” group, 2005 - 2010 starters to the “Ansulite” group, and post-2010 starters to the “Solberg RF6” group. Individuals who joined after 2010 but stated that they worked at Darwin or Townsville during the period of ongoing Ansulite use were reassigned to the “Ansulite” group (**Appendix C, C-2-2**).

A total of 502 participants reported the year they commenced service for Airservices: a total of 348 (61%) participants commenced employment prior to 2005 while 3M Light Water was still in use. A total of 85 (15%) participants started employment with Airservices while Ansulite was in use, while 69 (12%) started employment with Airservices after the replacement of AFFFs. Of these, 204 reported that they have also worked for other employers where they may have come into contact with AFFF/PFAS, such as the RAAF[5](**Appendix C, C-2**).

Figure 8 shows the PFAS serum concentrations according to the foam participants may have been in contact with when they commenced working at Airservices, excluding the participants who confirmed that they had worked for other employees where they may have been exposed to AFFF/PFAS, to better show possible exposure at Airservices Stations. The same figure, including all study participants regardless of if they have worked elsewhere is shown in **Appendix C, Figure A-5**. Estimated means within each foam group, and the relative differences between these foam groups, when adjusting for age, blood donation and other employment are shown in **Appendix C, Table A-13**.

Similar to what was observed in Airservices Exposure Study II, no clear trend is observed for PFOA with the foam used at the year of commencement. Moreover, regardless of what foam was used when participants started working for Airservices, the PFOA concentrations were comparable to the Australian population. Participants who started working for Airservices while 3M Light Water was in use showed highest serum concentrations of PFOS, PFHxS and PFHpS and the concentrations of

[5] Confirmed other roles in either of the questionnaire questions 30, 31 and 36. Within the cohort of the 502 participants that confirmed the day they commenced service at Airservices, 204 reported working elsewhere. In the full study cohort (n=566), six additional participants (i.e. total of 210 participants, 37%) confirmed that had worked elsewhere.

these PFAS were elevated compared to the Australian population. Participants who started working after the replacement of 3M Light Water, but while Ansulite was still in use showed a higher average compared to those who started after Ansulite had been replaced by Solberg RF, however, neither of these two latter groups were elevated compared to the Australian population on a group level, indicating limited occupational exposure to those chemicals after the replacement of 3M Light Water. For participants who commenced employment after the introduction of Solberg RF6, mean PFAS concentrations were comparable to those observed in the Australian population, and fewer than 5% had concentrations above the estimated 95th percentile of the Australian population (**Appendix C, Table A-11**). These findings suggest limited ongoing occupational PFAS exposure beyond the levels expected from background exposure in everyday life in the Australian population. However, the small number of participants in the Solberg RF6 group (n=35) limits the precision and generalisability of these findings to the broader Airservices cohort.

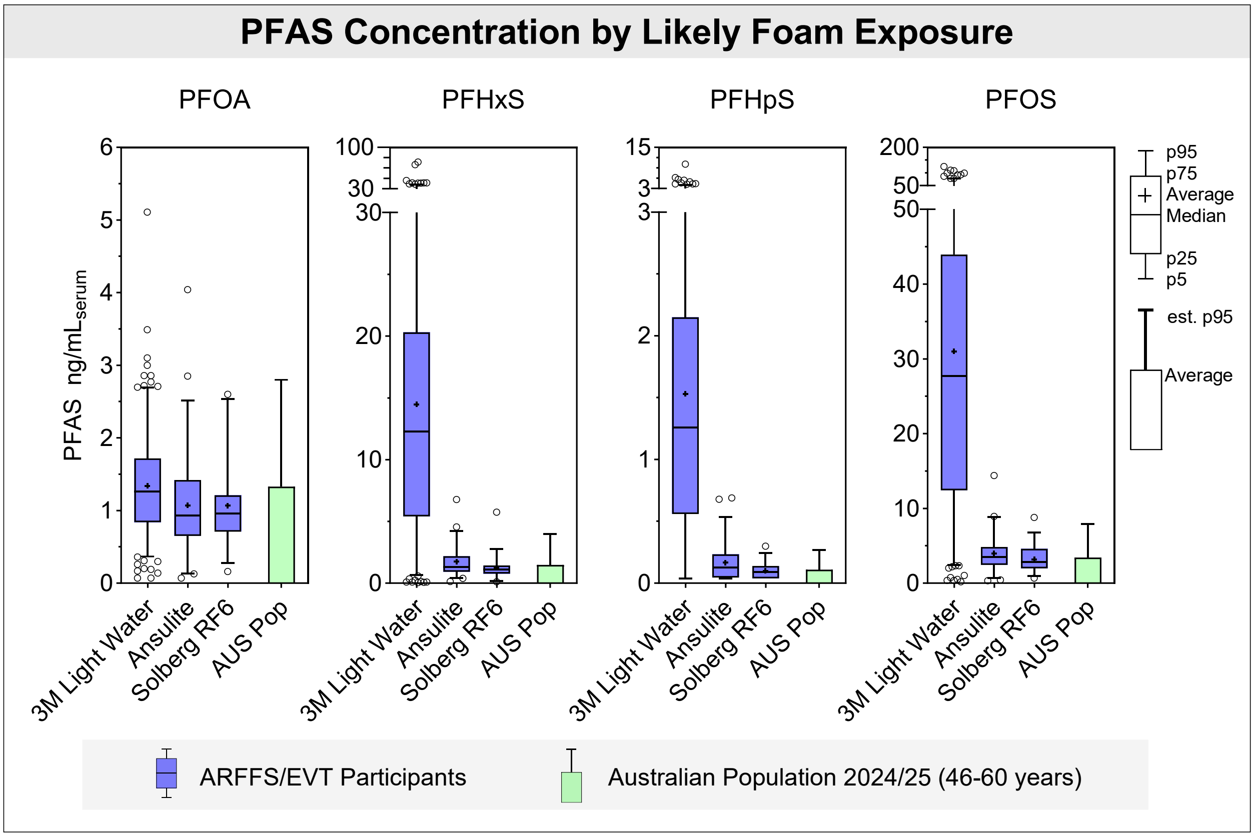

Figure 8 *PFAS concentrations grouped by category of what foam participants have likely been exposed to at Airservices; 3M Light Water (n=215), Ansulite (n=48) and Solberg RF6 (n=35), and how these concentrations compare to the Australian population (green), estimated from pooled pathology samples collected from 46-60-year-olds in 2024-2025. Only participants who did not report working for other employers where they may have been exposed to AFFF/PFAS are included. The same graph including all participants are shown in* ***Appendix C, Figure A-5****. Statistical outcomes are shown in* ***Appendix C, Table A-13. Note 1:*** *Blue box-and-whisker plots show the distribution of individual-level PFAS concentrations in the ARFFS/EVT cohort. Australian population data are based on pooled samples and are therefore shown as the average and estimated p95 only. For comparison of average concentrations, the average indicated by "+" in each blue box plot should be compared with the Australian population average (green bar). The box-and-whisker plots additionally illustrate the distribution of individual cohort concentrations.* ***Note 2;*** *y-axis is broken to fit the full range of PFAS concentrations.*

3.3.2.2 PFAS Concentrations Among Employees Commencing Service Post 2005

Compared with the Australian population, no clear elevation in serum PFAS concentrations was observed among participants who commenced service after 2005 **Figure 8**. However, this does not exclude low-level exposure accumulation in some participants over time. Therefore, the relationship between employment history and serum PFAS concentrations was assessed among participants who commenced service after 2005. The assessment was limited to participants who had confirmed their commencement date and duration of employment. Participants who had worked at Avalon during the 2020–2023 drinking water contamination period or had worked for other employers where they may have been exposed to AFFF/PFAS were excluded to minimise the influence of other known or potential exposure sources. In total, n=74 participants were included.

Multiple linear regression was conducted to assess the relationship between PFAS concentrations and duration of employment, adjusting for age and blood/plasma donation (**Appendix C, Table A-14**). Duration of employment was significantly positively associated with all PFAS. Mean PFHxS, PFHpS and PFOS concentrations were higher than the average concentrations measured in the Australian population among participants who had worked between 16-20 years. Participants who had worked less than 16 years were in the range of the PFAS serum concentrations observed in the Australian population.

To further explore the temporal structure of exposure, the relationship between PFAS concentration and year of commencement (after 2005) was also assessed using a separate regression model (**Appendix C, Table A-14**). Earlier commencement of service was associated with higher PFHxS, PFHpS and PFOS concentrations but not PFOA. This trend can also be observed in **Figure 9.**

Findings suggest that PFAS concentrations in blood vary according to employment history, with higher concentrations of PFHxS, PFHpS and PFOS observed among participants with longer employment durations and earlier commencement of service. Year of commencement and duration of employment were highly correlated, as employees who commenced employment earlier generally had longer employment histories, limiting the ability to reliably estimate their independent contributions. Given the long biological half-lives of PFAS, serum concentrations reflect cumulative historical exposure rather than current exposure alone. The higher concentrations observed among participants who commenced service earlier, closer to the transition away from 3M Light Water use, may be consistent with greater exposure opportunity during the early post-transition period from 3M Light Water to Ansulite. There were no comprehensive cleaning activities undertaken during this transition, meaning there existed a greater potential for exposure to residual PFOS, PFHpS and PFHxS closer to the time of the transition. This is in contrast to the transition from Ansulite to Solberg RF6 in 2010, when comprehensive cleaning of infrastructure and assets took place, possibly reducing the potential for exposure to residual PFAS[6].

This interpretation is supported by the findings in the Solberg RF6 group discussed above (section **3.3.2.1)**, where participants who commenced service after 2010 had PFAS concentrations comparable to those observed in the Australian population. This may indicate that the higher concentrations observed among earlier starters and those with longer duration of employment are

[6] Further, understanding of occupational PFAS exposure and associated exposure-control measures continued to develop following the transitions from AFFF. This evolving understanding, informed by the biomonitoring and risk assessments, contributed to ongoing improvements in exposure-control measures implemented after 2010.

more likely to reflect historical exposure and persistence of PFAS body burdens than ongoing occupational exposure.

It is important to note that current assessments cannot determine whether observed differences are attributable solely to historical exposure and persistence of PFAS body burdens or whether ongoing lower-level exposure sources may also contribute. Further, the cross-sectional design of this assessment limits causal inference; longitudinal assessments are required to better understand temporal changes in PFAS concentrations and the relative contribution of ongoing versus historical exposure sources.

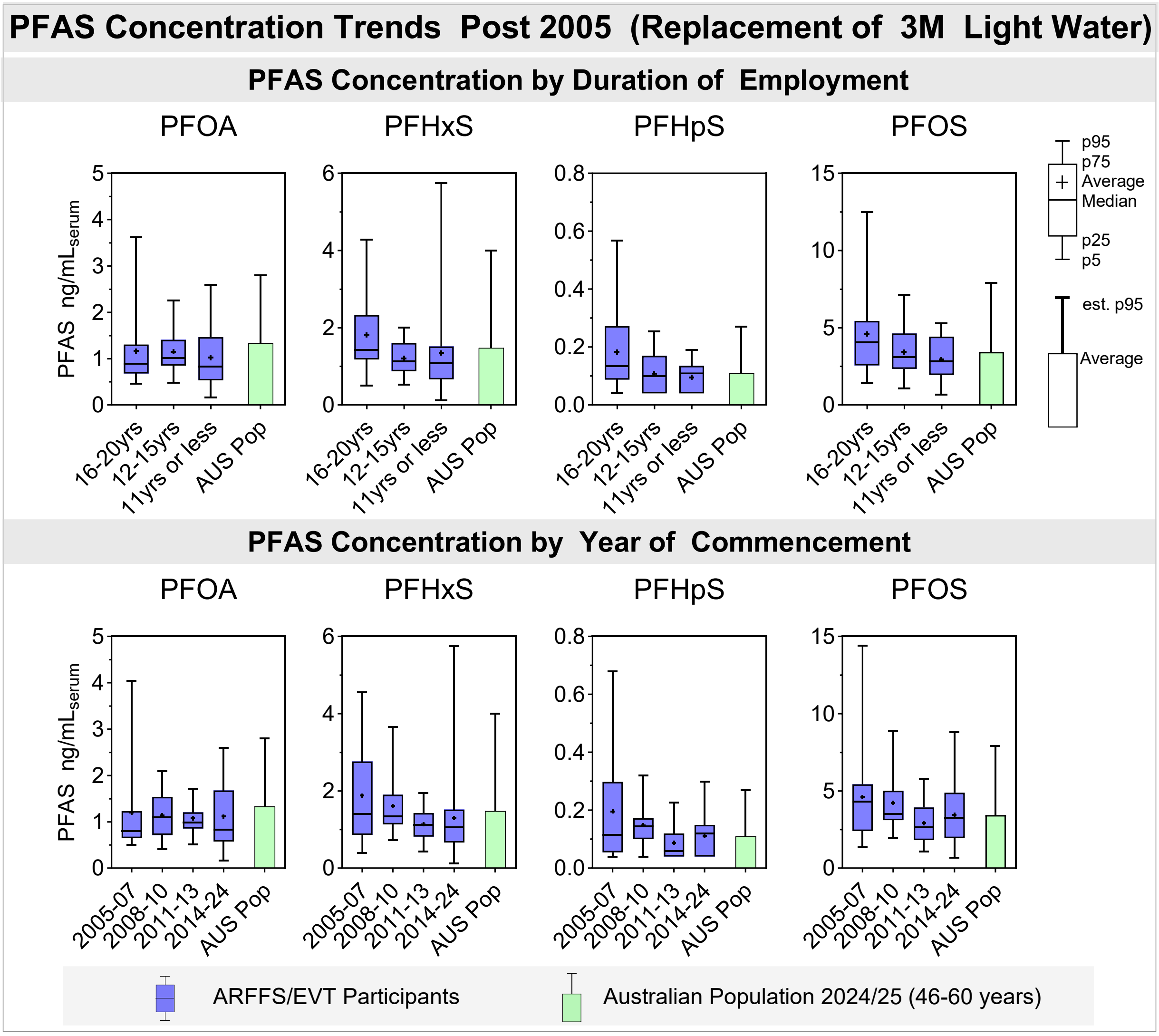

Figure 9 *PFAS concentrations grouped by duration of employment (top panel) or year of commencement (bottom panel) at Airservices and how these concentrations compare to the Australian population (green), estimated from pooled pathology samples collected from 46–60-year-olds in 2024-2025. Duration of employment is grouped according to; 11 years or less (n=17), 12-15 years (n=32), 16-20 years (n=26), Duration of employment is not tied to specific years, i.e. a person employed between 1-4 years may have been employed for this length of time at any time since 2005. Year commenced service is grouped according to; 2005-07 (n=14), 2008-10 (n=22), 2011-13 (n-21) and 2014-24 (n-17). Participants who reported working at Avalon station between 2020-2023 or for other employers where they may have been exposed to AFFF are not included.* ***Note:*** *Blue box-and-whisker plots show the distribution of individual-level PFAS concentrations in the ARFFS/EVT cohort. Australian population data are based on pooled samples and are therefore shown as the average and estimated p95 only. For comparison of average concentrations, the average indicated by "+" in each blue box plot should be compared with the Australian population average (green bar). The box-and-whisker plots additionally illustrate the distribution of individual cohort concentrations.*

3.4 Changes in PFAS Serum Concentrations: Temporal Trends

3.4.1 PFAS Concentrations in Comparison to Previous Study Cohorts

Figure 10 show serum PFAS concentrations measured across Airservices ARFFS/EVT participants in previous Airservices (2013/14, 2018/19) and NHMRC (2020-2025) studies and the current study (2025/26). The study cohorts at each sampling period include different individuals with some overlap. Interpretation of trends should consider recruitment bias in the NHMRC study towards individuals with known elevated PFAS concentrations, and potential participation bias in each follow-up study; participants with higher PFAS concentrations may be more likely to continue participating compared to individuals with lower PFAS concentrations who may be less concerned. Thus, for each follow-up the study cohort may be more disproportionately composed of individuals with higher PFAS levels.

Overall decreasing trends can be observed across the study cohorts. Compared with the 2018/19 study cohort, mean/median concentrations of PFOA in the current study were 24%/27% lower (1.7 vs 1.3 (mean) and 1.5 vs 1.1 ng/mL(median)). Mean concentrations of PFHxS, PFHpS and PFOS were also lower by 21%, 27% and 15%, respectively (14 vs 11 ng/mL (PFHxS), 1.5 vs 1.1 ng/mL (PFHpS) and 27 vs 23 ng/mL (PFOS)). Median PFHxS, PFHpS and PFOS concentrations remain the same (6.4 vs 6.4 ng/mL (PFHxS), 0.62 vs 0.65 ng/mL (PFHpS) and 14 vs 14 ng/mL (PFOS)).

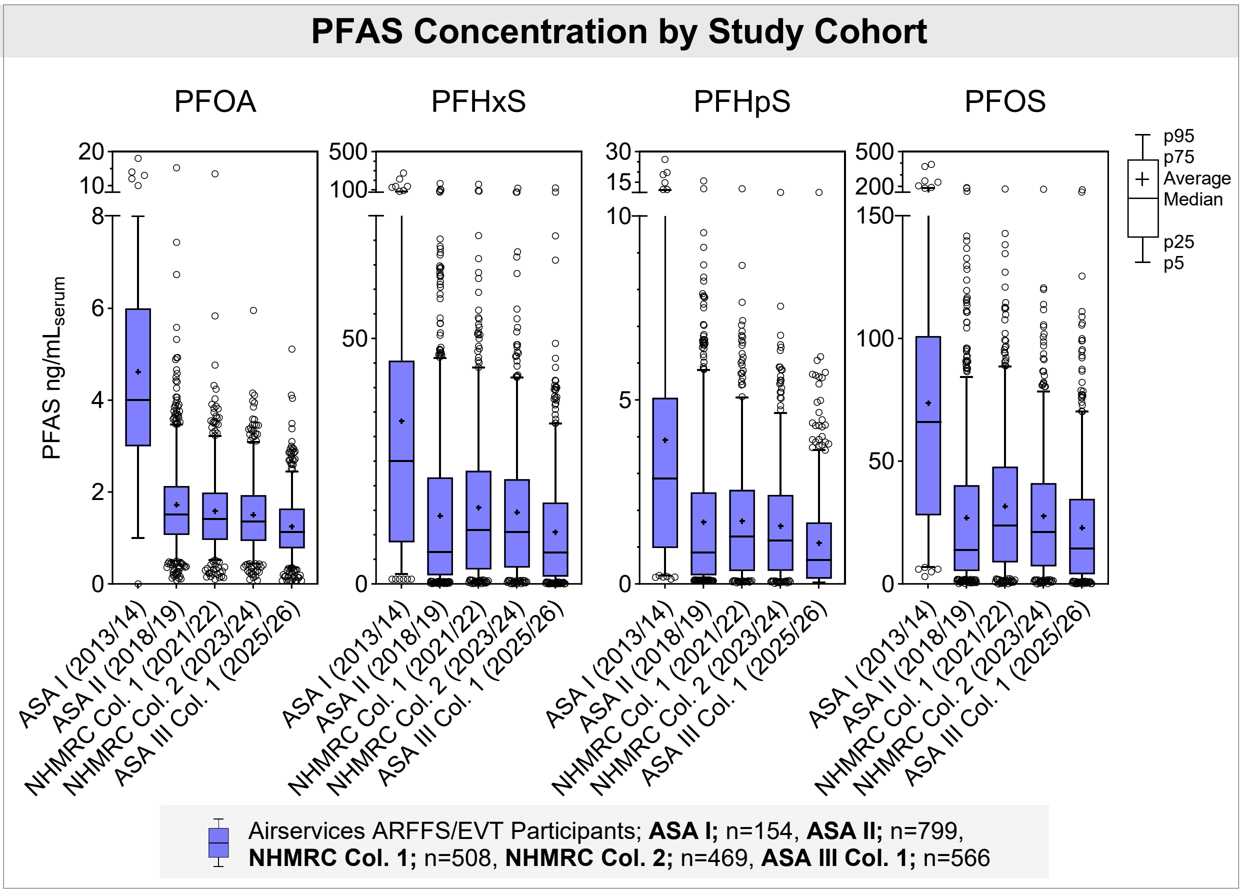

Figure 10 *Concentrations of PFOA, PFHxS, PFHpS and PFOS in previous and current study cohorts; 2013/14 Airservices Study (ASA I), 2018/19 Airservices Study (ASA II), the 2021/22 and 2023/24 collections as part of the NHMRC study, as well as the current 2025-2028 Airservices Study (ASA III, Collecton 1). The NHMRC Study only shows Airservices ARFFS/EVT participants.* ***Note;*** *y-axis is broken to fit the full range of PFAS concentrations.*

3.4.2 Change in PFAS Serum Concentrations Over Time in Participants with Repeat Measures

Among the 566 participants who provided a blood sample in the first collection round of the current study (2025/26), 514 (91%) have also provided a blood sample as part of any of the previous exposure studies (Airservices or NHMRC studies). This longitudinal sub cohort was used to determine the change in serum concentration over time.

As part of the 2018/19 Airservices Exposure Study, change in PFAS serum concentrations were calculated among participants providing blood samples for both the 2018/19 and the 2013/19 Airservices exposure studies (n=130). Between those years, all participants with elevated levels (i.e. those higher than the 95th percentile of the Australian population at the time) showed decreasing levels of PFAS, suggesting that occupational PFAS exposure had substantially reduced during that period. In this report, the focus is therefore on trends in serum PFAS concentrations since the 2018/19 study to determine whether there is evidence of recent occupational PFAS exposure among ARFFS/EVT employees. Trends were estimated using all available samples collected since 2018/19, including samples collected as part of the NHMRC and Avalon studies, and included 511 participants contributing between two and six samples (mean 3.7 samples). [7]

The initial analysis included all participants with longitudinal samples to describe overall changes in PFAS concentrations (section **3.4.2.1**). Subsequent analyses stratified participants by current employment status (section **3.4.2.2.1**) and station (section **3.4.2.2.2**) to determine whether changes in PFAS concentrations differed among groups with varying potential for ongoing occupational exposure.

3.4.2.1 Overall Temporal Trends Among All Participants

The overall temporal trend in the study cohort was calculated by fitting a regression line between PFAS serum concentration and the elapsed time across all sample collections for each participant. The slope was used to derive the annual change and half-life estimates. The annual change in PFHxS, PFHpS and PFOS all correlated relatively strongly (Pearsons r coefficient 0.69-0.78). Annual change in PFOA concentrations also correlated strongly to PFOS (Pearsons r coefficient 0.73), and moderately to PFHxS and PFHpS (0.66 and 0.51 respectively) (**Appendix C, Table A-16**). These correlations suggest that the change of these four PFAS generally showed similar temporal direction within each participant. Similar to what has been observed in previous studies, participants who were blood/plasma donors decreased at a faster rate compared to those who were not blood donors (**Appendix C, Table A-15**).

Each participant's annual percent change, in relation to their PFAS concentration in serum is shown in **Figure 11.** Most participants showed a decrease in PFAS concentration over time. Participants who increased were typically those with low serum PFAS concentrations similar to those concentrations observed in the Australian population. Thus, increases in PFAS concentration may reflect background exposure experienced by the Australian population in the everyday life, as opposed to occupational exposure. In addition, the variability in PFAS trends observed across participants may reflect interindividual differences in PFAS elimination. If widespread ongoing occupational exposure were occurring, a more consistent trend of increasing or stable PFAS serum concentrations would be expected across participants who are currently employed.

[7] The overall longitudinal analyses included all available samples, including those collected as part of the Avalon Exposure Study. As this study involved participants with known PFAS exposure through contaminated drinking water, analyses were repeated excluding these samples. When excluding participants who worked at Avalon and/or participated in the Avalon study comparable estimates were produced, indicating that inclusion of these participants did not materially influence the overall findings in the study cohort. Station-specific and sensitivity analyses excluding participants who worked at Avalon are presented in separate sections.

Among all participants, there was an overall average decrease of 5.4%/yr (PFOA), 5.8%/yr (PFHxS), 7.5%/yr (PFHpS) and 6.1%/yr (PFOS). This average decrease corresponds with an apparent population half-life of 12.5 years (PFOA), 11.7 years (PFHxS), 8.9 years (PFHpS) and 10.9 years (PFOS) (**Appendix C, Table A-15**). These estimates are derived from longitudinal repeated measurements within the ARFFS/EVT cohort between 2018/19 and 2024/25 and therefore represent the rate of decline observed within this population.

Longitudinal PFAS measurements are not available for the Australian population. However, analysis of cross-sectionally collected pooled serum samples from the Australian population between 2018/19 and 2024/25 indicates declining PFAS concentrations over time at the Australian population level. Within the 46-60-year age group, estimated apparent half-lives were 10.9 years for PFOA, 9.3 years for PFHxS, 4.8 years for PFHpS and 6.6 years for PFOS. Among the >60-year age group, estimated apparent half-lives were 8.0 years for PFOA, 14.1 years for PFHxS, 7.2 years for PFHpS and 9.1 years for PFOS (**Appendix A, Table A-2**).

While serum PFHxS concentrations are decreasing in a similar rate to that observed in the Australian population, other PFAS appear to be decreasing more slowly. However, direct comparison between the ARFFS/EVT study cohort and the Australian population data should be interpreted with caution due to fundamental differences in study design and population structure. The trends observed in ARFFS/EVT participants are based on longitudinal data, meaning the same individuals are repeatedly measured over time. As a result, the cohort also ages during the study period, and aging can influence how PFAS levels change. In contrast, estimates from the Australian population are derived from cross-sectional measures within age groups (e.g. 46–60 and >60 years), where different individuals contribute samples at each time point. Therefore, observed trends represent changes in PFAS concentrations between population samples over time and may be influenced by differences in the characteristics of individuals sampled at each time point. These estimates do not represent individual-level elimination trajectories and do not capture age-related changes occurring within the same individuals over time.

The half-lives estimated in the 2018/19 Airservices Exposure Study in the longitudinal cohort who participated in both the 2013/14 and 2018/19 Exposure studies were 5.2 years (PFOA), 8.7 years (PFHxS), 8.6 years (PFHpS), 6.7 years (PFOS) on average. These are individual half-lives, calculated among only those who showed decreasing concentrations (n=119-130). This is because half-life is a rate of decrease/elimination, so if an individual is not decreasing in concentration, individual half-life cannot be defined. In the current cohort, individual half-lives, calculated in the same way between 2018/19 and 2024/25, were longer; 10.4 years (PFOA), 11.7 years PFHxS, 8.8 years (PFHpS), and 9.9 years (PFOS) (**Appendix C, Table A-17**).

Longer half-lives (reduced rates of decline) were observed between 2018/19 to 2025/26 in comparison to the 2013/14- 2018/19 period. Several biological, analytical factors and/or ongoing exposure could have contributed to these slower estimated elimination rates in more recent years. For example, for individuals whose PFAS concentrations are not substantially elevated compared with the Australian population, estimated individual half-lives may be influenced by ongoing low-level background exposure. This is likely the situation for PFOA, where >95% of participants show comparable PFOA concentrations to those observed in the Australian population [18, 24]. In addition, age-related changes may influence elimination kinetics, with slower clearance reported among older individuals. The rate of PFAS elimination may also decrease over time [24].

The observed differences may also reflect PFAS-specific elimination characteristics. This is particularly relevant for PFOS. PFOS consists of multiple isomers, all with different elimination rates. As time goes by, the proportion of slower eliminating isomers increases and thus resulting in a slower decline in PFOS concentration over time [18]. The PFOS isomer profile among ARFFS/EVT participants exposed to 3M Light Water, which contains a mixture of PFOS isomers, may also differ from that of the general Australian population, potentially also contributing to the observed differences in PFOS temporal trends between ARFFS/EVT participants and the Australian population. Additionally, as discussed in **Appendix A, A-2-2,** greater analytical uncertainty and the observed potential bias associated with PFOS measurements due to differences in isomer composition may also contribute to the observed differences. These will be investigated further, as additional analyses become available, and reported in future reports.

It is also important to consider differences in analytical approaches between assessments. In the previous assessment (2018/19 Airservices Exposure Study), all longitudinal serum samples were analysed concurrently, minimising potential analytical variation between batches. In the current assessment, serum PFAS measurements were generated from analyses conducted at different time points over approximately six years, which may introduce additional batch-to-batch analytical variation and contribute to uncertainty in estimated individual trends.

Similar to the half-lives reported in the 2018/19 Airservices Exposure Study, the individual half-lives are widely different between individual participants (**Appendix C, Figure A-6**). In the final Airservices report (2028), a more comprehensive evaluation and assessment of individual half-lives will be conducted, including assessment of what influences these half-lives, such as demographic/biological (e.g. associations with age, health), temporal (i.e. if the half-life changes over time), lifestyle (e.g. blood/plasma donations, diet) and occupational factors.

For the purpose of this report, focus is on each individual's annual change in PFAS concentrations in serum over time, to not only assess rate of elimination/decrease, but also capture increasing and no-change trends. This provides a more directly interpretable measure of longitudinal PFAS trends across all individuals.

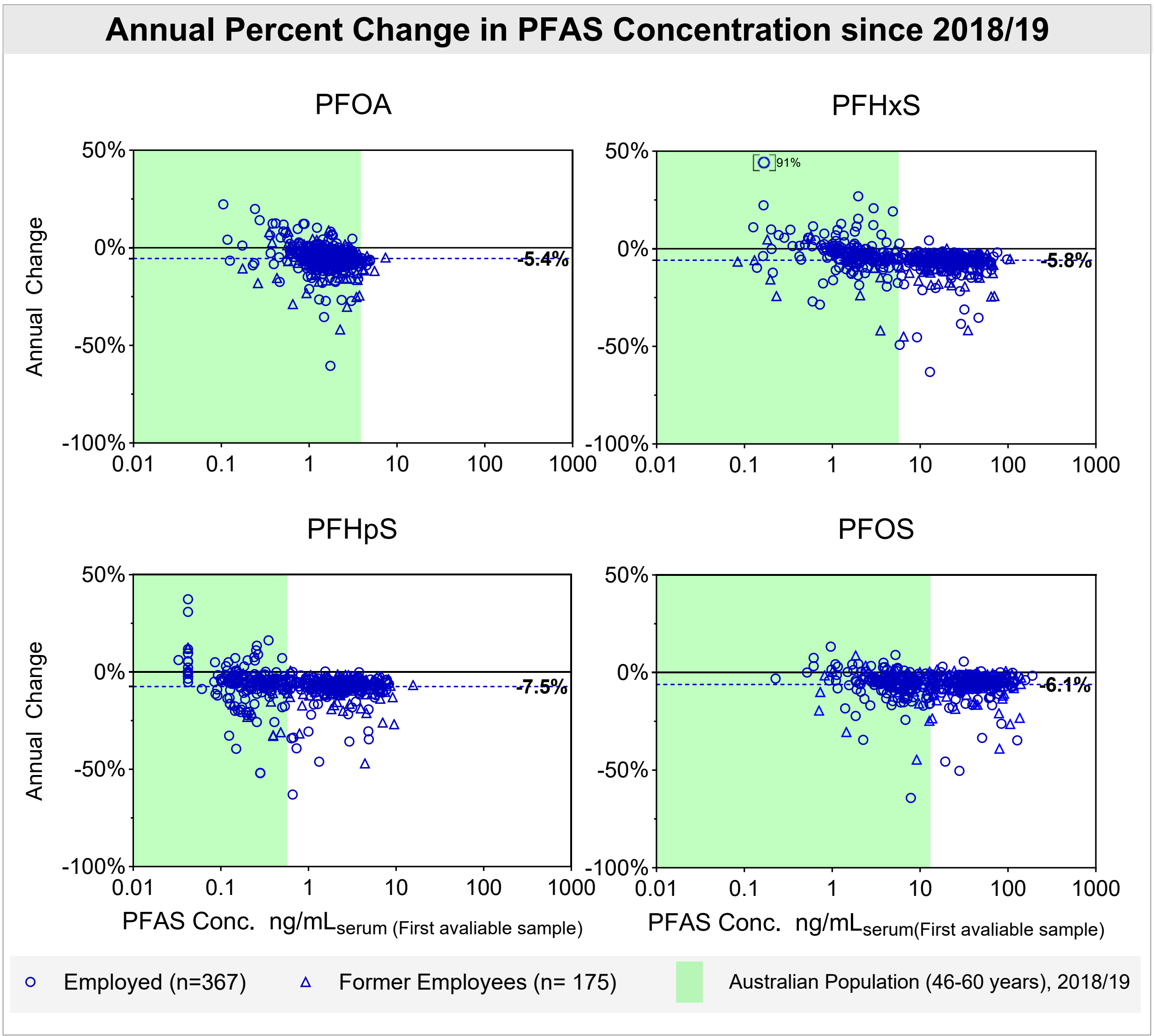

***Figure 11** Annual percent change in concentration since 2018/19 plotted against the PFAS concentration measured in their first available sample in the time trend assessed (i.e. in either 2018/19 Airservices exposure Study or any collections since, including NHMRC or Avalon study collections) among study participants. Circles represent participants who were employed at Airservices at some point during the time assessed. Triangles represent former employees that did not work at Airservices during the time assessed. The blue dotted line represents the average annual change among all participants. The shaded green area represents the concentration that is expected in the Australian population; up to the estimated 95th percentile, estimated from pooled pathology samples collected from 46-60-year-olds from 2018-2019. **Note:** The x-axis uses an exponential scale, with each major step representing a tenfold increase (i.e., 10 times the previous value).*

***How to read Figure 11**: Each blue dot represents one participant; The further to the right a point is, the higher that participant's PFAS concentration was at the start of the assessment period. Points below the horizontal line indicate PFAS concentrations decreased over time, while points above the line indicate concentrations increased. The green shaded area shows the range of PFAS concentrations expected in the Australian population (up to the estimated 95th percentile). The blue dashed line shows the average annual change across all participants, with values below zero indicating an overall decline in PFAS concentrations since 2018/19. Most participants with PFAS concentrations above the Australian population range experienced decreasing concentrations, indicating that elevated PFAS levels have generally continued to decline since 2018/19.*

3.4.2.2 Temporal Trends by Work Status

To assess potential ongoing occupational exposure among Airservices employees, linear mixed models were used to estimate changes in PFAS concentrations over time and determine whether temporal trends differed between current and former employees (Section **3.4.2.2.1**), as well as between stations (Section **3.4.2.2.2**). There were insufficient numbers of participants who had worked across different positions to assess whether PFAS trends differed by job role. Models accounted for repeated PFAS measurements collected from the same participant at multiple time points during the assessment period and were adjusted for baseline PFAS concentration category (elevated vs background), age, and blood donation status. This approach enabled estimation of PFAS trends over time while accounting for individual-level variability and allowed adjusted comparisons between the groups assessed.

3.4.2.2.1 Change in PFAS Serum Concentrations by Employment Status

Two models were applied to assess whether temporal changes in PFAS concentrations differed between employed and former employees. The primary model excluded participants who reported working at Avalon station between 2020 and 2023 (n=14) because of known PFAS exposure through contaminated drinking water during this period. This model is presented in the main results. A secondary model, which included all participants, is presented in **Appendix C, C-5-4**. Inclusion of the Avalon participants resulted in slightly slower overall declines in PFAS concentrations but did not change the overall conclusions.

Figure 12 shows the PFAS concentration trends generated from the model to show the trajectory over time in PFAS serum concentration for current and former employees, stratified by blood/plasma donation status among those who had elevated PFAS concentrations at their first sample (Elevated group, **Figure 12 a-c**) and among those who did have similar concentrations to the Australian population (Background group, **Figure 12 d-e**).

There was no statistically significant difference in the rates of decline in PFAS concentration between participants who have been employed during the 2018/19 - 2025/26 time-period and former employees, when adjusting for age, blood donation and initial PFAS concentration (**Appendix C, Table A-19)**. Overall, PFAS levels in blood donors decreased significantly faster compared to non-blood donors (up to 3 times faster). The PFAS levels in participants with elevated PFAS concentrations decreased faster than those with background concentrations. This trend reached statistical significancy for PFHxS (1.8 times faster) and PFHpS (1.3 times faster) (Initial PFAS concentration was not included as a grouping variable for PFOA because fewer than 5% of participants had elevated initial PFOA concentrations).

No statistically significant differences in PFAS trajectories between employees and former employees was identified. This suggests that there was minimal ongoing occupational exposure among workers, beyond exposure experienced outside of work during the study period. Although not statistically significant, current employees consistently demonstrated slightly slower declines in PFAS concentrations than former employees across all PFAS compounds **(Appendix C, Table A-19)**. However, the magnitude of these differences was small, generally approximately 1 percentage point per year or less, indicating that employment status had limited influence on the overall rate of PFAS decline during the study period. However, substantial inter-individual variability in PFAS concentration trajectories likely reduced the statistical power to detect small differences in temporal trends between employment groups. Continued longitudinal monitoring of PFAS concentrations among current employees remains important to confirm whether these patterns persist over time and to identify any potential changes associated with ongoing occupational activities.

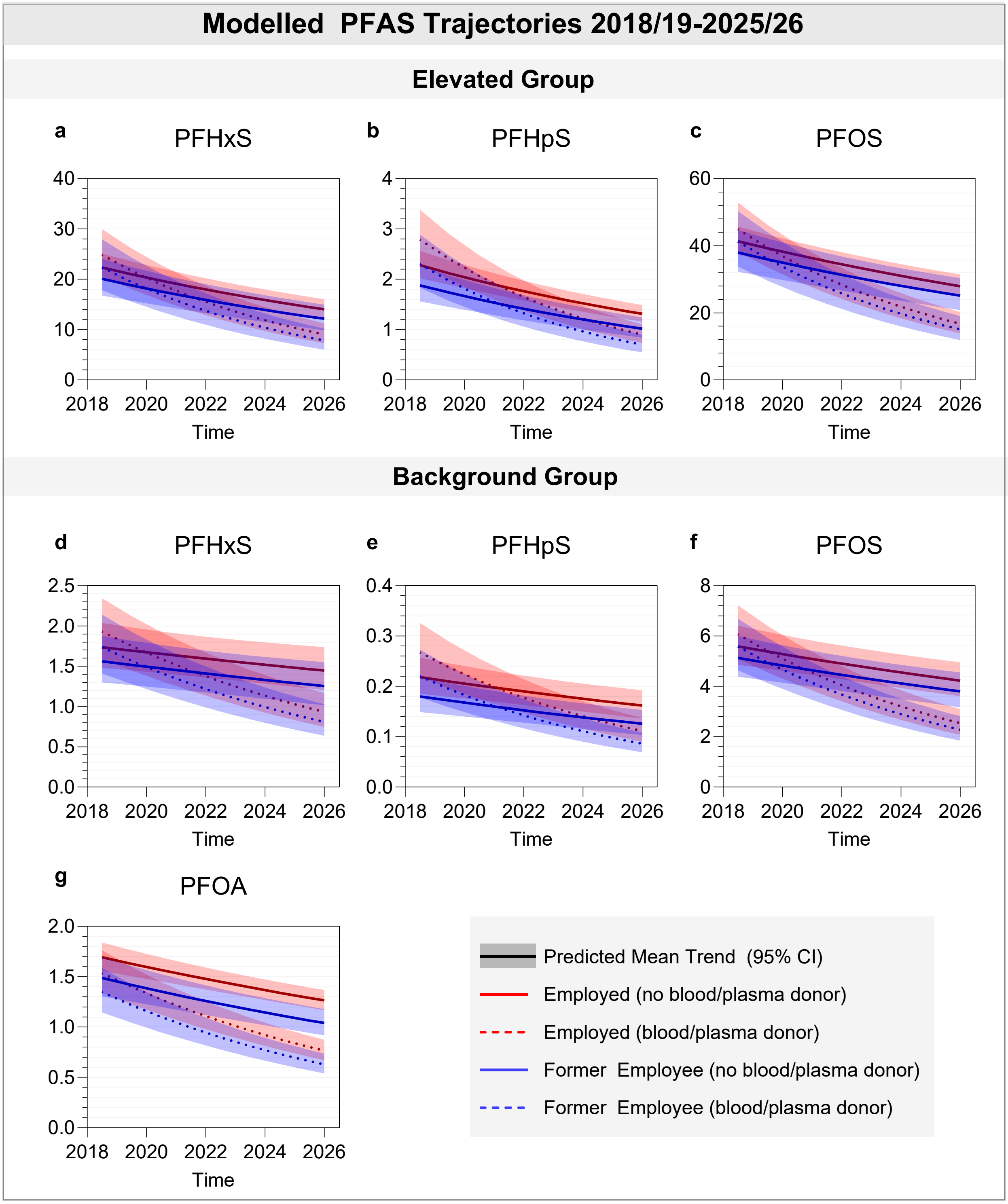

Figure 12 *Serum PFAS concentration trajectories over the 2018/19 and 2025/26 period for those who worked at some point during the time assessed (Employed, red) and former employees (blue) separated by blood/plasma donation status (dashed line represent donors) among those who had elevated PFAS concentrations (Elevated group, Figures a-c) and comparable concentrations to the Australian population (Background group, Figures d-e) at their first sample. The modelled trend represents the predicted trend based on a mixed-effects linear model accounting for repeated measurements within individuals, while adjusting for age. Participants who reported working at Avalon station during the 2020-2023 period were not included in this model.*

3.4.2.2.2 Change in PFAS Serum Concentrations by Station

Station specific annual changes over time were investigated to assess if there are any stations that may experience ongoing exposure, adjusting for baseline PFAS concentration (elevated vs background), age and blood donation. The assessment was limited to participants who had identified in their questionnaire both the station(s) they had worked at and corresponding year of working at the station, as well as had provided information about blood donation. Only stations with a minimum of six participants were assessed to ensure sufficient sample size for meaningful comparisons, as well as safeguard the confidentiality of participants. Participants who had worked at more than one station during this time period were grouped according to their most recent station.

A total of nine Airservices fire stations could be represented by at least six ARFFS/EVT participants: Adelaide (ADL), Avalon (AVV), Brisbane (BNE), Cairns (CNS), Coolangatta (OOL), Melbourne (MEL), Perth (PER), Sydney (SYD), and Townsville (TSV). Stations with less than six individuals were grouped together according to region. These included: Northern Territory Stations (NT; Darwin, Alice Springs and Ayers Rock), Queensland Stations (QLD; Mackay, Rockhampton, Sunshine Coast, Hamilton Island), Tasmania (TAS; Hobart and Launceston), and Western Australia Stations (WA; Broome, Karratha, Newman and Port Headland). Remaining New South Wales Stations (Ballina and Coffs Harbour) did not have enough participants to be shown. Out of the 149 participants who were grouped, approximately 27% had worked at more than one station during the time period assessed. **Figure 13 and Appendix C, Table A-22** show the estimated annual change at each station**.** Overall, PFAS concentrations declined across most stations, with no statistically significant differences in PFAS trajectories observed between stations, suggesting broadly similar temporal trends across stations. Exceptions included Townsville (TSV), where PFOA concentrations did not appear to decline over the study period, and Avalon (AVV), where PFHxS and PFHpS showed increasing trends.

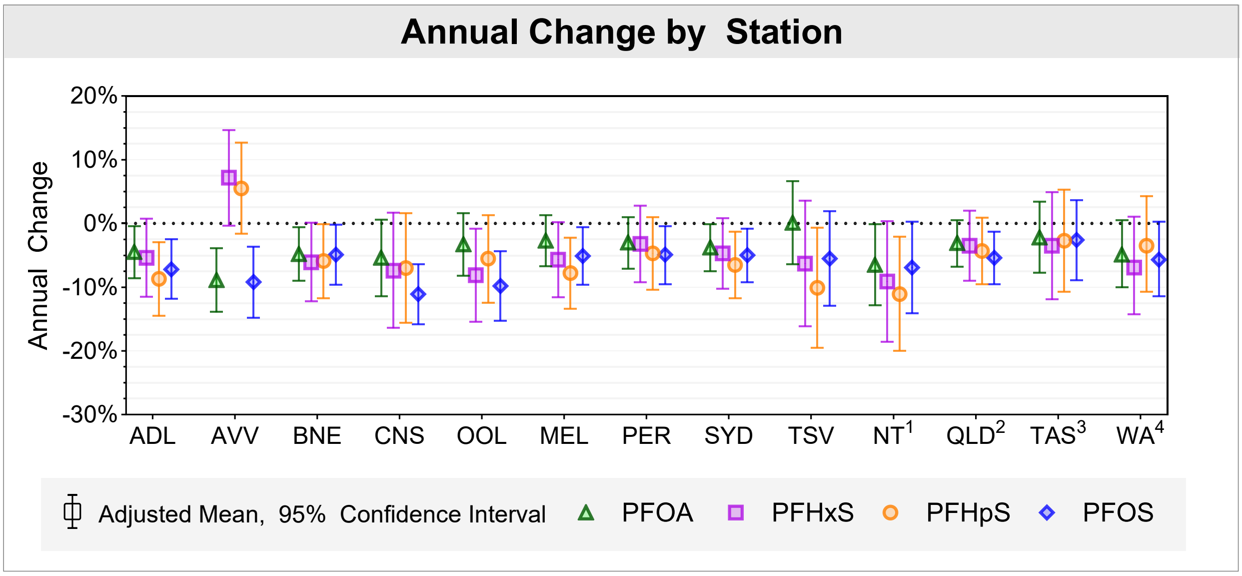

***Figure 13** show the estimated annual change (mean, 95% confidence interval) in PFOA (green), PFHxS (purple), PFHpS (orange) and PFOS (Blue) serum concentration according to station; Adelaide (ADL, n=13), Avalon (AVV, n=11), Brisbane (BNE, n=13), Cairns (CNS, n=8), Coolangatta (OOL, n=10), Melbourne (MEL, n=15), Perth (PER, n=16), Sydney (SYD, n=17), Townsville (TSV, n=6), NT (n=8), QLD (n=16), TAS (n=8), WA (n=8). [1-4.] Stations with less than 6 participants were grouped together according to state; NT: Darwin, Alice Springs and Ayers Rock; QLD: Mackay, Rockhampton, Sunshine Coast, Hamilton Island; TAS: Hobart and Launceston; WA: Broome, Karratha, Newman and Port Headland. The mean is based on a mixed linear effects model, adjusted for baseline PFAS concentration (elevated, background), age, and blood donation.*

The apparent no change in PFOA concentration at Townsville may be explained by longer historical use of Ansulite AFFF at this location, which continued until 2020. Given the longer duration of potential exposure to legacy AFFF products, slower PFOA decline at Townsville may reflect differences in historical exposure profiles rather than ongoing occupational exposure during the study period. However, as station-specific changes were not statistically different from each other, these findings should be interpreted cautiously. Continued monitoring will be important to determine whether the observed differences persist over time.

The exposure trend at Avalon station was further assessed by graphing all sample measurements since 2018/19 for all participants who reported working at Avalon at some point since (n=14, **Figure 14**). The increase in PFAS observed in the station specific exposure assessment above (**Figure 13**) captures an exposure event where staff were exposed to contaminated mains water, which was discovered in October 2022. Although all the four PFAS were found to have increased due to this contamination, PFHxS had the greatest proportional increase among exposed participants (**Figure 3 and Figure 14**). Since the discovery and subsequent exposure control measures, further blood tests as part of the Avalon study and the current study showed that all PFAS are decreasing among all participants. However, the current PFAS serum concentrations (particularly PFHpS and PFHxS) are still higher than the pre-contamination blood tests (**Figure 14**).

The elimination rate of PFHxS and PFHpS from the body, have previously been reported to be slower compared to PFOS and PFOA. Thus, without any ongoing exposure, PFHxS and PFHpS serum concentrations are expected to continue to decrease, albeit at a slower rate compared to PFOS and PFOA [24]. This explains the apparent increasing trend in PFAS concentration at Avalon station shown in **Figure 13** .

It is important to note that most participants at Avalon station are regular blood donors (≈70%), which complicates interpretation of the data. Because blood/plasma donation accelerates PFAS elimination, any potential ongoing exposure may be partially masked by the increased rate of elimination associated with blood/plasma donation. Although recent declining PFAS concentrations were also observed among non-donors, these findings are based on relatively few individuals. Consequently, while suggestive, the available data by itself cannot be taken as definitive evidence that all occupational exposure has ceased. Ongoing follow-up blood testing is therefore important to confirm that PFAS concentrations continue to decline over time and to identify any indication of continuing exposure.

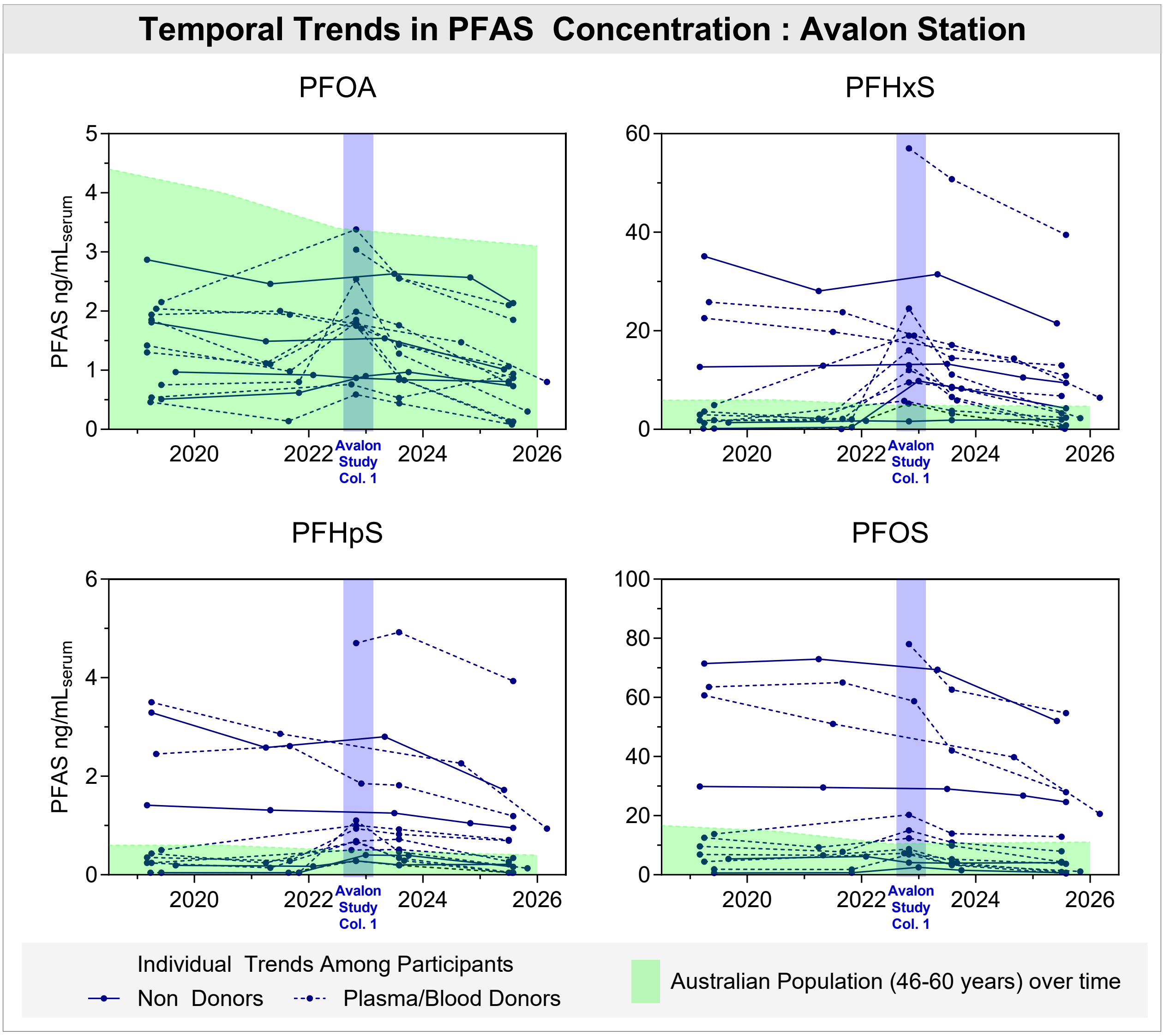

Figure 14 *Temporal trends of serum PFAS concentrations across all sample points since the 2018/19 Airservices Exposure Study II among participants who reported working at Avalon Staton at some point during this time-period. The shaded green area represents the concentration that is expected in the Australian population; up to the estimated 95th percentile, estimated from pooled pathology samples collected from the 46-60-year-olds at comparable time points. The timepoint of the first blood collection as part of the Avalon Study is highlighted blue.*

4. Limitations

The findings should be interpreted in consideration of the following limitations and uncertainties:

- Comparison population: Comparisons with the Australian population should be interpreted with caution because the population estimates are based on cross-sectionally collected pooled surplus pathology serum samples, which may differ from the general population in terms of health and other characteristics. Samples were collected from different individuals at different time points. Consequently, observed changes in the Australian population over time may reflect differences in the people sampled at each time point, including differences in age and other characteristics, rather than true changes in PFAS concentrations within individuals. Results from participants in this study are based on individual samples, including repeated measurements from the same individuals over time. The different study designs limits direct comparison of cross-sectional and temporal trends between the Australian population and the Airservices cohort.

- Participation bias: Participation was voluntary, and participants with greater concern about PFAS exposure (e.g. due to higher PFAS concentrations and/or slower previous reduction in PFAS concentration) may have been more likely to participate. This may result in PFAS concentrations being higher and having a different temporal trend in comparison to previous study rounds, as well as in comparison to those in the broader Airservices workforce. Furthermore, the study cohort was older than the current Airservices workforce. Although analyses are adjusted for age where appropriate, differences in age and other participant characteristics may influence comparisons with the wider workforce.
- Small subgroup sample sizes: Some analyses, particularly those involving post-2010 starters and individual stations, included relatively small numbers of participants. Smaller sample sizes reduce statistical power, meaning that real differences between groups may be more difficult to detect. They also result in less precise estimates and limit the generalisability of subgroup findings.
- Blood/plasma donation: Blood/plasma donation accelerates PFAS elimination. A large proportion of participants in some subgroups (e.g., Avalon station) were blood or plasma donors, which may mask evidence of ongoing exposure by increasing the rate of PFAS elimination.
- Longitudinal assessment: Large differences in PFAS concentrations and rates of change between individuals limit the ability to detect small changes or differences between groups.
- Causal inference: PFAS concentrations can also be affected by previous exposure, environmental and lifestyle factors, and differences between individuals. Therefore, the findings show associations rather than proof of cause and effect.
- Analytical uncertainty:
    - Longitudinal assessment**:** Longitudinal analyses included measurements collected across different studies and analytical periods. Differences in analytical batches may contribute to variability in measured concentrations and estimates of temporal change.
    - PFOS measurements: Interlaboratory comparison found greater variation in PFOS measurements compared with other PFAS, with QAEHS generally reporting higher concentrations, particularly in samples with elevated PFOS. Preliminary investigations suggest this may be related to differences in analytical methods and PFOS isomer composition. This introduces the possibility that PFOS concentrations in this report may be biased towards higher concentrations and slower apparent rates of decrease. QAEHS is investigating and refining the analytical method, and if warranted, updated PFOS results will be provided in future reports. However, these analytical uncertainties are not expected to change the overall conclusions of the current report.

Taken together, these uncertainties mean that the findings presented in this report provide evidence regarding patterns of PFAS concentrations and temporal change within the Airservices cohort but cannot definitively determine the extent to which current occupational exposure contributes to serum PFAS concentrations. Continued monitoring of current employees, particularly those who commenced employment after 3M Light Water was replaced, will be important for determining whether PFAS concentrations remain stable or increase over time in individuals without a history of exposure to 3M Light Water. Continued longitudinal monitoring and targeted exposure assessment will help address these uncertainties.

5. Summary of Findings

Overall Cross-sectional trends

- Employees who commenced service prior to 2005 when 3M Light Water was in use continue to have higher PFHxS, PFHpS and PFOS concentrations compared to both the Australian population and to those who commenced service at a later date.
- Those who commenced service after the replacement of 3M Light Water generally show concentrations comparable to the Australian population. However, longer duration of employment and earlier commencement rate was associated with higher PFAS concentrations, consistent with cumulative historical exposure. This is likely due to greater exposure opportunities among those who commenced closer to the transition from 3M Light Water to Ansulite. Concentrations among those who commenced while Solberg RF6 was in use were comparable to the Australian population, supporting this interpretation.
- Approximately half of the participants reported that they had been impacted due to the possible or actual occupational exposure to PFAS, most commonly citing physical health effects and mental health impacts such as anxiety and stress.

Overall temporal trends

- PFAS serum concentrations among ARFFS/EVT participants continue to decline from 2018/19 to 2025/26.
- The rate of decline is slower than that observed between 2013/14 and 2018/19.
- Declining rates are broadly consistent with those observed in the Australian population for PFHxS while PFOA, PFHpS and PFOS show a comparatively slower decline.
- The slower rate of decline for PFOS is likely influenced by isomer-specific elimination kinetics.

Occupational exposure assessment

- No statistically significant differences in PFAS temporal trends between current and former employees.
- No evidence of widespread ongoing or new occupational exposure during the period assessed.

Station level exposure assessment

- No consistent evidence of ongoing exposure across most stations.
- Avalon remains the only site with a clearly identifiable exposure event, consistent with contaminated mains water in 2022, followed by declining concentrations after implementation of controls.
- Apparent differences between stations are limited by sample size, workforce mobility, and historical assignment uncertainty.

Overall interpretation

- Historical occupational exposure remains the primary driver of elevated PFAS concentrations.
- Current findings do not indicate widespread or station specific elevated occupational exposure to PFAS by Airservices ARFFS/EVT employees.

Implications

Continued longitudinal monitoring is required to:

- Refine elimination estimates,
- Improve statistical power for subgroup analyses,
- Confirm persistence of declining trends,
- Detect any new emerging exposure sources

6. Conclusion

The first sample-collection round (March 2025–April 2026) of the 2025-2028 Airservices Exposure Study has enrolled 580 participants to date, with 566 included in this report. Each participant completed a questionnaire covering work history and lifestyle factors and provided a serum sample analysed for health biomarkers and a suite of PFAS. Assessments involving health biomarkers will be undertaken at the end of the study (2028); the current report focuses solely on PFAS trends. With reference to the study aims, the findings of this are:

- Assess whether PFAS serum concentrations are changing among ARFFS participants differently from the general population

Approximately 90% of participants had taken part in previous Airservices or NHMRC exposure studies, enabling robust temporal analysis. Overall, PFAS serum concentrations continue to decline among participants. The rate of decline over the past 6–7 years (2018/19–2025/26) is slower than that observed between 2013/14 and 2018/19, but remains broadly consistent with national trends for PFHxS, while PFOA, PFHpS and PFOS appears to decline at a slower rate. The slower decline in PFOS appears to be influenced by an increasing proportion of slower-eliminating isomers.

No statistically significant differences in longitudinal PFAS trends were observed between current and former employees, indicating no clear evidence of ongoing or new occupational exposure at a study population level during the assessment period.

- Assess whether work-related factors are associated with PFAS trends

Consistent with previous Airservices studies, participants who commenced employment prior to 2005 (during the period when 3M Light Water was in use) continue to show higher concentrations of PFHxS, PFHpS, and PFOS. Participants who joined after 2005 generally exhibit concentrations similar to the Australian population; however, longer employment duration is associated with higher PFAS concentrations, likely reflecting greater exposure intensity around the time of the AFFF transition.

Station-level assessments did not identify consistent or statistically robust evidence of ongoing exposure at most sites. Avalon remains an exception due to the well-documented, time-limited exposure event linked to contaminated mains water identified in 2022, after which concentrations have declined following exposure-control measures. Apparent differences at other stations are limited by small sample sizes, staff mobility, and uncertainty in station assignment, and should be interpreted cautiously.

- Assess associations between PFAS changes and biochemical markers

Evaluation of associations between PFAS serum concentrations, clinical biochemical markers, and potential confounders will be conducted at study completion. Additional repeated measurements will improve control of inter-individual variability, increase statistical power, and allow more robust assessment of temporal relationships while distinguishing short-term fluctuations from meaningful long-term changes.

- Provide ongoing advice to Airservices on minimising PFAS exposure

Overall, results from this collection round indicate that historical occupational exposure remains the primary driver of elevated PFAS concentrations in the cohort. Current data do not suggest widespread ongoing elevated occupational exposure across Airservices stations during the 2018/19-2025/26 period. However, the persistence of elevated concentrations in many participants, the slow rate of decline, and substantial inter-individual variability highlight the importance of continued monitoring.

Ongoing longitudinal assessment will enhance statistical power, refine elimination half-life estimates, clarify associations with biochemical markers, and improve understanding of station- and potentially role-specific effects. Continued monitoring will also be essential for confirming whether declines persist and for detecting any emerging or previously unrecognised exposure sources. Collectively, these findings will support Airservices in maintaining and refining exposure-control strategies and ensuring PFAS exposures remain as low as reasonably achievable.

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For more information

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Appendix A

A-1 Additional Background Information

A-1-1 PFAS Chemical Structures

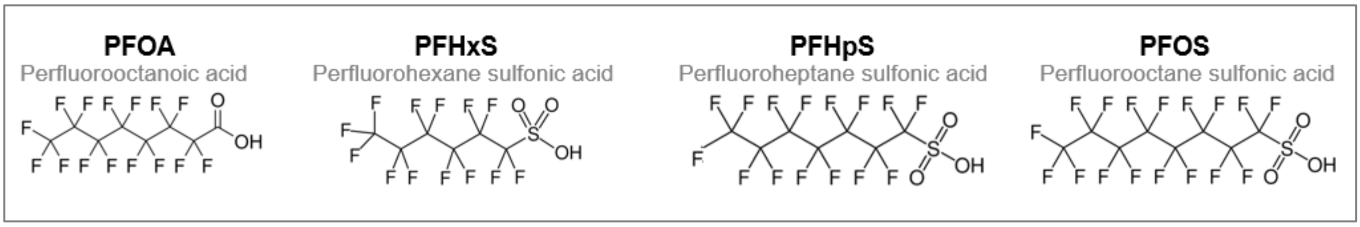

Figure A-1 *Chemical structure of PFOA, PFHxS, PFHpS and PFOS*

A-1-2 The QAEHS Human Biomonitoring Programme

The QAEHS Human biomonitoring is Australia's most comprehensive and longest running human biomonitoring program for the monitoring of population exposure to environmental chemicals. The program includes systematic pooling of biennial collections of 2400-48000 individual pathology samples from across Australia since 2002, stratified by age group and sex. These collections have provided a robust and comprehensive data source and has been fundamental to the understanding of exposure trends in the general Australian population for many legacy and emerging environmental pollutants, including PFAS. PFAS data from this program has been published in several peer reviewed publications [e.g. 1-3].

The data on PFAS concentrations obtained from the pooled serum samples from the Australian population can be used to evaluate whether participants in the current study had PFAS concentrations above those expected in the general population, which may indicate exposure to PFASs through occupational sources. Since the data for the Australian populations stems from pooled samples, only an average PFAS concentration is available. However, the 95th percentile for PFOA, PFHxS and PFOS can be estimated based on population variation from available datasets from the National Health and Nutrition Examination Survey (NHANES) in the United States [4, 5]. NHANES does not measure PFHpS concentrations in the population, therefore the average of the population variation for PFOA, PFHxS and PFOS was applied to derive the 95th percentile for PFHpS. While this adds some uncertainty to the 95th percentile of PFHpS it still gives an indication of general population variation. Individual data on PFAS serum concentrations published by the Australian Bureau of Statistics (ABS) summarising the National Health Measures Survey (NHMS, 2022-24) recently became available [6]. The mean: 95th percentile ratios used in this report agree well with those reported by ABS.

Mean and estimated 95th percentile values that were used for reference in the current report are those estimated from the most recent round of sample collection (2024/2025), shown in **Table A-1**. As a reference for the temporal trends in PFAS serum concentration in the Australian population, the mean and estimated 95th percentiles estimated from sample collections in 2018/19, 2020/21 and 2022/23 as a reference for the temporal trends in the general population are also used, shown in **Table A-2.**

Table A-1 *Mean and estimated 95th percentile (P95) PFAS serum concentration (ng/mL) from pooled serum samples collected from the Australian population in 2024/25.*

		PFOA	PFNA	PFDA	PFHxS	PFHpS	PFOS
16–30	Mean	1.0	0.21	0.12	0.83	0.04	1.8
	Est. P95	2.1	0.50	0.32	2.3	0.10	4.1
31–45	Mean	1.1	0.24	0.13	1.2	0.08	2.6
	Est. P95	2.2	0.58	0.37	3.4	0.20	6.1
46–60	Mean	1.3	0.35	0.16	1.5	0.11	3.4
	Est. P95	2.8	0.81	0.41	4.0	0.27	7.9
60-75	Mean	1.4	0.33	0.15	1.5	0.15	3.9
	Est. P95	3.0	0.82	0.38	4.12	0.37	9.0
>75	Mean	1.5	0.35	0.16	1.9	0.21	5.6
	Est. P95	3.2	0.88	0.41	5.2	0.49	13

Table A-2 *Mean and estimated 95th percentile (P95) of PFOA, PFHxS, PFHpS and PFOS (ng/mL) from pooled serum samples collected from the Australian population in the 46-60 and >60 age groups in 2018/19, 2020/21, 2022/23 and 2024/25.*

	Age group		PFOA	PFHxS	PFHpS	PFOS
2018/19	46–60	Mean	1.8	2.1	0.24	5.7
		Est P95	3.9	5.7	0.57	13
	>60	Mean	2.5	2.3	0.31	7.3
		Est P95	5.3	6.2	0.74	17
2020/21	46–60	Mean	1.6	1.9	0.19	5.1
		Est P95	3.4	5.0	0.45	12
	>60	Mean	1.9	2.2	0.25	6.5
		Est P95	4.0	6.0	0.60	15
2022/23	46–60	Mean	1.2	1.2	0.10	2.9
		Est P95	2.6	3.2	0.24	6.6
	>60	Mean	1.6	1.8	0.17	4.6
		Est P95	3.4	5.0	0.41	11
2024/25	46–60	Mean	1.3	1.5	0.11	3.4
		Est P95	2.8	4.0	0.27	7.9
	>60	Mean	1.5	1.7	0.19	4.9
		Est P95	3.1	4.8	0.4	11

Temporal Trends 2018/19- 2024/25

	Age group	PFOA	PFHxS	PFHpS	PFOS
Slope (LnPFAS)	46–60	-0.06	-0.07	-0.15	-0.10
	>60	-0.09	-0.05	-0.10	-0.08
Annual Change	46–60	-6.1% /year	-7.2%/year	-13.5%/year	-9.9%/year
	>60	-8.3%/year	-4.8%/year	-9.2%/year	-7.3%/year
Population half-life	46–60	10.9 years	9.3 years	4.8 years	6.6 years
	>60	8.0 years	14.1 years	7.2 years	years

A-1-3 Overview of Previous Exposure Studies: Station Specific Exposure Assessment (2023)

Concurrent to the Avalon Exposure study, Airservices commissioned QAEHS to investigate whether there is any evidence of new (potential ongoing) exposure for ARFFS/EVT employees at any other Airservices stations, using the existing QAEHS database available from previous and ongoing studies (i.e. Airservices Exposure Studies and NHMRC Study).

Analyses of 500 ARFFS from the PFAS data base were undertaken to evaluate if PFAS results from any station showed trends that may indicate ongoing exposure. This was done by calculating the individual change (annual change) in PFAS serum concentration and comparing the median change at each station with the full study cohort (n=500).

As part of the Airservices 2018/19 Exposure Study, participants provided information regarding their current employment. No information was available on the movements of ARFFS employees after 2018/19. Thus, the 2018/19 location information was used for the assessment. A total of 221 ARFFS confirmed current employment at only one station at the time they completed the 2018/19 survey, and these ARFFS were attributed to represent that specific station. A total of 14 Airservices fire stations could be represented by more than six ARFFS/EVT employees: Adelaide, Avalon, Brisbane, Cairns, Canberra, Coolangatta, Darwin, Hobart, Launceston, Melbourne, Perth, Sunshine Coast, Sydney, and Townsville. Stations with less than six individuals were grouped together according to region. These included Northern Territory (NT) Stations (Alice Springs and Ayers Rock), Western Australia (WA) Stations (Broome, Karratha, Newman and Port Headland), Queensland (QLD) Stations (Hamilton Island, Mackay and Rockhampton), and New South Wales (NSW) Stations (Ballina and Coffs Harbour). The comparison of PFOS is shown in **Figure A-2.**

Compared to the full study group, Avalon station (n= 9) had a consistently slower decrease of PFHxS, PFHpS and PFOS (the three PFAS associated with 3M Light Water. In addition to Avalon station, NT stations also had a consistently slower decrease of PFAS. The slow rate of decrease between 2018/19 and 2020/21 may suggest ongoing PFAS exposure at these two sites during this period. Some other stations also showed slower decrease of specific PFAS compared to the full study group, but there was no consistent trend of all three PFAS associated 3M Light Water for these stations (i.e., the patterns of decrease of PFHxS, PFHpS and PFOS were not all consistent). If ARFFS employees were exposed to 3M Light Water related contamination, it would be expected that each of the three-3M AFFF related PFAS would have demonstrated a slower decrease.

The trends observed in these data should be interpreted with consideration of the limitations of this assessment; lack of information regarding the employment of ARFFS employees during the time assessed, the small number of participants representing each station, and the analytical uncertainties associated with the short timeframe assessed. The results of this report cannot be considered to be definitive, but they provide important insights to be considered in context of the other information available about these Airservices stations. For example, Airservices tested the mains water at all facilities across the country between and found no other unexpected detections of PFAS.

This study has been documented in a report for Airservices.

Summary Study Findings: Station Specific Exposure Assessment

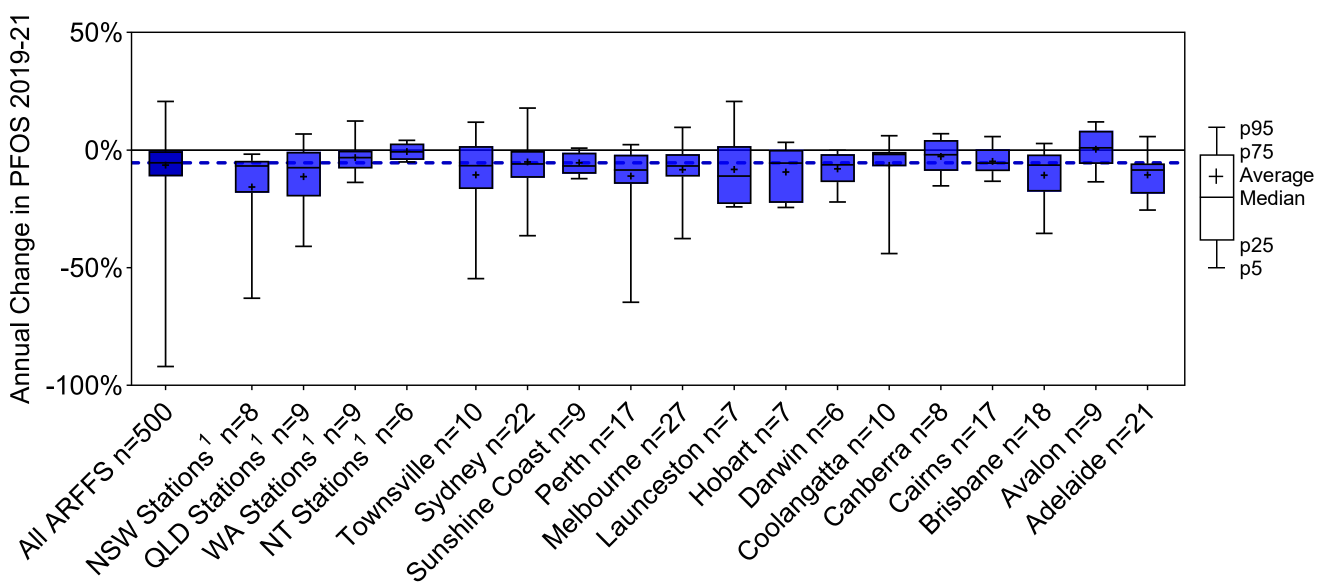

Figure A-2 *Main findings from the Station Specific Exposure Assessment. Station-specific percent annual change of PFOS serum concentration of ARFFS/EVT employees, assuming location remains as per the 2018/19 Airservices Exposure Study. Note that stations with less than six individuals were grouped together according to region. Annual change in PFOS serum concentration was calculated between blood sample collections in 2018/19 (Airservices Exposure Study) and 2021/22 (NHMRC Study). The black line represents no change. The blue dotted line represents the median change among all ARFFS/EVT participants who participated in both the in 2018/19 Airservices Exposure Study and 2021/22 NHMRC Study.1, Northern Territory (NT) stations represents Alice Springs and Ayers Rock); Western Australia (WA) stations represents Broome, Karratha, Newman and Port Headland; Queensland (QLD) stations represents Hamilton Island, Mackay and Rockhampton; New South Wales (NSW) Stations represents Ballina and Coffs Harbour.*

A-2 Methodology

A-2-1 Biochemical analysis

Table A-3 *List of biochemical markers targeted in the Airservices 2025-2028 Exposure Study*

Endpoints	Biochemical markers
Lipid profile *Biomarkers for cardiovascular disease, metabolic effects*	Total Cholesterol Triglycerides High Density Lipoprotein (HDL) Low Density Lipoprotein (LDL) Total Cholesterol/HDL Non-High-Density Lipoprotein (HDLC)
Thyroid function tests *Biomarkers for thyroid disease*	Thyroid Stimulating Hormone (TSH) Free Thyroxine (T4) Free Triiodothyronine (T3)
Liver function *Biomarkers for liver disease*	Alanine Aminotransferase (ALT) Bilirubin[1] Alkaline Phosphate[1] Gamma-glutamyl transferase (Gamma GT) [1]
Kidney function *Biomarkers for kidney disease*	Uric acid Creatinine Estimated Glomerular Filtration Rate (eGFR)
Serum proteins *Provide binding sites for PFASs in blood*	Globulin Albumin Total protein

[1] These biomarkers were not included in the 2018/19 Airservices Exposure Study.

A-2-2 PFAS analysis

The PFAS analysis was performed according to previously published protocols [5, 7]. Briefly, an aliquot of 200 µL serum was transferred to a 1.5 mL Eppendorf tube followed by addition of 2 ng of labelled internal standards. Acetonitrile was used to precipitate the proteins, and the extraction was facilitated by vortex mixing and ultrasonication (30min). After centrifugation (4750 rpm, 30 min), the supernatant filtrated into an LC vial through a 2 µm RC Membrane filter (Phenomenex) and blown down to 200 µL using nitrogen, after which 300 µL MilliQ and 2ng recovery standards were added. PFAS were analysed by HPLC-MS/MS using a high-performance liquid chromatograph (HPLC, Nexera, Shimadzu Corp., Kyoto Japan), coupled to a tandem mass spectrometer (SCIEX Triple Quad 6500+, Concord, Ontario, Canada) equipped with an electrospray ionisation and using scheduled multiple reaction monitoring mode (sMRM). A volume of 5 µL was injected and separation was achieved using a Kinetex 2.6 µm EVO C18, 100Å, 100 x 2.1 mm column (Phenomenex, Lane Cove) held at 50 °C, with a flow rate of 0.45 mL min^{-1} and a gradient elution using mobile phases 1% (Phase A) and 90% (Phase B) methanol, respectively, with 8mM ammonium acetate.

A total of 53 PFAS was quantified, listed in **Table A-4.** Quantification was performed using the internal standard method with non-extracted calibration standards. In this report, reported concentrations are for linear isomers of all PFAS, with the exception of PFOS, where the total concentration of both linear and branched isomers is presented. Method detection limits (MDLs) were determined using EPA guidelines (40 CFR 136) and set as 3.14 times the standard deviation of seven spiked blank replicates and are presented in **Table A-5.**

Table A-4 *List of PFAS targeted in the Airservices 2025-2028 Exposure Study. Note that while all the PFAS analytes are included in analysis, only a subset will be reported to individuals*

Group	PFAS	Acronym
Perfluoroalkyl carboxylic acids	Perfluoro-n-butanoic acid	PFBA
	Perfluoro-n-pentanoic acid	PFPeA
	Perfluoro-n-hexanoic acid	PFHxA
	Perfluoro-n-heptanoic acid	PFHpA
	Perfluoro-n-octanoic acid	PFOA
	Perfluoro-n-nonanoic acid	PFNA
	Perfluoro-n-decanoic acid	PFDA
	Perfluoro-n-undecanoic acid	PFUnDA
	Perfluoro-n-dodecanoic acid	PFDoDA
	Perfluoro-n-tridecanoic acid	PFTriDA
	Perfluoro-n-tetradecanoic acid	PFTreDA
	Perfluoro-n-hexadecanoic acid	PFHxDA
Perfluoroalkyl sulfonates	Perfluoropropane sulfonate	PFPrS
	Perfluorobutane sulfonate	PFBS
	Perfluoropentane sulfonate	PFPeS
	Perfluorohexane sulfonate	PFHxS
	Perfluoroheptane sulfonate	PFHpS
	Perfluorooctane sulfonate	PFOS[1]
	Perfluorononane sulfonate	PFNS
	Perfluorodecane sulfonate	PFDS
	Perfluorododecane sulfonate	PFDoDS
Perfluoroalkane sulfonamides	Perfluorobutane sulfonamide	FBSA
	Perfluorohexane sulfonamide	FHxSA
	Perfluorooctane sulfonamide	FOSA
	N-methylperfluoro-1-octane sulfonamide	N-Me FOSA
	N-ethylperfluoro-1-octane sulfonamide	N-Et FOSA
Alcohol perfluoroalkane sulfonamides	N-methylperfluorooctane sulfonamido ethanol	N-Me FOSE
	N-ethylperfluorooctane sulfonamido ethanol	N-Et FOSE
Perfluoroalkane sulfonamido acetic acid	Perfluorooctane sulfonamido acetic acid	FOSAA
	N-methylperfluorooctane sulfonamido acetic acid	N-Me FOSAA
	N-ethylperfluorooctane sulfonamido acetic acid	N-Et FOSAA
Fluorotelomer sulfonates	4:2 fluorotelomer sulfonate	4:2 FTS
	6:2 fluorotelomer sulfonate	6:2 FTS
	8:2 fluorotelomer sulfonate	8:2 FTS
	10:2 fluorotelomer sulfonate	10:2 FTS
Chlorinated PFOS	8-chloroperfluoro-1-octanesulfonate	8Cl-PFOS
Cyclic PFAS	Perfluoro-4-ethylcyclohexanesulfonates	PFECHS
PFAS Replacement Compounds	Hexafluoropropylene oxide dimer acid	GenX
	Trifluoromethoxy propoxy propanoate	ADONA
	Potassium 9-chlorohexadecafluoro-3-oxanonane-1-sulfonate	9Cl-F53B (9Cl-PF3ONS)
	Potassium 11-chloroeicosafluoro-3-oxaundecane-1-sulfonate	11Cl-F53B (11Cl PF3OUdS)

1. PFOS is measured as total concentration of linear and branched isomers, all other PFAS are measured as linear isomer concentration

Quality Assurance/Quality Control (QA/QC)

QA/QC included blanks to assess contamination, standard reference material (NIST 1957) to assure accuracy, and replicates and duplicates to assess precision. QAEHS has also participated in an interlaboratory proficiency testing programme (3x samples, 3x per year since 2019) and consistently passes acceptable criteria. The QA/QC results are presented in **Table A-5**. Additionally, 20 randomly selected samples were sent to two other laboratories for comparison. The results of this interlaboratory comparison is discussed in the next section

Interlaboratory Comparison

A total of 20 randomly selected samples was sent to two different laboratories: Sullivan Nicolaides Pathology and Envirolab. Figure A-3 presents the measured concentrations of the most frequently detected PFAS in each sample.

Overall, serum concentrations of PFOA, PFNA, PFHxS and PFHpS showed good agreement between laboratories, with average relative standard deviations (RSDs) of 14%, 9%, 7%, and 15%, respectively. However, there was a larger variation between the laboratories for PFOS (relative standard deviation of 25%). QAEHS consistently reported higher PFOS concentrations than the other laboratories, particularly in samples with elevated PFAS concentrations (**Figure A-3**).

It was noted that all three laboratories used different analytical methods for the determination of PFOS in the serum samples. QAEHS is currently investigating the observed differences by evaluating the various analytical methodologies in-house.

The findings from the interlaboratory comparison were unexpected, as QAEHS has consistently demonstrated strong performance in international interlaboratory studies and has routinely reported PFAS concentrations that closely match certified values in quality control reference materials included in every analytical batch. The same reference material has also been analysed by Sullivan Nicolaides Pathology, with results showing good agreement between laboratories.

Preliminary finding from the investigation to understand the different PFOS results suggest that elevated proportions of certain PFOS isomers present in firefighter serum samples may influence measured concentrations, with the magnitude and direction of the bias depending on the analytical method used. The reference materials, as well as samples used in interlaboratory studies do not contain high proportions of these isomers, which may explain why PFOS measures agree well in those samples.

QAEHS is currently working on developing an analytical approach that is less susceptible to isomer-related bias. It is anticipated that PFOS measurements in future rounds of PFAS analysis will be performed using this revised methodology. To ensure continuity in longitudinal assessments, selected archived samples may also be re-analysed using the new approach. Further details will be provided once the investigation is complete and a validated solution has been established.

__Table A-5__ Quality Assurance/Quality Control (QA/QC) outcomes of the PFAS analysis

PFAS	Method Detection Limit ng/mL	Blanks RO Water/ Solvent ng/mL	Accuracy Standard Reference Material (NIST 1957) ng/mL		Precision Replicates/Duplicates				Recovery of spiked standards Recovery (%)		Interlaboratory proficiency testing 2025-2026[2]		
					Replicates RSD[1] (%)		Duplicates Difference (%)						
			Measured Values	Reference Values	Non-Spiked	Spiked	Intra Batch	Inter Batch	Native Standards	Mass labelled Standards	Satisfactory Results (%)	Questionable Results (%)	Unsatisfactory Results (%)
		N=72	N=36		N=35	N=35	N=35 pairs	N=35 pairs	N=11	N=766			
			Average (SD)	Average (SD)			Average (SD)	Average (SD)	Average (SD)	Average (SD)			
PFBA	0.0	<mdl	<mdl	n/a	0.2	7.5	6.9 (6.5)	11.6 (9.9)	105 (8)	95 (5)	n/a	n/a	n/a
PFPeA	1.0	<mdl	<mdl	n/a	n/a	7.4	n/a	n/a	104 (7)	96 (6)	n/a	n/a	n/a
PFHxA	0.0	<mdl	<mdl	n/a	n/a	7.9	n/a	n/a	102 (6)	93 (7)	100%	0%	0%
PFHpA	0.1	<mdl	0.25 (0.03)	0.31 (0.05)	n/a	7.0	n/a	23.5 (0)	99 (8)	96 (11)	100%	0%	0%
PFOA	0.1	<mdl	5.1 (0.37)	5.0 (0.44)	6.3	8.8	10.6 (7.4)	9.8 (6.6)	103 (7)	105 (10)	100%	0%	0%
PFNA	0.1	<mdl	0.84 (0.09)	0.88 (0.08)	9.3	11.4	14.6 (11)	15 (12.5)	102 (6)	92 (9)	100%	0%	0%
PFDA	0.1	<mdl	0.27 (0.03)	0.39 (0.12)	8.8	9.3	13.8 (12.4)	16.6 (15.3)	103 (7)	100 (9)	100%	0%	0%
PFUnDA	0.1	<mdl	0.13 (0.01)	0.17 (0.04)	12.1	8.7	12.2 (6.1)	n/a	103 (6)	101 (10)	100%	0%	0%
PFDoDA	0.1	<mdl	<mdl	n/a	n/a	9.6	n/a	n/a	101 (9)	98 (11)	100%	0%	0%
PFTriDA	0.2	<mdl	<mdl	n/a	n/a	11.2	n/a	n/a	105 (9)	98 (11)	92%	8%	0%
PFTreDA	0.1	<mdl	<mdl	n/a	n/a	8.1	n/a	n/a	104 (10)	82 (14)	83%	17%	0%
PFHxDA	0.3	<mdl	<mdl	n/a	10.4	7.7	9.5 (8.9)	11.6 (9.5)	109 (8)	63 (17)	n/a	n/a	n/a
PFPrS	0.0	<mdl	<mdl	n/a	n/a	8.2	n/a	n/a	105 (7)	97 (7)	n/a	n/a	n/a
PFBS	0.0	<mdl	<mdl	n/a	n/a	8.2	n/a	n/a	106 (6)	97 (7)	n/a	n/a	n/a
PFPeS	0.1	<mdl	<mdl	n/a	n/a	7.9	n/a	n/a	107 (7)	98 (8)	100%	0%	0%
PFHxS	0.1	<mdl	3.7 (0.21)	4 (0.83)	6.4	7.7	6.8 (6)	6.6 (4.5)	104 (8)	98 (8)	100%	0%	0%
PFHpS	0.1	<mdl	<mdl	n/a	12.9	8.2	7.7 (7.2)	9.2 (6.6)	108 (6)	98 (8)	100%	0%	0%
PFOS*	0.3	<mdl	19.6 (1.1)	18.1-21.1 (1.3)	6.5	6.6	4.4 (2.8)	7.3 (6.4)	100 (7)	95 (6)	100%	0%	0%
PFNS	0.2	<mdl	<mdl	n/a	n/a	8.0	n/a	n/a	106 (4)	95 (6)	n/a	n/a	n/a
PFDS	0.1	<mdl	<mdl	n/a	n/a	9.5	n/a	n/a	107 (5)	95 (6)	n/a	n/a	n/a
PFDoDS	0.1	<mdl	<mdl	n/a	n/a	45.4	n/a	n/a	105 (18)	95 (6)	n/a	n/a	n/a
FBSA	0.0	<mdl	<mdl	n/a	39.5	9.7	n/a	n/a	105 (6)	97 (7)	n/a	n/a	n/a
FHxSA	1.0	<mdl	<mdl	n/a	n/a	8.1	n/a	n/a	108 (6)	98 (8)	n/a	n/a	n/a
FOSA	0.2	<mdl	<mdl	n/a	n/a	9.7	n/a	n/a	102 (5)	104 (12)	n/a	n/a	n/a

N-Me FOSA	0.9	<mdl	<mdl	n/a	n/a	12.8	n/a	n/a	104 (9)	105 (16)	n/a	n/a	n/a
N-Et FOSA	0.7	<mdl	<mdl	n/a	n/a	9.3	n/a	n/a	105 (11)	88 (14)	n/a	n/a	n/a
N-Me FOSE	0.3	<mdl	<mdl	n/a	n/a	11.2	n/a	n/a	104 (13)	79 (17)	n/a	n/a	n/a
N-Et FOSE	0.3	<mdl	<mdl	n/a	6.9	6.7	n/a	n/a	103 (12)	79 (15)	n/a	n/a	n/a
FOSAA	0.2	<mdl	<mdl	n/a	43.1	11.9	n/a	n/a	108 (10)	120 (24)	n/a	n/a	n/a
N-Me FOSAA	0.4	<mdl	<mdl	n/a	23.4	7.5	n/a	n/a	101 (11)	120 (24)	100%	0%	0%
N-Et FOSAA	0.1	<mdl	<mdl	n/a	n/a	9.7	n/a	n/a	103 (11)	117 (23)	100%	0%	0%
4:2 FTS	0.1	<mdl	<mdl	n/a	n/a	10.0	n/a	n/a	108 (12)	129 (31)	n/a	n/a	n/a
6:2 FTS	0.2	<mdl	<mdl	n/a	n/a	11.9	n/a	n/a	106 (10)	142 (46)	n/a	n/a	n/a
8:2 FTS	0.1	<mdl	<mdl	n/a	n/a	180.1	n/a	n/a	106 (8)	144 (41)	n/a	n/a	n/a
10:2 FTS	0.2	<mdl	<mdl	n/a	n/a	151.2	n/a	n/a	118 (20)	144 (41)	n/a	n/a	n/a
8Cl-PFOS	0.2	<mdl	<mdl	n/a	n/a	8.5	n/a	n/a	104 (10)	95 (6)	n/a	n/a	n/a
PFECHS	0.2	<mdl	<mdl	n/a	n/a	8.3	n/a	n/a	102 (8)	95 (6)	100%	0%	0%
GenX	0.5	<mdl	<mdl	n/a	n/a	8.6	n/a	n/a	109 (7)	107 (11)	n/a	n/a	n/a
ADONA	0.5	<mdl	<mdl	n/a	n/a	7.8	n/a	n/a	96 (6)	96 (11)	n/a	n/a	n/a
9Cl-F53B (9Cl-PF3ONS)	0.1	<mdl	<mdl	n/a	18.9	12.1	n/a	n/a	104 (5)	95 (6)	n/a	n/a	n/a
11Cl-F53B (11Cl PF3OUdS)	0.1	<mdl	<mdl	n/a	n/a	9.6	n/a	n/a	105 (5)	95 (6)	n/a	n/a	n/a

1. RSD; Relative Standard Deviation
2. Interlaboratory proficiency testing (AMAP) is an international quality assurance initiative designed to evaluate and harmonise laboratory performance in the chemical analysis of human specimens. Participating laboratories analyse standardised PFAS test materials, and their results are assessed against assigned values using statistical performance criteria, including z-scores. The programme supports analytical comparability, method validation, and continuous improvement in PFAS measurement across laboratories involved in environmental and human exposure monitoring. including 12 serum samples tested during the 2025-2026 period. Laboratory performance was evaluated using z-scores, with results classified as satisfactory (|z| < 2), questionable (2 ≤ |z| < 3), or unsatisfactory (|z| ≥ 3)

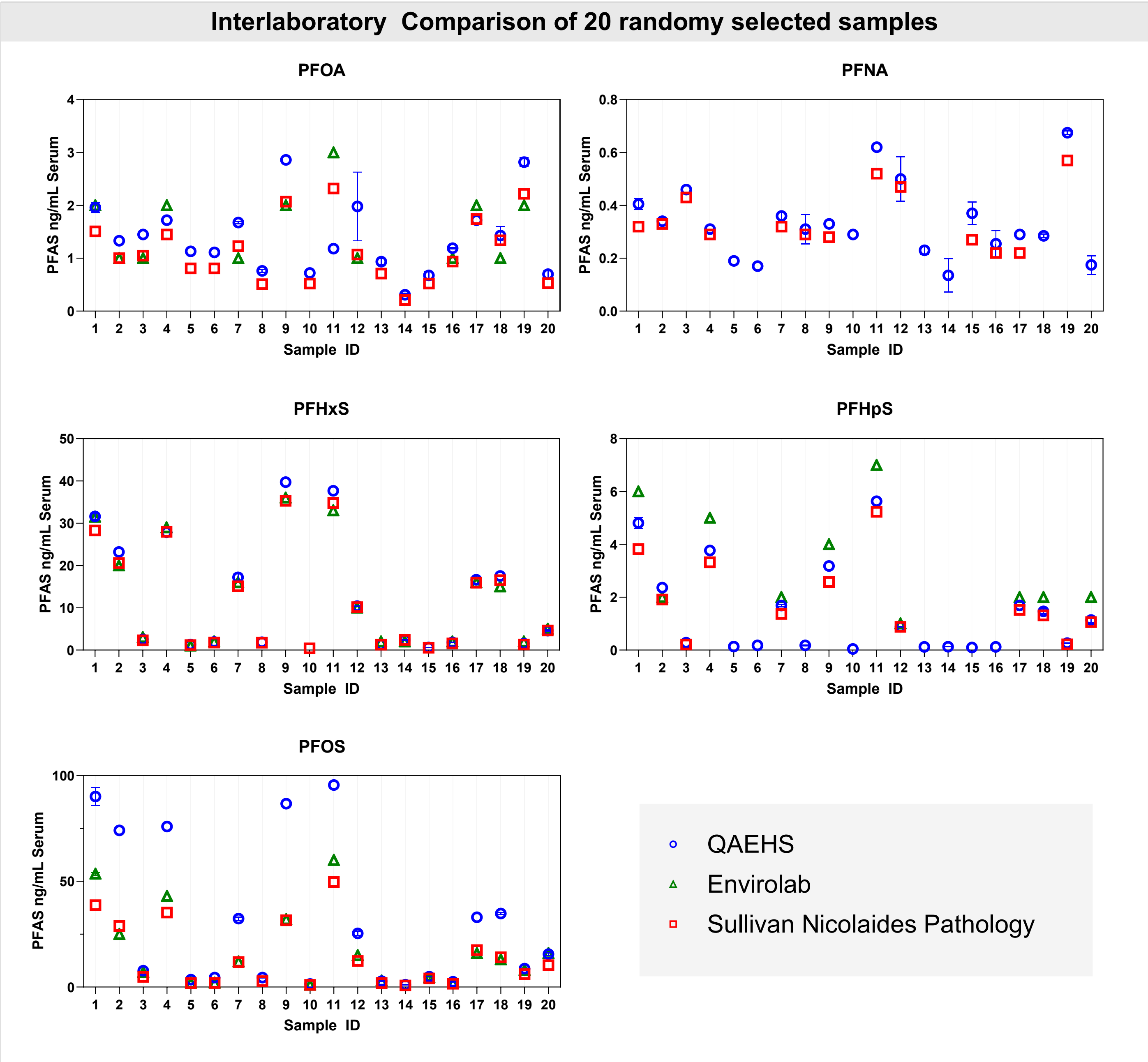

Figure A-3 *PFAS serum concentrations reported among 20 randomly selected samples by the three different laboratories. Only PFAS that were detected are graphed.*

Appendix B

B-1 Full Questionnaire

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Participant Code | | | | |

Evaluation of changes in PFASs in Airservices Australia's Aviation Rescue Fire Fighting Services (ARFFS) and Emergency Vehicle Technician (EVT) staff - PFAS Exposure Study III
2025-2028

Questionnaire for Participants

Please complete the following questionnaire providing as much detail as possible.

Only the researchers will have access to these details, and these will be kept securely as approved by one of The University of Queensland's Ethics Committees.
No information gathered from you during this project will be provided directly to your employer.

If you need help or have any questions or comments?

Please ring us on *toll free number* **1800 370 760**
OR Mobile 0419 110 176
OR email us on *ASAstudy@uq.edu.au*

There are no right or wrong answers or trick questions in this survey. Your responses are simply to help better understand the data gathered in this study.

We appreciate your time in completing this questionnaire which will provide us with the information we need to know about you, your lifestyle, your health, your diet and your work. This information is important for the interpretation of the chemical results obtained in this study.

Should you wish to withdraw at any stage from the study, or to withdraw any unprocessed data you have supplied, you are free to do so without prejudice.

YOUR DETAILS

1. **Please state your date of birth** |__|__| _ |__|__| _ |__|__|__|__|

DD MM YYYY

2. **What is your gender?**

Male	1
Female	2
Gender not specified	3

3. **What is your country of birth?** ______________________________

If you were NOT born in Australia – what year did you come to live in Australia? |____|

YYYY

LIFESTYLE INFORMATION

We are now going to ask you a few questions about your lifestyle, your health, your diet and your work. This information is important for the interpretation of the chemical results obtained in this study.

4. Which of the following best describes your smoking status now? (smoking includes using vapes and/or e-cigarettes containing nicotine).

I have never smoked	1	***(go to Question 9)***
I used to smoke	2	
I now smoke occasionally	3	
I now smoke regularly	4	

5. If you used to smoke, how long ago did you quit smoking?

I quit within the last 6 months	1
I quit 6 – 12 months ago	2
I quit more than one year ago	3
I still smoke	4

6. In the LAST WEEK how many cigarettes did you usually smoke PER DAY?

Did not smoke at all	1
1 – 9 per day	2
10 – 19 per day	3
20 – 29 per day	4
30 – 49 per day	5
50 or more per day	6

7. How often do you vape or use e-cigarettes?

Did not use at all	1
Daily	2
At least weekly (but not daily)	3
At least monthly (but not weekly)	4
Less than monthly	5
I used to use them but no longer use	6
I only tried them once or twice	7

8. Estimated number of years smoking or vaping?

		Number of years

The next questions are about your use of alcoholic beverages during this past year. Some items below ask questions about how many **'standard drinks'** you have had.

When referring to 'a standard drink':
1 standard drink = 1 pot (QLD) or middy (NSW) full strength beer,
1 can (375ml) of mid-strength beer, 100ml (small glass) of wine, 1 nip of spirits

9. How often do you have an alcoholic drink?

Never	1	*(go to Question 12)*
Monthly or less	2	
Two to four times per month	3	
Two to three times per week	4	
Four or more times per week	5	

10. How many standard alcoholic drinks do you have in a typical day when drinking?

1 or 2 drinks	1
3 or 4 drinks	2
5 or 6 drinks	3
7, 8 or 9 drinks	4
10 or more drinks	5

11. How often do you have 5 or more standard alcoholic drinks during one occasion?

Never	1
Less than monthly	2
Monthly	3
Weekly	4
Daily or almost daily	5

12. How many times each week do you do moderate to strenuous exercise (on average)?

(Examples of moderate to strenuous exercise is fast walking, playing tennis, dancing, biking, swimming, going to the gym)

Never	1
Once a week	2
Two to three times a week	3
Four to five times a week	4
More than five times a week	5

13. Which diet best describes your <u>normal diet</u>?

Mixed Diet – meat and vegetables	1
Vegetarian	2
Vegan (no animal products)	3

14. On average, how often do you eat <u>fish</u> or other seafood, including tinned fish (e.g. tinned tuna)?

Never	1
Less than once a week	2
Once a week	3
Two to three times a week	4
Four to five times a week	5
Daily	6

15. On average, how often do you consume <u>milk and milk products</u>, including cheese?

Never	1
Less than once a week	2
Once a week	3
Two to three times a week	4
Four to five times a week	5
Daily	6

16. On average, how often do you consume <u>meat</u>?

Never	1
Less than once a week	2
Once a week	3
Two to three times a week	4
Four to five times a week	5
Daily	6

17. Are you a blood or plasma donor?

Yes, Blood	1
Yes, Plasma	2
Yes, both blood and plasma	3
I have not donated blood or plasma	4 ***(go to Question 22)***

18. In what year (approximately) did you <u>start</u> donating blood or plasma?

Year of first donation ______________________

Don't know 1

19. In what year (approximately) did you <u>last</u> donate blood or plasma?

Year of last donation ______________________

Don't know 1

20. How <u>frequently</u> do you or did you donate blood or plasma? Please tick the appropriate box for each type of donation.

Frequency	***Blood***	***Plasma***
Less than once a year		
Once a year		
2 to 4 times per year		
More than 4 times per year		

21. How many times have you donated blood or plasma in the <u>last two years</u>? This may be recorded in your blood donation records or app on your smartphone.

How many times have you donated blood in the last two years	
How many times have you donated plasma in the last two years	
Don't know	1

YOUR HEALTH

22. The following questions are about health problems you might have had at any time in your life. **Has a doctor ever diagnosed you as having any of the following:** *Please answer 'Yes/No' to each condition*		**No**	**Yes**	**If 'YES' What was your age when first diagnosed?**
a.	Diabetes (high blood sugar) type 1	1	2	
b.	Diabetes (high blood sugar) type 2	1	2	
c.	High blood pressure *(Hypertension)*	1	2	
d.	Cardiovascular disease (*e.g. Heart Attack, Stroke, Angina)*	1	2	
	Please answer 'Yes/No' to each condition	**No**	**Yes**	**If 'YES' What was your age when first diagnosed?**
e.	Kidney problems *(incl. kidney stones)*	1	2	
f.	Liver problems	1	2	
g.	Asthma	1	2	
h.	Reproductive or fertility problems	1	2	
i.	Thyroid problems	1	2	
j.	Serious Arthritis *(incl. Rheumatoid arthritis)*	1	2	
k.	Chronic back or neck problems	1	2	
The next section is about **cancer** diagnoses. Please note the 'primary' site of any cancer diagnosed.				
l.	Brain cancer	1	2	
m.	Bladder cancer	1	2	
n.	Kidney cancer	1	2	
o.	Non-Hodgkins lymphoma	1	2	
p.	Leukaemia	1	2	
q.	Breast cancer	1	2	

		No	Yes	If 'YES' What was your age when first diagnosed?
r.	Testicular cancer	1	2	
s.	Multiple Myeloma	1	2	
t.	Prostate cancer	1	2	
u.	Ureter cancer	1	2	
v.	Colorectal (Bowel) Cancer	1	2	
w.	Oesophageal Cancer	1	2	
x.	An other form of Cancer *please specify:*____________________	1	2	
y.	Other major physical illness or condition *please specify:*____________________	1	2	
	Please answer 'Yes/No' to each condition	**No**	**Yes**	**If 'YES'** **What was your age when first diagnosed?**
z.	Other major physical illness or condition *please specify:*____________________	1	2	
aa.	Other major physical illness or condition *please specify:*____________________	1	2	
bb.	Other major physical illness or condition *please specify:*____________________	1	2	

23. Are you currently taking any of the following medications?

If, YES, please provide the details of the medication

Please answer 'Yes/No' to each condition

		No	Yes	If 'YES' What is the name of the medicine/s?
a.	Medication for **High Cholesterol**	1	2	
b.	Medication for **Gout**	1	2	
c.	Medication for **Diabetes**	1	2	
d.	Medication for **Epilepsy**	1	2	
e.	**Fluid tablets**	1	2	
f.	**Antibiotics** *(incl. treatment for TB)*	1	2	
g.	Medication for **Thyroid problems**	1	2	
h.	**Chemotherapy** *(incl. methotrexate)*	1	2	
i.	**Medication for Mental Health** (eg. anxiety, depression)	1	2	

24. How tall are you without shoes?

__________cm

25. How much do you weigh (in very little or no clothing and without shoes**)?**

__________Kgs

The next questions ask about any impacts that exposure to PFAS may have had on your physical, psychological or social wellbeing.

26. How has possible or actual, work-related exposure to PFAS impacted you? ***Select all that apply***

No impact	1
Physical health (eg. need for additional or more frequent health checks)	2
Mental health (eg. anxiety, stress, depression)	3
Difficulties with personal and/or social interactions with friends and family	4
Other impacts on your wellbeing Please describe ____________	5

27. Do you currently receive any support for managing possible or actual work-related exposure to PFAS? If yes, please tell us what services you use or access. ***Select all that apply***

No impact or do no access any support services	1
External health checks with your normal health provider	2
Psychological care from a mental health provider (eg. psychologist, GP etc)	3
Participation in PFAS blood testing programs or studies	4
Participation in your regular yearly health screening with Airservices	5
Employee Assistance Program	6
Peer Assistance Network (PAN)	7
Support via Airservices ARFFs leaders	8
Airservices ARFFs Health and Safety Committees	9
Family and friends	10
Another source of support to help you manage. Please describe ____________	11

28. How has possible or actual work-related exposure to PFAS impacted on your work? ***Select all that apply***

No impact on my work	1
Reduced motivation at work	2
Reduced productivity at work	3
Reduced engagement in my work	4
Increased awareness about exposure to PFAS	5
Increased awareness about exposure reduction strategies	6
Increased desire to support Airservices Australia in risk management around PFAS	7
Any other impacts on your work *Please describe* ____________________	8

OCCUPATIONAL HISTORY with ARFFS

The following are some questions regarding your job assignments/employment at roles currently or previously held at Airservices Australia or any of its predecessor organisations. In future questions, we will ask about any jobs you have held at other agencies (such as Department of Defence, rural fire brigade) and with any other employer, so please **do not** include these jobs or roles here.

Instructions for Question 29:

i) If you have held any of the below positions during your employment at Airservices Australia (or its predecessor organisations), please complete the required information in the table below (i.e. duration, timeframe, employer, where/location, frequency of contact with AFFF).
ii) If you have worked in a number of locations within each role and time period, please use a separate line for each location.
iii) Please try to provide as much detail as possible.

29. Have you ever held the following positions during your employment at Airservices Australia (or its predecessors)? If, YES, please write when and for what organisation?
Please include roles or locations where you have worked for at least one month.

Role at Airservices Australia (and its predecessors)	Duration	Timeframe	Employer (one employer per row)	Where/location (one location per row)	How frequently did you have contact with aqueous film forming foams (*including Ansul Ansulite and 3M Lightwater*) when employed? **Do NOT** include exposure to Solberg foam (*i.e. RF6 or Training Foam*).
e.g. Firefighter	***5 years***	***2005-2010***	***Airservices***	***Eg Hobart***	***Never; Less than once a month; once a week; twice a week; most days***
Senior Officer (eg. AALL, Fire Commander)					
				.	
Officer (eg. station and substation officer)					

Role at Airservices Australia (and its predecessors)	Duration	Timeframe	Employer	Where/location	How frequently did you have contact with aqueous film forming foams (*including Ansul Ansulite and 3M Lightwater*) when employed? Do NOT include exposure to Solberg foam (*i.e. RF6 or Training Foam*).
	Number of years	Year range	(one employer per row)	(one location per row)	***Never; Less than once a month; once a week; twice a week; most days***
Firefighter					
Instructor					
Emergency vehicle technician (EVT)					

Please answer Questions 30 and 31 using the same instructions as for Question 29. Please provide as much detail as possible.

30. Role with other agencies (eg. Defence, rural fire service etc). Please write your role or job title on each line.	Duration	Timeframe	Employer	Location	How frequently were you exposed to AFFF
	Number of years	Year range	(one employer per row)	(one location per row)	*Never; Less than once a month; once a week; twice a week; most days*

31. Any other roles with another employer where you were exposed to AFFF. Please write your role or job title	Duration	Timeframe	Employer	Location	How frequently were you exposed to AFFF
	Number of years	Year range	(one employer per row)	(one location per row)	*Never; Less than once a month; once a week; twice a week; most days*

32. Have you attended training (for at least one week) at other Airservices Australia's fire stations or fire training ground sites?

No	1	***(go to Question 34)***
Yes	2	

33. If 'YES', please specify location and duration (of at least one week's duration) :

Location	Duration of training	Approximate year of this training

34. Have you attended any emergency response where <u>aqueous film forming foams</u> (incl. Ansul Ansulite and 3M Lightwater) **were used? *(Released either by Airservices or other)?***

No	1	***(go to Question 36)***
Yes	2	

35. If 'YES', please specify location and year of incident :

Location	Year of Incident

36. Have you had any <u>other</u> jobs (*<u>NOT</u> included at Q29, Q30 or Q31 above*) in which you were in <u>contact with PFAS</u>?

e.g. facility producing/processing PFAS, metal plating, carpet cleaning, retreating carpets or rugs, or professional carpet installation

No	1	***(go to Question 38)***
Yes	2	

37. For other jobs, please describe the job, the number and range of years and how frequently you were exposed to PFAS chemicals.

Job Description	**Duration**	**Timeframe**	**How frequently you were exposed to PFAS** *Never; Less than once a month; once a week; twice a week; most days*

38. Have you ever lived <u>within 5km</u> of a <u>Defence base or Airport</u>?

No 1 ***(go to Question 41)***

Yes 2

39. If 'YES', please specify location and years of residence:

Location	**Years of Residence**

40. If you lived <u>within 5km</u> of a <u>Defence base or Airport, did you use bore water or consume home grown produce</u>?

No 1

Yes, used bore water 2

Yes, consumed home grown produce 3

Yes, used bore water and home grown produce 4

41. Can you think of any other ways you may have been exposed to <u>aqueous film forming foams</u>?

____

____

____

____

Hooray you're finished !!!!!
*Once again, **Thank You** for taking the time to complete this questionnaire.*

If you would like to make any comments or need to add more information, please include below:

Appendix C

C-1 Common terms used when presenting summary data and outcomes from statistical assessments

***Table A-6** Commonly used terms for data summary and statistical assessments.*

Term	Explanation
Mean/Average	The mean, often referred to as the average, is calculated by adding all individual values together and dividing by the number of individuals measured. The mean provides an estimate of the typical value within a group. However, it is important to keep in mind that it can be influenced by very high or very low values (known as outliers). For PFAS biomonitoring data, because a small number of individuals may have much higher concentrations than most participants. In these situations, the mean may be biased towards higher concentrations than the typical concentration in the population. The mean/average is used when the study cohort is reported as it is comparable to the Australian population data (pooled samples represents means).
The geometric mean (GM)	GM is a type of average that is calculated using the logarithm of the values. It is commonly used for environmental exposure data, including PFAS concentrations, because these data are typically right skewed (most people have lower concentrations, while fewer people have much higher concentrations). The geometric mean gives a better estimate of the typical concentration for a population when values vary widely between individuals. Where statistical comparisons are presented in this report, PFAS concentrations are presented as geometric means.
95% confidence intervals:	The 95% confidence interval shows the range of values within which the true average PFAS concentration is expected to fall, accounting for uncertainty in the estimate. Narrow confidence intervals indicate that the estimated concentration is more precise, while wider confidence intervals indicate greater uncertainty. When comparing groups, confidence intervals provide an indication of the uncertainty around each estimate. Greater overlap generally suggests that differences may be less certain; however, statistical tests are used to determine whether differences are unlikely to be explained by chance alone.
Median	The median is the middle value when all measurements are arranged from lowest to highest. The median divides the population into two equal groups: 50% of participants have concentrations below the median and 50% of participants have concentrations above the median. Unlike the mean, the median is not strongly affected by very high or very low values, making it useful for describing data with large variation or skewed distributions
Percentiles (p)	A percentile describes the position of a value within a population. It indicates the percentage of people with a value at or below that level. For example, the 25th percentile (p25) is the value below which 25% of the population falls, the 75th percentile (p75) is the value below which 75% falls, and the 95th percentile (p95) is the value below which 95% falls. The 95th percentile is therefore often used to describe the upper end of a population distribution. These values are shown in the graphs (e.g. boxplots and bars) shown in this report.
Quartiles	Quartiles divide data into four equal groups when values are arranged from lowest to highest. The first quartile (Q1; 25th percentile) represents the value below which 25% of participants fall, while the third quartile (Q3; 75th percentile) represents the value below which 75% of participants fall. The range between Q1 and Q3 (the interquartile range; IQR) describes the spread of the middle 50% of PFAS concentrations.
Adjustments	For comparisons between groups in our statistical models, PFAS concentrations were adjusted for factors that may influence PFAS levels and that differed between individuals. PFAS concentrations naturally vary between people for many reasons. For example, PFAS levels can increase with age because PFAS accumulate in the body over time, while plasma donation can reduce PFAS concentrations because PFAS are removed with plasma. Adjustment allows the comparison between groups and factors to be made as if the groups had similar distributions of these factors, and this helps separate the influence of these factors from the factor of interest. When such adjustments are made in the report, we refer to it as 'adjusted for …" or "accounting for …".
p-values:	The p-value indicates the likelihood of observing the difference between groups or factors that are compared there was no true difference in PFAS concentrations between the groups/with the factors. A smaller p-value provides stronger evidence that the groups differ. In this report, a p-value below 0.05 was considered statistically significant, meaning that the difference between groups was unlikely to be explained by chance alone.

C-2 Participant Overview

C-2-1 Participant Demographics

Table A-7 *Study Cohort Demographics*

		N	Percent of the full study cohort
Total Number of Participants		566	
General Demographics			
Gender	Male	554	98%
	Female	12	2%
Age Group	≤45	102	18%
	46-60	178	31%
	61-75	242	43%
	>75	44	8%
Blood/Plasma Donors	Plasma donor	47	8%
	Blood donor	51	9%
	Both blood and plasma donor	78	14%
	No donor	331	58%
	Did not confirm	59	10%
New Participants		52	9%
Participants with Longitudinal Samples		514	91%
Number of samples[1]	2	88	16%
	3	26	5%
	4	280	49%
	5	107	19%
	6	13	2%
Work History			
Employment Status	Current Employees	295	52%
	Former Employees	271	48%
Year Commenced Service	<2005	348	61%
	2005-2010	77	14%
	>2010	77	14%
	Did Not Confirm	64	11%
Likely foam exposure[2]	3M AFFF	348	61%
	Ansulite	85	15%
	Solberg	69	12%
	Did Not Confirm	64	11%
Have worked for other employers with potential AFFF/PFAS contact		210	37%
Position[3]	Firefighter	470	83%
	EVT	32	6%
	Officer (e.g. station and substation officer)	244	43%
	Senior Officer (e.g. AALL, Fire Commander)	160	28%
	Instructor	55	10%
	Had multiple positions	273	48%
	Did not report position	62	11%

1. *Number of samples including the current collection*
2. *See "A-1-1"*
3. *Ever worked in the stated position.*

Table A-8 *Study Cohort Demographics, separated by current and former employees*

		Current Employees		Former Employees	
		n	**%**	**n**	**%**
Total Number of Participants		295		271	
General Demographics					
Gender	Male	284	96%	270	100%
	Female	11	4%	1	<1%
Age	Mean/Median	50/ 51 years		68/ 68 years	
Blood/Plasma Donors	Plasma donor	26	9%	21	8%
	Blood donor	40	14%	38	14%
	Both blood and plasma donor	33	11%	18	7%
	No donor	160	54%	171	63%
	Did not confirm	36	12%	23	8%
New Participants		37	13%	15	6%
Participants with Longitudinal Samples		258	87%	256	94%
Number of samples [1]	2	72	24%	16	6%
	3	20	7%	6	2%
	4	114	39%	166	61%
	5	43	15%	64	24%
	6	9	3%	4	1%
Work History					
Year Commenced Service	<2005	109	37%	239	88%
	2005-2010	71	24%	6	2%
	>2010	73	25%	4	1%
	Did Not Confirm	42	14%	22	8%
Likely foam exposure[3]	3M AFFF	109	37%	239	88%
	Ansulite	79	27%	6	2%
	Solberg	65	22%	4	1%
	Did Not Confirm	42	14%	22	8%
Have worked for other employers with potential AFFF/PFAS contact		124	44%	86	32%
Position	Firefighter	241	82%	229	85%
	EVT	15	5%	17	6%
	Officer (e.g. station and substation officer)	123	42%	121	45%
	Senior Officer (e.g. AALL, Fire Commander)	65	22%	95	35%
	Instructor	28	9%	27	10%
	Had multiple positions	139	47%	134	49%
	Did not report position	41	14%	21	8%

1. Number of samples including the current collection
2. See “C-2-2”
3. Ever worked in the stated position.

C-2-2 Grouping of "Likely foam exposure'

Airservices employees could have been exposed to PFAS from the 3M Light Water between approximately 1980 and 2003, and Ansulite between 2002 and 2010; since 2010 the PFAS-free Solberg RF6 has been used at all locations except Darwin and Townsville. These airports are operated jointly with the Royal Australian Air Force (RAAF) and the ARFF services agreement with Defence required the use of Ansulite to continue for a longer period. Darwin was transitioned to Solberg RF6 in 2019 and Townsville in 2020. Accordingly, participants who reported the year they commenced service at Airservices were grouped based on the foam in use at the time they commenced employment. Note, 2005 is used as the transition point between 3M Light Water and Ansulite to ensure that those grouped as 'Ansulite' are most likely not to have been exposed to 3M Light Water or elevated levels of residual PFAS from 3M Light Water.

AFFF; Likely exposed to 3M Light Water or Ansulite

> **3M Light Water;** Exposed or likely exposed to 3M Light Water at Airservices. Participants who reported that they commenced service pre-2005
>
> **Ansulite;** Likely not exposed to 3M Light water; likely exposed to Ansulite (and or Solberg RF6) at Airservices. Participants who reported that they commenced service between 2005 (inclusive) and 2010 at any stations. Participants who commenced after 2010 and worked at Darwin before 2019 (inclusive) or Townsville before 2020 (inclusive), where Ansulite remained in use.

Solberg RF6; Likely not exposed any AFFF (3M Light water or Ansulite). Likely only exposed to Solberg RF6 at Airservices. Participants who commenced after 2010 and were not employed at Darwin or Townsville before their transition to Solberg RF6 (i.e. before 2019 (Darwin) or 2020 (Townsville)

A total of 64 participants did not report the year they commenced service and were not grouped. Some participants did report the year they commenced service, but not the station they commenced service, these participants were still included in the grouping. Thus, there is a possibility that some participants in the 'Solberg RF6 group' may have worked with Ansulite at Darwin or Townsville without reporting this.

C-3 Self-Reported Impacts Related to Possible or Actual Occupational Exposure to PFAS

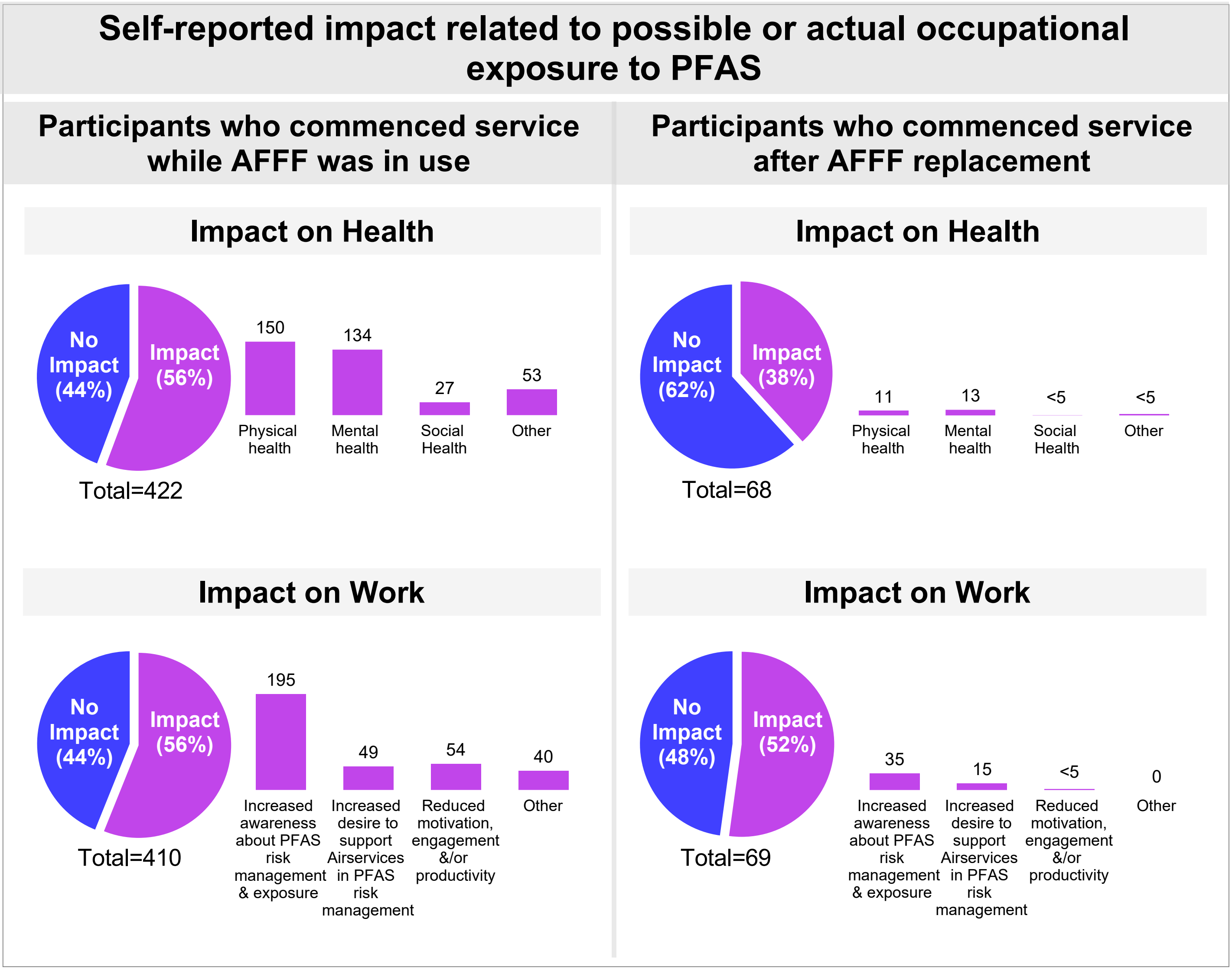

Figure A-4 *Answers related to the questionnaire question 'How has possible or actual, work-related exposure to PFAS impacted you?" Each participant could provide multiple reasons each. Participants are grouped according to what foam was used when they commenced service (see C-2-2). This grouping distinguishes participants with potential direct occupational exposure to AFFF from those whose potential exposure was limited to legacy environmental contamination, allowing comparison of perceived health impacts between these groups.*

C-4 PFAS Serum Concentrations: Cross sectional Trends

C-4-1 Measured PFAS Serum Concentrations

Table A-9 presents the measured PFAS concentrations by participant characteristics. Values are descriptive summaries of the observed data and have not been adjusted for potential confounding factors, including age, blood donation history, or other occupational characteristics. Consequently, apparent differences between groups should be interpreted with caution, as they may partly reflect differences in participant characteristics rather than the grouping variable itself. For example, the higher PFAS concentrations observed among former employees are likely influenced, at least in part, by their older age compared with current employees.

Table A-9 *Measured concentrations of PFAS[1] (ng/mL) in the study cohort.*

			PFOA	PFNA	PFDA	PFHxS	PFHpS	PFOS
Full Study Cohort n=566		Detection Frequency	99%	82%	41%	99%	86%	99%
		Range	<0.11 - 5.1	<0.11 - 1.5	<0.09 - 1.8	<0.07 - 121	<0.06 - 10	<0.26 - 172
		Median	1.1	0.23	0.06	6.4	0.65	14
		Average (SD)	1.3 (0.67)	0.25 (0.16)	0.12 (0.12)	11 (12)	1.1 (1.3)	23 (24)
		p95	2.5	0.49	0.28	32.32	3.6	70.13
By age group	<45 n=102	Median	0.94	0.20	0.09	1.2	0.11	3.1
		Average (SD)	1 (0.48)	0.22 (0.13)	0.13 (0.11)	1.6 (1.3)	0.14 (0.12)	4.1 (4.7)
	>45-60 n=178	Median	1.1	0.22	0.06	2.9	0.31	7.1
		Average (SD)	1.2 (0.63)	0.23 (0.14)	0.12 (0.16)	6.5 (8.6)	0.73 (1)	15 (18)
	>60-75 n=242	Median	1.3	0.24	0.06	15	1.4	31
		Average (SD)	1.4 (0.68)	0.27 (0.16)	0.11 (0.08)	17 (14)	1.7 (1.3)	35 (26)
	>75 n=44	Median	1.3	0.23	0.06	11	1.3	23
		Average (SD)	1.4 (0.94)	0.29 (0.27)	0.1 (0.09)	15 (12)	1.5 (1.4)	34 (28)
By Employment Status	Current n=295	Median	1.10	0.22	0.09	2.04	0.21	5.1
		Average (SD)	1.2 (0.6)	0.24 (0.14)	0.13 (0.14)	6.1 (8.84)	0.68 (1.0)	14 (19)
	Former n=271	Median	1.18	0.23	0.06	13	1.3	28
		Average	1.3 (0.73)	0.26 (0.18)	0.11 (0.08)	15 (13)	1.6 (1.3)	32 (26)
By year of commencement	<2005 n=348	Median	1.2	0.23	0.06	12	1.2	27
		Average (SD)	1.3 (0.68)	0.26 (0.16)	0.11 (0.13)	15 (12)	1.6 (1.3)	31 (25)
	2005-2010 n=77	Median	0.93	0.19	0.06	1.8	0.17	4.1
		Average (SD)	1.1 (0.65)	0.22 (0.14)	0.11 (0.08)	3.3 (5.3)	0.33 (0.53)	7.2 (10.8)
	>2010 n=77	Median	0.98	0.20	0.10	1.1	0.09	2.9
		Average (SD)	1.1 (0.52)	0.22 (0.12)	0.14 (0.11)	1.4 (1.2)	0.12 (0.13)	3.4 (2.3)
By likely foam exposure	3M AFFF n=348	Median	1.23	0.23	0.06	12	1.2	27
		Average (SD)	1.3 (0.68)	0.26 (0.16)	0.11 (0.13)	14 (12)	1.5 (1.3)	31 (25)
	Ansulite n=85	Median	0.94	0.20	0.06	1.8	0.16	4.1
		Average (SD)	1.1 (0.64)	0.22 (0.14)	0.11 (0.08)	3.1 (5.1)	0.31 (0.51)	6.8 (10)
	Solberg n=69	Median	0.97	0.20	0.10	1.1	0.09	2.87
		Average (SD)	1.1 (0.51)	0.21 (0.12)	0.14 (0.12)	1.4 (1.2)	0.12 (0.14)	3.5 (2.3)

1. Only PFAS detected in >15 of the cohort is shown. Values are unadjusted descriptive statistics. Differences between groups do not account for potential confounding factors (e.g., age, blood donation history, employment duration, or year of commencement) and should therefore be interpreted descriptively. Adjusted associations are presented in the regression analyses.

C-4-2 Current vs former employees

To assess differences in PFAS concentrations between current and former employees, ANCOVAs (analysis of covariance) were used. The models adjusted for age and plasma donation history, as both factors are associated with PFAS concentrations.

Outcomes from this assessment is presented in **Table A-10**. Values presented are adjusted geometric mean concentrations. These represent the estimated PFAS concentration for current and former employees after considering differences in age and plasma donation history between the groups. Adjustment allows a fairer comparison between current and former employees by accounting for factors that are known to influence PFAS concentrations.

Table A-10 *Estimated mean PFAS concentrations (ng/mL)[1] among current and former employees when adjusting for age and blood donation*

	Current Employees	**Former employees**	**Difference between groups**
	Mean (95%CI)	Mean (95%CI)	P Value[2]
PFOA	1.1 (1.0-1.2)	1.0 (0.90-1.1)	0.511
PFNA	0.21 (0.20-0.23)	0.20 (0.18-0.21)	0.245
PFDA	0.10 (0.09-0.11)	0.09 (0.08-0.10)	0.106
PFHxS	4.3 (3.6-5.0)	5.5 (4.6-6.5)	0.075
PFHpS	0.46 (0.39-0.54)	0.51 (0.43-0.60)	0.487
PFOS	10.5 (9.0-12.2)	12.5 (10.7-14.5)	0.173

1. Estimated means are adjusted for age and plasma donation history (number of donations in the previous two years). The estimated means represents Age = 59, and blood/plasma donations in the last two years = 2.05. Concentrations are presented as geometric means because PFAS concentrations typically have a skewed distribution.
2. P-values indicate how likely it is that an observed difference or association could have occurred by chance. Smaller p-values indicate stronger evidence that the observed finding is not due to chance. A p-value below 0.05 was considered statistically significant.

*Example of interpretation of **Table A-10**: For PFOS, the adjusted geometric mean concentration was estimated to be 10.5 ng/mL (95% confidence interval (CI): 9.0–12.2 ng/mL) among current employees and 12.5 ng/mL (95% CI: 10.7–14.5 ng/mL) among former employees. Although the estimated PFOS concentration was approximately 19% higher among former employees, the 95% CI overlap and the difference between groups was not statistically significant (p = 0.173, i.e. p=>0.05), meaning the observed difference may be due to chance variation rather than evidence of a true difference between employment groups.*

C-4-3 Elevated PFAS concentrations

Table A-11 *Participants with elevated PFAS serum concentrations i.e. PFAS serum concentrations greater than the 95th Percentile of the Australian Population*

		n in group	Elevated PFOA		Elevated PFHxS		Elevated PFHpS		Elevated PFOS		Elevated Either PFAS	
			n	%	n	%	n	%	n	%	n	%
Full Study Cohort		566	10	2%	324	57%	362	64%	332	73%	372	66%
By age group												
<45		102	2	2%	9	9%	20	20%	9	9%	21	21%
>45-60		178	3	2%	71	40%	96	54%	80	45%	99	56%
>60-75		242	3	1%	206	85%	209	86%	206	85%	212	88%
>75		44	2	5%	37	84%	36	82%	36	82%	39	89%
By Employment Status												
Current		295	5	2%	103	35%	137	46%	112	38%	142	48%
Former		271	5	2%	221	82%	225	83%	220	81%	230	85%
By likely foam exposure at Airservices												
3M AFFF	All	348	4	1%	277	80%	291	84%	282	81%	297	85%
	Did not work elsewhere	215	3	1%	169	79%	179	83%	174	81%	182	85%
Ansulite	All	85	4	5%	13	15%	28	33%	13	15%	30	35%
	Did not work elsewhere	48	2	4%	3	6%	10	21%	4	8%	11	23%
Solberg RF6	All	69	0	0%	2	3%	6	9%	3	4%	7	10%
	Did not work elsewhere	35	0	0%	1	3%	1	3%	0	0%	2	6%

C-4-4 Correlations

Table A-12 *Pearsons r from correlations[1] between PFAS serum concentrations among all participants, numbers in bold and * are significantly correlated (p<0.05).*

	PFOA	PFNA	PFDA	PFHxS	PFHpS	PFOS
PFOA	1.00	0.55	**0.28***	**0.41***	**0.46***	**0.42***
PFNA	**0.55***	1.00	**0.58***	**0.20***	**0.24***	**0.27***
PFDA	**0.28***	**0.58***	**1.00**	0.02	0.03	**0.08***
PFHxS	**0.41***	**0.20***	0.02	1.00	**0.92***	**0.93***
PFHpS	**0.46***	**0.24***	0.03	**0.92***	1.00	**0.93***
PFOS	**0.42***	**0.27***	**0.08***	**0.93***	**0.93***	1.00

0-0.3; weak/no correlation, 0.-0.7 moderate correlation, 0.7-1.0 strong correlation.

*Example interpretation of **Table A-12**: PFHxS and PFOS showed a strong positive correlation (r = 0.93, p < 0.05), indicating that participants with higher PFHxS concentrations also tended to have higher PFOS concentrations. In contrast, PFDA and PFHxS were not correlated (r = 0.02, p >0.05), suggesting no consistent relationship between these compounds.*

C-4-5 PFAS concentration by Likely foam Exposure

Complimentary figure to **Figure 8**

Figure 8 excluded any participants who confirmed that they had worked for other employees where they may have been exposed to AFFF/PFAS, to better show possible exposure at Airservices Stations. **Figure A-5** below show the same figure but including all participants regardless of if the participants had worked for other employees where they may have been exposed to AFFF/PFAS.

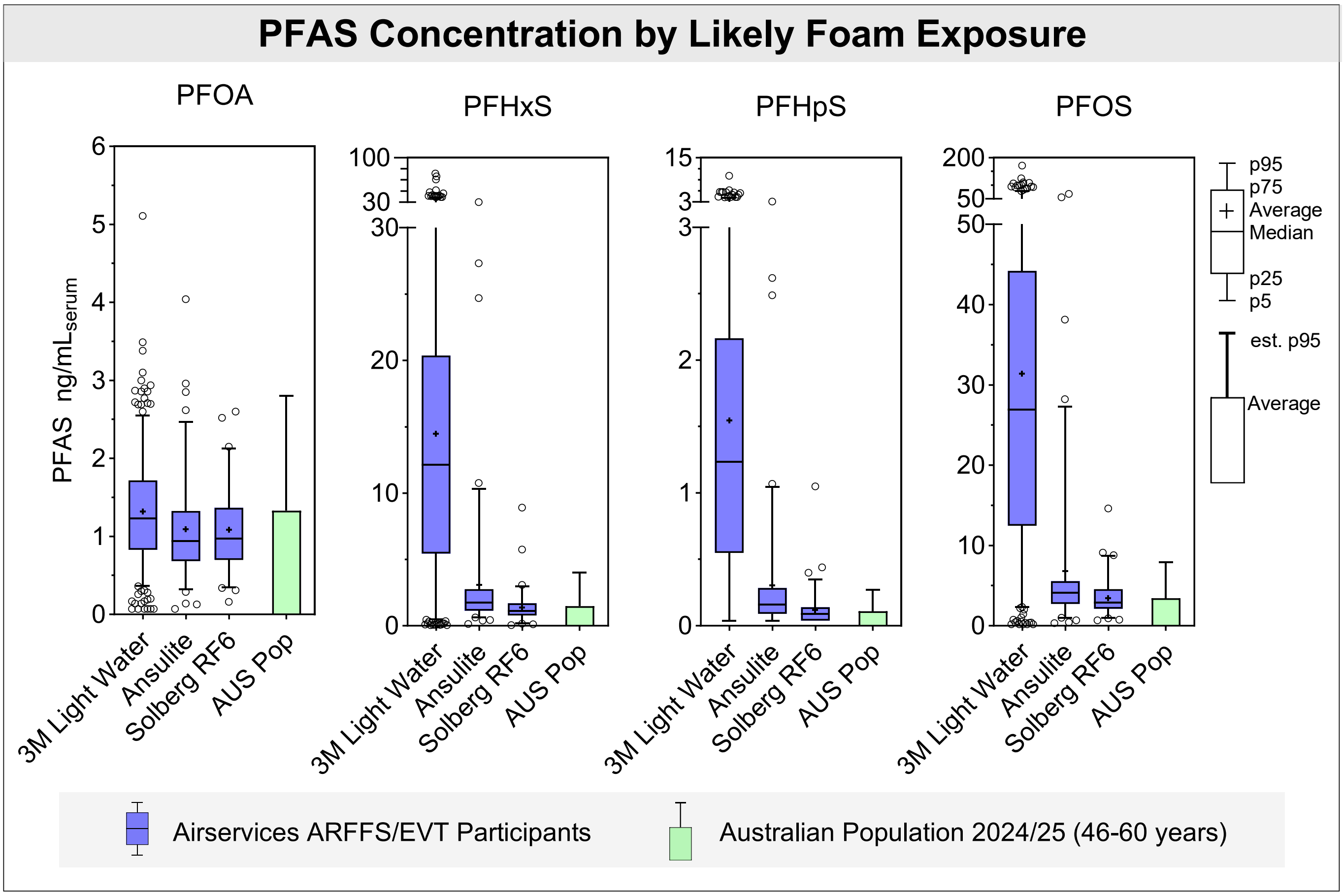

***Figure A-5** PFAS concentrations grouped by category of what foam participants have likely been exposed to at Airservices (blue); 3M Light Water (n=348). Ansulite (n=85) and Solberg RF6 (n=69), and how these concentrations compare to the Australian population (green), estimated from pooled pathology samples collected from 46–60-year-olds in 2024-2025. The current figure includes all participants who confirmed commencement date, regardless of if they had also worked for other employers where they may have been exposed to AFFF. **Note 1:** Blue box-and-whisker plots show the distribution of individual-level PFAS concentrations in the ARFFS/EVT cohort. Australian population data are based on pooled samples and are therefore shown as the average and estimated p95 only. For comparison of average concentrations, the average indicated by "+" in each blue box plot should be compared with the Australian population average (green bar). The box-and-whisker plots additionally illustrate the distribution of individual cohort concentrations. **Note 2;** y-axis is broken to fit the full range of PFAS concentrations.*

Statistical Assessment

The association between serum PFAS concentrations and the likely firefighting foam exposure group (3M Light Water, Ansulite and Solberg RF6) was assessed using analysis of covariance (ANCOVA) general linear model. The analysis adjusted for age, plasma donation history (number of donations in the previous two years), and other employment with potential AFFF/PFAS exposure, as these factors are known to influence PFAS concentrations. A total of 292 participants had provided sufficient information to be included in this assessment.

Results are presented in **Table A-13** as adjusted geometric mean (estimated mean) PFAS concentrations for each likely foam exposure group. These estimated means represent the expected PFAS concentration for participants in each group after accounting for differences in age, plasma donation history and other employment, allowing a fair comparison between groups. Pairwise comparisons between foam exposure groups were performed using Bonferroni-adjusted comparisons, with results presented as the ratio difference between estimated means and corresponding *p*-values.

Table A-13 *Estimated mean PFAS concentrations (ng/mL)[1] among participants current and former employees who were likely exposed to 3M light water, Ansulite and Solberg foams, as well as comparisons between groups, when adjusting for age blood donation and other employments with possible AFFF/PFAS exposure. Statistically significant differences are shown in* ***bold*** *and with a **

	Estimated Means (ng/mL)			**Pairwise Comparison Between groups**					
	3M Light Water	Ansulite	Solberg	3M Light Water vs Ansulite		3M Light Water vs Solberg		Ansulite vs Solberg	
	Mean (95%CI)	Mean (95%CI)	Mean (95%CI)	Ratio Difference ((95%CI))	p-value[2]	Ratio Difference (95%CI)	p-value[2]	Ratio Difference (95%CI)	p-value[2]
PFOS	16.5 (14.7-18.5)	6.4 (5.2-8.1)	4.7 (3.6-6.1)	**2.6* (1.8-3.6)**	0.000	**3.5* (2.4-5.2)**	0.000	1.4 (0.96-2.0)	0.101
PFHpS	0.75 (0.66-0.85)	0.27 (0.21-0.34)	0.15 (0.11-0.21)	**2.8* (1.9-4.1)**	0.000	**4.9* (3.1.0-7.6)**	0.000	**1.7* (1.2-2.6)**	0.003
PFHxS	7.0 (6.1-8)	3.0 (2.3-3.8)	1.8 (1.3-2.5)	**2.3* (1.6-3.4)**	0.000	**3.9* (2.5-6.1.0)**	0.000	**1.7* (1.1-2.5)**	0.011
PFOA	1.1 (1-1.1)	1.0 (0.9-1.2)	1.0 (0.9-1.2)	1.0 (0.90-1.0)	1	1 (0.8-1.0)	1	1.0 (0.82-1.0)	1

1. Estimated means are adjusted for age, plasma donation history (number of donations in the previous two years), and other employment with potential AFFF/PFAS exposure. The estimated means are calculated for a participant with the mean covariate values in the study population (age = 59 years; blood/plasma donations in the previous two years = 2.05). PFAS concentrations are presented as adjusted geometric means because serum PFAS concentrations are positively skewed.
2. P-values indicate how likely it is that an observed difference or association could have occurred by chance. Smaller p-values indicate stronger evidence that the observed finding is not due to chance. A p-value below 0.05 was considered statistically significant.

Example interpretation of ***Table A-13****: After adjustment for age, plasma donation history and other employment with potential AFFF/PFAS exposure, participants in the 3M Light Water group had higher PFOS concentrations compared with both the Ansulite and Solberg groups. Estimated PFOS concentrations were 2.6 times higher in the 3M Light Water group compared with the Ansulite group (ratio difference = 2.6, 95% CI: 1.8–3.6; p < 0.05) and 3.5 times higher compared with the Solberg group (ratio difference = 3.5, 95% CI: 2.4–5.2; p < 0.05). In contrast, PFOS concentrations did not differ significantly between the Ansulite and Solberg groups (ratio difference = 1.4, 95% CI: 0.96–2.0; p = 0.101).*

C-4-6 PFAS Concentrations Among Employees Commencing Service Post 2005

Multiple linear regression was used to examine occupational determinants of PFAS concentrations, with natural log-transformed serum PFAS concentrations modelled against duration of employment after adjustment for age (continuous) and blood donation history (Blood/plasma donor vs no donor). Additional analyses assessed year of commencement of service to distinguish potential cumulative exposure effects from historical or more recent occupational exposures. A total of 74 participants had provided sufficient information to be included in this assessment.

Outcomes from the statistical assessment is shown in ***Table A-14*** Longer duration of employment was associated with higher PFAS concentrations, while earlier commencement of service was also associated with higher concentrations. The findings are consistent with occupational PFAS exposure, with higher concentrations observed among workers with longer employment duration and among those who commenced employment earlier. This pattern suggests that occupational exposures were likely greater historically and that current PFAS concentrations primarily reflect cumulative retention from past exposures rather than recent exposure alone.

Table A-14 *Results from the multiple linear regression models. Model 1 assessed the association between PFAS concentration and the number of years worked at Airservices. Model 2 assessed the association between PFAS concentrations and the year of commencement. Both models were adjusted for age and blood donation history. Regression coefficients were converted to percentage change per increase in increment estimates to aid interpretation[1] Statistically significant associations are shown in* ***bold*** *and with a **

PFAS	Model 1[2]: Years worked		Model 2[2]: Year commenced Service	
	% change, Estimated Mean (95%CI)	p-value[3]	% change, Estimated Mean (95%CI)	p-value[3]
PFOA	**2.9%* (0%, 5.8%)**	0.049	-1.2% (-4.3%, 1.9%)	0.444
PFHxS	**5.6%* (2.2%, 8.9%)**	0.002	**-6.2%* (-9.7%, -2.8%)**	0.001
PFHpS	**4.9%* (1%, 8.8%)**	0.014	**-4.5%* (-8.6%, -0.4%)**	0.033
PFOS	**3.6%* (0.6%, 6.5%)**	0.018	**-3.8%* (-6.8%, -0.7%)**	0.017

1. For example, a beta coefficient of 0.036 In PFAS was interpreted as an estimated 3.6% increase in PFAS concentration for each additional increment increase in year assessed.
2. Correlation between Age and Years of working/year of commencing service <0.4. This is moderate but acceptable
3. P-values indicate how likely it is that an observed difference or association could have occurred by chance. Smaller p-values indicate stronger evidence that the observed finding is not due to chance. A p-value below 0.05 was considered statistically significant.

Example interpretation of ***Table A-14****: For PFOS, after adjusting for age and blood donation history, each additional year worked at Airservices was associated with a 3.6% increase in PFOS concentrations (95% CI: 0.6% to 6.5%; p< 0.05). Conversely, each one-year later commencement of service was associated with 3.8% lower PFOS concentrations (95% CI: −6.8% to −0.7%; p<0.05). Both associations were statistically significant (p<0.05), which suggests that this association is unlikely to be explained by chance alone. Together, these findings suggest that longer employment duration and earlier commencement of service were associated with higher PFOS concentrations, independent of age and blood donation history.*

C-5 Changes in PFAS Serum Concentrations: Temporal Trends

C-5-1 Overall Temporal Trends

The trend was estimated across all samples collected since 2018/19, by fitting individual regression lines between natural log-transformed serum PFAS serum concentration and the elapsed time across all sample collections (including 2-6 samples (average 3.7 samples) for each individual). The slope of the regression line was used to estimate the annual % change. This participant-level approach provides a straightforward descriptive summary of longitudinal trends and allows the distribution of individual rates of change to be presented. This approach provides a simple and intuitive summary of individual temporal trends; however, it does not account for the unbalanced longitudinal design, as participants contributed different numbers of samples and therefore regression slopes were estimated with differing precision. Furthermore, these analyses were not adjusted for participant characteristics or other factors that may influence PFAS elimination. Consequently, the estimated annual percentage changes should be interpreted as descriptive summaries of the observed trends rather than adjusted population-level estimates.

Table A-15 *Temporal trends[1] in PFAS serum concentrations among Airservices III study participants estimated between 2018/19 and 2025/26.*

			Annual Change (%)				Corresponding half-life (years)[3]	
		n	Average	Median	Q1[2]	Q3[2]	Average	Median
PFOA	All	511	-5.4% (7.1%)	-5%	-7.7%	-2.4%	12.5	13.6
	Blood/Plasma donors[4]	136	-8.3% (10.2%)	-6.7%	-11.1%	-2.7%	8.0	10.1
	Non donors[4]	310	-4.4% (4.7%)	-4.7%	-6.8%	-2.3%	15.6	14.4
PFHxS	All	511	-5.8% (9.3%)	-5.2%	-7.5%	-2.9%	11.7	13.1
	Blood/Plasma donors[4]	136	-8.9% (12.5%)	-8%	-13.1%	-4.3%	7.4	8.3
	Non donors[4]	310	-4.6% (7.6%)	-4.9%	-6.3%	-2.8%	14.7	13.8
PFHpS	All	511	-7.5% (9%)	-6.2%	-9.1%	-3.8%	8.9	10.8
	Blood/Plasma donors[4]	136	-10.8% (12.2%)	-9.6%	-16.7%	-4.4%	6.0	6.9
	Non donors[4]	310	-6.1% (6.6%)	-5.9%	-7.7%	-3.7%	11.0	11.5
PFOS	All	511	-6.1% (7.3%)	-4.8%	-7.4%	-2.8%	10.9	14.2
	Blood/Plasma donors[4]	136	-10.5% (10.7%)	-8.1%	-13.5%	-4.1%	6.2	8.2
	Non donors[4]	310	-4.5% (4.3%)	-4.3%	-6%	-2.4%	15.1	15.9

1. The trend was estimated across all samples collected since 2018/19 with 2-6 samples (average 3.7 samples) by fitting regression lines between PFAS serum concentration and the elapsed time across all sample collections.
2. Q1 and Q2 correspond to the 25th and 75th percentiles, respectively, defining the range containing the middle 50% of participants.
3. Corresponding Half-life is calculated from the average/median annual change observed in the full study population
4. Blood/Plasma donors: participants who reported that they had donated either blood or plasma at least once between 2018/19 and 2025/26. Non donors: participants who confirmed that they had not donated blood or plasma between 2018/19 and 2025/26.

C-5-2 Correlations

Table A-16 *Pearsons r from correlations between annual change in PFAS serum concentrations among all participants with longitudinal measures, numbers in* ***bold*** *and with * are significantly correlated ($p<0.05$).*

	PFOA	PFHxS	PFHpS	PFOS
PFOA	1.00	**0.66***	**0.51***	**0.73***
PFHxS	**0.66***	1.00	**0.72***	**0.78***
PFHpS	**0.51***	**0.72***	1.00	**0.69***
PFOS	**0.73***	0.78*	0.69*	1.00

0-0.3; weak/no correlation, 0.-0.7 moderate correlation, 0.7-1.0 strong correlation.

Example interpretation of ***Table A-16****: Annual changes in PFHxS and PFOS were strongly positively correlated (r = 0.78, p < 0.05), indicating that participants who decreased faster in PFHxS also tended to decrease faster in PFOS. Annual changes in PFOA and PFHxS showed a moderate positive correlation (r = 0.66, p < 0.05), suggesting that changes in these compounds were related but less closely aligned than those observed between PFHxS and PFOS.*

C-5-3 Individual Half lives

Individual half-lives were estimated only for participants demonstrating a meaningful decline in serum PFAS concentrations. A meaningful decline was defined as an overall model-predicted percentage decrease over the follow-up period exceeding the analytical uncertainty, estimated as the 95th percentile of absolute percentage differences between duplicate analyses. For eligible participants, PFAS elimination rates were estimated from log-linear regression models of serum concentrations over time, with half-lives calculated from the regression slope. **Table A-17** show the mean/median individual half-lives estimated in the population. The large inter-individual variation is shown in **Figure A-6.**

Table A-17 *Individual half-lives[1] (years) in among Airservices III study participants, estimated between 2018/19 and 2025/26.*

		n	Average	Median	Q1[4]	Q3[4]
PFOA	All	334	10.4 (5)	9.9	7.1	13.3
PFHxS	All	393	11.7 (6.1)	11.1	7.3	14.7
	Elevated at baseline[2]	277	11.4 (5.5)	10.9	8.0	13.8
	Background at baseline[3]	111	12.7 (7.3)	12.2	6.8	16.9
PFHpS	All	367	8.8 (4)	8.8	6.0	11.4
	Elevated at baseline	262	9 (3.9)	9.0	6.6	11.2
	Background at baseline	105	8 (4.3)	7.9	3.9	11.5
PFOS	All	294	9.9 (4.7)	9.9	6.7	12.8
	Elevated at baseline	190	10.5 (4.8)	10.6	7.7	13.3
	Background at baseline	104	8.7 (4.2)	8.8	5.0	11.6

1. Individual half-lives were estimated only for participants demonstrating a meaningful decline in serum PFAS concentrations. A meaningful decline was defined as an overall model-predicted percentage decrease over the follow-up period exceeding the analytical uncertainty, estimated as the 95th percentile of absolute percentage differences between duplicate analyses.
2. Elevated group; Participants whose PFAS concentration measured in their first available sample in the time trend assessed (i.e. in either 2018/19 Airservices exposure Study or any collections since), were greater than the estimated 95th percentile of the Australian population in 2018/19.
3. Background Group Participants whose PFAS concentration measured in their first available sample in the time trend assessed (i.e. in either 2018/19 Airservices exposure Study or any collections since), were comparable to those of the Australian population in 2018/19). <5% of the participants had elevated PFOA concentrations. Thus, half-lives are just shown among the full study group.
4. Q1 and Q2 correspond to the 25th and 75th percentiles, respectively, defining the range containing the middle 50% of participants.

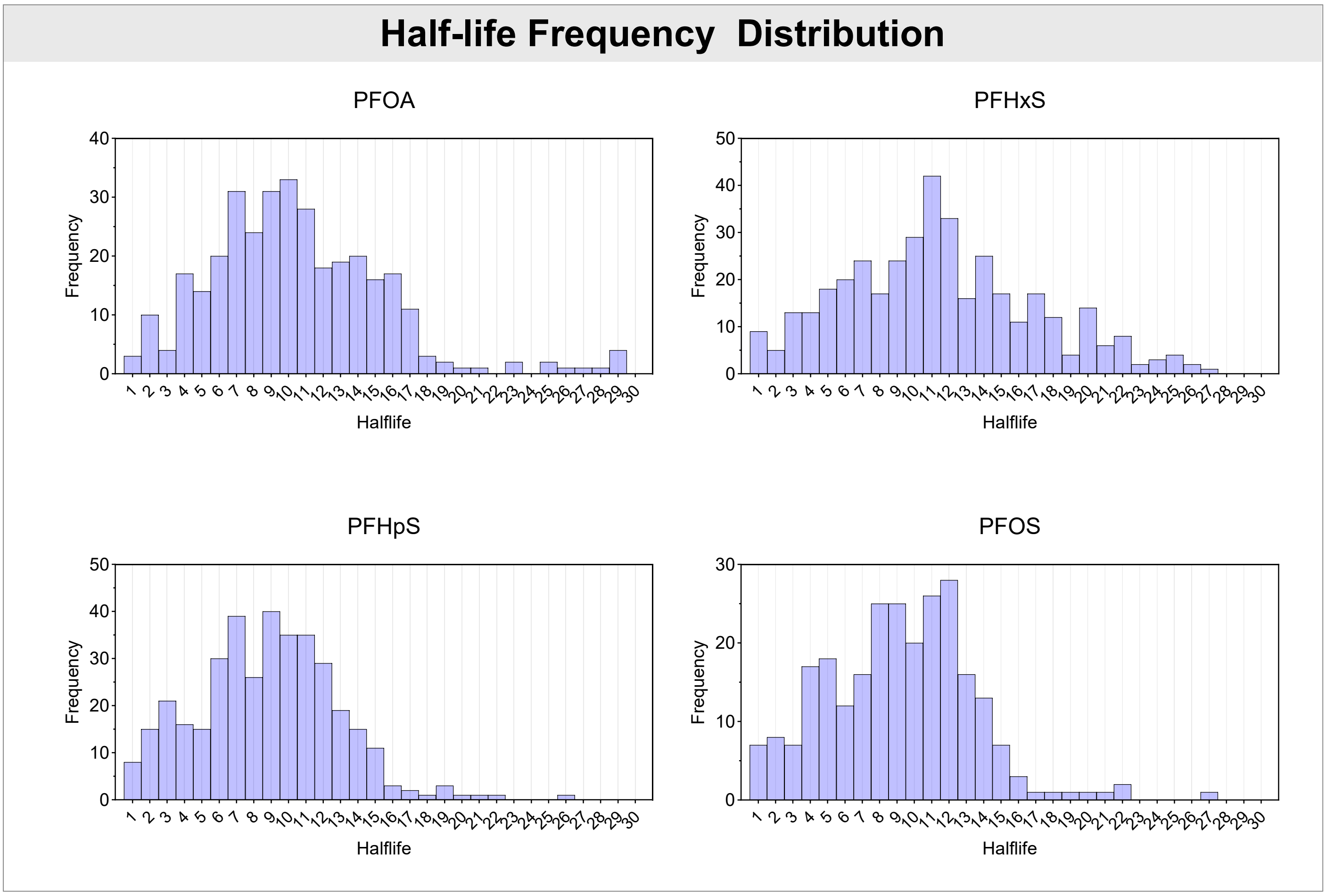

Figure A-6 *Distribition of individual half-lives estimated among Airservices ARFFS/EVT participants between 2018/19-2024/25. Outliers (Half-lives >30 years, n=4) were are excluded from the graph.*

C-5-4 Change in PFAS concentration by Employment Status

Longitudinal changes in serum PFAS concentrations were assessed using linear mixed-effects models to account for repeated measurements collected from the same participants over time. Trends were estimated among 452 participants who provided longitudinal samples and completed the relevant questions in the questionnaire (**Table A-18**).

Separate models were fitted for each PFAS compound, with the natural log-transformed serum PFAS concentration included as the dependent variable. Elapsed time (years) was modelled as a continuous variable. Fixed effects included employment status during the 2018/19–2025/26 study period (Employed or former employee), baseline PFAS concentration category (elevated or background), recent blood/plasma donation status (donation within the previous two years; yes/no), age at first sample, and interactions between elapsed time and each covariate to assess whether PFAS trajectories differed between groups.

$$\begin{aligned}\ln\left(PFAS_{ij}\right) = \beta_0 + \beta_1 Employment_i + \beta_2 Donation_i + \beta_3 PFASGroup_i\, \beta_4 Age_i + \beta_5 Time_{ij} \\ + \beta_6\left(Time_{ij} \times Employment_i\right) + \beta_7\left(Time_{ij} \times Donation_i\right) + \beta_8\left(Time_{ij} \times PFASGroup\right) \\ + \beta_9\left(Time_{ij} \times Age\right) + u_{0i} + u_{1i} Timeij + \epsilon_{ij}\end{aligned}$$

Where's;

Fixed effects

β_0: population average intercept (expected log PFAS at baseline for the reference group)

$\beta_1 Employment_i$: difference between current and former employees

$\beta_2 Donation_i$: difference in PFAS concentration by recent blood/plasma donation status

$\beta_3 PFASGroup_i$: difference between elevated and background baseline PFAS groups

$\beta_4 Age_i$: association between age at first sample and PFAS concentration

$\beta_5 Time_{ij}$: average change in log PFAS per year for the reference group

Time interactions (these modify the PFAS decline rate)

$\beta_6(Time \times Employment)$: whether the PFAS trajectory differs between current and former employees

$\beta_7(Time \times Donation)$: whether the PFAS trajectory differs by blood/plasma donation status

$\beta_8(Time \times PFASGroup)$: whether the PFAS trajectory differs between elevated and background PFAS groups

$\beta_9(Time \times Age)$: whether the PFAS trajectory differs by age

Random effects:

u_{0i}: participant-specific random intercept accounting for differences in baseline PFAS concentrations between individuals

$u_{1i} Time_{ij}$: participant-specific random slope accounting for differences in PFAS trajectories over time

ϵ_{ij}: residual error representing within-participant variation not explained by the model

Models were estimated using restricted maximum likelihood (REML), with an unstructured covariance matrix specified for the random effects. Model-based predictions were generated from the fitted models to estimate adjusted PFAS trajectories for current and former employees, stratified by baseline PFAS concentration category and recent blood/plasma donation status, while adjusting for age.

Table A-18 *Overview of the longitudinal Cohort included in the model*

Variable	Summary Demographics	
Participants	n	452
Total samples	n	1655
Median follow-up	years	6.24 years
Blood donors	(%)	30%
Elevated PFOA	(%)	2%
Elevated PFHxS	(%)	61%
Elevated PFHpS	(%)	62%
Elevated PFOS	(%)	60%
Employees[1]	(%)	66%
Worked at Avalon station	(%)	3%

1. Employees were defined as anyone who worked at some point during the 2018/19 -2025/26 period, based on information provided in the questionnaire.

Two analyses were conducted to assess the robustness of PFAS temporal trends. The primary analysis excluded participants who reported working at Avalon Station between 2020 and 2023 (n=14), due to potential PFAS exposure through contaminated drinking water during this period. A sensitivity analysis was subsequently conducted including all participants with longitudinal PFAS measurements. **Table A-19** (Excluding participants from Avalon) and **Table A-20** (All participants) present the model-estimated annual percentage changes in serum PFAS concentrations, stratified by baseline PFAS concentration category (elevated or background), employment status (employed or former employee during the assessed time period), and recent blood/plasma donation status. Estimates represent adjusted annual changes derived from the linear mixed-effects models and are presented with 95% confidence intervals. Estimates are adjusted for age, and time interaction terms. This adjustment allows comparison of PFAS trajectories between employed and former employed participants while accounting for differences in participant characteristics.

Across all PFAS compounds, participants with elevated baseline PFAS concentrations generally experienced greater annual declines than those with background concentrations. Participants who had donated blood/plasma within the previous two years also generally demonstrated greater annual declines than non-donors. Differences between current and former employees were consistently small, with substantial overlap in the 95% confidence intervals, indicating no evidence of statistically significant differences in PFAS trajectories according to employment status after adjustment for age, baseline PFAS concentration, and blood/plasma donation status. The absence of differences in PFAS decline between employed participants and former employees suggests that ongoing employment-related exposure is unlikely to be a major contributor to PFAS concentrations during the study period, consistent with continued reduced occupational exposure following changes in firefighting foam use and management practices

Table A-19 *Adjusted annual change (%)[1] in serum PFAS concentrations by employment status, blood/plasma donation status, and baseline PFAS concentration category, excluding participants who confirmed that they worked at Avalon Station*

PFAS	Employment status	Elevated		Background	
		Donor	Non-Donor	Donor	Non-Donor
		Average (CI95%)	Average (CI95%)	Average (CI95%)	Average (CI95%)
PFOA[2]	Employed			-8.0 (-9.3, -6.7)	-2.9 (-3.8, -2)
	Former Employee			-8.8 (-10.7, -6.8)	-3.7 (-5.6, -1.8)
PFHxS	Employed	-12.0 (-14, -9.9)	-5.4 (-7, -3.8)	-8.6 (-10.3, -7)	-1.8 (-3.1, -0.4)
	Former Employee	-12.4 (-15.2, -9.6)	-5.8 (-8.5, -3.1)	-9.1 (-11.4, -6.6)	-2.2 (-4.6, 0.2)
PFHpS	Employed	-13.9 (-15.9, -11.8)	-7.0 (-8.6, -5.4)	-10.9 (-12.6, -9.2)	-3.8 (-5.2, -2.4)
	Former Employee	-14.6 (-17.4, -11.7)	-7.7 (-10.4, -4.9)	-11.6 (-14.1, -9.2)	-4.6 (-7, -2.1)
PFOS	Employed	-12.2 (-14, -10.4)	-5.0 (-6.4, -3.6)	-10.9 (-12.4, -9.4)	-3.6 (-4.8, -2.3)
	Former Employee	-12.5 (-15.1, -9.9)	-5.3 (-7.8, -2.7)	-11.2 (-13.3, -9)	-3.8 (-6, -1.6)

1. Annual percentage changes were calculated from model-derived log-scale slopes and back-transformed to the original PFAS scale. Estimates are adjusted for age, employment status, baseline PFAS, recent blood/plasma donation status, and time interactions.
2. Estimates for elevated PFOA were not presented due to insufficient numbers of participants classified in this category.

Table A-20 *Adjusted annual change (%)[1] in serum PFAS concentrations by employment status, blood/plasma donation status, and baseline PFAS concentration category, including all participants with longitudinal PFAS measures.*

PFAS	Employment status	Elevated		Background	
		Donor	Non-Donor	Donor	Non-Donor
		Average (CI95%)	Average (CI95%)	Average (CI95%)	Average (CI95%)
PFOA[2]	Employed			-8.3 (-9.6, -7.1)	-2.9 (-3.8, -1.9)
	Former Employee			-9 (-10.9, -7)	-3.6 (-5.5, -1.6)
PFHxS	Employed	-11.6 (-13.8, -9.3)	-5.5 (-7.2, -3.6)	-7.1 (-8.9, -5.3)	-0.7 (-2.2, 0.8)
	Former Employee	-12.2 (-15.2, -9)	-6.1 (-9, -3)	-7.7 (-10.4, -5)	-1.4 (-4, 1.3)
PFHpS	Employed	-12.9 (-15, -10.7)	-6.7 (-8.4, -5)	-9.2 (-11, -7.4)	-2.8 (-4.4, -1.3)
	Former Employee	-13.7 (-16.7, -10.5)	-7.6 (-10.5, -4.6)	-10.1 (-12.7, -7.4)	-3.7 (-6.3, -1)
PFOS	Employed	-12.0 (-13.7, -10.2)	-4.8 (-6.2, -3.3)	-10.9 (-12.3, -9.4)	-3.5 (-4.8, -2.2)
	Former Employee	-12.1 (-14.7, -9.4)	-4.9 (-7.4, -2.3)	-11 (-13.2, -8.7)	-3.7 (-5.8, -1.4)

1. Annual percentage changes were calculated from model-derived log-scale slopes and back-transformed to the original PFAS scale. Estimates are adjusted for age, employment status, baseline PFAS, recent blood/plasma donation status, and time interactions.
2. Estimates for elevated PFOA were not presented due to insufficient numbers of participants classified in this category.

*Example interpretation of **Table A-19**: PFOS concentrations declined over time across all participant groups, with all estimated annual changes being negative. Declines were generally similar between employed and former employees. Overlapping 95% confidence intervals suggest no significant difference in PFOS trajectories according to employment status. Among participants with elevated baseline PFOS concentrations, annual declines ranged from 12.2% (95% CI: -14.0% to -10.4%) in employed participants and 12.5% (95% CI: -15.1% to -9.9%) in former employees among blood donors, and from 10.9% (95% CI: -12.4% to -9.4%) in employed participants to 11.2% (95% CI: -13.3% to -9.0%) in former employees among non-donors. Among participants with background PFOS concentrations, declines were smaller, ranging from 3.6% (95% CI: -4.8% to -2.3%) in employed non-donors to 5.3% (95% CI: -7.8% to -2.7%) in former donors. Overall, the trajectories indicate faster declines among participants with elevated baseline PFOS concentrations, and those who were donors, while employment status had little influence on the rate of PFOS decline.*

C-5-5 Change in PFAS concentration by Station

To assess whether PFAS concentration trends differed between Airservices stations, a linear mixed-effects model was fitted among participants with longitudinal PFAS measurements. The model accounted for repeated measurements collected from the same participants over time through the inclusion of participant-specific random effects. The assessment was limited to 149 participants who had identified in their questionnaire both the station(s) they had worked at and corresponding year of working at the station (between 2018-2025/26), as well as had provided information about blood donation (**Table A-21**). Only stations with a minimum of six participants were assessed to ensure sufficient sample size for meaningful comparisons, as well as safeguard the confidentiality of participants. Participants who had worked at more than one station during this time were grouped according to their most recent station.

The natural log-transformed serum PFAS concentration (lnPFAS) was included as the dependent variable. Elapsed time (years) was modelled as a continuous variable to estimate changes in PFAS concentrations over time. Fixed effects included station, baseline PFAS concentration category (elevated vs background), recent blood/plasma donation status (donation within the previous two years; yes/no), and age at first sample collection. Interaction terms between elapsed time and station were included to assess whether PFAS trajectories differed between stations, which may indicate differences in ongoing exposure patterns or elimination rates.

$$\begin{aligned}\ln(PFAS_{ij}) = \quad & \beta_0 + \beta_1(Station_i) + \beta_2(Donation_i) + \beta_3(PFASGroup_i) + \beta_4(Age_i) + \beta_5(Time_{ij}) \\ & +\beta_6(Time_{ij} \times Station_i) + u_{0i} + u_{1i}(Time_{ij}) + \epsilon_{ij}\end{aligned}$$

Where:

Fixed effects

β_0: population-average intercept, representing the expected log PFOS concentration at baseline for the reference station and reference categories of the other covariates.

$\beta_1(Station_i)$: difference in baseline PFAS concentration between each station and the reference station. Since station is a categorical variable, this represents a set of coefficients comparing each station with the reference station.

$\beta_2(Donation_i)$: difference in baseline PFAS concentration according to recent blood/plasma donation status.

$\beta_3(PFOSGroup_i)$: difference in baseline PFAS concentration between participants with elevated and background PFAS concentrations.

$\beta_4(Age_i)$: association between age at first sample collection and PFOS concentration.

$\beta_5(Time_{ij})$: average annual change in log PFAS concentration over time for the reference station.

Time interactions (these modify the PFAS decline rate)

$\beta_6(Time_{ij} \times Station_i)$: assesses whether the annual change in PFAS concentration differs between stations. This represents the difference in PFAS trajectory (slope) for each station compared with the reference station.

Random effects

u_{0i}: participant-specific random intercept accounting for differences in baseline PFAS concentrations between individuals.

$u_{1i}(Time_{ij})$: participant-specific random slope accounting for differences in PFAS change over time between individuals.

ϵ_{ij}: residual error representing within-participant variation not explained by the model.

The inclusion of random intercepts and random slopes allowed participants to have different baseline PFAS concentrations and different rates of PFAS change over time.

Table A-22 presents the estimated mean annual percentage change in serum PFAS concentrations for each station, with corresponding 95% confidence intervals, adjusted for baseline PFAS category, age, and recent blood/plasma donation status. This adjustment allows comparison of PFAS trajectories between stations while accounting for differences in participant characteristics and initial PFAS concentration.

Table A-21 *Stations and respective number of participants and samples included in the station specific assessment*

Stations		No People	No samples
Adelaide	ADL	13	84
Avalon	AVV	11	66
Brisbane	BNE	13	78
Cairns	CNS	8	48
Coolangatta	OOL	10	60
Melbourne	MEL	15	90
Perth	PER	16	90
Sydney	SYD	17	102
Townsville	TSV	6	36
Northern Territory Stations[1]	NT	8	36
Queensland Stations[1]	QLD	16	108
Tasmania Stations[1]	TAS	8	48
Western Australia Stations[1]	WA	8	48
Total		149	894
Participants who worked at multiple stations		40 (27%)	

1. Stations with participants less than 6 were grouped together according to state; NT: Darwin, Alice Springs and Ayers Rock; QLD: Mackay, Rockhampton, Sunshine Coast, Hamilton Island; TAS: Hobart and Launceston; WA: Broome, Karratha, Newman and Port Headland

Table A-22 *Adjusted annual change (%)[1] in serum PFAS concentrations by employment status, blood/plasma donation status, and baseline PFAS concentration category, including all participants with longitudinal PFAS measures*

	PFOA	PFHxS	PFHpS	PFOS
Stations[2]	Mean Annual Change (CI95%)	Mean Annual Change (CI95%)	Mean Annual Change (CI95%)	Mean Annual Change (CI95%)
ADL	-4.5 (-8.6, -0.3)	-5.4 (-11.5, 0.7)	-8.7 (-14.5, -2.9)	-7.2 (-11.8, -2.5)
AVV	-8.9 (-13.9, -3.9)	7.2 (-0.3, 14.6)	5.5 (-1.6, 12.6)	-9.2 (-14.8, -3.5)
BNE	-4.8 (-9, -0.6)	-6.1 (-12.2, 0.1)	-5.9 (-11.7, -0.1)	-4.9 (-9.6, -0.2)
CNS	-5.4 (-11.4, 0.6)	-7.4 (-16.4, 1.6)	-7 (-15.6, 1.6)	-11.1 (-15.8, -6.3)
OOL	-3.3 (-8.2, 1.5)	-8.1 (-15.4, -0.8)	-5.5 (-12.4, 1.3)	-9.8 (-15.3, -4.3)
MEL	-2.7 (-6.7, 1.2)	-5.7 (-11.6, 0.2)	-7.8 (-13.4, -2.2)	-5.1 (-9.6, -0.6)
PER	-3 (-7.1, 1)	-3.2 (-9.2, 2.7)	-4.7 (-10.4, 0.9)	-4.9 (-9.5, -0.3)
SYD	-3.8 (-7.5, 0)	-4.7 (-10.2, 0.8)	-6.5 (-11.7, -1.3)	-5 (-9.2, -0.8)
TSV	0.1 (-6.4, 6.5)	-6.3 (-16.1, 3.5)	-10.1 (-19.5, -0.6)	-5.5 (-12.9, 1.8)
NT	-6.5 (-12.8, -0.1)	-9.1 (-18.6, 0.4)	-11.1 (-20, -2.1)	-6.9 (-14.1, 0.2)
QLD	-3.1 (-6.8, 0.5)	-3.5 (-9, 1.9)	-4.3 (-9.5, 0.8)	-5.4 (-9.5, -1.2)
TAS	-2.2 (-7.7, 3.4)	-3.5 (-11.9, 4.9)	-2.7 (-10.7, 5.3)	-2.6 (-8.9, 3.7)
WA	-4.9 (-10, 0.5)	-6.9 (-14.2, 1)	-3.5 (-10.7, 4.2)	-5.7 (-11.4, 0.3)
Weighted Mean Change	-4.04	-4.47	-5.48	-6.22

1. Annual percentage changes were calculated from model-derived log-scale slopes and back-transformed to the original PFAS scale. Estimates are adjusted for age, employment status, baseline PFAS category, recent blood/plasma donation status, and time interactions.
2. See table **Table A-21**

*Example interpretation: **Table A-22** After adjustment for baseline PFAS concentration category, age, and recent blood/plasma donation status, PFHxS concentrations generally declined across stations. For example, at Coolangatta, PFHxS decreased by an estimated 8.1% per year (95% CI: -15.4%, -0.8%). In contrast, Avalon showed a positive estimated change of 7.2% per year (95% CI: -0.3%, 14.6%) for PFHxS; however, the confidence interval included zero, indicating that this increase was not statistically significant.*

Appendixes References

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