Off-Site Human Health Risk Assessment
December 2017

Executive Summary

RAAF Base Williamtown
Stage 2B Environmental Investigation
Department of Defence
Executive Summary

Introduction

As part of the 2017 Stage 2B Environmental Investigation (2017 Stage 2B EI), AECOM Australia Pty Ltd (AECOM) was engaged by the Department of Defence (Defence) to undertake an off-Site human health risk assessment (HHRA) as part of its response to the detection of per- and poly-fluoroalkyl substances (PFAS) contamination associated with historical activities at the Royal Australian Air Force (RAAF) Base Williamtown, in New South Wales (the Site) (Figure F1, Appendix A).

The Site has been an active airbase since 1941. The Site is headquarters of the Air Combat Group, including several aviation squadrons and support organisations which conduct training and operational activities. As was common practice across Australian industry, and as part of typical airbase activities, aqueous film forming foam (AFFF) was used at the Site for fire training and emergency response.

Previous environmental investigations, including the 2015 Stage 2A Environmental Investigation (2015 Stage 2A EI), 2016 Stage 2B Environmental Investigation (2016 Stage 2B EI) and 2017 Stage 2B Environmental Investigation (2017 Stage 2B EI), have identified the presence of PFAS, including perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA), on and in the vicinity of the Site in soil, groundwater, surface water, sediment, terrestrial biota and seafood. The environmental investigations have been documented in the following reports:

- Stage 2B Environmental Investigation Report (2016 Stage 2B EI) (AECOM, 2016a)
- Off-Site Human Health Risk Assessment (2016 HHRA) (AECOM, 2016b)
- Preliminary Ecological Risk Assessment (2016 ERA) (AECOM, 2016c)

On 3 September 2015, the NSW government defined an area encompassing the Site and surrounds as the ‘NSW Environment Protection Authority (EPA) Investigation Area’. The NSW EPA Investigation Area was determined through consultation between NSW EPA, Williamtown Contamination Expert Panel (WCEP), Hunter Water and Department of Primary Industries (DPI), and based on consideration of surface water drainage patterns and groundwater flow directions in the region and preliminary surface water and groundwater PFAS concentrations. The NSW EPA Investigation Area (as updated 21 October 2015) is shown in Figure F1, Appendix A and in Appendix B.

Groundwater and surface water from the NSW EPA Investigation Area is understood to be currently (or to have been historically) used for a range of purposes, including as a potable water supply and for domestic activities.

The 2016 HHRA identified a number of data gaps or uncertainties requiring further assessment. Subsequently, additional investigation works have been conducted as part of the 2017 Stage 2B EI to address these data gaps by further characterising the nature and extent of PFAS impacts and potential for human exposure to PFAS in soil, groundwater, surface water, sediment, home grown produce, and seafood. This 2017 HHRA therefore provides an updated assessment of potential risk to human health based on these additional data. For the purpose of this HHRA, risk refers to the comparison of the estimated human exposure to PFAS, expressed as daily chemical intake, with a toxicological value referred to as a tolerable daily intake (TDI), adjusted to account for background exposure.

Residents within the NSW EPA Investigation Area have been advised by the NSW government to take precautions to minimise their exposure to PFAS pending further information becoming available. The precautions, released in April 2017 which remained current as of 18 November 2017 are as follows:

- Do not use groundwater, bore water or surface water for drinking or cooking
- Avoid swallowing groundwater or surface water when bathing, showering, swimming and paddling
- It is safe to drink water from the reticulated supply (town water)
- Avoid eating home grown food produced using contaminated water, including home slaughtered meat, eggs, milk, poultry, fruit and vegetables
- Moderate intake of, and seek further advice, regarding home produce that was grown within the area but was not produced with contaminated water
- People who personally source and eat fish and seafood from a body of water where the water is contaminated, such as fishers and local residents, should moderate the number of servings of individual species.

These precautions will be referred to by this HHRA as the ‘April 2017 NSW government precautionary advice’.

It is noted that during the finalisation of this report, on the 19 November 2017, the NSW government revised its precautionary advice based on data presented in a draft of this HHRA.

**Context of Risk Assessment**

A phased approach to the assessment of risks has been adopted in consultation with the NSW EPA. It is understood that the NSW EPA has been advised by the WCEP. The WCEP was established under Division 4 of the *Protection of the Environment Administration Act 1991* for the purpose of providing informed scientific advice to the NSW EPA to assist in developing the NSW government’s response to Defence in relation to investigations to characterise and manage the PFAS contamination associated with the Site.

The phases of the human health risk assessment reporting process are as follows:

- Preliminary human health risk assessments previously reported by the NSW government:
  - Preliminary Dietary Exposure Assessment – Seafood – Tilligerry Creek and Fullerton Cove, Williamtown NSW, WCEP dated 3 November 2015 (WCEP, 2015a)
  - Preliminary Dietary Exposure Assessment – Commercial Oysters – Tilligerry Creek and Fullerton Cove, Williamtown NSW, WCEP dated 20 October 2015 (WCEP, 2015b)
  - Preliminary PFOS Risk Assessment for Seafood – Hunter River prawns (WCEP, 2015c)
- AECOM 2016b, Off-Site Human Health Risk Assessment, RAAF Base Williamtown Stage 2B Environmental Investigation (2016 HHRA), which:
  - presented a multiple pathway HHRA to evaluate the potential human health risks to identified receptors within the Williamtown area from PFAS contamination
  - included consideration of direct contact exposures to environmental media (e.g. soil, groundwater, surface water, sediment) as well as secondary exposures via dietary intakes, including seafood and home-grown plant and animal produce
  - assessed potentially complete exposure pathways identified by community surveys.

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1. The EPA advice observes that in the Williamtown area, it may be difficult to ensure produce is not exposed to PFAS migrating from the Site. Therefore, the EPA advice recommends that cultivation techniques such as raised garden beds watered with reticulated water may be appropriate and that further advice should be sought from the EPA.

2. The EPA advice recommends that people who personally source and eat fish and seafood from the Hunter River Estuary, Fullerton Cove and Tilligerry Creek, such as fishers and local residents, should limit the number of servings of individual species. Sourcing seafood from a variety of locations including the ocean and waterways outside these areas will assist in minimising exposure. Seafood for sale remains safe to eat. The recommended maximum number of servings per day, based on an 150 gram serving, varies per species type.
• AECOM 2017a, Addendum to Off-Site Human Health Risk Assessment – July 2016. Sensitivity Assessment of Outcomes of Food Standards Australia New Zealand Tolerable Daily Intakes, which:
  - assessed whether the adoption of the Commonwealth Department of Health’s (DoH) health based guidance values (HBGV) developed in 2017 by Food Standards Australia New Zealand (FSANZ) for PFOS, PFOA and perfluorohexane sulfonate (PFHxS) would affect the conclusions of the 2016 HHRA. All other parameters remained consistent with the 2016 HHRA. The final HBGVs for PFAS were released on 3 April 2017 by the DoH. These HBGVs were developed by FSANZ at the request of DoH and replace the interim guidelines released in June 2016 by the Environmental Health Standing Committee (enHealth)
  - concluded that the overall outcome of adopting the more conservative (i.e. lower) 2017 FSANZ HBGV is an increase in the estimated hazard index (HI) for each pathway/scenario modelled.
• AECOM 2017b, Off-Site Human Health Risk Assessment, RAAF Base Williamtown Stage 2B Environmental Investigation (2017 HHRA) – this report, which:
  - updates the 2016 HHRA using additional data collected as part of the 2017 Stage 2B EI to address data gaps identified in the 2016 HHRA
  - is based on the 2017 FSANZ TDI.

The area investigated as part of the 2016 Stage 2B EI and 2017 Stage 2B EI to inform the staged risk assessments described above is hereafter referred to as the Stage 2B Investigation Area. The Stage 2B Investigation Area includes the on-Site and off-Site areas, both within the NSW EPA Investigation Area and outside the NSW EPA Investigation Area. The focus of this risk assessment is the identified off-Site receptors only. No assessment of the potential risk to on-Site receptors has been made in this HHRA.

Objectives of the HHRA

The overall objective of this HHRA is to quantitatively assess the potential human health risks to identified off-Site receptors associated with exposure to PFAS impacted soil, groundwater, surface water, sediment, terrestrial biota and seafood within the off-Site Stage 2B Investigation Area. This HHRA follows from and builds on previous quantitative risk assessments and is part of the phased approach to the assessment of risks adopted in consultation with the NSW EPA.

HHRA Framework and Methodology

The assessment of potential human health risks associated with environmental contamination has been conducted in accordance with the National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013) [ASC NEPM 2013]. The HHRA has been prepared in accordance with the ASC NEPM 2013 and Environmental Health Risk Assessment, Guidelines for Assessing Human Health Risks from Environmental Hazards, Department of Health and Aging, 2012 Update (enHealth, 2012a).

Exposure Assessment

To facilitate preparation of the HHRA a conceptual site model (CSM) was prepared based on the available information to identify the following:

• a source and mechanism of chemical release
• a retention or transport medium (or media where chemicals are transferred between media)
• a point of potential human contact with the contaminated media

3 The FSANZ HBGV presented by DoH was in the form of an oral tolerable daily intake (TDI). The term TDI is used in the remainder of this HHRA to be consistent with the Australian regulatory framework.
an exposure route (e.g. ingestion, inhalation) at the point of exposure.

Where a linkage between a source and receptor via a complete pathway was identified, these were assessed quantitatively in the HHRA.

The focus of this risk assessment is the identified off-Site receptors only. Therefore, the representative groups of people (receptors) who may be exposed to the PFAS contamination assessed in the HHRA were considered to be:

- residents (including adults, children and infants)
- (recreational) creek and drain users (land based)
- recreational (marine water) users (marine based)
- local farmers
- commercial fishers
- council workers.

Identification of the potential frequency, extent and duration of exposure to environmental media by the above groups of receptors via identified exposure pathways was based on information gathered from community surveys and from published data from Australian and international sources.

Representative exposure point concentrations (EPC) were identified through evaluation of the available data characterising the environmental media and the current understanding of how off-Site receptors might be exposed to PFAS contamination in the environment.

Overall the data quantity and quality are considered to be sufficient for refinement and characterisation of PFAS related contamination in off-Site areas for the purpose of this HHRA.

Toxicity Assessment

The use of screening level (‘Tier 1’) generic assessment criteria for selection of chemicals of potential concern (CoPC) is not considered appropriate for this HHRA because PFAS have the potential to bioaccumulate within the food chain. Available Tier 1 guideline values have not been established which are protective of the potential for bioaccumulation via all potential pathways. The identification of CoPC for this HHRA was therefore based on the availability of toxicity reference values (TRV) either released by an authoritative Australian body, such as the DoH, or derived in a manner consistent with relevant Australian guidelines, for those PFAS detected above the laboratory limit of reporting (LOR).

It is noted that there is currently no consistent evidence that exposure to the PFAS assessed in this HHRA causes adverse human health effects (FSANZ, 2017b). However, because these chemicals have been shown to have health effects in animals and because these chemicals persist in humans and the environment, enHealth (2016b) recommended that human exposure to these chemicals is minimised as a precaution. The TRV adopted in this HHRA were the tolerable daily intakes (TDI) sourced from FSANZ (2017a) for PFOS, PFHxS and PFOA, and from ToxConsult (2016b) for PFHxA.

The TDI is a daily intake which, over a lifetime, is considered to be without appreciable adverse health effects, based on toxicological studies and incorporating a range of uncertainty (safety) factors. It is noted that exceeding the TDI does not necessarily mean that health effects will occur.

Risk Characterisation

Areas Adopted for Risk Characterisation – Soil and groundwater

Similar to the 2016 HHRA, the groundwater and unsaturated soil PFAS concentrations reported from the area immediately south of the Site are not consistent with the groundwater and unsaturated soil PFAS concentrations reported for the broader off-Site Stage 2B Investigation Area. The extent of the Southern Area has been refined compared to the 2016 HHRA and has been assessed as a specific zone as part of this risk assessment.
The additional soil and groundwater data collected as part of the 2017 Stage 2B EI, combined with historical data, has allowed for the development of a second soil and groundwater area referred to as the Eastern Area. This area, generally along the alignment of Moor’s Drain but also extending around the Southern Area and east of the Site, is characterised by lower soil and groundwater concentrations than the Southern Area, but higher concentrations than the broader off-Site Stage 2B Investigation Area.

Therefore, potential risks to residents from soil and groundwater have been assessed separately in:

- the Southern Area
- the Eastern Area
- the remainder of the off-Site Stage 2B Investigation Area.

The Southern Area and Eastern Area are illustrated on Figure F2, Appendix A.

Areas Adopted for Risk Characterisation – Surface Water and Sediment

The collection of additional surface water and sediment data has also allowed for refinement of the assessment of land based exposure to users of the creeks and drains across the off-Site Stage 2B Investigation Area. Similar to the groundwater and soil areas, three distinct land-based surface water regions have been established for the purpose of assessing risk associated with surface water and sediment exposure:

- Region 1 – characterised by the area east of the Site, generally following Moors Drain and discharging at the tidal portion of Tilligerry Creek
- Region 2 – characterised by the area along Tilligerry Creek south-east of the Site which discharges in the tidal portion of Tilligerry Creek
- Region 3 – characterised by the surface water drainage network south of the Site, which predominantly discharges at Fullerton Cove.

Region 1, Region 2 and Region 3 are illustrated on Figure F2, Appendix A and described further in Section Error! Reference source not found. and Section Error! Reference source not found..

Risk Estimates

In calculating the risk, the following is noted:

- An elevated risk refers to a group of exposure pathways with common exposure mechanisms where the estimated human exposure to PFAS is more than half of the TDI
- A low and acceptable risk refers to a group of exposure pathways with common exposure mechanisms where the estimated human exposure to PFAS is less than half of the TDI
- The ‘typical’ exposure scenario is intended to represent typical and average exposure scenarios for the majority of the population based on a combination of site-specific data, published values, and ‘common sense’ professional judgement. It is anticipated that the assessment of the typical scenario will be applicable to the majority of the population
- The ‘upper’ exposure scenario is based on reasonable maximum exposure and is intended to represent receptors that undertake activities at a higher frequency or ingest more than the average person. It is considered that the exposure frequency and quantity assumed by the upper scenario will only apply to a small percentage of the population
- Groundwater results used in calculation of risk were taken from residential bores and shallow groundwater monitoring wells which were considered representative of groundwater abstracted from the shallow aquifer beneath the off-Site Stage 2B Investigation Area. However, for the purposes of ongoing management, all recommended precautions applicable to groundwater should be applied to all accessible groundwater, irrespective of depth.

Risk estimates for the groundwater and soil areas and surface water and sediment regions are presented in Section Error! Reference source not found..
Conclusions

The following conclusions are provided with respect to the potential for elevated human health risks to identified off-Site human receptors as a result of PFAS concentrations reported in soil, groundwater, surface water, sediment, terrestrial biota and seafood within the off-Site Stage 2B Investigation Area.

Table ES1 to Table ES3 provide an overall risk summary for the various exposure pathways identified by the HHRA.

As above, residents living inside the NSW EPA Investigation Area have been advised by the NSW government to take precautions to minimise their exposure to PFAS pending further information becoming available.

In summary, the assessment undertaken within this HHRA concludes that if people within the off-Site Stage 2B Investigation Area follow the April 2017 NSW government precautionary advice, their exposure to PFAS is unlikely to exceed the TDI. Conversely, it is concluded that unrestricted exposure to PFAS across the off-Site Stage 2B Investigation Area is likely to result in an exceedance of the TDI.

The conclusions of the risk estimate calculations for each of the groundwater and soil areas and surface water and sediment regions have resulted in a number of common recommended precautions. Where recommended precautions are applicable to more than one area or region, similar management outcomes are recommended. Considering the future management recommendations identified across the off-Site Stage 2B Investigation Area, four Risk Zones have been identified; referred to as Risk Zone A to Risk Zone D (refer to Figure F19 in Appendix A).

These conclusions should be read in conjunction with the data gaps presented in Section Error! Reference source not found. and sensitivity assessment presented in Section Error! Reference source not found..

Risk Zone A

Risk Zone A is defined by the footprint of the Southern Area, which includes a portion of Region 3.

- The potential risks to residents from PFAS exposure through the following relevant exposure pathways are considered to be low and acceptable:
  - inhalation of dust (from soil irrigated by PFAS impacted groundwater or flooded by PFAS impacted surface water)
  - dermal contact with groundwater as a result of indoor use, outdoor use (including swimming pools, dams and surface water bodies) and irrigation
  - incidental ingestion of soil as a result of outdoor activities
  - dermal contact with soil as a result of outdoor activities
  - dermal contact with surface water from drains and/or creeks as a result of outdoor recreational use and domestic irrigation (i.e. watering gardens and lawns)
  - incidental ingestion and dermal contact with sediment (drains/creeks) as a result of outdoor activities
  - consumption of low to moderate quantities of locally sourced seafood (including finfish, prawns and crabs)
  - consumption of locally grown fruit

- Exposure of residents to PFAS impact through the following exposure pathways may result in elevated risks under conservative scenarios considered representative of typical and upper level exposure:
  - ingestion of groundwater
  - incidental ingestion of groundwater as a result of indoor use, outdoor use and irrigation, specifically:
    - showering and bathing using extracted groundwater
- food preparation and clean-up
- filling swimming pools and children’s wading pools with extracted groundwater
- sprinkler play with extracted groundwater
- during domestic irrigation (i.e. watering gardens or lawns)
- consumption of eggs from home grown backyard poultry
- consumption of home grown vegetables

Exposure of residents, commercial fishermen and farmers from relevant exposure pathways to PFAS impact may result in elevated risks under conservative scenarios considered representative of upper level exposure:
- consumption of home grown and home slaughtered beef
- consumption of home grown cow milk
- consumption of locally sourced seafood (finfish only)
- Incidental ingestion of surface water from drains and/or creeks as a result of swimming/outdoor recreational use

**Recommended Precautions Risk Zone A**

Consistent with the April 2017 NSW government advice, it is suggested that consideration is given to the following for Risk Zone A:
- Continue to not drink groundwater
- Continue to not use extracted groundwater for:
  - showering and bathing
  - food preparation and clean-up
  - filling swimming pools and children’s wading pools
  - sprinkler play
  - domestic irrigation (i.e. watering gardens or lawns)
- Continue to not consume eggs from home grown backyard poultry that are exposed to surface water or groundwater containing detectable PFAS concentrations as their primary source of drinking water and/or soil or plants that have been irrigated or flooded with water containing detectable PFAS concentrations
- Continue to minimise consumption of nuts that have been irrigated with surface water or groundwater containing detectable PFAS concentrations and/or have been grown in soil that has been irrigated or flooded with water containing detectable PFAS concentrations
- Continue to minimise consumption of milk from dairy cows that are exposed to surface water or groundwater containing detectable PFAS concentrations as their primary source of drinking water and/or soil or plants that have been irrigated or flooded with water containing detectable PFAS concentrations
- Continue to minimise consumption of home slaughtered beef from cattle exposed to surface water or groundwater containing detectable PFAS concentrations as their primary source of drinking water supply and/or soil or plants that have been irrigated or flooded with water containing detectable PFAS concentrations
- Continue to minimise the consumption of high quantities of locally caught finfish
- Continue to minimise the ingestion of surface water during swimming and recreational activities within creeks and drains.
Risk Zone B

Risk Zone B is defined by the footprint of the Eastern Area, which includes a portion of both Region 1 and Region 3.

- The potential risks to residents from PFAS exposure through the following relevant exposure pathways are considered to be low and acceptable:
  - inhalation of dust (from soil irrigated by PFAS impacted groundwater or flooded by PFAS impacted surface water)
  - dermal contact with groundwater as a result of indoor use, outdoor use (including swimming pools, dams and surface water bodies) and irrigation
  - incidental ingestion of groundwater as a result of indoor use (excluding drinking water)
  - incidental ingestion of soil as a result of outdoor activities
  - dermal contact with soil as a result of outdoor activities
  - dermal contact with surface water as a result of outdoor recreational use (drains/creeks) and domestic irrigation
  - incidental ingestion and dermal contact with sediment (drains/creeks) as a result of outdoor activities
  - consumption of low to moderate quantities of locally sourced seafood (including finfish, prawns and crabs)
  - consumption of locally grown fruit

- Exposure of residents to PFAS impact through the following exposure pathways may result in elevated risks under conservative scenarios considered representative of typical and upper level exposure:
  - ingestion of groundwater
  - consumption of eggs from home grown backyard poultry

- Exposure of residents, commercial fishermen and farmers from relevant exposure pathways to PFAS impact may result in elevated risks under conservative scenarios considered representative of upper level exposure:
  - incidental ingestion of groundwater as a result of outdoor use, specifically:
    - filling swimming pools and children’s wading pools with extracted groundwater.
  - consumption of home grown and home slaughtered beef
  - consumption of home grown cow milk
  - consumption of locally sourced seafood (finfish only)
  - consumption of home grown vegetables
  - Incidental ingestion of surface water from drains and/or creeks as a result of swimming/outdoor recreational use

- Recommended Precautions Risk Zone B

Consistent with the April 2017 NSW government advice, it is suggested that consideration is given to the following for Risk Zone B:

- Continue to not drink groundwater
- Continue to not fill swimming pools and children’s wading pools with extracted groundwater
- Continue to not consume eggs from home grown backyard poultry that are exposed to surface water or groundwater containing detectable PFAS concentrations as their primary source of drinking water and/or soil or plants that have been irrigated or flooded with water containing detectable PFAS concentrations
- Continue to minimise consumption of vegetables that have been irrigated with surface water or groundwater containing detectable PFAS concentrations and/or have been grown in soil that has been irrigated or flooded with water containing detectable PFAS concentrations.

- Continue to minimise consumption of milk from dairy cows that are exposed to surface water or groundwater containing detectable PFAS concentrations as their primary source of drinking water and/or soil or plants that have been irrigated or flooded with water containing detectable PFAS concentrations.

- Continue to minimise consumption of home slaughtered beef from cattle exposed to surface water or groundwater containing detectable PFAS concentrations as their primary source of drinking water supply and/or soil or plants that have been irrigated or flooded with water containing detectable PFAS concentrations.

- Continue to minimise consumption of high quantities of locally caught finfish.

- Continue to minimise the ingestion of surface water during swimming and recreational activities within creeks and drains.

**Risk Zone C**

Risk Zone C is defined by that portion of the footprint of the remainder of the off-Site Stage 2B Investigation Area which corresponds with Region 1 and Region 3.

- The potential risks to residents from PFAS exposure through the following relevant exposure pathways are considered to be low and acceptable:
  - drinking groundwater. It is noted that less than 1.5% of groundwater samples, adopted in the HHRA, from within the remainder of the off-Site Stage 2B Investigation Area were reported to contain PFAS concentrations greater than the 2017 drinking water criteria (FSANZ, 2017a). Therefore, it is recommended that groundwater only be consumed where the average concentration is known to be less than the drinking water criteria.
  - inhalation of dust (from soil irrigated by PFAS impacted groundwater or flooded by PFAS impacted surface water).
  - dermal contact with groundwater as a result of indoor use, outdoor use (including swimming pools, dams and surface water bodies) and domestic irrigation.
  - incidental ingestion of groundwater as a result of indoor use (excluding drinking water) or outdoor use (swimming pools, irrigation [i.e. watering gardens or lawns]).
  - incidental ingestion of soil as a result of outdoor activities.
  - dermal contact with soil as a result of outdoor activities.
  - dermal contact with surface water from drains and/or creeks as a result of outdoor recreational use and domestic irrigation (i.e. watering gardens and lawns).
  - incidental ingestion and dermal contact with sediment from drains and/or creeks as a result of outdoor activities.
  - consumption of low to moderate quantities of locally sourced seafood (including finfish, prawns and crabs).
  - consumption of locally grown fruit.

- Exposure of residents to PFAS impact through the following exposure pathway may result in elevated risks under conservative scenarios considered representative of typical and upper level exposure:
  - consumption of eggs from home grown backyard poultry.

- Exposure of residents, commercial fishermen and farmers from relevant exposure pathways to PFAS impact may result in elevated risks under conservative scenarios considered representative of upper level exposure:
- consumption of home grown and home slaughtered beef
- consumption of home grown cow milk
- consumption of locally sourced seafood (finfish only).
- Incidental ingestion of surface water from drains and/or creeks as a result of swimming/outdoor recreational use

**Recommended Precautions Risk Zone C**

Consistent with the April 2017 NSW government advice, it is suggested that consideration is given to the following for Risk Zone C:

- Drink groundwater only if the average concentration does not exceed the drinking water guidelines established by FSANZ (2017a)
- Continue to not consume eggs from home grown backyard poultry that are exposed to surface water or groundwater containing detectable PFAS concentrations as their primary source of drinking water and/or soil or plants that have been irrigated or flooded with water containing detectable PFAS concentrations
- Continue to minimise consumption of milk from dairy cows that are exposed to surface water or groundwater containing detectable PFAS concentrations as their primary source of drinking water and/or soil or plants that have been irrigated or flooded with water containing detectable PFAS concentrations
- Continue to minimise consumption of home slaughtered beef from cattle exposed to surface water or groundwater containing detectable PFAS concentrations as their primary source of drinking water supply and/or soil or plants that have been irrigated or flooded with water containing detectable PFAS concentrations
- Continue to minimise consumption of high quantities of locally caught finfish
- Continue to minimise the ingestion of surface water during swimming and recreational activities within creeks and drains

**Risk Zone D**

Risk Zone D is defined by that portion of the footprint of the remainder of the off-Site Stage 2B Investigation Area which corresponds with Region 2.

- The potential risks to residents from PFAS exposure through the following relevant exposure pathways are considered to be low and acceptable:
  - drinking groundwater. It is noted that less than 1.5% of groundwater samples, adopted in the HHRA, from within the remainder of the off-Site Stage 2B Investigation Area were reported to contain PFAS concentrations greater than the 2017 drinking water criteria (FSANZ, 2017a). Therefore, it is recommended that groundwater only be consumed where the average concentration is known to be less than the drinking water criteria
  - inhalation of dust (from soil irrigated by PFAS impacted groundwater or flooded by PFAS impacted surface water)
  - dermal contact with groundwater as a result of indoor use, outdoor use (including swimming pools, dams and surface water bodies) and domestic irrigation
  - incidental ingestion of groundwater as a result of indoor use (excluding drinking water) or outdoor use (swimming pools, irrigation [i.e. watering gardens or lawns])
  - incidental ingestion of soil as a result of outdoor activities
  - dermal contact with soil as a result of outdoor activities
  - incidental ingestion and dermal contact with surface water from drains and/or creeks as a result of outdoor recreational use and domestic irrigation (i.e. watering gardens and lawns)
• incidental ingestion and dermal contact with sediment (drains/creeks) as a result of outdoor activities.
• consumption of low to moderate quantities of locally sourced seafood (including finfish, prawns and crabs)
• consumption of locally grown fruit

- Exposure of residents to PFAS impact through the following exposure pathway may result in elevated risks under conservative scenarios considered representative of typical and upper level exposure:
  - consumption of eggs from home grown backyard poultry

- Exposure of residents, commercial fishermen and farmers from relevant exposure pathways to PFAS impact may result in elevated risks under conservative scenarios considered representative of upper level exposure:
  - consumption of home grown and home slaughtered beef
  - consumption of home grown cow milk
  - consumption of locally sourced seafood (finfish only).

• **Recommended Precautions Risk Zone D**

  Consistent with the April 2017 NSW government advice, it is suggested that consideration is given to the following for Risk Zone D:
  - Drink groundwater only if the average concentration does not exceed the drinking water guidelines established by FSANZ (2017a).
  - Continue to not consume eggs from home grown backyard poultry that are exposed to surface water or groundwater containing detectable PFAS concentrations as their primary source of drinking water and/or soil or plants that have been irrigated or flooded with water containing detectable PFAS concentrations
  - Continue to minimise consumption of milk from dairy cows that are exposed to surface water or groundwater containing detectable PFAS concentrations as their primary source of drinking water and/or soil or plants that have been irrigated or flooded with water containing detectable PFAS concentrations
  - Continue to minimise consumption of home slaughtered beef from cattle exposed to surface water or groundwater containing detectable PFAS concentrations as their primary source of drinking water supply and/or soil or plants that have been irrigated or flooded with water containing detectable PFAS concentrations
  - Continue to minimise consumption of high quantities of locally caught finfish.

**Council Workers**

The potential risks to a council worker from exposure to PFAS impact are considered to be low and acceptable from all pathways assessed.

**Marine Environment**

The potential risks to recreational and commercial fishers from exposure to PFAS in the marine environment are considered to be low and acceptable, from all pathways assessed, with the exception of the consumption of high quantities of finfish.
### Table ES1 – Overall risk summary – Risk Zones A to D

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<td>Dermal contact with soil as a result of outdoor activities</td>
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<td>Low &amp; Acceptable</td>
<td>Low &amp; Acceptable</td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td>Inhalation of Dust as a result of indoor and outdoor activities (from soil irrigated by PFAS impacted groundwater or flooded by PFAS impacted surface water)</td>
<td>Low &amp; Acceptable</td>
<td>Low &amp; Acceptable</td>
<td>Low &amp; Acceptable</td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td><strong>Locally sourced food (from the land)</strong></td>
<td></td>
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<tr>
<td></td>
<td>Upper</td>
<td>Typical</td>
<td>Upper</td>
<td>Typical</td>
</tr>
<tr>
<td>Consumption of eggs from home grown backyard poultry that are exposed to groundwater or surface water as their primary drinking water supply and/or consumed soil or plants that have accumulated PFAS from irrigation water</td>
<td>Elevated</td>
<td>Elevated</td>
<td>Elevated</td>
<td>Elevated</td>
</tr>
<tr>
<td>Consumption of locally grown vegetables</td>
<td>Elevated</td>
<td>Elevated</td>
<td>Elevated</td>
<td>Low &amp; Acceptable</td>
</tr>
</tbody>
</table>

**Land-based surface water and Sediment**

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Incidental ingestion of surface water as a result of swimming/ outdoor recreational use (drains/creeks)</td>
<td>Elevated</td>
<td>Low &amp; Acceptable</td>
<td>Elevated</td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td>Dermal contact with surface water as a result of outdoor recreational use (drains/creeks) and irrigation</td>
<td>Low &amp; Acceptable</td>
<td>Low &amp; Acceptable</td>
<td>Low &amp; Acceptable</td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td>Incidental ingestion sediment (drains/creeks) as a result of outdoor activities</td>
<td>Low &amp; Acceptable</td>
<td>Low &amp; Acceptable</td>
<td>Low &amp; Acceptable</td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td>Dermal contact with sediment (drains/creeks) as a result of outdoor activities</td>
<td>Low &amp; Acceptable</td>
<td>Low &amp; Acceptable</td>
<td>Low &amp; Acceptable</td>
<td>Low &amp; Acceptable</td>
</tr>
</tbody>
</table>
### Exposure Pathway

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</thead>
<tbody>
<tr>
<td></td>
<td>Upper</td>
<td>Typical</td>
<td>Upper</td>
<td>Typical</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Responder</th>
<th>Risk Zone</th>
<th>Potential Exposure</th>
</tr>
</thead>
</table>

#### Locally sourced food (from the land)

**Residential Receptors**

**Consumption of beef** from locally grown cattle and exposed to surface water or groundwater as their primary drinking water supply and/or consumed soil or plants that have accumulated PFAS from irrigation water

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>Elevated</td>
<td>Low &amp; Acceptable</td>
<td>Elevated</td>
<td>Low &amp; Acceptable</td>
</tr>
</tbody>
</table>

**Local Farmer Receptor**

**Consumption of beef** from locally grown cattle and exposed to surface water or groundwater as their primary drinking water supply and/or consumed soil or plants that have accumulated PFAS from irrigation water

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<thead>
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<tbody>
<tr>
<td></td>
<td>Elevated</td>
<td>Elevated</td>
<td>Elevated</td>
<td>Elevated</td>
</tr>
</tbody>
</table>

**Consumption of milk** from locally grown cattle and exposed to surface or groundwater as their primary source of drinking water and/or soil or plants that have accumulated PFAS from irrigation water

<table>
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<tbody>
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<td>Elevated</td>
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</tbody>
</table>

#### Notes:

1. It is suggested that where PFAS concentrations in water exceeding the FSANZ (2017a) drinking water guideline that consideration be given to restricting drinking groundwater or using it to prepare food.

2. As noted in Section 7.15 this Risk Zone encompasses part of Region 1 and Region 3. The more conservative risk outcome, from Region 3, is presented in the table. It is noted that the consumption of milk from animals in Region 2 under the typical scenario would be low and acceptable.

3. Under circumstances where exposure of backyard chickens to media containing detectable PFAS can be prevented Scolexia (2017) estimated that a period of 100 days after cessation of PFAS exposure to hens would be required for all four PFAS studied to reduce to less than the laboratory LOR in eggs.
<table>
<thead>
<tr>
<th>Exposure Pathway</th>
<th>Receptor/Exposed Community</th>
<th>PFAS Exposures - Marine Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Upper</td>
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<tr>
<td></td>
<td></td>
<td>Typical</td>
</tr>
<tr>
<td><strong>Sediment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incidental ingestion of sediment as a result of fishing</td>
<td>Commercial fisher</td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td>Dermal contact with sediment as a result of fishing</td>
<td>Commercial fisher</td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td><strong>Surface Water</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incidental ingestion of surface water as a result of fishing</td>
<td>Commercial fisher</td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td>Dermal contact with surface water as a result of fishing</td>
<td>Commercial fisher</td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td>Incidental ingestion of sediment as a result of outdoor activities (i.e. fishing, boating and swimming)</td>
<td>Recreational user (marine)</td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td>Dermal contact with sediment as a result of outdoor activities (i.e. fishing, boating and swimming)</td>
<td>Recreational user (marine)</td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td>Incidental ingestion of surface water as a result fishing and boating</td>
<td>Recreational user (marine)</td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td>Dermal contact with surface water as a result fishing and boating</td>
<td>Recreational user (marine)</td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td>Incidental ingestion of surface water as a result swimming</td>
<td>Recreational user (marine)</td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td>Dermal contact with surface water as a result swimming</td>
<td>Recreational user (marine)</td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td><strong>Locally sourced food (from the marine environment)</strong></td>
<td>Recreational user (marine)</td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td>Consumption of high quantities of locally sourced finfish</td>
<td>Commercial fisher</td>
<td>Elevated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td>Consumption of high quantities of locally sourced crustaceans (prawns, crabs)</td>
<td>Commercial fisher</td>
<td>Low &amp; Acceptable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low &amp; Acceptable</td>
</tr>
</tbody>
</table>
### Table ES3 - Overall risk summary – council worker

<table>
<thead>
<tr>
<th>Exposure Pathway</th>
<th>Receptor</th>
<th>PFAS Exposures – Council Worker</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Upper</td>
<td>Typical</td>
<td></td>
</tr>
<tr>
<td><strong>Incidental ingestion sediment and soil as a result of outdoor activities</strong></td>
<td>Council worker</td>
<td>Low &amp; Acceptable</td>
<td>Low &amp; Acceptable</td>
<td></td>
</tr>
<tr>
<td><strong>Dermal contact with sediment and soil as a result of outdoor activities</strong></td>
<td>Council worker</td>
<td>Low &amp; Acceptable</td>
<td>Low &amp; Acceptable</td>
<td></td>
</tr>
<tr>
<td><strong>Incidental ingestion of surface water during routine maintenance work in drains / creeks</strong></td>
<td>Council worker</td>
<td>Low &amp; Acceptable¹</td>
<td>Low &amp; Acceptable</td>
<td></td>
</tr>
<tr>
<td><strong>Dermal contact with surface water during routine maintenance work in drains / creeks</strong></td>
<td>Council worker</td>
<td>Low &amp; Acceptable</td>
<td>Low &amp; Acceptable</td>
<td></td>
</tr>
</tbody>
</table>

Note: 1 – assumes council worker is not a resident