RAAF Base Tindal

Prepared for
Department of Defence

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Quality information

Revision history

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EXECUTIVE SUMMARY

Introduction

Department of Defence has engaged Coffey Environments Australia Pty Ltd (Coffey) to undertake a Detailed Site Investigation (DSI) of per- and polyfluoroalkyl substance (PFAS) at the Royal Australian Air Force (RAAF) Base Tindal (the Base). The extent of the Investigation Area of the DSI includes the Base, and surrounding off-Base areas to the extent necessary (based on current understanding) to characterise the nature and extent of PFAS contamination derived from RAAF Base Tindal activities. The Investigation Area is shown on Figure E.1.

This document is a summary of the assessment and findings that are detailed in the Detailed Site Investigation Report (reference 754-MELEN199420_R05, dated 12 February 2018).

Figure E.1: Investigation area

The Base is located approximately 13 km south-east of the township of Katherine in the Northern Territory (approximately 320 km south-east of Darwin). The Base covers an area of approximately 122 square kilometres. The formal Base facility forms a small portion of the overall land area, the remainder of which is composed of Eucalypt bushland and open forest.

PFAS Background

PFAS are a group of manufactured chemicals that have been used since the 1950s in products that are resistant to heat, water and oil. Due to their heat resistant properties, and ability to form aqueous film forming foams (AFFF), they have been used extensively in fire-fighting foam applications in Australia for decades. A significant amount of research has been conducted into the health and ecological effects of these substances, and they are understood to be highly persistent within the environment, readily leachable from soils, and bio-accumulate up the food-chain. The potential health and ecological effects of these substances are not well defined, however given their environmental persistence, Environmental Health Standing Committee (enHealth) have issued a precautionary warning to limit exposure to humans from these compounds.
Defence has historically used PFAS containing AFFF on the greater Defence Estate between 1983 and 2009. Defence recognised that the former use of these chemicals may have impacted on the environment. They are seeking to better understand the nature and extent of PFAS impacts via a comprehensive investigation of PFAS conditions to meet the aims of Defence's National Plan for managing PFAS contamination.

AFFF containing PFAS were routinely used for fire training activities, hangar and fuel farm fire suppression system operation and testing, incident response and response equipment testing. The volume and extent of AFFF discharged at each of these source areas is likely to have varied considerably, and it is recognised that several of the identified on-Base source areas present a higher likelihood of PFAS impact (such as where AFFF was used frequently including fire training areas and hangars).

The fully fluorinated compounds (per) are water soluble and mobile, and will tend to migrate with water. Different compounds in the PFAS group adsorb at different rates to organic carbon in soil and long chain compounds (six or more carbons) bio accumulate in animals. Due to the mobility, PFAS compounds can be present in very large plumes associated with groundwater migration and surface waters. Organic rich sediments may act as ongoing or seasonal sources of PFAS contamination to surface waters through leaching. The fully fluorinated compounds (per) found in the AFFF fire extinguishing agent does not readily degrade in the environment and are known to be highly persistent, remaining for many years following release.

Objective and Scope

The environmental investigation of potential PFAS contamination is focussed on characterising sources of contamination as a result of the use, storage and waste management of historical AFFF products on the Defence Estate. In accordance with the principles of the National Environment Protection (Assessment of Site Contamination) Measure, a conceptual site model has been developed to identify possible connections between potential contamination and humans, the human food chain and ecology. Sampling of soils, waters and biota has been conducted to validate the model, and quantify the exposure pathways between the sources and receptors. These outcomes will then guide the development and implementation of appropriate risk management actions associated with identified PFAS risks.

The objective of the DSI was to:

- Identify known and potential sources of PFAS contamination.
- Characterise the Base setting sufficient to describe likely contaminant migration behaviour.
- Identify receptors and the associated exposure concentrations.
- Delineate and characterise PFAS contamination in source areas on the Base to inform preliminary risk assessment and contaminant transport models

The DSI works program included:

- Literature review of over 30 historical reports and documents.
- Collection and analysis of approximately 470 soil and sediment samples for PFAS.
- Collection and analysis of 100 surface water samples across multiple events, including on-Base drains, Tindal Creek and Katherine River.
- Installation of 44 targeted groundwater monitoring wells.
- Collection and analysis of 306 groundwater samples from 173 locations between April 2017 and September 2017.
- Vertical profiling in 18 groundwater wells and aquifer hydraulic conductivity testing in 22 wells.
- Collection and analysis of aquatic biota including 24 whole body fish and crayfish samples from four locations in Tindal Creek and three locations in Katherine River conducted at the end of the wet season (April 2017). Additional aquatic and terrestrial biota testing has been conducted subsequently, and has been reported in an Interim Human Health Risk Assessment (IHHRA).
Additional monitoring of contaminant concentrations in surface water and groundwater will continue across March 2018 to monitor seasonal fluctuations and inform development and refinement of the conceptual site model and contaminant transport models. These models will provide input to the sensitivity review of risk assessments to guide appropriate risk management approaches.

Further biota assessment will also occur to inform the assessment of risk to human health and ecosystems as a result of bio-accumulation of PFAS compounds in the environment. In addition to the IHHRA, biota assessment will also be included in a broader Human Health Risk Assessment (HHRA) and an Ecological Risk Assessment (ERA), to be published in 2018.

Site Setting

The Katherine and Tindal area has a sub-tropical climate with distinct wet and dry seasons. The dry season generally occurs between May and September and the wet season nominally begins in December after months of build-up conditions. The majority of rain falls between December and March.

RAAF Base Tindal lies within the Daly Basin, a broad basin structure elongated in a north-west/south-east direction. The basin is approximately 70 km wide by 350 km long. The Daly River Group is a sedimentary sequence of Lower Palaeozoic age rocks (~500 million years old) that comprise the Daly Basin. The basal unit of the Daly River Group is the Tindall Limestone. This is overlain by the siltstone dominated Jinduckin Formation, which in turn is overlain by the Ooloo Dolostone. Localised on-Base geology generally comprised of localised cretaceous sediments overlying Tindall Limestone. During drilling works, localised cavernous areas where identified throughout the Tindall Limestone. This is generally consistent with the regional geology.

Hydrogeological units in the Investigation Area comprise the:

- Antrim Plateau Volcanics (basalts forming the base of the Tindall Limestone aquifer).
- Tindall Limestone aquifer.
- Jinduckin Formation.
- Cretaceous sediments.

The Tindall Limestone aquifer is unconfined near Katherine but is confined by the Jinduckin Formation to the south-west. Drilling depths of production bores range from 30 to 150 m and yields are typically 2 to 20 L/s, with maximum yields >100 L/s. The limestone immediately below the Jinduckin Formation/Tindall Limestone aquifer contact appears to be of karst origin and forms a highly productive aquifer.

Figure E.2 provides a conceptual model of the Tindall Limestone Aquifer around the Katherine area. The model shows the interaction of the surface water and groundwater systems and accounts for ‘basin wide’ water usage in terms of impact on river flows, spring discharges and water availability to groundwater dependent ecosystems. Water pressure in the confined Tindall aquifer is higher than the adjacent unconfined Tindall aquifer and therefore there is limited interaction of water between these aquifers.

As the PFAS plume migrates towards Katherine, it discharges into the Katherine River. The likely discharge points are associated with springs and seepages (i.e. Katherine Hot Springs). These seeps have been mapped between Morris Road to the north of Katherine Township and the low-level crossing (Zimin Drive) to the south.
Nature and Extent of Contamination in Groundwater

PFAS impacts in groundwater are highest at the two primary source areas (RAAF Base Tindal Fire Station and Fire Training Area). Other minor sources of PFAS impacted groundwater are in the vicinity of RAAF Base Tindal Fuel Farm 1 and Mechanical Equipment Operations Maintenance Section.

The PFAS plume extends across most of the Base and extends off-Base, migrating in a north-westerly direction towards the Township of Katherine, under the northern portion of Uralla, approximately parallel with the Stuart Highway. The PFAS plume does not extend off-Base to the north, east or south and has been delineated in these directions to the extent practicable. The PFOS concentration distribution is shown graphically in Figure E.3 below. Detailed concentration results and contours are presented in the DSI report figures.
The southern edge of the PFAS plume (defined by groundwater concentrations of 0.1 to 1 µg/L PFOS+PFHxS) extends across most of the southern portion of Uralla. Groundwater concentrations recorded in groundwater bores at the southern end of Uralla Road have consistently reported PFAS concentrations below the laboratory limit of reporting, indicating that the extent of the plume has been delineated in this area.

The southern edge of the plume at Katherine East is considered delineated at the confluence of Tindal Creek and the Katherine River. It is noted however that PFAS concentrations above the laboratory limit of reporting have been detected at Katherine Tip on the southern boundary, however this is considered to be associated with another source, such as fabrics and waste chemicals that have been disposed of at the Tip.

The northern edge of the plume (defined by groundwater concentrations above 0.07 µg/L PFOS+PFHxS) extends slightly to the north of the Stuart Highway, migrating towards the greater Katherine Township. The north-western edge of the PFAS plume is controlled by activities undertaken at the Katherine Research Station and at the Power and Water Corporation Water Treatment Plant at the end of Morris Road. PFOS+PFHxS concentrations are ~1.5 µg/L. The shape of the plume is likely due to high volumes of groundwater extraction.

**Conceptual Site Model**

In accordance with the principles of the National Environment Protection (Assessment of Site Contamination) Measure, a Conceptual Site Model is developed to identify possible connections between potential contamination and humans, the human food chain or ecology. Sampling of soils, waters and biota is then conducted to validate the model, and quantify the exposure pathways between the sources and receptors. These outcomes then guide the development and implementation of appropriate risk management actions associated with identified PFAS risks.

Based on the information collected over the course of the DSI, the key sources, pathways and receptors for PFAS contamination are summarised below and in Table E.1.
**Source Areas**

AFFF, containing PFOS (3M 3% or 6%) was used on the Base during the period 1993 to 2004. At that time, AFFF was transitioned to Ansulite, which contains significantly lower concentrations of PFOS and PFOA.

A number of known and potential sources of PFAS contamination were identified during the investigation and included areas on the RAAF Base Tindal where fire-fighting and training occurred; the Fire Station, fuel farms (which had fire-suppressions systems) and vehicle storage and maintenance areas. These key areas of environmental concern were investigated in more detail to further characterise the magnitude of PFAS within soil, sediment and groundwater at these locations. These primary source areas are described in Table E.1, along with a summary of the investigation works completed in the area.

**Pathways**

Potential pathways for the migration of PFAS associated with application and use at the Base include:

- Vertical migration of PFAS through soil to the groundwater system.
- Lateral migration of PFAS in groundwater towards Uralla, Katherine and the Katherine River. Pumping from large production bores, such as those present at the Research Farm and the Power and Water Corporation facility, is likely to influence the groundwater flow direction and may be drawing groundwater from the Base further north than anticipated based on natural groundwater flow regimes.
- Leaching of PFAS from Base soils or sediments into groundwater or surface water.
- Surface water runoff of PFAS to Base drains, depressions, open pits and Tindal Creek.
- Migration of PFAS in surface water (Base drains and Tindal Creek). The inferred surface water flow direction is to the north-west, towards Uralla, and then west and south-west to Katherine and the Katherine River.
- Infiltration of PFAS in surface water to soil and groundwater.
- Extraction of groundwater for domestic and stock watering use.
- Migration of PFAS through the Base sewage system and potential application of wastewater to land.

**Receivers**

Potential receptors where plausible pathways are present include:

- Users of extracted impacted groundwater (i.e. drinking water, swimming, irrigation, stock watering).
- Ecological receptors including flora and fauna in and around Tindal Creek and Katherine River.
- Users (including consumption of aquatic biota) of Tindal Creek and Katherine River (i.e. drinking water, swimming).
- Base personnel in impacted areas across the Base.

A summary of the source-pathway-receptor pollutant linkages identified from this DSI are provided in Table E.2. A detailed assessment of the potential exposures and risks to human health are described further in the Interim Human Health Risk Assessment (Coffey, 2017) and will be expanded in the subsequent broader Human Health Risk Assessment. A detailed assessment of the potential exposures and risks to ecological receptors are to be described further in the ERA, which is due to be issued in the early to mid-2018.
Table E.1: Primary source areas and works completed

<table>
<thead>
<tr>
<th>Area</th>
<th>Works completed</th>
<th>Extent of impact</th>
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<tr>
<td>Fire Training Area</td>
<td>• Soil and sediment sampling from approximately 22 soil bores to investigate</td>
<td>PFAS impacts in soil were centred around the fire training pad and</td>
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<td></td>
<td>surface and sub-surface PFAS concentrations across the Fire Training Area</td>
<td>surface water drains. Concentrations in these areas decreased with</td>
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<td></td>
<td>and fill data gaps from previous soil investigations.</td>
<td>depth, whereas concentrations were observed to increase with depth</td>
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<tr>
<td></td>
<td>• Surface sediment to investigate surface</td>
<td>further from the training pad, which is consistent with lateral</td>
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<td></td>
<td>PFAS concentration in the drainage network.</td>
<td>spreading in the layered Jinduckin unit.</td>
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<tr>
<td></td>
<td>• Installation of five new groundwater</td>
<td>PFOA and PFHxS were measured in soils ranging from &lt;0.5 to</td>
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<td></td>
<td>monitoring wells in the vicinity of the Fire</td>
<td>1,100 µg/kg and &lt;5 to 7,700 µg/kg (respectively). The maximum</td>
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<td></td>
<td>Training Area to assess impacts to ground water and fill data gaps in</td>
<td>concentrations were not typically at the surface, and therefore</td>
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<td></td>
<td>the existing groundwater monitoring network.</td>
<td>exposure is limited unless soil disturbance occurs. In the most</td>
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<td></td>
<td>• Installation of four new groundwater</td>
<td>impacted areas PFOS was vertically delineated (below the human</td>
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<td></td>
<td>monitoring wells approximately 200 m down-gradient (north-west) of the Fire</td>
<td>health screening criteria) within the top 1.0 m of the soil profile.</td>
</tr>
<tr>
<td></td>
<td>Training Area to assess PFAS impact in ground water</td>
<td>PFAS concentrations in groundwater in the vicinity of the Fire</td>
</tr>
<tr>
<td></td>
<td>leaving the Fire Training Area.</td>
<td>Training Area are the highest reported on-Base. The extent of impact</td>
</tr>
<tr>
<td></td>
<td>• Vertical contaminant profiling of two existing</td>
<td>from the Fire Training Area has not been delineated within the Base</td>
</tr>
<tr>
<td></td>
<td>wells and one new monitoring well.</td>
<td>and extends off-Base to the north-west. Based on relative</td>
</tr>
<tr>
<td></td>
<td>• Sampling and analysis of groundwater from all new and existing wells.</td>
<td>groundwater elevations and relative PFAS concentrations, this</td>
</tr>
<tr>
<td></td>
<td>• Collection of concrete samples from three locations.</td>
<td>source area appears to be contributing to impact detected down-</td>
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<td></td>
<td></td>
<td>gradient, flowing toward Tindal Creek.</td>
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</table>

Samples of surface water and sediment were collected from the evaporation ponds and fire training pit at the Fire Training Area. Concentrations of PFOS in sediments and surface water indicating potential for leaching of PFAS to surface runoff in the area.
## Detailed Site Investigation - Per- and Poly-fluoroalkyl Substances (PFAS)

### Executive Summary

**RAAF Base Tindal**

**Coffey**

**754-MELEN199420-R05ES**

**12 February 2018**

**RAAF Base Tindal**

**Detailed Site Investigation - Per- and Poly-fluoroalkyl Substances (PFAS)**

**Executive Summary**

**Coffey**

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**12 February 2018**

### Area

#### Fire Station

The Fire Station is located on the northern side of the runway and is understood to have been in this location since the Base was established in the 1980s. Wet testing of fire hoses on vehicles was conducted daily at crew changeover and weekly foam testing was conducted.

- Soil sampling from approximately 32 soil bores to investigate surface and sub-surface PFAS concentrations.
- Sediment sampling from seven surface drains directly down-gradient (north-west) of the Fire Station.
- Installation of one groundwater monitoring well next to the Fire Station to supplement existing wells and assess for impacts in the vicinity of the AFFF above-ground storage tank.
- Installation of five monitoring wells 250 m down-gradient (north-west) of the Fire Station to assess PFAS impact leaving the area.
- Vertical contaminant profiling in two existing wells.
- Sampling and analysis of groundwater from all new and existing wells.

The areas with the highest concentrations in soil were closest to the Fire Station, where AFFF was stored, and in the areas to the south and south-west of the Fire Station, in the low lying area that receives runoff from the hardstand outside of the Fire Station, where equipment may have been tested and washed out on a regular basis. Delineation of PFAS (to 10 µg/kg) was achieved to the north, north-west and north-east. The area of highest impact is approximately 250 m x 180 m, located to the south and south-west of the Fire Station.

The highest PFAS concentration in groundwater at the Fire Station area in the low lying area that receives drainage from the hardstand outside the Fire Station. The impact from the fire station has not been delineated down-gradient to the north-west.

PFAS concentrations in surface waters in Base drains were generally highest within the two open drains running parallel with the runway along the north-eastern side adjacent to the Fire Station. PFOS was reported in concrete samples up to 110,000 µg/kg, indicating potential for leaching of PFAS to surface runoff in the area.

<table>
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<tr>
<th>Soil</th>
<th>&lt;LOR – 17,000 µg/kg PFOS</th>
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<tbody>
<tr>
<td>Groundwater</td>
<td>0.07 – 5,300 µg/L PFOS+PFHxS</td>
</tr>
<tr>
<td>Surface water</td>
<td>0.11 – 4.71 µg/L PFOS+PFHxS</td>
</tr>
</tbody>
</table>

#### Mechanical Equipment Operations Maintenance Section

The Mechanical Equipment Operations Maintenance Section is located at 17 Squadron in the north-west of the Base. Vehicle and equipment maintenance activities occur in this area, which is likely to have historically included some equipment containing PFAS materials.

- Soil and sediment sampling from approximately 25 shallow soil bores across the Mechanical Equipment Operations Maintenance Section area to investigate surface and sub-surface PFAS concentrations and fill data gaps from previous soil investigations of Mechanical Equipment Operations Maintenance Section.
- Groundwater sampling from existing monitoring wells to assess PFAS impact in groundwater from sources in the Mechanical Equipment Operations Maintenance Section area.
- Collection of concrete samples from three locations.

PFOS impacts in soil have been delineated laterally to the west and south of Mechanical Equipment Operations Maintenance Section. Impacts have not been fully delineated vertically or laterally to the north and east of Mechanical Equipment Operations Maintenance Section. The impact appears to be related to drainage lines and infrastructure.

Samples of concrete were also collected from Mechanical Equipment Operations Maintenance Section, with maximum PFOS concentrations reported of 110,000 µg/kg, indicating moderate potential for leaching of PFAS to surface runoff in the area.

PFAS concentrations in groundwater indicate that historical releases have occurred in the area. Several targeted wells were dry in September 2017 and results from monitoring of additional wells through the area in the wet season will assist in defining the main sources of release in the area.

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<th>Soil</th>
<th>&lt;LOR – 120 µg/kg PFOS</th>
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<tr>
<td>Groundwater</td>
<td>0.09 – 14.6 µg/L PFOS+PFHxS</td>
</tr>
<tr>
<td>Surface water</td>
<td>0.11 – 4.71 µg/L PFOS+PFHxS</td>
</tr>
</tbody>
</table>
## Area

**Fuel Farm 1**
Fuel Farm 1 is a bunded above ground and underground fuel facility located near to 75 Squadron, in the east of the Base. Based on a site walkover of the Fuel Farm, the fire suppression system in place consists of a ring main of water around Fuel Farm 1, which is connected to the Base fire water supply. This is then connected to the Base sprinkler system via a fire truck to the boost value and the system is them operation. The fire truck supplies AFF which is connected to the ring main to mix with water.

- Installation of two new groundwater monitoring wells next to the down-gradient (north-western) boundary of Fuel Farm 1 to assess PFAS in groundwater leaving the Fuel Farm 1 area.
- Groundwater sampling of new and existing monitoring wells.
- Collection of sediment samples from low-lying areas and open drains to assess for PFAS impacts in the Base drainage network.

Detectable PFOS was reported in soils from Fuel Farm 1 between 0 m and 0.5 m. PFOS was reported in soil samples from a stockpile to the south-west of the farm, thought to contain waste AFFF containers.

A sample of water from the retention pond at Fuel Farm 1 contained 0.52 µg/L of PFOS, which does not indicate a significant ongoing source of PFAS contamination in the infrastructure, but does confirm that AFFF has previously been used at the facility.

PFAS concentrations in groundwater indicate that historical releases have occurred. PFOA and fluorotelemers are present, suggesting that some releases may have involved Ansulite.

### Soil:
- <LOR – 62 µg/kg PFOS

### Groundwater:
- <LOR – 26.1 µg/L PFOS+PFHxS

### Surface water:
0.64 µg/L PFOS+PFHxS

**Fuel Farm 2**
Fuel Farm 2 is a bunded above ground and underground fuel facility located to the north of the runway and to the west of the Ordinance Loading Area on Link Dispersal Road. Fuel Farm 2 is understood to have a similar fire suppression system to Fuel Farm 1.

- Groundwater sampling of existing monitoring wells to assess for potential PFAS impacts in groundwater.
- Collection of sediment samples from low-lying areas and open drains to assess for PFAS impacts in the Base drainage network.

PFAS concentrations in groundwater indicate that a release has occurred historically. The maximum concentrations reported were in a UPSS monitoring well installed in the area identified as containing the AFFF tank when the facility was constructed. Other wells around the facility have consistently reported PFOS. Fluorotelemers are present, suggesting that some releases may have involved Ansulite.

### Groundwater:
- 0.53 – 1.22 µg/L PFOS+PFHxS

### Surface water:
0.44 – 0.55 µg/L PFOS+PFHxS
**Table E.2: Summary of conceptual site model pollutant linkages**

<table>
<thead>
<tr>
<th>Sources</th>
<th>Pathways</th>
<th>Receptors</th>
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<tbody>
<tr>
<td><strong>Primary source areas:</strong></td>
<td>• Vertical migration of PFAS in shallow soils around source areas into groundwater&lt;br&gt;• Migration of PFAS in groundwater through the Tindall Limestone aquifer, flowing to the west-north-west, towards Katherine River.&lt;br&gt;• Transfer of PFAS between groundwater and surface water via sinkholes and shallow groundwater (during the wet season).&lt;br&gt;• Discharge of PFAS in groundwater into Katherine River through springs.&lt;br&gt;• Migration of PFAS down-stream in Katherine River.&lt;br&gt;• Extraction of groundwater from the Tindall Limestone aquifer via groundwater bores for potable (drinking water) and non-potable (irrigation and recreational) uses.</td>
<td><strong>Human Health:</strong>&lt;br&gt;• Drinking PFAS impacted bore water.&lt;br&gt;• Ingestion of PFAS impacted bore water used to fill swimming pools.&lt;br&gt;• Ingestion of home-grown produce irrigated using PFAS impacted bore water.&lt;br&gt;• Users (including consumption of aquatic biota) Tindal of Creek and Katherine River.&lt;br&gt;• Base personnel in impacted areas across the Base.</td>
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<tr>
<td><strong>Additional minor source areas:</strong></td>
<td>• Fuel Farm 1 and Fuel Farm 2&lt;br&gt;• Mechanical Equipment Operations Maintenance Section</td>
<td><strong>Ecological:</strong>&lt;br&gt;• Uptake of PFAS by plants and animals connected to Tindal Creek and Katherine River.</td>
</tr>
<tr>
<td><strong>Secondary source areas:</strong></td>
<td>• PFAS impacts in sediments mobilised through influx of surface water runoff in the wet season. PFAS migration through the on-Base drainage network into Tindal Creek.&lt;br&gt;• Migration of PFAS in surface water along Tindal Creek, into Katherine River.</td>
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<tr>
<td><strong>Secondary source areas:</strong></td>
<td>• Sediments in open drains on Base and Tindal Creek.&lt;br&gt;• Sediments and water in Base closed drainage infrastructure (pits, drains and sewerage).</td>
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Further Work

Several areas of uncertainty and data gaps were noted during the course of the DSI. Table E.3 describes these areas of uncertainty for each environmental media and potential further works to provide additional information. Where these further works are conducted as ongoing DSI works the results will be reported in the supplementary DSI report, scheduled for release in mid-2018. Other further assessments may be recommended as part of future environmental management programs.

Table E.3: Proposed additional works

<table>
<thead>
<tr>
<th>Environmental media</th>
<th>Data gap / area of uncertainty</th>
<th>Proposed further works</th>
</tr>
</thead>
</table>
| Groundwater         | Temporal and seasonal trends of PFAS concentrations in groundwater have not been characterised over the wet season. | Quarterly surface and groundwater sampling at selected locations through the 2017/2018 wet season.  
Ongoing sampling of private residential bores to further inform the DSI as well as the CHHRA. |
|                     | Temporal and seasonal trends of groundwater elevation and flow rate have not been characterised over the wet season. | Gauging of depth to water during quarterly groundwater monitoring events.  
Collection of data from groundwater loggers installed across the Investigation Area. |
|                     | Several existing wells across the Base that were proposed to be sampled were found to be damaged during the field program and samples could not be collected from them. | Repair/replace and sample damaged monitoring wells, where practicable. |
|                     | The vertical extent of PFAS in groundwater has not been characterised off-Base. | Installation of new deep bores in Uralla and Katherine. Collection of additional groundwater samples from these bores. |
|                     | Temporal and seasonal trends of PFAS concentrations in surface water have not been characterised over the wet season. | Quarterly surface water and sampling at existing locations in on-Base drainage channels, Tindal Creek and Katherine River through the 2017/2018 wet season. |
|                     | The first flush of surface water through Tindal Creek after heavy rain events at the start of the wet season may contain higher concentrations of PFAS than the remainder of the wet season. | Installation of auto-samplers in Tindal Creek to collect regular surface water samples over a 24 to 72 hour period after a high rainfall event at the start of the wet season. Two auto-sampling events will be carried out over the wet season. |
|                     | PFAS impacts in Katherine River have not been delineated downstream. | Collection of additional downstream surface water samples from Katherine River and the lower Daley River. |
| Soil                | Potential for PFAS impacts to be present in soils in the Investigation Area in areas where bore water is used for irrigation of sports grounds (such as in schools). | Collection of shallow soil samples at school sports grounds within the Investigation Area. |
| Sediment            | PFAS has been identified in sediments within the Base drainage infrastructure. Further inspections and sampling of sediments is required to refine a remediation approach. | Additional inspections of stormwater drains and pits across the Base to define the management requirements. |
**Introduction**

This report has been prepared by Coffey for you, as Coffey's client, in accordance with our agreed purpose, scope, schedule and budget.

The report has been prepared using accepted procedures and practices of the consulting profession at the time it was prepared, and the opinions, recommendations and conclusions set out in the report are made in accordance with generally accepted principles and practices of that profession.

The report is based on information gained from environmental conditions (including assessment of some or all of soil, groundwater, vapour and surface water) and supplemented by reported data of the local area and professional experience. Assessment has been scoped with consideration to industry standards, regulations, guidelines and your specific requirements, including budget and timing. The characterisation of site conditions is an interpretation of information collected during assessment, in accordance with industry practice.

This interpretation is not a complete description of all material on or in the vicinity of the site, due to the inherent variation in spatial and temporal patterns of contaminant presence and impact in the natural environment. Coffey may have also relied on data and other information provided by you and other qualified individuals in preparing this report. Coffey has not verified the accuracy or completeness of such data or information except as otherwise stated in the report. For these reasons the report must be regarded as interpretative, in accordance with industry standards and practice, rather than being a definitive record.

**Your report has been written for a specific purpose**

Your report has been developed for a specific purpose as agreed by us and applies only to the site or area investigated. Unless otherwise stated in the report, this report cannot be applied to an adjacent site or area, nor can it be used when the nature of the specific purpose changes from that which we agreed.

For each purpose, a tailored approach to the assessment of potential soil and groundwater contamination is required. In most cases, a key objective is to identify, and if possible quantify, risks that both recognised and potential contamination pose in the context of the agreed purpose. Such risks may be financial (for example, clean up costs or constraints on site use) and/or physical (for example, potential health risks to users of the site or the general public).

**Limitations of the Report**

The work was conducted, and the report has been prepared, in response to an agreed purpose and scope, within time and budgetary constraints, and in reliance on certain data and information made available to Coffey.

The analyses, evaluations, opinions and conclusions presented in this report are based on that purpose and scope, requirements, data or information, and they could change if such requirements or data are inaccurate or incomplete.

This report is valid as of the date of preparation. The condition of the site (including subsurface conditions) and extent or nature of contamination or other environmental hazards can change over time, as a result of either natural processes or human influence. Coffey should be kept appraised of any such events and should be consulted for further investigations if any changes are noted, particularly during construction activities where excavations often reveal subsurface conditions.

In addition, advancements in professional practice regarding contaminated land and changes in applicable statues and/or guidelines may affect the validity of this report. Consequently, the currency of conclusions and recommendations in this report should be verified if you propose to use this report more than 6 months after its date of issue.

The report does not include the evaluation or assessment of potential geotechnical engineering constraints of the site.

**Interpretation of factual data**

Environmental site assessments identify actual conditions only at those points where samples are taken and on the date collected. Data derived from indirect field measurements, and sometimes other reports on the site, are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact with respect to the report purpose and recommended actions.

Variations in soil and groundwater conditions may occur between test or sample locations and actual conditions may differ from those inferred to exist. No environmental assessment program, no matter how comprehensive, can reveal all subsurface details and anomalies. Similarly, no professional, no matter how well qualified, can reveal what is hidden by earth, rock or changed through time.

The actual interface between different materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but...
steps can be taken to reduce the impact of unexpected conditions.

For this reason, parties involved with land acquisition, management and/or redevelopment should retain the services of a suitably qualified and experienced environmental consultant through the development and use of the site to identify variances, conduct additional tests if required, and recommend solutions to unexpected conditions or other unrecognised features encountered on site. Coffey would be pleased to assist with any investigation or advice in such circumstances.

**Recommendations in this report**

This report assumes, in accordance with industry practice, that the site conditions recognised through discrete sampling are representative of actual conditions throughout the investigation area. Recommendations are based on the resulting interpretation.

Should further data be obtained that differs from the data on which the report recommendations are based (such as through excavation or other additional assessment), then the recommendations would need to be reviewed and may need to be revised.

**Report for benefit of client**

Unless otherwise agreed between us, the report has been prepared for your benefit and no other party. Other parties should not rely upon the report or the accuracy or completeness of any recommendation and should make their own enquiries and obtain independent advice in relation to such matters.

Coffey assumes no responsibility and will not be liable to any other person or organisation for, or in relation to, any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report.

To avoid misuse of the information presented in your report, we recommend that Coffey be consulted before the report is provided to another party who may not be familiar with the background and the purpose of the report. In particular, an environmental disclosure report for a property vendor may not be suitable for satisfying the needs of that property’s purchaser. This report should not be applied for any purpose other than that stated in the report.

**Interpretation by other professionals**

Costly problems can occur when other professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, a suitably qualified and experienced environmental consultant should be retained to explain the implications of the report to other professionals referring to the report and then review plans and specifications produced to see how other professionals have incorporated the report findings.

Given Coffey prepared the report and has familiarity with the site, Coffey is well placed to provide such assistance. If another party is engaged to interpret the recommendations of the report, there is a risk that the contents of the report may be misinterpreted and Coffey disowns any responsibility for such misinterpretation.

**Data should not be separated from the report**

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, laboratory data, drawings, etc. are customarily included in our reports and are developed by scientists or engineers based on their interpretation of field logs, field testing and laboratory evaluation of samples. This information should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

This report should be reproduced in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties.

**Responsibility**

Environmental reporting relies on interpretation of factual information using professional judgement and opinion and has a level of uncertainty attached to it, which is much less exact than other design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. As noted earlier, the recommendations and findings set out in this report should only be regarded as interpretive and should not be taken as accurate and complete information about all environmental media at all depths and locations across the site.