Australian Government
Defence

PFAS INVESTIGATION AND MANAGEMENT PROGRAM

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Robertson Barracks

PFAS ONGOING MONITORING PLAN

February 2025

ACKNOWLEDGEMENT OF COUNTRY

Defence acknowledges the Traditional Custodians of Country throughout Australia. Defence recognises their continuing connection to traditional lands and waters and would like to pay respect to their Elders both past and present.

Defence would also like to pay respect to the Aboriginal and Torres Strait Islander peoples who have contributed to the defence of Australia in times of peace and war.

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GLOSSARY

AFFF	Aqueous Film Forming Foam
AHD	Australian Height Datum
AS	Australian Standard
ASC NEPM	National Environment Protection (Assessment of Site Contamination) Measure, as amended 2013
Base	Robertson Barracks
BDE	Brigade
BoM	Bureau of Meteorology
BSM	Base Services Manager
COC	Chain of custody
CER	Combat Engineer Regiment
CSM	Conceptual site model
CSR	Contaminated sites register
CSSB	Combat Service Support Battalion
CTA	Close Training Area
DO	Dissolved oxygen
DoH	Department of Health
DQI	Data quality indicators
DQO	Data quality objectives
DSI	Detailed site investigation
EC	Electrical conductivity
EPA	Environment Protection Authority (or relevant state/territory jurisdiction)
ERS	Emergency Response Squadron
FSANZ	Food Standards Australia New Zealand
HEPA	Heads of EPA
HHERA	Human health and ecological risk assessment
HQ	Headquarters
JLU	Joint Logistics Unit
LOR	Limit of reporting
Management Area	The geographical area subject to Defence risk management actions. May include private or Defence owned detached properties beyond the boundaries of the base.
m bgl	Metres below ground level
MRF	Marine Rotational Force
MTR	Marksmanship Training Range

NATA	National Association of Testing Authorities
NHMRC	National Health and Medical Research Council
NT	Northern Territory
Off-site	Off-base (or other Defence property)
OMP	Ongoing Monitoring Plan
OMR	Ongoing Monitoring Report
On-site	On-base (or other Defence property)
PFES	Police, Fire and Emergency Services
PFAS	Per- and polyfluoroalkyl Substances
PFAS NEMP	PFAS National Environmental Management Plan
PFHxS	Perfluorohexane sulfonate
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
PMAP	PFAS Management Area Plan
QA	Quality assurance
QC	Quality control
RAP	Remediation action plan
RAR	Royal Australian Regiment
Risk management actions	Remediation and management actions to address potential risks to receptors from PFAS contamination
ROA	Remediation options assessment
SADFO	Senior Australian Defence Force Officer
SAQP	Sampling, analysis and quality plan
SBRS	Shoal Bay Receiving Station
SFARP	So far as reasonably practicable
Source	A source can be primary or secondary. Primary sources are areas where AFFF was used or stored. Secondary sources may be an accumulation of contamination in the environment, such as in soil, sediments, or surface water bodies.
SWL	Standing water level
TDS	Total dissolved solids
TOC	Top of casing

1 INTRODUCTION

1.1 Background

In November 2018 Defence prepared a PFAS Management Area Plan (PMAP) for managing risks to human health and the environment from per- and poly-fluoroalkyl substances (PFAS) contamination associated with Robertson Barracks ('the base') and surrounding areas. An important requirement of the PMAP is to undertake ongoing monitoring of PFAS in the environment and to assess for changes in risks to human and ecological receptors from PFAS originating from the base. The PMAP is in the process of being reviewed to assess if ongoing management of PFAS is required, or whether there are limited ongoing risks to human health, or the environment and the base can transition to ongoing monitoring only. The OMP has been updated in response to how PFAS impacts are managed on the base.

This Ongoing Monitoring Plan (OMP) replaces the February 2023 OMP.

1.2 Objective

The objective of the OMP is to outline the monitoring program to be implemented at Robertson Barracks to allow for the ongoing evaluation of PFAS contamination risks to human health and the environment, and to inform management requirements.

The OMP sets out requirements for collection of adequate data to identify and evaluate:

- spatial, and temporal (including seasonal) variability of PFAS in the environment
- changes to sources, transport pathways and/or receptors, described as a conceptual site model (CSM) for the base
- whether risks to human and ecological receptors require review
- the influence that risk management activities at the base, as outlined in the November 2018 PMAP have had on PFAS in the environment, and
- whether the identified changes trigger an action and/or review.

The data collected may be used to inform where new risk management actions may be required, or to support a determination that remediation has been completed so-far-as-reasonably-practicable (SFARP).

1.3 Supporting information

The 2018 Robertson Barracks PMAP, was used to inform the development of this OMP, along with the following relevant studies:

- Detailed Site Investigation, Robertson Barracks (Senversa, 2018a)
- Human Health and Ecological Risk Assessment, Robertson Barracks – Per- and Poly-fluoroalkyl Substances (PFAS) Investigations (Senversa, 2018b)
- Interpretive Report 2020, PFAS OMP – Robertson Barracks (Senversa, 2021)
- Ongoing Monitoring Report (November 2021 – March 2023), PFAS OMP – Robertson Barracks (Senversa, 2024).

In developing the OMP, reference has been made to the PFAS National Environmental Management Plan (PFAS NEMP), the National Environment Protection (Assessment of Site Contamination)

Measure 2013 (ASC NEPM) and Defence estate, environmental and PFAS-specific strategies and guidance, and other information as provided in the References section of this document.

1.4 Constraints and assumptions

This OMP has been prepared based on information available at the time of writing and relies on the findings of the detailed site investigation (DSI – Senversa, 2018a), risk assessment (Senversa, 2018b), ongoing monitoring program data (Senversa, 2021 and Senversa, 2024), and management of risks documented in the November 2018 PMAP. Defence recognises that there may still be gaps in information, and if required these will be progressively addressed while impacted sites are being managed.

This document has been developed based on the following assumptions:

- The current legislative setting and guidance for the assessment of risks to receptors from PFAS contamination.
- The sampling of various media to monitor the behaviour of PFAS in the environment is often limited by climatic conditions with significant seasonal variation between the wet and dry seasons limiting collection of samples at some locations. It has been assumed that all sampling locations and media are available for the purposes of monitoring PFAS at the base.

1.5 Base description

Robertson Barracks is located approximately 17 km east of Darwin city centre in the Northern Territory (NT). The base encompasses an area of approximately 455 hectares (ha), with a large (approximately 1,500 ha) open bush and swamp area to the east (referred to as the Close Training Area or CTA), and the Marksmanship Training Range (MTR - approximately 230 ha) to the north, forming part of the broader base. The area surrounding Robertson Barracks contains semi-rural residential land uses, with open wetland and swamp areas as well as multiple quarrying areas including within the CTA.

Robertson Barracks is a major training ground for the Australian Defence Force. Over 2,600 staff work daily at Robertson Barracks. Key features of the base include helicopter airfield and infrastructure (including Hangars, vehicle and aircraft maintenance areas and fuel supply infrastructure), commercial/office buildings, residential housing for personnel, sports and recreational facilities (including gyms, swimming pools, children's play parks, cafes and a chapel), a childcare centre, catering kitchens, wash bay, refuelling areas, dangerous good stores, and training areas.

Water supply for the base (including filling of the pool) is supplied from the regional water authority, Power and Water Corporation, not from bore water.

2 SITE SETTING

2.1 Site and management area setting

The PFAS Management Area, covering an area of approximately 625 ha (as shown in Figure 1), encompasses two parcels of Commonwealth owned land being managed by Defence, namely:

- Robertson Barracks, which includes the southern drainage channel running along the southern boundary of the Barracks, and
- A portion of the western part of the CTA.

2.1.1 Current site use

A summary of the planning information is provided in Table 2-1 below.

Table 2-1. Site planning information

Item	Relevant Information
Management Area Address	The management area includes the following addresses: Robertson Barracks, Thorngate Road, Holtze, NT, 0829 CTA, Thorngate Road, Holtze, NT, 0829
Investigation area	The PFAS Management area covers approximately 625 ha including: • Robertson Barracks: 455 ha, and • Part of the CTA: 170 ha.
Current Site Owner	The Commonwealth of Australia
Land Parcels	Robertson Barracks (including the MTR): Tenure 805/990 CTA: Tenure 820/13
Municipality	Litchfield Municipality
Current Land Use Zoning	Commonwealth Land (CA)
Current Site Occupier	Department of Defence

Robertson Barracks is the home of Australia's 1st Brigade whose mission is to provide forces to conduct operations to defend Australia and its national interests. 1st Brigade is a Combat Brigade with the purpose of contributing to provide enabled land forces. The following units and regiments are located at Robertson Barracks:

- 1st Aviation Regiment (1 Avn Regt)
- 1st Combat Service Support Battalion (1 CSSB)
- 8th/12th Medium Regiment (8/12 Regt)
- 1st Command Signals Regiment (1 CSR)
- 5th Battalion (Motorised) Royal Australian Regiment (5 RAR)
- 17 Combat Service Support BDE Force Elements
- Matilda Lines - Marine Rotational Force - Darwin (MRF-D)

- 1st Combat Engineer Regiment (1 CER)
- 6 BDE Force Elements
- Joint Logistic Unit - North (1 JLU-N)
- 1st Brigade Headquarters (1 BDE HQ).

In addition to the above, Robertson Barracks contains training areas (including live training areas at the MTR and CTA), accommodation and recreational facilities.

2.1.2 Surrounding land uses

The PFAS Management Area surrounding land use is Commonwealth owned land, with no privately-owned rural residential homes within a 1 km radius of Robertson Barracks. Identified land uses surrounding Robertson Barracks are summarised in Table 2-2 below.

Table 2-2. Surrounding land uses

Direction	Land Uses
North	Shoal Bay Receiving Station (SBRS) is located to the north comprising open woodlands, wetlands and swamps. Shoal Bay lies immediately north of SBRS.
East	Former sand and gravel quarries lie immediately to the north and northeast. CTA (Commonwealth owned and managed by Defence) lies directly east of Robertson Barracks and is used for live fire training by Defence. Further east is the Darwin Correctional Facility.
South	Small woodland open reserve area, light industrial, commercial retail, office facilities and the Stuart Highway.
West	Open woodlands, tall shrubland, plains and swamps as well as an area managed by Airservices (not related to fire training exercises). Further west are semi-rural residential dwellings and Knuckey Lagoons Conservation Reserve. The Thorak Regional Cemetery is located approximately 900 m northwest of Robertson Barracks.

2.1.3 Environmental setting

The environmental setting of the PFAS Management Area, is outlined in Table 2-3 below. The information provided has largely been sourced from the DSI (Senversa, 2018a), and updated as part of this OMP where more recent information was available.

Table 2-3. Environmental setting

Item	Detail
Traditional owners	The Larrakia people are the traditional owners of the Darwin region encompassing an area from Cox Peninsula in the west to Gunn Point in the north, Adelaide River to the east and Manton Dam in the south.
Topography	The PFAS Management Area is slightly undulating sloping down towards the east, with the elevation ranging from approximately 37 metres Australian Height Datum (m AHD) in the northwest and 19 m AHD in the northeast. The surrounding area slopes to the northeast towards Shoal Bay.

Item	Detail
Climate	The base has a tropical climate with distinct monsoonal wet and dry seasons. Most of the rainfall occurs from November to April (wet season), although isolated rainfall events also occur at the beginning and end of the dry season. Significant monsoon and tropical cyclone rainfall events are common during the wet season and likely to cause localised flooding. Evaporation is relatively constant with peaks during the wet season build-up. Maximum temperatures also occur during the wet season build-up, and minimum temperatures are reached in July. The average annual rainfall is 1,727 mm (Bureau of Meteorology, Aug 2024, Station 014015, located approximately 16 km west of the base).
Hydrology and drainage	Robertson Barracks is in the Kings Creek Catchment, which flows north out into Shoal Bay, located northeast of Darwin Harbour. Robertson Barracks is situated partly on a wetland area which extends to the west of the Barracks and drains south along the western boundary into the southern drainage channel which discharges into the southern tributary of Milners Creek located in the CTA to the east of the base. There are a number of lined and unlined drainage channels located within the base that generally follow the local topography. Stormwater on the base discharges to open channels before discharging along points on the eastern, western and southern boundaries to the broader surface water system. The drainage lines in the south and south-west of Robertson Barracks discharge to the unlined southern drainage channel, which joins the headwaters of Milners Creek. The drainage lines in the central portion of Robertson Barracks discharge to a drain that runs underneath Thorngate Road to the east and into the western tributary of Milners Creek (in the CTA). The two tributaries of the Milners Creek system converge within the CTA with the creek then flowing to the northeast and to the area known as Milners Swamp. These two tributaries of Milners Creek flow only at certain times of the year depending on rainfall. Milners Swamp drains into Kings Creek which flows through Noogoo Swamp before entering Shoal Bay. Various artificial lakes are scattered across the CTA from historical quarrying activities. The lakes in the CTA are not connected to the surface water discharge system from the base or connected to Milners Creek.
Geology	The Monitoring Area is generally underlain by the Bathurst Island Formation which overlies the Wildman Siltstone Formation except for an outcrop of the Acacia Gap Quartzite Member located within the CTA. The nature of each of these formations is summarised below: • Bathurst Island Formation typically comprises radiolarian claystone, sandy claystone, clayey sandstone, quartz sandstone, glauconitic sandstone and basal conglomerate up to 50 m in thickness. • Wildman Siltstone Formation comprises siltstone, silty sandstone and minor quartzite encountered between 50 m to over 1,000 metres below ground level (m bgl). • Acacia Gap Quartzite Member comprises quartzite, commonly pyritic sandstone with interbedded siltstone.

Item	Detail
Hydrogeology	The upper aquifer of the Tertiary colluvial and alluvial deposits and the Bathurst Island Formation are unconfined. Groundwater levels in the aquifer have been recorded at ground surface during the wet season and approximately 10 m bgl during the dry season. During the wet season groundwater discharges to Milners Creek and some of the drains on the base when levels rise to near the surface. However, as groundwater drops during the dry season, the drains and parts of Milners Creek stop flowing. Groundwater flow directions at the base generally follow topography with: • Groundwater in the north and central portions of the base flows to the east or north-east. • Groundwater in the south flows to the south towards the southern drainage channel. The groundwater seepage velocity for the upper portion of the Bathurst Island Formation aquifer is between 46 m/year (dry season) to 77 m/year (wet season). The lower portion of Bathurst Formation aquifer has a seepage rate of approximately 2 m/year.

3 EXTENT OF PFAS CONTAMINATION

This section provides an outline of the PFAS sources, transport pathways for migration of PFAS from a source area, and potential receptors such as humans and ecosystems that may be exposed to PFAS from the base.

3.1 Source areas

Source areas are generally areas of PFAS contamination where aqueous film forming foam (AFFF) was used or stored, for example, where firefighting equipment was tested or maintained. The primary PFAS compounds identified at the base include:

- Perfluorooctane sulfonic acid (PFOS)
- Perfluorohexane sulfonic acid (PFHxS), and
- Perfluorooctanoic acid (PFOA).

Other PFAS compounds were identified but were considered to be a negligible proportion of the total PFAS identified at the base.

The PFAS source areas that have been identified through previous investigations Appendix A is provided in Table 3-1. A map showing these source areas is provided as Figure 1 in Appendix B.

Table 3-1. Known source areas of PFAS

Source area	Extent of PFAS contamination
Source Area 1 (CSR_NT_000162)	This PFAS source area was the former Emergency Response Squadron (ERS) compound (within Building 137). The ERS provided firefighting services to the base, and deployed forces and stored fire-fighting equipment, and undertook testing and maintenance of PFAS containing firefighting equipment.
Source Area 2 (CSR_NT_000133, CSR_NT_000165 and CSR_NT_000245)	This PFAS source area comprises the 17th Combat Service Support Elements which was where the ERS parked their trucks prior to moving to Building 137.
Source Area 3: (CSR_NT_000241 and CSR_NT_000108)	This source area comprises vehicle wash down bays and refuelling areas within the southern portion of Robertson Barracks. The source of the PFAS in this area is inferred to be a combination of up-stream sources (Source Area 2) and washing or emptying of AFFF containing equipment.

3.2 Transport pathways

PFAS can travel from a source to human or environmental receptors via transport pathways, such as surface water, groundwater and stormwater.

The following pathways are potentially present at the base:

- Underground and open stormwater network including potential leaks from the network to soils and groundwater.
- Overland water run off during the wet season.
- Groundwater, including potential minor vertical and predominately horizontal migration.

- Adsorption and desorption of PFAS in soils during highly variable fluctuations in groundwater at shallow levels below surface.
- Consumption of fish and molluscs into which PFAS may have bioaccumulated.

The DSI (Senversa, 2018a) concluded that a key pathway for the migration of PFAS at the base was via surface water through the drainage network. Localised migration of PFAS in groundwater has also been observed.

3.3 Receptors and risks

Senversa undertook a Human Health and Ecological Risk Assessment (HHERA) in 2018 (Senversa, 2018b) which identified potentially complete exposure pathways to receptors from the elevated concentrations of PFAS in groundwater and surface water. The receptors and the conclusions on risk are summarised in Table 3-2.

Table 3-2. Summary of receptors and conclusions on risk

Receptor	Conclusion on risk
Human health risk associated with exposure to shallow groundwater by intrusive workers on Robertson Barracks	Low and acceptable.
Ecological risk to terrestrial flora and fauna in the investigation area (Robertson Barracks, CTA and southern drainage channel) from PFAS in soil, sediment and groundwater (Robertson Barracks only)	Low and acceptable associated with both direct contact with PFAS in environmental media, and bioaccumulation of PFAS through the food chain.
Human health risk associated with consumption of recreationally caught fish and molluscs from the CTA and southern drainage channel	Risk is likely to be low, however, elevated exposure due to consumption of finfish and molluscs cannot excluded.
Ecological risk to aquatic flora and fauna in Milners Creek and Milners Swamp with associated sediment and surface water exposure	Potential for elevated exposure to PFAS by aquatic ecosystems in the key habitat area (Milners Creek and Milners Swamp) due to conservation significance and known PFAS in surface water. Potential risks to lower order organisms directly exposed to PFAS within surface water and sediment are low and acceptable. Potential elevated exposure to higher order biota due to PFAS bioaccumulation in the food chain cannot be excluded based on the available data.

4 ONGOING MONITORING PLAN

This section sets out the data quality objectives, monitoring scope and assessment requirements. Changes made to the 2023 OMP are summarised in the following sections, and supporting rationale is provided in Appendix D.

4.1 Sampling, analysis and quality plan

A sampling, analysis and quality plan (SAQP) will be developed prior to implementation of the OMP. The SAQP provides information on data quality assurance procedures and measures including data quality indicators (DQI), sampling methodologies and analytical methods. The SAQP will be reviewed regularly and updated as required.

4.2 Data quality objectives

The data quality objective (DQO) process is an iterative planning approach used to define the type, quantity and quality of data that is needed to inform decisions relating to the environmental condition of a site. The seven-step DQO process:

- clarifies the study objective
- defines the most appropriate collection of data as relevant to the study objective
- determines the conditions from which to collect data, and
- specifies tolerable limits on decision errors, which will be used as the basis for establishing the quantity and quality of data, needed to support the decision.

The DQOs for monitoring are presented in Table 4-1. They have been prepared in line with the DQO process outlined in the ASC NEPM (Schedule B2).

Table 4-1. Data quality objectives

Process	Description
Step 1: State the problem	PFAS compounds have been reported above adopted screening levels in soil, groundwater, sediment and surface water within the PFAS Management Area, including the southern drainage channel and in Milners Creek located to the east of Robertson Barracks. Potential human health and ecological exposure risks as a result of PFAS contamination in soil and groundwater (including offsite migration of groundwater contamination) are considered to be low, acceptable and manageable. Potential risks are considered likely to be present as a result of PFAS contaminated surface water and sediments contributing to a potentially elevated risk for ecosystem receptors and potential consumption of fish and molluscs by humans.

Process	Description
Step 2: Identify the decision/goal of the study	The goal is to monitor the nature and extent of PFAS impacts and identify changes in PFAS concentrations in the PFAS Management Area that may change how PFAS is managed. The decisions of the OMP monitoring include: • Are concentrations of PFAS increasing and are further management and monitoring actions required? • Are concentrations of PFAS stable or decreasing and is active management and monitoring actions still required? • Is the dataset sufficient to characterise the risk to offsite receptors with respect to the identified potential exposure pathways?
Step 3: Identify the information inputs	• Existing data relevant to PFAS in soil, sediment, waters, and biota • The collection of additional surface water and groundwater samples • Surface water and groundwater flow regimes • Location and types of human and environmental receptors
Step 4: Define the boundaries of the study	Based on the understood extent of contaminated surface water or shallow groundwater at the base, the study area includes land and waterways on the base, and to the east of the base, within the CTA. The study area includes the PFAS Management Area as presented in Figure 1 (Appendix B).
Step 5: Develop the analytical approach/decision rules	Primary environmental samples are to be collected and analysed for the 28 PFAS compounds included in Appendix E. PFOS, PFHxS and PFOA concentrations will be compared against screening levels relevant to the potential beneficial uses of water to identify changes to risk profile. Confirm sufficient data exists to allow for the assessment of PFAS concentration over time in groundwater and surface water such that the potential change in extent or magnitude of PFAS contamination can be assessed with respect to offsite receptor exposure risks.
Step 6: Specify performance or acceptance criteria	The ongoing monitoring program must reliably characterise the changes in PFAS contamination within surface water and groundwater compared with the baseline conditions and describe the risk that the contamination poses to human or ecological receptors. Analytical data quality indicators to achieve these acceptance criteria are to be developed in the SAQP for each monitoring event with specific regard to the requirements of the PFAS NEMP.
Step 7: Develop the plan for obtaining data	The methodology and rationale for obtaining relevant data for the OMP is described below.

4.3 Proposed monitoring intervals

Ongoing monitoring will be conducted twice a year, in line with the previous (2023) OMP, to gather datasets at the end of both the wet and dry seasons. This timing ensures groundwater and surface water conditions reflect seasonal variations. Monitoring events should be conducted in the following periods to capture these seasonal differences, and to provide ongoing comparative results from those obtained to date during the OMP program:

- End of wet season in March/April
- End of dry season in October/November

4.4 Monitoring locations

The ongoing monitoring program will include the collection of groundwater and surface water samples twice yearly (as outlined in Section 4.3). The proposed monitoring locations are separated into groundwater and surface water.

4.4.1 Groundwater

Detectable concentrations of PFAS in groundwater collected during the DSI (Senversa, 2018a) and subsequent ongoing monitoring program between 2018 and 2023 reported concentrations of PFOS and/or PFHxS above the drinking water and ecological screening criteria at or immediately down-gradient of source areas. PFAS concentration in groundwater above the screening criteria was contained within the boundary of the base and was not reported to extend into the down-gradient groundwater within the CTA.

Table 4-2 below summarises the groundwater wells included in the ongoing monitoring for Robertson Barracks and the rationale for inclusion, with locations shown on Figure 2 (Appendix B) and location coordinates provided in Appendix C.

Table 4-2. Groundwater wells included in ongoing monitoring

Area	Groundwater well	Rationale
Source Area 1	MW067	This groundwater well was not included in the previous OMP (2023). This groundwater well is located down-hydraulic gradient of Source Area 1 and is indicative of the groundwater that may be discharging to the drain north of the source area.
	MW066	Included to build on the existing data set from the previous OMP (2023) and monitor changes in the source area.
	MW021D	Groundwater well located down-gradient of Source Area 1 with occasional historical detections near the laboratory limit of reporting (LOR). This well also monitors off-base PFAS impacts in the deeper portions of the groundwater aquifer within the CTA and the base to monitor changes in risk to the underlying Wildman Formation aquifer.

Area	Groundwater well	Rationale
Source Areas 2 & 3	MW004	Historical analytical results remain stable, but consistently above drinking water guidelines.
	MW004D	PFAS results have historically been reported below laboratory LOR, however sampling undertaken in October and November 2023 reported detections at or marginally above laboratory LOR suggesting a marginal downwards movement of impact in this area may be occurring.
	MW080	Whilst historical concentrations have been below drinking water guidelines, a slight increasing trend has been observed.
	MW030	This groundwater well is located on the southeastern boundary of Robertson Barracks and monitors potential impacts discharging off the Barracks and into Milners Creek. Whilst historical results have reported a stable trend, the results are consistently reported above drinking water guidelines.
	MW031	This groundwater well is located down-hydraulic gradient of the source areas and a key well for monitoring potential groundwater impacts migrating into the CTA.
North-eastern boundary	MW032	Whilst this groundwater well has reported a stable trend below drinking water criteria, results have been consistently above the laboratory LOR.
	MW034	An increasing trend has been observed at this well with concentrations also above drinking water criteria.

4.4.2 Surface water

PFAS in surface water was only detected down-stream of or within PFAS source areas. Table 4-3 below summarises the surface water locations included in the ongoing monitoring for the Management Area and the rationale for inclusion. The surface water locations discussed below are shown on Figure 3 (Appendix B) and location coordinates provided in Appendix C.

Table 4-3. Surface water locations included in ongoing monitoring

Area	Surface water location	Rationale
Source Area 1	SW059	The sampling of these locations will allow for changes in concentrations of PFAS in surface water leaving Robertson Barracks to be monitored. The locations SW059 and SW075 are down-stream of Source Areas 1 and 3 and any changes in PFAS concentrations in these locations informs the changes in PFAS leaving the base. Location SW123 is within Milners Creek in the CTA and monitors changes in surface water in the creek to assess changes in risk to ecological receptors, and SW091 monitors surface water at the confluence of the eastern base drainage lines and the southern drainage channel.
Source Area 3	SW075	
CTA	SW123 and SW091	

4.5 Sample analysis

Samples will be analysed by a National Association of Testing Authorities (NATA) accredited laboratory for a suite of PFAS as outlined in Appendix E, using NATA-accredited methods.

LORs must be selected to achieve the OMP objectives (Section 1.2) and the DQO's. The rationale for selecting LORs below the standard LOR must be provided.

Quality control and quality assurance measures will be outlined within the SAQP.

In addition to PFAS, field measurement of water quality parameters such as pH, electrical conductivity, redox potential, dissolved oxygen, temperature, total dissolved solids, salinity, and turbidity (where feasible) will be undertaken on all surface and groundwater samples.

5 OTHER ASPECTS

A review of other aspects that may result in changes to the nature, extent, fate or transport of PFAS at the base and within the Management Area is to be undertaken as a part of the annual Ongoing Monitoring Report (OMR). The purpose of this review is to update the CSM and assess any changes to receptors or risks that may be posed by changes within the Management Area, particularly associated with changes in land uses or water uses. The review will also be used to inform updates to the OMP.

The area where the review is to be conducted is to incorporate Robertson Barracks, the MTR, CTA, the Management Area, and land surrounding the base. This review should, at a minimum, include a review of aspects outlined in Table 5-1, and any changes observed since the previous OMR.

Table 5-1. Other aspects for review for updated CSM

Review	Rationale	Location	Suggested source/s
Land zoning	To identify where any changes in zoning may result in new sensitive receptors becoming exposed to PFAS.	Off-base	NT Atlas and Spatial Data Directory (https://www.ntlis.nt.gov.au/imfPublic/imf.jsp?site=nt_atlas)
Land-use	To identify where any new sensitive land uses may be occurring that may result in increased risks to receptors	Off-base	Aerial photograph review
	To identify any changes in receptors, or disturbance of PFAS that will require management or potential remediation.	On-base	Senior Australian Defence Force Officer (SADFO) / Base Services Manager (BSM)
Proposed development and/or infrastructure use	To identify where upgrades to infrastructure may allow access to PFAS impacted soils or alter PFAS behaviour in surface water or groundwater that may be beneficially undertaken concurrent with other developments.	On-base	SADFO / BSM
Remediation works in progress or planned	To identify any planned non-PFAS remediation works that may allow remediation of PFAS impacts or may result in changes to CSM.	On-base	SADFO / BSM
Potential PFAS releases	To inform potential changes in PFAS results off-base	Off-base	NT Environment Protection Authority (EPA), NT Police, Fire and Emergency Services (PFES)
	To inform potential changes in PFAS results on-base	On-base	SADFO / BSM

Review	Rationale	Location	Suggested source/s
Review of spoil management processes undertaken	To monitor ad-hoc PFAS testing in soils on the base to identify other potential source areas, or to assess potential impacts from beneficial spoil re-use area.	On-base	SADFO / BSM

Based on the current limited bore use, water use surveys are not considered to be relevant to the base as PFAS impacts in groundwater are contained within the base boundary.

6 PFAS SCREENING CRITERIA

Screening criteria used to assess the potential risks to receptors as a part of the monitoring program were sourced from the Heads of EPA (HEPA) 2020 PFAS National Environmental Management Plan Version 2.0 (HEPA, 2020), (herein referred to as the PFAS NEMP). The screening criteria in the PFAS NEMP was developed based on guidance provided in the following:

- Department of Health (DoH). Health based Guidance Values for PFAS for use in site investigations in Australia. April 2017 (DoH, 2017a)
- DoH. Perfluorinated Chemicals in Food - Consolidated Report, April 2017 (DoH, 2017b)
- National Health and Medical Research Council (NHMRC), 2019. Guidance on PFAS in Recreational Water. August 2019 (NHMRC, 2019), and
- National Environment Protection (Assessment of Site contamination) Measure 1999 (ASC NEPM), Schedule B1, as amended ion 2013 (NEPC, 2013).

Adopted PFAS screening values for groundwater and surface water are provided in Table 6-1 below.

Table 6-1. PFAS screening criteria

Media	Pathway	Compound	Criteria	Comment / Reference
Groundwater and surface water	Freshwater	PFOS	0.00023 µg/L	PFAS NEMP 99% species protection.[1]
		PFOA	19 µg/L	
Groundwater	Drinking water	PFHxS+ PFOS[2]	0.07 µg/L	The values presented in the PFAS NEMP are from DoH 2017. DoH used the tolerable daily intake for PFOS and PFOA from Food Standards Australia New Zealand (FSANZ), 2017 and the methodology described in Chapter 6.3.3 of NHMRC Australian Drinking Water Guidelines, 2016 to determine drinking water values.
		PFOA	0.56 µg/L	
Surface water	Recreational use	PFHxS+ PFOS[2]	2 µg/L	The values presented in PFAS NEMP were based on NHMRC guidance on the assessment of PFAS in surface water. The NHMRC adjusted the ingestion rate with consideration of an event frequency (150 events / year) to calculate an annual ingestion rate of 30 L per year.
		PFOA	10 µg/L	

Notes:
1. HEPA (2020) notes that 99% species protection level for PFOS is below the level of detection. Agencies may wish to apply a 'detect' threshold in such circumstances rather than a quantified measurement. For the purposes of this OMP, a 'detect' threshold has been applied.
2. HEPA (2020) notes where the criteria refer to the sum of PFOS and PFHxS, this includes PFOS only, PFHxS only, and the sum of the two

7 TRIGGERS FOR ACTION AND REVIEW

Trigger points have been identified which should be incorporated into any future SAQPs prepared in relation to this OMP. These trigger points and proposed further actions are summarised in the table below.

Table 7-1. Triggers points and actions

Media	Sampling Location	Trigger and Action
All media	All locations	PFAS concentrations show an increasing or decreasing trend (using statistical analysis) where they have not shown a similar trend in the previous OMR. Review the change in the context of the overall CSM and whether the change is material or not. Instances where a change may be considered immaterial is where a concentration change does not change the interpretation against the screening values. Review the OMP and/or HHERA and consider additional monitoring rounds and/or locations. Consider additional investigation of known or potential source areas. If decreasing trends observed, review whether location may be removed from program.
Groundwater	MW034	If the increasing trends continue for the next two monitoring events, add groundwater well MW024 to the program which is down gradient to monitor whether the PFAS plume is expanding.
	MW030	If groundwater results in the next two monitoring rounds show an increasing PFAS trend, add MW029 to the monitoring program.
	MW004D	If groundwater concentrations in this well show an increasing trend undertake the following stepwise actions: Review the risks to receptors, migration pathways and hydrogeological seepage velocities to assess whether the underlying Wildman formation aquifer may be at risk of contamination. If the review identifies a potential increased possibility of impact to the Wildman formation, install a well into the Wildman formation and add to monitoring program. If concentrations in the Wildman formation are below laboratory reporting limits for two consecutive rounds, or concentrations in MW004D show a decreasing trend or decrease to below the reporting limits, sampling of the new well can cease. If concentrations in the Wildman formation remain stable or increase, undertake a review of the risk assessment and re-design the sampling frequency considering the risks.

Media	Sampling Location	Trigger and Action
Groundwater	All groundwater monitoring locations	If any groundwater location reports a new detection of a PFAS compound, check and confirm with the laboratory that the concentration measured was not reported in error, or a quality assurance (QA) / quality control (QC) discrepancy. If concentration is confirmed by laboratory as correct and QA/QC review does not identify any discrepancies that may have led to the result, undertake a round of confirmation sampling of the affected well within six weeks. If the additional sampling confirms the presence of PFAS, a review of potential sources, including uses of AFFF, soil disturbances, disposal or maintenance of equipment or other potential releases of PFAS in the vicinity or upgradient of the location is to be undertaken. If no potential source of PFAS is identified, a review of the potential risks to receptors is to be undertaken and if the risk is low and acceptable, resume normal monitoring frequencies. If there is a potential increased risk to receptors, or evidence of the plume expanding, review available monitoring locations in the vicinity of the location and design additional sampling to confirm the nature and extent of PFAS at the location.
		Groundwater monitoring well is not able to be sampled as it is dry, blocked, damaged, decommissioned, inaccessible, lost etc. Attempts should be made to locate/repair/unblock the monitoring well. If this is not successful, the contingency location (as listed in Table C1, Appendix C) should be sampled instead. If no contingency location is listed in Table C1 (Appendix C), the monitoring well should be reinstalled in a similar location, with materially the same depth and screened interval.
Surface water	SW075	If PFAS concentrations show an increasing trend in the next two monitoring events, include location SW001 in the monitoring program.

8 REPORTING REQUIREMENTS

8.1 Reporting

After each monitoring event, information, field and laboratory data will be documented in a factual report. Any trigger point realised during a given monitoring event will be communicated to Defence immediately upon receipt of results.

At the end of a specified monitoring period (typically 12 months but may vary), the whole data set (including current and historic data) will be reviewed, and an OMR will be prepared.

The OMR will report on the objectives of the OMP, which are to identify and evaluate:

- spatial, and temporal (including seasonal) variability of PFAS in the environment
- changes to sources, transport pathways or receptors, described as a CSM for the base
- changes in risks to human and environmental receptors
- the influence that risk management activities at the base, as outlined in the 2018 PMAP have had on PFAS in the environment, and
- whether the identified changes trigger a prescribed action and/or review (Section 7).

8.2 Stakeholder engagement

Engagement with a range of stakeholders, such as NT EPA, Councils, other agencies, and the community will be undertaken. A stakeholder engagement plan will be prepared and/or updated to manage the engagement process.

Where off-site monitoring is undertaken a separate letter will be provided to the stakeholder presenting the results of the monitoring event.

The OMP will be published on the Defence website, along with the current PMAP and OMR.

APPENDIX A REFERENCES

AECOM (2021a) Interpretive Report 2020, PFAS OMP - Robertson Barracks, dated 28 January 2021

AECOM (2021b) Sampling Event Factual Report, November and December 2020, PFAS OMP - Robertson Barracks, dated 8 March 2021

AECOM (2021c) Sampling Event Factual Report, April 2021, PFAS OMP - Robertson Barracks, dated 27 September 2021

AECOM (2023) Sampling Event Factual Report, Dry Season 2023, PFAS OMP Robertson Barracks, dated 13 February 2023

AECOM (2024) Ongoing monitoring report (November 2021 - March 2023), PFAS OMP - Robertson Barracks, dated 16 January 2024

Department of Defence (2018) Robertson Barracks PFAS Management Area Plan, November 2018.

Department of Health (DoH, 2017a). Health based Guidance Values for PFAS for use in site investigations in Australia. April 2017

Department of Health (DoH, 2017b). Perfluorinated Chemicals in Food - Consolidated Report, April 2017

Heads of EPA (HEPA) 2020 PFAS National Environmental Management Plan Version 2.0 (HEPA, 2020)

NHMRC (2019) National Health and Medical Research Council (NHMRC), 2019. Guidance on PFAS in Recreational Water. August 2019

National Environment Protection (Assessment of Site contamination) Measure 1999 (ASC NEPM), Schedule B1, as amended ion 2013

Senversa (2018a) Detailed Site Investigation, Robertson Barracks

Senversa (2018b) Human Health and Ecological Risk Assessment, Robertson Barracks - Per- and Poly-fluoroalkyl Substances (PFAS) Investigations

Senversa (2021) Interpretive Report 2020, PFAS OMP – Robertson Barracks

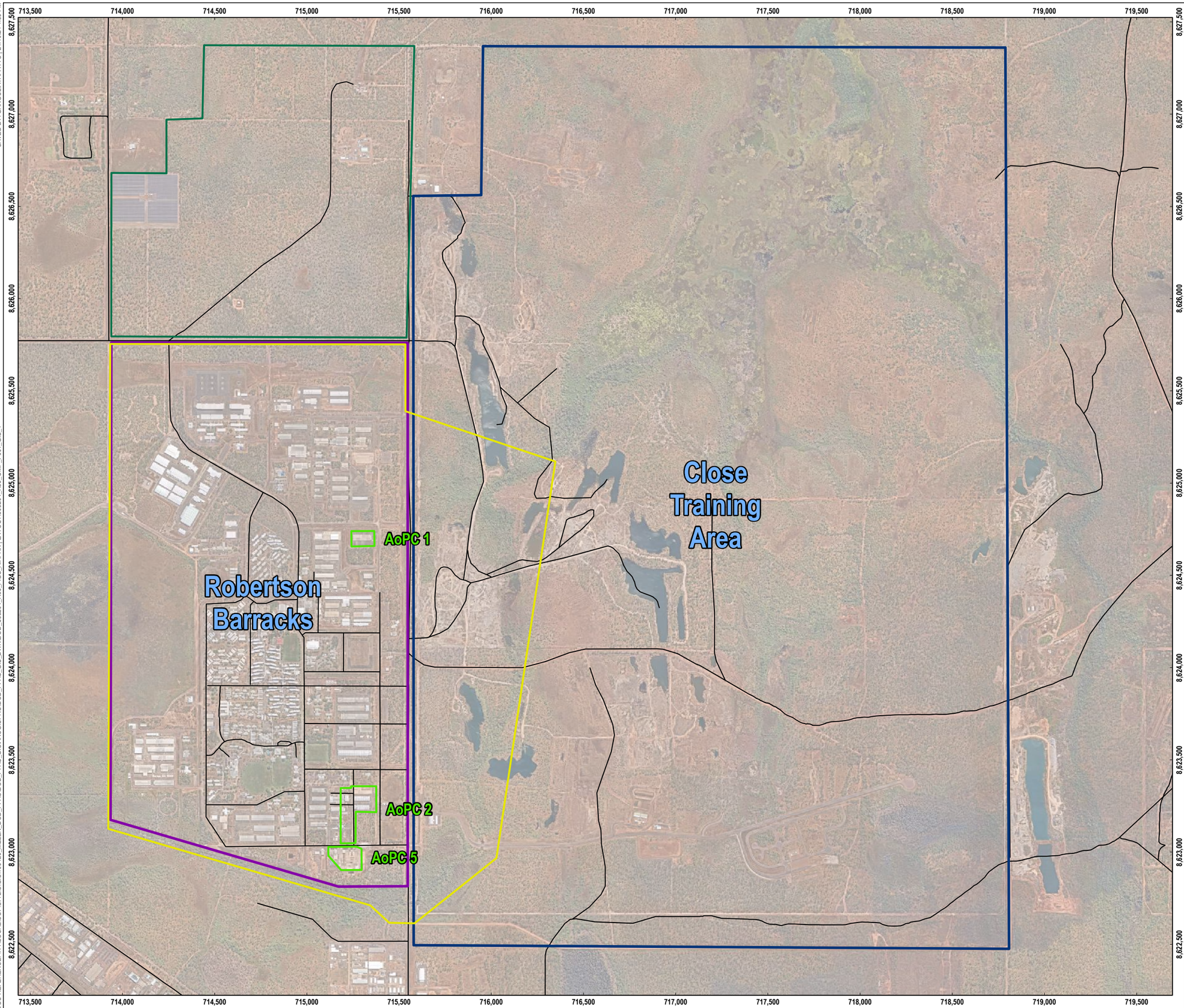
Senversa (2024) Ongoing Monitoring Report (November 2021 – March 2023), PFAS OMP – Robertson Barracks

APPENDIX B FIGURES

Figure 1 - Base location, Management Area and Source Areas

Figure 2 - Groundwater sampling locations

Figure 3 - Surface water sampling locations



LEGEND

- Road
- Area of Potential Concern (AoPC)
- Management area
- Marksmanship Training Range (MTR)
- Close Training Area
- Robertson Barracks

SOURCE
PFAS areas, Management area, MTR area and Site boundary (Indicative) from Tetra Tech Coffey
Roads, tracks, and creeks from DoD.
Imagery from Nearmap (06-06-2023).

N

0 250 500 m

SCALE **1:20,000**
PAGE SIZE: **A3**
PROJECTION: **GDA 1994 MGA Zone 52**

DEPARTMENT OF DEFENCE

ROBERTSON BARRACKS ONGOING MONITORING PLAN

FIGURE 1

Base location, Management Area and Source Areas

TETRA TECH COFFEY

DATE: **28.11.24** PROJECT: **754-MELEN338204** FILE: **308204_R09_OMP_F001_GIS**

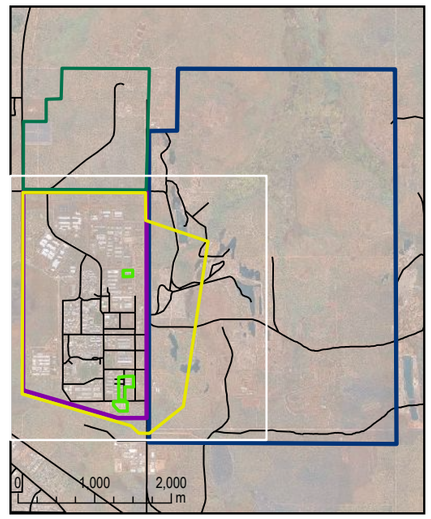
713,500 714,000 714,500 715,000 715,500 716,000 716,500 717,000

8,625,500 8,625,000 8,624,500 8,624,000 8,623,500 8,623,000

MW034 MW032 MW024 MW067 MW066 MW011 AoPC 1 MW022 MW021D MW004 MW004D AoPC 2 MW031 MW080 AoPC 5 MW001 MW030 MW029

LEGEND

- Alternative groundwater sampling location
- Groundwater sampling location
- Plume expansion contingency groundwater sampling location
- Road
- Area of Potential Concern (AoPC)
- Marksmanship Training Range (MTR)
- Management area
- Close Training Area
- Robertson Barracks



SOURCE
PFAS areas, Management area, MTR area and Site boundary (Indicative) from Tetra Tech Coffey
Soil bore locations, results and NEMP exceedance criteria (from 2018 DSI) from DoD.
Roads, tracks, and creeks from DoD.
Imagery from Nearmap (06-06-2023).

N

0 200 400 m

SCALE **1:13,000**
PAGE SIZE: **A3**
PROJECTION: **GDA 1994 MGA Zone 52**

DEPARTMENT OF DEFENCE

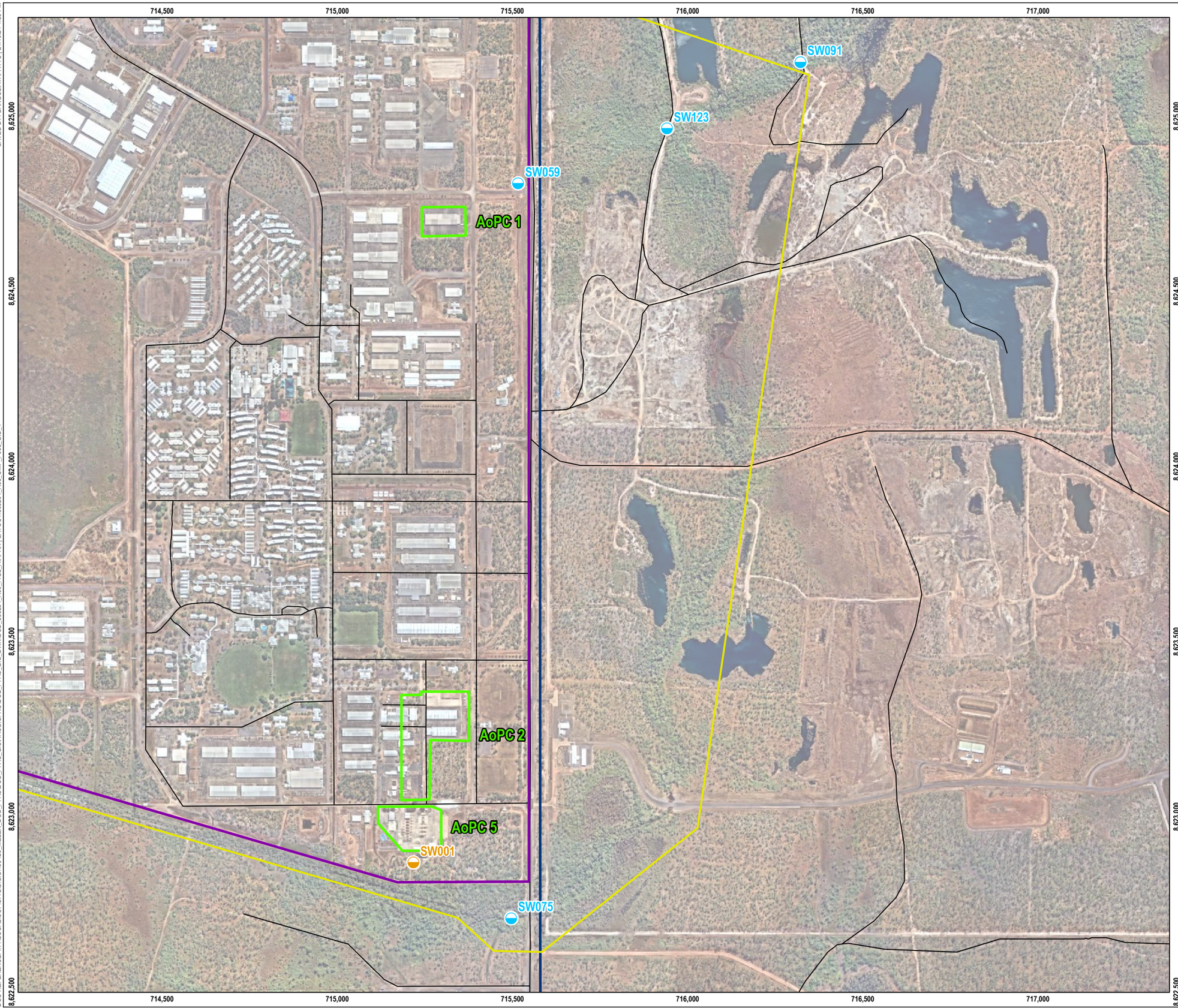
ROBERTSON BARRACKS ONGOING MONITORING PLAN

FIGURE 2

Groundwater sampling locations

TETRA TECH COFFEY

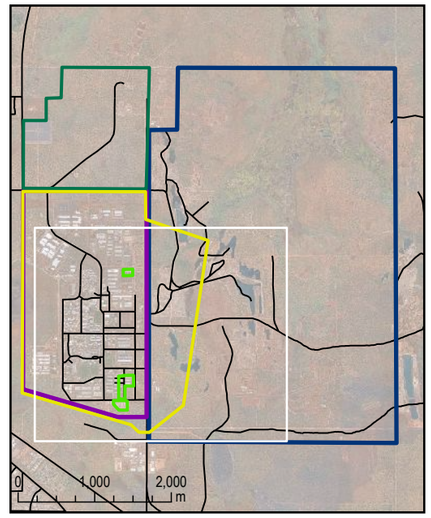
DATE: **28.11.24** PROJECT: **754-MELEN338204** FILE: **308204_R09_OMP_F002_GIS**



LEGEND

Purpose

- Contingency surface water sampling location
- Surface water sampling location
- Road
- Area of Potential Concern (AoPC)
- Marksmanship Training Range (MTR)
- Management area
- Close Training Area
- Robertson Barracks



SOURCE
PFAS areas, Management area, MTR area and Site boundary (Indicative) from Tetra Tech Coffey
Soil bore locations, results and NEMP exceedance criteria (from 2018 DSI) from DoD.
Roads, tracks, and creeks from DoD.
Imagery from Nearmap (06-06-2023).

N

0 200 400 m

SCALE **1:10,500**
PAGE SIZE: **A3**
PROJECTION: **GDA 1994 MGA Zone 52**

DEPARTMENT OF DEFENCE

ROBERTSON BARRACKS ONGOING MONITORING PLAN

FIGURE 3

Surface water sampling locations

TETRA TECH COFFEY

DATE: **28.11.24** PROJECT: **754-MELEN338204** FILE: **308204_R09_OMP_F003_GIS**

SAVED BY: GANGULATAPATTU | 21.10.24 4:56 PM
DOC REFERENCE: \\TT-LOCAL\COPIS\772\SIGIS\189420_MELEN_DOD_PFAS\DOD_PFAS_GIS\ARCGIS\PRO\DOD_PFAS_GIS_DWN\DOD_338204_R09_FIGS_A.APRX | LAYOUT:308204_R09_OMP_F003_GIS_1

APPENDIX C SAMPLE LOCATION INFORMATION

Table C1. Groundwater monitoring network

Location ID	Source Area / Location	Easting	Northing	Alternative	Easting / Northing
MW067	Source Area 1	715327.903	8624669.409	No alternate	Re-install
MW066	Source Area 1	715295.31	8624740.53	MW011	715245.24 / 8624659.83
MW021D	Source Area 1	715707.09	8624611.41	MW022	715724.38 / 8624736.20
MW004	Source Areas 2 & 3	715256.6	8623189.56	No alternate	Re-install
MW004D	Source Areas 2 & 3	715256.6	8623189	No alternate	Re-install
MW080	Source Areas 2 & 3	715107.901	8623047.543	No alternate	Re-install
MW030	Source Areas 2 & 3	715519.142	8622806.908	MW001	715505.57 / 8622822.33
MW031	Source Areas 2 & 3	715567.947	8623210.939	No alternate	Re-install
MW032	North-east of base	715572.273	8625358.973	No alternate	Re-install
MW034	North-east of base	715485.43	8625341.737	No alternate	Re-install

Table C2. Surface water monitoring network

ID	Source Area/ Location	Easting	Northing
SW059	Source Area 1	715516.282	8624807.516
SW075	Source Area 3	715496.647	8622710.176
SW091	Close Training Area	716328.780	8625165.040
SW123	Close Training Area	715941.2214	8624964.438

APPENDIX D OMP REVIEW

Table 8-1 OMP monitoring location and frequency review

Location	Does the location inform the nature of PFAS at the site	Does the location inform the extent of PFAS at the site	Does the location inform the risk profile at the site	Does the sampling frequency inform the risk profile	OMP Review Outcome	Reason
MW067	Yes	Yes	Yes	Yes	Add to OMP on twice-yearly sampling frequency	This groundwater well was not included in the previous OMP (2023). This groundwater well is located down-hydraulic gradient of Source Area 1 and is indicative of the groundwater that may be discharging to the drain north of the source area.
MW021	No	Yes	No	No	Remove location from OMP	This shallow groundwater well in the CTA is screened to 8 m bgl and only sampling shallow groundwater infiltration in this area. Historical results have all been below laboratory LOR.
MW012	No	Yes	No	No	Remove location from OMP	Located west (up-hydraulic gradient) of Source Area 1 in the approximate centre of the Barracks. This well has consistently reported PFAS below laboratory LOR.
MW012D	No	Yes	No	No	Remove location from OMP	Located west (up-hydraulic gradient) of Source Area 1 in the approximate centre of the Barracks. This well has

Location	Does the location inform the nature of PFAS at the site	Does the location inform the extent of PFAS at the site	Does the location inform the risk profile at the site	Does the sampling frequency inform the risk profile	OMP Review Outcome	Reason
						consistently reported PFAS below laboratory LOR.
MW018	No	Yes	No	No	Remove location from OMP	Located on the eastern side of Robertson Barracks. This well has consistently reported PFAS below laboratory LOR.
1200_MW001	No	Yes	No	No	Remove location from OMP	Located within 2 m from MW030 which is being retained in the monitoring program. Given the proximity of this well to MW030, ongoing monitoring of MW001 is not considered warranted.
1200_MW023	No	Yes	No	No	Remove location from OMP	This groundwater water well is not located downgradient of a key source and PFAS results have consistently been below laboratory LOR.
1200_MW024	No	Yes	No	No	Remove location from OMP	This groundwater well is located more than 500 m down gradient of any source area, and PFAS results have consistently been below laboratory LOR.
SBRS1	No	Yes	No	No	Remove location from OMP	Whilst these are groundwater abstraction bores, they are located 6 km north of Robertson Barracks and have consistently reported PFAS below the laboratory LOR
SBRS2	No	Yes	No	No	Remove location from OMP	

Location	Does the location inform the nature of PFAS at the site	Does the location inform the extent of PFAS at the site	Does the location inform the risk profile at the site	Does the sampling frequency inform the risk profile	OMP Review Outcome	Reason
						and are screened in a different (deeper) aquifer.
SW028	No	Yes	No	No	Remove location from OMP	All results have been reported below the laboratory LOR.
SW023	No	Yes	No	No	Remove location from OMP	Except for the first monitoring event in 2018, all results have historically been below laboratory LOR.
SW007	No	Yes	No	No	Remove location from OMP	Except for two monitoring events (one in 2018 and one in 2023), all results, including the two subsequent sampling rounds since the last detect, have been below laboratory LOR.
SW086	No	Yes	No	No	Remove location from OMP	On Milners creek, located mid-way along the creek. Results have historically been limited to below or at detection limits only.

APPENDIX E PFAS ANALYTICAL SUITE

Target analytes	
Perfluoroalkane sulfonic acids	
PFBS	Perfluorobutane sulfonic acid
PFPeS	Perfluoropentane sulfonic acid
PFHxS	Perfluorohexane sulfonic acid
PFHpS	Perfluoroheptane sulfonic acid
PFOS	Perfluorooctane sulfonic acid
PFDS	Perfluorodecane sulfonic acid
Perfluoroalkyl carboxylic acids	
PFBA	Perfluorobutanoic acid
PFPeA	Perfluoropentanoic acid
PFHxA	Perfluorohexanoic acid
PFHpA	Perfluoroheptanoic acid
PFOA	Perfluorooctanoic acid
PFNA	Perfluorononanoic acid
PFDA	Perfluorodecanoic acid
PFUnDA	Perfluoroundecanoic acid
PFDoDA	Perfluorododecanoic acid
PFTrDA	Perfluorotridecanoic acid
PFTeDA	Perfluorotetradecanoic acid
Perfluoroalkyl sulfonamides	
FOSA	Perfluorooctane sulfonamide
MeFOSA	N-Methyl perfluorooctane sulfonamide
EtFOSA	N-Ethyl perfluorooctane sulfonamide
MeFOSE	N-Methyl perfluorooctane sulfonamidoethanol
EtFOSE	N-Ethyl perfluorooctane sulfonamidoethanol
MeFOSAA	N-Methyl perfluorooctane sulfonamidoacetic acid
EtFOSAA	N-Ethyl perfluorooctane sulfonamidoacetic acid
(n:2) Fluorotelomer sulfonic acids	
4:2 FTS	4:2 Fluorotelomer sulfonic acid
6:2 FTS	6:2 Fluorotelomer sulfonic acid
8:2 FTS	8:2 Fluorotelomer sulfonic acid
10:2 FTS	10:2 Fluorotelomer sulfonic acid