Australian Government
Defence

PFAS INVESTIGATION AND MANAGEMENT PROGRAM

SERVICE
COURAGE
RESPECT
INTEGRITY
EXCELLENCE

RAAF BASE TOWNSVILLE

PFAS MANAGEMENT AREA PLAN

REVISION 1

March 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.

ABOUT THIS DOCUMENT

This is the Defence PFAS Management Area Plan (PMAP) Revision 1 for RAAF Base Townsville, Queensland.

This PMAP Revision replaces the PMAP for RAAF Base Townsville dated December 2019 (the 2019 PMAP).

The purpose of this PMAP is to document Defence's plan to manage potential risks to human health and the environment from PFAS on and from RAAF Base Townsville. It provides an overview of the risk management actions undertaken to date, ongoing and future actions.

The Queensland Department of Environment, Tourism, Science and Innovation (DETSI) and other relevant state and local agencies have been consulted in the development of this document.

PMAP Revision	Date	Status	Comments
0	2019	Final	Initial PMAP preparation
1	26 March 2025	Final Draft	2025 PMAP revision

EXECUTIVE SUMMARY

In 2019, Defence published the RAAF Base Townsville (base) PFAS Management Area Plan (2019 PMAP) for managing risks to human health and the environment from per- and poly-fluoroalkyl substances (PFAS) contamination associated with RAAF Base Townsville and surrounding areas.

Since the 2019 PMAP was developed, Defence has implemented parts of the plan and reassessed what is now needed to best manage these contamination risks.

This PMAP revision sets out the updated plan to manage risks to human health and the environment from exposure to PFAS contamination from RAAF Base Townsville.

Management Area

The Management Area boundary is formed by the RAAF Base Townsville boundary ('on-base area'). Within the Management Area there are three discrete Sub-Management Areas (or primary source areas) including:

- Sub-Management Area One (SMA1): Former Fire Training Area
- Sub-Management Area Two (SMA2): Fire Station Locale and Fuel Farm 2, and
- Sub-Management Area Three (SMA3): 5th Aviation Regiment (5AVN).

Additional source areas include:

- Former Fuel Farm 1
- Cadet training area (38 SQN & domestic area)
- Disused runway 13/31
- Former Fire Training Area (near Ordnance Loading Areas)
- Former Fire Training Area (between Fire station and Runway) and Emergency response adjacent to Runways 07/25 and 01/19 (Areas V, W, X and Y)
- Pad Brahman
- Ingham Road sports field (including Ruediger Park), and
- Former Fire Training Ground at the northern end of the main runway 01/19.

The areas surrounding the base are referred to as the off-base Monitoring Area and include the Mundy Creek catchment, the Three Mile Creek catchment, the Louisa Creek and Bohle River catchment, the Town Common Conservation Park and the suburbs of the Bohle, Garbutt, Pallarenda, Rowes Bay and Belgian Gardens. The areas to the east of the base mainly consist of low-density residential properties. To the north is the conservation area of the Town Common wetlands. Areas to the south and west mainly comprise commercial and light industrial properties. Schools and public recreational areas are also located within the Monitoring Area. The areas to the north, east and west have been included in the Monitoring Area as they receive discharges from the base either via groundwater or surface water flow.

PFAS source areas, pathways and risk:

- **Sources**: Source areas were identified at the base in the 2019 PMAP, as listed above. Remediation has been completed at SMA1.
- **Pathwa**y: The primary transport pathway for PFAS migration off-base is via surface water and to a lesser extent, groundwater.
- **Risk to Receptors**: the potential risk to human health from exposure to PFAS both on- and off-base (through contact or ingestion of soils, contact with extracted groundwater used for irrigation

or drinking extracted groundwater), were low and acceptable, except for two potential exposure scenarios. Potential risks that were identified as elevated or marginal included:

- Eating locally caught fish from catchments within the Monitoring Area: Specifically, children eating high quantities of the fish flesh, and adults and children eating average quantities of the fish liver, and
- On-base workers incidentally ingesting groundwater during maintenance activities, during the wet season when the water table is high, however, the assumptions that underpin the marginal risk are conservative and unlikely to occur.

The ecological risk assessment identified that there is a potential risk to lower order species (i.e. plants, terrestrial invertebrates, aquatic invertebrates, fish) that are directly exposed to the elevated PFAS concentrations, and potential risks to higher order species (i.e. predatory birds, mammals and reptiles) both on- and off-base through bioaccumulation (where animals eat plants and other animals containing PFAS).

Risk management actions:

The following risk management actions have been implemented, are planned or ongoing at the base since 2019:

- Completion of mass discharge investigations at the three primary source areas to identify the factors affecting PFAS movement – Completed.
- Remediation of the former fire training area (Sub-Management Area 1) was completed in 2024. The remediation involved the removal of approximately 1,900 m^3 of soils containing high concentrations of PFAS and stabilisation of approximately 6,500 m^3 of remaining soils – Completed.
- Preparation of Remediation Action Plans for the Fuel Farm 2 and Fire Station source areas (Sub-Management Area 2) - Completed.
- Implementation of the Remediation Action Plan for SMA2 is scheduled for 2025 to remediate accessible portions of SMA2 - Planned Works.
- Investigation of additional potential source areas has positively identified the presence of former burn pits. The objective of investigating this area is to better understand potential contributions to PFAS mass discharges – Commenced.
- Review of existing PFAS data for the base to consider if further assessment or remediation is required to achieve closure of PFAS contamination with respect to remediation so far as reasonably practicable principles (Defence, 2024a) - Planned Works.
- Re-evaluation of human health risks, based on the outcomes of additional biota sampling to be completed in 2025 - Planned Works, and
- Routine surface water, groundwater and sediment monitoring in accordance with the Ongoing Monitoring Plan - Ongoing.

CONTENTS

GLOSSARY

5AVN	5th Aviation Regiment
ACM	Asbestos Containing Material
AFFF	Aqueous Film Forming Foam
ASC NEPM	National Environment Protection (Assessment of Site Contamination) Measure, as amended 2013 (NEPC, 1999)
Base	RAAF Base Townsville (the base)
CSM	Conceptual Site Model
DETSI	Queensland Department of Environment, Tourism, Science and Innovation
DSI	Detailed Site Investigation
ERA	Ecological Risk Assessment
Food Standards	Food Standards Australia New Zealand
GEMS EFM – CSR	Garrison Estate Management System Environmental Factor Management – Contaminated Site Record
HEPA	Heads of Environmental Protection Authority
HHRA	Human Health Risk Assessment
ITRC	Interstate Technology Regulatory Council
LTEMP	Long-term environmental management plan
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.
NEPC	National Environment Protection Council
Off-base	Not on the base (or other Defence property) – non-Defence owned land and includes suburbs surrounding the base.
OLA	Ordnance loading area
OMP	Ongoing Monitoring Plan
On-base	On the Defence base (or other Defence property) – Defence owned land
PAC	Powdered activated carbon
PFAS	Per- and polyfluoroalkyl Substances
PFAS NEMP	PFAS National Environmental Management Plan (2020)
PFHxS	Perfluorohexane sulfonate
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
RAAF	Royal Australian Air Force
RAP	Remediation Action Plan
Risk assessment(s)	The HHRA and/or ERA

Risk management actions	Remediation and management actions to address potential risks to receptors from PFAS contamination.
ROA	Remediation Options Assessment
SFARP	So Far as Reasonably Practicable
SMA	Sub-Management Area
Source	A source can be primary or secondary and is the place or event from which the contamination originated. Primary sources are generally areas where AFFF was used or stored. Secondary sources may be an accumulation of contamination in the environment, such as in soil, sediments, groundwater or surface water bodies.
TDI	Tolerable Daily Intake
TRVs	Toxicity Reference Values

Unless otherwise defined in this document, definitions provided in the NEMP, or the ASC NEPM apply.

1 INTRODUCTION

1.1 Background and Purpose

In December 2019 Defence published the RAAF Base Townsville PFAS Management Area Plan (2019 PMAP) which outlined the actions for managing potential risks to human health and the environment from per- and poly-fluoroalkyl substances (PFAS) contamination at RAAF Base Townsville (the base) and the surrounding area. The location of the base is shown on Figure 1 in Appendix C.

Since the RAAF Base Townsville 2019 PMAP was developed, Defence has implemented parts of the plan and reassessed what is now needed to best manage risks associated with PFAS contamination.

This assessment considered:

- progress made in the implementation of the 2019 PMAP including remediation works completed
- the outcomes of the PFAS mass discharge studies which provided an understanding of the volumes and flow rates of PFAS leaving the key source areas via surface water and groundwater
- whether potential risks to human health or the environment from PFAS contamination have changed, based on data collected through the ongoing monitoring program (OMP) and other studies, and
- a review of factors such as changes to government policy settings, PFAS guidance, site conditions and scientific methodologies and technology.

This PMAP revision sets out the updated plan to manage risks to human health and the environment from exposure to PFAS contamination from RAAF Base Townsville.

This PMAP revision has been developed in accordance with the PFAS National Environmental Management Plan (NEMP) 2.0 (HEPA, 2020), which provides nationally consistent environmental guidance and standards for managing PFAS contamination. It is also consistent with Defence estate, environmental, and PFAS-specific strategies and guidance.

PMAPs are reviewed and updated periodically to account for changes in circumstances, such as progress in management and remediation, new data, changes in legislation, guidelines and policy, and advances in scientific information.

1.2 Management Priorities

In managing PFAS contamination to reduce risks to human health and the environment, Defence prioritises:

- minimising exposure to PFAS
- preventing or minimising migration of PFAS, and
- keeping the community informed.

Minimising PFAS movement from the base will, in the long term, contribute to the reduction of PFAS concentrations in the surrounding environment. However, the process will take time, and therefore other measures will also be implemented to reduce risks to human health and the environment.

1.3 Supporting Information

The PMAP revision is based on information from a range of different investigations, human health and ecological risk assessments and remediation activities. Details of these reports are provided in Appendix A, including web links where available.

The reports identified a range of elevated risks to receptors from exposure to PFAS, which are the focus of the risk management actions outlined in this document.

1.4 Limitations and Assumptions

This document has been developed based on the information available at the time of preparation, and with the following limitations and assumptions:

- Access to some areas to be investigated was restricted at the time of investigation, due to soft ground, in wet season conditions, preventing access for machinery
- Access to some areas to be remediated is restricted due to the presence of the back-up power station at Sub-Management Area 1, underground services and operational facilities (at Sub-Management Area 2) and Base redevelopment activities in active operational areas (at Sub-Management Area 3)
- Access to private properties and municipal facilities for the purposes of sampling has been and will continue to be granted
- The understanding of mass discharge at RAAF Base Townsville is based on sampling and results directly associated with three primary source areas rather than a base boundary understanding. This is due to the diffuse nature of discharges from the base across a wide area (i.e. the Town Common wetlands and during flood events) rather than discrete drainage boundaries (such as stormwater drains and culverts)
- The Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA) were based on the data available at the time of preparation and the limitations associated with these studies are presented in the HHRA (WSP, 2018a) and ERA (WSP, 2019a) respectively, and
- Remediation Technology: there are limited proven remediation technologies available for PFAS remediation. Remediation technologies are subject to continual research and development. Future remediation designs will consider remediation technology that are commercially available in Australia at the time of preparation.

The PMAP will be revised if new information becomes available and the characterisation of risk changes, requiring a revised management or remediation approach.

2 MANAGEMENT AREA

The PFAS Management Area comprises RAAF Base Townsville (defined by the base boundary) and the surrounding Monitoring Area, as shown on Figure 1 in Appendix C.

The base boundary comprises the limits of the base where management actions, including those where institutional controls have been adopted, are identified, and managed including monitoring for changes in PFAS concentrations in groundwater, surface water and sediment. The base is within Defence's jurisdiction for management in consultation and collaboration with Townsville Airport (Queensland Airports Limited). Information about source areas is presented in Section 3.

Land uses within the Management Area are predominantly commercial/industrial activities associated with Defence activities, airport activities including four military units, a fire station, current and former fire training grounds, fuel farms and an aircraft runway. Other land uses include residential and commercial uses including live in accommodation, healthcare and childcare facilities.

The areas surrounding the base are referred to as the Off-base Monitoring Area and include the Mundy Creek catchment, the Three Mile Creek catchment, the Louisa Creek and Bohle River catchment, the Town Common Conservation Park and the suburbs of the Bohle, Garbutt, Pallarenda, Rowes Bay and Belgian Gardens. The areas to the north, east and west of the base have been included in the Monitoring Area as they receive discharges from the base either via groundwater or surface water flow. The areas to the south of the base have been included in the Monitoring Area as they are up gradient, represent background conditions.

Current land uses within the Off-base Monitoring Area include:

- Townsville domestic airport and associated services
- Low-density residential properties
- Schools and other educational institutions
- Cemetery
- Public recreational areas including parks
- Commercial and industrial properties, and
- The Town Common (a nature conservation park)

As changes to the land uses occur over time, this PMAP will be updated accordingly.

Information about the Management Area environmental setting, such as climate, topography, geology, hydrology and various other aspects is provided in the Detailed Site Investigation (DSI) (WSP, 2018b).

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.

This information is described further in the Conceptual Site Model (CSM), which is provided in Appendix B. As part of this PMAP revision, the CSM for RAAF Townsville and surrounding areas was reviewed for currency and updated where required. For more detailed information informing the CSM, refer to the reports listed in Appendix A.

3.1 Source Areas

Source areas can be primary or secondary. Primary sources are generally areas of PFAS contamination where aqueous film forming foam (AFFF) was used or stored, for example, a fire training area. Secondary source areas, contain an accumulation of PFAS contamination in the environment, such as in soil, sediment, or surface water bodies, which has migrated from a primary source area.

The source areas that have been identified through previous investigation are presented in Table 1. A figure showing the key source areas is presented as Figure 2 in Appendix C. The 2019 PMAP identified three Sub-Management Areas for which further assessment and management actions may be appropriate. They are:

- Sub-Management Area One (SMA1): Former Fire Training Area
- Sub-Management Area Two (SMA2): Fire Station Locale and Fuel Farm 2, and
- Sub-Management Area Three (SMA3): 5th Aviation Regiment (5AVN), which is a large area that includes aviation hangers.

Table 1: Known PFAS source areas

Source area name	Garrison Estate Management System Environmental Factor Management – Contaminated Site Record (GEMS EFM – CSR)	PMAP Source	Catchment	Extent of PFAS contamination
Former Fire Training Area.	CSR_QLD_000246	SMA1	Mundy Creek Catchment.	• Soils have been remediated through a combination of off-base treatment, off-base disposal and on-base soil stabilisation. • The surface water drainage channel has been upgraded to limit groundwater/surface water interaction and improve drainage through SMA1. • The stabilised soils and residual PFAS contamination are managed under a long-term environmental management plan (LTEMP). • Post-remediation monitoring will be undertaken as part of the OMP and post remediation mass discharge assessments.
Former Fuel Farm 1.	CSR_QLD_000236	-		• Limited assessment due to the presence of critical Defence infrastructure, however, concentrations to date were moderate to high. • Re-evaluation of available data to consider further investigation or management options. • Ongoing monitoring required
Cadet training area (38 SQN & domestic area).	-	-		• Low concentrations of PFAS in soil and groundwater, compared to other areas of the base. Although PFAS concentrations exceeded the residential criteria adopted for this portion of the base, the HHRA found the health risks were low. • No further action required.
Fire Station Locale.	CSR_QLD_000245	SMA2	Bohle River / Louisa Creek / Town Common Catchment.	• High concentrations of PFAS have been measured in soil, groundwater, and surface water, that is centrally located on-base and was historically used for sparging of fire truck tanks, equipment testing and other fire response training activities.

Source area name	Garrison Estate Management System Environmental Factor Management – Contaminated Site Record (GEMS EFM – CSR)	PMAP Source	Catchment	Extent of PFAS contamination
Fuel Farm 2 Forecourt and Eastern Flank.	CSR_QLD_000351 CSR_QLD_000679			• Based on the mass discharge assessments completed for surface water and groundwater, SMA2 is the greatest contributor to PFAS migration from the base. • Remediation actions for this area scheduled for 2025.
5th Aviation Regiment (5AVN) facilities 5th Aviation Regiment (5AVN) wash bay.	CSR_QLD_000680 CSR_QLD_000681	SMA3		• Historical activities have included testing of deluge systems, including discharges and spills from hangars. • Moderate concentrations of PFAS have been measured in soil, groundwater, and surface water. • Groundwater and surface water from SMA3 discharge to the west (to the Louisa Creek catchment area). Baseline mass discharge assessment in surface water and groundwater has been completed. • Remediation and management options for SMA3 are limited due to the area's operational status and sealed ground (comprising buildings, concrete, tarmac and roads). • Re-evaluation of available data to consider further investigation or management options. • Ongoing monitoring required.
Disused runway 13/31. Historical training including former burn pit adjacent to the western end of disused runway 13/31.	CSR_QLD_000682	-		• Visual evidence of burn pits was identified. • Moderate concentration of PFAS measured in soils • Re-evaluation of available data to consider further investigation or management options. • Further investigation required to assess PFAS mass contribution and viability for remediation. • Ongoing monitoring required.

Source area name	Garrison Estate Management System Environmental Factor Management – Contaminated Site Record (GEMS EFM – CSR)	PMAP Source	Catchment	Extent of PFAS contamination
Former Fire Training Area (near OLAs).	CSR_QLD_000248	-	Bohle River / Louisa Creek / Town Common Catchment.	• Moderate concentrations of PFAS in soil and groundwater. • Re-evaluation of available data to consider further investigation or management options. • Ongoing monitoring required.
Former Fire Training Area (between Fire station and Runway) and Emergency response adjacent to Runways 07/25 and 01/19 (Areas V, W, X and Y).	CSR_QLD_000244	-		• Low concentrations of PFAS in soil. • No further action required.
Pad Brahman.	-	-		• Low concentrations of PFAS measured in soil, and groundwater. • No further action required.
Ingham Road sports field (including Ruediger Park).	-	-		• Low concentrations of PFAS measured in soil, groundwater and surface water. • No further action required.
Former Fire Training Ground at the northern end of the main runway 01/19.	CSR_QLD_000247	-	Three Mile Creek Catchment.	• Visual evidence of burn pits was identified adjacent to the northern end of the main runway 01/19 (in service). • Moderate concentrations of PFAS measured in soils. • Re-evaluation of available data to consider further investigation or management options. • Further investigation required to assess extent, PFAS mass contribution and viability for remediation.

3.2 Transport Pathways

PFAS can travel from a source area to human or environmental receptors by surface water, groundwater and stormwater. These are referred to as transport (or migration) pathways. The DSI (WSP, 2018b) identified that the dominant transport pathway for PFAS from the base is via surface water including discharge of groundwater to surface water and pumping of excess stormwater from the active runways to the adjacent wetlands on-base.

Whilst groundwater pathways exist, they are interconnected with surface water due to seasonal effects and the low-lying nature of the base. The regular wet season flooding causes groundwater to discharge to the surface across significant portions of the base from the rising water table.

These migration pathways, and the potential mass of PFAS migrating from the SMAs was further assessed as part of the PFAS Mass Flux Investigations (Golder Associates Pty Ltd, 2023), (WSP, 2023a) and (WSP, 2023b). These investigations identified that the mass of PFAS migrating in surface water is greater than the mass from the groundwater transport pathway. Comparison of the relative contribution of PFAS from surface water and groundwater from each of the SMAs are summarised below in Table 2. The mass discharge investigations also demonstrated that surface water and groundwater migration transport pathways for PFAS are dominated by contributions from SMA2.

Table 2: Comparison of surface water and groundwater migration pathways and relative mass contribution for the three primary source areas

Source	SMA1		SMA2		SMA3		All SMAs	
	Mass (g)	% of Total Mass	Mass (g)	% of Total Mass	Mass (g)	% of Total Mass	Mass (g)	% of Total Mass
Surface water	**510**	**3.9%**	**11,122**	**85.3%**	**928**	**7.1%**	**12,560**	**96.3%**
Groundwater	14	0.1%	339	2.6%	127	1.0%	480	3.7%
SMA Subtotal	524	4.0%	11,461	87.9%	1,055	8.1%	13,040	100.0%

In addition to the three primary source areas, there may be additional sources at the base, contributing to the overall PFAS mass being discharged from the base. The total PFAS discharge leaving the base has not yet been assessed and investigations to date have been limited to the three primary source areas (SMA1 to SMA3) only.

3.3 Receptors and Risks

Figures showing the spatial distribution of PFAS (presented as Perfluorooctane sulfonate [PFOS] + Perfluorohexane sulfonate [PFHxS]) in groundwater (Figure 4), surface water (Figure 5) and sediment (Figure 6) are provided in Appendix C. PFOS + PFHxS are the dominant PFAS compounds at RAAF Base Townsville and therefore these are the data presented in the figures.

3.3.1 Human receptors and Assessment of Risk

The HHRA (WSP, 2018a) was completed to assess potential risk to human health associated with exposure to PFAS both on- and off-base. The HHRA considered exposure to PFAS in soil, sediment, surface water, and groundwater and included uptake from home-grown fruit, vegetables, locally caught fish species.

A complete exposure pathway must exist for a person to be exposed to PFAS. If the exposure pathway is not complete, then no PFAS exposure will occur and, as a result, no risk to health exists. Conversely, if a complete exposure pathway does exist, then the total uptake or dose of PFAS over time, (that is, the amount of PFAS that enters a person's body), dictates the potential for an adverse health outcome. The health-based guideline levels used in the HHRA are based on the known dose-response relationship combined with several safety factors to account for uncertainties.

The HHRA process included a comparison of PFAS concentrations within the different media (for example, soil) to health-based investigation levels (HIL) or guideline values published by Australian regulators. This is considered a Tier 1 or screening level assessment. These criteria and guideline values are highly conservative, deliberately set at concentrations below where adverse health effects are not expected to occur in the general population. Therefore, if concentrations of PFAS are below the respective guideline values, adverse health effects are not expected to occur, even in sensitive individuals within a population. Where PFAS concentrations exceed the guidelines in the Tier 1 or screening level assessment, less conservative assessment is undertaken which specifically considers the complete source, pathway receptor linkage and associated dose.

The HHRA for RAAF Base Townsville concluded that the potential risk from exposure to PFAS both on-and off-base were low and acceptable, except for two potential exposure scenarios. Potential risks that were identified as elevated or marginal in the HHRA included:

- Eating locally caught fish: Specifically, children eating high quantities of the fish flesh, and adults and children eating average quantities of the fish liver, and
- On-base workers incidentally ingesting groundwater during maintenance activities, particularly during the wet season when the water table is high.

Below is a summary of the key receptors and risk.

Table 3: PFAS Receptors and Risk – Human Health (adapted from HHRA (WSP, 2018a))

Who (Receptor populations)	Where (Source location)	How (Exposure Pathway)	What (Assessment of Risk)	Why (Reason for Risk)	Context	Has the risk profile changed?
Off-base						
Local residents.	Off-base soil in yards.	Touching soils or accidental ingestion (swallowing) of soil. Inhalation of soil and dust (soil-derived). This includes soils that have been irrigated with bore water.	Low.	Low PFAS concentrations in soil.	PFAS levels measured within off-base **soil** from private residential land were below health-based investigation levels set for residential soil except for one location. The estimated total PFAS intake dose for the soil-based exposure scenario at that location was assessed and the risk was considered low.	Although no additional soil data have been collected, the screening criteria against which the screening was completed have changed (the guideline values are higher than they were previously). As the screening criteria have increased rather than decreased, the risk profile is unlikely to have changed as a result.
Local residents.	Off-base garden produce.	Eating fruit, vegetables, and poultry eggs irrigated with groundwater and grown/ collected at home.	Low.	Concentrations of PFAS in home grown produce are low. Assumes 10% of food consumed daily comes from garden produce.	To supplement the analytical results, theoretical PFAS concentrations were calculated for the HHRA, based on the results of the Water Use Survey and the risk was considered low. It was also noted that the home grown produce, vegetables, fruit and poultry do not appear to be widely grown within the Monitoring Area.	As home-grown produce was not identified to be widely grown and irrigated with bore water off-base, this risk profile is unchanged. There was a low response rate for the Water Use Survey and due to changes in property ownership, water uses may have changed and therefore the risk profile may change over time.

Who (Receptor populations)	Where (Source location)	How (Exposure Pathway)	What (Assessment of Risk)	Why (Reason for Risk)	Context	Has the risk profile changed?
Local residents.	Off-base groundwater.	Touching of or accidental ingestion (swallowing) of extracted groundwater used for irrigation of gardens and garden produce.	Low.	Limited use of groundwater for irrigation.	The Water Use Survey indicated that 11% of residents had a groundwater bore used to irrigate lawns, gardens, vegetables or fruit trees. There are no guidelines for PFAS in irrigation water. Based on the risk assessment outcomes, the risk is low.	Although PFAS concentrations have exceeded the drinking water guidelines in groundwater monitoring wells, these wells are only used for irrigation. There was a low response rate for the Water Use Survey and due to changes in property ownership, water uses may have changed and therefore the risk profile may change over time.
Local residents and recreational users of local swimming pools and parks.	Off-base groundwater.	Touching of or accidental ingestion (swallowing) of extracted groundwater used for filling swimming pools.	Negligible.	Based on the outcomes of the water use survey, groundwater is not used for drinking, filling of swimming pools (public or private) and other non-potable water uses.	No Water Use Survey respondents indicated using bore (groundwater) water or surface water as a primary source of drinking water or filling of pools. The Off-base Monitoring Area is serviced by Townsville City Council supplied water which is primary water source for drinking and for filling pools. Based on the risk assessment outcomes, the risk is low.	Although PFAS concentrations have exceeded the drinking water guidelines in groundwater monitoring wells, these wells are not used for filling pools or drinking water. It is noted that there was a low response rate for the Water Use Survey and changes in land ownership may result in changes to water uses over time.

Who (Receptor populations)	Where (Source location)	How (Exposure Pathway)	What (Assessment of Risk)	Why (Reason for Risk)	Context	Has the risk profile changed?
Local residents and recreational users.	Off-base Surface water & sediments (in Mundy Creek, Bohle River, Louisa Creek, Town Common, Three Mile Creek).	Accidental ingestion and inhalation of water during swimming, boating, and other water activities.	Negligible.	Low PFAS concentrations in sediments. Low to moderate PFAS concentrations in surface waters.	PFAS levels measured in surface water and sediments of local rivers, creeks, rivers and tributaries exceeded the health-based recreational screening criteria which have been developed to consider incidental ingestion and dermal exposures, however waterways in the Off-base Monitoring Area are not deemed safe for swimming due to dangerous wildlife (as signposted with crocodile and stinger warnings).	The risk profile remains unchanged as the hazards associated with swimming in the creeks remain unchanged and therefore the assumptions made in the HHRA remain valid. The way in which the creeks and waterways are used may change over time and this may change the risk profile.
Recreational Anglers.	Off-base Local waterways and tributaries within the off-base Monitoring Area (Mundy Creek, Bohle River, Louisa Creek, Town Common, Three Mile Creek).	Eating locally caught seafood.	Fish - Low for adults, marginal for a child consuming higher than average amounts of fish. Fish liver – marginal (for average intakes) to elevated risk. (for upper limit intakes).	Exposure scenarios considered fish flesh or fish liver (assuming the whole fish was consumed or utilised). Based on number of local fish meals eaten each week.	PFAS within the fish (flesh) samples were reported above the Food Standards screening criteria in estuarine waterways only. All other fish flesh results were reported below the food standards screening criteria.	The risk profile remains unchanged as the assumptions made in the HHRA are still valid.

Who (Receptor populations)	Where (Source location)	How (Exposure Pathway)	What (Assessment of Risk)	Why (Reason for Risk)	Context	Has the risk profile changed?
Recreational users of Ingham Road Sports Field (Ruediger Park).	Off-base Soil at playing fields.	Touching and accidental ingestion (swallowing) of soil. Inhalation of soil and dust (soil-derived).	Low.	Low concentrations in publicly accessible soil.	PFAS levels measured within off-base soil at the Ingham Road Sprots Fields were below health-based investigation levels set for public open space and therefore this pathway was not considered further.	The risk profile remains unchanged as the assumptions made in the HHRA are still valid.
Maintenance / utility workers off-base working in a trench or open ground.	Off-base PFAS in soil, sediment and water.	Touching and accidental ingestion (swallowing) of soil, sediment and water. Inhalation of soil and dust (soil-derived).	Low.	Low PFAS concentrations in soils and sediments. Low to moderate PFAS concentrations in waters.	There are no available soil, sediment or water screening criteria for intrusive maintenance works, therefore the scenario was quantified in the risk assessment. The estimated total PFAS intake due to dust inhalation or contact with or ingestion of water, soil or sediment was assessed, and the risk was low.	The risk profile remains unchanged as the assumptions made in the HHRA are still valid.
On-base						
Defence personnel, contractors (including maintenance and utility workers), and visitors.	On-base Soil.	Touching and accidental ingestion of soil. Inhalation of soil and dust (soil-derived).	Low.	Low PFAS concentrations in soil.	PFAS levels in on-base soils were lower than screening levels for industrial and commercial worker scenarios, and the risks to health are low and manageable. Exposures can be further managed and reduced through	The risk profile remains unchanged as the assumptions made in the HHRA are still valid.

Who (Receptor populations)	Where (Source location)	How (Exposure Pathway)	What (Assessment of Risk)	Why (Reason for Risk)	Context	Has the risk profile changed?
					the implementation of standard health and safety procedures.	
Defence personnel, contractors, and visitors.	On-base Groundwater.	Drinking extracted groundwater.	Negligible.	No exposure pathway to groundwater	On-base groundwater is not extracted or used for drinking or irrigation; therefore, this exposure pathway does not exist for this receptor.	The risk profile remains unchanged as there is no new information to indicate a change.
Defence personnel, contractors (including maintenance and utility workers), and visitors.	On-base Surface water and sediments.	Direct contact with surface water and sediments.	Negligible to low.	No exposure pathway to surface water and sediments.	Base personnel do not enter surface water bodies on-base to swim or boat. Therefore, no complete exposure pathways exist. There are no screening criteria for PFAS in sediments and the risk assessment concluded the risks to health from direct contact with on-base sediment were low. There are no specific water guidelines for maintenance and excavation workers, however PFAS concentrations in surface water are sufficiently low to not present a risk to health. Exposures can be further managed and reduced through the implementation of standard health and safety procedures.	The risk profile remains unchanged as the assumptions made in the HHRA are still valid. The surface water screening criteria for recreational use have changed (the guideline values are now higher than they were previously). The risk profile therefore remains unchanged as more conservative measures were applied to the HHRA, and the risk was low.

Who (Receptor populations)	Where (Source location)	How (Exposure Pathway)	What (Assessment of Risk)	Why (Reason for Risk)	Context	Has the risk profile changed?
Kindergarten – children and adult workers.	On-base Exposure to PFAS in soils greater than 0.5 metres deep.	Inhalation of soil-derived dust.	Low.	There is a potential elevated health risk for soils brought to the surface from depth. This exposure would occur under construction and base maintenance activities and therefore be managed under Defence procedures.	Soil PFAS concentrations exceeded the health-based investigation levels (for residential with garden/accessible soil) at depths greater than 0.5 m and therefore this scenario was further quantified in the HHRA. The risk to children from inhalation of dusts containing PFAS is considered low. Soils brought to the surface from greater than 0.5 metres deep are not suitable for re-use within the kindergarten area. The soils are suitable for re-use elsewhere on-base in accordance with the Defence PFAS Construction and Maintenance Framework (Department of Defence, 2021). Additional administrative controls may be required to manage disturbance of soils at the kindergarten, such as a long-term environmental management plan.	Whilst the soils, at the kindergarten, remain at depths greater than 0.5 m, the risk profile remains unchanged. Where soils, at the kindergarten, may be brought to the surface during construction or maintenance activities, a change in the risk profile may occur and additional mitigations may be required to use the soils elsewhere on-base.

Who (Receptor populations)	Where (Source location)	How (Exposure Pathway)	What (Assessment of Risk)	Why (Reason for Risk)	Context	Has the risk profile changed?
Kindergarten – children and adult workers.	On-base Exposure to PFAS in surface soils and soils less than 0.5 metres deep.	Direct contact pathways (oral ingestion, dermal contact and dust inhalation).	Low.	Low PFAS concentrations in soil.	Soils that are readily accessible to users of the kindergarten (that is, soils less than 0.5 m deep) were lower than health-based investigation levels (for residential with garden/accessible soil).	Although no additional soil data have been collected the screening criteria against which the screening was completed have changed (the guideline values are higher than they were previously). The risk profile therefore remains unchanged as more conservative measures were applied to the HHRA.
Kindergarten – children and adult workers.	On-base Sediment and surface water.	Direct contact with sediments and surface water.	Negligible.	No exposure pathway to surface water and sediments	There are no on-base drains, open pits, open stormwater drains and waterways at the kindergarten for children to swim in.	The risk profile remains unchanged as the assumptions made in the HHRA are still valid.
Maintenance / utility workers on-base working in a trench or open ground.	On-base Groundwater in excavations.	Touching and accidentally drinking groundwater during construction dewatering or installation of service trenches.	Marginal – wet season. Low – dry season.	PFAS concentrations in groundwater present a slightly elevated risk when groundwater is intersected during works.	There are no specific water guidelines for maintenance and excavation workers. PFAS concentrations in groundwater exceeded the drinking water criteria, although the groundwater is not used for drinking. The risk was considered low where groundwater was not intersected during works. However, when groundwater is intersected during works, (which is more likely to occur	The risk profile remains unchanged as there is no new information to indicate a change.

Who (Receptor populations)	Where (Source location)	How (Exposure Pathway)	What (Assessment of Risk)	Why (Reason for Risk)	Context	Has the risk profile changed?
					when the water table is high during wet season), the risk increases from low to marginal. If groundwater is to be encountered during excavation, exposure can be controlled through work health and safety protocols. As such, people are not exposed to PFAS in groundwater and the risks are low.	

3.3.2 Ecological receptors

An Ecological Risk Assessment (ERA) (WSP, 2019a) was undertaken to assess potential risk to the environment. The ERA assessed potentially complete exposure pathways associated with PFAS in surface water, sediment and sediment pore water within the Monitoring Area for:

- lower order species (i.e. plants, terrestrial invertebrates, aquatic invertebrates and fish) – based on comparison to adopted screening benchmarks, and
- higher order species (i.e. predatory birds, mammals and reptiles) – based on quantitative food web modelling.

Mammals that spend most of their time in trees (arboreal mammals) were excluded from the ERA as they were considered to have a lower potential exposure compared to terrestrial animals. The ingestion of PFAS in groundwater was not evaluated as a separate exposure scenario as assessment of surface waters provided a better representation of potential ingestion exposures. PFOA concentrations in surface water, groundwater and soils did not exceed adopted ecological screening criteria and were therefore not carried further in the ERA.

In summary, the ERA identified that there is a potential for direct toxicity effects to occur to lower order terrestrial/semi-terrestrial and aquatic species (i.e. plants, terrestrial invertebrates, aquatic invertebrates, fish), and for bioaccumulation of PFOS to occur to higher order species both on- and off-base.

A summary of the ecological risk outcomes is presented in Table 4 for terrestrial and semi-terrestrial receptors and Table 5 for aquatic receptors, below.

Table 4: PFAS Receptors – Terrestrial Ecological Receptors (land based) (based on ERA, (WSP, 2019a))

Who (Receptor populations)	How (Exposure Pathway)	What (Assessment of Risk)	Why (Reason for Risk)	Added Context	Has the risk profile changed?
On-base (Where - source location)					
Herbivorous mammals (Pale Field Rat, Agile Wallaby).	Ingestion of food (eating plants containing PFAS) and drinking water containing PFAS, incidental ingestion of soil/sediment (when eating and drinking).	Moderate.	There is a potential for exposure to PFOS through bioaccumulation in the food web. PFOS concentrations in surface water, groundwater, and soil on-base exceeded the adopted ecological screening criteria at most on-base locations. PFOA concentrations in surface water, groundwater and soils did not exceed adopted ecological screening criteria.	PFAS were not detected in any plant samples. The total intake doses modelled from dietary exposure for herbivorous mammals indicated the potential for bioaccumulation for both dry and wet seasons and therefore the risk was categorised as elevated. The exception being for the herbivorous Agile Wallaby whose modelled total intake during the wet season was assessed as low and acceptable.	No new site-specific information has been identified that would impact the findings of the ERA and therefore the risk profile remains unchanged.
Herbivorous birds (Magpie Goose, Wandering Whistling Duck).				The total intake dose modelled from dietary exposure, for multiple bird species, indicated the potential for bioaccumulation all year round, therefore the risk was categorised as moderate.	
Invertivorous and omnivorous mammals (Canefield Rat, Lesser Long Eared Bat).	Ingestion of food (eating plants and animals containing PFAS) and drinking water containing PFAS, incidental ingestion of soil/sediment (when eating and drinking).			The total intake dose modelled from dietary exposure for the Canefield Rat indicated the potential for bioaccumulation all year round and therefore the risk was categorised as moderate. The total intake dose modelled from dietary exposure for the Lesser Long Eared Bat was acceptable all year round. As there was variability between species in the modelled exposure due to seasonal conditions, the risk was categorised as moderate.	
Invertivorous and				The total intake doses modelled from dietary exposure, for multiple bird species, indicated the potential for	

Who (Receptor populations)	How (Exposure Pathway)	What (Assessment of Risk)	Why (Reason for Risk)	Added Context	Has the risk profile changed?
omnivorous birds (White-browed Crake, Little Pied Cormorant, Pacific Black Duck).				bioaccumulation all year round and therefore the risk was categorised as moderate.	
Off-base (Where)					
Herbivorous mammals (Pale Field Rat, Agile Wallaby).	Ingestion of food (eating plants containing PFAS) and drinking water containing PFAS, incidental ingestion of soil/sediment (when eating and drinking).	Low.	PFOS concentrations in soils, surface water and groundwater exceeded the adopted ecological screening criteria at some locations off-base but were lower than on-base concentrations. Concentrations of PFOA in soil, groundwater and surface water off-base did not exceed adopted ecological screening criteria.	PFAS were not detected in any plant samples. The total intake doses modelled from dietary exposure for multiple species were acceptable all year round for all receptors modelled and therefore the risk was categorised as low.	No new information has been discovered that would impact the findings of the ERA and therefore the risk profile remains unchanged.
Herbivorous birds (Magpie Goose, Wandering Whistling Duck).					
Invertivorous and omnivorous mammals (Canefield Rat, Lesser Long Eared Bat).	Ingestion of food (eating animals and plants containing PFAS) and drinking water containing PFAS, incidental ingestion of soil/sediment				
Invertivorous and omnivorous					

Who (Receptor populations)	How (Exposure Pathway)	What (Assessment of Risk)	Why (Reason for Risk)	Added Context	Has the risk profile changed?
birds (White-browed Crake, Little Pied Cormorant, Pacific Black Duck).	(when eating and drinking).				
On- and off-base (Where)					
Predatory mammals and reptiles* (Water Rat and Eastern Water Dragon).	Ingestion of food (eating animals containing PFAS) and drinking water containing PFAS, incidental ingestion of soil/sediment (when eating and drinking).	Low.	There is a potential for exposure to PFOS that may bioaccumulate through the food web. PFOS concentrations in surface water, groundwater and soil on-base and off-base exceeded the adopted ecological screening criteria with higher concentrations reported on-base. PFOA concentrations in surface water, groundwater and soils did not exceed adopted ecological screening criteria.	PFAS (specifically PFOS + PFHxS) concentrations in the liver were generally higher in predatory species. The total intake doses modelled from dietary exposure for predatory mammals and reptiles were acceptable all year round and therefore the risk has been categorised as low.	No new information has been discovered that would impact the findings of the ERA and therefore the risk profile remains unchanged.
Predatory birds (Swamp Harrier, Brahminy Kite, Black Kite).	Ingestion of food (eating animals containing PFAS) and drinking water containing PFAS.	Moderate.		The total intake dose modelled from dietary exposure, for multiple bird species indicated the potential for bioaccumulation and therefore the risk was categorised as moderate.	

*Excluding Freshwater Snake, Cann's Longnecked Turtle and Australian Freshwater Crocodile.

Table 5: PFAS Receptors – Ecological Aquatic (living in water) (based on ERA, (WSP, 2019a))

Who? (Receptor populations)	How? (Exposure Pathway)	What? (Assessment of Risk)	Why? (Reason for Risk)	Added Context	Has the risk profile changed?
On-base (Where - Source location)					
Predatory mammals (Water Rat).	Ingestion of food (eating animals containing PFAS) and drinking water containing PFAS, incidental ingestion of soil/sediment (when eating and drinking).	Moderate during wet season.	There is a potential for exposure to bioaccumulate PFOS through the food web. PFOS concentrations in surface water, groundwater and soil on-base exceeded the adopted ecological screening criteria at most on-base locations. PFOA concentrations in surface water, groundwater and soils did not exceed adopted ecological screening criteria.	The total intake doses modelled from dietary exposure for multiple species indicated the potential for bioaccumulation. The risk was categorised as elevated due to seasonal variability.	No new information has been discovered that would impact the findings of the ERA and therefore the risk profile remains unchanged.
Invertivorous and omnivorous birds aquatic birds – birds that live in wetlands and forage in water (White-browed Crake, Little Pied Cormorant, Pacific Black Duck).	Ingestion of food (eating plants and animals containing PFAS) and drinking water containing PFAS, incidental ingestion of soil/sediment (when eating and drinking).	Moderate.			

Who? (Receptor populations)	How? (Exposure Pathway)	What? (Assessment of Risk)	Why? (Reason for Risk)	Added Context	Has the risk profile changed?
Off-base (Where)					
Predatory mammals (Water Rat, Australian Snubfin Dolphin).	Ingestion of food (eating animals containing PFAS) and drinking water containing PFAS, incidental ingestion of soil/sediment (when eating and drinking).	Low.	PFOS concentrations in soils, surface water and groundwater exceeded the adopted ecological screening criteria for at some locations off-base but were lower than on-base. Concentrations of PFOA in soil, groundwater and surface water off-base did not exceed adopted ecological screening criteria.	The total intake doses modelled from dietary exposure for multiple species and satisfied the TRVs, all year round and therefore the risk was categorised as low.	No new information has been discovered that would impact the findings of the ERA and therefore the risk profile remains unchanged.
Herbivorous mammals (Dugong).	Ingestion of food (eating seagrass containing PFAS) and water (during feeding/breathing).				
Invertivorous and omnivorous birds, including aquatic birds – birds that live in wetlands and forage in water (White-browed Crake, Little Pied Cormorant).	Ingestion of food (eating plants and animals containing PFAS) and drinking water containing PFAS, incidental ingestion of soil/sediment (when eating and drinking).				
On- and Off-base (Where)					
Predatory birds (Eastern Great Egret, Little Black Cormorant).	Ingestion of food (eating mainly fish containing PFAS) and drinking water containing PFAS.	Low.	There is a potential for exposure to bioaccumulate PFOS through the food web. PFOS concentrations in surface water, groundwater and soil on-base exceeded the adopted	The total intake dose modelled from dietary exposure for multiple species and satisfied the TRVs all year round and	No new information has been discovered that would impact the findings of the ERA and therefore the risk profile remains unchanged.
Predatory reptiles (Freshwater Snake, Cann's	Ingestion of food (eating animals containing PFAS)				

Who? (Receptor populations)	How? (Exposure Pathway)	What? (Assessment of Risk)	Why? (Reason for Risk)	Added Context	Has the risk profile changed?
Longnecked Turtle, and Australian Freshwater Crocodile, Eastern Water Dragon).	and drinking water containing PFAS. Incidental ingestion of sediment considered for Eastern Water Dragon only.		ecological screening criteria for at most on-base locations. PFOA concentrations in surface water, groundwater and soils did not exceed adopted ecological screening criteria.	therefore the risk was categorised as low.	

* Freshwater Snake, Cann's Longnecked Turtle, Eastern Water Dragon and Australian Freshwater Crocodile.

4 RISK MANAGEMENT ACTIONS

This section outlines Defence's actions to manage the risks associated with PFAS that are described in Section 3.

4.1 Background

In developing actions to address potential risks to receptors from PFAS contamination, Defence considers:

- whether an option is proportional to risks
- the sustainability and longevity of an option (environmental, economic and social) in achieving an appropriate balance between benefits and effects
- views of the jurisdictional regulator and other stakeholders
- availability of best-practice management systems, treatments and technologies
- site specific issues (including transformation, cross-contamination, and remobilisation)
- logistical and operational constraints
- effectiveness and validation status of technology
- success measures for the treatment or remediation outcomes
- the need for ongoing operations, management, maintenance or monitoring, and
- the net environmental benefit.

Defence prioritises source, and pathway management as preferable to receptor management, but these components may also be progressed concurrently.

4.2 Implementation

Defence takes a risk-based approach to implementing actions under this PMAP and considers value for money in the use of public resources. Defence engages consultants to implement the PMAP.

Key factors for progressing and prioritising PMAP actions include:

Mitigating PFAS migration and protecting human health	Implementation of practicable solutions to prevent or minimise the migration of PFAS beyond the Defence property boundary, and measures to protect the community from exposure to PFAS.
Higher risks	The relative level of risk being addressed, including changes in land use.
Outcomes of completed works	Outcomes from further studies, technology trials or validated remedial works may change the profile or priority of source areas or works.
Linked actions	Whether the implementation of one response action is dependent on the implementation of another response action.
Use of public resources	Application of the Commonwealth Procurement Rules (issued under the *Public Governance, Performance and Accountability Act 2013*) including the Defence Infrastructure Panel – Environment, Heritage and Estate Engineering Services 2020-2025, to achieve value for money in procurement; and to use public money in an efficient, effective, economical and ethical manner. Cost-effectiveness may be facilitated through: • grouping the implementation of similar risk management actions within one or more Management Areas • aligning Defence infrastructure and maintenance plans with a PFAS response action.

Mandatory approvals	Timeframes for mandatory approvals and notification processes.
New legislation or policy	Development of relevant legislation, policy, guidelines and whole-of-government positioning.
Science and technology	The availability of new relevant science and technology.
Stakeholder input	Information from stakeholders that may impact a risk profile.

4.3 Completed and Proposed Risk Management Actions

A screening assessment of options to manage the risks presented in Section 3 was undertaken as part of the 2019 PMAP. Based on this assessment, Remediation Action Plans (RAPs) were developed for the sources areas where remediation was considered appropriate. Some remediation activities have also since been completed.

The current status of the above listed actions in the 2019 PMAP (Department of Defence, 2019) are detailed in Table 6 below.

Table 6: Status of risk management actions

Source Area	Response Action	Description	Status	Reason / timeframe
SMA1 (Former Fire Training Area - CSR_QLD_000246).	Preparation of a RAP for SMA1.	Remediation options assessment to identify preferred remediation strategy, and development of remediation action plan for future remediation of the source area to minimise soil / surface water interactions in this area resulting in PFAS discharging from the base into the Mundy Creek Catchment.	Completed.	A RAP was prepared from December 2019 to October 2021 and included a remediation options assessment to select a preferred remediation strategy to be implemented to reduce the available PFAS mass migrating from the base.
	PFAS Surface Water Mass Discharge Investigation (for SMA1 and SMA2).	The purpose of the mass flux assessments was to: • Quantify the scale of PFAS mass discharging from each of the source areas and identify priorities for remediation. • Establish a quantitative baseline of PFAS mass discharge from each SMA against which the effectiveness of the remediation can be measured post-remediation.	Completed.	Surface water mass flux assessments were completed in the 2021/2022 wet season for SMA1 and SMA2. SMA1 was the smallest contributor of PFAS mass in surface water leaving the base.
	PFAS Groundwater Mass Discharge.		Completed.	Groundwater mass flux assessment was completed in 2023. SMA1 was the smallest contributor of PFAS mass in groundwater leaving the base.
	Implementation of remediation of SMA1.	Excavation, stabilisation and off-base disposal of soils containing PFAS as required by the RAP (further information is provided in Section 4.5). The drainage culvert through SMA1 was also lined to reduce the groundwater to surface water connections and further reduce PFAS mass leaving the base.	Remediation Completed.	PFAS in soils at SMA1 were identified as contributing to PFAS in the Mundy Creek catchment and therefore this area was prioritised for remediation. A pre-remediation characterisation assessment was undertaken to refine the volumes to be treated and disposed. The remediation included removal of soils containing high concentrations of PFAS and stabilisation of remaining soils.

Source Area	Response Action	Description	Status	Reason / timeframe
				The drain and culvert were reshaped and lined to reduce groundwater/surface water interaction. The work was completed from September 2022 to November 2023. The overall average PFAS (mass) reduction efficiency at SMA1 was 87%.
	Long Term Environmental Management Plan (LTEMP).	A LTEMP has been prepared for SMA1 to document the presence of residual contamination in this area and the required management (including procedures and responsibilities required) to protect users from exposure during normal use and maintenance of the area. The requirement for post-remediation environmental monitoring (surface water and groundwater) is also documented.	On-going.	The LTEMP was prepared in March 2024 and will be implemented alongside the Ongoing Monitoring Plan (OMP).
SMA2 (Fire Station Locale [CSR_QLD_000245] Fuel Farm 2 Forecourt and Eastern Flank [CSR_QLD_000351 CSR_QLD_000679])	Preparation of a RAP for the Fire Station Locale and Fuel Farm 2.	Two separate RAPs were prepared for the Fire Station Locale and Fuel Farm 2.	Completed.	The RAPs were prepared in June 2023 and included a remediation options assessment to select a preferred remediation strategy to be implemented. The RAPs focused on reducing the mass of PFAS in soils contributing to movement of PFAS through surface water and groundwater pathways.
	PFAS Surface water Mass Discharge Investigation (for SMA1 and SMA2).	The purpose of the mass flux assessments was to: • Quantify the scale of PFAS mass discharging from each of the source areas and identify priorities for remediation.	Completed.	Surface water mass flux assessments were completed in the 2021/2022 and 2022/2023 wet season at SMA2. SMA2 was the largest contributor of PFAS mass in surface water leaving the base.

Source Area	Response Action	Description	Status	Reason / timeframe
	PFAS Surface water Mass Discharge Investigation (for SMA2 and SMA3).	• Establish a quantitative baseline of PFAS mass discharge from each SMA against which the effectiveness of the remediation can be measured post-remediation.		
	PFAS Groundwater Mass Discharge.		Completed.	Groundwater mass flux assessment was completed in 2023. SMA2 was the largest contributor of PFAS mass in groundwater leaving the base.
SMA3 (5th Aviation Regiment (5AVN) facilities 5th Aviation Regiment (5AVN) wash bay) (CSR_QLD_000680 CSR_QLD_000681)	Preparation of a RAP.	The 2019 PMAP identified one remedial option comprising hydraulic control of surface water to limit runoff from SMA3.	On hold Following completion of the mass flux study (discussed below), the efficacy of implementing the proposed remedial option was reconsidered. For SMA3, groundwater remediation works are currently considered to be a lower priority than planned remediation works at other SMAs to achieve reductions in PFAS mass discharge from the Base.	The Groundwater and Surface Water PFAS Mass Discharge assessments recommended that groundwater (and surface water) monitoring at SMA3 including annual mass discharge estimates should continue, to enable trends to be tracked and allow future risk-based assessment of possible groundwater remediation (so far as reasonably practicable). It is noted that source areas within SMA3 are currently beneath operational buildings, and any source area remediation works would directly affect operational capability. Where redevelopment of the 5AVN precinct provides opportunities to complete PFAS remediation as part of construction works, this will be considered on a project-by-project basis.

Source Area	Response Action	Description	Status	Reason / timeframe
SMA3 (5th Aviation Regiment (5AVN) facilities 5th Aviation Regiment (5AVN) wash bay) (CSR_QLD_000680 CSR_QLD_000681)	PFAS Surface water Mass Discharge Investigation (for SMA2 and SMA3).	The purpose of the mass flux investigations was to: • Quantify the scale of PFAS mass discharging from each of the source areas and identify priorities for remediation. • Establish a quantitative baseline of PFAS mass discharge from each SMA against which the effectiveness of the remediation can be measured post-remediation.	Completed.	Surface water mass flux assessments were completed in the 2022/2023 wet season for SMA3. SMA3 was a minor contributor to PFAS mass in surface water leaving the base when compared to SMA2.
	PFAS Groundwater Mass Discharge.		Completed.	Groundwater mass flux assessment was completed in 2023. SMA3 was a minor contributor of PFAS mass in groundwater leaving the base. Based on the outcomes of the mass flux studies completed to date and the operational nature of the 5AVN precinct, remediation activities have been deferred. Where construction projects present an opportunity for PFAS mass removal, these will be undertaken.

4.4 Additional Risk Management Actions

Additional management actions have been identified and implemented since publication of the 2019 PMAP. A description and the status of these actions are set out in Table 7 below.

Table 7: Status of additional risk management actions

Source Area	Action	Description	Status	Reason / timeframe
SMA2 (Fire Station Locale [CSR_QLD_000245] Fuel Farm 2 Forecourt and Eastern Flank [CSR_QLD_000351 CSR_QLD_000679]).	Remediation and Validation.	Implementation of RAP. The remedial approach includes the excavation, treatment and off-base disposal (to landfill or thermal destruction) of approximately 6,244 m^3 of soil from the Fire Station Locale and 2,400 m^3 of soil from the Fuel Farm 2 Forecourt, and Eastern Flank.	Planned Works.	Remediation of the Fire Station Locale and Fuel Farm 2 in accordance with the RAP is to be undertaken during the 2025 dry season.
Stockpiles 1 and 2 (CSR_QLD_000232).	Remediation and Validation.	Two covered stockpiles of soil combined with demolition wastes that originated from previous projects on the base.	In progress.	The stockpiles were sampled to facilitate waste classification for disposal. Based on the reported concentrations exceeding the landfill acceptance criteria, the stockpiles are not suitable for landfill disposal and the remediation of the stockpiles will be integrated into the remediation delivery for SMA2 in 2025 which will include treatment to meet landfill disposal criteria or off-base thermal destruction.
Disused runway 13/31 (CSR_QLD_000682).	Further investigation to assess PFAS mass contribution and viability for remediation.	Historical training including former burn pit adjacent to the western end of disused runway 13/31. Visual evidence of burn pits was previously identified however the extent of contamination was not able to be verified due to access constraints at the time (boggy conditions).	In progress.	Preliminary investigation has been completed that identified the presence of PFOS + PFHxS concentrations in soils below the human health criteria in a commercial land use setting however the ecological criteria for soils were exceeded. Further investigation is planned for 2025.
Former Fire Training Ground at the	Further investigation to	Visual evidence of burn pits was previously identified however the	In progress.	Preliminary investigation has been completed, that identified the presence of

Source Area	Action	Description	Status	Reason / timeframe
northern end of the main runway 01/19 [in service]) – (CSR_QLD_000247).	assess PFAS mass contribution and viability for remediation.	extent of contamination was not able to be verified due to access constraints at the time (boggy conditions).		PFOS + PFHxS concentrations in soils exceeding the human health criteria in a commercial land use setting and the ecological criteria. Further investigation is planned for 2025.
Former Fuel Farm 1 (CSR_QLD_000236).	Re-evaluation of existing contamination data.	Limited PFAS assessment due to the presence of new Defence infrastructure (back-up power station and other smaller buildings).	Planned Works.	A re-evaluation of the existing PFAS data collected since the DSI is proposed ascertain if further investigation may be required. Ongoing monitoring as part of the OMP.
Former Fire Training Area (near OLAs) - CSR_QLD_000248.		Limited PFAS assessment to date due to seasonal conditions and Defence operations.		
Whole of base.	Re-evaluation of existing contamination data.	Undertake review of existing PFAS data for the base for consideration with respect to remediation so far as reasonably practicable (SFARP) principles and identify if further assessment or remediation is required.	Planned Works.	Defence has adopted a remediation SFARP approach to address PFAS contamination at the base. A re-evaluation of the existing PFAS data is proposed to ascertain if further investigation, and potential remediation may be required to achieve the remediation SFARP principles. The re-evaluation is to be undertaken in 2025. Subsequent investigation, monitoring or remediation, will be scheduled upon completion, where required.
Off-base.	Biota sampling and revised human health risk assessment.	To inform and update the HHRA , additional biota sampling has been scheduled for 2025.	Planned Works.	The previous risk assessments were completed in 2018 (for the HHRA) and 2019 (for the ERA). To identify changes within the Off-base Monitoring Area which may affect the risk profile for seafood consumption, ecological risks and resultant exposure pathways, additional biota sampling has been scheduled for 2025.

Source Area	Action	Description	Status	Reason / timeframe
				This will be followed by updates to the HHRA.
Off-base	Update Water Use Survey	To assess if there have been any changes to the risk profile, an updated Water Use Survey is proposed to confirm the current understanding of how people are using the water of the Monitoring and Management Areas.	On-hold.	The need for updating the Water Use Survey will be further assessed following the outcomes of the biota sampling and ongoing monitoring.

4.5 Completed Remediation

The PFAS remediation program has been implemented at SMA1. The remediation works were completed between September 2022 to November 2023 and a validation report was completed in March 2024.

The remediation was based on the following rationale:

- Excavation, treatment and re-use of soils with PFOS+PFHxS >1 mg/kg
- Excavation and treatment of soils with PFOS+PFHxS >20 mg/kg for landfill disposal, and
- Excavation and off-base thermal treatment of soils with PFOS+PFHxS >20 mg/kg which unable to meet landfill acceptance criteria for either total concentrations or leachability.

Excavation and treatment were undertaken in approximately 100 m^3 in-situ 'Lots', based on pre-validation and pre-characterisation. PFAS contaminated soils were treated on-site using powdered activated carbon (PAC) at dosing rate of 1.5% PAC (based on pre-remediation trials).

The volumes of soil and concrete excavated, and the fate are presented in Table 8.

Table 8: Excavated material volumes and fate

Fate of material	*In-situ* volume (m^3)	Disposal (t)	PFAS mass (kg and %)	Comment
Treatment and Reuse	6,536	NA	55.1 (44%)	Treatment of soil with PAC (with re-treatment as required) to meet the treatment criteria. Treated soil was used to backfill excavations in 250 mm lifts and compacted.
Treatment and Landfill	411	860	16.9 (13.4%)	Treatment with 1.5% PAC, followed by waste acceptance and transport to landfill for disposal in accordance with Queensland environmental legislation including requirements for waste tracking.
Thermal Treatment	341	520	46.6 (37.0%)	Preparation of waste classification and regulatory acceptance to transport waste interstate (in appropriate containers with waste tracking documentation) to a hazardous waste management facility for thermal treatment of PFAS impacted soils and final disposal.
Monocell (ACM)	203	568	7.5 (5.9%)	Following an unexpected find of Asbestos Containing Material (ACM), the ACM including soil with high PFAS concentrations were disposed off-base to a regulated waste monocell disposal facility with waste tracking documentation. Excavations (wall and base) were visually cleared of asbestos prior to backfilling.
Concrete	NA	184	NA	Concrete slabs were demolished and tested prior to remediation works

Fate of material	*In-situ* volume (m^3)	Disposal (t)	PFAS mass (kg and %)	Comment
				commencing. Concrete was transported and disposed to a regulated waste facility with appropriate waste tracking documentation.

Excavations were backfilled using treated soils (as per Table 8). 4,224 tonnes of topsoil, and 2,849 tonnes of road base (PAC added) were imported to the base. Imported fill material was tested and validated for use either prior to or immediately upon import to the site.

The final swale drain reconstruction design comprised 2-3% PAC-treated imported road base to backfill the drain and a Tiltex® (needle punch composite consisting of a concrete-sand mix embedded and fixed between two layers of geotextile) lining keyed into the road base soil interface. An interceptor trench was excavated on both sides of the drain to a depth of 1 m and filled with treated (5% PAC) soil from the trench excavation.

The final ground surface slopes toward the swale drain. Topsoil (approximately 150 mm) was placed over the surface and hydroseeded to establish ground cover.

The overall average PFAS (mass) reduction efficiency at SMA1 was 87% which accounts for the mass of PFAS treated and re-instated, disposed off-base, and the PFAS mass left around services or outside the excavation footprint.

4.6 Ongoing Monitoring and Trigger Levels

Defence continues to monitor PFAS concentrations in the environment at the base through an ongoing monitoring program. This allows for the timely identification and management of emerging risks and informs Defence's approach to the management of PFAS. Monitoring requirements are outlined in an Ongoing Monitoring Plan (OMP). The OMP is reviewed regularly and, if required, amended to ensure it continues to provide the data needed to monitor important changes in PFAS concentrations and distribution.

The results from the ongoing monitoring program are shared with the Queensland Department of Environment, Tourism, Science and Innovation (DETSI) and are provided in an Ongoing Monitoring Report, available on the Defence website. The Ongoing Monitoring Report provides the PFAS data, and an analysis of what changes in concentrations may mean to the profile of PFAS contamination set out in the CSM, or potential changes to risks to human health or the environment.

Based on the data collected to date and presented in the Ongoing Monitoring Report (July, 2024), it was considered that the monitoring data was consistent with the CSM prepared as part of the DSI, HHRA and ERA and as outlined in Section 3.

The OMP outlines triggers and actions that Defence will undertake if certain results or trends are reported from the ongoing monitoring program sampling. This includes actions to confirm the accuracy of results, notification to DETSI and other agencies upon new PFAS detections, increasing trends, and implementing additional investigations and risk management actions if the monitoring data indicates changes to the current risk profile.

5 NEXT STEPS

Defence will carry out the risk management actions set out in this PMAP and continue to reassess actions based on a range of factors, such as the outcomes of remediation, monitoring results, changes to government policy settings, site conditions and scientific methodologies and technologies.

Defence will review, and, if required revise the PMAP at regular intervals to ensure the PMAP remains current, relevant and prioritises the right actions to protect human health and the environment. Defence will continue to engage with the community, Townsville City Council, Queensland DETSI, Queensland Health and other stakeholders to ensure information is available in an easily accessible form.

It is not possible to remove all PFAS from the environment. Remediation at RAAF Base Townsville will be undertaken so far as reasonably practicable, and unacceptable risks that may remain will be identified, through monitoring, and appropriately managed.

In determining what is reasonably practicable, a range of aspects will be considered, including the:

- level of risk from PFAS to human and ecological receptors
- environmental site setting
- nature and extent of PFAS contamination
- availability of proven technologies suitable for the characteristics of the site
- logistical and operational constraints of the site, and
- financial and sustainability aspects of each technology.

At completion of remediation, an independent professional, accredited as a site auditor in Queensland and engaged by Defence will assess whether remediation has been conducted so far as reasonably practicable. The PMAP will then be updated to reflect a transition to ongoing monitoring, and long-term management of remaining risks.

APPENDIX A REFERENCES

Key documents

Department of Defence (Defence) 2019	*RAAF Townsville PFAS Management Area Plan.* Australian Government Department of Defence, December 2019.
Defence, 2024a	*Remediation So Far As Reasonably Practicable Guidance.* Australian Government Department of Defence, 20 September 2024.
Department of Health 2019	*Health Based Guidance Values for PFAS for use in site investigations in Australia* (updated September 2019), Australian Government, Department of Health.
HEPA 2020	*PFAS National Environmental Management Plan (NEMP), version 2.0 .* Heads of Environmental Protection Authorities Australia and New Zealand (HEPA).
National Health and Medical Research Council (NHRMC) 2019	*Guidance on Per and Polyfluoroalkyl substances (PFAS) in Recreational Water.* Canberra: National Health and Medical Research Council (2019)
WSP 2018a	*RAAF Base Townsville Human Health Risk Assessment (HHRA).* https://web.archive.org.au/awa/20230427183323mp_/https://defence.gov.au/Environment/PFAS/docs/Townsville/Reports/HumanHealthRiskAssessmentReportBody.pdf
WSP 2018b	*RAAF Base Townsville Detailed Site Investigations - PFAS.* https://web.archive.org.au/awa/20230427183359mp_/https://defence.gov.au/Environment/PFAS/docs/Townsville/Reports/DetailedSiteInvestigationVol1MainReport.pdf
WSP 2019	*RAAF Base Townsville - Ecological Risk Assessment (ERA).* https://web.archive.org.au/awa/20230427183117mp_/https://defence.gov.au/Environment/PFAS/docs/Townsville/Reports/201912EcologicalRiskAssessmentReport.pdf
WSP 2023a	*PFAS Surface Water Mass Discharge Sub-Management Areas 2 and 3: RAAF Base Townsville.* WSP Australia Pty Limited, 28 June 2023, document reference: PS119662-WSP-SYD-CLM-REP-021
WSP 2023b	*PFAS Groundwater Mass Discharge 2023.* WSP Australia Pty Limited, 29 June 2023, document reference: *PS119662-WSP-SYD-CLM-REP-022*

Other References

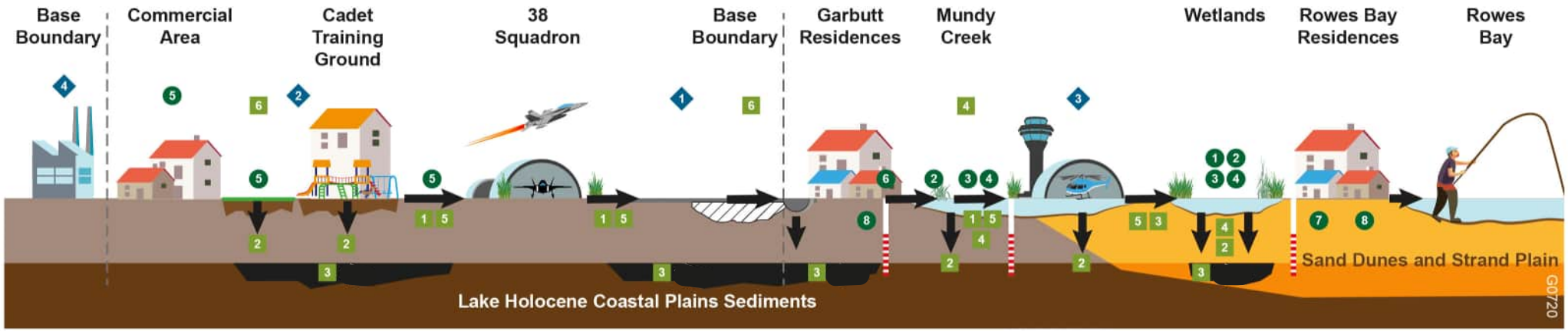
AECOM 2024	*Ongoing Monitoring Interpretive Report (June 2023 - March 2024) - RAAF Base Townsville*. https://www.defence.gov.au/sites/default/files/2024-07/2023-2024OngoingMonitoringReport-RAAFBaseTownsville.pdf
AECOM 2024a	*Sampling and Analysis Quality Plan*, PFAS OMP RAAF Base Townsville, Revision 11. Townsville: AECOM.
BOM 2024, March 25	*Bureau of Meteorology (BOM) Townsville Aero (Station number 032040).* Retrieved from Townsville Aero (Station number 032040): http://www.bom.gov.au/climate/averages/tables/cw_032040.shtml
Department of Climate Change, Energy, the	*Protected Matters Search Tool*. Retrieved from https://www.dcceew.gov.au/environment/epbc/protected-matters-search-tool

Environment and Water 2024)	
Defence 2024	*Ongoing monitoring program reporting guidance.* Directorate of PFAS Investigation and Management Branch / Infrastructure Division. Revision 0 issued February 2024.
Golder Associates Pty Ltd (Golder) 2023	*PFAS Surface Water Mass Discharge, Sub-Management Areas 1 and 2: RAAF Base Townsville.*
NEPC 1999	National Environment Protection Council (NEPC) *National Environment Protection (Assessment of Site Contamination) Amendment Measure* (NEPC), 1999, as amended 2013
Townsville City Council 2014	*City of Townsville*. Retrieved from City Plan (planning scheme): https://www.townsville.qld.gov.au/building-planning-and-projects/planning-and-building-approval/planning-guidelines-and-tools/city-plan-planning-scheme
Townsville City Council (2024).	Stream Level Data - Louisa Creek (station 532032) obtained by direct request to Townsville City Council database.
WSP 2019b	*RAAF Base Townsville - Seasonal Monitoring Report 1 - PFAS, March 2018.* https://web.archive.org.au/awa/20230427112840mp_/https://defence.gov.au/Environment/PFAS/docs/Townsville/Reports/201912SeasonalMonitoringReport1.pdf
WSP 2019c	*RAAF Base Townsville Seasonal Monitoring Report 2 - PFAS - December 2018 and May 2019.* https://web.archive.org.au/awa/20230427112850mp_/https://defence.gov.au/Environment/PFAS/docs/Townsville/Reports/201912SeasonalMonitoringReport2.pdf

APPENDIX B CONCEPTUAL SITE MODEL

This Appendix provides visualisations of the source – pathway – receptor relationships in the form of a Conceptual Site Model.

Mundy Creek Catchment



KEY

- Surface Water Runoff / Migration
- Groundwater Impact and Migration
- Groundwater Table
- Subsurface Migration
- Stabilised Soils

SOURCES

1. Former fire training ground SMA1 (CSR_QLD _000246)
2. Former cadet training ground
3. Potential former fire training ground
4. Potential unidentified off-Base source

PATHWAYS

1. Surface water runoff
2. Surface water infiltration
3. Groundwater migration
4. Biomagnification
5. Sediment migration
6. Wind erosion - aerial transport of dust particles

POTENTIALLY COMPLETED PATHWAYS

1. Human direct contact (surface water)
2. Human ingestion of aquatic organisms
3. Aquatic ecosystems - direct contact (wind/sediment)
4. Terrestrial and aquatic predators
5. Human inhalation and direct contact (soil/dust)
6. Human ingestion/inhalation of groundwater aerosols
7. Human ingestion/ inhalation of groundwater
8. Human ingestion of stock or produce grown with groundwater

CLIENT
Department of Defence

PROJECT
PFAS Management Area Plan – RAAF Base Townsville

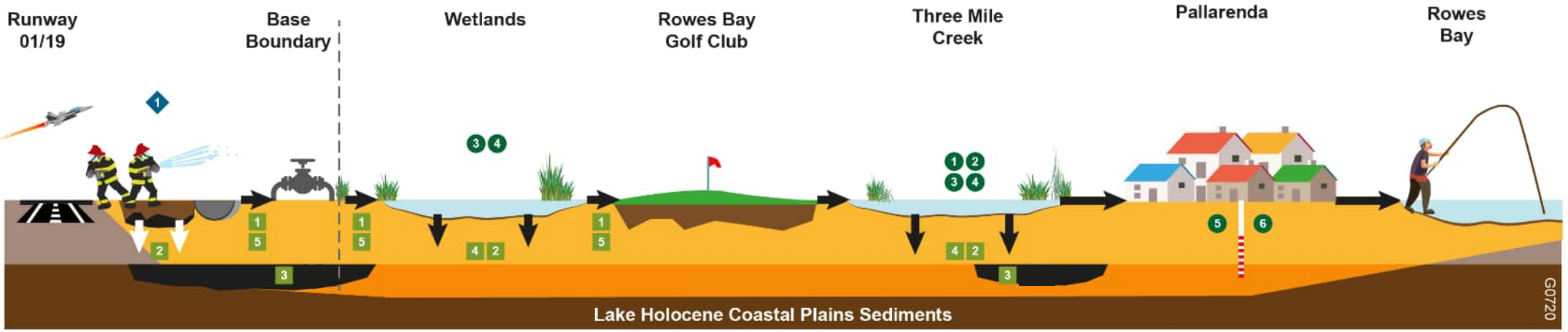
TITLE
Conceptual Site Model

CONSULTANT
WSP

YYYY-MM-DD	2024-12-06
PREPARED	JJGB
DESIGN	JJGB
REVIEW	AH
APPROVED	AH

PROJECT No.	CONTROL	Rev.	FIGURE
PS129286	0001	A	7

Three Mile Creek Catchment



KEY

- Surface Water Runoff / Migration
- Groundwater Impact and Migration
- Groundwater Table
- Subsurface Migration

SOURCES

1. Former fire training ground CSR_QLD_000247

PATHWAYS

1. Surface water runoff
2. Surface water infiltration
3. Groundwater migration
4. Biomagnification
5. Sediment migration

POTENTIALLY COMPLETED PATHWAYS

1. Human direct contact (surface water)
2. Human ingestion of aquatic organisms
3. Aquatic ecosystems - direct contact (surface water and sediment)
4. Terrestrial and aquatic predators
5. Human ingestion/ inhalation of groundwater
6. Human ingestion of stock or produce grown with groundwater

CLIENT
Department of Defence

PROJECT
PFAS Management Area Plan – RAAF Base Townsville

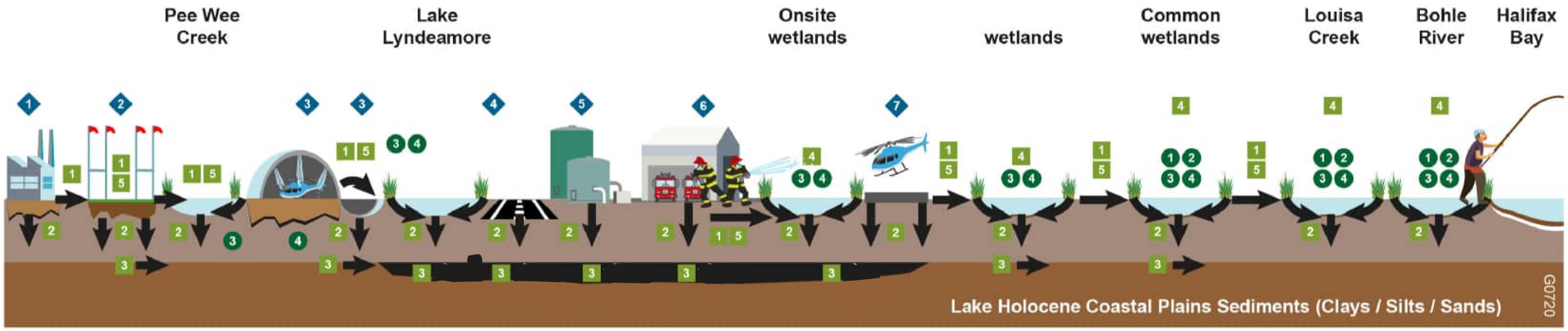
TITLE
Conceptual Site Model

CONSULTANT
WSP

YYYY-MM-DD	2024-12-06
PREPARED	JJGB
DESIGN	JJGB
REVIEW	AH
APPROVED	AH

PROJECT No.	CONTROL	Rev.	FIGURE
PS129286	0001	A	8

Louisa Creek / Town Common Catchment



KEY

- Surface Water Runoff / Migration
- Groundwater Impact and Migration
- Groundwater Table
- Subsurface Migration

SOURCES

1. Potential unidentified off-Base source
2. Ingham Road sports field
3. 5AVN hangers and washplant (CSR_QLD_000680 and CSR_QLD_000681)
4. Runway 13/31
5. Fuel farm 2 SMA2 (CSR_QLD_000351)
6. Fire station SMA2 (CSR_QLD_244 and CSR_QLD_000245)
7. Pad Brahman

PATHWAYS

1. Surface water runoff
2. Surface water infiltration
3. Groundwater migration
4. Biomagnification
5. Sediment migration

POTENTIALLY COMPLETED PATHWAYS

1. Human direct contact (Surface water)
2. Human ingestion of aquatic organisms
3. Aquatic ecosystems direct contact (Surface water and sediment)
4. Terrestrial and aquatic predators

CLIENT
Department of Defence

PROJECT
PFAS Management Area Plan – RAAF Base Townsville

TITLE
Conceptual Site Model

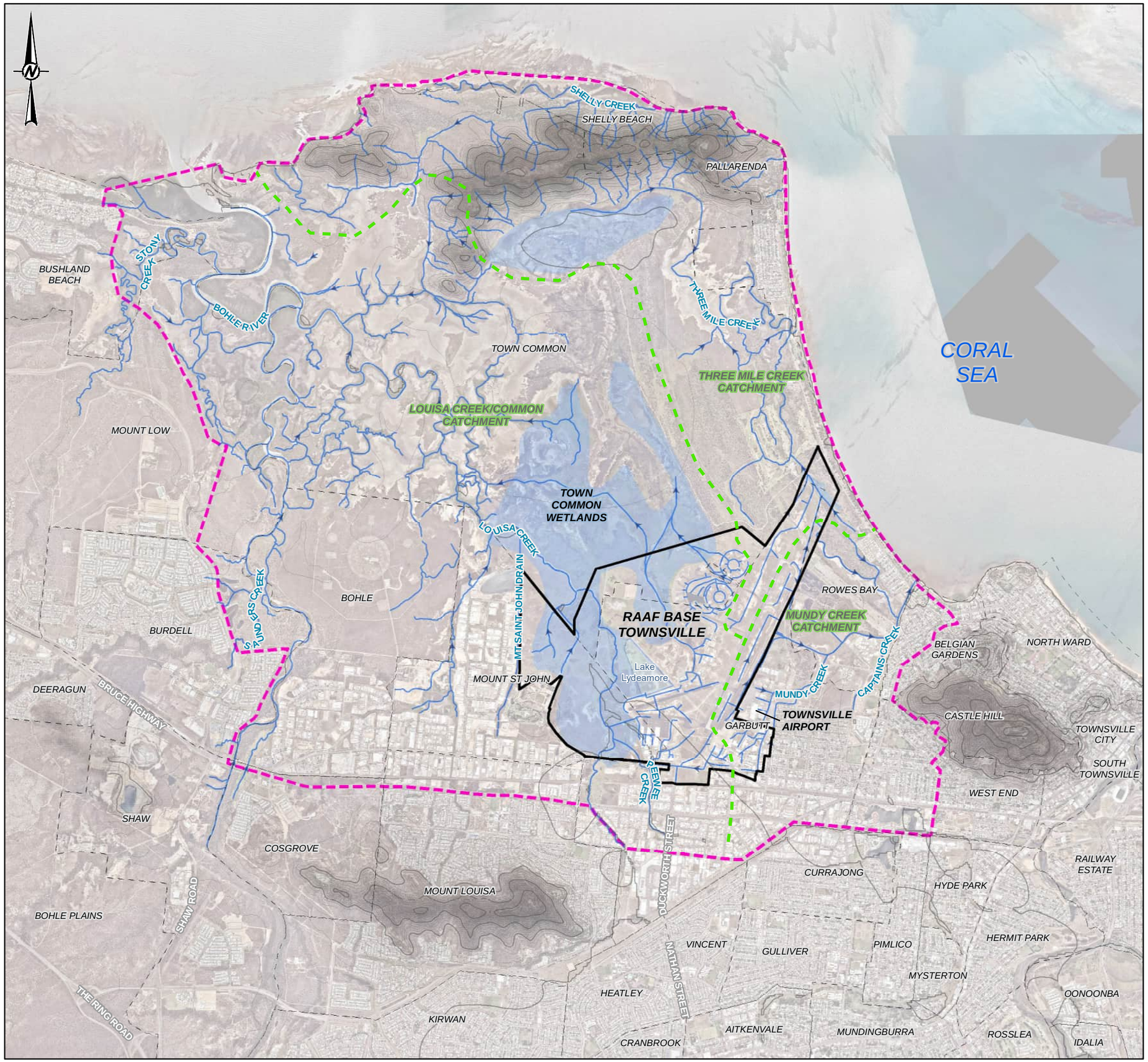
CONSULTANT
wsp

YYYY-MM-DD	2024-12-06
PREPARED	JJGB
DESIGN	JJGB
REVIEW	AH
APPROVED	AH

PROJECT No.	CONTROL	Rev.	FIGURE
PS129286	0001	A	9

APPENDIX C FIGURES

List of Figures



KEY MAP

LEGEND

- Monitoring Area Boundary
- Management Area
- Suburb Boundary
- Wetlands
- Lake Lydeamore
- Drainage Catchment Boundary
- Watercourse

0 1,000 2,000 3,000 4,000

1:50,000 METRES

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 55.

REFERENCE(S)
1. KEY MAP SOURCED FROM ESRI ONLINE BASEMAPS.
2. STATE REFERENCE DATA SOURCED FROM DATA.QLD.GOV.AU.
3. AERIAL IMAGERY SOURCED FROM NEARMAP.COM.

CLIENT
DEPARTMENT OF DEFENCE

PROJECT
PFAS MANAGEMENT AREA PLAN – RAAF BASE TOWNSVILLE

TITLE
SITE LOCATION, MONITORING AREA AND MANAGEMENT AREA

CONSULTANT

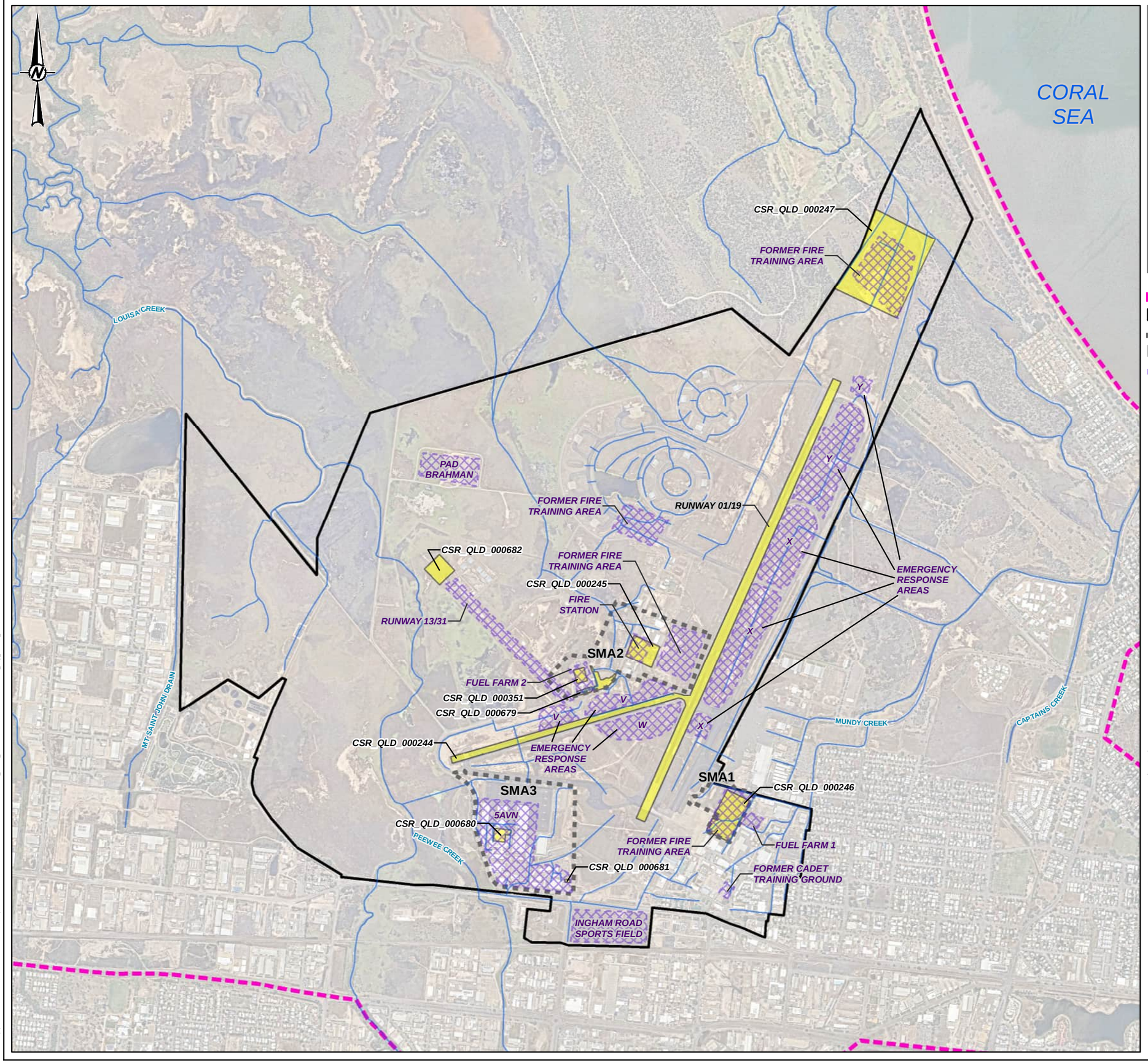
YYYY-MM-DD	2025-02-06
DESIGNED	-
PREPARED	MAH
REVIEWED	CJ
APPROVED	AH

REPORT PS210238-030-R | REV. 2 | FIGURE 1

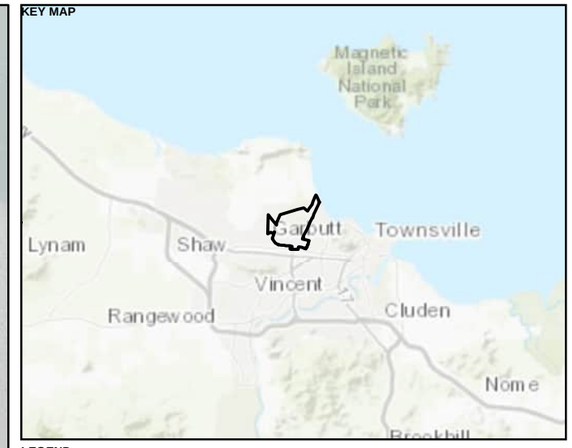
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ISO A3

25mm

0



KEY MAP



LEGEND

- Monitoring Area Boundary
- Management Area
- Sub-management Area (SMA) (PMAP
- Contaminated Site Record (CSR)
- Potential PFAS Source Area (Identified in DSI, 2018)

0 500 1,000 1,500

1:20,000 METRES

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 55.

REFERENCE(S)
1. AERIAL IMAGERY SOURCED FROM NEARMAP.COM.
2. KEY MAP SOURCED FROM ESRI ONLINE BASEMAPS.
3. STATE REFERENCE DATA SOURCED FROM DATA.QLD.GOV.AU.

CLIENT
DEPARTMENT OF DEFENCE

PROJECT
PFAS MANAGEMENT AREA PLAN – RAAF BASE TOWNSVILLE

TITLE
SITE LAYOUT AND KEY SOURCE AREAS

CONSULTANT
wsp

YYYY-MM-DD	2025-02-06
DESIGNED	-
PREPARED	MAH
REVIEWED	CJ
APPROVED	AH

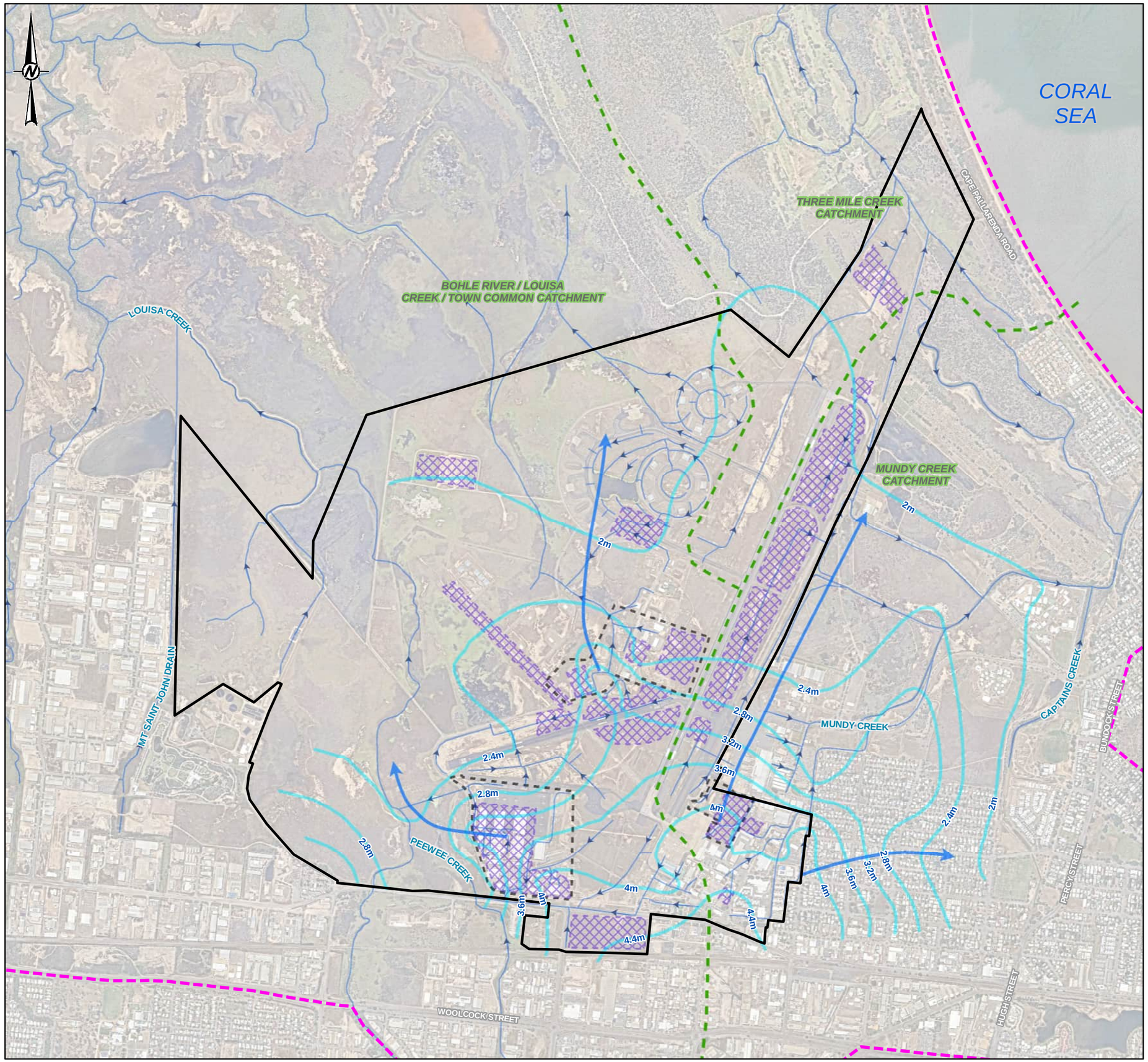
REPORT PS210238-030-R | REV. 2 | FIGURE 2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ISO A3

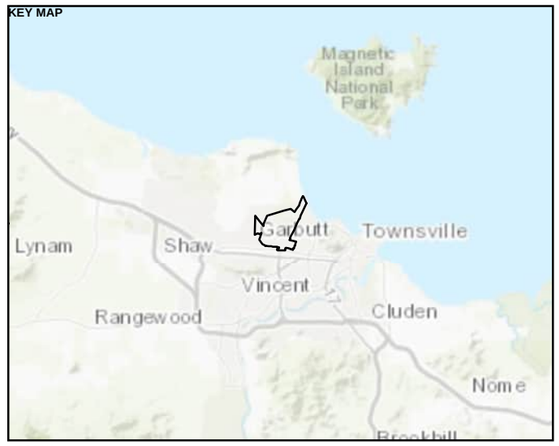
25mm

0

PATH: \\corp.pbwan.net\ap\vol2\Transition\Golder\Melbourne\Complex\Data\GIS\Jobs\2022\PS119982\Mxd\PS210238-030-R_PMAP_2024\PS210238-030-R-F0002-Rev2_Key_Source_Areas.mxd PRINTED ON: 2025-02-06 AT 3:36:55 PM



KEY MAP



LEGEND

- Monitoring Area Boundary
- Management Area
- Sub-management Area
- Potential PFAS Source Area (Identified in DSI, 2018)
- Watercourse
- Surface Water Flow Direction
- March 2024 Inferred Groundwater Elevation Contour (m AHD)
- Inferred Groundwater Flow Direction

0 500 1,000 1,500

1:20,000 METRES

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 55.

REFERENCE(S)
1. KEY MAP SOURCED FROM ESRI ONLINE BASEMAPS.
2. STATE REFERENCE DATA SOURCED FROM DATA.QLD.GOV.AU.
3. AERIAL IMAGERY SOURCED FROM NEARMAP.COM.

CLIENT
DEPARTMENT OF DEFENCE

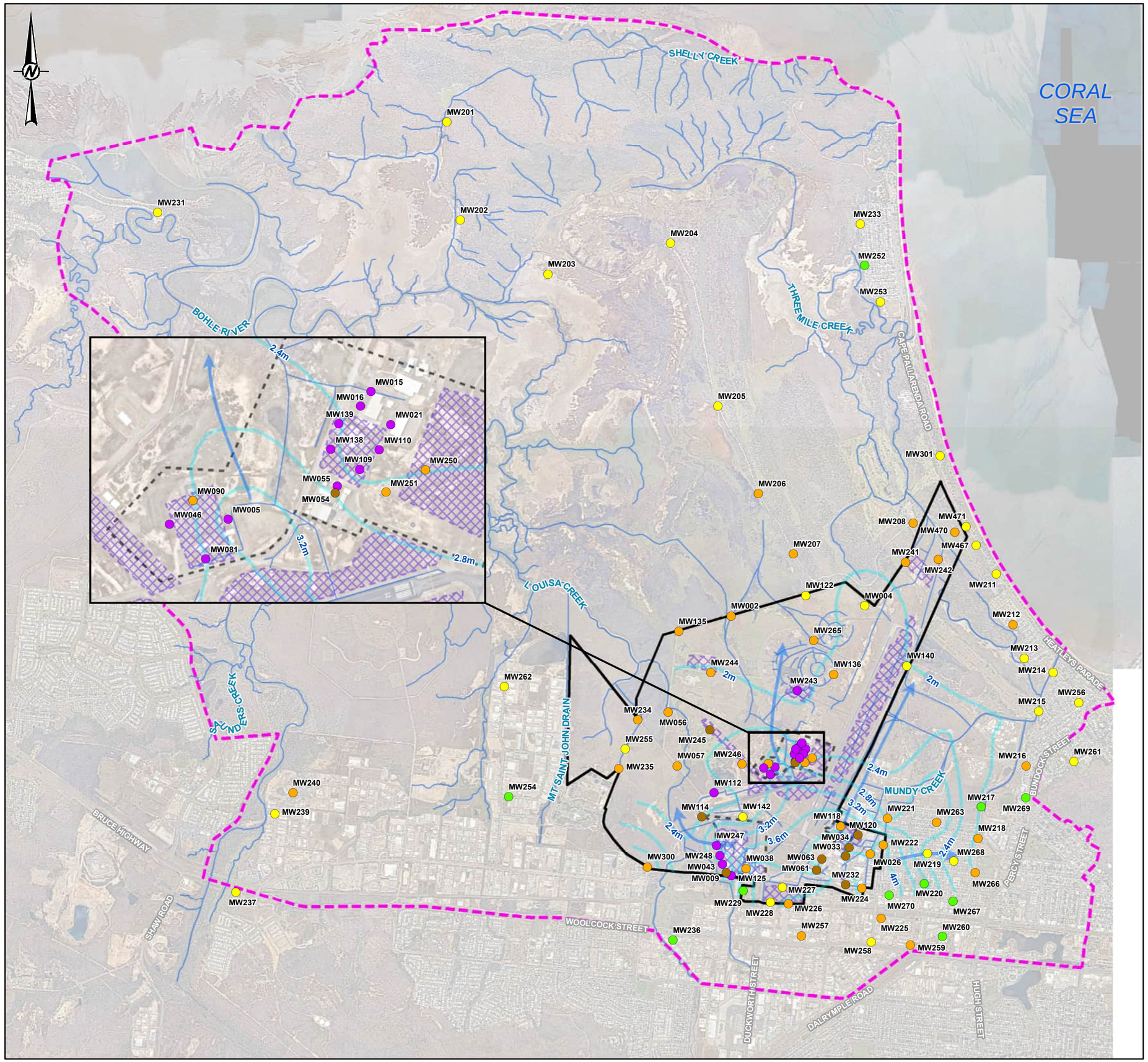
PROJECT
PFAS MANAGEMENT AREA PLAN – RAAF BASE TOWNSVILLE

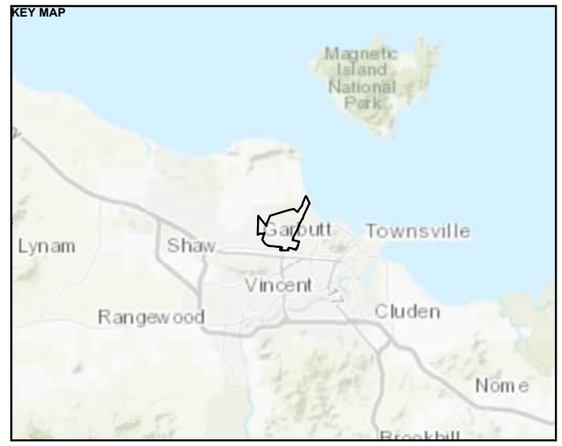
TITLE
GROUNDWATER AND SURFACE WATER FLOW

CONSULTANT

YYYY-MM-DD	2025-02-06
DESIGNED	-
PREPARED	MAH
REVIEWED	CJ
APPROVED	AH

REPORT PS210238-030-R | REV. 2 | FIGURE 3





LEGEND

- Monitoring Area Boundary
- Management Area
- Sub-management Area
- Potential PFAS Source Area (Identified in DSI, 2018)
- Watercourse
- March 2024 Inferred Groundwater Elevation Contour (m AHD)
- Inferred Groundwater Flow Direction

March 2024 Groundwater PFOS + PFHxS Result (ug/L)

- <LOR
- >LOR - 0.07
- 0.07 - 10
- 10 - 50
- >50

0 1,000 2,000 3,000

1:40,000 METRES

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 55.

REFERENCE(S)
1. KEY MAP SOURCED FROM ESRI ONLINE BASEMAPS.
2. STATE REFERENCE DATA SOURCED FROM DATA.QLD.GOV.AU.
3. AERIAL IMAGERY SOURCED FROM NEARMAP.COM.

CLIENT
DEPARTMENT OF DEFENCE

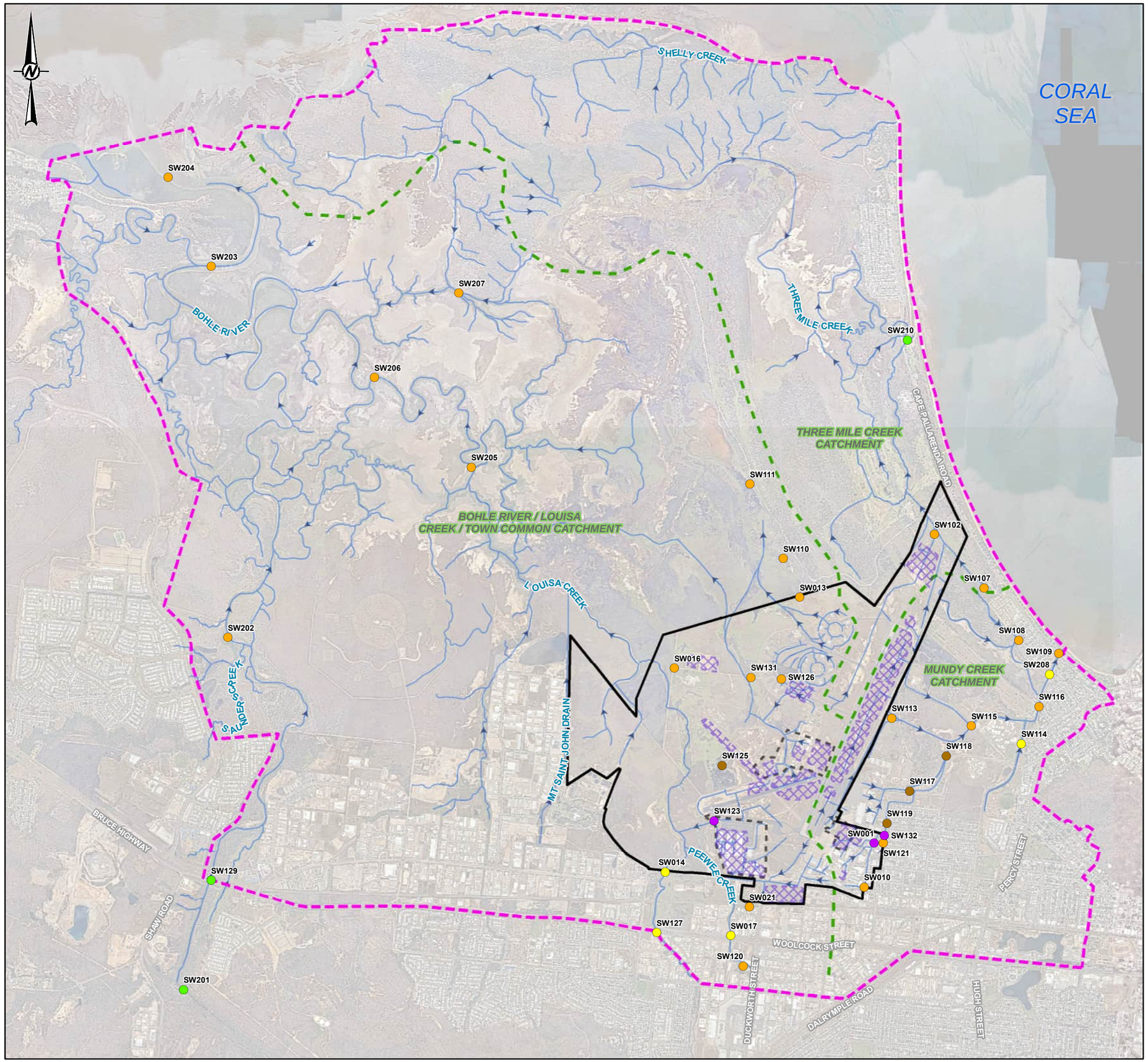
PROJECT
PFAS MANAGEMENT AREA PLAN – RAAF BASE TOWNSVILLE

TITLE
GROUNDWATER ANALYTICAL RESULTS – PFOS + PFHxS – MARCH 2024

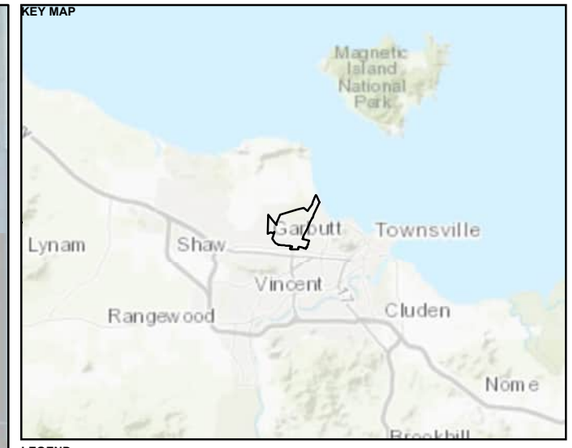
CONSULTANT

YYYY-MM-DD	2025-02-06
DESIGNED	-
PREPARED	MAH
REVIEWED	CJ
APPROVED	AH

REPORT PS210238-030-R | REV. 2 | FIGURE 4



KEY MAP



LEGEND

- Monitoring Area Boundary
- Management Area
- Drainage Catchment Boundary
- Sub-management Area
- Potential PFAS Source Area (Identified in DSI, 2018)
- Watercourse
- Surface Water Flow Direction

March 2024 Surface Water PFOS + PFHxS Result (ug/L)

- <LOR
- >LOR - 0.07
- 0.07 - 10
- 10 - 50
- >50

0 1,000 2,000 3,000

1:40,000 METRES

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 55.

REFERENCE(S)
1. KEY MAP SOURCED FROM ESRI ONLINE BASEMAPS.
2. STATE REFERENCE DATA SOURCED FROM DATA.QLD.GOV.AU.
3. AERIAL IMAGERY SOURCED FROM NEARMAP.COM.

CLIENT
DEPARTMENT OF DEFENCE

PROJECT
PFAS MANAGEMENT AREA PLAN – RAAF BASE TOWNSVILLE

TITLE
SURFACE WATER ANALYTICAL RESULTS – PFOS + PFHxS – MARCH 2024

CONSULTANT

wsp

YYYY-MM-DD	2025-02-06
DESIGNED	-
PREPARED	MAH
REVIEWED	CJ
APPROVED	AH

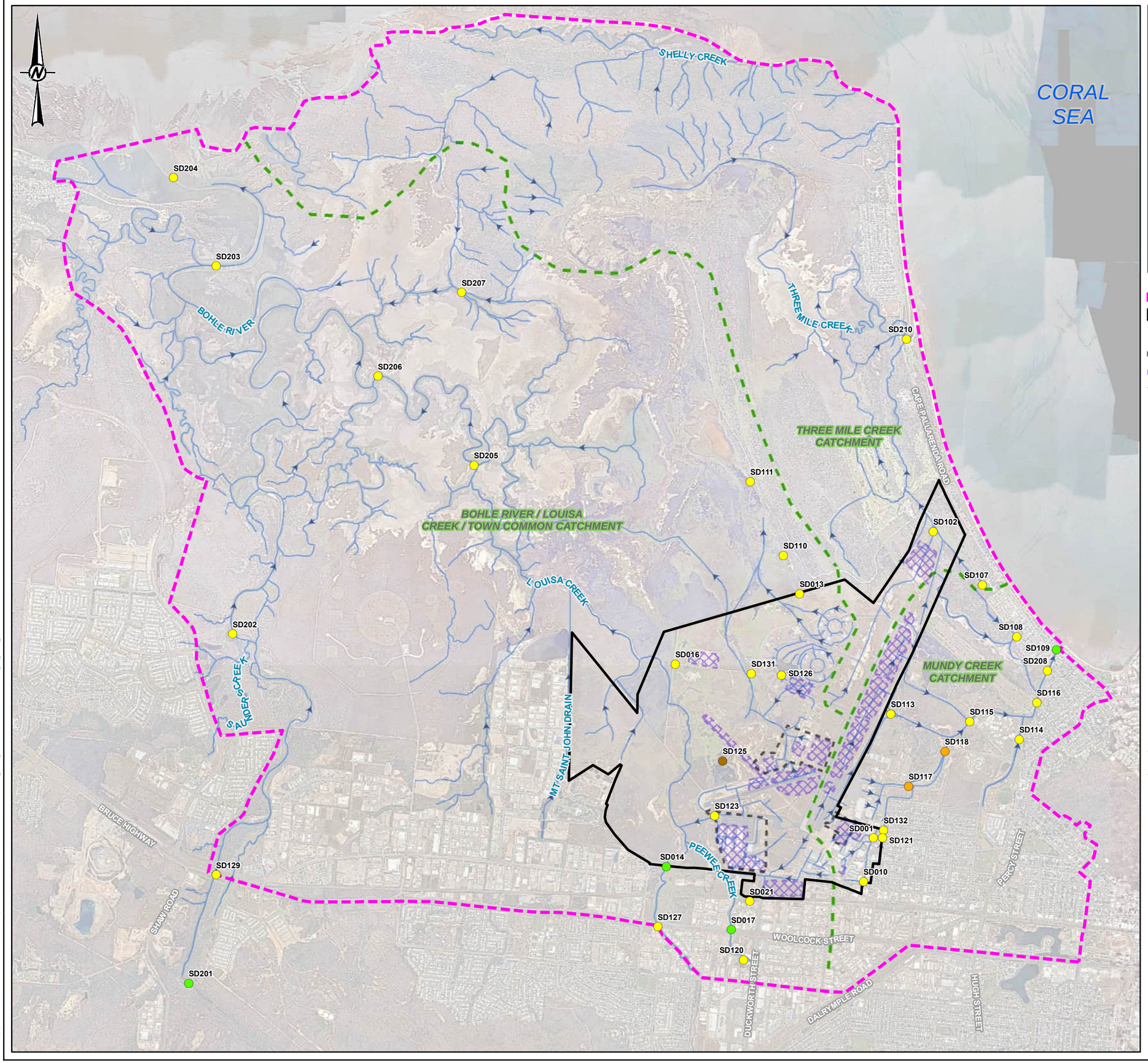
REPORT PS210238-030-R | REV. 2 | FIGURE 5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ISO A3

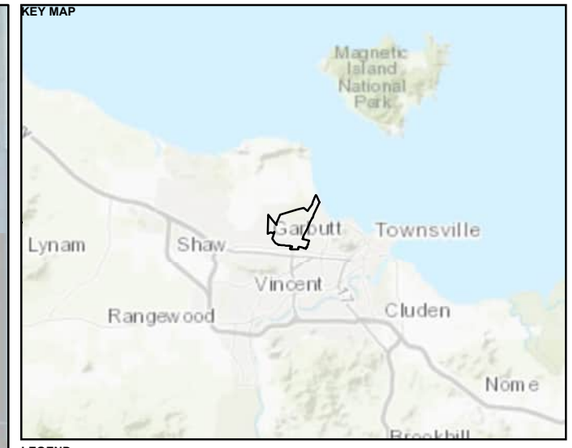
25mm

0

PATH: \\corp.pbwan.net\an2\Transition\Golder\Melbourne\Complex\Data\GIS\Jobs\2022\PS11996\02\Mxd\PS210238-030-R_PMAP_202\APS210238-030-R-F0005-Rev2_SW_PFOS_PFHxS.mxd PRINTED ON: 2025-02-06 AT 3:46:02 PM



KEY MAP



LEGEND

- Monitoring Area Boundary
- Management Area
- Drainage Catchment Boundary
- Sub-management Area
- Potential PFAS Source Area (Identified in DSI, 2018)
- Watercourse
- Surface Water Flow Direction

March 2024 Sediment PFOS + PFHxS Result (mg/kg)

- <LOR
- >LOR - 0.3
- 0.3 - 1
- 1 - 10
- >10

0 1,000 2,000 3,000

1:40,000 METRES

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 55.

REFERENCE(S)
1. KEY MAP SOURCED FROM ESRI ONLINE BASEMAPS.
2. STATE REFERENCE DATA SOURCED FROM DATA.QLD.GOV.AU.
3. AERIAL IMAGERY SOURCED FROM NEARMAP.COM.

CLIENT
DEPARTMENT OF DEFENCE

PROJECT
PFAS MANAGEMENT AREA PLAN – RAAF BASE TOWNSVILLE

TITLE
SEDIMENT ANALYTICAL RESULTS – PFOS + PFHxS – MARCH 2024

CONSULTANT

YYYY-MM-DD	2025-02-06
DESIGNED	-
PREPARED	MAH
REVIEWED	CJ
APPROVED	AH

REPORT PS210238-030-R | REV. 2 | FIGURE 6

PATH: \\corp.pbwan.net\ae\x1Transition\Golder\Melbourne\Complex\Data\GIS\Jobs\2022\PS119\MXD\Mxd\PS210238-030-R_PMAP_20240PS210238-030-R-FI006-Rev2_SD_PFOS_PFHxS.mxd PRINTED ON: 2025-02-06 AT: 3:48:11 PM

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ISO A3

25mm

0