Lavarack Barracks

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 Lavarack Barracks, Queensland.

This PMAP Revision replaces the PMAP for Lavarack Barracks dated 5 August 2020 (the 2020 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 Lavarack Barracks. 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	Comment
0	2020	Final	Initial preparation of the PMAP
A	3 March 2025	Final	2025 revision of PMAP

EXECUTIVE SUMMARY

In 2020 Defence published the Lavarack Barracks (Base) PFAS Management Area Plan (2020 PMAP) for managing risks to human health and the environment from per- and poly-fluoroalkyl substances (PFAS) contamination associated with Lavarack Barracks and surrounding areas.

Since the 2020 PMAP for the Base 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 Lavarack Barracks.

Management Area

The Management Area includes the Base ('On-Base' area) and the surrounding residential suburbs of Murray, Douglas, Annandale, Idalia, Oonoonba, and Wulguru ('Off-Base' area). The Management Area boundary is formed by Ross River to the north, the relevant sub-catchment boundaries to the east and west, and the southern Base boundary to the south. Ross River and its tributaries are considered key ecological receptor within the Management Area, and the location of discharge of surface water and groundwater migrating from the Base. The area north of the Base mainly consists of low-density residential properties. In addition, schools, public recreational areas, commercial and light industrial properties are also located within the Management Area.

PFAS source areas, pathways and risk:

- **Sources:** Twelve primary source areas were identified at the Base. A Remediation Action Plan has been prepared for the Former Fire Station
- **Pathway**: The primary transport pathway for PFAS to migrate off-Base is via surface water and to a lesser extent, groundwater. This was quantified through mass discharge assessment completed since the 2020 PMAP
- **Risk to Receptors**: The risks to human health are considered to be low and acceptable based on the source-pathway-receptor linkages and the known concentrations of PFAS in the environment. Notwithstanding this:
  - Groundwater or surface water (based on Water Use Survey) is not used as a primary source of drinking water. However two residents, in areas with PFAS concentrations below current health advisory levels, indicated using bore (groundwater) water for drinking. The Management Area is served by Townsville City supplied water. As On-Base and Off-Base groundwater is limited to a small number of residents for drinking water uses, this exposure pathway is considered potentially complete
  - Precautionary health warnings have been issued for the consumption of fish from the lakes within the suburb of Idalia, as well as the Gordon Creek. 'No Fishing' signage has been erected, and
  - Elevated risks to aquatic biota have been identified associated with the concentrations of PFAS in surface water migrating from the Base.

Risk management actions:

Defence has completed several investigation and remediation programs at the Base:

- Remediation of 31,000 m^3 of PFAS contaminated soil associated with a legacy stockpile (LAND121) - Completed

- Preparation of Remediation Action Plan for the Former Fire Station has been completed, with the remediation scheduled for 2025 - Planned Works.
- Investigations concluded that the Monocell was not considered to be an ongoing source of PFAS, and remediation was not required - Completed
- Investigations concluded that the Former Fire Training Area was not contributing to PFAS present within Catchment J/K, and contamination was migrating towards Catchment G - Completed. Further investigation of this area is required when Defence infrastructure has been removed - Opportunistic
- Investigations are presently being undertaken to determine the source of PFAS within Catchment K – Commenced, and
- A review of existing PFAS data for the Base is to be undertaken to consider if further assessment or remediation is required to achieve closure of PFAS contamination with respect to Remediation SFARP principles (Defence, 2024a) - Planned Works.

CONTENTS

GLOSSARY

AFFF	Aqueous Film Forming Foam
ASC NEPM	National Environment Protection (Assessment of Site Contamination) Measure, as amended 2013 (NEPC, 1999)
Base	Lavarack Barracks
CSM	Conceptual Site Model
DSI	Detailed Site Investigation
ERA	Ecological Risk Assessment
HHERA	Human Health and Ecological Risk Assessment
HHRA	Human Health Risk Assessment
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
Off-Base	Off-Base (or other Defence property)
OMP	Ongoing Monitoring Plan
On-Base	On-Base (or other Defence property)
PFAS	Per- and polyfluoroalkyl Substances
PFAS NEMP	PFAS National Environmental Management Plan
PFHxS	Perfluorohexane sulfonate
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
PSC	Potential Sources of Contamination
RAP	Remediation Action Plan
Risk management actions	Remediation and management actions to address potential risks to receptors from PFAS contamination.
ROA	Remediation Options Assessment
Risk assessment(s)	The HHERA, HHRA and/or ERA
SFARP	So Far as Reasonably Practicable
Source	A source can be primary or secondary. 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, or surface water bodies.

Unless otherwise defined in this document, definitions provided in the NEMP (HEPA, 2020) or the ASC NEPM (NEPC, 2019) apply.

1 INTRODUCTION

1.1 Background and purpose

In August 2020 Defence published the PFAS Management Area Plan (2020 PMAP) for Lavarack Barracks (the Base) for managing risks to human health and the environment from per- and poly-fluoroalkyl substances (PFAS) contamination associated at the Base and the surrounding area. The location of the Base is shown on Figure 1 in Appendix C.

Since the 2020 PMAP for Lavarack Barracks was developed, Defence has implemented parts of the plan and reassessed what is now needed to best manage risks from PFAS contamination.

This assessment considered:

- Progress made in the implementation of the 2020 PMAP
- The outcomes of the PFAS mass discharge study which provided a detailed understanding of the mass of PFAS leaving the Base, the pathway, and at which locations
- Whether potential risks to human health or the environment from PFAS contamination have changed, based on data collected throughout the ongoing monitoring program and other studies, and
- A review of factors such as changes to government policy setting, 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 the Base.

The PMAP revision has been developed in accordance with the PFAS National Environmental Management Plan 2.0 (NEMP) (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 the following limitations and assumptions:

- The Risk Assessments upon which the consideration of risk to human and ecological receptors are based were completed in 2018 to 2020 and based on the available data at that time. Whilst additional PFAS data has been collected as part of investigation and monitoring programs, and the concentrations of PFAS are broadly consistent, there is potential for changes in water use within the community and these have not been validated
- Base operations; existing infrastructure and infrastructure development (Defence Capability) place limitations on the extent of investigation and remediation in parts of the Base, for example, Former Fire Training Area [Potential Sources of Contamination - 6 (PSC-6)], and
- Remediation Technology, there are limited proven remediation technologies available for PFAS remediation. Remediation technologies are subject of continual research and development. Future remediation designs will consider remediation technology that are commercially available in Australia at the time of preparation.
- Investigation and remediation programs have been completed in accordance with the applicable legislation 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 Lavarack Barracks and surrounding area, as shown on Figure 1 in Appendix C.

The Management Area includes the Base and the surrounding residential suburbs of Murray, Douglas, Annandale, Idalia, Oonoonba, and Wulguru. The Management Area is divided into 'On-Base' and 'Off-Base' areas and comprises 2,365 ha. The Management Area boundary is formed by Ross River to the north, the relevant sub-catchment boundaries to the east and west, and the southern Base boundary to the south.

The On-Base area covers an area of approximately 740 hectares (ha). The Base consists of a working, training, and accommodation facility, which houses the Australian Army 3rd and 11th Brigades and supporting organisations. Activities carried out at the Base are mainly related to general Defence training activities, and vehicle maintenance works. Vehicle maintenance workshops include wash-down bays, interceptor pits, and battery storage areas. The Base also contains numerous workshops and bulk fuel area/oil storage and distribution facilities, including a former Mobil Service Station. Surface water On-Base is located within a number of catchments with the main features being the Top, Middle and Lower Dams (Figure 3, Appendix C).

The Off-Base area to the north of the Base mainly consists of low-density residential properties. In addition, schools, public recreational areas, commercial and light industrial properties are also located within the Management Area. The Ross River and its tributaries are considered key ecological receptor within the Management Area, and the location of discharge of surface water and groundwater migrating from the Base.

The Management Area is located within the dry tropics of Queensland. Townsville's climate is dominated by a wet season (November to April) and dry season (May to October). Townsville's average yearly rainfall is 1,135.8 millimetres (mm) with contrasting wet (90% of rainfall) and dry (10% of rainfall) seasons (BoM, 2024). As a result, many of the watercourses (and drains) that flow through the on-Base and off-Base areas of the Management Area are ephemeral, with little to no water (ponded or flowing) present during the dry season. Surface water is generally limited to downstream water courses (i.e. lower tributaries to Ross Rover) and waterbodies in the On-Base and Off-Base areas (e.g., Top, Middle and Lower Dams on Lavarack Barracks, the lakes in the suburb of Idalia) and Ross River.

Information about the Management Area environmental setting, such as climate, topography, geology, hydrology and various other aspects is provided in the DSI (RPS/Wood, 2019) and the OMP (Defence, 2024b).

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 as a Conceptual Site Model (CSM), which is provided in Appendix B. As part of this PMAP revision, the CSM for the Lavarack Barracks and surrounding areas was reviewed for currency and updated. 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 [referred to as Potential Sources of Contamination (PSC)] 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 PFAS source areas that have been identified through previous investigations (Appendix A) are provided in Table 1. These investigations include the detailed site investigation (RPS/Wood 2019), the annual mass discharge assessment (WSP Golder 2023a), and soil and groundwater delineation investigations for PSC-4 (WSP Golder 2023b), and PSC-5 and PSC-6 (WSP Golder 2023c). A map showing these source areas is provided as Figure 2 in Appendix C.

Table 1: Known source areas of PFAS, Lavarack Barracks, to 2024

Potential Sources of Contamination (PSC)	Source area	Contaminated Site Record (CSR) Number	Extent of PFAS contamination
PSC-1	Soil Stockpile Area	CSR_QLD_000534	• Low concentrations of PFAS in soil, groundwater and surface water • Further sampling required to characterise soil for ongoing training use
PSC-2	Suspected AFFF Disposal Area	CSR_QLD_000535	• Low concentrations of PFAS in soil, groundwater and surface water • No further action required
PSC-3	Former Helicopter Squadron 2CAV Buried OCP Waste Material	CSR_QLD_000488 CSR_QLD_000055	• Low concentrations of PFAS in soil, groundwater and surface water • Possible contribution of PFAS to Top Dam.
PSC-4	Former Fire Station	CSR_QLD_000536	• PFAS present in concrete and soil associated with the former Fire Station, estimate mass of PFAS was 55.6 kg (∑28 PFAS). • Migration via groundwater and surface water to Lower Dam, then off-Base. • Remediation Action Plan prepared • Further assessment under the Dental building to be undertaken in the future if land use changes. Remediation to be undertaken
PSC-5	Monocell	CSR_QLD_000315	• Delineation of soil and groundwater undertaken, with assessment of interactions with surface water indicating no detectable PFAS. Water within Monocell had low concentrations of PFAS. • Surface water and groundwater flow direction toward Catchment G (north-west), with negligible contribution to Catchment J (north-east) and associated off-Base receptors. • The Monocell is not considered to be an ongoing source of PFAS, that requires active management. No remediation action is required for the Monocell.
PSC-6	Former Fire Training Area	CSR_QLD_000313	• Delineation of soil and groundwater undertaken which indicated limited soil PFAS mass associated with one of the burn-pits. • Surface water and groundwater flow direction toward Catchment G (north-west), with negligible contribution to Catchment J (north-east) and associated off-Base receptors.

Potential Sources of Contamination (PSC)	Source area	Contaminated Site Record (CSR) Number	Extent of PFAS contamination
			• Investigation limited to one of the two burn-pit areas due to Defence infrastructure; however, based on principles of remediation SFARP and incomplete PFAS mass migration, remediation of the former Fire Training Area is not warranted at this time. Ongoing monitoring required and additional investigation under Defence infrastructure in the future land use changes.
PSC-7	Land 121 Project	CSR_QLD_000538	• Land121 area excavated as part of development and soil placed in stockpile. Remediation of Land121 stockpile containing PFAS by off-Base disposal was completed in 2024.
PSC-8	Former Helicopter Landing Area (Building 750)		• Low concentrations of PFAS in soil, groundwater and surface water • No further action required
PSC-9	Suspected Fire Training Area		• Low concentrations of PFAS in soil, groundwater and surface water • No further action required
PSC-10	Former Caribou Airfield		• Low concentrations of PFAS in soil, groundwater and surface water • No further action required
PSC-11	Former B Squadron	CSR_QLD_000540	• Low concentrations of PFAS in soil, groundwater and surface water • No further action required
PSC-12	Stockpile Designated Area 2	CSR_QLD_000314	• Low concentrations of PFAS in soil, groundwater and surface water • No further action required
-	Potential source area within Catchment K • - Bulk Fuel Facility • - Petroleum Platoon • - Wash-down Bays	CSR_QLD_000388 CSR_QLD_000387	• Assessment to identify sources within Catchment K which are contributing to Surface Water PFAS mass • Ongoing investigation of Bulk Fuel Facility, Wash-down Bays and Petroleum Platoon.
Secondary	Lavarack Golf Course Sporting Fields	CSR_QLD_000537	• Potential secondary source of PFAS due to irrigation practices at the Base. Irrigation has ceased. • Low concentrations of PFAS in groundwater and surface water • No further action required

Potential Sources of Contamination (PSC)	Source area	Contaminated Site Record (CSR) Number	Extent of PFAS contamination
Secondary	Top, Middle and Lower Dams	CSR_QLD_000539	• Secondary source of PFAS due to discharge either via groundwater or surface water from primary source areas within Catchment G. • Low concentrations of PFAS in groundwater and surface water • No further action required

[1] – Technical sources of extent of PFAS contamination include RPS/Wood (2019a), Department of Defence (2020), WSP Golder (2023a); WSP Golder 2023b); WSP Golder (2023c)

PSC = potential source area; AFFF = aqueous film forming foam; SFARP = so far as reasonably practical; OCP = organochlorine pesticides.

3.2 Transport pathways

PFAS can travel from a source to human or environmental receptors by surface water or groundwater. These are referred to as transport (or migration) pathways. The DSI identified that the dominant transport pathway for PFAS was via surface water migration. It was noted that whilst groundwater pathways do exist, they are limited due to the nature of the geology/hydrogeological setting, such as low hydraulic conductivity, as well as the intermitting and disconnected groundwater flow paths on-Base. In general, there is likely limited groundwater-surface water connectivity due to the low permeability of the alluvial soils on-Base, except around drains and creeks up-stream of the Lower Dam.

These migration pathways, and the potential mass of PFAS migrating off-Base was further assessed as part of the PFAS Annual Mass Discharge Report (Golder, 22 May 2023). This report identifies the mass of PFAS migrating in both the surface water and groundwater transport pathway. The surface water migration was sub-divided into catchments based on the natural surface water flow to enable an understanding of the source areas (Table 1) that may be contributing to the PFAS mass in each catchment at the northern (downstream) boundary of the Base. The surface water catchments are presented in Figure 3, in Appendix C. The groundwater was assessed along the north (down hydraulic gradient) boundary, along a flux plane, divided unto individual ‘faces’ connecting adjoining wells.

The annualized PFAS mass discharge indicates that surface water is the dominant transport pathway for PFAS, with 93% of the PFAS mass migrating via this pathway, with PFAS mass discharge via groundwater estimated to account for, at most, 7% of the annual PFAS mass migration. Off-Base PFAS mass discharge via surface water is dominated by discharge from Catchment G – containing the on-Base series of dams and the priority source area PSC4, the former Fire Station.

The transport pathways identified at and surrounding the Base are summarised in Table 2.

Table 2: PFAS transport pathways

Transport mechanisms	Catchment/ Well ID	Source areas with Catchment	Annual* PFAS Mass discharge (g) at Boundary (estimated)	
			PFOS + PFHxS	∑28 PFAS
Surface Water	A-2	None Identified	44.4	44.4
	B	None Identified	2.9	2.9
	C	None Identified	21.0	21.0
	D	PSC-1 (Soil stockpile area)	10.5	10.5
	E	Secondary PSC-13 (golf course)	3.3	3.6
	F	Secondary PSC-13 (golf course)	5.0	6.1
	G	PSC-2 (suspected AFFF disposal area), PSC-3 (former helicopter squadron), PSC-4 (former fire station), PSC-5 (Monocell), and PSC-6 (former fire training area)	880.0	1,068.4
	H	Secondary PSC-14 (sporting fields- western portion)	1.7	1.7
	I	Secondary PSC-14 (sporting fields- eastern portion)	1.7	1.7
	J	PSC-12 (Stockpile designated area 2) and part of PSC 11 (former B Squadron)	27.2	27.4
	K	PSC-7 (Land 121 Project), PSC-8 (former helicopter landing area), PSC-9 (suspected fire training area), PSC-10 (former Caribou airfield) and PSC-11 (former B Squadron), and potential new sources Bulk Fuel Facility and Petroleum Platoon.	175.7	216.5
	L	None Identified	13.3	14.7
Surface Water Total			**1186.7**	**1418.9**

Transport mechanisms	Catchment/ Well ID	Source areas with Catchment	Annual* PFAS Mass discharge (g) at Boundary (estimated)	
			PFOS + PFHxS	∑28 PFAS
Groundwater	MW125S		2.8	5.6
	MW124		0.05	0.08
	MW123S	PSC 4 (former fire station)**	44.1	53.2
	MW121		0.4	0.5
	MW120		0.1	0.3
	MW002	PSC 8 (former helicopter landing area), PSC 10 (former Caribou airfield) and PSC 11 (former B Squadron)	19.6	22.4
	MW116		0.02	0.05
	MW139		2.2	2.5
	MW117S		1.1	1.4
Groundwater Total			**70**	**86**

Notes:

- Annualised Mass discharge was based on monitoring completed between 1 August 2021 and 31 July 2022
- PSC 5 (Monocell), and PSC 6 (former fire training area) were originally considered to be within Catchment J, however subsequent investigation confirmed that flow from these areas were into Catchment G (Golder, 2023a)
- * Maximum estimated PFAS mass flux for groundwater
- ** MW123S was assigned to PSC-4 Former Fire Station in the Mass Discharge Study (Golder, 2023c)

3.3 Receptors and risks

Figures showing the spatial distribution of PFAS (presented as Perfluorooctane sulfonate (PFOS) + Perfluorohexane sulfonate (PFHxS) as this is the dominant PFAS constituent) in groundwater (Figure 4) and surface water (Figure 5) and sediment (Figure 6) are provided in Appendix C.

3.3.1 Human receptors and assessment of risk

A Human Health Risk Assessment (HHRA) (RPS, December 2019) was undertaken to quantitatively assess potential risk to human health associated with exposure to PFAS in soil, sediment, surface water and groundwater within the Management Area. The HHRA also considered potential human health risks from the consumption of home-grown fruit, vegetables, chicken eggs and seafood within the Ross River and associated tributaries.

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. Furthermore, if a complete exposure pathway does exist, then the total uptake or dose of PFAS over time, (that is, the amount of PFAS that actually enters a person's body), dictates the potential for an adverse (unfavourable) health response. Health-based guideline levels are based on the known dose-response relationship combined with several safety factors to account for uncertainties.

The HHRA process included a comparison of Base PFAS concentrations within the different media (for example, soil) to health-based investigation levels (HIL) or guideline values published by Australian regulators. This is a Tier 1 or screening level assessment. These criteria and guideline values are highly conservative, deliberately set at concentrations below levels 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 for 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 linkages and associated dose.

Concentrations of PFAS in the tissue of some fish species were found to be above Tier 1 screening values. This triggered a Tier 2 assessment that considered a more detailed evaluation of the potential exposure from eating locally caught fish. Samples of water from one dam used to irrigate the golf course were found to exceed Tier 1 screening values for recreational use. Although the dam was not used for swimming, the potential for exposure to PFAS in water to irrigate the golf course was further considered in the Tier 2 assessment. Additionally, because there are no applicable Tier 1 criteria to evaluate produce consumption following irrigation, this pathway was also carried into the Tier 2 assessment.

The HHRA concluded that the potential risk from exposure to PFAS impacted media from the Base was low and acceptable. A summary of the key human receptors is presented in Table 3.

Table 3: PFAS Receptors and risk – Human Health (based on HHRA, RPS December 2019)

Who (Receptor populations)	Where (Source location)	How (Exposure Pathway)	What (Risk to health)	Why (Reason for risk)	More details (Discussion)	Has the risk profile changed?
Off-Base						
Local residents	Off-Base Soil in yards	Accidental ingestion (swallowing) of soil Inhalation of soil and dust (soil-derived)	Very low to negligible	Low concentrations in residential and public soil	PFAS levels measured within off-Base **soil** from private residential land were below health-based investigation levels set for residential soil. Two samples taken from public walkways were below health-based guideline values for recreational areas.	Although no additional soil data have been collected the screening criteria 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 Groundwater	Drinking the water extracted from groundwater	Very low	Limited use of groundwater for consumption.	The Water Use Survey (204 respondents) indicated that 25% of residents had either a groundwater bore or surface water on their property. No respondent indicated bore (groundwater) water or surface water used as a primary source of drinking water. The Management Area is served by Townsville City supplied water. Two residents, in areas with PFAS concentrations below current drinking water guideline values, indicated using bore (groundwater) water for drinking.	Concentrations of PFAS have exceeded the nominated human health guidelines in groundwater monitoring wells since the HHRA was completed, there is limited use of groundwater for drinking water therefore the exposure pathway is considered to be potentially complete. It is noted that there was a limited response rate

Who (Receptor populations)	Where (Source location)	How (Exposure Pathway)	What (Risk to health)	Why (Reason for risk)	More details (Discussion)	Has the risk profile changed?
					As use of groundwater has been identified as a source of drinking water to a limited number of residents, this indicates a potentially complete exposure pathway to human health risk. It is recognised that this exposure pathway is limited to a small proportion of residents.	for the Water Use Survey.
Local residents	Off-Base Garden produce	Eating fruit, vegetables, and poultry eggs irrigated with groundwater and grown/ collected at home	Very low	Concentrations of PFAS in home grown produce are low Consumption of 10% of food consumed daily is home grown	PFAS concentrations in home-grown produce, due to bioaccumulation from groundwater used for irrigation, was below guideline levels for ingestion based on the assumption that 10% of total fruits, vegetables and poultry eggs eaten daily was home-grown (i.e. not from outside sources) It was also noted that the home grown produce, vegetables, fruit and poultry do not appear to be widely grown within the Management Area.	As home-grown produce was not identified to be widely grown and irrigated with bore water, within the Monitoring Area, this risk profile is unchanged. It is noted that there was a limited response rate for the Water Use Survey.
Recreational users of the Ross River, tributaries, and local lakes	Off-Base Surface water & sediments	Accidental ingestion and inhalation of water during swimming, boating, and	Very low to negligible	Low concentrations in surface water and sediments	PFAS levels measured in surface water and sediments of local rivers, creeks, lakes and tributaries were below the health-based recreational screening criteria that are developed considering incidental ingestion and dermal exposures.	The risk profile remains unchanged as the hazards associated with swimming in the creeks remains unchanged and therefore the

Who (Receptor populations)	Where (Source location)	How (Exposure Pathway)	What (Risk to health)	Why (Reason for risk)	More details (Discussion)	Has the risk profile changed?
		other water activities				assumptions made in the HHRA are still valid.
Recreational Anglers	Off-Base Ross River and its tributaries (estuarine and freshwater)	Eating locally caught seafood	Low	Considering a combination of: Generally low PFAS concentrations in fish and the specific species Number of local fish meals per week Includes various locations - Ross River, Northview Lake and Fairfield Lake.	Measured PFAS concentrations within milkfish suggested that consumption of two meals per week caught from within Fairfield Lake (within the suburb of Idalia) will not result in levels of PFAS above TDI. Regardless, because of difficulties in guaranteeing that the public do not over-consume, precautionary advice has been issued by Queensland Health for recreational fishing and the consumption of fish from the lakes within Idalia and Gordon Creek. 'No Fishing' signage has been erected around the lakes within Idalia, as well as existing signage at Alpin's Weir.	No new information has been discovered that would impact the findings of the HHRA and therefore the risk profile remains unchanged.
Recreational Shellfish Harvesters	Off-Base Ross River and its tributaries (estuarine and freshwater)	Eating locally harvested shellfish	Very low to negligible	Low concentrations of PFAS in shellfish.	Recreational shellfish harvesting was considered negligible risk based on concentrations of blue swimmer crab and mud crab being below screening levels.	No new information has been discovered that would impact the findings of the HHRA and therefore the risk profile remains unchanged.

Who (Receptor populations)	Where (Source location)	How (Exposure Pathway)	What (Risk to health)	Why (Reason for risk)	More details (Discussion)	Has the risk profile changed?
On-Base						
Defence personnel, contractors, and visitors	On-Base Soil	Accidental ingestion of soil Inhalation of soil and dust (soil-derived)	Very low to negligible	Low concentrations in soil	PFAS levels within on-Base soil were generally 10 to 1,000 times lower than health-based investigation levels for industrial and commercial worker scenarios. This includes maintenance workers working in trenches and pits within the soil. PFOS + PFHxS concentrations were found to exceed the investigation levels in 6 soil samples in the Former Fire Station where remediation is scheduled to be completed. One concrete sample was also found to have PFOS + PFHxS concentrations that exceeded the investigation levels. These are considered to be outliers within a small area, and people would not commonly access that location, resulting in minor, irregular exposure.	No new information has been discovered that would impact the findings of the HHRA and therefore the risk profile remains unchanged.
Defence personnel, contractors, and visitors	On-Base Groundwater	Drinking the water extracted from groundwater	Very low to negligible	No exposure pathway to groundwater	On-Base groundwater is not extracted. It is not used for drinking or irrigation; therefore, this exposure pathway does not exist.	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 (Risk to health)	Why (Reason for risk)	More details (Discussion)	Has the risk profile changed?
					Groundwater is found at levels greater than 3 m below ground level; therefore, construction or services workers are unlikely to encounter. If groundwater is to be encountered during excavation, exposure can be controlled through Work Health Safety protocols. As such, people are not exposed to PFAS in groundwater.	
Defence personnel, contractors, and visitors	On-Base Surface water Sediments	Direct contact with surface water and sediments	Very low to negligible	No exposure pathway to surface water and sediments	Surface water bodies, such as Top, Middle and Lower Dams, on-Base are not used for recreation. Base personnel do not enter these water bodies to swim or boat. Therefore, no complete exposure pathways exist	The risk profile remains unchanged as the assumptions made in the HHRA are still valid.
Defence personnel, contractors, and visitors. Adults and children utilising the golf course	On-Base Golf course irrigated with water from the Lower Dams	Direct contact with surface water used to irrigate the golf course	Very low	Limited exposure	The potential for exposure to PFAS in water was used to irrigate the golf course is limited. This is based on the intermittent frequency of use of the golf course, the duration of time spent on irrigated areas, and the limited exposure pathway to the water once it has been used to irrigate the golf course areas. The golf course has subsequently been closed and as such irrigation has ceased.	As the golf course has been closed and irrigation is no longer occurring the risk profile associated with irrigated water from Lower Dams is likely to have decreased.

3.3.2 Ecological receptors

An Ecological Risk Assessment (ERA) (RPS, August 2020) was undertaken to assess potential risk to environment. Terrestrial plants and invertebrates, including herbivorous and predatory wildlife, exposure pathways were considered as either not complete or not significant based on PFAS concentrations and current/future land use. Aquatic plants, aquatic invertebrates (e.g. crabs, water bugs, leeches etc.) and fish, as well as herbivorous (plant-eating), piscivorous (fish-eating) and predatory (meat-eating) wildlife, were considered to have potential complete exposure pathways associated with PFAS in surface water, sediment and sediment pore water within the Management Area.

Key conclusions from the ERA are:

- Risks from PFAS to the aquatic environment are likely elevated, with surface water from the central drainage (Catchments G and R) and eastern drainage (Catchments J, K and L) categorised as high risk
- Risks from PFAS to the aquatic environment within the lakes in the suburb of Idalia are considered to be low to moderate risk, and
- PFOS was noted to be accumulating in biota both On- and Off-Base, most likely to accumulate in fish tissue, and less likely to accumulate in aquatic plants.

A summary of the key ecological receptors is presented in Table 4.

Table 4: PFAS Receptors – Ecological (based on ERA, RPS, August 2020)

Who (Receptor populations)	Where (Source Area)	How (Exposure Pathway)	What (Assessment of Risk)	Why (Reason for Risk)	More Details (Discussion)	Has the risk profile changed?
Piscivorous, invertivores and herbivores wildlife	Central Drainage (Catchments G and R)	Based on the bird and mammal diet	High	Elevated Concentrations of PFOS+PFHxS in tissue samples	PFOS is accumulating in biota both on- and off-Base. PFOS least likely to accumulate in aquatic plant tissue and most likely to accumulate in fish tissue	Surface water and groundwater concentrations associated with ecological receptors remain consistent, therefore the risk profile remains unchanged.
	Eastern Drainage (Catchments J, K and L)		High			
	Idalia Suburb Lakes		Low to Moderate			
Aquatic plants, aquatic macroinvertebrates, fish	Central Drainage (Catchments G and R)	Direct contact exposure	Low	Elevated concentrations of PFOS in surface water	Maximum and average PFOS concentrations in surface water were above the screening value protective of direct contact exposure	
	Eastern Drainage (Catchments J, K and L)		Low			
	Lakes in Suburb of Idalia		Low			
Aquatic plants, aquatic macroinvertebrates, fish. Piscivorous, invertivores and herbivores wildlife.	Catchment A	Assessment of all exposure pathways	Negligible	Low concentrations in all media.	PFAS concentrations in surface water, pore water, aquatic plants, aquatic invertebrates, and fish were all below the EILs	
	Catchment C		Negligible			
	Gordon Creek		Negligible			
	Ross River		Negligible			

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 Ongoing Risk Management Actions

A screening assessment of options to manage the risks presented in Section 3 was undertaken as part of the 2020 PMAP. Based on this assessment, the strategy adopted was for further assessment and delineation of soil contamination in the high-risk source areas, and development of Remediation Action Plans (RAPs) for the sources areas where remediation was considered appropriate.

The current status of the actions in the 2020 PMAP are detailed in Table 5 below.

Table 5: Status of 2020 PMAP recommended actions

Source Area	Action	Description	Status	Reason / timeframe
Former Fire Station (PSC-4)	Source area delineation	Delineation of soil contamination within the source area and additional characterisation of extent of groundwater and surface water interaction downgradient of the source area	Completed	Delineation investigation of soil contamination, and assessment for groundwater / surface water action completed in 2022. Investigation results used in the remediation option assessment and development of the RAP (see below).
	Preparation of RAP	Remediation options assessment to identified preferred remediation strategy, and development of remediation action plan for future remediation of the source area	Completed	RAP prepared in 2023. Remediation Contractor to be engaged to commence the remediation works in 2025.
Former Fire Training Area (PSC-6) and Monocell (PSC-5)	Source area delineation of Former Fire Training Area (PSC-6)	Delineation of the soil hot spot identified within the Former Fire Training Area	Completed	Soil and groundwater delineation completed in 2022 to determine if remediation was required. Limited PFAS mass was detected in soil associated with one of the burn-pits at the Former Fire Training Area. Investigation of the second burn pit was not possible as it is located beneath Defence infrastructure (constructed between 2009 to 2011). There is potential for PFAS to be present beneath this infrastructure. Surface water discharge contained PFAS; however, it was discharging to the west into Catchment G and the Top Dam via stormwater infrastructure, rather than Catchment J. Groundwater at the Former Fire Training Area contains PFAS; however, groundwater is migrating to the west toward Top or Lower Dam within Catchment G, rather than Catchment J. Investigation beneath the existing infrastructure should be performed if future land use changes. Based on SFARP principles remediation was not recommended at this time.

Source Area	Action	Description	Status	Reason / timeframe
	Monocell structure (PSC-5)	Further assessment of the Monocell structure and its suitability for ongoing containment of PFAS contaminated material (if present)	Completed	Surface water results indicted no detectable PFAS concentrations discharging from the parade ground above the Monocell area. Concentrations of PFAS from within the Monocell indicated that contents of the Monocell are unlikely to be significantly contaminated with PFAS. No evidence that the Monocell is an ongoing source of PFAS, and no remediation action is required of the Monocell. (note, the Monocell was constructed to contain pesticide impacted materials sourced from the Base)
Soil Stockpile Area 1 (PSC-1)	Characterisation of Stockpile	Further characterisation of the stockpile through the collection of additional soil samples to determine its suitability for ongoing use in civil earthworks training. Available data suggests suitability for re-use on-Base.	Planned Works	Review of existing data for PSC-1 as part of the Re-evaluation of existing contamination data (Table 6). If warranted undertake further assessment of the Soil Stockpile Area 1 (PSC-1) located in the south-western portion of the Base. PSC-1 was ranked at the DSI as a low priority. The proposed stockpile characterisation was associated with the use of the stockpile for civil earthworks training or re-use of the stockpile soil on-Base.
Whole of Base	PFAS Mass Discharge assessment	Completion of a flux study to assess the groundwater and surface water migration pathways from on-Base PFAS source areas to the northern Base boundary to establish the contributions of groundwater and surface water flow to PFAS concentrations in the off-Base Management Area	Completed	The PFAS Mass Discharge Assessment (completed between 1 August 2021 and 31 July 2022) established a qualitative baseline from which remediation actions completed as part of the PMAP can be assessed against. The mass discharge assessment established that surface water was the dominant migration pathway, with Catchment G being the dominant pathway of off-Base PFAS mass discharge.

4.4 Additional risk management actions

Additional management actions have been identified and implemented since publication of the 2020 PMAP. A description and the status of these actions are set out in Table 6 below.

Table 6: Status of additional risk management actions

Source Area	Action	Description	Status	Reason / timeframe
Former Fire Station (PSC-4)	Remediation and Validation	Implementation of RAP	Planned Works	Remediation of Former Fire Station in accordance with the RAP is to be undertaken during the 2025 dry season.
Former Fire Training Area (PSC-6)	Groundwater and surface water monitoring	Inclusion of groundwater and surface water monitoring locations into the OMP	Ongoing	Incorporation of appropriate groundwater and surface water monitoring locations into the Ongoing Monitoring Plan (OMP) to confirm understanding of PFAS migrating from the Former Fire Training Area. The OMP will be routinely implemented at the Base.
	Further investigation if/when access available	Further investigation in this area is currently not accessible	Opportunistic	List Former Fire Training Area on Base records for future investigation and, if warranted, remediation when future access to the area is available (i.e. if Defence infrastructure is removed). Undertake investigation when access to the area is available.
Catchment K	Investigation of potential source areas within Catchment K	Assessment to identify sources within Catchment K which are contributing to Surface Water PFAS mass	Commenced	The PFAS Mass Discharge Assessment identified Catchment K as the primary source of PFAS mass being discharged via surface water to the lakes within Idalia. Investigations commenced in 2023 and are continuing to assess whether the mass discharge is associated with a specific primary source area, or wide spread secondary source areas. The investigations will also assess if active remediation is practicable and should be considered further through the development of a RAP.
LAND121 Stockpile (related to PSC-7)	No specific action in 2020 PMAP	LAND121 Project created soil stockpile of approximately 31,600 m^3 from the LAND121 project which contained low concentrations of PFAS	Remediation Completed	The LAND121 soil stockpile was disposed off-Base to a licensed landfill. Disposal of the soil was completed in 2024. Validation of the footprint of the LAND121 Stockpile is to be completed.

Source Area	Action	Description	Status	Reason / timeframe
Former Helicopter Squadron (PSC-3)	Assessment to understand PFAS contribution to Top Dam	Assessment of source and groundwater and surface water to assess potential migration of PFAS to Top Dam	Planned Works	The PFAS Mass Discharge assessment identified that the Former Helicopter Squadron (PSC-3) is a source area within Catchment G that may be contributing to the PFAS mass associated with Catchment G. Subject to the Whole of Base review (see below), undertake an investigation to assess potential for the migration of PFAS mass from the source area to Top Dam (Catchment G).
Whole of Base	Re-evaluation of existing contamination data	Undertake review of existing PFAS data for the Base for consideration with respect to Remediation SFARP principles and identify if further assessment or remediation is required.	Planned Works	Defence has adopted a Remediation SFARP approach to addressing PFAS contamination at the Base. A re-evaluation of the existing PFAS data is to be undertaken to ascertain if further investigation and potential remediation may be required to achieve the SFARP principles. The re-evaluation is to be undertaken in 2025. Subsequent investigation, monitoring or remediation, including Former Helicopter Squadron (as discussed above), will be scheduled upon completion.

4.5 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 Queensland Health 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 important changes in concentrations may mean to the profile of PFAS contamination set out in the CSM, or potential changes to risks to humans or the environment.

Based on the data collected to date and presented in the Ongoing Monitoring Interpretive Report (AECOM, 2023a), 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 or 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, the Council, Queensland DETSI and 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 the Base 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

Defence 2020	*Lavarack Barracks Townsville: PFAS Management Area Plan,* Australian Government Department of Defence, 5 August 2020
Defence, 2024a	*Remediation So Far As Reasonably Practicable Guidance.* Australian Government Department of Defence, 20 September 2024.
Defence, 2024b	*Draft - PFAS Ongoing Monitoring Plan.* Australian Government Department of Defence, November 2024
Golder 2022c	*Soil and Groundwater Delineation Report, Former Fire Station (PSC-4) Lavarack Barracks, Brisbane.* Golder Associates Pty Ltd, 7 October 2022, document reference: 21455018-040-R-RevA
Golder 2023a	*Remediation Action Plan: Former Fire Station (PSC-4) Lavarack Barracks,* Golder Associates Pty Ltd, 16 February 2023, document reference: 21455048-049-R-RevA
Golder 2023c	*PFAS Annual Mass Discharge Report: Lavarack Barracks PMAP Delivery*, Golder Associates Pty Ltd, 22 May 2023, document reference: 21455048-041-R-RevA
HEPA, 2020	*PFAS National Environmental Management Plan.* Version 2.0 – January 2020. National Chemicals Working Group of the Heads of EPAs Australia and New Zealand
RPS/Wood 2019a	*Detailed Site Investigation: Lavarack Barracks PFAS Investigation,* RPS Australia West Pty Ltd and Wood Public Limited Company, 3 December 2019, document reference: EEC16094.32 Rev4
RPS/Wood 2019b	*Human Health Risk Assessment: Lavarack Barracks - PFAS Investigation*, RPS Australia West Pty Ltd and Wood Public Limited Company, 3 December 2019, document reference: EEC16094.040 Rev3
RPS/Wood 2020	*Ecological Risk Assessment: Lavarack Barracks - PFAS Investigation,* RPS Australia West Pty Ltd and Wood Public Limited Company, 18 August 2020, document reference: EEC16094.043 Rev4.

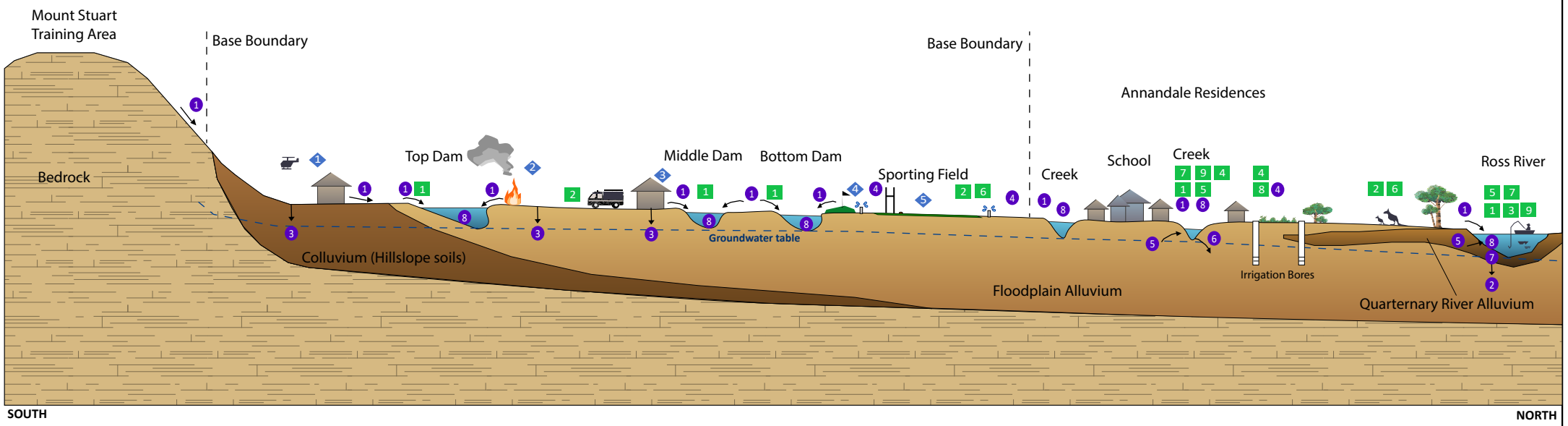
Other References

AECOM 2023a	*Ongoing Monitoring Interpretive Report (October 2020 – March 2023): Lavarack Barracks, Townsville*, AECOM Australia Pty Ltd, 24 October 2023, document reference: 60612487_RP97_20231024_Rev1
AECOM 2023b	*Sampling and Analysis Quality Plan: PFAS OMP Lavarack Barracks, Revision 7,* AECOM Australia Pty Ltd, 23 February 2023
BOM (2024)	Climate statistics for Australian locations. Townsville AERO. http://www.bom.gov.au/climate/averages/tables/cw_032040_All.shtml.
Defence 2021	*Defence PFAS Construction and Maintenance Framework, Guidance for managing the risk of PFAS contamination for works on the Defence estate. Version 3.0, Defence Infrastructure Division, Directorate of PFAS Investigation and Remediation. August 2021*
Defence 2022	*PFAS OMP Annual Interpretive Report Guidance. Directorate of PFAS Investigation and Remediation Infrastructure Division. Version 0.4,* Department of Defence, October 2022

Golder 2021a	*Overarching Sampling, Analysis and Quality Plan, Lavarack Barracks PMAP Delivery,* Golder Associates Pty Ltd, 2021, document reference: 21455018-002
Golder 2021b	*Sampling Analysis and Quality Plan for Work Packages 1 and 2 Investigations, Lavarack Barracks PMAP Delivery,* Golder Associates Pty Ltd, 2021, document reference: 21455018-011
Golder 2022a	*Sampling, Analysis and Quality Plan for Works Packages 1 and 2 Additional Investigations, Lavarack Barracks PMAP Delivery,* Golder Associates Pty Ltd, 29 April 2022, document reference: 21455018-031_R_RevA
Golder 2022b	*Factual Investigation Report – Work Packages 1 and 2 Additional Investigations, Lavarack Barracks PMAP Deliver,* Golder Associates Pty Ltd, 2 September 2022, document reference 21455018-022-R-RevA
Golder 2023b	*Sampling, Analysis and Quality Plan for Catchment K, Lavarack Barracks PMAP Delivery*, Golder Associates Pty Ltd, 2 March 2023, document reference 21455018-060
Golder 2023d	*Technical Specifications: Lavarack Barracks – Former Fire Station (PSC-4) PFAS Remediation Works,* Golder Associates Pty Ltd, 29 August 2023, document reference: 21455048-057-R-RevA
Golder 2023e	*Soil and Groundwater Delineation Report, Former Fire Training Area (PSC-5) / Monocell (PSC-6) Lavarack Barracks, Brisbane.* Golder Associates Pty Ltd, 3-October 2023, document reference: 21455018-042-R-RevB
Golder 2023f	*Factual Investigation Report – Catchment K PFAS Surface Water Study, Lavarack Barracks, Townsville, Golder Associates Pty Ltd, 30 October 2023 (document Reference: 21455048-061-R-RevA)*
Golder 2023g	*Catchment K PFAS Stage 1 and Stage 2 Report – Surface Soil and Wash-Down Test Investigation, Lavarack Barracks PMAP Delivery*, Golder Associates Pty Ltd, 18 December 2023, document reference: 21455048-081-R-Rev0
NEPC 1999	National Environment Protection Council (NEPC) *National Environment Protection (Assessment of Site Contamination) Amendment Measure* (NEPC), 1999, as amended 2013.
RPS/Wood 2019c	*Seafood Consumption Human Health Risk Assessment: Lavarack Barracks - PFAS Investigation*, RPS Australia West Pty Ltd and Wood Public Limited Company, 28 August 2019, document reference: EEC16094.043 Rev3.
RPS/Wood 2019d	*Seasonal Monitoring Report, Lavarack Barracks PFAS Investigation* RPS Australia West Pty Ltd and Wood Public Limited Company, 3 December 2019 (document reference: EEC16094.039 Rev1).

APPENDIX B CONCEPTUAL SITE MODEL

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



SOURCE

1. PSC 3 - Former Helicopter Squadron
2. PSC 6 - Former Fire Training Area
3. PSC 4 - Former Fire Station
4. Golf Course (secondary source)
5. Sporting Fields (secondary source)

TRANSPORT PATHWAYS

1. Surface water runoff
2. Surface water infiltration
3. Leaching of soil to groundwater
4. Irrigation using surface water
5. Groundwater discharge to surface water
6. Surface water discharge to groundwater
7. Bioaccumulation within marine ecosystems
8. Sediment transport

POTENTIAL EXPOSURE PATHWAYS

1. Human direct contact - ingestion of surface water
2. Human direct contact - ingestion of soil and/or dust
3. Human direct contact - ingestion of sediments
4. Human direct contact - ingestion of groundwater
5. Aquatic organisms - ingestion of sediment/surface water/porewater
6. Terrestrial organisms root uptake
7. Biomagnification in ecosystems
8. Human ingestion of home grown produce with groundwater or surface water
9. Human ingestion of aquatic organisms (e.g. fish, shellfish)

CLIENT
Department of Defence

PROJECT
PMAP – Lavarack Barracks

TITLE
Conceptual Site Model

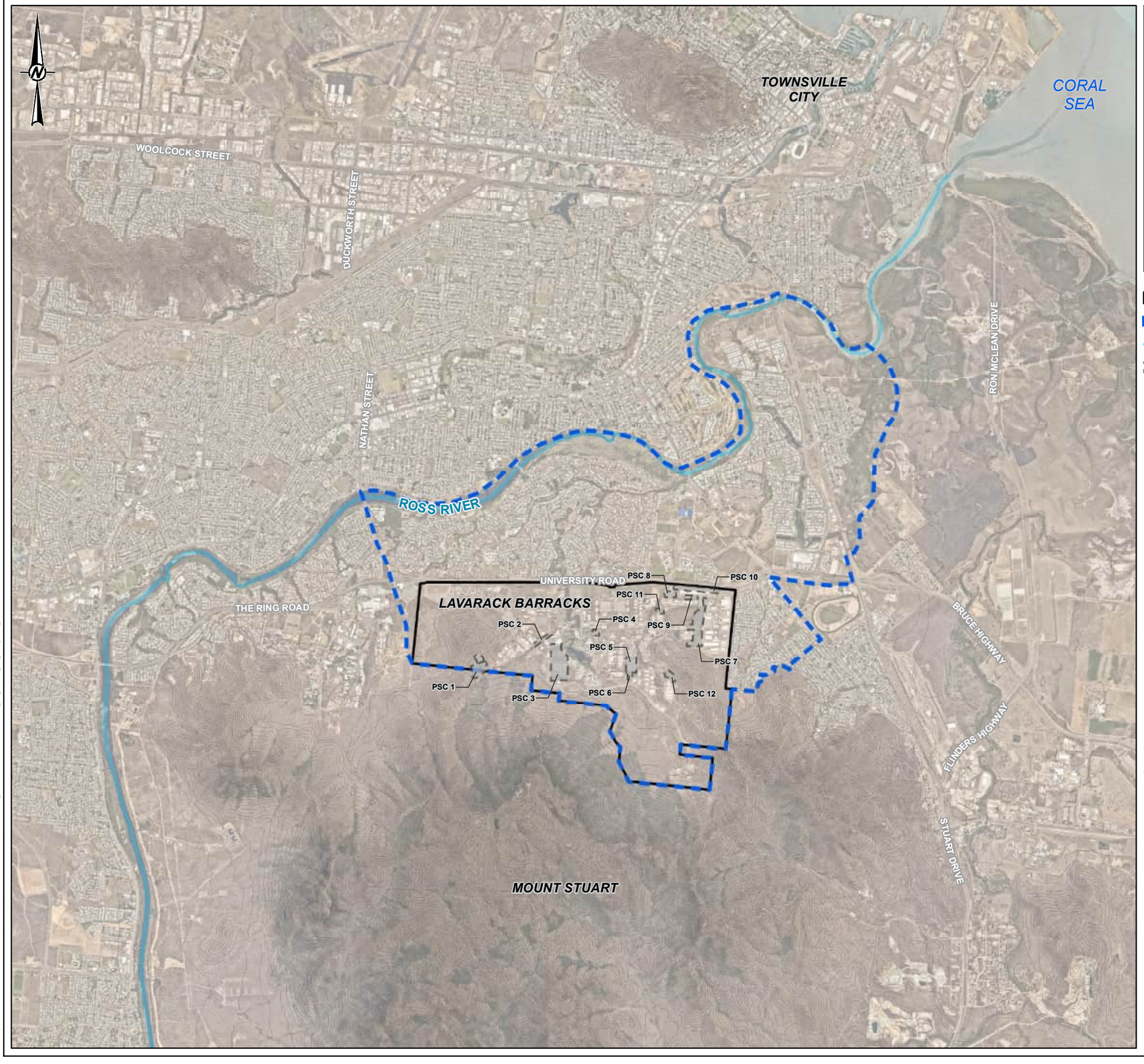
CONSULTANT

YYYY-MM-DD	2024-11-15
PREPARED	JJGB
DESIGN	JJGB
REVIEW	AH
APPROVED	AH

PROJECT No.	CONTROL	Rev.	FIGURE
PS129286	0001	A	7

APPENDIX C FIGURES

List of Figures



KEY MAP

LEGEND

- Lavarack Barracks Base Boundary
- Management Area
- Watercourse
- Potential Source of Contamination (PSC)

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. AERIAL IMAGERY AND KEY MAP SOURCED FROM ESRI ONLINE BASEMAPS.
2. STATE REFERENCE DATA SOURCED FROM DATA.QLD.GOV.AU.

CLIENT
DEPARTMENT OF DEFENCE

PROJECT
LAVARACK BARRACKS PFAS MANAGEMENT AREA PLAN

TITLE
SITE LOCATION AND MANAGEMENT AREA

CONSULTANT

YYYY-MM-DD	2024-11-18
DESIGNED	-
PREPARED	MAH
REVIEWED	AH
APPROVED	JD

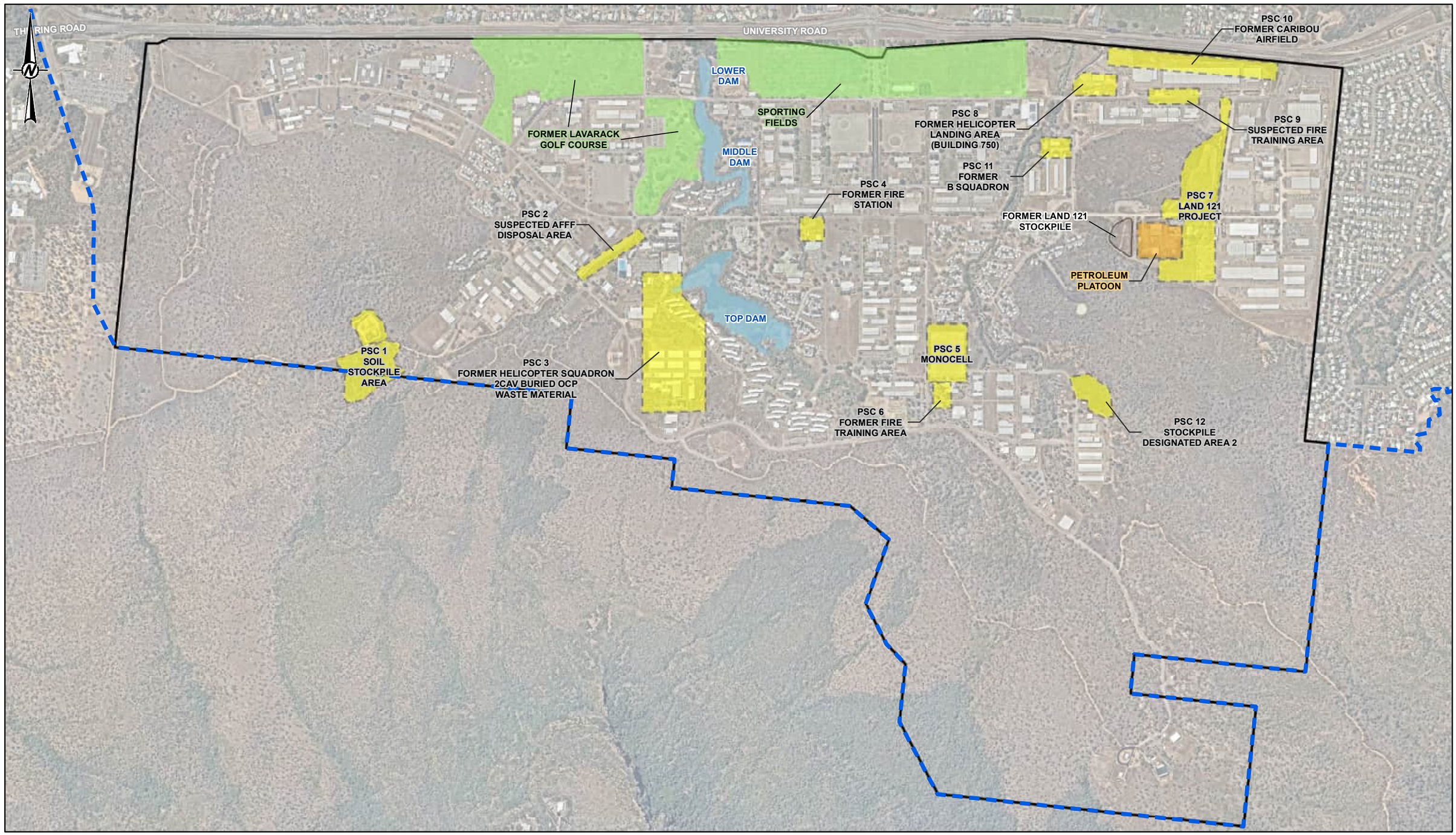
PROJECT NO.	CONTROL	REV.	FIGURE
PS129286	085-R	A	1

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

25mm

0

PATH: \\corp.pbwan.net\ANZ\Transition\Golder\Melbourne\Complex\Data\GIS\Jobs\2021\21457048\Mxd\085-R_PMAPPS129286-085-R-F0001-RevA_Site_Location_and_Management_Area.mxd PRINTED ON: 2024-11-18 AT: 4:95:27 PM



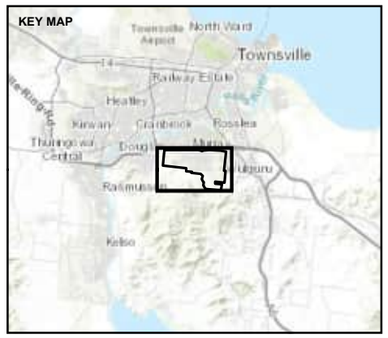
LEGEND

- Base Boundary
- Management Area
- Former Stockpile
- Potential Source of Contamination (PSC)
- Additional PSC

Secondary Source Areas

- Dam
- Outdoor Recreation Area

KEY MAP



0 200 400 600 800

1:13,000 METRES

CLIENT
DEPARTMENT OF DEFENCE

CONSULTANT
wsp

YYYY-MM-DD	2024-11-19
DESIGNED	-
PREPARED	MAH
REVIEWED	AH
APPROVED	JD

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

REFERENCE(S)
1. AERIAL IMAGERY SOURCED FROM NEARMAP.COM. DATE OF CAPTURE 01/10/2024.
2. KEY MAP SOURCED FROM ESRI ONLINE BASEMAPS.
3. STATE DATA SOURCED FROM DATA.QLD.GOV.AU.

PROJECT
LAVARACK BARRACKS PFAS MANAGEMENT AREA PLAN

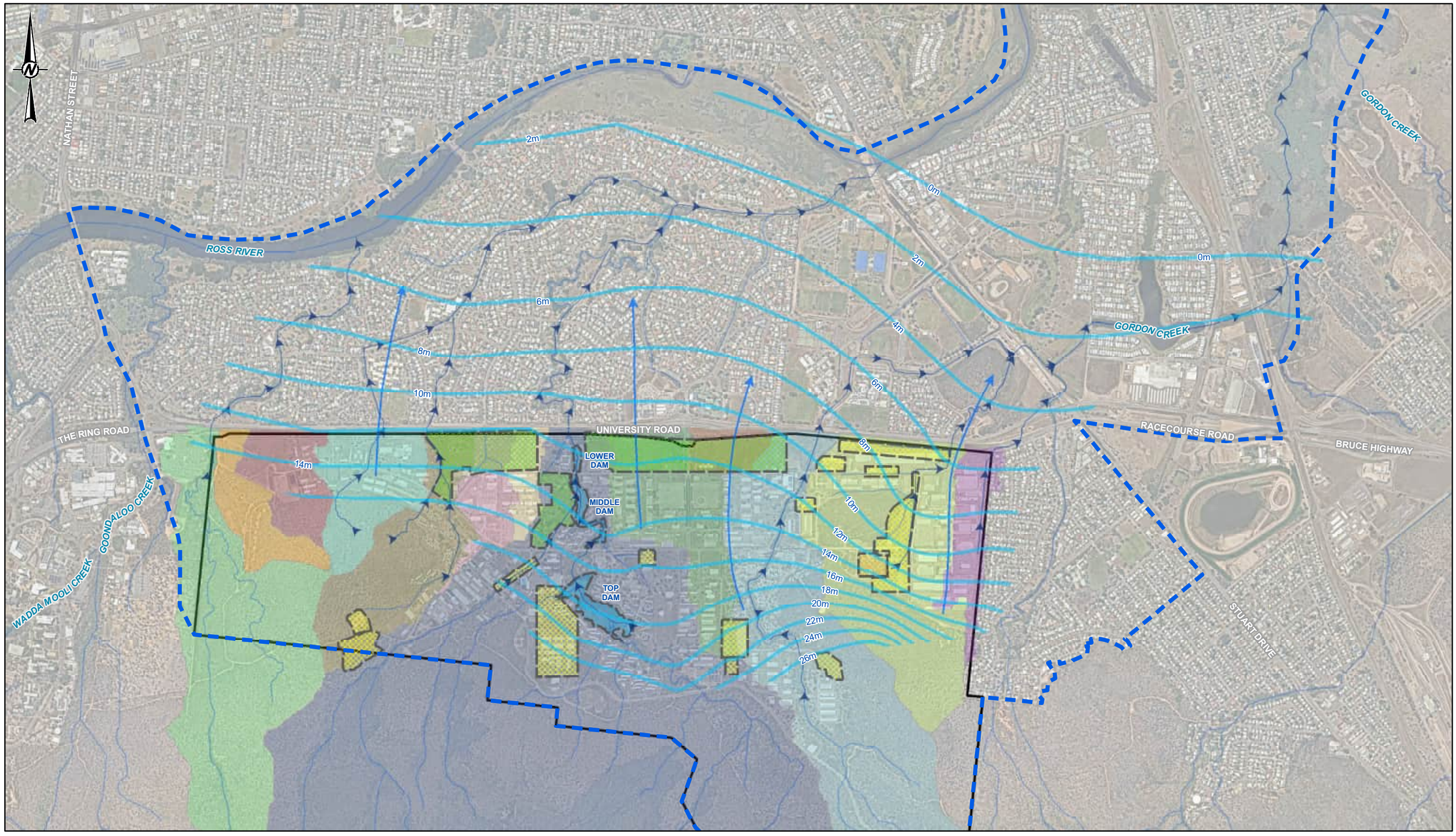
TITLE
KEY SOURCE AREAS

PROJECT NO.	CONTROL	REV.	FIGURE
PS129286	085-R	A	2

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

0 25mm

PATH: \\corp.pbwan.net\au\Transition\Golder\Melbourn\Complex Data\GEL\Jobs\2021\21456048\Mxd\085-R_PMAP\PS129286-085-R-F0002-RevA_Key_Source_Areas.mxd PRINTED ON: 2024-11-19 AT 2:06:18 PM



LEGEND

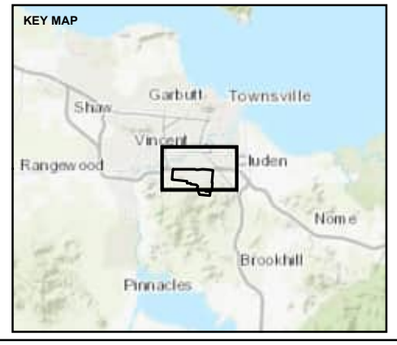
- Base Boundary
- Management Area
- Potential Source of Contamination (PSC)
- Additional PSC

Secondary Source Areas

- Dam
- Outdoor Recreation Area
- March 2023 Approximate Groundwater Elevation Contour (m AHD)
- Inferred Groundwater Flow Direction
- Surface Water Flow Direction

Surface Water Catchment ID

A-1	E	J
A-2	F	K
B	G	L
C	H	
D	I	



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. DATE OF CAPTURE 01/10/2024.
2. KEY MAP SOURCED FROM ESRI ONLINE BASEMAPS.
3. STATE DATA SOURCED FROM DATA.QLD.GOV.AU.

CLIENT
DEPARTMENT OF DEFENCE

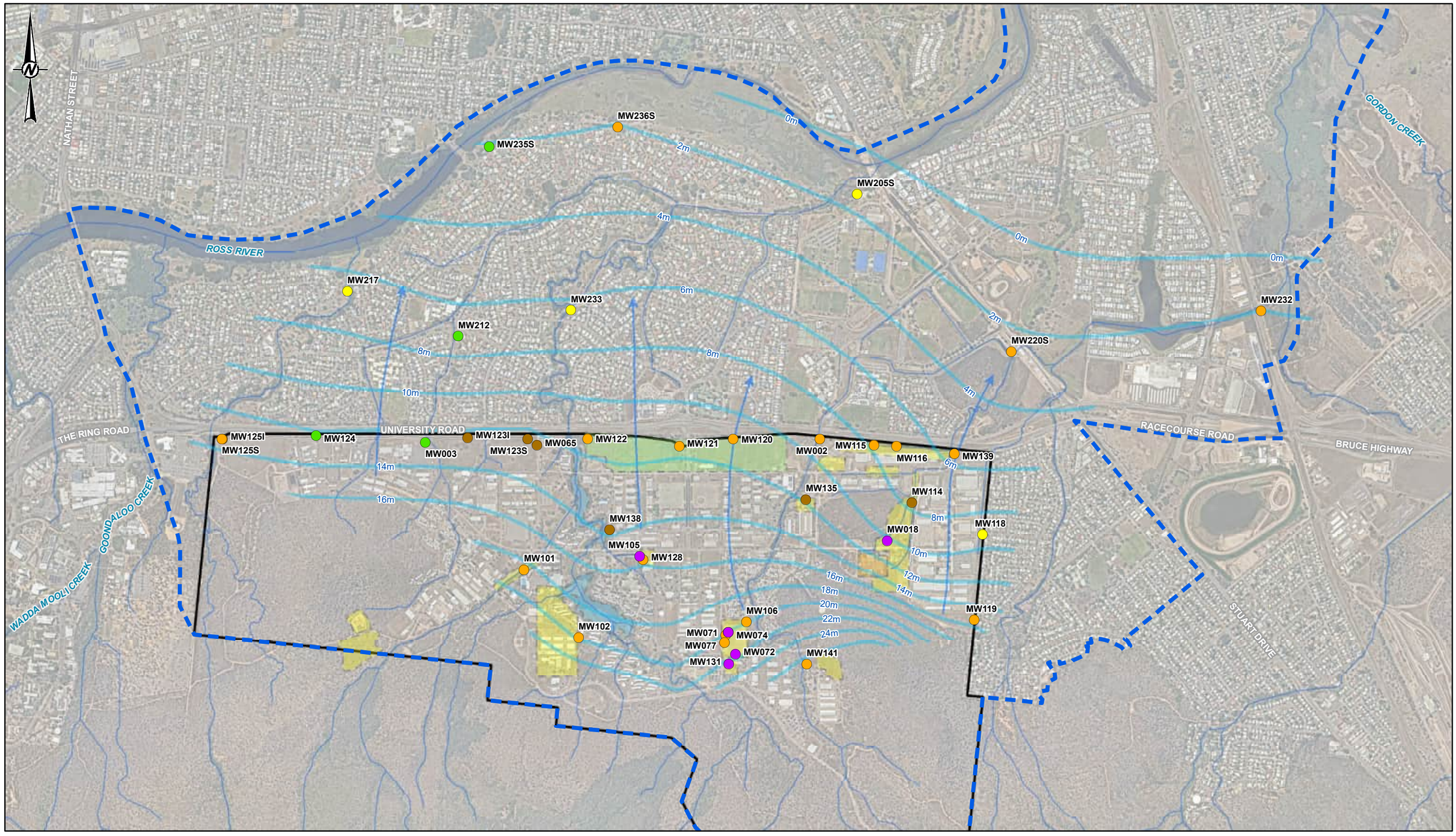
CONSULTANT
wsp

YYYY-MM-DD	2024-11-19
DESIGNED	-
PREPARED	MAH
REVIEWED	AH
APPROVED	JD

PROJECT
LAVARACK BARRACKS PFAS MANAGEMENT AREA PLAN

TITLE
SHALLOW GROUNDWATER AND SURFACE WATER FLOW

PROJECT NO.	CONTROL	REV.	FIGURE
21455048	085-R	A	3



LEGEND

- Base Boundary
- Management Area
- Watercourse
- March 2023 Approximate Groundwater Elevation Contour (m AHD)
- Inferred Groundwater Flow Direction
- Potential Source of Contamination (PSC)
- Additional PSC

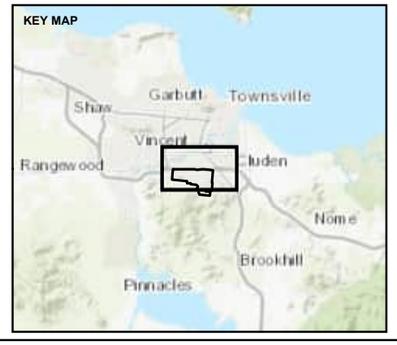
Secondary Source Areas

- Dam
- Outdoor Recreation Area

March 2023 Groundwater PFOS + PFHxS Result (ug/L)

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

KEY MAP



DRAFT

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. DATE OF CAPTURE 01/10/2024.
2. KEY MAP SOURCED FROM ESRI ONLINE BASEMAPS.
3. STATE DATA SOURCED FROM DATA.QLD.GOV.AU.

CLIENT
DEPARTMENT OF DEFENCE

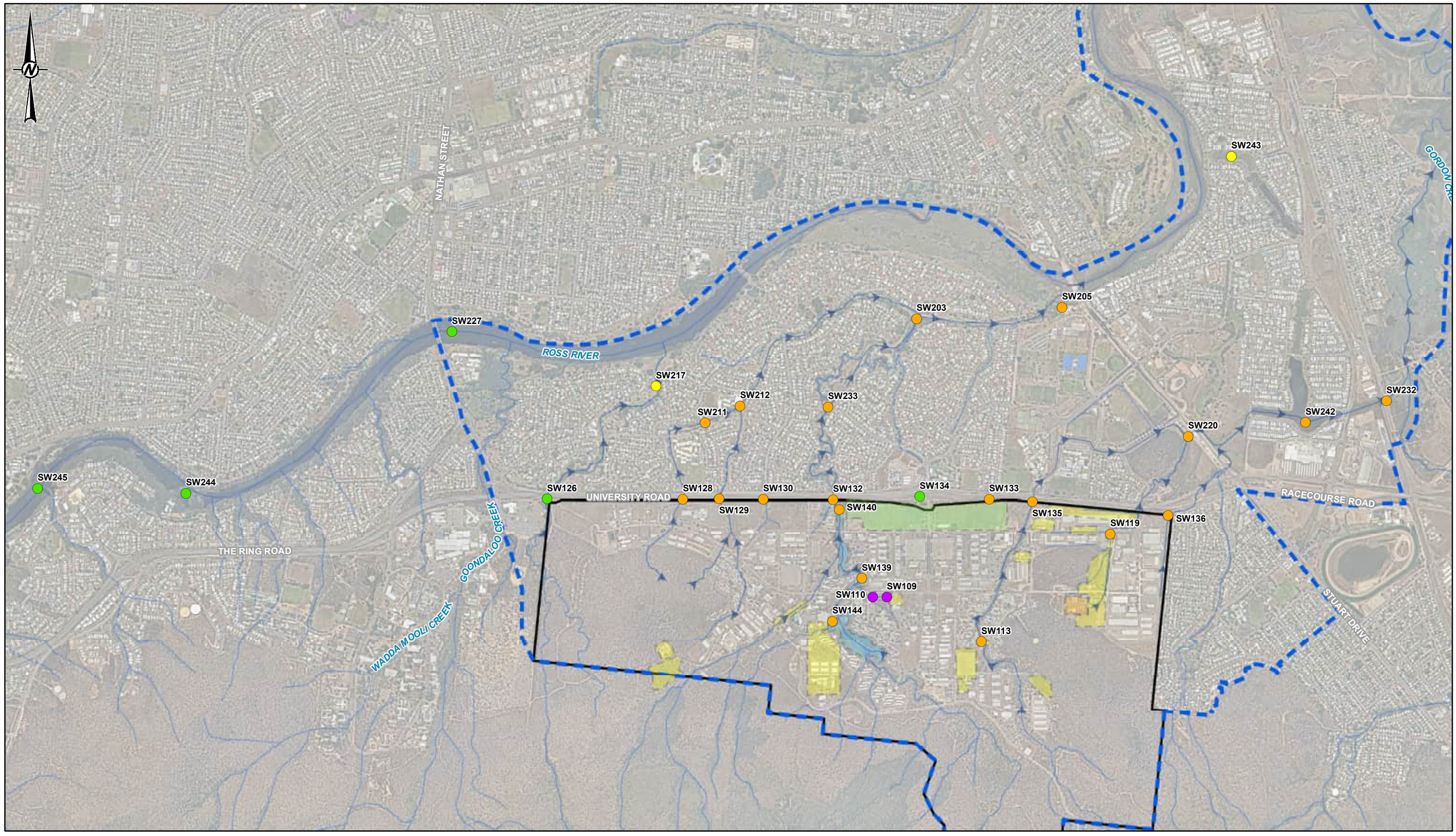
CONSULTANT
WSP

YYYY-MM-DD	2024-11-18
DESIGNED	-
PREPARED	MAH
REVIEWED	AH
APPROVED	JD

PROJECT
LAVARACK BARRACKS PFAS MANAGEMENT AREA PLAN

TITLE
GROUNDWATER ANALYTICAL RESULTS - PFOS + PFHxS MARCH 2023

PROJECT NO.	CONTROL	REV.	FIGURE
21455048	085-R	A	4



LEGEND

- Base Boundary
- Management Area
- Watercourse
- Surface Water Flow Direction
- Potential Source of Contamination (PSC)
- Additional PSC

Secondary Source Areas

- Dam
- Outdoor Recreation Area

March 2023 Surface Water PFOS + PFHxS Result (ug/L)

- <LOR
- >LOR - 0.07
- 0.07 - 1
- 1 - 10
- 10 - 50
- >50

KEY MAP

0 500 1,000 1,500

1:25,000 METRES

CLIENT
DEPARTMENT OF DEFENCE

CONSULTANT
wsp

YYYY-MM-DD	2024-11-18
DESIGNED	-
PREPARED	MAH
REVIEWED	AH
APPROVED	JD

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

REFERENCE(S)
1. AERIAL IMAGERY SOURCED FROM NEARMAP.COM. DATE OF CAPTURE 01/10/2024.
2. KEY MAP SOURCED FROM ESRI ONLINE BASEMAPS.
3. STATE DATA SOURCED FROM DATA.QLD.GOV.AU.

PROJECT
LAVARACK BARRACKS PFAS MANAGEMENT AREA PLAN

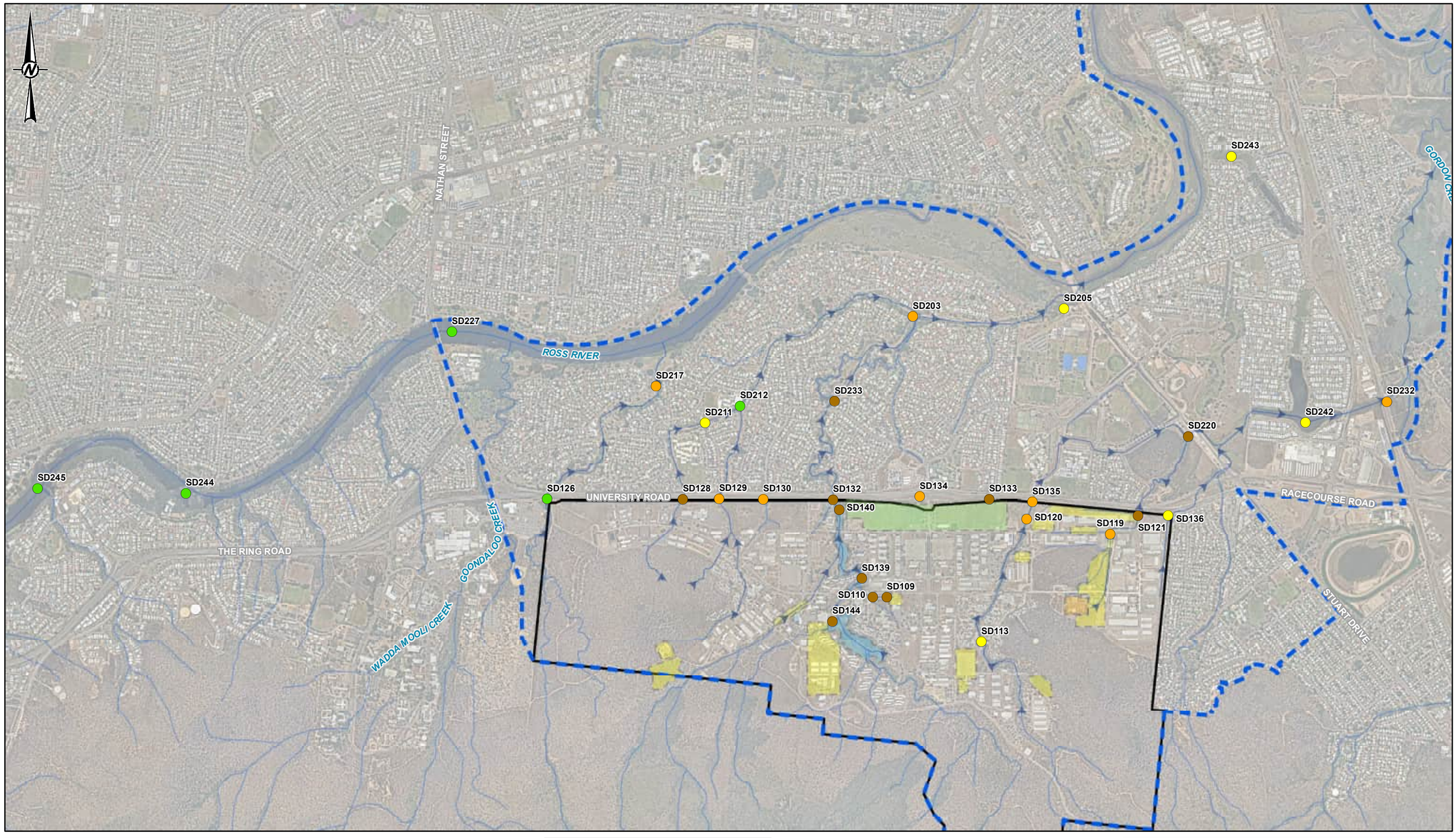
TITLE
SURFACE WATER ANALYTICAL RESULTS - PFOS + PFHxS MARCH 2023

PROJECT NO.	CONTROL	REV.	FIGURE
21455048	085-R	A	5

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

0 25mm

PATH: \\corp.pbwan.net\ANZ\Transform\Golden\Melbourne\ComplexData\GIS\Jobs\2021\21455048\Mxd\085-R_PMAPFES129286_485-R-F0005-RevA_Surface_Water_PFOS_PFHxS.mxd PRINTED ON: 2024-11-18 AT 8:33:54 PM



LEGEND

- Base Boundary
- Management Area
- Watercourse
- Surface Water Flow Direction
- Potential Source of Contamination (PSC)
- Additional PSC

Secondary Source Areas

- Dam
- Outdoor Recreation Area

March 2023 Sediment PFOS + PFHxS Result (mg/kg)

- <LOR
- >LOR - 0.001
- 0.001 - 0.01
- 0.01 - 1
- >1

KEY MAP

0 500 1,000 1,500

1:25,000 METRES

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

REFERENCE(S)
1. AERIAL IMAGERY SOURCED FROM NEARMAP.COM. DATE OF CAPTURE 01/10/2024.
2. KEY MAP SOURCED FROM ESRI ONLINE BASEMAPS.
3. STATE DATA SOURCED FROM DATA.QLD.GOV.AU.

CLIENT
DEPARTMENT OF DEFENCE

CONSULTANT
wsp

YYYY-MM-DD	2024-11-18
DESIGNED	-
PREPARED	MAH
REVIEWED	AH
APPROVED	JD

PROJECT
LAVARACK BARRACKS PFAS MANAGEMENT AREA PLAN

TITLE
SEDIMENT ANALYTICAL RESULTS - PFOS + PFHxS MARCH 2023

PROJECT NO.	CONTROL	REV.	FIGURE
21455048	085-R	A	6

PATH: \\corp.pbwan.net\ANZ\Transfer\n\Golder\Melbourne\Complex\Data\GIS\Jobs\21212145048\Mxd\085-R_PMAPFS129296_085-R-F0006-RevA_Sediment_PFOS_PFHxS.mxd PRINTED ON: 2024-11-18 AT: 8:34:11 PM

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

25mm
0