Taxiway Zulu and Northern Compound Project

Melbourne Airport

PFAS Management Plan

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1. Introduction

1.1 Background

Jacobs have been engaged by Melbourne Airport to prepare a per- and polyfluorinated alkyl substances (PFAS) Management Plan for the Taxiway Zulu and Northern Access Route (also referred to as the Northern Compound) ('the Project') project areas at Melbourne Airport.

The purpose of the PFAS Management Plan is to address potential environmental risks associated with the disturbance of PFAS impacted material as a result of project activities. Preparation of the PFAS Management Plan is a condition of the Environment Protection and Biodiversity Conservation Act 1999 (EPBCA) approval dated 9 January 2018. It is also required to obtain a number of airport permits for the works.

The PFAS Management Plan has been developed to provide Contractors with a document that describes how construction spoil generated following soil disturbance activities can be managed in accordance with Melbourne Airport guidance, relevant legislation as well as stakeholder expectations.

1.2 Approvals and compliance

1.2.1 EPBCA referral (Jan 09, 2018)

This PFAS Management Plan has been developed to fulfil approval conditions defined in Approval Notice 2016/7837, issued under sections 130 (1) and 133 of the Environment Protection and Biodiversity Conservation Act 1999, signed on 9 January 2018.

The proposed action to which approval applies is 'to expand airside infrastructure including taxiways, taxi lanes and aprons, and construct a northern construction-site compound and associated infrastructure at Melbourne Airport, approximately 20 km north-west of Melbourne'. Approval conditions relevant to this EMP and a summary assessment of compliance with these conditions are detailed in Appendix A.

1.2.2 DoE Environmental Management Plan Guidelines (DoE, 2014)

The structure and content of this PFAS Management Plan has been developed in accordance with the Environmental Management Plan Guidelines (DoE, 2014) (the Guidelines). Table 1 1 below provides a summary of content requirements as per the Guidelines, along with relevant sections of the report in which requirements are addressed. It is understood that this PFAS Management Plan will be used to inform development of a broader Construction Environmental Management Plan (CEMP) for the Project, which will be required to address some of the elements defined in the Guidelines in greater detail. Details and credentials of the authors of this PFAS Management Plan are provided in Appendix D

Table 1 1: DoE guideline compliance

DoE Guideline Requirement	PFAS EMP Section
Cover page and declaration of accuracy	Front of document
Document version control	Page i
Table of contents	Page ii
Executive summary or introduction	Section 1: Introduction
Conditions of approval reference table	Appendix A: Approvals and compliance
Project description	Section 2: Context
Objectives	Section 1.3.1: Objectives
EM Roles and responsibilities	Section 6.4: Site responsibilities and construction EMP
Reporting	Section 7.2: Reporting

DoE Guideline Requirement	PFAS EMP Section
Environmental training	Section 6.5: Site responsibilities and construction EMP
Emergency contacts and procedures	Section 6.4: Site responsibilities and construction EMP, Section 6.15: Emergency / contingency plans
Potential impacts and risks	Section 4: Conceptual site model
Environmental management measures	Section 5: Soil and spoil management options
Audit and review	Section 6: Management Plan

1.2.3 PFAS National Environmental Management Plan (PFAS NEMP) (HEPA, 2018)

The PFAS NEMP provides guidance about per-and poly-fluoroalkyl substances (PFAS), developed to guide regulation of PFAS contaminated sites. The plan provides guideline values to inform site investigations and management strategies, which cover risks to human and ecological health. These values are discussed further in Section 4.2.4.

The PFAS NEMP is the primary source of guidance on PFAS for which compliance at Melbourne Airport is a requirement.

1.3 Objectives and structure of PFAS Management Plan

1.3.1 Objectives

The principal objective of the PFAS Management Plan is the identification of an approach or plan to manage potential soil related risks associated with the disturbance (excavation, transport and storage) of PFAS impacted material as part of the Project.

In order to meet the above objective, this PFAS Management Plan aims to:

- Identify areas that require management.
- To identify and assess risks associated with the excavation, transport and storage of PFAS impacted material as part of the Project.
- To provide recommendations relating to the short and long term management of PFAS impacted waste soil generated as a result of the Taxiway Zulu and Northern Access Route (NAR) projects.
- To provide a work method / soil management procedure for waste soil generated as a result of the works – to meet environmental legislation requirements.
- Describe the requirements for the validation and monitoring of the works.

1.3.2 PFAS Management Plan Structure

The structure of the PFAS Management Plan is summarised below:

- **Section 2** – Context. This section provides a description of the project, project area and proposed use, along with scope of activities and excavation volumes.
- **Section 3** – PFAS. This section provides a description of the key contaminants of concern with a primary focus on PFAS.
- **Section 4** – Conceptual Site Model. A description of the findings of previous soil assessment programs is provided, along with an assessment of risks associated with potential source-pathway-receptor linkages in the context of project activities.
- **Section 5** – Soil management options assessment. Proposed management options for excavated materials are described and a preferred option identified following application of a multi-criteria analysis.
- **Section 6** – Management Plan. This section details the environmental protocols to be followed during construction works to manage any potentially contaminated soil, as well as site responsibilities.

- **Section 7** – Monitoring, reporting, audit and review section. This section monitoring and reporting requirements, along with auditing and review triggers.

1.4 Glossary of terms

Acronym	Definition
AOPC	Area of Potential Concern
ASTM	American Society for Testing and Materials (formerly)
CEMP	Construction Environmental Management Plan
CSM	Conceptual Site Model
DoE	Department of Environment
EA	Environment Agency
EMP	Environmental Management Plan
EPA	Environmental Protection Agency
EPBCA	Environmental Protection and Biodiversity Conservation Act 1999
HDPE	High Density Polyethylene
HEPA	Heads of EPAs Australia and New Zealand
LDPE	Low Density Polyethylene
LoR	Limit of reporting
NAR	Northern Access Route
NEPC	National Environmental Protection Council
NEPM	National Environmental Protection Measure
PFAS	Per- and polyfluorinated alkyl substances
PFAS NEMP	PFAS National Environmental Management Plan
PFHxS	Perfluorohexane sulfonate
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
R&D	Research and Development
SQO	Soil quality objective
WSO	Works Safety Officer

2. Context

2.1 The project

The Taxiway Zulu Program comprises the provision of new and realigned taxiways and associated infrastructure to facilitate the future expansion of Terminal 2 and thereby accommodate increased growth in passenger numbers and associated aircraft movements. The taxiway works will also minimize operational delays and optimise aircraft movements to and from existing Runway 09/27 as well as enabling the replacement of poor condition airfield pavement.

The detailed design scope included the realignment of Taxiway Echo, the establishment of parallel Taxiways Echo and Zulu and the ability for the airport to accommodate increased Code F operations. These parallel taxiways will facilitate the future expansion of Terminal 2 which requires the ultimate closure of Taxiways Tango and Sierra.

The Northern Access Route (NAR) involves new / upgraded access from Sunbury Road and the construction of access/haul roads to and from the Taxiway Zulu project. The construction of the facility will include a security access point, Works Safety Officer (WSO) and contractor facilities to support construction activities within the northern precinct of the airport. The primary function of the Northern Access Route project will be to manage, screen and control the entry of construction traffic for various airside projects scheduled for delivery over the next 10 years and beyond.

2.2 The project area

The Taxiway Zulu Program works area is generally situated on the south east side of the intersection of the two existing runways and north of existing Terminal 2 (Pier Delta). The site of works interfaces with both runways 09/27 and 16/34, and Taxiways Alpha, Echo, Foxtrot, Papa, Quebec, Sierra, Tango, and Victor.

Due to its proximity to the Terminal buildings, intersection of runways and interconnected taxiways there is a high degree of aircraft traffic through the area of works. The existing site consists of a mix of operational taxiways and gently undulating grassed areas with a range of existing underground services. Two parallel east-west taxiways (Tango and Echo) are currently located perpendicular to Runway 16/34 providing aircraft taxiway access to the existing runways, the northern precinct and piers connectivity to Terminals 1 and 2.

The NAR area of works occupies the north-eastern zone of the airport. The proposed construction access shall be via Gate 3 which is the southern arm of the existing Sunbury Road / Oaklands Road roundabout and follows the airport boundary where it will eventually merge with the existing perimeter road (airside). The site is generally clear of existing airport infrastructure (i.e. runways, taxiways, aircraft lighting and buildings) although this in turn means the site will need to be serviced by augmentation of the airport's current utilities network.

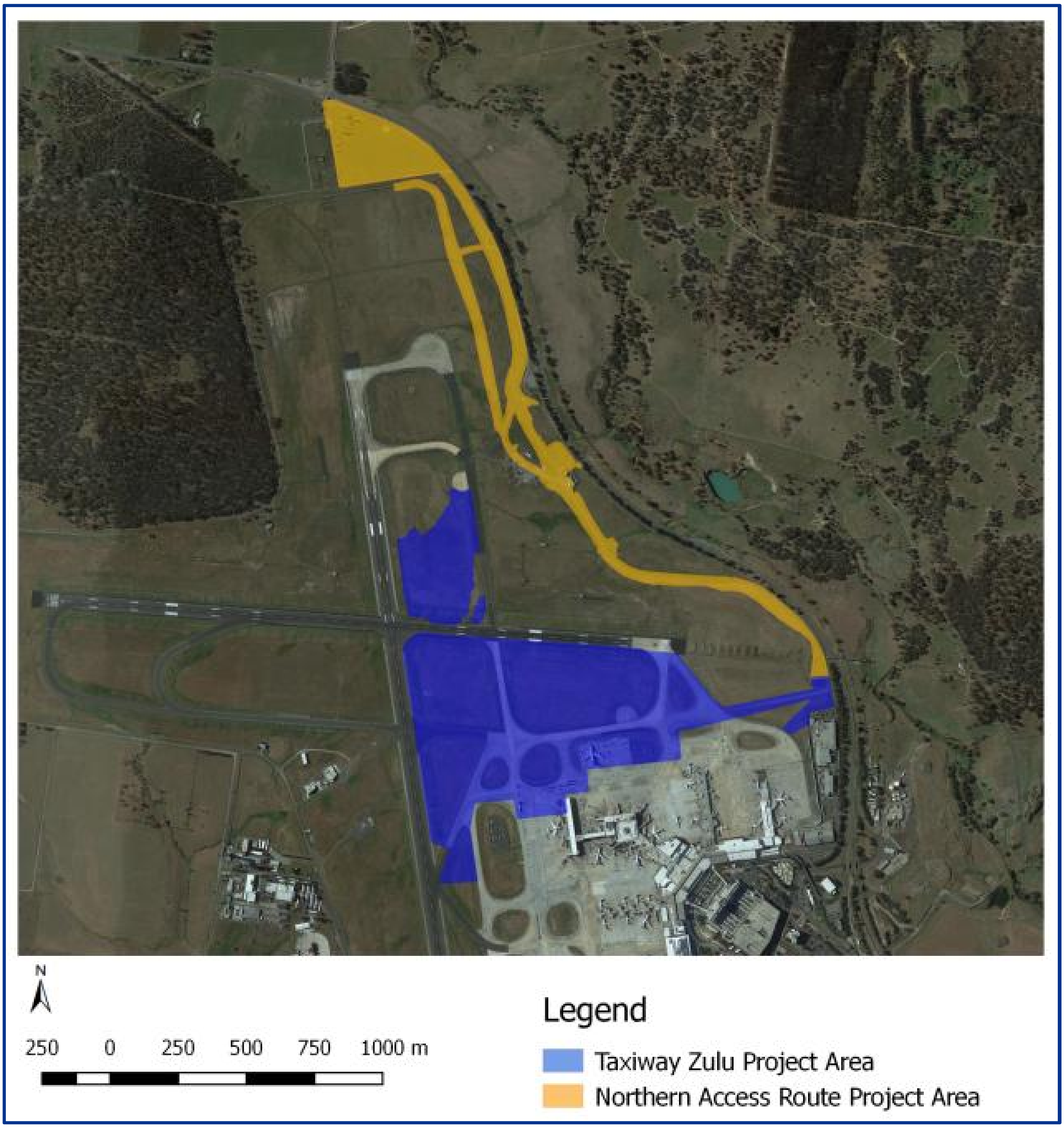


Figure 2.1: Taxiway Zulu and Northern Access Route Footprints

2.3 Construction

The construction phase of the project is set to commence in early 2019. A construction contractor is yet to be appointed for the works.

2.4 Overview of scope

The following scope applies to all project areas, and comprises activities for which soil disturbance is likely:

- Occupation of the project area for the duration of the Project construction phase.
- Exposure of existing services and underground infrastructure via non-destructive digging.
- Stripping of existing topsoil and grass and removal of pavements.
- Grading and bulk earthworks – bulk excavation down to subgrade.
- Drainage construction and service installation – excavation of service trenches and drainage channels, installation of services, culverts, grated pits and swales.
- Construction of access and haul roads, and laydown areas.

2.4.1 Excavation areas and volumes

2.4.1.1 Taxiway Zulu Project

Estimates of excavation volumes are provided below (Jacobs note that these are estimates only and should not be relied upon for construction planning purposes).

	Entire project
Total Cut (m3)	407,820

This includes an approximate 17,850m3 of existing concrete and very minor amounts of asphalt.

Modelling of cut / fill balances is not yet complete for the Taxiway Zulu project, with detailed visual information on areas of cutting and filling not available at the time of reporting.

2.4.1.2 Northern Access Route Project

Estimates of excavation volumes are provided below (Jacobs note that these are estimates only and are “bank volumes” and should not be relied upon for construction planning purposes).

Table 2 1: Indicative Bulk Earthworks Volumes

	All Areas (Access roads, hardstands, drainage swales and bunds	WSO Compound	Total
Total Cut (m3)	30,433	1,801	32,234

Table 2 2: Pavement vs Stripping Area

	All Areas (Access roads, hardstands, drainage swales and bunds
Pavement Area (m2)	53,815
Stripping Area (m2)	175,042
Stripping Volume (m3)	26,256

It is noted that the earthworks volumes exclude over-excavation of earthworks surfaces to allow for top soiling to finished design levels, and excavation volumes for drainage and service trenches. Estimates for these (potential) additional volumes will be defined during subsequent design phases and/or during construction. The adopted soil management approach will allow for potential increases in expected volumes.

3. Per- and polyfluoroalkyl substances

Per- and polyfluoroalkyl substances (PFAS) are part of a large group of perfluoroalkylated compounds consisting of a fully fluorinated hydrophobic alkyl chain of varying length (typically 4 to 16 carbon atoms) and a hydrophilic end group. In the last 10 years or so, PFAS have been recognised as a widespread contaminant in the environment and are of particular concern because they are now known to be persistent, bioaccumulate and, due to their persistence in the environment and moderate solubility, can be transported significant distances from the source zone, in both water and air.

Due to the favourable chemical and physical properties of PFAS, they are commonly used in stain, grease and water resistant surface treatment products; paints; coatings; cleaning products and firefighting foams. In relation to Melbourne Airport, PFAS were historically used in firefighting foams, also referred to as AFFF.

For the purposes of the PFAS Management Plan, PFAS refers to the following compounds:

- Perfluorooctanesulfonic acid (PFOS) – including perfluorohexane sulfonate (PFHxS).
- Perfluorooctanoic acid (PFOA).

4. Conceptual site model

4.1 General

The following sections identify sources, pathways (transport mechanisms, exposure media and exposure routes) and receptors. The CSM provides the basis for assessing contaminated land risks and identifying uncertainties or gaps in knowledge and provides a link to consideration of potential contaminated land management issues on the project (See Section 6).

This section also discusses construction related spoil and management options.

According to National Environmental Protection (Assessment of Site Contamination) Measure 1999 (as amended in 2013) (NEPC, 2013) the essential elements of a CSM are:

- Identification of potential contamination and sources.
  - Areas of potential concern (AOPCs) or domains. Known and potential sources of contamination and contaminants of concern including the mechanism(s) of contamination.
  - Contaminants of potential concern (COPC). Identity of potential contaminants and potentially affected media (soil, sediment, groundwater, surface water, indoor and ambient air).
- Identification of potential pathways and transport mechanisms.
- Identification of sensitive receptors.
- Assessment of potential and complete exposure pathways and preliminary risk assessment.
- Data gap and uncertainty assessment.

The procedure to develop the preliminary CSM followed generally followed the ASC NEPM and is as described in detail in ASTM E1689-95 (ASTM, 1995), ASTM E2531-06 (ASTM, 2006) and Environment Agency's R&D publication NC/99/38/2 (EA, 2000).

4.2 Identified contamination

4.2.1 Ground profile

The Geological Survey of Victoria (1977) 1:63,360 scale Sunbury geological map sheet indicates the proposed Taxiway Zulu and Northern Access Route sites are underlain by the Quaternary aged Newer Volcanics Formation. Newer Volcanics is identified as olivine basalt. The upper portion of the basalt profile in this formation is typically weathered residual clay. However, shallow rock can be encountered, and large near surface basalt boulders (known as "floaters" or "corestones") are often encountered in a clay matrix.

Based on the assessments undertaken to date, a summary of the typical ground profile across the site area is presented in Table 4 1 below.

Table 4 1: Summary of typical ground profile

Typical thickness (mbgl)	Unit name	General description
0.0 – 0.4	Fill soils	FILL: Silty gravelly CLAY
0.0 – 0.1	Top soil	Brown, grey-brown with coarse gravels. Brick fragment observed in ZULU_SS030. Fill soils not present in all locations.
0.1 – 1.0	Natural	TOPSOIL: Silty CLAY
~1.0 and greater	Basalt	Black, brown and grey with frequent rootlets and trace fine sand. Soft to firm constancy

4.2.2 Groundwater

The main body of groundwater is deeper than the proposed depth of works and occurs greater than 10 m below existing ground level. As such groundwater is not anticipated to be encountered during construction.

4.2.3 Sampling dataset within proposed works area

Table 4 2 below provides a summary of assessment works conducted to date in the vicinity of the Taxiway Zulu and NAR project areas. Full details of investigations conducted to date (2014, 2015, 2018) are available in the Environmental Site Assessment Report (Jacobs, 2018). These investigations were undertaken in general accordance with EPA Victoria soil sampling guidelines (IWRG 702) (EPA Victoria, 2009a), the NEPM (NEPC, 2013) and Australian Standard AS4482.1-2005 (Standards Australia, 2005).

Table 4 2: Summary of investigations

Year	Number of locations	Number of soil samples analysed for PFAS	
		Total concentrations	Leachable concentrations
2014	24 (test pits)	17	17
2015	20 (bore holes)	36	0
2018	45 (bore holes)	53	52
Total	87 Locations	106	69

Total PFAS (mg/kg) was detected in six of 106 samples (5.7%) while leachable PFAS (µg/L) was detected in 47 of 69 analysed samples (68.1% of samples) (Jacobs, 2018). The reported leachable results are of particular note, as these provide an insight into the mobility of the contaminant and the potential for migration to underlying soils and / or groundwater.

A summary of data collected in previous investigations is presented in Table 4.3 below, and in Figure 1 and Figure 2 at the end of this document.

Table 4 3: Reported maximum total and leachable PFAS concentrations

Project area	Maximum Total Values		Maximum Leachable Values	
	LOR (mg/kg)	Concentration (mg/kg)	LOR (µg/L)	Concentration (µg/L)
Perfluorooctanesulfonic acid (PFOS)	0.0005	0.032	0.01	0.85
Perfluorooctanoic acid (PFOA)	0.0005	<0.005	0.01	0.02
Perfluorohexanesulfonic acid (PFHxS)	0.005	<0.005	0.01	0.13
Sum of PFOS and PFHxS	0.005	0.032	0.01	0.88

On the basis of data collected to date, PFAS concentrations appear to be higher in the vicinity of the NAR (as compared to Zulu) and to increase with depth, however these observations are preliminary in nature.

The concentrations found across Zulu and NAR are generally comparable to concentrations found in soils across the wider airport estate.

4.2.3.1 Total mass of PFAS in soils

Considering the full data set from which the maximum values outlined above are sourced, an estimate of the approximate total mass of PFAS in soils within the area of proposed cut can be made by adopting the average sum of PFOS and PFHxS concentration (0.0038 mg/kg), multiplying it by the estimated total cut volume converted to mass with a bulking factor 1.8 kg/m^3 (839,358 kg). Based on this logic, the estimated approximate total mass of sum of PFOS and PFHxS (based on the data set presented in the ESA (Jacobs, 2018)) within the cut volume is 3,189 mg, being equivalent to 3.19 g.

4.2.3.2 Vertical distribution of existing dataset

A summary of sample depth ranges is provided below in Table 4.4. Excavation depths are based on approximate final excavation depths prior to pavement installation and top soiling and may be subject to change in subsequent design revisions and/or construction. Additional soil testing will be conducted within the Taxiway Zulu and NAR project footprints to supplement the existing dataset prior to construction. This is incorporated in the monitoring strategy (refer to Section 7.1.1).

Table 4 4: Sampling depth and maximum excavation depths

Project Area	Sampling depth range (m)	Expected maximum excavation depth (m)
Taxiway Zulu[1]	0.11 – 1.15	2.0
NAR[2]	0.2 – 0.6	1.5

Notes:

1. Taxiway Zulu is currently in detailed design phase and final excavation depths may be subject to change.
2. Limited areas associated with swale installation may require cutting beyond 1.5 m.

4.2.4 Data from other sites within the airport

APAM has undertaken soil testing for PFAS at over 600 locations across the airport. The main sources of PFAS contamination have been identified in areas where PFAS foams were previously used or stored (Melbourne Airport, 2018). Figure 3 shows locations at the airport where PFOS+PFHxS concentrations greater than 1 mg/kg have been identified in soil or sediment. These locations are in the vicinity of the fire training grounds, the Learning Academy Hot Fire Training Ground / Smoke Hut and the Melbourne Airport Fire Station.

4.2.5 Guideline values and risk evaluation

Guideline values provided in the in the NEMP (HEPA, 2018) were selected to assess potential risk to human and ecological health associated with disturbance and on-site storage of PFAS contaminated soils. These values are provided below in Table 4 5.

4.2.5.1 Human health

Given construction workers may work in an exposed soil environment, a public open space exposure scenario (parks, playgrounds, playing fields (e.g. ovals), secondary schools and footpaths) has been selected to approximate a “construction worker scenario”. This is likely to be highly conservative with respect to construction workers as it is based on a child receptor. Construction workers have a significantly greater body mass than a child, hence the toxicity of analytes of interest will be reduced compared to a child.

4.2.5.2 Ecological health

Guidelines values for the protection of ecological health are derived from different land use scenarios as well as specific soil physiochemical properties. These properties can include the cation exchange capacity, pH, percentage clay and grain size. For this site, a commercial industrial land use setting has been applied to determine soil quality objectives (SQOs), as per the description provided in the NEPM (NEPC, 2013).

Guidelines for assessment of leachable concentrations of PFOS in soils are based on fresh and marine water guidelines for 99% species protection provided in the NEMP (HEPA, 2018). (HEPA, 2018). These guideline values have been adjusted to align with standard laboratory limits of reporting (LoR), as per guidance provided in the NEMP, and by EPA Victoria.

4.2.5.3 Guidelines values

Adopted guideline values are provided below in Table 4.5. Groundwater and surface water were not part of the investigation scope.

Table 4 5: Adopted guideline values

Compound - receptor	Guideline value (PFAS NEMP)	
	Total concentrations	Leachable concentrations
PFOS + PFHxS – human health	1 mg / kg	NA
PFOS – ecological health	0.14 mg / kg	0.001 µg/L (standard laboratory LoR)
PFOA – human health	10 mg / kg	NA
PFOA – ecological health	NA	19 µg/L

4.2.6 Overview of findings

The key conclusions with respect to risk from contaminated soils within the project area are:

- No total concentrations of PFAS in soils were reported above the guidance values for the protection of human and ecological health.
- A trend of generally higher concentrations of PFAS (PFOS) has been noted along the NAR and at depth.
- Comparison of “non-PFAS” soil chemistry to IWRG 621 criteria (EPA Victoria, 2009b) indicates that the likely waste classification of soils is Fill Material. Fill Material can typically be re-used on or off-site or disposed at an appropriate off-site facility.
- The risk to human health as a result of exposure to impacted soils is considered to be low, with no exceedances of screening values for the protection of human health.
- A number of reported leached concentrations (PFOS) exceeding adopted guideline values for the protection of ecological health (freshwater 99% species protection).

4.3 Pathways and transport mechanisms

PFAS compounds are soluble in water and are often transported via surface water pathways or leaching to groundwater. They can also be transported in the air within suspended dust particles. PFAS does not fully degrade (such as benzene can degrade to carbon dioxide), however it will transform ultimately forming terminal degradation products that do not break down easily or via natural processes, and tend to persist within the environment.

At the airport, PFAS could be transported via either surface or groundwater. Permanent surface water bodies do not exist within the NAR and Zulu site. However, temporary surface water may be generated for short periods of time after heavy rains etc. Where present, surface water will be focused into overland drainage channels and through other preferential pathways towards Moonee Ponds Creek.

Compared to over land flow or flow within surface water, transport of contaminants through groundwater is a slow process. In order for PFAS in soil to be transported into groundwater, surface water needs to percolate through the soils, leach out and carry PFAS before then connecting up with groundwater aquifers where PFAS will readily be incorporated and transported. Factors such as the type of soil and depth to groundwater will influence the rate at which this process occurs. At site, the soils are mostly dense basaltic clays and depth to groundwater is anticipated to be greater than 10 mbgl. The dense clays have low hydraulic conductivity and will retard the flow of groundwater and any soluble contaminants.

Dust generation potential is more likely on parts of the site devoid of vegetation with dusts mobilised by the wind, by vehicles or during other earth moving activities. This dust can be deposited back to the ground generally in the direction of the prevailing winds, thus spreading the PFAS away from the original source. This pathway will depend on the characteristics of the surface soil and the atmospheric conditions. Construction earthworks activities on “dust generating days” can also mobilise PFAS within dust. This pathway is not considered very likely with the airport in its current condition, however with the forthcoming development, is more likely to be potential significant pathway.

The various fate and transport pathways possible for the site are summarised in Table 4 6. A 2D conceptual site model for construction and operation phases of the project is shown in Figure 4.1 and Figure 4.2 respectively.

Table 4 6: Potential contamination pathways

Project Phase	Activity	Potential contamination pathways
Construction	Excavation, soil disturbance and transport of PFAS impacted materials (includes stripping and grading, excavation to sub-grade, NDD works, excavation and installation of services and drainage infrastructure, transport of materials)	· Dust generation during excavation and transport · Direct contact with soils · Surface water collection in excavations · Surface water runoff from cleared areas and/or bare soil at construction sites
	Temporary stockpiling and storage of PFAS impacted material	· Dust generation from stockpiled material · Direct contact with soils · Surface water runoff from stockpiled material · Fluid ingress and leaching of contaminants to groundwater from stockpiled material
Operation	Medium to long-term on-site storage of PFAS impacted materials (at designated storage area as advised by APAM, shown as Site 2 in Figure 6)	· Dust generation from stored material · Direct contact with soils · Surface water runoff from stockpiled material · Fluid ingress to stockpiles and leaching of contaminants to groundwater

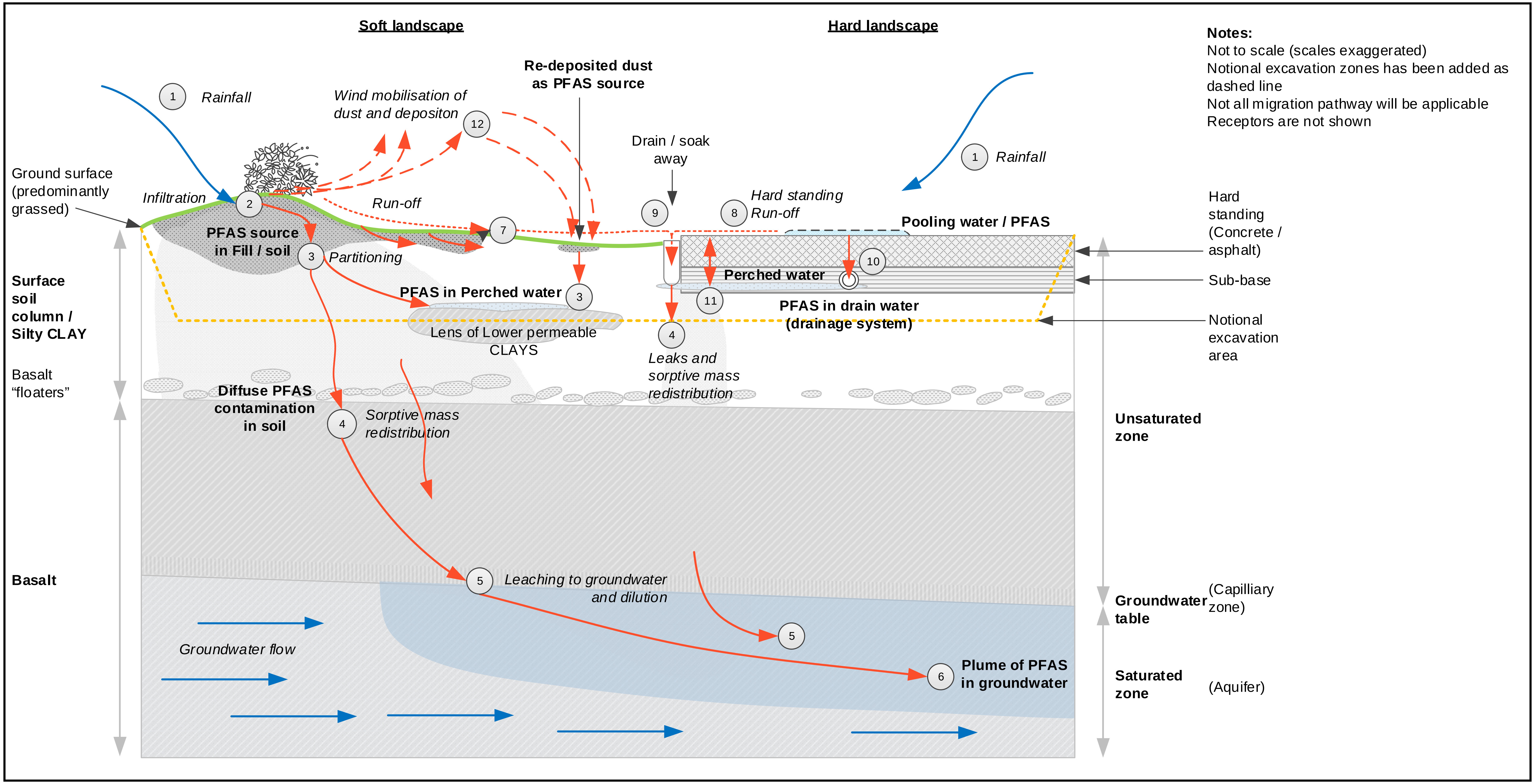


Figure 4.1: Visual conceptual site model – construction phase project area

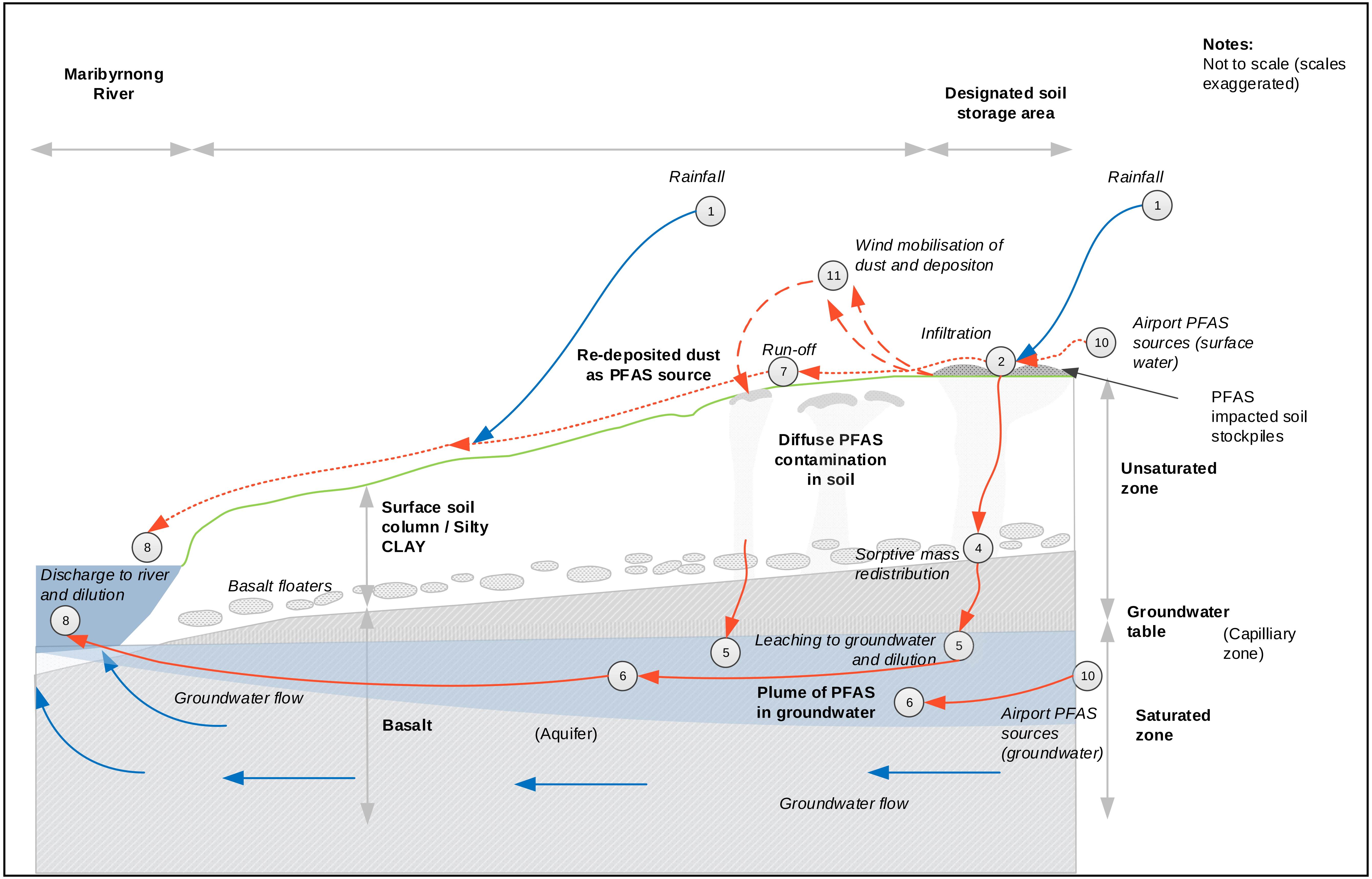


Figure 4.2: Visual conceptual site model – operational phase (soil storage)

4.4 Sensitive receptors and exposure scenarios

An indication of potential receptors that might be impacted by PFAS at site has been determined by first reviewing the potential beneficial uses of the site. "Beneficial use" is defined in Section 2.03 of the Airports (Environment Protection) Regulations 1997 as a use of the environment or any element or segment of the environment which is:

Conducive to public benefit, welfare, safety, health or aesthetic enjoyment, and which requires protection from the effects of waste discharges, emissions or deposits, or of the emission of noise.

An element of the environment is any of the principal constituent parts of the environment including land, water, atmosphere, vegetation, climate, sound, odour, aesthetics, fish and wildlife.

The following on and off-site receptors have been identified:

Human Health

- Construction workers related to upgrade of the NAR and Zulu and reuse of the soils.
- Maintenance and contract workers at Melbourne Airport.
- General public on and off-site.
- Recreational users of Moonee Ponds Creek and Arundel Creek.

Ecological Health

- On-site flora and fauna, including aquatic ecosystems associated with Arundel Creek located approximately 1 km to the west of the project area.
- Aquatic and terrestrial ecosystems within Moonee Ponds Creek - a surface water way located about 150-250 m to the east of the NAR, and Deep Creek – a surface water way located about 270 m west from proposed soil storage area.
- The Growling Grass Frog and Australian Grayling (both EPBCA listed threatened species) are identified as relevant to the aquatic and terrestrial ecosystems outline above. The Growling Grass Frog and/or their likely habitat have been verified to be present in Arundel Creek, Moonee Ponds Creek and Deep Creek. The Australian Grayling is present in Deep Creek (Flora and Fauna Assessment of the Runway Development Program, Melbourne Airport: Existing Conditions and Impact Assessment Report, Biosis, April 2015).
- Key receptors, surface water features, monitoring points and potential ground and surface water extraction points in the vicinity of the Project are shown in Figure 3 at the end of this document.

4.4.1 Baseline conditions for nearby aquatic ecosystems

Melbourne Airport undertakes annual stream health monitoring in Arundel Creek, Deep Creek and Moonee Ponds Creek, as part of a long-term monitoring program that commenced in 2008.

Monitoring is been undertaken in accordance with EPA Publication 604.1 'Guideline for Environmental Management – Rapid Bioassessment Methodology for Rivers and Streams' (EPA Victoria, 2003). Each monitoring site is assessed against macroinvertebrate biological objectives and indicators outlined in the State Environment Protection Policy (Waters) (SEPP Waters) (Victorian Government, 2018). This assessment includes collection and assessment of water chemistry data, number and species of invertebrates, stream physical attributes, condition of habitat and riparian zone. Opportunistic observations of vertebrate fauna including Growling Grass Frogs are also part of the assessment. The findings of the most recent stream health monitoring conducted in 2018 are summarised below.

Arundel Creek

The results were mixed with some biological indices meeting the SEPP Waters objectives whilst others did not. The SEPP Waters objective for AusRivAS Band B was met for some parts of the creek but not others. The sites have minimal riparian zones, generally degraded in-stream habitats and have reported poor water quality. The poor stream health and impacted water quality at the Arundel Creek sites is consistent with previous monitoring results.

Deep Creek

The calculated biological indices met or were better than SEPP Waters objectives, with a high diversity of macroinvertebrate communities and AusRivAS Band X or A classifications. These classifications mean that the macroinvertebrate communities at these sites were similar to or richer than the expected diversity at Victorian reference site locations. Water quality at these sites is generally very good except for impacts by PFAS. The results indicate that the macroinvertebrate diversity have not been adversely impacted by PFAS.

Moonee Ponds Creek

The results were mixed with some biological indices meeting the SEPP Waters objectives whilst others did not. The AusRivAS Band was calculated at Band C noting that Moonee Ponds Creek has historically always reported Band C. Most indices either improved or were stable when compared with historical results.

As outlined in Section 7.1.2, Melbourne Airport will continue to undertake annual stream health monitoring during construction and operation of the Project.

4.5 Preliminary risk assessment

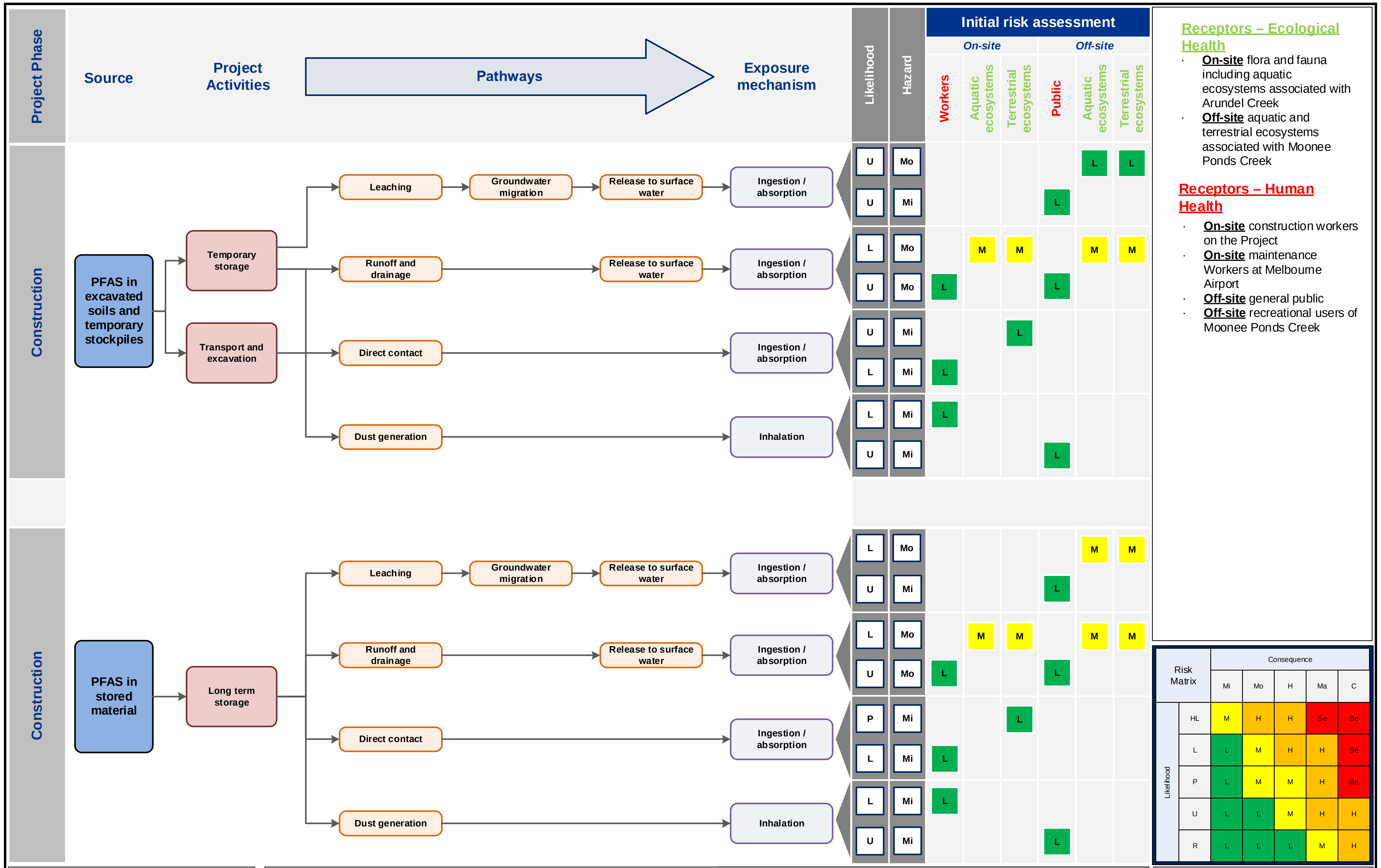
A risk assessment of potentially complete source-pathway-receptor linkages was undertaken using the methods provided in the Department of Environment (DoE) Environmental Management Plan Guidelines, with results detailed in the schematic diagram in Figure 4.1 below. A risk summary is presented below.

Construction phase – excavation, transport and stockpiling of material

- Risk to human receptors on and off-site is considered to be low.
- Risk to ecological receptors on and off-site through contaminant migration via groundwater is considered to be low.
- Risk to ecological receptors on and off-site through contaminant migration via surface water is considered to be medium.

Operational phase – medium to long-term storage of material

- Risk to human receptors on and off-site is considered to be low.
- Risk to ecological receptors on and off-site during the through contaminant migration via groundwater is considered to medium.
- Risk to ecological receptors on and off-site through contaminant migration via surface water is considered to be medium.



Qualitative measure of likelihood (how likely is it that this event/issue will occur after control strategies have been put in place)	
Highly likely	Is expected to occur in most circumstances
Likely	Will probably occur during the life of the project
Possible	Might occur during the life of the project
Unlikely	Could occur but considered unlikely or doubtful
Rare	May occur in exceptional circumstances

Qualitative measure of consequences (what will be the consequence/result if this issue does occur rating)	
Minor	Minor incident of environmental damage that can be reversed
Moderate	Isolated but substantial instances of environmental damage that could be reversed with intensive efforts
High	Substantial instances of environmental damage that could be reversed with intensive efforts
Major	Major loss of environmental amenity and real danger of continuing
Critical	Severe widespread loss of environmental amenity and irrecoverable environmental damage

Taxiway Zulu including Northern Access Route CSM and Preliminary Risk Assessment

Figure 4.3: Conceptual Site Model and Preliminary Risk Assessment

5. Soil and spoil management options assessment

5.1 Potential re-use options and constraints of PFAS impacted soils

The NEMP outlines a number of potential reuse options for PFAS impacted material contingent upon physical and chemical suitability of both the material to be reused, and the receiving areas. Potential reuse options include:

- Fill material in construction developments with minimal access to soils.
- Fill material beneath sealed surfaces including roads and runways.
- Construction fill on road embankments.
- Use as fill material in areas where background PFAS levels present a similar or higher contamination risk profile. Volume of the contaminant present in soils must be substantially less than the total mass present in the receiving area.
- Construction waste (bitumen and concrete rubble) may be used for engineered fill such as road base (crushed).

5.2 Soil categorisation

As described in Section 4.2.3, the concentrations of PFAS in soils are all below the criteria relevant to human health. Concentrations of leachable PFAS (and in particular PFOS) in some soil samples have been detected above the adopted assessment criterion for the protection of ecological health (NEMP Freshwater 99% Species Protection). As such, the most likely pathway for PFAS migration from stored material on-site and potential environmental impact is mobilisation via surface water runoff and towards surface water drains and nearby surface water creeks and streams and / or infiltration and leaching to groundwater and thus laterally to potentially discharge to surface water.

In assessing potential risk from leachable fractions of PFOS, two soil categories have been defined to account for the range of leachable concentrations observed across the project area. These are:

- **Category 1:** Soils with low concentrations of PFAS such that risks of harm to human health OR the environment is acceptably low. Management of these soils is not general required.
- **Category 2:** Soils with raised concentrations of PFAS such that risk of harm to human health OR the environmental are possible. These soils are likely to require some kind of management if retained on-site.

A site-specific management concentration differentiating Category 1 and Category 2 leachable concentrations was back calculated assuming a simple redistribution of the PFAS from a contaminated layer to the underlying groundwater, dilution and attenuation in the underlying groundwater and further dilution within the groundwater between the proposed storage facility and the nearest surface water receptor.

When considering the physical separation of the management area from the surface water receptor, a default dilution attenuation factor of 400 has been calculated for use at Melbourne Airport with respect to determining whether soils would be classed as Category 1 or Category 2 spoil. Using 0.001 µg/L as the water quality objective at the surface water receptor as a surrogate for the 99% species protection target, then the threshold leachable concentration in soil is 0.4 µg/L. The basis for this value is described in Appendix C.

Based on the above, an estimate of the proportion of soils being in which category is given in Table 5 1. Soil category distributions based on results from previous investigations are provided in Figure 4 at the end of this document.

Table 5 1: Soil categories

Soil Category	Threshold (leachable concentration µg/l)	Likely percentage of total soils	Total Mass of PFAS (approx.) (mg)[1]
Category 1	Less than or equal to 0.4	90%	2417 (2.4g)
Category 2	Greater than 0.4	10%	772 (0.77g)

Note 1: Total mass of PFAS has been estimated by taking the average total concentration (PFOS + PFHxS) – 0.0032 mg/kg in Category 1 soils, and multiplying by the total mass of Category 1 soils (assumed to be approximately 90% of total soils to be excavated – 755, 422 kg). The mass of PFAS in category 1 soils can then by subtracted from the total mass of PFAS in soils given in section 4.2.3.1 to give the approximate mass of PFAS in category 2 soils.

5.3 Spoil management approach

The approach to spoil management associated with this project will be in general accordance with Melbourne Airport's Environment Strategy (APAM, 2013) and Environment Policy (2018), and specifically guided by the waste hierarchy framework, which aims to reduce, reuse, recycle and treat waste rather than dispose of it, particularly to landfill. In the context of the project, the following preference list applies (from preferred to least preferred).

Table 5 2: Spoil management approach

Aspect	Description	Relevance to the project
Avoidance (and reduction)	Avoidance of contaminated materials at the concept and design stage of procurement	Not feasible given soil will be excavated for placement of concrete slabs, footing and services (cannot be directly reinstated into excavation) and disposal quantities have been calculated on the basis of the cut / fill balance for each project area.
Reuse	Reuse requires the design and utilisation of re-useable materials without subjecting the item to a manufacturing process that changes its original configuration and composition	Re-use within the wider airport estate is the preferred approach. However, immediate re-use might not be feasible, and thus options for temporary storage in anticipation of a future identified re-use have been identified (in Section 5.4 below).
Recycling	Product recycling requires the raw material to be recovered and used to manufacture another product	Similar to reuse above.
Energy recovery	Energy recovery aims to minimise the need to consume new resources in manufacturing energy by recovering waste and using it as fuel (e.g. harnessing methane gases as a fuel from the decomposition of organics materials). Energy recovery is not to be confused with incineration, in which wastes are simply burned	Not applicable.
Deposit to landfill	Disposal of waste to landfill is the least acceptable form of waste management, and is to be regarded as the option of last resort	Feasible option.

Thus, in summary, reuse of spoil is considered the preferable management solution for all soils generated during construction at the Airport. Note that reuse would only be feasible subject to a risk assessment.

If, however a reuse option is unavailable, then an option to store the spoil until a future reuse option becomes available is considered the next most favourable outcome for construction related spoil. Storage is thus considered a time bound solution with the stored soils ultimately being moved to a suitable reuse location. The PFAS NEMP (HEPA, 2018) considers storage in the short term (6 months to 2 years), medium term (2 to 5 years) and long term (greater than 5 years). Jacobs has considered that storage of soils associated with this project would be medium and long term.

5.4 Management options for temporary storage prior to reuse

5.4.1 General

There are a number of technologies that may be suitable for treatment and disposal of PFAS contaminated soils. In identifying an appropriate management solution for PFAS impacted soils at Melbourne Airport, a number of these technologies have been considered and concluded to be non-viable, primarily on the basis of likely cost and availability. Whilst a number of techniques such as stabilisation, thermal desorption, incineration and chemical oxidation are at trial or demonstration stages, most remedial methods currently available for PFAS impacted soils relate to clean cover technology or in ground barriers.

Based on Jacobs' experience and current knowledge, and in accordance with the NEMP (HEPA, 2018), the most practical management options for PFAS impacted soil are as follows:

- Option 1 – Storage on-site and placed over soil / land with a similar or higher risk profile; and
- Option 2 – Placement within constructed engineered and contained stockpile on-site.

Whilst not a temporary storage solution, a third option (Option 3) has been identified with this being disposal off-site to landfill. This option is mainly considered a contingency option should temporary storage solution not be available.

These three options are described in more detail below.

5.4.2 Option 1 – Stored on-site and placed over soil / land with a similar or higher risk profile

In cases where site conditions allow, it may be acceptable to relocate and stockpile PFAS impacted soil to another area of the same site, providing that the contamination risk profile at the destination area is not increased.

In considering the applicability of this management option, the underlying assumptions are that:

- Only applicable for Category 1 soils ("low concentration").
- Placement of the soil does not raise the contamination risk profile of the area where it is placed for the lifetime of the stockpile.
- Appropriate 'stabilisation' methodology would be required to control dust generation and surface water runoff (for example, hydro-seeding with a site specific vegetation varietal and temporary stabiliser would be an effective, low cost option).
- The excavation work is part of construction activities where site remediation or contamination management is not the key objective.
- There are no other chemical or physical characteristics of the soil / sediment (e.g. other contaminants) that would give rise to an unacceptable risk.

Advantages

- Minimises volume of waste directed off-site and associated construction traffic on public highways.
- Retains soil on-site for reuse in other airport projects.
- Effective approach for "low concentration" soils.
- Can be integrated into construction phase of the project timeframe.
- Potentially suitable stockpiling area has already been identified within the airport grounds (proposed location of stockpiling facility).

Disadvantages

- Transferring impacted soil to other area of site – may further impact underlying soils and / groundwater at the receiving area of site.
- Will require additional data to pre-classify the soils with respect to PFAS concentrations.
- Requires a suitable receiving area in order to be viable.
- Likely not appropriate for soils with “higher” concentrations of PFAS.
- “Legacy” contamination will remain on airport land for future management.

5.4.3 Option 2 – Contain spoil on-site in engineered stockpiles

5.4.3.1 General

This option refers to the containment of PFAS impacted soils in long-term, engineered stockpiles at a selected location(s) within the airport. Stockpiles would require an impermeable cover to prevent rainfall infiltration along with consideration of the following:

- Applicable for Category 1 and 2 soils.
- There is a suitable area for siting of engineered stockpiles.
- Placement of soils does not raise the contamination profile of the receiving area for the lifetime of the stockpile.
- Cover material is designed such that it would mitigate rainwater infiltration with the clean cover having a permeability of 1 x 10-9 m/s or less.
- Detailed design would be required in advance of construction.
- The stockpile should be constructed on suitably engineered base with berms and drains as required and should be completed in advance of soil excavations.
- Stockpile design and placement adheres to airport standards for stockpile construction as in the Melbourne Airport Environmental Management Plan (2018).
- The stockpiles are able to be decommissioned if a future use of the soil is found.

Two containment variants have been identified:

- Option 2(a) – Contain all spoil in an on-site engineered containment facility sized for the entire anticipated volume of excavated spoil.
- Option 2(b) – Contain only spoil that does not meet Option 1 criteria in a number of discrete engineered stockpiles.

5.4.3.2 Option 2(a) – Contain spoil in an on-site engineered containment facility sized for the entire anticipated volume of excavated spoil

This option refers to a dedicated containment cell designed and sited with a primary intention to prevent the spread of contamination and is designed to contain all spoil generated during the construction activity irrespective of contamination concentration.

Advantages

- Minimises volume of waste directed off-site.
- Effective control of PFAS migration with engineered containment cell (less risk of PFAS migrating through to underlying soils and / or groundwater) for both soil categories.

- Provides all-in-one solution for soil and spoil – could likely be used for all soils (contingent upon final storage capacity) requiring an on-site storage solution at the Melbourne Airport.
- Retains soil on-site for future reuse in other airport projects.

Disadvantages

- High cost and timing implications related to containment cell construction.
- High cost implications related to containment cell decommissioning.
- Relatively high level of logistical complexity related to siting and approval requirements.
- Ongoing management would be required (including groundwater monitoring, cap inspections, etc.).
- "Legacy" contamination will remain on airport land for future management.

5.4.3.3 Option 2(b) - Contain spoil on-site in a number of discrete engineered stockpiles

This option relates to the construction of a number of smaller stockpiles sized to take only the material that does not meet the Option 1 criteria.

Advantages

- Minimises volume of waste directed off-site.
- Retains soils on-site for future reuse in other Airport projects.
- Effective control of PFAS migration with engineered containment cell (less risk of PFAS migrating through to underlying soils and / or groundwater) for Category 2 soils.
- Readily decommissioned if another use for the soils is identified.
- Relatively inexpensive compared with engineered containment or off-site disposal options.

Disadvantages

- Would require further testing of the soils at Zulu and NAR to classify the soils (i.e. to identify the extent of Category 2 soils).
- Would require mobilisation of installation equipment for each new 'batch' of soils.
- Ongoing management would be required (including inspections of capping materials, ground and surface water monitoring).
- "Legacy" contamination will remain on airport land for future management.

5.5 Option 3 – Off-site disposal

As noted above, whilst not strictly an option that should be directly compared to on-site solutions, off-site disposal is a valid option for managing spoil materials generated on-site. This involves landfilling of material at a suitable secure commercial landfill off-site. Although an indicative waste classification basis is suggested in the NEMP (HEPA, 2018), EPA has not currently issued guidance on the hazard category or waste classification of soils contaminated with PFAS.

IWRG 621 (EPA Victoria, 2009b) requires that if the waste contains a contaminant that is potentially poisonous (acute), toxic (delayed or chronic) and / or ecotoxic and the contaminant is not listed in Table 2 (of IWRG 621), the waste generator must apply to EPA for a determination of hazard category. PFASs are not included in Table 2 of IWRG 621, and hence in this case.

The data presented in Jacobs ESA Report (Jacobs, 2018) shows that (PFAS excepting), the spoil material would be categorized as Fill Material. Fill Material is normally not regulated by EPA, with fill material being able to be reused both on and off-site (subject to satisfying a few conditions). Jacobs' experience with other projects in Melbourne is that, Fill Material containing PFAS is considered separately within the EPA classification as "non-prescribed industrial waste". EPA would also be likely to impose conditions that any Fill Material containing low levels of PFAS may be disposed of at an EPA licenced landfill or used as daily cover in a landfill cell. Deposition as an industrial waste will attract a Landfill Levy, whereas fill material (without PFAS) disposed to landfill does not normally attract a levy; the levy as of the date of this report is $63.28 per tonne, to be paid by the generator (note this is not the final disposal costs – but just the levy).

In summary, the following applies at the present time:

- Applicable for Category 1 and 2 soils.
- Applicability would require to be confirmed following discussion with EPA Victoria. EPA would then draft an approval and waste classification.
- The acceptability of disposing of contaminated soil at established commercial landfills is uncertain and is in state of flux.
- Considerable effort is being directed in the industry to determining acceptable options for treatment and disposal of PFAS contaminated soil and it is likely that options that have regulatory acceptance will become available in the coming years.

Advantages

- Technically feasible.
- A permanent solution to protecting human health and the environment at the airport and thus very effective.

Disadvantages

- Low down on the waste hierarchy and thus not as sustainable as other options.
- Costs would likely be high.
- Significant additional construction traffic on the public highway.
- Will require off-site transport of wastes

5.6 Assessment methodology

Feasible soil management options as outlined in Sections 5.4 and 5.5 were incorporated into a 'matrix of options' for each soil Category (1 and 2) – a detailed table of comparisons is provided in Appendix B – Management Options Assessment. Respective options were compared and evaluated against criteria including:

- Operations and maintenance (O&M)
- Capital setup expenditure
- Reliability and maintainability
- Availability
- Waste management hierarchy
- Logistics
- Relative costs
- Ongoing liability

Each of the soil management options was screened against the assessment criteria above and given a score based on information provided by Melbourne Airport and Jacobs' own experience, as follows:

- Above average performance: 2
- Average performance: 1
- Below average performance: 0

The sums of the scores for each remedial option were then compared. Higher scoring options were considered preferable whereas low scoring options were deemed least preferable. The following section provides an evaluation of possible options capable of meeting the management objectives.

5.7 Recommended management approach

Based on the results of the evaluation undertaken, the following options received the highest score for each soil category and are preferred based on the assessment matrix provided in Appendix B.

Table 5 3: Management options assessment results

Soil category	Recommended approach	Score
Category 1	Option 1 – Place soil at another site with a similar or higher risk profile	16
Category 2	Option 2b – Contain spoil on-site in discrete smaller engineered stockpiles with capping / cover	16

Based on results obtained in previous investigations it is estimated that the majority of soils – approximately 90% – within the excavation footprint of the Project will be classified as Category 1 soils and thus Option 1 (or Option 2) would be applicable for these soils. These soils are considered to present a low risk of environmental impact in an uncontained environment on the basis of the assessment detailed in section 5.2.

Category 2 soils will require further management if being retained on-site with an effective management option being to contain within an engineered containment facility. This containment facility would be designed to take all of the anticipated spoil generated from Zulu and NAR and has the major advantage of being suitable to receive all the soils generated as part of Zulu / NAR. However, given that the majority of material is Category 1 soils and would be suitably managed using Option 1, an alternative to Option 2(a) has been identified – namely Option 2(b) – which is a smaller more flexible concept.

Thus, the recommended management solution is Option 1 combined with Option 2(b). This is described further below.

5.8 Recommended temporary management approach

5.8.1 Siting assessment for temporary storage area

An options assessment and comparison of two potential sites for temporary storage of PFAS impacted soils was undertaken by APAM in 2018. Both sites (Site 1 and Site 2) are presented in Figure 5, along with environmental features relevant to the suitability of each site for storage of soils. It is noted that Site 1 was included as the proposed stockpile area in the Additional information for assessment by Preliminary Documentation (EPBC 2016/7837)[1].

The siting assessment identified a number of potential limitations and requirements for further investigation associated with Site 1, including the following:

- Potential for shallow groundwater (<5 m) identified in the north western portion of the Site 1, indicating the need for further groundwater investigation.
- Potential for impact to part of the Site 1 by east west runway extensions works.
- Site 1 may be underlain by fill material and requires further geotechnical investigate suitability of material as a liner / stable base for stockpiles.
- Site gradient (change of over 5 m) and possible presence of fill could necessitate a more complex site investigation and design approach that that of Site 2.
- Site 1 (150 000 m^2) is significantly smaller than Site 2 (360 000 m^2), and will require material to be stockpiled to a greater height in order to meet volume requirements.

[1] Biosis, Taxiway Zulu and Northern Compound project Melbourne Airport, Victoria: Additional information for assessment by Preliminary Documentation (EPBC 2016/7837), 11 July 2017.

- Site 1 is located on the edge of the approach surfaces, and is also in the building restricted area of the runway glide path.
- On this basis, Site 2 was selected as the more suitable option for temporary storage of PFAS impacted soils.

5.8.2 Storage of Category 1 soils

Category 1 soils should be stored within the temporary spoil storage facility shown as Site 2 in Figure 6. Results of a soil investigation conducted at the proposed Site for temporary spoil storage indicate that total concentrations of PFOS range from < 0.2 to 112 µg/kg, and leachable concentrations of PFOS range from <0.01 to 5.98 µg/L. Results are summarised in Figures 5a and 5b. .

As described in Section 5.2 and Appendix C, leaching to groundwater from Category 1 soils is not considered to pose a significant risk to human or ecological receptors on the basis of reported leachable concentrations of PFOS, and the mass redistribution of contaminants in soils during vertical migration of leachate.

Stockpiles will require stabilisation to prevent dust generation and surface water runoff using hydromulching or a similar product. Hydromulching applies seed, fertiliser, tracking dye and a binder to large areas utilising water as a carrier, along with a temporary stabilising layer to control against wind and erosion while germination takes place. Formation of stockpiles and application of Hydromulch can occur in line with generation of spoil throughout the Project, and stockpiled soils will be easily accessible should they be required for use in future projects.

Surface water runoff will be captured via drainage infrastructure (swale system) and flow to a retention basin within the temporary spoil storage facility. Captured runoff will be tested for PFAS and managed on the basis of results (treatment via Water Treatment Plant or release).

Residual risk to human and environmental receptors due to migration of PFOS from Category 1 stored on-site in the mid to long term is considered to be low and acceptable.

5.8.3 Storage of Category 2 soils

Engineered stockpiles of Category 2 soils will also be stored at the temporary spoil storage facility, shown as Site 2 in Figure 6. These soils are considered to pose a moderate risk of environmental impact via PFOS mobilisation to groundwater and surface water in an uncontained environment, and will require construction of an engineered cap to prevent rainwater infiltration, and to control against dust generation and surface water runoff as soon as reasonably practicable following excavation.

A geotechnical assessment of the proposed soil storage area has been undertaken to ensure suitability of the base material with respect to ground conditions, and to identify / refine requirements for base preparation (i.e. grading and compaction). Ground conditions have been confirmed as primarily low permeability clays (1×10^{-10} m/s) and groundwater at the south western extent of the Site has been confirmed as >40 m below surface level. Civil and drainage design should allow for collection of PFAS impacted runoff and prevention of environmental release. As discussed above, it is anticipated that stockpiled material will be capped / contained discretely within the storage area and bunding will not be required for soil containment purposes; however, bunding may be necessary as a drainage feature to control storm water runoff within the soil storage area.

Excavation of this material will likely occur progressively and require management as it is encountered within the excavation plan to be prepared by the Contractor. Category 2 soils would be placed on the prepared base in a similar manner as Option 2(a), and once a suitable volume of soil has been stockpiled this would be covered using an impermeable cover. Proprietary geocomposite materials can be readily purchased giving permeabilities of 1×10^{-9} m/s. The "modular" concept is based on managing sufficient volumes of soil based on the dimensions of delivered rolls. This method is conceived as enabling a flexible arrangement of stockpiles which could be positioned, structured and expanded as required and in line with the volume of Category 2 soils encountered in the project excavation area. Siting and stockpiling methodologies are discussed further in Section 6.

Residual risk to human and environmental receptors due to migration of PFOS from Category 2 stored on-site in the mid to long term is considered to be low.

6. Management plan

6.1 General

As described in Section 5.4.2, reuse of material in future airport projects is considered a preferred end point for excavated spoil in accordance with the Melbourne Airport Waste Management Principles. Material will require geotechnical and chemical assessment in order to identify viable end use options, with storage in the proposed soil containment area considered the most appropriate interim measure. Material will be temporarily stockpiled in a designated stockpile area prior to transport to the containment area upon its completion.

The following control measures are recommended to prevent / reduce the risk of exposure to construction workers and to assist with the management of contaminated soils.

Works must be undertaken with the following published guidance documents:

- National Environment Protection (Assessment of Site Contamination) Measure, 1999
- CCF, 2010. Environmental Guidelines for Civil Construction. Civil Contractors Federation, May 2010
- EPA, 1996. Environmental Guidelines for Major Construction-sites. Publication 480. Environment Protection Authority Victoria, Publication 480, February 1996
- EPA / Worksafe, 2017. Contaminated Construction-sites – Construction and Utilities. Environment Protection Authority Victoria / Worksafe, June 2017
- SWA, 2015. Excavation Work – Code of Practice. Safe Work Australia, March 2015
- Airports (Environment Protection) Regulations 1997 (Cth)
- PFAS National Environmental Management Plan, January 2018
- Melbourne Airport Environmental Management Plan, July 2018

A PFAS management workflow diagram is provided below in

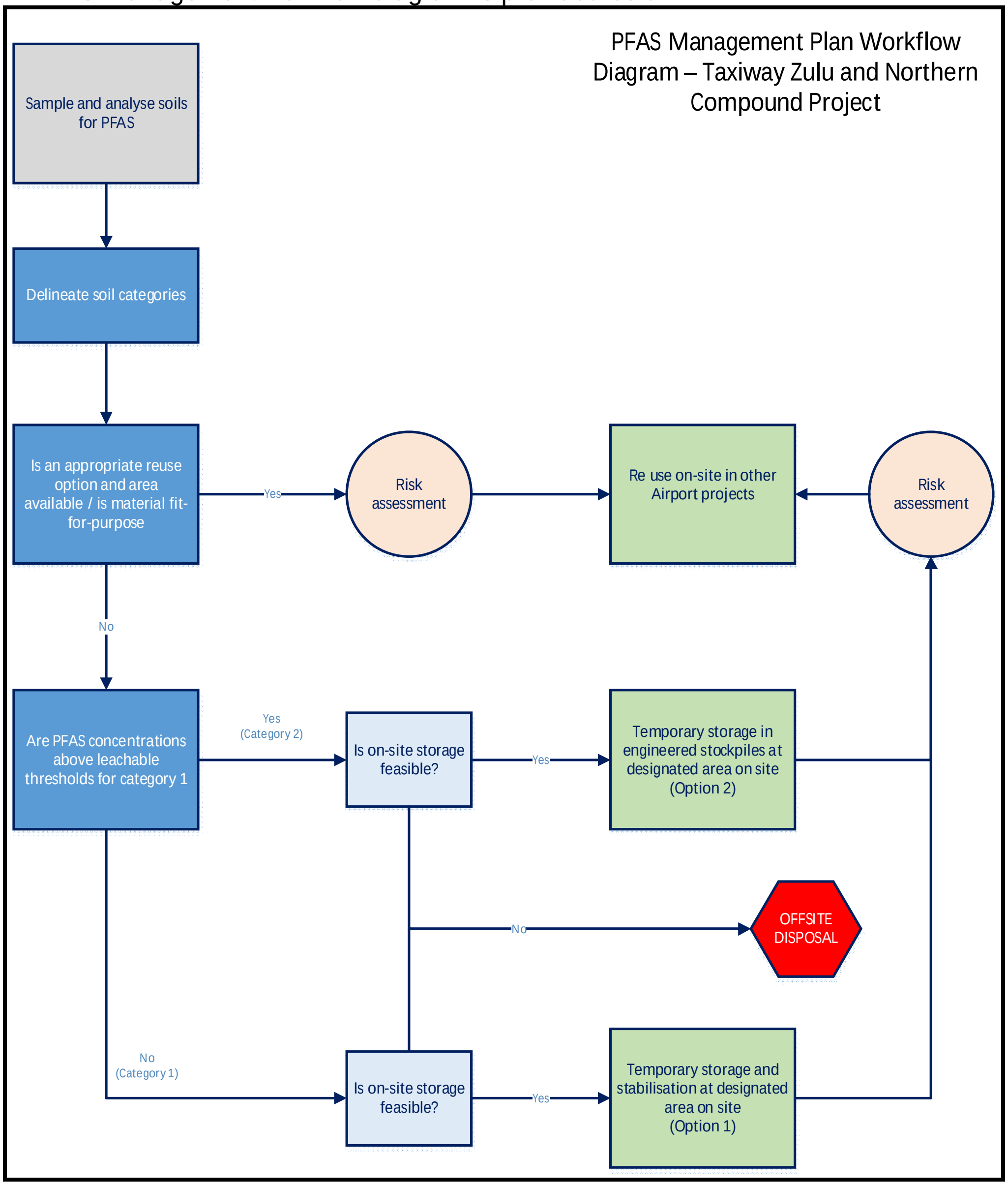


Figure 6.1.

Once soil classification and delineation of excavation areas has occurred and immediate reuse excluded as a feasible option, excavated material will be transported to the designated stockpiling area shown as Site 2 in Figure 6. A detailed methodology for preparation, excavation and stockpiling of Category 1 and Category 2 soils is provided below in Section 6.2.

Temporary stockpiling of PFAS impacted materials in designated laydown areas is not anticipated; however, should temporary stockpiling be necessary, a detailed methodology is provided in Section 6.14.

Similarly, off-site disposal of PFAS impacted material is not anticipated during the Project, however, should disposal to landfill be required, methodologies and relevant information are provided in Section 5.5.

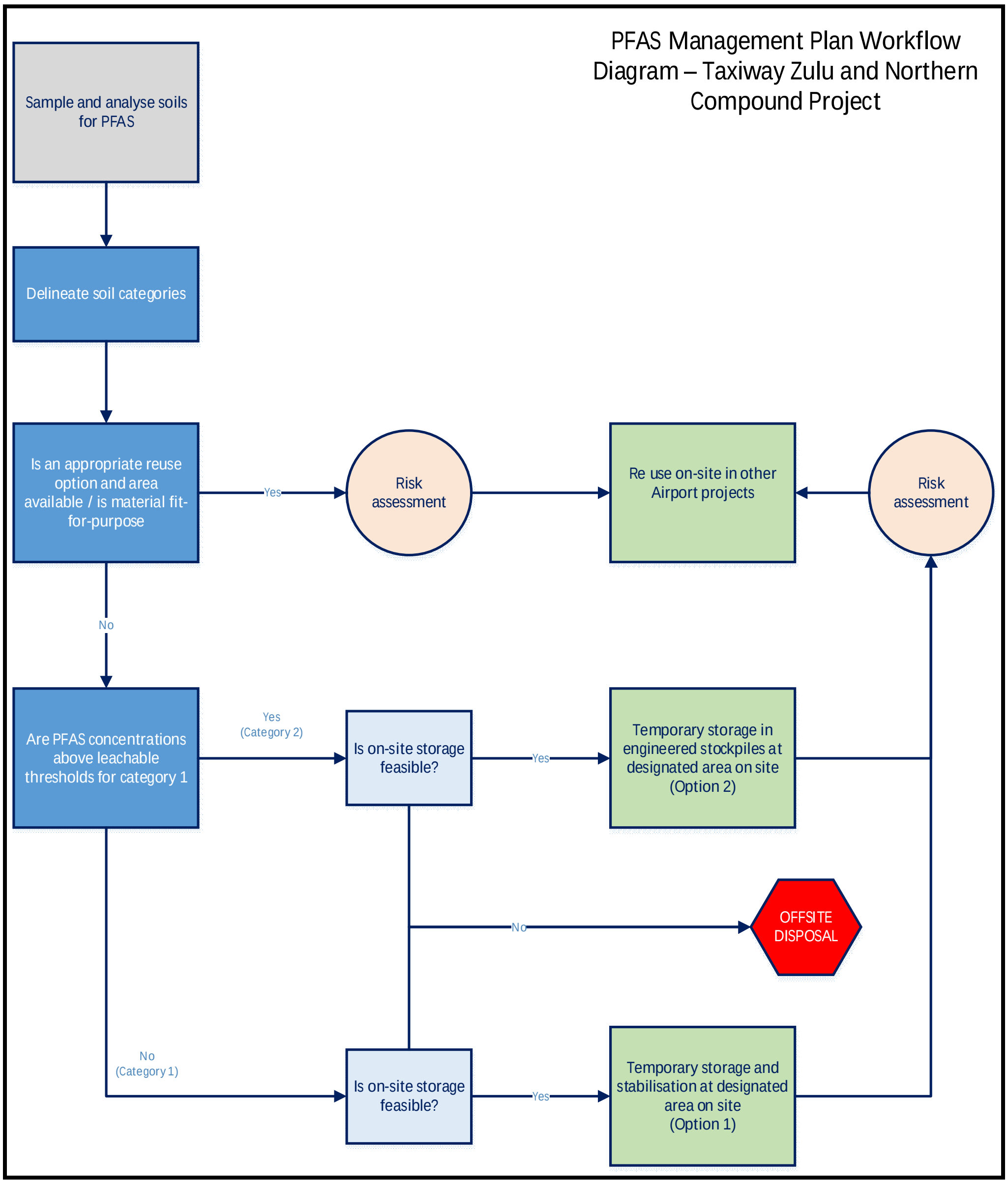


Figure 6.1: PFAS Management workflow

6.2 On-site storage

6.2.1 General

A designated soil storage area for PFAS impacted material has been nominated by Melbourne Airport and is depicted in Figure 6 (Site 2). The following considerations were made when nominating the storage area:

- Hydrological features including drainage, topography and proximate surface water features.
- Hydrogeological features including groundwater depth, quality and flow.
- Site geology and soil conditions.
- Proximate sensitive receptors.
- Ecological and heritage values.
- Legislative requirements and airport regulations.
- Climate and extreme weather events.

- Existing contamination at the receiving site.
- Proximity to airfields and other critical infrastructure.
- Logistical considerations such as size and transport constraints.

6.2.2 Preparation phase

- A Construction Environmental Management Plan will be prepared in accordance with the EPBC approval conditions prior to commencement of works.
- Prior to work commencing, relevant airport specific approvals will be obtained (i.e. PERCOW, excavation permit, ABC building permit/exemption) and relevant personnel notified of the planned works. Other major airport permits should be obtained for a precinct sized project.
- In the case of Category 1 soils, soil samples will be taken to assess physical and chemical characteristics of stockpiled material to optimise the revegetation product contained in Hydromulching mix (or similar).
- Earthworks and ground disturbing activities will be planned and staged to reduce the duration and extent of exposed soils, and weather forecasts will be considered when planning earthwork. Works during periods of heavy wind or rainfall will be avoided where possible.
- Adequate planning will be undertaken, including preparation of Safe Work Method Statements (SWMSs), securing the work area and preparation of an emergency plan (in the event of an unexpected contamination).
- Work areas will be demarcated, with appropriate signage placed on the barricading / fencing, showing the site is a construction zone and only inducted personnel are able to gain access.
- Storage areas will be proof rolled with a smooth drum roller.

6.2.3 Excavation phase

- Plant being used must be appropriate for the work and maintained in good condition.
- At the cessation of excavated works, areas will be adequately barricaded to prevent unauthorised entry.

6.2.4 Storage pile(s) - construction phase

- Storage piles will be located within the designated storage area depicted in Figure 6 (Site 2).
- Locate piles away from drainage lines and at least thirty metres (30 m) from waterways. Piles are to be demarcated and barricaded, to prevent accidental reuse or exposure.

6.2.5 Storage of Category 1 Soils

- The stockpile area for Category 1 soils will be located in the southern portion of the facility – the draft layout (subject to detailed design changes) for the temporary spoil storage facility is depicted in Figure 7.
- Pile batters must achieve a 2:1 width to height ratio at all times.
- Piles will be sprayed with Hydromulch or a similar product to stabilise and control against wind and water erosion. Spraying must occur as soon as practicable after stockpiling, and product should include a temporary stabiliser to protect against erosion while vegetation germination is underway.
- Sediment control structures (silt fences) will be in place at all times during construction and stockpiling activities. Regular checks will be made in the first two weeks after spraying to ensure that germination is progressing adequately.
- A log of stockpile locations will be maintained, detailing their origins and contamination classification.

6.2.6 Storage of Category 2 Soils

Prior to final engineering containment construction, any temporary stockpiles will be covered with minimum 0.25 mm LDPE sheeting or a similarly material and constructed to an appropriate level of construction quality assurance (CQA). It is noted that covering may pose a visual and / or physical hazard due to reflected light or dislodgement from wind. Once stockpiles reach an adequate size / volume, covers should be removed for installation of final cover material. The draft layout (subject to detailed design changes) for the temporary spoil storage facility is shown in Figure 7.

The base of the storage areas should be formed on natural clays with a slight slope to a sump. Storage piles should be formed to dimensions required for the chosen cover product.

Installation of proprietary geocomposite covers will be undertaken by the supplier under CQA and should consider the following:

- Overlaps and / or welds must be formed in a consistent direction (allowing run-off).
- Covers must extent a minimum of 0.5 m from the toe of the stockpiles.
- Given the potentially extended periods of storage (over 6 months), the liner should be anchored into the ground. Anchor material may include crushed rock, and function as a drainage channel for surface water runoff.

The engineered containment dimensions can be sized based on “as delivered” rolls of material and should consider the excavation logistics.

6.2.7 Concrete / Bitumen

Concrete and bitumen (and other similar construction and demolition waste types) will also be sampled for PFAS to determine appropriate management. Concrete and bitumen will be analysed and managed as follows:

- Core samples (> 50 x 50mm) of concrete and bitumen will be provided to a laboratory with NATA accredited testing processes for crushing followed by analysis for PFAS (total and leachable concentrations). Crushed core samples are considered an appropriate surrogate for decommissioned pavements to be removed as part of the Project, which will be subjected to crushing and storage at the temporary soil storage facility.
- Where no PFAS is detected: If possible, this material will be reused on or off-site for a suitable use (i.e. crushed and used for road base, etc). If no reuse option can be identified, this material can be disposed off-site as an Industrial Waste in accordance with EPA waste guidance
- Where PFAS is detected: Material will be treated in the same manner as PFAS impacted soils and on the basis of identified contaminant concentrations (if any). Material will be classified as either Category 1 or 2, on the basis of the thresholds established in Section 5.6.

6.2.8 Soils generated in preparation of temporary spoil storage area

Soil generation as part of preparation of the temporary spoil storage area will be minimised, with material excavated in construction of swales and drainage infrastructure to be reused where possible in Site bunding. Stripping is not anticipated to be required in stockpiling and road areas.

Any excess soil generated will be tested and managed as either Category 1 or Category 2 material in accordance with this management plan.

6.3 Site setup

Site setup will consist of the following as a minimum:

- The work area will be barricaded and signed to prevent unauthorised access.
- Dust suppression techniques described in the Construction environmental Management Plan (CEMP).
- Establishment of decontamination facilities and procedures to decontaminate the required plant and equipment.

6.4 Site responsibilities and construction EMP

The Managing Contractor (MC) will be responsible for supplying labour, plant / equipment, obtaining relevant permits and excavating / managing the nominated materials. The MC will also be responsible for the implementation of a site-specific CEMP. The MC must provide a copy of this PFAS Management Plan to construction workers requiring access to soils or performing excavation works on the site so that they are aware of their obligations with regards to protecting themselves, other site workers, the general public and the environment.

Definitions of roles and responsibilities are provided in Section 3 of the Project Environmental Management Strategy (EMS).

6.5 Environmental training

All site personnel, including subcontractors must be appropriately inducted onto the site, including reading and understanding the PFAS Management Plan and the requirements associated with its implementation. The induction will include but not be limited to the following:

- Individual roles and responsibilities as defined by the PFAS Management Plan.
- Key environmental values on and around the Site.
- Environmental incident emergency response procedures as described in Section 6.15.
- Site environmental controls.
- Potential consequences of failure to adhere to the requirements of the PFAS Management Plan.

The following requirements will apply both prior to commencement and during works:

- All workers inducted to the site are to read and understand the soil contamination issues on-site and sign site specific safe work method statements for intrusive site ground works and soil management.
- No intrusive works are to be undertaken at the site unless approved by nominated Melbourne Airport representatives (via permits, email approvals, etc.).
- Workers are to avoid unnecessary disturbance of the ground or contact with soils.
- Workers and staff undertaking soil excavation related activities should wear the appropriate personal protective equipment (PPE) as outlined in relevant sections of the SWMS.

Induction records will be maintained throughout the works, and will include:

- The person receiving training.
- The date the training was received.
- The name of the person conducting the training.
- A summary of the training.

6.6 Dust suppression

Dust suppression measures will be addressed as part of the project CEMP.

6.7 Protection of existing environment

All excavation related works shall be performed to minimise damage to surrounding vegetation and ground cover so as to manage erosion and unnecessary environmental degradation. Any designated exclusion zones (i.e. protected grasslands, etc.) are not to be entered unless prior approval has been obtained from the Airport Environmental Team. Exclusion zones will be defined in the project CEMP.

6.8 Decontamination

Plant and equipment must be decontaminated prior to leaving site or taken to an appropriate off-site facility for decontamination. Bins will be placed in the dedicated decontamination area for disposable gloves, etc.

Where machinery has been in contact with site soils (and where possible), decontamination will be undertaken using a waterless method to minimise the generation of a waste slurry / wastewater. This may be undertaken using brushes and brooms (hand tooling – no water).

During wet weather conditions, runoff generated in the vicinity of decontamination activities should be managed in accordance with Sections 6.10 of this PFAS Management Plan.

Once decontamination is complete, the equipment and tools will be inspected by the site manager or OHS representative to ensure decontamination activities have been performed satisfactorily.

6.9 Waste management

All PFAS impacted waste will be managed in accordance with Sections 5 and 6 of this management plan for solid waste, and Section 6.10 for liquid wastes. Any mixed waste i.e. NDD slurry from exposure of underground services will be contained and disposed off-site by a licensed waste contractor.

6.10 Management of surface water

Surface water / rainwater should be managed in accordance with the project CEMP and existing Airport storm water management Procedures.

6.11 Personal protective equipment

Appropriate Occupational Health and Safety measures are to be established by the Main Contractor. The levels of protection and the procedures specified in this section are related to contamination issues only and do not represent an OH&S Plan for the site.

6.12 Excavated soil – tracking requirements

All excavated or disturbed soil is to be tracked from origin to final destination in order to minimise the risk of cross-contamination and to ensure documentation exists, which demonstrate to third parties that materials have been properly managed and disposed of. Soil tracking systems will be defined in the Project CEMP.

6.13 Transport of soils across site boundaries

No off-site disposal of PFAS containing material is likely to occur as part of the Project. Details for off-site disposal of PFAS containing material, if required, are provided in Section 5.5.

6.14 Temporary stockpiling

Temporary stockpiling of PFAS impacted soils is not anticipated during the project. Temporary stockpiling refers to the case where material is stockpiled on-site in an temporary location awaiting movement to final storage locations. Should temporary stockpiling occur, the following should be considered:

- Locate stockpiles away from drainage lines and at least thirty metres (30 m) from waterways. Avoid locating stockpiles adjacent to, or in close proximity to, site boundaries.
- Stockpiles should be located within the project area and as close to the excavation as practicable.
- Stockpiles shall not be greater than 2 m in height.
- Stockpiles should be shaped to for a rounded crest with continuous side slopes not exceeding 1V:3H

- Stockpiles should be covered with minimum 0.25 mm LDPE sheeting or a similarly material and constructed to an appropriate level of construction quality assurance (CQA). It is noted that covering may pose a visual and / or physical hazard due to reflected light or dislodgement from wind. These factors should be considered when selecting material and anchoring methods. Consideration should be given to the following:
  - Overlaps and / or welds must be formed in a consistent direction (allowing run-off).
  - Covers must extend a minimum of 0.5 m from the toe of the stockpiles and be secured via anchoring to surrounding soils or a similarly effective method.
  - Potential degradation from exposure to the sun (UV radiation).
- Stockpiles are to be demarcated and barricaded, to prevent accidental re-use or exposure.
- Circle stockpiles with silt fences (or other appropriate bunding).
- Maintain a log of stockpile locations, their origins and contamination classification.
- Stockpiles and covers should be inspected on a weekly basis and after any adverse weather events (such as rain, wind).

6.15 Emergency / contingency plans

6.15.1 Emergency contacts

Emergency contacts and roles are provided below in Table 6 1. Incident management and emergency response procedures are detailed in Section 9 of the project EMS, and under incident management and emergency response procedures in the project CEMP.

Table 6 1: Emergency contacts

Managing Contractor		Melbourne Airport	
Role	**Contact**	**Role**	**Contact number**
		ACC Melbourne Airport Coordination Center: 03 9297 1601	
Construction Manager	TBC	APAM Environmental Manager	Nick Walker: 03 8326 3033
Project Director	TBC	Airport Interface Manager	Peter Gaukrodger: 0499 789 977
Environmental Manager	TBC	Senior Project Manager	Ben Torwick: 0425 785 256
Site Manager	TBC	APAM Environmental Representative	Amelia Donato: 0438 531 392
Regional Environmental Manager	TBC	Development Manager	Kevin McFarlane: 03 9297 1134

Unexpected conditions relevant this PFAS Management Plan that could feasibly occur at the site include:

- Increased volumes of contaminated material.
- Uncovering presently unknown types of contamination.
- Identification of Material exceeding total concentrations of PFOS, PFOA or PFHxS in exceedance of 50 mg/kg.

Procedures and allowances that will be used to address these contingencies are provided in the following sections.

6.15.2 Increased volumes of contaminated material

Throughout the project, the quantity of materials encountered will be monitored as part of the materials tracking system. In the case of a significant increase in the estimated volume of material to be excavated and stockpiled, a review of the re-use strategy will be led by the APAM Environmental Manager and MC Environmental Manager.

6.15.3 Unknown types of material

The presence of unknown or suspicious materials would be highlighted during works by the observation of any unusual physical or sensory characteristics of the materials encountered.

In the event that any significant unknown type of material is identified during the Project, an assessment of the impact of the material on the works would be undertaken by the Environmental Representative.

If evidence suggests that the level and extent of PFAS impacts is significantly greater than assumed, including the potential for contamination to impact local groundwater, further investigation will be performed to determine its extent.

6.15.4 Material exceeding total concentrations of PFOS, PFOA or PFHxS in exceedance of 50 mg/kg

In accordance with the PFAS NEMP, material for which concentrations of PFOS, PFOA or PFHxS exceed 50 mg / kg cannot be considered for on-site reuse nor disposal to landfill. Should such material be identified, off-site treatment will be required to reduce concentrations to below 50 mg/kg, after which material can be assessed for disposal to landfill. All transport of such material off-site would require approval from the Victorian EPA.

Note: the highest concentration of total PFAS encountered within the project area to date was 0.032 mg/kg for PFOS.

7. Monitoring, reporting, audit and review

7.1 Monitoring strategy

7.1.1 Soil

A validation process will be carried out by the nominated Environmental Representative, to demonstrate that the site works have complied with the requirements of the PFAS Management Plan. This will be undertaken in accordance with Section Nine of the Project EMS and the monitoring procedures detailed in the Project CEMP. Monitoring requirements relevant to the management of material potentially containing PFAS will include:

- Additional testing of soil, concrete and bitumen in the project area will be conducted to provide further delineation of Category 1 and Category 2 impacted material prior to construction. This testing will extend to the depth of excavation across the project.
- The excavation method detailed in section 6.2 shall be observed and relevant records provided to the Environmental Representative.
- A visual record (e.g. photographs) of material being excavated and stockpiled will be maintained.
- The MC is to provide soil tracking documentation to the Environmental Representative (source and place of deposition).
- A survey of the excavated areas will be undertaken by the MC, with survey information provided to the Environmental Representative – this will provide information on the total estimated volume of material excavated.
- Periodic monitoring of engineered stockpiles (Category 2 storage) will be undertaken, to ensure that covers remain in place and impermeable. Stockpile covers will be checked visually for cracks, tears and punctures on a regular basis. Any damaged areas should be repaired using a similar material to maintain the permeability of the cover. Depending on the material selected, repairs may require heat sealing and hydration in order to set patch material.
- Ongoing management of stockpiled material will include capture of stormwater runoff (and leachate) from stockpiling areas within the temporary spoil storage facility. Runoff will be fed via above ground drainage infrastructure to a storage area for testing and treatment (if required). Testing of leachate and stormwater runoff will be conducted in accordance with the PFAS NEMP.
- Soil testing to assess the condition of the storage area after such time that the stockpiles have been reused in future airport projects. Should this testing identify any increase in PFAS contamination compared to the baseline site conditions, then the assessment will be extended beyond the storage area to delineate identified contamination as required. Soil testing beyond the storage area will also be conducted in response to a spill or other incident that results in potential impact to land outside of the storage area. Soil testing will be conducted in accordance with the following:
  - Airports (Environment Protection) Regulations 1997
  - National Environment Protection (Assessment of Site Contamination) Measure 1999
  - PFAS National Environmental Management Plan
  - any other applicable legislation or guidance at that point in time.

7.1.2 Surface water

Quarterly surface water monitoring will be undertaken during construction and operation in line with APAM's airport-wide ongoing monitoring program. This will include the extended PFAS suite (28 compounds).

Surface water monitoring locations and baseline water quality data are shown in Figure 8. The monitoring network is considered sufficient to capture up-gradient river locations, discharge point sites and downstream sites.

Surface water sampling will be conducted in accordance with:

- Airports (Environment Protection) Regulations 1997
- National Environment Protection (Assessment of Site Contamination) Measure 1999

- EPA Victoria, Sampling and Analysis of Waters, Wastewaters, Soils and Wastes, Publication 701, June 2009
- AS/NZ 5667.1:1998 Water Quality – Sampling. Part 6: Guidance on the design of sampling programs, sampling techniques and the preservation and handling samples
- AS/NZ 5667.6:1998 Water Quality – Sampling. Part 6: Guidance on sampling of rivers and streams
- HEPA, PFAS National Environmental Management Plan, January 2018.

Annual stream health monitoring in Arundel Creek, Deep Creek and Moonee Ponds Creek will also continue during construction and operation in accordance with the EPA Publication 604.1 'Guideline for Environmental Management – Rapid Bioassessment Methodology for Rivers and Streams' (EPA Victoria, 2003). The results from this monitoring will be compared to previous baseline results to determine if any impacts (positive or negative) are occurring due to the project. These results are quantifiable and directly comparable to the previous decade of monitoring data.

Surface water monitoring results will be evaluated against baseline data after each monitoring event. If a statistically significant increase in PFAS concentrations or a decline in stream health is observed at surface water monitoring locations downstream of the project site, then the following actions will be undertaken:

- Assess whether the increasing trend is because of seasonal fluctuations or other anomalies (e.g. sediment loads in samples, varying sampling depths etc.).
- Determine if a verification-sampling event of selected locations is required to assess potential extent.
- Determine if more frequent sampling is required.
- Investigate site operational practices and the integrity of any relevant water quality management infrastructure to determine potential source.
- Determine if any additional management measures are required.
- Include details of the exceedance and outcome of the above actions as part of routine environmental performance reporting.

7.1.3 Groundwater

Annual groundwater monitoring will be undertaken during construction and operation in line with APAM's ongoing monitoring program. This will include the extended PFAS suite (28 compounds).

Groundwater monitoring locations and baseline groundwater quality data are shown in Figure 9. The monitoring network is considered sufficient to capture up-gradient and down-gradient sites, key potential sources of PFAS as well as the condition of groundwater at the boundary of the airport.

Groundwater sampling will be conducted in accordance with:

- Airports (Environment Protection) Regulations 1997
- National Environment Protection (Assessment of Site Contamination) Measure 1999
- EPA Victoria, Sampling and Analysis of Waters, Wastewaters, Soils and Wastes, Publication 701, June 2009
- EPA Victoria, Groundwater Sampling Guidelines, Publication 669, April 2000
- National Environment Protection (Assessment of Site Contamination) Measure 1999
- HEPA, PFAS National Environmental Management Plan, January 2018.

Groundwater monitoring results will be evaluated against baseline data after each annual monitoring event. If a statistically significant change in PFAS concentrations is observed at groundwater monitoring locations down-gradient of the project site, then the following actions will be undertaken:

- Compare the results to historical trends in the same groundwater monitoring well and evaluated the trend at this location and locations near the exceedance.
- Assess whether the trend is because of seasonal fluctuations or other anomalies (e.g. sediment loads in samples, varying sampling depths etc).

- Determine if a verification-sampling event of selected wells or more frequent monitoring is required.
- Investigate site operational practices and the integrity of any relevant water quality management infrastructure to determine potential source.
- Determine if any additional management measures are required.
- Include details of the exceedance and outcome of the above actions as part of routine environmental performance reporting.

7.1.4 Summary

A summary of the proposed monitoring strategy is outlined in Table 7 1 below.

Table 7 1: Summary of PFAS monitoring strategy

Monitoring Type	Details	Frequency of Monitoring	Timing
Soil	Additional testing of soil, concrete and bitumen in the project area	As required	Prior to and/or during construction
	Observation and recording of excavation methods	During each excavation activity	During construction
	Visual records (e.g. photographs) of material being excavated and stockpiled	During each excavation activity	During construction
	Tracking of soil movements	As required	During construction
	Survey of excavated areas to provide estimated volumes	At the completion of excavation works	During construction
	Monitoring the integrity of engineered stockpile covers for Category 2 material	Weekly Before / after significant weather events	During construction and operation
	Soil testing to assess the condition of the stockpile area after the stockpiles have been removed for reuse	After the stockpiles have been removed	During operation
Surface Water	Monitoring for PFAS extended suite (28 compounds), in line with APAM's airport-wide ongoing monitoring program	Quarterly	During construction and operation
	Stream health monitoring in Arundel Creek, Deep Creek and Moonee Ponds Creek	Annual	During construction and operation
Groundwater	Monitoring for PFAS extended suite (28 compounds), in line with APAM's airport-wide ongoing monitoring program	Annual	During construction and operation

7.2 Reporting

Reporting will be conducted in accordance with the Section 8 of the project EMS, and will include:

- Environmental inspections will be conducted on no less than a weekly basis – formal reporting of these inspections will be limited to circumstances where environmental incidents or issues are observed.
- Reporting of all non-conformances and environmental incidents will occur via the Contractor's incident Reporting System.
- Monthly Environmental Reporting.
- Quarterly reporting of Environmental Statistics.

- Final location and condition of all PFAS impacted material upon project completion.

7.3 Audits

Audits of the application of this PFAS management plan and CEMP will be undertaken in accordance with Section 8 of the project EMS and are the responsibility of the MC Environmental Manager. External audits may be undertaken by APAM throughout the life of the project.

7.4 PFAS Management Plan Review

The PFAS Management Plan will be reviewed on an annual basis as a minimum and in accordance with the project EMS. Reviews will serve to assess whether the plan is meeting its objectives in accordance with conditions of Approval Notice 2016/7837, detailed in Appendix A of this document. Other triggers for review of the document include:

- Changes to relevant legislation.
- Changes to project scope.
- Significant environmental incident or non-conformance.
- Identification of potential improvements to the PFAS Management Plan.
- Identification through monitoring and reporting of potential issues with PFAS management procedures.

Review outcomes should be documented in monthly reporting structures, as detailed in Section 7.2, and Section 8 of the project EMS.

As per EPBC approval condition 6-e (see Appendix A, Table A.1), review procedures are commensurate to the risk posed by PFAS impacts at the Site.

8. References

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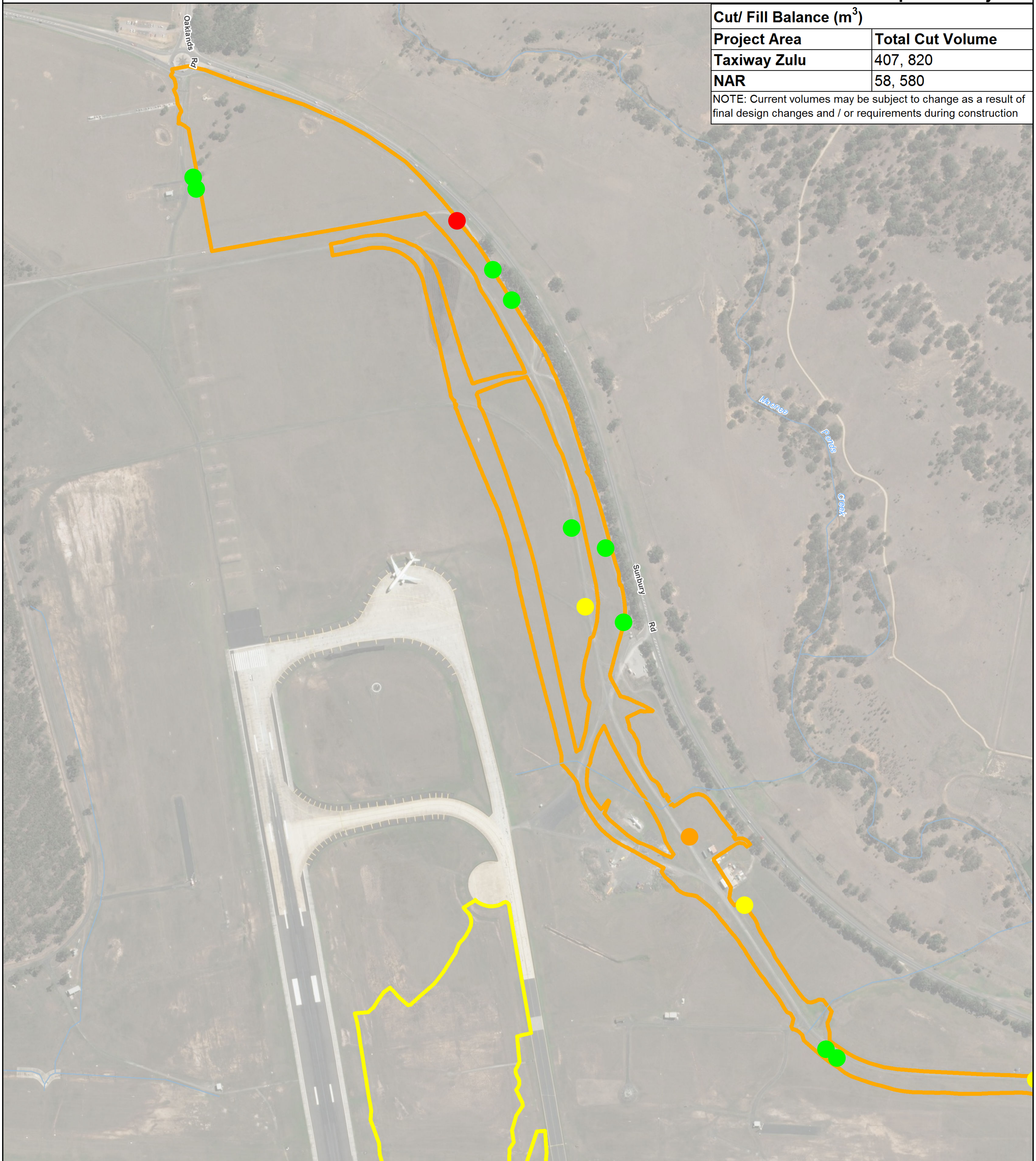
Figures

Figure 1: Total PFAS concentrations

Taxiway Zulu and Northern Compound Project

Cut/ Fill Balance (m^3)	
Project Area	**Total Cut Volume**
Taxiway Zulu	407, 820
NAR	58, 580

NOTE: Current volumes may be subject to change as a result of final design changes and / or requirements during construction



Legend

- Zulu Boundary
- NAR Boundary
- Watercourse

PFAS Concentration

PFOS

- non-detect (<0.005 mg/kg)
- 0.005-0.014 mg/kg
- 0.015-0.029 mg/kg
- 0.030-0.032 mg/kg

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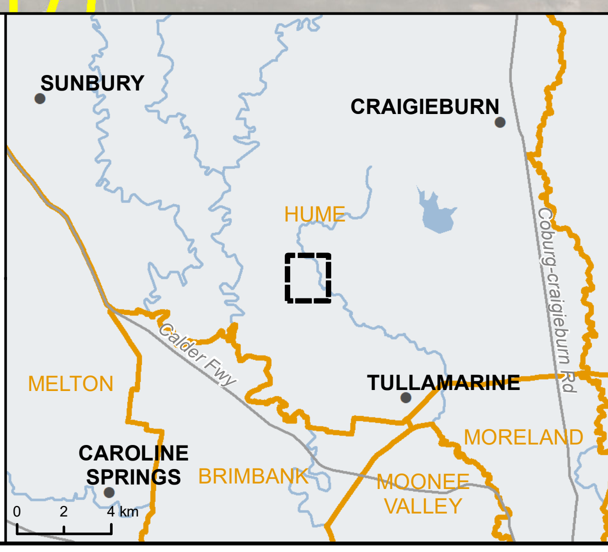

N

IS272300

GDA 1994 MGA Zone 55

0 100 200 metres

DATA SOURCES
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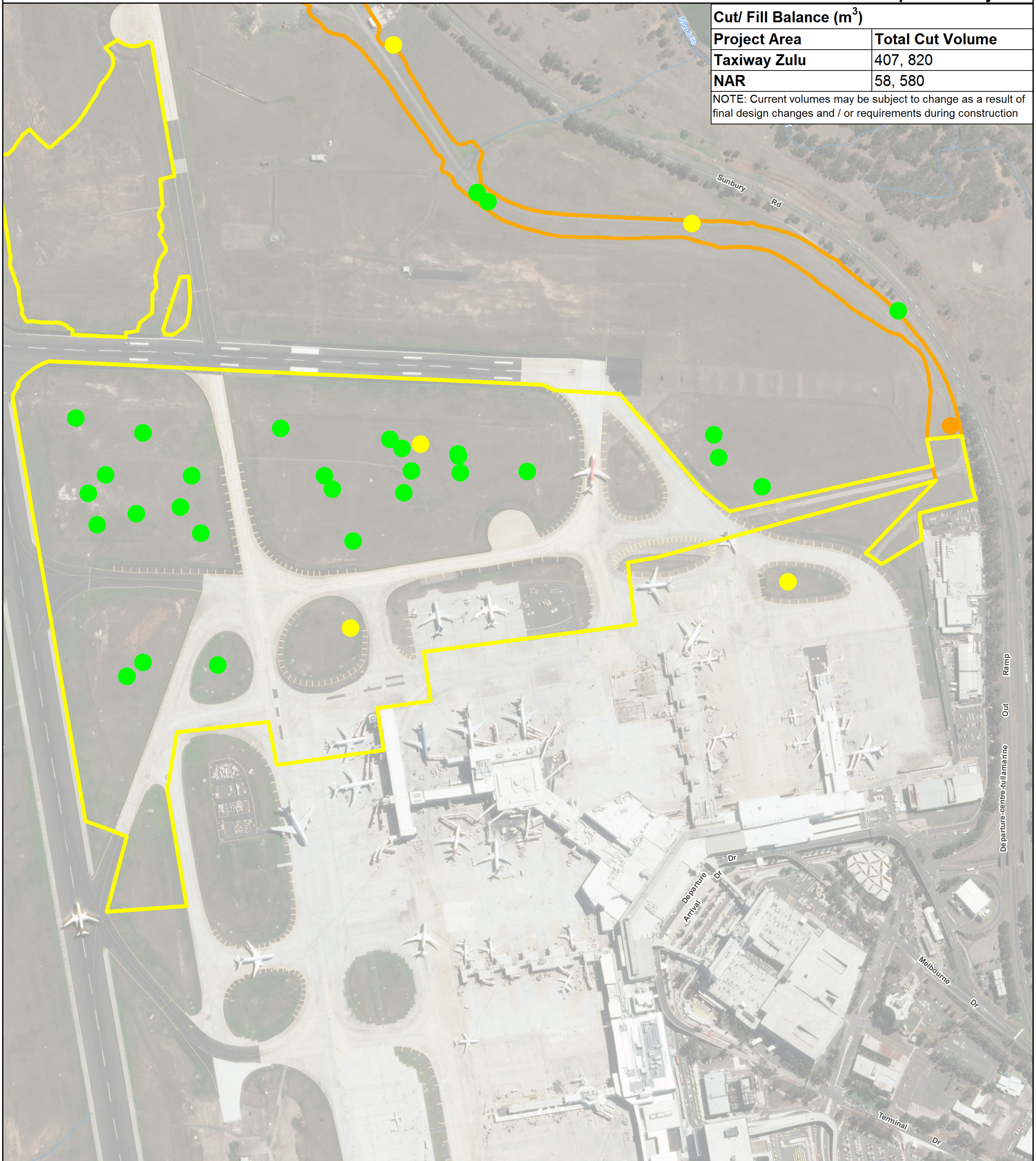
Figure 1: Total PFAS concentrations

Taxiway Zulu and Northern Compound Project



Cut/ Fill Balance (m^3)	
Project Area	**Total Cut Volume**
Taxiway Zulu	407, 820
NAR	58, 580

NOTE: Current volumes may be subject to change as a result of final design changes and / or requirements during construction

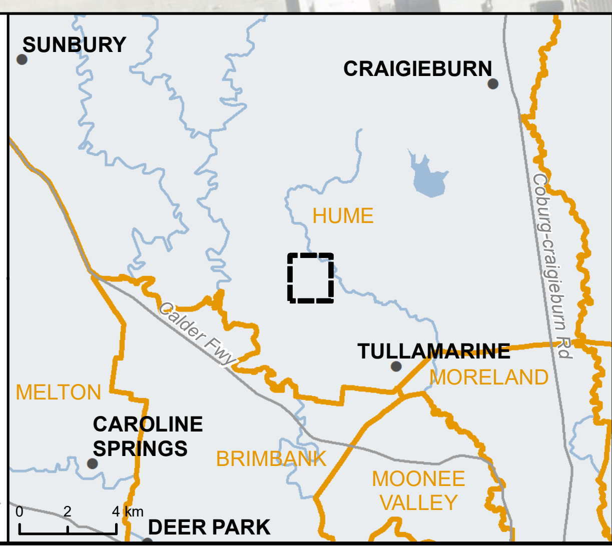
Legend

- Zulu Boundary
- NAR Boundary
- Watercourse

PFAS Concentration

PFOS

- non-detect (<0.005 mg/kg)
- 0.005-0.014 mg/kg
- 0.015-0.029 mg/kg



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0 100 200 metres

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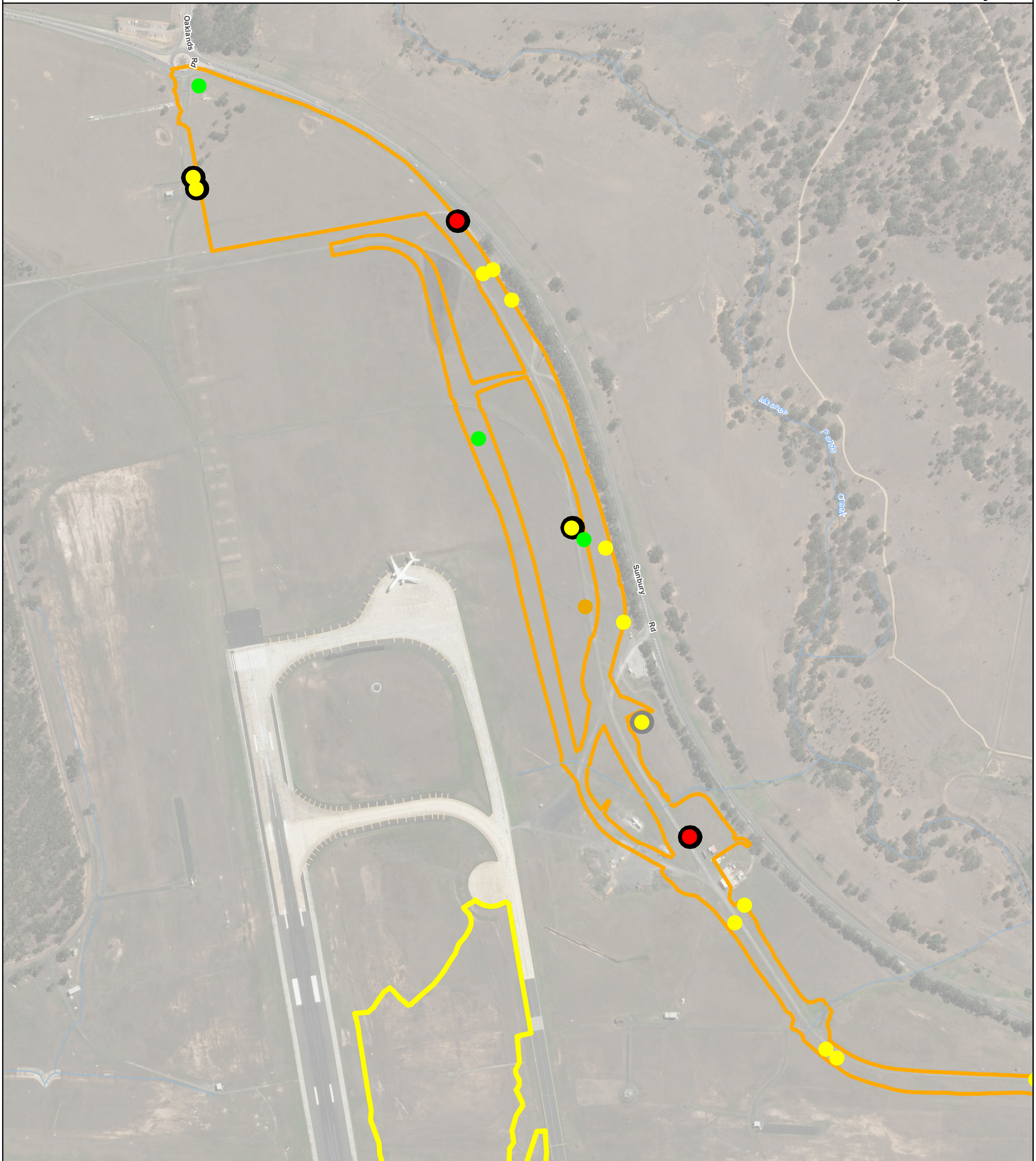


Legend

- Zulu Boundary
- NAR Boundary

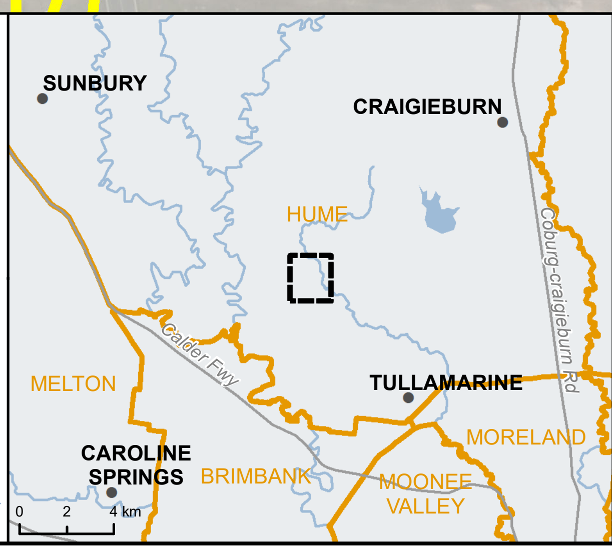
PFAS Concentration

PFOS
- non-detect (<0.01 ug/L)
- 0.01-19 ug/L
- 20-39 ug/L
- 40-59 ug/L
- 60-79 ug/L
- 85 ug/L

PFOA
- 0.01-0.02 ug/L

PFHxS
- 0.01-0.13 ug/L

- Watercourse



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IS272300

GDA 1994 MGA Zone 55

0 100 200
metres

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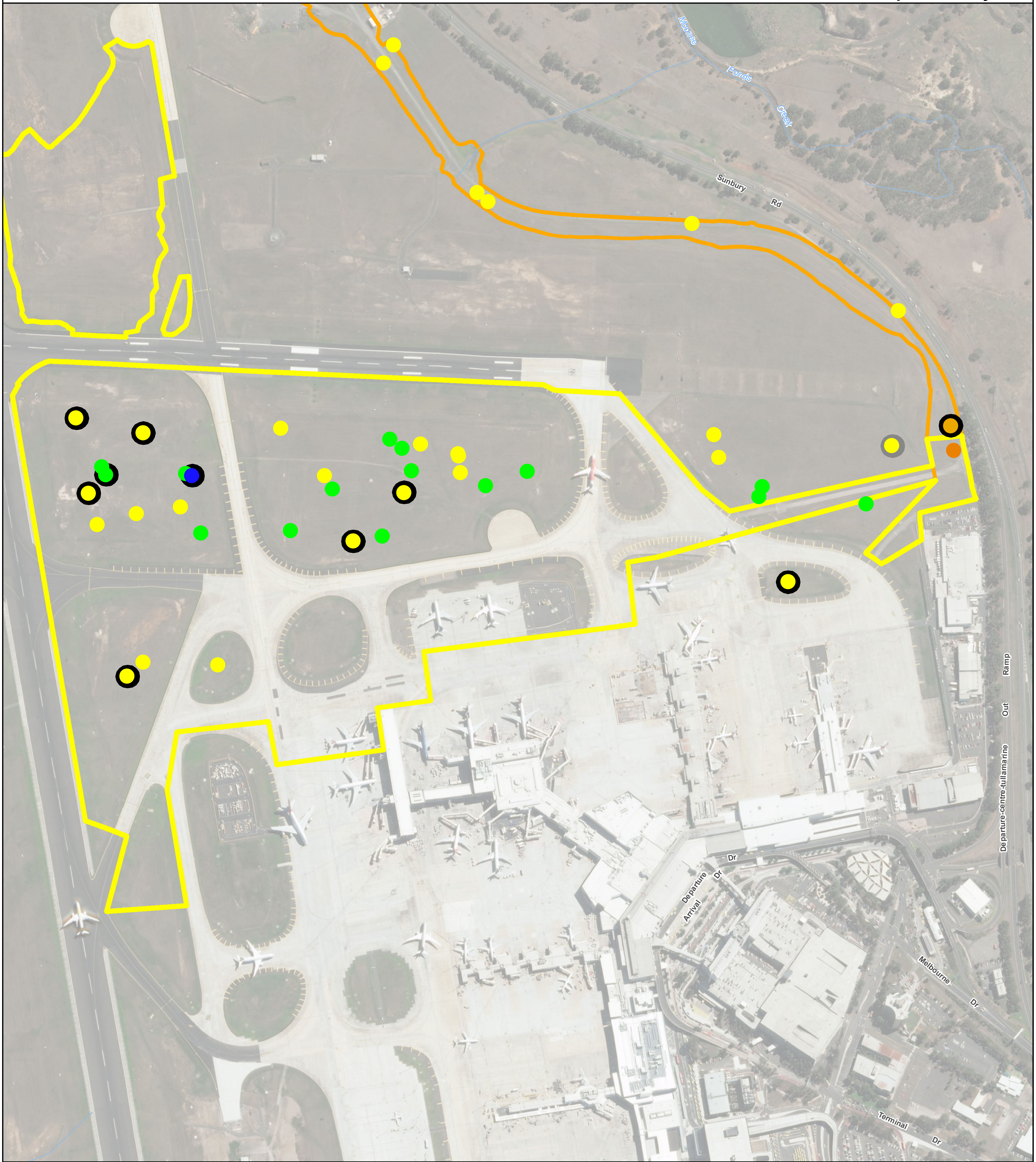
Figure 2: Leachable PFAS concentrations

Taxiway Zulu and Northern Compound Project



Legend

- Zulu Boundary
- NAR Boundary

PFAS Concentration

PFOS

- non-detect (<0.01 ug/L)
- 0.01-19 ug/L
- 20-39 ug/L
- 40-59 ug/L
- 60-79 ug/L
- 85 ug/L

PFOA

- 0.01-0.02 ug/L

PFHxS

- 0.01-0.13 ug/L
- Watercourse

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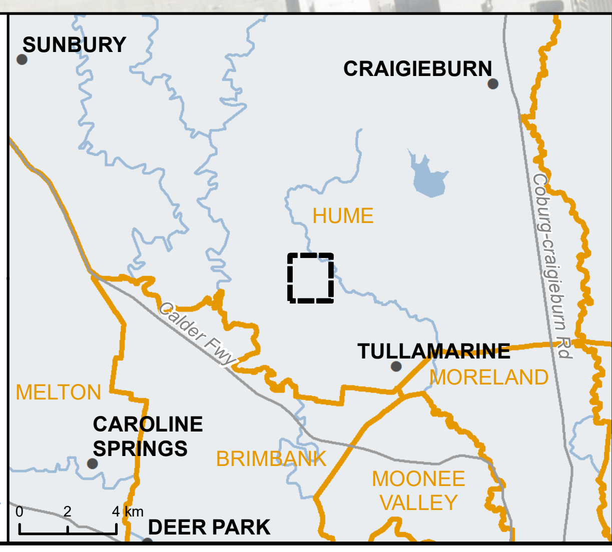

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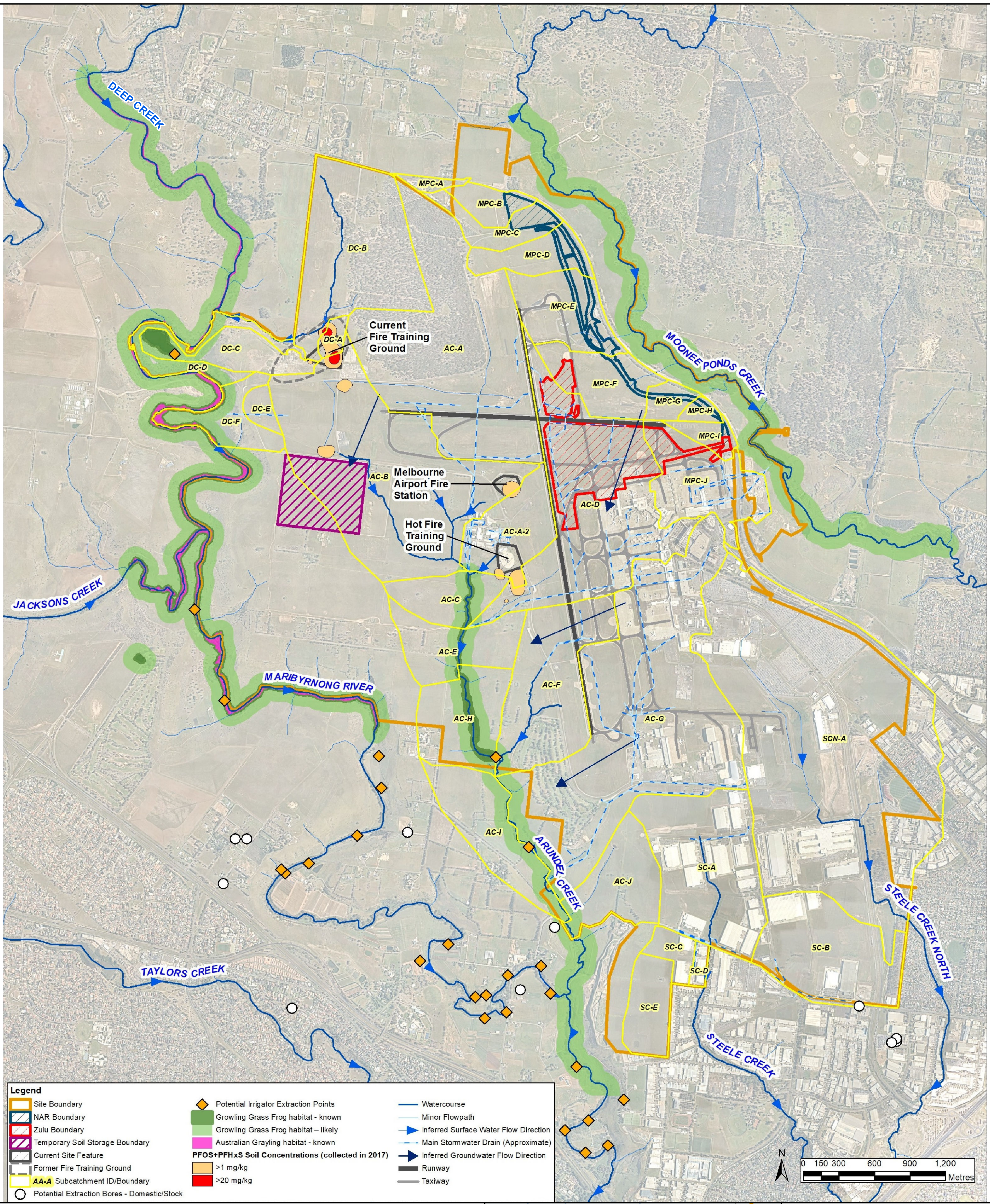

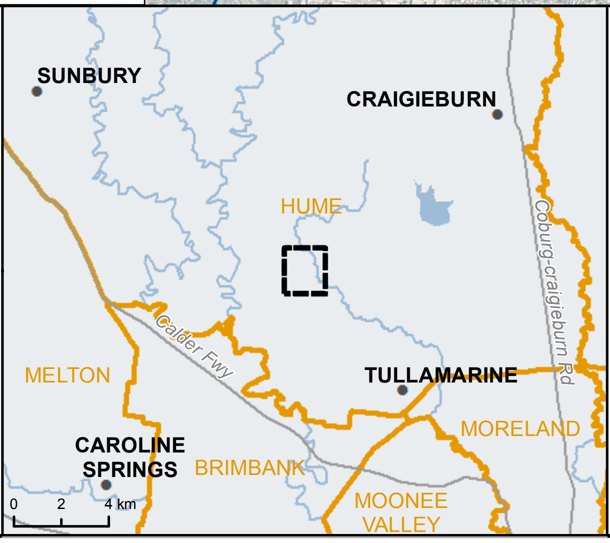

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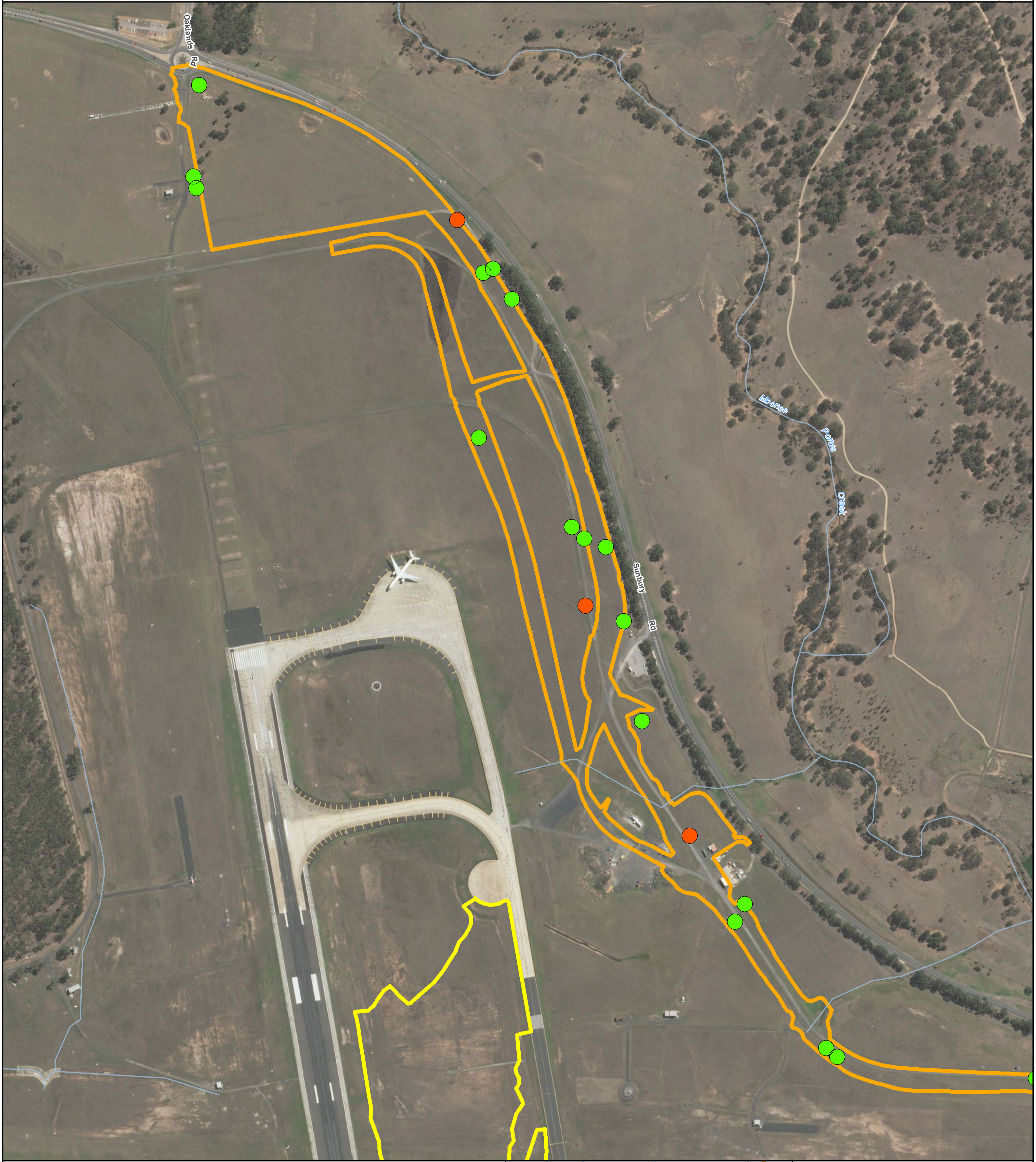
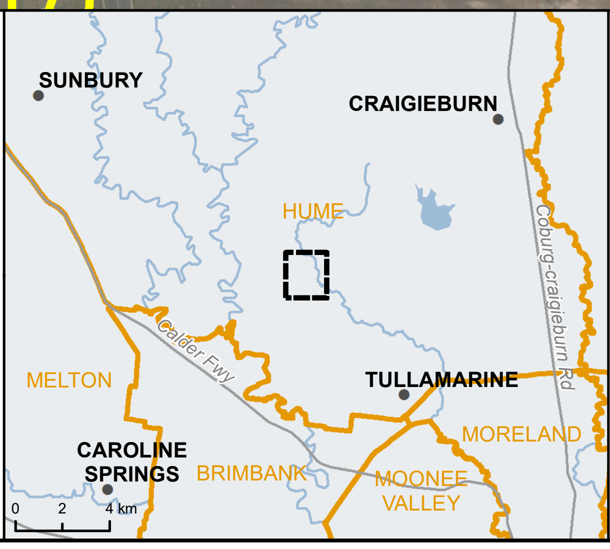
Taxiway Zulu and Northern Compound Project





Legend

- NAR Boundary
- Zulu Boundary
- Temporary Spoil Storage Area
- Watercourse

Sample location results *(22/10/2018)*

- Category 1
- Category 2

IS272300
GDA 1994 MGA Zone 55

0 100 200 metres

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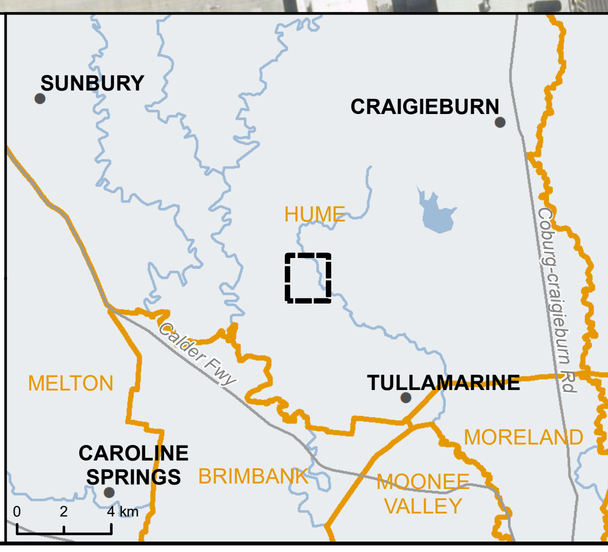
Legend

- NAR Boundary
- Zulu Boundary
- Temporary Spoil Storage Area
- Watercourse

Sample location results *(22/10/2018)*

- Category 1
- Category 2



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N

0 100 200 metres

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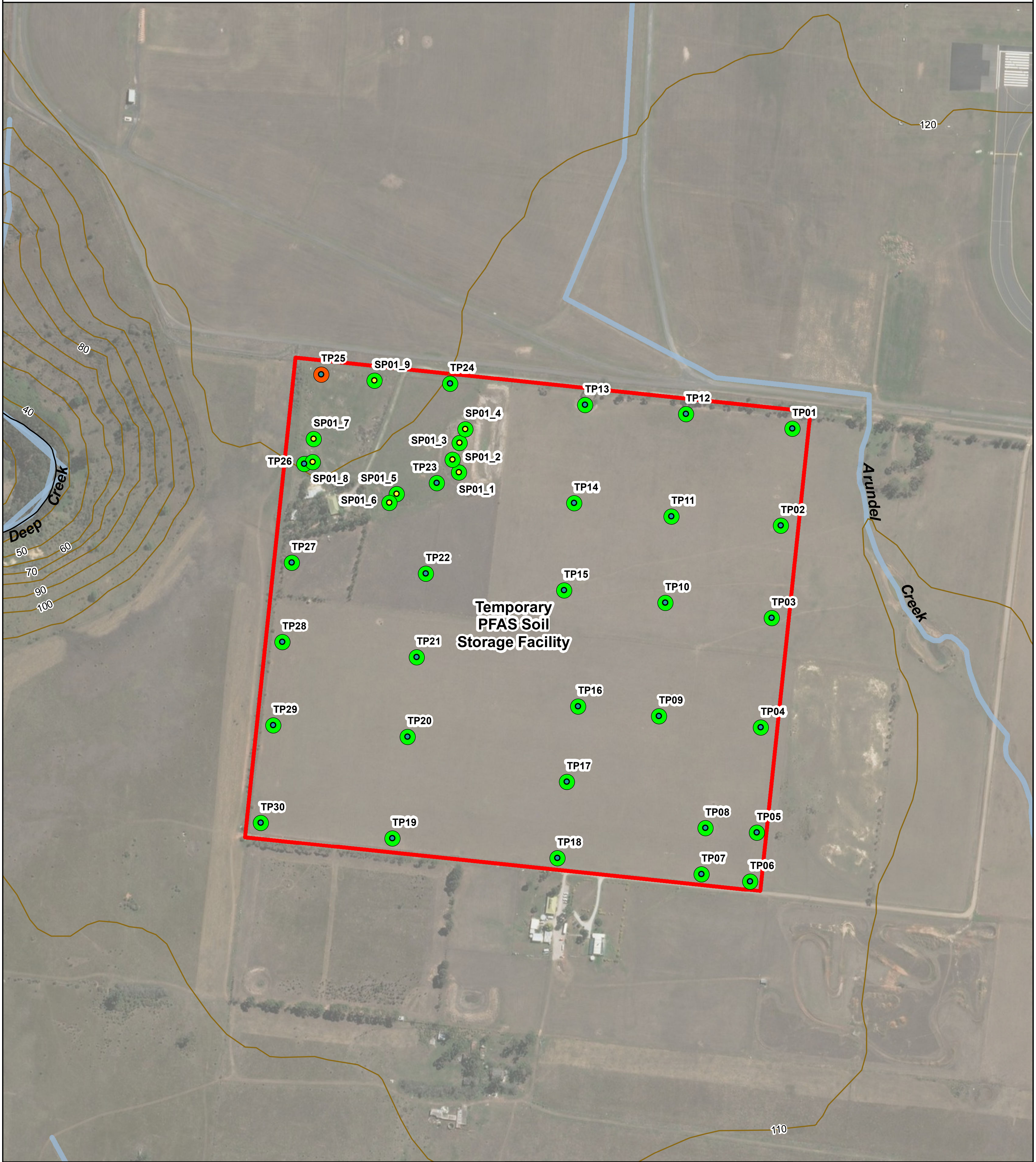
Figure 5a: Results for proposed temporary spoil storage area (shallow)

Taxiway Zulu and Northern Compound Project



Legend

SP Samples (Jacobs, 15/02/2019)

- Stockpile - indicative coordinates
- Test pit
- ≤0.4 µg/L PFOS leachable concentration
- >0.4 µg/L PFOS leachable concentration
- Temporary PFAS Soil Storage Facility
- Melbourne Airport Boundary
- Contours (10m)
- Watercourse

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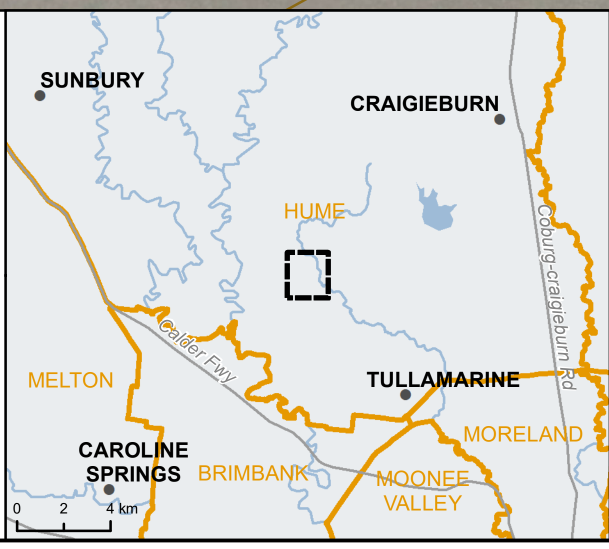

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IS272300

GDA 1994 MGA Zone 55

0 100 200

Metres

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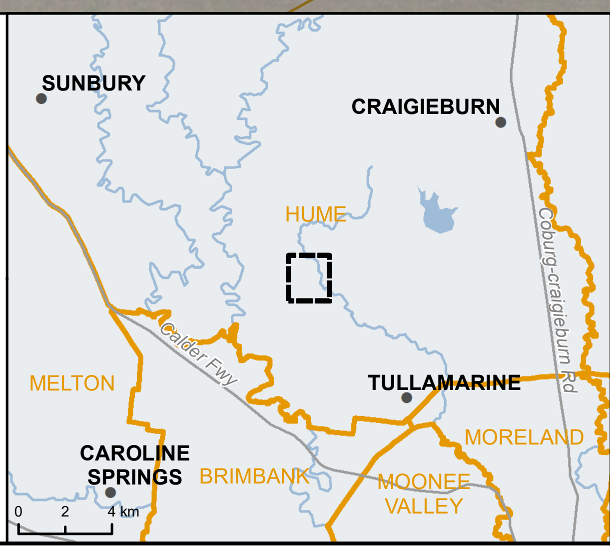
Figure 5b: Results for proposed temporary spoil storage area (deep)

Taxiway Zulu and Northern Compound Project

Legend

SP Samples (Jacobs, 15/02/2019)

- Test pit
- ≤0.4 µg/L PFOS leachable concentration
- Temporary PFAS Soil Storage Facility
- Melbourne Airport Boundary
- Contours (10m)
- Watercourse



IS272300

GDA 1994 MGA Zone 55

0 100 200 Metres

DATA SOURCES
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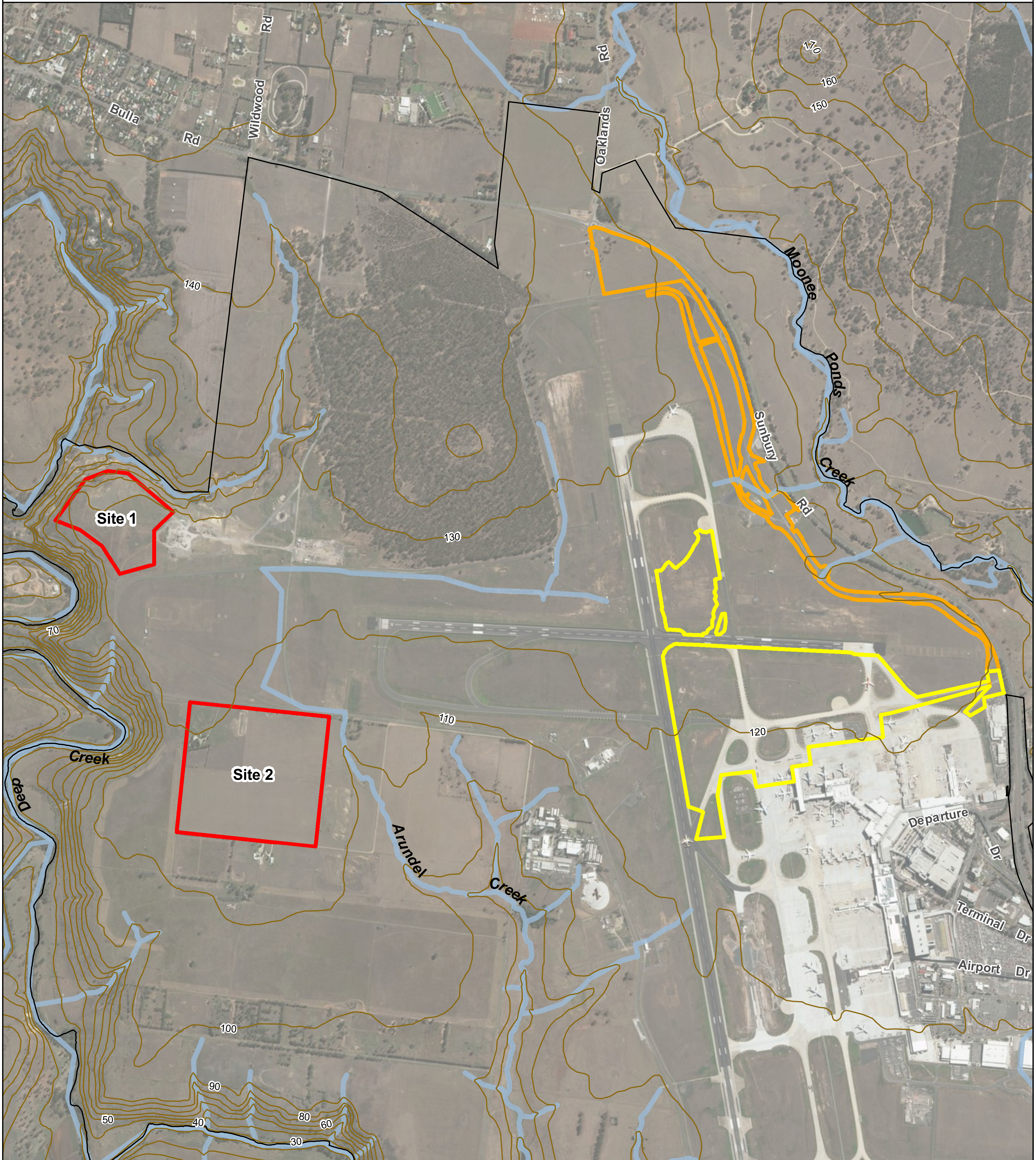
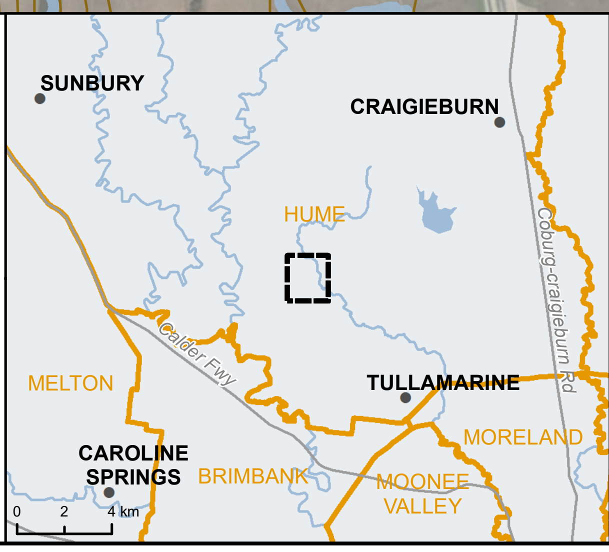
Figure 6: Temporary spoil storage area - siting options

Taxiway Zulu and Northern Compound Project



Legend

- NAR Boundary
- Zulu Boundary
- Site 2
- Melbourne Airport Boundary
- Contours (10m)
- Watercourse



N

IS272300

GDA 1994 MGA Zone 55

0 0.5 1

Kilometres

DATA SOURCES
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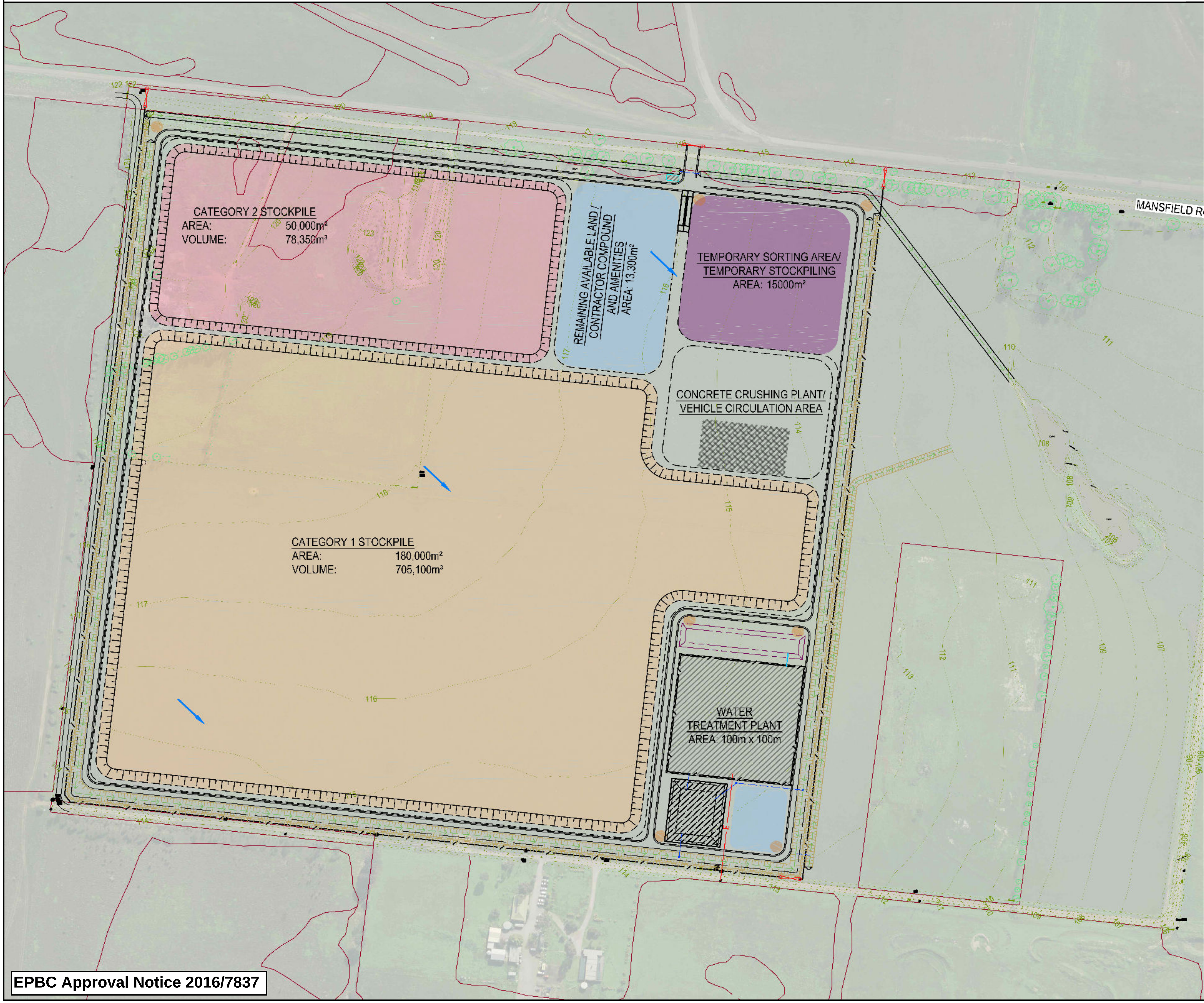
Figure 7: Draft plan for temporary spoil storage area

Taxiway Zulu and Northern Compound Project



N

IS272300

GDA 1994 MGA Zone 55

0 100 200

Meters

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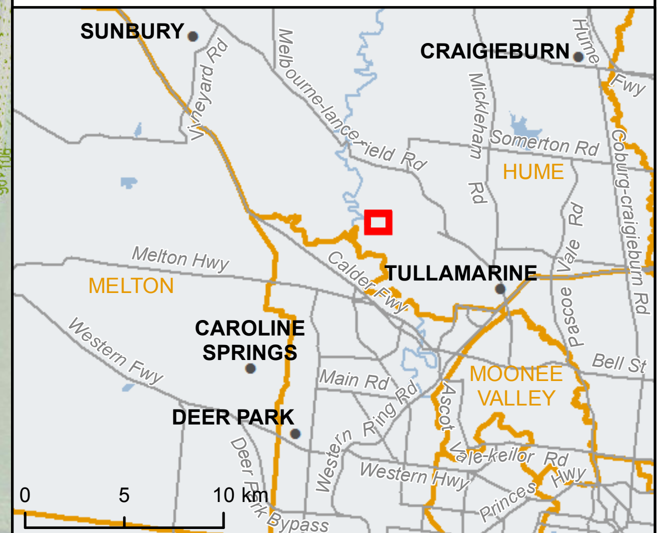

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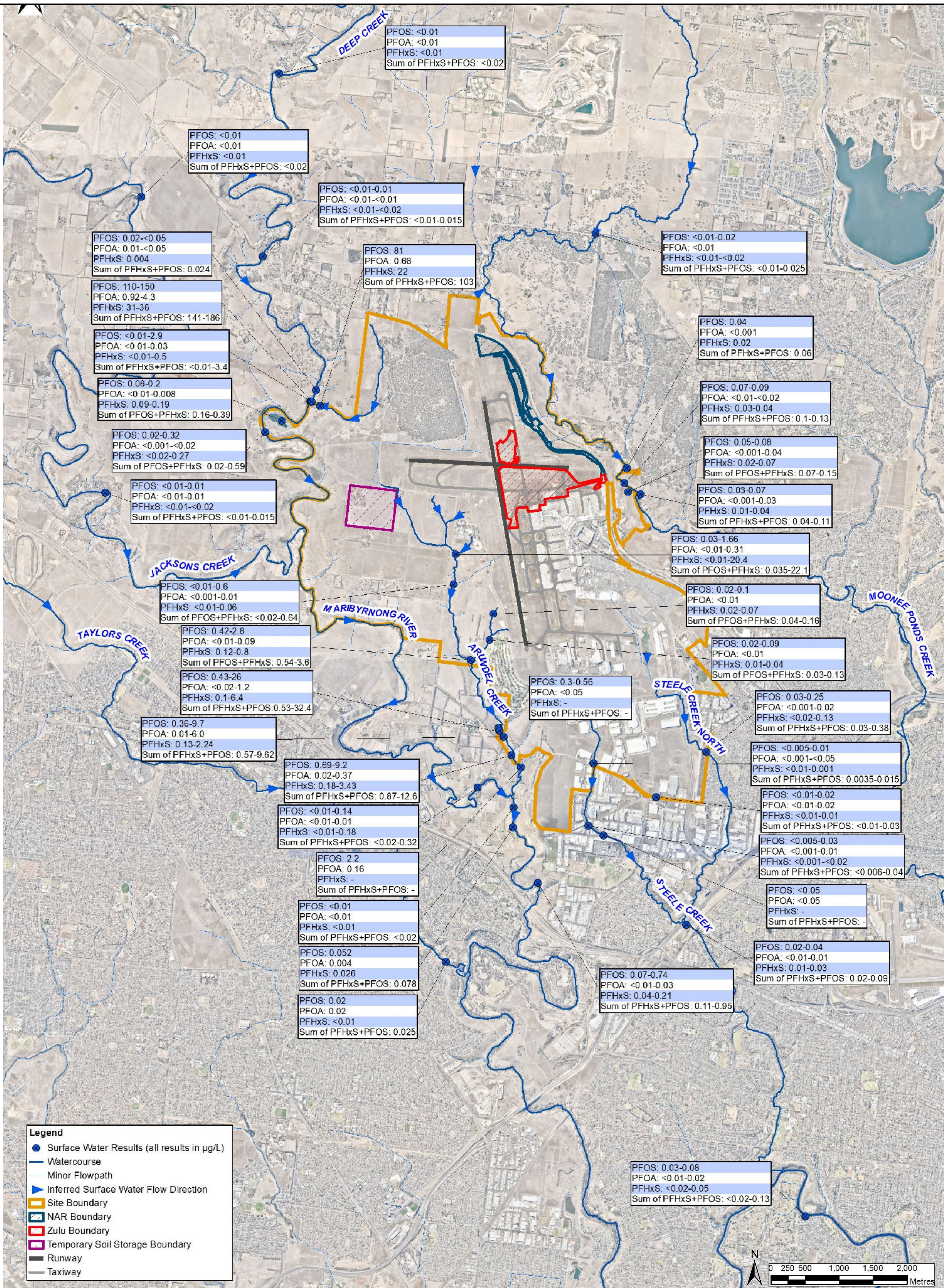
Figure 8: Surface water monitoring points

Taxiway Zulu and Northern Compound Project



Includes data until January 2018

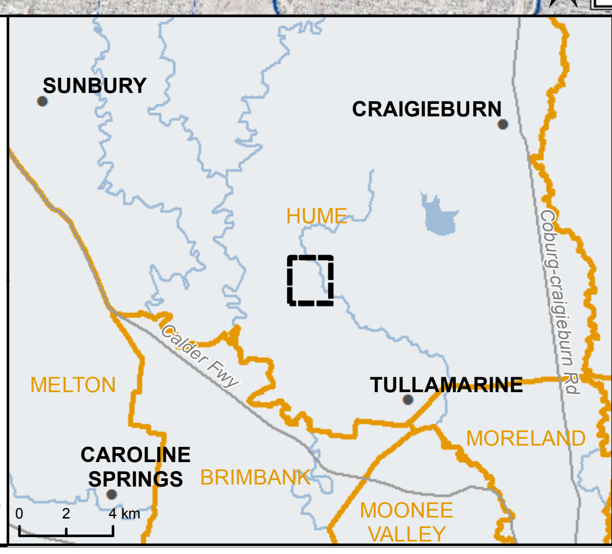


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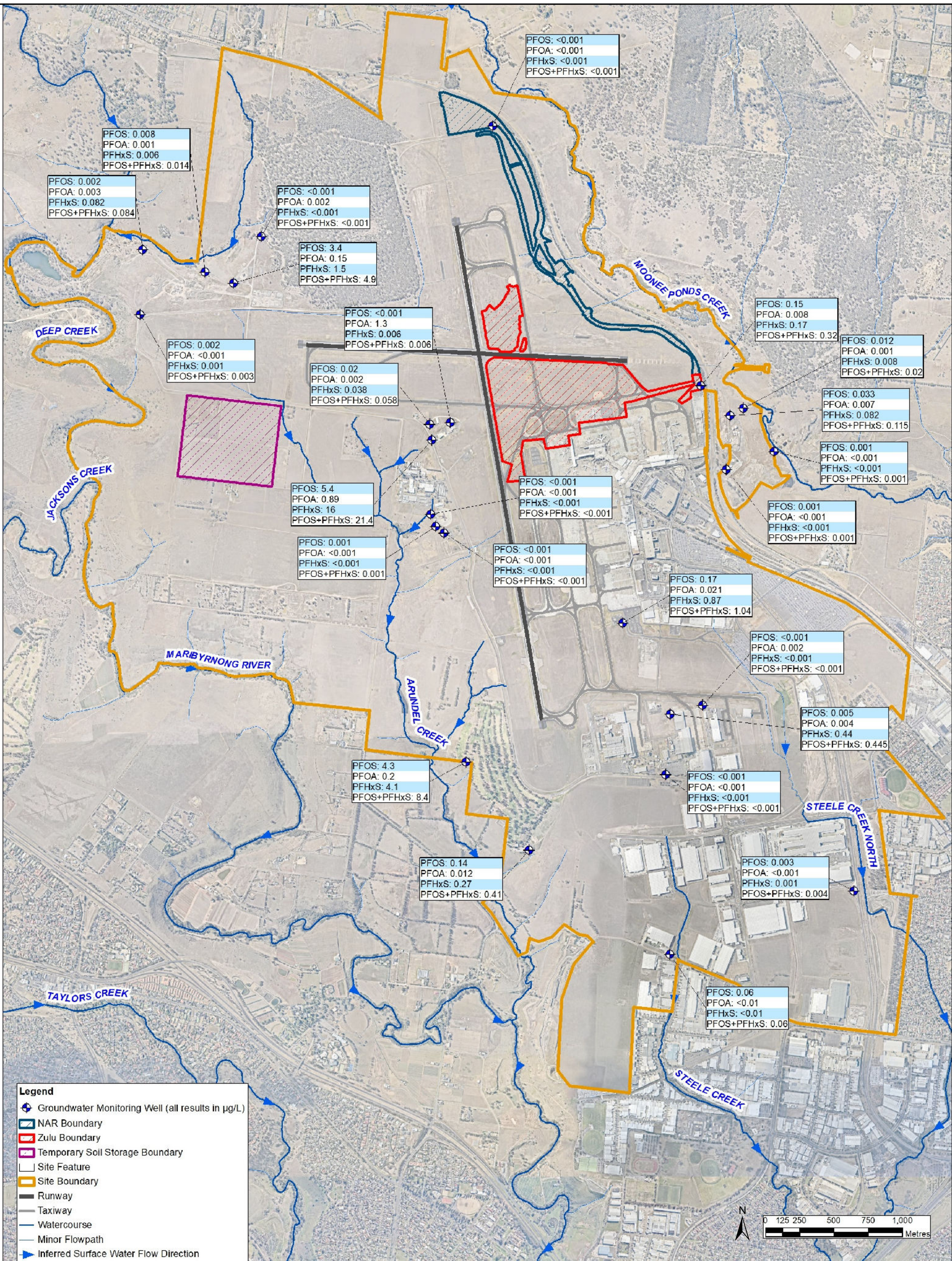
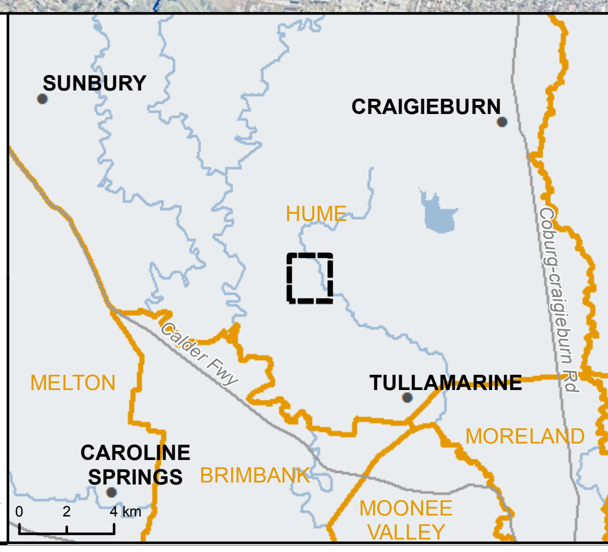
Figure 9: Groundwater monitoring points

Zulu and Northern Access Route



Includes 2017 data



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Important note about your report

This Report (PFAS Environmental Management Plan) has been prepared by Jacobs for the sole use of Melbourne Airport ("the Client") and in accordance with the scope of services defined at the request of the Client.

Undertaking an assessment or study of the on-site conditions may reduce the potential for exposure to the presence of contaminated or inadequate bearing land, sediment, surface water or groundwater. All reports and conclusions that deal with sub-surface conditions are based on interpretation and judgement and as a result have uncertainty attached to them. You should be aware that this report contains interpretations and conclusions which are uncertain, due to the nature of the investigations. No study can completely eliminate risk, and even a rigorous assessment and/or sampling program may not detect all problem areas within a site. The following information sets out the limitations of the Report.

This Report should only be presented in full and should not be used to support any objective other than those detailed within the Agreement. In particular, the Report does not contain sufficient information to enable it to be used for any use other than the project specific requirements for which the Report was carried out, which are detailed in our Agreement. Jacobs accepts no liability to the Client for any loss and / or damage incurred as a result of changes to the usage, size, design, layout, location or any other material change to the intended purpose contemplated under this Agreement.

It is imperative to note that the Report only considers the site conditions current at the time of investigation, and to be aware that conditions may have changed due to natural forces and/or operations on or near the site. Any decisions based on the findings of the Report must take into account any subsequent changes in site conditions and/or developments in legislative and regulatory requirements. Jacobs accepts no liability to the Client for any loss and/or damage incurred as a result of a change in the site conditions and / or regulatory/legislative framework since the date of the Report.

The Report is based on an interpretation of factual information available and the professional opinion and judgement of Jacobs. Unless stated to the contrary, Jacobs has not verified the accuracy or completeness of any information received from the Client or a third party during the performance of the services under the Agreement, and Jacobs accepts no liability to the Client for any loss and/or damage incurred as a result of any inaccurate or incomplete information.

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Appendix A. Approvals and compliance

Table A.1 below details approval conditions as per Approval Notice 2016/7837.

Table A.1: Approvals and EMP compliance

Approval Conditions				Compliance assessment		Key commitments
Section	**Detail**	**Sub-Section**	**Detail**	**Compliant**	**EMP Sections**	
5	The approval holder must submit a PFAS Management Plan for the Minister's approval prior to the commencement of the action. The PFAS Management Plan must be prepared by a suitably qualified expert. Commencement of the action may not occur until the PFAS Management Plan has been approved by the Minister in writing. The approved plan must be implemented. The PFAS Management Plan must include but not be limited to:	**A**	Identification of the extent and concentrations of possible contamination within the project footprint	ü	4.2.3	-A conceptual site model has been prepared using data collected during three intrusive soil investigations (Jacobs 2014, 2015 and 2016). The model considers existing PFAS concentrations in soils to be excavated, potential pathways and exposure mechanisms, along with human and ecological receptors. -The CSM has been used to inform a Site and Project specific risk assessment of potential source – pathway – receptor linkages, which is summarised schematically in Section 4.5. -Management strategies have been determined on the basis of risks identified via the process summarised above and include a site specific risk assessment of designated material storage areas. Management requirements have been developed in accordance with the EPBC Environmental Management Plan Guidelines, the Project Environmental Management Strategy (EMS) and the Construction Environmental Management Plan (CEMP)
		B	Identifications of possible exposure pathways and ecological receptors including from stored material	ü	4.3	
		C	Relevant baseline data for the identified possible exposure pathways and ecological receptors	ü	4.4	
		D	Possible risks tailored to the identified concentrations, pathways and receptors	ü	4.5	
		E	The outline of management strategies, as well as any remediation action plans or strategies, to manage any identified or potential risks.	ü	5 and 6	
6	The PFAS Management Plan, along with the sections of the Construction Environment Management Plan (CEMP) and Operational Environment Management Plan (OEMP) for the proposed action relating to contamination and soils, must be prepared by a suitably qualified	**A** – To be consistent with:				-This PFAS management plan has been developed in accordance with the NEPM and PFAS NEMP – it is noted that the PFAS NEMP had not been finalised at the time of receipt of approval 2016/7837, and compliance with these regulatory and guidance documents is considered adequate to meet approval conditions. -Management measures described in this plan include considerations and provisions for the management of potential PFAS migration via surface and groundwater pathways, including

Approval Conditions				Compliance assessment		Key commitments
Section	**Detail**	**Sub-Section**	**Detail**	**Compliant**	**EMP Sections**	
	expert and must, in relation to management of PFAS:					surface water runoff during rainfall events. Consideration has been given to the potential migration of contaminants within the site and beyond the site boundaries, and management measures are considered appropriate to manage project risks. -Emergency and contingency measures are addressed to account for unexpected finds and excess material, including unexpectedly high concentrations of PFAS. Emergency contacts and procedures are provided in line with the project EMS and CEMP. -Weekly, monthly and quarterly environmental monitoring requirements are laid out and align with APAM environmental management systems, and the project EMS and CEMP. Existing monitoring of on and off-site ground and surface water will continue throughout the life of the project. -Review procedures and triggers for the PFAS Management Plan have been developed to align with airport requirements and the project EMS and CEMP. These include requirements for minimum annual review, along with triggers for review – environmental incidents, changes to legislation or project scope, improvement opportunities and identified issues with plan implementation. -Strategies for the management of PFAS impacted soils and other waste material have been developed on the basis of robust risk assessment, as detailed in Section 5. Two categories of soils have been identified based on reported concentrations of PFAS, with risk based management approaches tailored to each soil category. Potential release of PFAS to the environment, primarily through migration via ground and surface water pathways, have been considered and minimised to an acceptable level as per the PFAS NEMP. -Provisions for the management of material above 50 mg/kg are provided in Section 6.16.4, and indicate requirements for off-site
		A (i)	The National Environment Protection Council's National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013), and	ü	6.1	
		A (ii)	The Department of the Environment and Energy's National Water Quality Management Strategy, including the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000), noting that the draft default guideline values for PFOS and PFOA in freshwater, as applied by the Victorian state government, are to be used until the default guideline values are finalised, and	ü	4.2.4, 5.2	
		B – detail implementation and operational procedures that are appropriate to the risk posed by any contamination, noting the persistence, mobility and/or bioaccumulation potential of PFOS, PFHxS and PFOA, including:				
		B (i)	roles and responsibilities; and	ü	6.4	
		B (ii)	management of PFAS contamination within the project area, including strategies to reduce runoff and migration of contamination across and off the proposed site; and	ü	5.7, 5.8 and 6	
		B (iii)	a contingency action plan for unexpected PFAS contaminant discoveries, including coordination, communication and engagement requirements, and	ü	6.15.2	

Approval Conditions – Section	Detail	Sub-Section	Detail	Compliance assessment – Compliant	EMP Sections	Key commitments
		C	detail soil and water monitoring requirements and testing and disposal procedures within the project area that are appropriate to the risk posed by any contamination, including references to relevant provisions of airport environmental management plan/s including on-site and, where relevant, off-site, PFAS contamination monitoring arrangements, and	ü	6.10 and 7	treatment and disposal, along with regulatory approval for transport. It is noted that encountering any such material is not considered likely within the project area, based on data obtained to date. -Management measures described in this plan and summarised above comprise provisions for the safe on-site storage and future reuse (contingent upon reuse risk assessment).
		D	detail review procedures that are appropriate to the risk posed by any PFAS contamination, and	ü	7.4	
		E – impose the following performance measures for managing earthworks and storage of spoil to minimise the release of PFAS, due to disturbance of PFAS contaminated soils or sediments within the project area:				
		E (i)	contaminated waste material (including excavated soil or sediment, and any leachate from soil or sediment, or water arising from de-watering of sediment or soil) to be handled appropriately to the risk posed by the contamination and disposed of in an environmentally sound manner such that potential for the PFAS content to enter the environment is minimised; and	ü	5.7, 5.8 and 6	
		E (ii)	contaminated waste material, including excavated soil or sediment, with a PFOS + PFHxS or PFOA content above 50 milligrams per kilogram (mg / kg) to be stored or disposed of in an	ü	6.15.4	

Approval Conditions				Compliance assessment		Key commitments
Section	**Detail**	**Sub-Section**	**Detail**	**Compliant**	**EMP Sections**	
			environmentally sound manner, to achieve nil environmental release of PFOS, PFHxS and PFOA content. The PFAS Management Plan will need to detail how materials at these concentrations, if encountered, would be handled to achieve nil environmental release; and			
		E (iii)	all soil remaining at the site of the action to be suitable for purpose.	ü	5.7, 5.8 and 6	

Appendix B. Management Options Assessment

Table B.1: Management options assessment matrix

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Table B.1: Management options assessment matrix

MANAGEMENT OPTIONS ASSESSMENT - MELBOURNE AIRPORT											
Soil Management Option	Relative Overall Technical Performance (TP)						Overall TP	Logistics	Financial	Liability	Overall Score
	Environment	O&M	Capital	R&M	Availability	Waste Hierarchy					
Option 1 – Place soil at another site with a similar or higher risk profile											
Uncontained	2	2	2	2	2	2	**12**	1	2	2	**17**
Contained	0	2	2	1	2	2	**9**	1	2	0	**12**
Option 2 – Contain spoil on-site in engineered stockpiles											
Uncontained	2	2	1	2	2	2	**11**	1	2	2	**16**
Contained	2	2	1	2	2	2	**11**	1	2	2	**16**
Option 3 – Contain spoil in a temporary on-site storage facility											
Uncontained	2	1	0	2	1	2	**8**	1	1	2	**12**
Contained	2	1	0	2	1	2	**8**	1	1	2	**12**
Option 4 – Off-site disposal											
Uncontained	2	2	0	2	2	0	**8**	2	0	2	**12**
Contained	2	2	0	2	2	0	**8**	2	0	2	**12**
Option 5 – Temporary stockpiling											
Uncontained	2	1	2	2	2	2	**11**	0	2	1	**14**
Contained	0	1	2	0	2	2	**7**	0	2	0	**9**

Factor	Description	2 Above Average	1 Average	0 Below Average
Environment	Suitability of management option for containment of contaminants	Low level of residual potential risk to the environment	Moderate level of residual potential risk to the environment	High level of residual potential risk to the environment
O&M	Operation and Maintenance Intensive	Low degree of O&M intensity	Average degree of O&M intensity	High degree of O&M intensity
Capital	Capital intensive	Low degree of capital investment	Average degree of capital investment	High degree of capital investment
Reliability & Maintainability	The expected range of demonstrated reliability and maintenance relative to other options	High reliability and low maintenance	Average reliability and average maintenance	Low reliability and high maintenance
Availability	Availability of the management solution within the required timeframe	Highly likely to be available within the required timeframe	May be available within the required timeframe	Unlikely to be available within the required timeframe
Waste Hierarchy	Conformance with Melbourne Airports EMP and Waste Hierarchy	High conformance with the waste hierarchy (items 1 and 2)	Moderate conformance with the waste hierarchy (items 3 and 4)	Low conformance with the waste hierarchy (item 5)
Logistics	Site Specific Practicalities and Logistics, such as availability of space, operational site etc	Limited site specific constraints.	Some site constraints but a relatively easy work around	Many site constraints. Limited availability of land and other operational factors
Relative Costs	Design, construction, operations, maintenance (O&M) and decommissioning costs	Low degree of general costs relative to other options	Average degree of general costs relative to other options	High degree of general costs relative to other options
Liability	The potential for ongoing liability associated with the presence of unremediated contaminated material, contingent on risk profile	Soil remediated, removed or contained, therefore no ongoing contingent liability	Presents partial contingent liability as partially remediated, removed or contained (medium risk)	Presents an ongoing contingent liability as the soil has not been remediated, removed or contained.

Appendix C. Dilution attenuation factors

C.1 Approach

For pollutants that impact on the beneficial use of water with respect to ecological receptors, the "point of compliance" or "point of assessment" is taken as the nearest surface water body to the potential source zone. In this case, the nearest surface water body to the proposed PFAS management facility is the Deep Creek about 400 m to the west. It is noted that groundwater flow between the proposed soil storage area and Deep Creek is likely to the south-southwest rather than directly west, and the distance to the "point of assessment" is likely to be greater than 400 m as a result. The adopted approach is considered conservative on this basis.

Any PFAS in impacted soils that are not contained below an engineered liner could migrate vertically downwards being carried by rainwater infiltrating into the soils. When this mobilised PFAS reaches the groundwater table, it will mix into the groundwater forming a PFAS plume. The plume will mirror the movement of groundwater in general, and thus move down hydraulic groundwater gradient. Three separate dilution processes can be conceptualized:

- Dilution event 1 – redistribution of PFAS in the unsaturated zone. This will depend on the relative thicknesses of PFAS contamination versus non-PFAS impacted unsaturated soils.
- Dilution event 2 – mixing of the PFAS as it transfers from the unsaturated soils to the saturated soils. This will depend on the relative thicknesses of the mixing zone versus the total thickness of the saturated zone.
- Dilution event 3 – mixing / dispersion of the plume formed below the impacted soils as this plume moves down gradient.

No other attenuation processes (such as retardation and biodegradation) have been considered in this assessment.

To determine a threshold leachable concentration (LC) the following approach was taken:

- Step 1 - define the water quality objective
- Step 2 determine the dilution and attenuation within the saturated zone
  - Step 2a - Dilution in groundwater with distance to receptor (DAF1)
  - Step 2b - Dilution from soil leachate to groundwater (DAF2)
- Step 3 – determine attenuation in the unsaturated zone (L2/L1)

C.2 Step 1 – define the water quality objective

The adoption of an appropriate water quality objectives (WQO) follows the process outlined in the SEPP Waters (Victorian Government, 2018), the ANZECC guidance (ANZECC and ARMCANZ, 2000) and the NEMP (HEPA, 2018). The WQO is derived as follows:

- Step 1 – what is the segment of environment of the nearest river and stream water body?

  The reaches of the Maribyrnong River adjacent to the airport are defined as being within the "Central Foothills and Coastal Plains" rivers and stream segment as noted in the SEPP Waters (Victorian Government, 2018)
- Step 2 – what is the beneficial use of the segment of the water in relation to ecosystems?

  The relevant beneficial use segment for water dependent ecosystems for this segment is "Slightly to moderately modified" (SEPP Waters).
- Step 3 – what is the stated level of ecosystem protection for this segment?

The WQO for slightly to moderately modified ecosystems is the 95% species protection level.

- Step 4 – are there are modifying factors or considerations to be taken into account?

  Given that PFOS bioaccumulate and biomagnify in wildlife and consistent with guidance within the NEMP (HEPA, 2018) “slightly to moderately disturbed systems”, should be elevated to a “high conservation value system” and thus the water quality objective is 99% species protection level.

  The 99% species protection level for PFOS is 0.00023 µg/L. This is less than the current practical LoR, and whilst this remains an aspirational target, in the interim, this is then substituted with the practical LoR for the relevant analytical method (HEPA, 2018).

- Step 5 - what then is the adopted WQO?

  The WQO is 0.001 µg/L.

According to data provided in ‘PFAS at Melbourne Airport’ (document provided in attachment B, background concentrations in the groundwater at the north western portion of the airport estate ranged from 0.001 µg/L to 0.008 µg/L.

C.3 Step 2 determine the dilution and attenuation within the saturated zone

C.3.1 Step 2a – Dilution in groundwater with distance to receptor (DAF1)

Dilution within groundwater flow path was calculated using the Domenico Model as utilized by the Louisiana Department of Environmental Quality (LDEQ, 2018). Calculating the distance related DAF is based on five parameters[2]:

- Distance to down gradient of the source; = 400 m (reasonable estimate of the centre of the potential spoil management area and the Maribyrnong River)
- Vertical depth of plume; = 21 m (assumed depth of plume which penetrates through most of the assumed saturated zone)
- Groundwater plume width perpendicular to the groundwater flow; = 200 m (assuming a reasonable large spoil heap 200 m x 200 m)
- Groundwater velocity; 0.365 m/year (assumes low end of typical hydraulic conductivities for Newer Volcanics from Leonard (Leonard, 2006) and a shallow gradient of 0.01)
- Soil porosity; 0.02 (assumes typical value of effective porosity for Newer Volcanics from Leonard (Leonard, 2006)

Modelling output is shown in Attachment A. The calculated DAF1 is 4 (rounded from 3.8).

C.3.2 Step 2b – Dilution from soil leachate to groundwater (DAF2)

The discharge and mixing of infiltrating rainwater (containing PFOS) into the groundwater has been estimated by adopting a dilution attenuation factor (DAF) of 20. The DAF of 20 is the default value in the US EPA Soil Screening Level (US EPA SSL) document (US EPA, 1996). Appendix E of this document describes in detail the approach to estimating a dilution attenuation factor (DAF) and the sensitivity assessment completed. The sensitivity assessment was completed in “Monte Carlo mode” where a number of parameters were varied the impact on DAF noted.

In summary, the top 5 ranking parameters (out of 14) with respect to impact on the DAF were: infiltration rate, saturated thickness, groundwater velocity, source area and hydraulic conductivity; source area is ranked 4th of the top 5 and thus source could only be described as having "somewhat of an influence on the DAF". US EPA

[2] Note that the LDEQ Excel spreadsheet requires input in imperial units.

provide a further discussion on the impact of source area and the DAF based on a number of scenarios. Scenario 5 of the 6 scenarios assessed by the US EPA is the closest to the PFAS Facility setting although still conservative. As shown in Table A5 of Appendix E to US EPA, for a site of around 5 ha (500,000 ft^2), DAFs of around 33 are achieved at the 85^{th} percentile, about 6 at 90^{th} percentile and about 1.4 at 95^{th} percentile. Given the low permeability of the basaltic clays at the Site (less than 1 x 10^{-9} m/s) and distance to the potential receptor (400 m) are all “less sensitive” than the scenarios presented in the US EPA document, the default DAF of 20 is considered considered sufficiently conservative accounting for a variety of spoil heap dimensions, soil types and rainwater infiltration (being a DAF equivalent to the US EPA's 85^{th} and 90^{th} percentiles using US EPA default parameters).

C.4 Step 3 – determine the attenuation in the unsaturated zone

In order to calculate the Category 1 management level, calculations presented in Soil Attenuation Model (SAM) developed by GSI (GW Services Inc, 1997) was used, where leachate would be redistributed through the unsaturated zone based on the ratio of the contaminated layer thickness and the thickness of the unsaturated zone.

In this case:

- L_1 = stockpile height – assumed maximum 2 m placed onto the current soil surface based on Melbourne Airport Environmental Management Plan (2018)
- L_2 = depth from infiltration point at current soil surface to groundwater – assumed 10 m

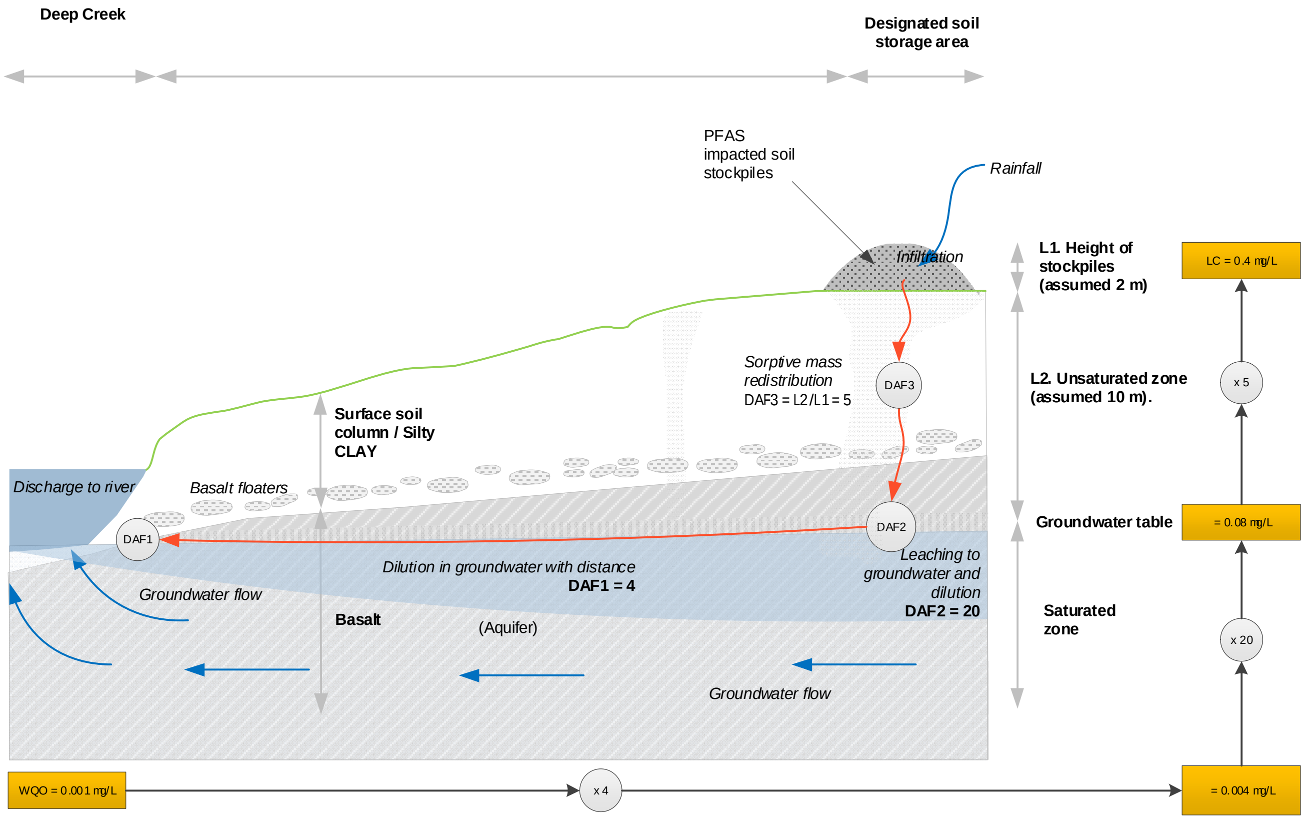
Thus, the ratio L2/L1 = 5.

C.5 Total overall DAF and the leaching criteria

The overall DAF is the product of DAF_1, DAF_2 and L2/L1; = 4 x 20 x 5 = 400

Thus, the threshold leachable concentration (LC) in soil is the WQO x DAF; = 0.001 x 400 = 0.4 µg/L.

This is summarized in the following figure.



Note that site investigations for the temporary spoil storage facility have found that groundwater is greater than 40 m below ground level. The L2/L1 ratio would thus be around 20 (instead of the current 5). This would thus result in a threshold leachable concentration of 1.6 mg/L for Category 2 soils. Jacobs proposes to retain the 0.4 mg/L threshold with this being a conservative outcome.

C.6 Attachment A

Domenico Analytical Solute Transport Model **Management Option 1**

LDEQ Risk Evaluation/Corrective Action Program
Revision date: 07/10/2002
Run date: 30-10-18

General assumptions:
1. A single continuous source of one chemical compound dissolved in the groundwater. No NAPL.
2. No initial groundwater contamination.
3. Chemical compound is non-reactive.
4. No biodegradation or retardation occuring.
5. Groundwater flow is in one direction.
6. Saturated zone is homogeneous and isotropic.
7. Contaminant plume is a planar source spreading infinitely laterally in two directions and vertically in one direction.
8. The point "X" is behind the point where "X = v * time since spill".
9. Longitudinal, transverse, and vertical groundwater dispersivities are based on ASTM E 1739-95 example.
10. The DAF is based on the estimated contaminant concentration (Cxi) at the center line of the plume.

Example Calculation of the Groundwater Dilution Attenuation Factor

Site-specific inputs:
1310 (ft) = X = distance downgradient from source.
69 (ft) = Sd = vertical depth of plume (measured vertical extent of affected groundwater plume or the full thickness of the groundwater stratum).

Defaults:
656 (ft) = Sw = groundwater plume width perpendicular to groundwater flow.

3.78E+07 (ft/yr) = Dv = K*i = Darcy groundwater velocity.
0.02 (dimensionless) = O = soil porosity.
1888875000 (ft/yr) = Dv / O = v = linear Darcy groundwater transport velocity.

131 (ft) = X * 0.1 = Ax = longitudinal groundwater dispersivity.
43.66666667 (ft) = Ax / 3 = Ay = transverse groundwater dispersivity.
6.55 (ft) = Ax / 20 = Az = vertical groundwater dispersivity.

1 (dimensionless) = Ri = retardation factor for constituent i.
0 (yr-1) = Yi = first-order degradation constant for constituent i.

Model equation:
(Csi/Cxi)= DAF = 1/[EXP(X/(2*Ax) * (1-SQRT(1+(4*Yi*Ax*Ri/v))))
* Erf(Sw/(4*SQRT(Ay*X))) * Erf(Sd/(2*SQRT(Az*X)))]
= 3.8 (dimensionless)

X (ft) = distance downgradient from source =	Management Option 1 DF for 0.5 acre (dimensionless)			
Sd =	5 ft	10 ft	15 ft	20 ft
0 - 50	1.5	1	1	1
50 - 100	2.6	1.5	1.2	1.1
100 - 150	4.1	2.1	1.6	1.3
150 - 250	8.4	4.3	3	2.3
250 - 500	29	15	9.8	7.4
500 - 750	63	32	21	16
750 - 1000	111	57	37	28
1000 - 1250	173	86	58	43
1250 - 1500	248	124	83	62
1500 - 1750	337	169	113	84
1750 - 2000	440	220	147	110

C.7 Attachment B

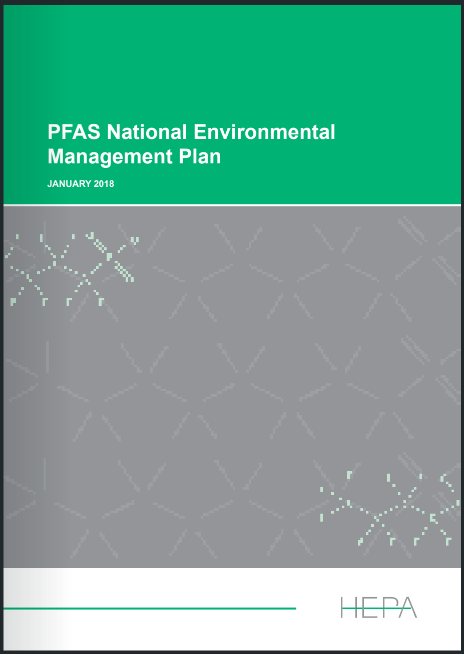
OCTOBER 2018

PFAS at Melbourne Airport

MELBOURNE AIRPORT

Melbourne Airport has prepared this document to inform the community about the presence of per- and poly- fluorinated alkyl substances (PFAS) at the airport.

This forms part of our ongoing commitment to engage with relevant stakeholders regarding assessment and management of PFAS. This document provides general information on PFAS, summarises test results and describes proposed future actions.



[PFAS NEMP Document 2018](#)

02. What is PFAS?

Per- and poly- fluorinated alkyl substances (PFAS) are manufactured chemicals that are used to make products resistant to heat, stains, grease and water.

PFAS have been widely used for more than 50 years in many consumer and industrial products, including carpets, cookware, clothing, food packaging, pesticides, stain repellents, firefighting foams, mist suppressants and coatings.

PFAS are stable chemicals that are resistant to physical, chemical and biological degradation. Because of these properties, PFAS last for a long time and they can be found in humans, animals and throughout the environment in Australia and other parts of the world.

There are many types of PFAS. The PFAS most commonly encountered in the environment and in wildlife are perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS). These are also the most studied PFAS due to their frequent occurrence in the environment, persistence and potential for bioaccumulation.

> ***'Surface water'*** *is water that collects on the surface of the ground. This includes water in creeks, rivers, dams, lakes. It also includes water that temporarily pools or flows along the ground or in a drain during or after rainfall events. In general, surface water flows towards lower lying areas.*

> ***'Groundwater'*** *is the water found underground in the cracks and spaces within soil, sand and rock. It moves slowly through the subsurface and may flow into surface water bodies.*

PFAS molecules are made up of a carbon chain with attached fluorine atoms, and a hydrophilic (water soluble) group at one end. The hydrophilic headgroups make PFAS very soluble in water. Consequently, PFAS can move from soil to surface water or groundwater and then migrate to creeks, rivers and lakes. PFAS can also be taken up by organisms in contaminated areas and be transferred through the food chain.

Due to widespread historical PFAS use, there are now PFAS contaminated sites in Australia and other parts of the world. In some cases, PFAS from these sites have migrated to surface water, groundwater and/or adjoining land. PFAS can also be released into the environment from landfill sites where PFAS-containing products are disposed of, and through sewer discharges.

PFAS at airports

At airports, foams containing PFAS (known as aqueous film forming foams or AFFF) were historically used because they are very effective at putting out liquid fuel fires.

At Melbourne Airport, AFFF have been stored in aircraft hangers for deluge systems and used extensively in training for and responding to firefighting emergencies involving liquid fuels.

03. Health Effects of PFAS

The following information is provided by the Australian Government Department of Health, Department of Health and Human Services Victoria and Environment Protection Authority Victoria:

①

While there is no consistent evidence that PFAS exposure causes adverse human health impacts or illness, research in this area is ongoing.

②

Studies of human populations that have been exposed to PFAS at their workplace or in the environment have not provided definitive or consistent results. Possible links between PFAS exposure and some health effects have been reported in some studies, but other studies have not identified any effects.

③

In studies where large doses of PFAS are given to laboratory animals, possible effects on the immune system, liver, reproduction, development and benign (non-cancer) tumours have been identified. However, PFAS behaves differently in the bodies of animals compared to humans, so effects shown in animals may not occur in humans.

04. PFAS in the Environment

In the environment, PFAS have been shown to have adverse effects on some plants and animals, including fish. Studies on fish and animals have identified effects on reproductive, developmental and other systems. The concentrations at which effects have been observed varies between different types and species of organisms.

PFAS can accumulate in the bodies of animals, particularly those that eat fish such as dolphins, whales, seals, sea birds and polar bears. Because of the persistence of PFAS, exposure can occur in the environment over long time periods, and concentrations can increase in animals higher up the food chain.

In agricultural settings, livestock may be exposed to PFAS in water, soil and feed, resulting in accumulation in edible tissue or milk.

Agriculture Victoria has advised that there has been no evidence of PFAS affecting the health or production of grazing livestock in Australia.

05. History of PFAS Use at the Airport

The Civil Aviation Safety Authority (CASA) requires and regulates aviation rescue firefighting (ARFF) services at Melbourne Airport. CASA also regulates the equipment and training used for firefighting services.

From the beginning of airport operations in 1970 to 1995, firefighting services have been provided by various commonwealth agencies. Since 1995, these services have been provided by Airservices Australia.

Prior to Airservices being established, the ARFF function was performed by the Civil Aviation Authority from 1988 to 1995 and prior to that by the Commonwealth Department of Civil Aviation.

The firefighting foams historically used at Melbourne and other airports contained PFAS and included commercial products such as 3M LightWater™ and Ansulite™. These products were used for both operational and training purposes until 2010, after which Airservices transitioned to a PFAS-free foam.

Other tenants have also used PFAS containing products, including in aviation hangar deluge systems and fuel storage facilities.

> *Melbourne Airport is working with these tenants to phase out the use of PFAS products, including Qantas which has already removed them from their deluge systems.*

Foams containing PFAS have been stored and/or used at a number of locations within the airport, including the following sites leased by Airservices Australia:

- The current and former fire training grounds, located in the north-west corner of the airport.
- The Melbourne Airport Fire Station, Learning Academy Hot Fire Training Ground and Smoke Hut located in the central portion of the airport, to the west of the main runway.
- A Satellite Fire Station and Hangar/Maintenance Area located to the east of the main runway.

Other tenants have stored and/or used the foams in maintenance hangars and the aviation fuel storage depot.

06. Australian Regulatory Guidance

The PFAS National Environment Management Plan (NEMP) provides guidance on the assessment and management of sites contaminated by PFAS. The PFAS NEMP was released in February 2018 and was developed by the Heads of EPAs Australia and New Zealand (HEPA) and the Australian Government Department of Environment and Energy. The Commonwealth, State and Territory Environment Ministers have endorsed the PFAS NEMP.

The PFAS NEMP includes environmental guideline values that should be used to assess risks posed by PFAS. Guideline values have been developed for different aspects of the environment (such as soil and water) and for a range of situations (such as an industrial yard or a residential block). Where concentrations are below the guideline values, risks for that scenario are considered low and acceptable.

The guideline values have been calculated to be highly protective and include a considerable margin of safety.

This means that a test result higher than a guideline value does not mean that exposure or risk is above acceptable levels. Rather, the result indicates that further investigation is warranted.

The table below summarises selected health-based guidance values for key PFAS (PFOS+PFHxS) in soil and water. The PFAS NEMP also includes guidance values for PFOA. At Melbourne Airport, PFOA concentrations have typically been below the guideline levels and have not warranted further assessment.

The values below are those relevant to the airport or surrounds. For the majority of the airport the commercial/industrial values for soil apply. Recreation / open space values may also be relevant in some locations (such as the airport golf course).

Environmental Media	Exposure Scenario	Exposure Pathways	Health-based guidance value for PFOS+PFHxS
Soil	Commercial or industrial land use	Allows for direct contact with soil and inhalation of airborne dust derived from soil.	20 milligrams per kilogram (mg/kg)
	Recreation or open space land use		1 mg/kg
Water	Drinking water	Assumes ingestion of up to 2 litres of water per day.	0.07 micrograms per litre (µg/L)
	Recreational water	Assumes a person may swim every day of the year and ingest up to 0.2 L of water each time they swim.	0.7 µg/L

Note: The recreational water value (0.7 µg/L) has been recently reviewed. A revised number of 2.0 µg/L has been proposed and released for public consultation by the National Health and Medical Research Council.

The PFAS NEMP also includes ecological guidance values for freshwater aquatic ecosystems. The creeks and rivers surrounding the airport are considered to be slightly to moderately modified aquatic ecosystems and typically require a guideline value that protects 95% of species. However, for chemicals that bioaccumulate or biomagnify in wildlife, a guideline value that protects 99% of species is recommended. The 99% species protection value for PFOS is 0.00023 µg/L.

This value may be below background concentrations in some locations. It is also below concentrations that can currently be reliably detected by most Australian analytical laboratories. For this reason, EPA Victoria (Publication 1633.2) use the current laboratory detection limit of 0.001 µg/L as the practical guideline value until laboratories can reliably detect lower levels.

Note: The 99% species protection guideline value (0.00023 µg/L) is currently being reviewed. Melbourne Airport understands this number is likely to be revised up to a higher value later this year.

07. PFAS Investigation and Monitoring

As part of its ongoing environmental management and monitoring of the airport in accordance with the Airports Act and regulations, Melbourne Airport is assessing and monitoring PFAS contamination on airport property. As part of this process, Melbourne Airport has established a Project Control Group (PCG) to review this issue in detail. The PCG consists of Melbourne Airport and:

- Commonwealth Department of Infrastructure, Regional Development and Cities (DIRDC)
- EPA Victoria
- Airservices Australia

Melbourne Airport is also working closely with other relevant stakeholders including:

- Melbourne Water
- Other airport tenants
- Neighbouring local councils
- Community stakeholders

To date, testing of soil, groundwater and surface water has been conducted on and around the airport as part of our monitoring requirements and obligations. The results of investigations conducted by Melbourne Airport are summarised in the sections below.

7.1 Soil

Melbourne Airport has undertaken soil testing for PFAS at over 600 locations across the airport.

The main sources of PFAS contamination have been identified in areas where PFAS foams were previously used or stored. *Figure 1* shows locations at the airport where PFOS+PFHxS concentrations greater than 1 mg/kg have been identified in soil or sediment. These locations are in the vicinity of the fire training grounds, the Learning Academy Hot Fire Training Ground / Smoke Hut and the Melbourne Airport Fire Station. The results suggest that the most intensive historical use of PFAS has occurred at these locations.

The investigations to date have identified only three soil sample locations that had PFOS+PFHxS concentrations exceeding the health-based guidance value for commercial/industrial land use (20 mg/kg). These locations were in or near current and previous fire training grounds in the northwest portion of the site. Concentrations above 20 mg/kg were also reported in three sediment samples (collected within drains) near the fire training grounds and Melbourne Airport Fire Station.

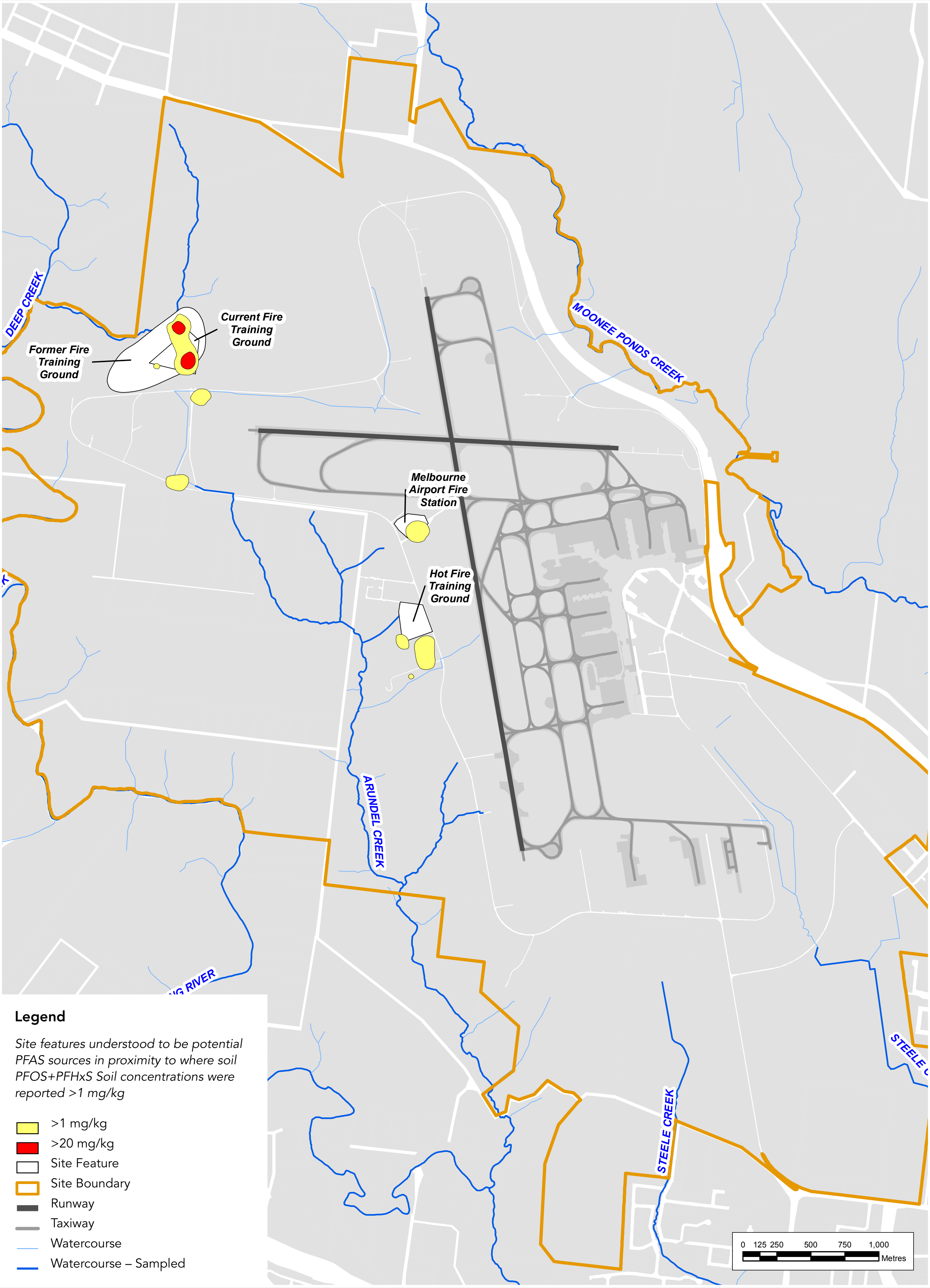
Soil concentrations in nine soil sample locations exceeded the health-based guidance value for soil on land used for recreation or open space (1 mg/kg). These were in operational parts of the airport (vicinity of fire training grounds and fire station) and not in parts of airport land used for recreation purposes (e.g. the golf course). Concentrations above 1 mg/kg were also reported in six sediment samples (within drains) near the fire training grounds and Melbourne Airport Fire Station.

The PFAS concentrations in soil and sediment are considered unlikely to result in unacceptable risks to human health. This is because the concentrations above guidance values are limited in extent and in locations that people are not frequently in contact with the soil or sediment.

01

Soil PFAS Results

PFOS+PFHxS Concentrations Above Screening Levels Results in mg/kg



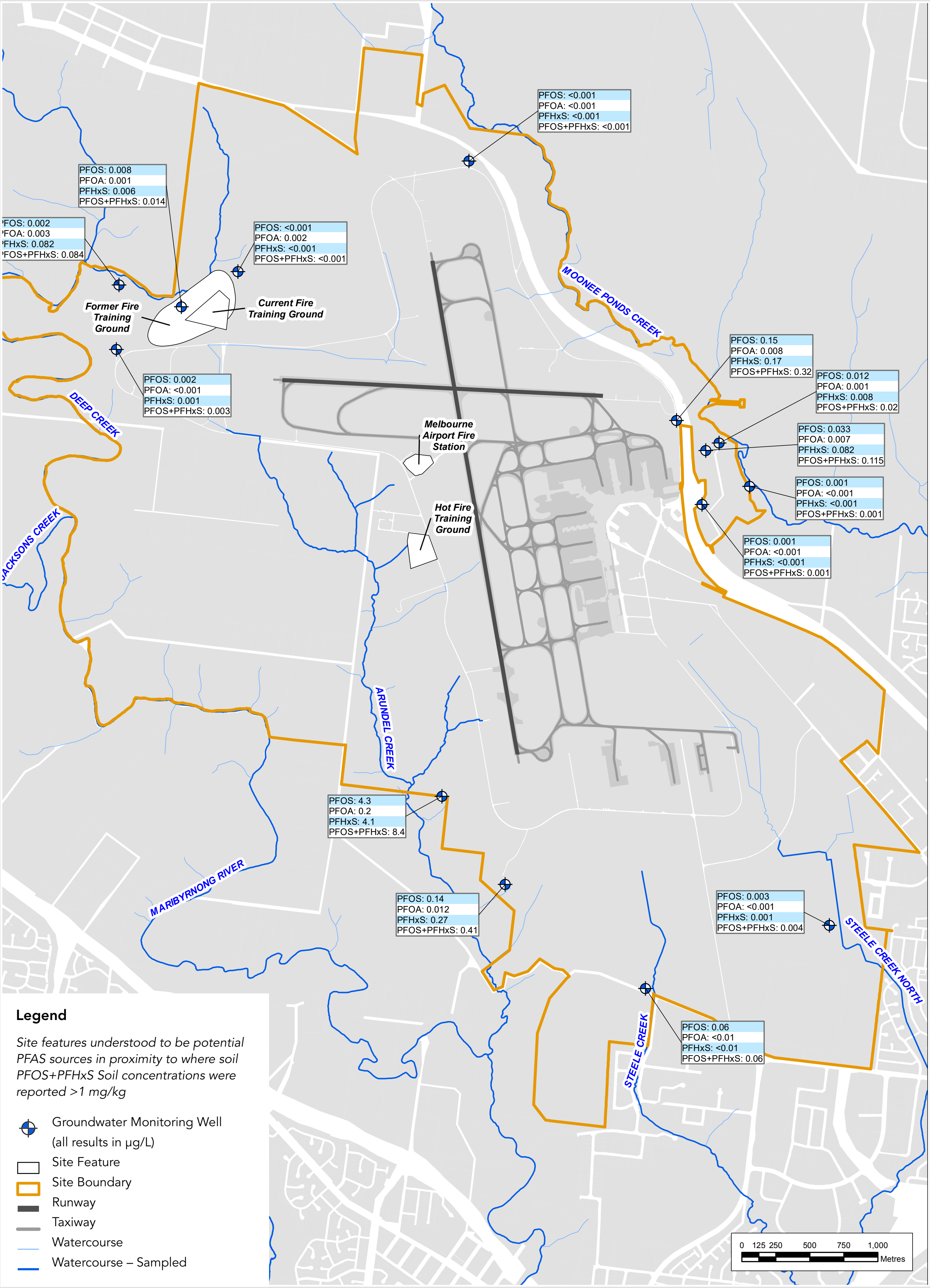
Legend

Site features understood to be potential PFAS sources in proximity to where soil PFOS+PFHxS Soil concentrations were reported >1 mg/kg

- >1 mg/kg
- >20 mg/kg
- Site Feature
- Site Boundary
- Runway
- Taxiway
- Watercourse
- Watercourse – Sampled

02 Summary of PFAS Results

Groundwater Near Airport Boundary Results in µg/L



7.2 Groundwater

Groundwater monitoring wells have been installed and tested in locations on and down gradient of identified potential PFAS source areas. Wells have also been installed at locations along the down gradient (south-west) airport boundary to identify what concentrations may be migrating beyond the boundary. *Figure 2* shows PFAS concentrations in groundwater wells adjacent the airport boundary.

PFOS+PFHxS concentrations have been identified in some groundwater samples above health-based guidance values in some locations. As noted in section 6, a test result higher than a guideline value does not mean the exposure or risk is above unacceptable levels. Rather, it indicates that further investigation is warranted.

The airport is working with other relevant stakeholders to confirm groundwater usage in the surrounding area and is continuing to undertake groundwater monitoring. **This has included reviewing publicly available groundwater use information and verifying with Melbourne Water that the catchment below the airport is not a drinking water catchment.**

7.3 Surface Water

Surface water testing has been conducted at a number of locations within and outside the airport for many years as part of our regulatory obligations. Since 2016, PFAS testing has been included in this monitoring program. The testing locations have been selected to assess conditions upstream and downstream of the airport, and at points where surface water or stormwater drainage discharges from the airport into adjacent waterways.

Where water has been in contact with PFAS contaminated soil or sediment, PFAS may dissolve in the water and be transported into adjacent waterways. This migration pathway is shown in *Figure 3* below.

PFAS concentrations in surface water outside the airport boundary are summarised in *Figure 4* below.

PFOS+PFHxS concentrations in a number of locations have exceeded the health-based guidance value for drinking water. However, this guidance value is only relevant where water is used for drinking. The airport is not within a Melbourne Water drinking water catchment, so use of surface water for drinking purposes is not expected to occur.

> *Melbourne Water's Diversions Agreement entitlements state diverted water is not fit for any use that may involve human consumption, directly or indirectly, without first being properly treated.*

PFOS+PFHxS concentrations in some locations have sometimes been higher than the health-based guidance value for recreational water. The majority of these locations are in Arundel Creek between the airport boundary and the Maribyrnong River. The concentration in a Maribyrnong River location downstream of the airport was also higher than the recreational water guideline during one sampling event, but has been below the guideline on other occasions. These results indicate that potentially elevated exposure may occur if people regularly swim in this area of Arundel Creek. However, unacceptable health risks due to direct contact with surface water is considered unlikely. This is because the guideline number is based on a person swimming in a water body every day of the year for up to two hours per day. The frequency of swimming, wading or other human contact in the creeks surrounding the airport is expected to be much lower than this.

Concentrations in a tributary leading from the Old Fire Training Ground to Deep Creek have also exceeded the recreational water guideline. Recreational contact with water in this tributary is not considered likely to occur because the tributary only flows during high rainfall events within a narrow channel.

03 Surface Water Migration Pathways

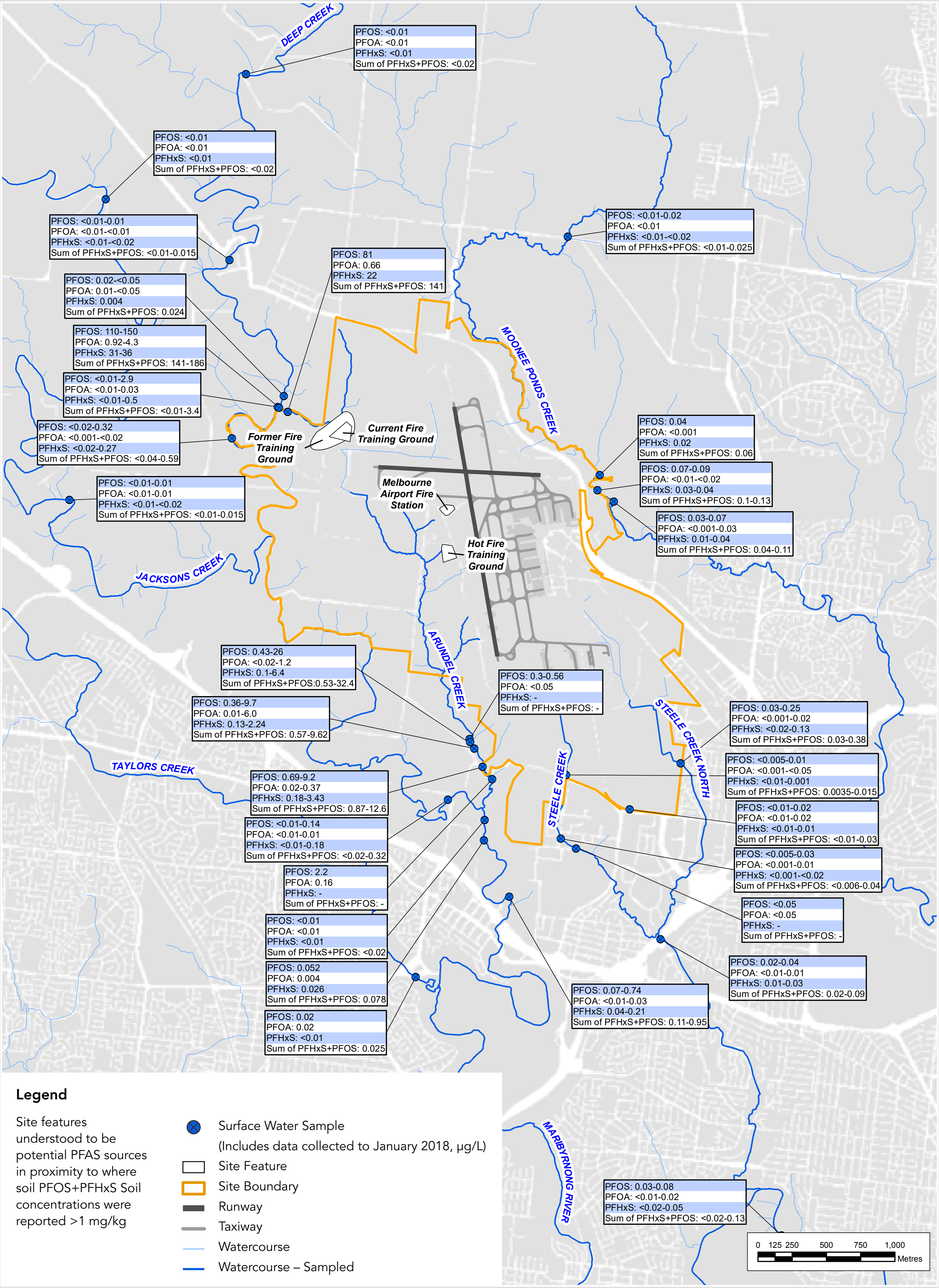
Legend

Site features understood to be potential PFAS sources in proximity to where soil PFOS+PFHxS Soil concentrations were reported >1 mg/kg

- >1 mg/kg
- >20 mg/kg
- Site Feature
- Site Boundary
- Runway
- Taxiway
- Watercourse
- Watercourse – Sampled
- Flow Direction

04 Summary of PFAS Results

Off-site Surface Water Locations Results in µg/L



The health-based guidance values for surface water do not consider some other potential human exposure pathways which may result in exposure to PFAS. These pathways primarily relate to bioaccumulation and include:

01

Ingestion of fish that have accumulated PFAS due to surface water exposure.

02

Ingestion of fruits or vegetables (home-grown or for market) that have been irrigated with PFAS-impacted water.

03

Ingestion of livestock or products from livestock (milk, eggs) that have ingested PFAS-impacted water.

Agricultural Victoria provides further information regarding PFAS in livestock on their website (links below). They advise that, unless you receive advice from a government authority that meat or other animal products from livestock are unsafe, these products should be considered safe for human consumption.

08. Risks to Ecological Receptors in Off-site Waterways

PFAS concentrations in some waterways surrounding the airport are higher than the guideline value for aquatic ecosystems. This indicates that further consideration of potential impacts on ecological receptors is warranted.

Detailed assessments have not yet been completed. However stream health assessments have been conducted as part of Melbourne Airport's routine monitoring program. The stream health assessments provide a line of evidence regarding potential impacts on ecosystems within the waterways. The assessments have not identified measurable impacts on invertebrate communities due to PFAS.

Other parties including EPA Victoria and Melbourne Water are undertaking broader assessments of PFAS in Victorian waterways, including those surrounding the airport.

09. PFAS Investigation and Monitoring

Melbourne Airport will continue to work with airport tenants to manage potential risks from PFAS contamination at the airport. These activities include:

- Working with tenants to remove PFAS products and PFAS contaminated materials.
- Working with tenants to manage PFAS source areas.
- Management of stockpiled soil in accordance with the PFAS NEMP.
- Ensuring that PFAS contamination is managed during construction activities, through the development and implementation of construction environmental management plans.
- Ensuring that tenants develop and adhere to operational environmental management plans (OEMPs) to ensure compliance with PFAS management requirements.
- Ongoing monitoring of soil, surface water, groundwater and creek health.
- Development of a PFAS Management Strategy (in progress). This strategy will document the approach and recommended actions for the future management of legacy PFAS contamination issues at the airport, in the short to medium term (2–5 years).
- Supporting and participating in the PCG.

Links

[PFAS NEMP]

[Australian Department of Health]

[EPA Victoria]

[Department of Health and Human Services Victoria]

[Agriculture Victoria]

[Melbourne Airport]

[Airservices]

Version	Date	Comments
Final Draft	17 September 2018	
Final	3 October 2018	Minor changes to text and figures

HEPA, 2018. PFAS National Environmental Management Plan. Heads of EPAs of Australia and New Zealand. January 2018.

Appendix D. Curriculum Vitae - Authors

Author	Qualifications	Experience
Dr David Coutts: Principal Contaminated Land 	Bachelor of Science – University of Glasgow PhD – University of Stathclyde	Dr. David Coutts is a contaminated land specialist and environmental microbiologist with 23 years of experience in contaminated land consultancy. Currently David is a Principal within the contaminated land team in Melbourne. He has previously worked for a variety of consultancy firms in the UK. David has been in Melbourne since November 2010. David specializes in the areas of contaminated land site assessment and remediation having been the contaminated land specialist on a diverse range of projects covering transportation infrastructure, oil and gas, industrial pollution, landfill, utilities, buildings and land development in both the UK and Australia. David's key capabilities include risk assessment, sampling design with respect to sample sizes and dealing with statistical uncertainty, environmental statistics to evaluate confidence limits in contaminant concentrations, data correlations and significance of the data.
George Boyer: Consultant Contaminated Land 	Bachelor of Environmental Engineering (honours) – Monash University	George is an environmental engineer with project experience in environmental site investigations and due diligence studies across a range of sectors, including state and federal governments and private clients in the energy, water and property markets. He has skills in the collection, collation and review of site environmental information including the potential for site contamination based on Phase 1 and Phase 2 assessments of current and past potentially contaminating land uses. This includes development and execution of site sampling investigations and analysis of soil and water for a range of potentially contaminating substances, along with the processing, analysis and presentation of chemical datasets via data management software such as ESDAT. George has an extensive understanding of state and federal environmental legislative requirements relating to the assessment of potentially contaminated land and groundwater in multiple jurisdictions.