Environmental Site Assessment, December 2017

Army Aviation Centre Oakey
Stage 2C Environmental Investigation

Executive Summary

Department of Defence

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Executive Summary

Introduction

AECOM Australia Pty Ltd (AECOM) was commissioned by the Department of Defence (Defence) to undertake the 2017 Stage 2C Environmental Investigation (2017 Stage 2C EI) at the Army Aviation Centre Oakey (AACO) in Oakey, Queensland (the Site) and in surrounding off-Site areas (the Investigation Area).

The 2017 investigation principally targeted per- and poly-fluorinated alkyl substances (PFAS) and was designed to address data gaps identified at the completion of the Stage 2C 2016 EI studies. The 2017 Stage 2C EI built upon the results of the 2015 Stage 2B EI and the 2016 Stage 2C EI, specifically the Environmental Site Assessment. The Site and Investigation Area are presented on **Figure F1** in **Appendix B**.

The Site was constructed in 1943, initially as a training facility and overflow aircraft maintenance depot for RAAF Base Amberley. The Site currently operates as the Army's helicopter training school for pilots and aviation technicians and is also home to a Republic of Singapore Airforce helicopter squadron. As part of typical airbase activities, aqueous film forming foam (AFFF) was used at the Site for fire training and emergency response from the 1970s. The main AFFF product used historically by Defence was 3M Lightwater™, which contained Per- and poly-fluorinated alkyl substances (PFAS) including Perfluorooctane sulfonate (PFOS) and Perfluorooctanoic acid (PFOA).

From 2004, Defence commenced phasing out its use of legacy AFFF containing PFOS and PFOA as active ingredients and progressively transitioned to a product called Ansulite® for use on the Defence estate. The product currently used by Defence does not contain PFOS and PFOA as active ingredients, only in trace amounts. AECOM understands that Ansulite® is used by Defence only in emergency situations where human life is at risk, or in controlled environments to test equipment, and any Ansulite® used by Defence is captured and treated and/or disposed of at licensed waste disposal facilities in accordance with best practice regulations, and standards. Based on anecdotal evidence, for the purposes of this report, it has been assumed that Defence commenced phasing out the use of AFFF products containing PFOS and PFOA at the Site from 2005. This assumption has not been verified by Defence.

The previous investigations identified the presence of PFAS in soil, groundwater, surface water, sediment and terrestrial and aquatic biota. Investigations completed to date have identified nine key on-Site PFAS source areas, which are presented in **Figure F3** in **Appendix B**. These PFAS source areas include three depleting and six active source areas. No new additional source areas were identified since the 2016 Stage 2C EI:

- Depleting source areas
  - Former fire training ground area in Area North
  - Former fire station and foam training area in Area B3
  - Former fuel compound and hot refuelling point in Area F1
- Active source areas
  - Hot refuel area in Area A2
  - Spent AFFF recovery underground storage tank in Area A2
  - Spent AFFF recovery underground storage tank in Area S1
  - Spent AFFF recovery underground storage tank in Area C1
  - AFFF storage and decanting areas in Area D2
  - Current fire training ground in Area D2

The purpose of this 2017 Stage 2C EI Report is to provide the results of the sampling and analysis undertaken between January 2017 and June 2017 which was conducted to address the data gaps

described in **Section 1.3**, and to provide additional data to support the 2017 Human Health Risk Assessment (HHRA) and 2017 Ecological Risk Assessment (ERA).

Context of the 2017 Stage 2C Environmental Investigation

Tasks undertaken by AECOM between January and June 2017 have included the following:

Environmental Site Assessment (this Report): This includes investigation of on- and off-Site PFAS concentrations in soil, sediment, surface water and groundwater; hydrogeological investigations; and update of a groundwater flow model and PFAS solute transport model. Data collected from previous environmental investigations, analytical data from soil sampling undertaken during Site redevelopment projects and groundwater data from the Department of Natural Resources and Mines (DNRM) have also been incorporated into this 2017 Stage 2C EI.

Residential sampling: Sampling and analysis of bore water and soil samples (at landholder request to Defence) from residences within and near the Investigation Area. In some instances water was also sampled from rainwater tanks, taps and swimming pools. Selected data from this program have been used to inform the 2017 Stage 2C EI.

Off-Site biota sampling: Following a community survey (between February and May 2017) to investigate the consumption of edible flora and fauna within the Investigation Area, a sampling program was conducted. Samples of home-grown fruits and vegetables, chicken eggs and samples of yabbies, shrimps and mussels from local creeks were collected and analysed for PFAS. Co-located soil, sediment, surface water and groundwater were also collected and analysed for PFAS. This work was conducted to support the HHRA.

Human Health Risk Assessment (in preparation): A multiple pathway HHRA is being undertaken to evaluate the potential human health risks to identified receptors within the Oakey area. This report will update the 2016 HHRA report and include consideration of direct contact exposures to environmental media (e.g. soil, groundwater, surface water, and sediment) as well as secondary exposures via dietary intakes, including fish, invertebrates and home grown plant and animal produce. The report will also be updated to include the Human Health Based Guidance Values by the Food Standards Australia and New Zealand issued in April 2017.

Ecological Risk Assessment (in preparation): The ERA will be updated in 2017 to assess the potential risk from the identified PFAS contamination to ecological receptors which inhabit the Site and surrounding areas. The 2016 ERA assessed the potential for wider ecosystem impacts to result from the accumulation of PFAS in terrestrial and aquatic organisms exposed to PFAS contamination. The current investigation included the collection and analysis of flora and fauna samples including hares, fish, yabbies, shrimps, mussels and worms. River and bird surveys and habitat assessments were also carried out.

Community Engagement: Facilitation of community engagement as related to conduct of the 2017 Stage 2C EI and other tasks as listed above including land access, water and lifestyle surveys and community information events.

Ongoing Monitoring Plan: At the completion of the 2017 Stage 2C EI, an Ongoing Monitoring Plan (OMP) will be prepared that will cover both the environmental monitoring program and the residential sampling program. The OMP will be implemented to capture seasonal and temporal variations in groundwater and surface water PFAS concentrations and conditions (drains and creeks), provide early warning indicators for groundwater plume migration and monitor water levels and aquifer specific conditions.

Stage 2C EI Objectives and Conclusions

The purpose of this Stage 2C EI Report is to provide the results of the sampling and analysis undertaken between January and June 2017 to address data gaps described in **Section 1.3**, and to provide additional data to support the 2017 HHRA and 2017 ERA.

The objectives and conclusions of the 2017 Stage 2C EI are summarised in **Table ES1**.

Table ES1 Objectives and Conclusions of the 2017 Stage 2C EI

Data gap objective	Data gap conclusion
Refinement of Groundwater Zones 1 and 2	Information has been obtained to confirm the findings of the Stage 2C 2016 EI. The data collected in this 2017 Stage 2C EI will be used to refine the groundwater zones in the HHRA report, as they are material to the HHRA. The PFAS data set from the existing and newly installed monitoring wells is suitable to allow updating of exposure point concentrations in the 2017 HHRA. Groundwater monitoring results have refined the understanding of the current extent of contamination in the Oakey Creek Alluvium, Main Range Volcanics and Walloon Coal Measures aquifers. Evaluation of the groundwater data trends over time suggests evidence for stable PFAS concentrations in groundwater on-Site and areas adjacent to the Site. There is limited evidence for a minor increasing trend in PFAS concentrations in down-hydraulic gradient off-Site bores which is attributed to the migration of PFAS within groundwater towards the west.
Characterisation of the full PFAS suite	All soil, water and sediment samples were analysed for an extended PFAS suite of 28 compounds. The dataset shows there are 12 main PFAS present in the different media; PFOS, PFHxS, PFOA, PFHxA, PFPeS, PFBS, PFHpS, PFPeA, PFHpA, PFBA, 8:2 FTS and 6:2 FTS. The dominant contaminants present were PFHxS and PFOS. The investigation has characterised the distribution of these compounds in different media across the Investigation Area.
Acquire data to inform the OMP sampling requirements	The results of this investigation, together with the historical results, will be used to develop a suitable ongoing monitoring program for the Site. The combined dataset is adequate to allow this program to be developed.
Characterisation of non-PFAS contaminants of potential concern on-Site	The investigation has included characterisation of soil, sediment, groundwater and surface water for non-PFAS contaminants on-Site. No large areas of non-PFAS contaminants have been identified. Localised petroleum hydrocarbons impacts are present in groundwater in one area within the Site. The extent of the hydrocarbon contamination is considered to be adequately understood and does not extend beyond the Site boundary. Localised areas of elevated chromium and nickel concentrations in groundwater on-Site have been identified and do not extend beyond the Site boundary.
Potential risks to the Great Artesian Basin (GAB): • Investigate potential connections across multiple aquifers via bores that were constructed prior to current legislated standards	Information has been obtained to characterise groundwater in underlying aquifer units and allow assessment of the potential risks to the Great Artesian Basin. The dataset is considered suitable to assess the concepts and refine the conceptual site model, which is used as the basis of the groundwater model refinement. The GAB's vulnerability to PFAS concentration migration, from the Oakey Creek Alluvium aquifer to the Walloon Coal Measures aquifer (an aquifer of the Great Artesian Basin), is recognised to be limited, which

Data gap objective	Data gap conclusion
• Investigate registered bores RN107812, RN87439, and RN87369 • Investigate the risk that unregistered bores pose to the GAB and any remediation or mitigation measures • Investigate the risk to the GAB from both infiltration and via bores acting as conduits, including rectification options	is reflected in the Groundwater Model water balance. The level of risk to the Great Artesian Basin is influenced by: • a thin or permeable transition zone • the limited areas within the Investigation Area where Oakey Creek Alluvium and Walloon Coal Measures are unconformably in contact and Main Range Volcanics is not present • groundwater extraction resulting in steeper vertical gradients • secondary alteration, such as faulting and fracturing • elevated concentrations of PFAS. Bores that could create a connection between aquifers have been assessed, based on the field evaluations of the three licensed bores (RN107812, RN87439, and RN87369) within the Investigation Area. It is considered that the potential for hydraulic connection and PFAS migration from the Oakey Creek Alluvium aquifer to the underlying Walloon Coal Measures within such bores is limited, requiring several conditions to occur, including: • perforation in casing in both units • poor cement seal • thin or no transition zone • extraction of groundwater from the bore. The vulnerability of the GAB as a result of groundwater extraction was assessed through pump tests. Aquifer testing assessments indicate that the vulnerability of the GAB is related to: • transmissivity of the units intersected and screened within the bores, where the most transmissive unit provides the majority of groundwater into the bore (reducing mixing/blending potential) • the extraction schedule and volumes and recovery periods, which influence the extent and duration of drawdown cones, and vertical groundwater movement potential.
Investigate implications of extraction of potentially contaminated overland flow water and/or surface water by entitlement holders	An assessment of surface water storage and irrigation water has been conducted. Dams are considered to have the potential to act as localised point sources of enhanced recharge to the underlying aquifers with PFAS impacted water.
Investigate potential secondary source areas including irrigation return flow, landfill inputs and flooding along road side areas	Adequate information was collected to allow investigation of these potential secondary source areas. Evaluation of irrigation return water, the former landfill and flood inundation areas has been undertaken. It is considered that irrigation return water could be contributing to the PFAS in groundwater. However, as seepage of PFAS impacted surface water to the underlying aquifer from farm dams and drains occurs in the Investigation Area, it is not clear what contribution is as result of the more dispersed irrigation return

Data gap objective	Data gap conclusion
	water source. Based on groundwater analytical results, the former landfill is considered to be a secondary source of PFAS, based on groundwater results. The zone of impact around the former landfill is considered limited, possibly due to the lower permeability of the Oakey Creek Alluvium aquifer in this area. Available groundwater data indicate a possible correlation between the areas that have been historically flooded and the extent of PFAS within the Oakey Creek Alluvium. However, due to sediment dispersion during flooding, the coarse material is inferred to be deposited on or immediately adjacent to the Oakey Creek Alluvium and fines are transported further with the flood water. Variability in the permeability of the surficial soils may affect the rate of PFAS infiltration to underlying aquifers.
Investigate water interactions (surface water, groundwater, sediment and soil interactions)	The 2017 Stage 2C EI has investigated the migration of PFAS following interaction of surface water with sediment, surficial soils and groundwater. The results of the surface water modelling have been used to assess possible PFAS migration in surface water during flood events (sourced from PFAS in soil and sediment) to on-Site and off-Site areas. Regional and local flood modelling results suggest it is unlikely that PFAS impacted sediments will be mobilised from the Site. Under the local flood modelling scenario, PFAS has the potential to be transferred from impacted surface soils to stormwater as it passes over the soil. Surface water sources and water uses have been considered, in conjunction with sediment, to evaluate the potential for PFAS sources to alter groundwater resources.
Drainage channel characterisation • Soil sampling in drains on- and off-Site • Influence of drains on PFAS migration • Infiltration tests of drain beds • Investigate temporal variability of PFAS in surface water and temporal variability of flow	Investigation of the main drainage channels flowing off the Site included sampling of sediment and soil and leaching tests. PFAS is present in sediment and in underlying soil along drainage channels 1, 2 and 3. Infiltration testing of drain beds has been completed and vertical permeability data have been considered in the assessment of potential for PFAS migration from the drains to the underlying Oakey Creek Alluvium aquifer. Extensive surface water sampling has been undertaken in all creeks proximal to the site. Adequate characterisation data have been collected from Oakey Creek to infer the current distribution of contamination along the creek. The highest PFAS concentrations were detected at sampling locations downstream of the outfalls of drainage channels 1, 2 and 3. Sampling of Doctor Creek located to the northwest of the Site suggests there is no current hydraulic connection with on-Site sources. Temporal variability of surface water quality in Oakey Creek was evaluated. However, no distinct trends were identified in the three years of data available.

Data gap objective	Data gap conclusion
Source area characterisation • Ensure the nature and extent of existing contamination on-Site is properly characterised for all relevant media • Soil sampling on-Site where PFAS have been previously identified or in areas not yet tested • Ensure all potential sources of PFAS on-Site are identified and prioritised in terms of PFAS mass load and potential mobility to groundwater, surface water and biota	An investigation of previously identified potential PFAS source areas was conducted. Interpretation of the new and historical dataset has improved the understanding of the distribution of PFAS contaminants in the on-Site soil profile. In particular, the 2017 Stage 2C EI has improved understanding of the extent of elevated PFAS concentrations in near-surface soil at the former fire training ground. A site-wide groundwater monitoring event was conducted and identified locally elevated PFAS groundwater concentrations close to all active and depleting source areas. Review of the PFAS composition in groundwater indicated samples from areas close to the depleting sources (former fire training ground and former fire station) to have a higher proportion of PFOS and PFHxS compared to active potential sources. An assessment of primary and secondary PFAS sources has been undertaken, to assist with the evaluation of PFAS mass loads within the groundwater transport model.
More certainty around the influence of wind as a transport mechanism	The potential for PFAS transport in wind borne dust was evaluated. The dataset is not consistent with the potential migration of PFAS from the Site in wind-borne dust. The presence of higher PFAS concentrations in surface soil in the Oakey township area is attributed to surface transport of PFAS in floodwater and sediments during inundation events and the use of groundwater containing PFAS for irrigation purposes.
Residential sampling • Continue to monitor groundwater contamination levels where requested by the owner for agricultural enterprises within the current and future Investigation Area	This report presents the results of a sampling program of residential bores, tap water, tanks and pool water and soil across the Investigation Area. The results have been integrated with data from the dedicated groundwater monitoring network installed by Defence within the Investigation Area and residential data have only been used where the property owner has agreed for Defence to use it. Residential sample results have been provided to property owners under separate cover.
Composition of all firefighting foams should be characterised, including the identifiable PFAS suite and total oxidisable precursor assay (TOPA) analysis where foams are fluorinated	The investigation included characterisation of selected samples of soil and water for TOPA analysis from a range of locations across the Site to better characterise PFAS conditions within the Investigation Area. TOPA analysis was conducted to understand the potential for precursor compounds to be present in the Investigation Area. If present, precursor compounds have the potential to transform into PFAS end products. Statistical analysis suggests that the concentration of additional PFAS that can be generated from the transformation of unidentified precursor compounds in soil and groundwater under natural environmental conditions is expected to be low.

Data gap objective	Data gap conclusion
Refinement of the groundwater model • Update of the model conceptualisation based on data compiled during the site investigation works • Refinement of the groundwater model structure, calibration and predictions • Addressing the model limitations through the refinement of the model using new data compiled during the site investigation works • Utilising the model to investigate data gaps and facilitate decision making and inform the OMP	Data evaluation and interrogation has allowed for the assessment of concepts and refinement of the conceptual site model, which is used as the basis of the groundwater model refinement. The key groundwater model updates, forming the Reset Model, included: • a change to MODFLOW SURFACT modelling software for consistency with similar alluvium studies and for ease of forensic review • a reduction in model extent to simulate the plume at a local scale • the addition of three more layers to simulate the Walloon Coal Measures aquifer • an update of model layer structure using data from the most recent field investigations • an evaluation of potential source locations and source discharge rates through calibration. The Reset Model has been conducted in order to facilitate the heterogeneous calibration. The iterative calibration process minimises non-uniqueness that would arise from attempting the all-encompassing model calibration in a single step. The calibrated reset flow model provides parameters that are consistent with the conceptual site model and comparable to other groundwater modelling studies in alluvium systems. The updated model structure allows for further evaluation of potential plume movement within the Walloon Coal Measures aquifer, though the model projections need to be supported by further data before being assessed as reliable. PFOS plume migration, using a conservative approach of continuous contaminant sources in uniform permeable sediments, is predicted to continue in a westerly direction within the groundwater. This modelling allowed for the assessment of contaminant sources and plume shape, which is similar to the field measurements and observations. Future modelling within heterogenic sediments will provide a more robust assessment of migration. The groundwater assessment and model development has improved the understanding of the potential sources of PFOS and the contaminant discharge rate to groundwater. The current process of adding heterogeneity to the Oakey Creek Alluvium will further improve the matching of observed water levels and concentrations in the groundwater regime. The model results will be used to inform the OMP.

Conclusions

Refinement of the conceptual site model (CSM)

The results of the 2017 Stage 2C EI allowed for the following parameters of the CSM to be refined:

- transport mechanisms have been characterised by sampling
- exposure pathways have had data collected for use in the risk assessments
- exposed populations have had data collected for use in the risk assessments.

Generate input data for the 2017 HHRA and 2017 ERA

The following work was conducted to generate additional data for the 2017 HHRA and 2017 ERA:

- collection of soil and groundwater samples within the Investigation Area
- collection of water and sediment samples from locations in Doctor Creek, Oakey Creek and Westbrook Creek
- terrestrial and aquatic biota sampling and habitat surveys.

The additional data and refinement of the CSM will allow the development of the 2017 HHRA and 2017 ERA, which will be reported under separate cover. The data collected in this 2017 Stage 2C EI will be used to refine the groundwater zones in the HHRA report. The groundwater zones are material to the HHRA and will be redefined in the HHRA report.

Ongoing monitoring plan

The data collected as part of 2015 Stage 2B, 2016 Stage 2C, and the 2017 Stage 2C EI will be used to develop an OMP, which will cover both the environmental monitoring program and the residential sampling program. The OMP will be implemented to:

- capture seasonal and temporal variations in groundwater and surface water PFAS concentrations and conditions (in drains and creeks)
- provide early warning indicators for migration of contaminated groundwater
- monitor water levels and aquifer specific conditions.