Stage 2C Environmental Site Assessment, Army Aviation Centre Oakey

Executive Summary

Department of Defence

26 July 2016

60438981
Final

Stage 2C Environmental Site Assessment, Army Aviation Centre Oakey

Executive Summary

Client: Department of Defence

ABN: 68 706 814 312

Prepared by

AECOM Australia Pty Ltd
Level 8, 540 Wickham Street, PO Box 1307, Fortitude Valley QLD 4006, Australia
T +61 7 3553 2000 F +61 7 3553 2050 www.aecom.com
ABN 20 093 846 925

This document is an Executive Summary of the following report: Stage 2C Environmental Site Assessment - Army Aviation Centre Oakey, Doc No. 60438981_RP012_1 (the "Stage 2C ESA Report"), prepared by AECOM (2016).

This Executive Summary is for information purposes only and is not to be used as a basis for decision making and may not be relied upon by any party. For further information regarding the Stage 2C Environmental Site Assessment, including figures, tables, appendices and report sections referred to in the Executive Summary, the reader is requested to refer to the Stage 2C ESA Report.

26-Jul-2016

Job No.: 60438981

AECOM in Australia and New Zealand is certified to the latest version of ISO9001, ISO14001, AS/NZS4801 and OHSAS18001.

Executive Summary

Introduction

AECOM Australia Pty Ltd (AECOM) was commissioned by the Department of Defence (Defence) to undertake a Stage 2C Environmental Site Assessment (ESA) at the Army Aviation Centre Oakey (AACO) in Oakey, Queensland (the Site) and in surrounding off-Site areas (the Investigation Area). The Site location and the Investigation Area are shown on **Figure F1** of **Appendix A**.

The purpose of this ESA Report is to detail the results of the investigations undertaken between August 2015 and April 2016 which have further evaluated the issues identified in previous investigations, and to provide information for the development of a human health risk assessment (HHRA) and ecological risk assessment (ERA).

The Site was constructed in 1943, initially as a training facility and overflow aircraft maintenance depot for RAAF Base Amberley. The Site operates as the Army's helicopter training school for pilots and aviation technicians and is also home to a Republic of Singapore Air Force (RSAF) helicopter squadron. Fire-fighting training services involving the use of aqueous film forming foam (AFFF) have occurred at the Site since the 1970s.

The main AFFF product used historically by Defence was 3M Lightwater™, which contains PFAS including PFOS and PFOA. 3M Lightwater™ was phased out and replaced by Ansulite®, which was reported to contain significantly lower concentrations of PFOS and PFOA (AECOM, 2015a). 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 perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) from 2005. This assumption has not been verified by Defence.

The use of PFAS-containing AFFF for fire training and emergency response activities has created a legacy of contamination at the Site. It is inferred that PFAS (including PFOS and PFOA) have soaked into and accumulated in surface soils, and impregnated concrete and other pavements in the areas where they have been used. Areas affected include AFFF storage and handling areas, fire training areas, former fire stations and locations where AFFF has been used for emergency response actions, such as foaming the runway in advance of a damaged aircraft landing. It appears that the PFAS contamination has been mobilised in rainwater runoff and has impacted the drainage lines flowing off-Site towards the south. PFAS have been detected in water and sediment in the drains and in Oakey Creek. Contamination has also affected groundwater on-Site, which was historically extracted from on-Site bores and used for irrigation and other purposes. Off-Site groundwater has also been affected, with the impacted area extending approximately 4.5 km off-Site to the south-west.

Context of the ESA

Tasks undertaken by AECOM during the period August 2015 and April 2016 for the ESA have included the following:

Residential Water Sampling: Sampling and analysis of bore water (at landholder request to Defence) from residences within and near the Investigation Area. In some instances water was also sampled from rainwater tanks and swimming pools. Surveys of water usage patterns were undertaken. Selected data from this program have been used to inform the ESA.

ESA (this Report): These investigations have included investigation of on- and off-Site PFAS concentrations in soil, sediment, pore water, surface water and groundwater; hydrogeological investigations; development of a groundwater flow model and PFAS solute transport model. Data collected from previous environmental investigations, the residential water sampling program, testing data from Site redevelopment projects and data from the Department of Natural Resources and Mines have also been incorporated into this ESA Report.

Human Health Risk Assessment (HHRA, in preparation): Multiple pathway HHRA to evaluate the potential human health risks to identified receptors within the Oakey area. This report will include consideration of direct contact exposures to environmental media (e.g. soil, groundwater, surface water, pore water and sediment) as well as secondary exposures via dietary intakes, including both fish and home grown plant and animal produce. This assessment includes the development of toxicological profiles for PFAS including PFOS, PFOA, perfluorohexane sulfonic acid (PFHxS) and perfluorohexanoic acid (PFHxA), survey of community for relevant lifestyle factors, and considers data from the ESA (reported separately).

Ecological Risk Assessment (ERA, in preparation): Will assess the potential risk from the identified PFAS contamination to ecological receptors which inhabit habitats present at the Site and surrounding area. The ERA

will also assess the potential for wider ecosystem impacts to result from the accumulation of PFAS in terrestrial and aquatic organisms exposed to PFAS contamination. This assessment includes an ecological survey and utilises data from the ESA (reported separately).

Community engagement: Facilitation of community engagement as related to conduct of the ESA and other tasks as listed above including land access, water and lifestyle surveys and community information events.

Objectives of the ESA

The objectives of the ESA were to:

- further assess the nature and extent of PFAS impacts
- investigate PFAS fate and transport
- refine the conceptual site model (CSM)
- generate input data for the development of the HHRA and ERA.

Note that some of the investigations to meet these objectives have been conducted in parallel to meet Defence's project schedule, with the consequence that some data collection has not been optimised.

Objective: further assess the extent of PFAS impact

Investigations to further assess the extent of PFAS impact have involved drilling of new groundwater wells and soil, sediment, surface water and groundwater sampling and analysis as detailed below:

- undertaking well gauging to provide a snapshot of the groundwater elevation across the Investigation Area (including gauging of a select number of privately owned groundwater abstraction bores)
- using this gauging data to develop up-to-date groundwater contour maps for the Upper and Lower Oakey Creek Alluvium aquifers
- drilling and construction of 21 new groundwater monitoring wells on- and off-Site
- collection of three sediment samples from drainage lines on-Site to further assess contamination identified in the April 2015 sampling event (AECOM, 2015e)
- collection of 20 surface water samples from drainage lines on- and off-Site
- collection of one sediment pore water sample from Oakey Creek
- collection of an additional 12 surface water samples from Oakey Creek, Doctor Creek and farm dams
- collection of sediment samples from each of the above surface water sample locations (i.e. 12 sediment samples) to enable further characterisation of sediments in these waterways
- collection of soil, sediment and surface water samples from appropriate non-urbanised locations up-gradient and cross-gradient to the Site
- collection of soil samples at six locations in areas of the Site where groundwater has been used for irrigation or dust control
- collection of biota, soil and groundwater samples to inform the HHRA and ERA. These data will be reported under separate covers
- laboratory analysis of soil, groundwater, surface water, sediment and pore water samples for the key contaminants of potential concern (CoPC), namely PFOS and PFOA, 6:2 FtS and 8:2 FtS. It is noted that historical AFFF formulations potentially included a wider range of PFAS than just PFOS and PFOA. Hence, 10 percent of samples were screened for a broader range of PFAS
- analysis of 26 groundwater samples and eight surface water samples from drainage lines for a suite of non-PFAS contaminants.

The results are summarised in **Section 4**.

Objective: understand PFAS fate and transport

The following work was conducted to better understand the fate and transport of PFAS in the Investigation Area:

- review of investigation data and comparison with the previous results

- refinement of the hydrogeologic conceptual model
- development of a numerical groundwater flow and solute transport model.

Based on the results of the ESA, the current understanding of PFAS fate and transport is as follows:

- PFAS migrate vertically downward, infiltrating groundwater from source areas through the soil profile to groundwater
- PFAS migrate laterally in surface water runoff from source areas through the drain network across the Site and off-Site areas
- the lateral migration of PFAS in surface water and infiltration of PFAS-containing surface water to groundwater has spread the impact more widely than would have been expected from transport in groundwater alone.

Objective: generate input data for the HHRA and ERA and refinement of the CSM

The results of the ESA allowed the following aspects of the CSM to be refined:

- secondary sources have been characterised by sampling, flow gauging and additional sampling
- transport mechanisms have been characterised by sampling, flow gauging and groundwater modelling
- data have been collected to assess potential exposure pathways identified for the HHRA and ERA.

CONCLUSIONS

Hydrogeology

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) (2016) described the following hydrostratigraphic units, which were incorporated into the groundwater numerical model:

- Oakey Creek Alluvium
- Main Range Volcanics
- Walloon Coal Measures.

The Oakey Creek Alluvium was subdivided into four distinct units:

- **Surficial sediments**: The Oakey Creek Alluvium is flanked by Tertiary-aged colluvium and basalt (GSQ, 1980). The colluvium consists of cemented scree deposits and rock debris that overlie the Main Range Volcanics (basalt). Also overlying the Oakey Creek Alluvium in lower lying areas are unconsolidated unsaturated sediments consisting of soil and clay. These unconsolidated surficial sediments, representing the uppermost soil, clay and colluvium, are typically unsaturated but not always. These sediments have been classified as the uppermost model layer (Layer 1). The thickness of the surficial sediments based on an assessment of borehole lithological data is typically less than 10 m but can be up to 25 m thick.
- **Upper Oakey Creek Alluvium**: The Upper Oakey Creek Alluvium is composed of discontinuous sequences of sand, silt, gravel and clay. In some areas clayey lenses isolate sandy horizons causing localised perched zones within the Upper Oakey Creek Alluvium. Overall the grainsize tends to increase with depth. In comparison with the Lower Oakey Creek Alluvium, the Upper Oakey Creek Alluvium tends have a higher clay content, causing the upper aquifer to have a lower bulk hydraulic conductivity and generally lower groundwater yields than the lower aquifer.

  Examination of borelogs indicates that in some areas there is a discontinuous clayey horizon at the base of the Upper Oakey Creek Alluvium, which can partially confine the Lower Oakey Creek Alluvium aquifer. Typically, the maximum depth of the Upper Oakey Creek Alluvium is approximately 18 to 20 m below ground level at the Site. The main distinction between the upper and lower aquifers is the higher groundwater yield of the lower aquifer, which often makes a distinction based on lithological variations difficult. Based on an assessment of borehole lithological data, the Upper Oakey Creek Alluvium is up to 25 metres thick. The Upper Oakey Creek Alluvium forms Layer 2 of the groundwater model.
- **Lower Oakey Creek Alluvium**: The Lower Oakey Creek Alluvium is composed of sand, silt, gravel and clay but with a higher percentage of sands and gravels and less clay than the Upper Oakey Creek Alluvium. Consequently, the Lower Oakey Creek Alluvium has a higher groundwater yield than the upper aquifer and tends to be the primary groundwater resource in the Oakey area. The Upper Oakey Creek Alluvium, based

on an assessment of borehole lithological data, is up to 55 m thick, centred north of the current Oakey Creek alignment. The Lower Oakey Creek Alluvium forms Layer 3 of the groundwater model.

- **Basal clay transition zone**: Review of available borelogs indicates there is a basal clay layer (transition zone) below the sands and gravels of the Lower Oakey Creek Alluvium and above the basement rock. This layer is a combination of low permeability basal alluvial clays of the Oakey Creek Alluvium and the weathered upper part of the Walloon Coal Measures or the Main Range Volcanics. The transition zone forms an aquitard between the Oakey Creek Alluvium and the underlying bedrock, where present, restricting or preventing the mixing of groundwater and contamination between the aquifers. The basal clay was encountered during drilling on-Site in deep borehole MWA4-B-BB, which was constructed to a depth of 50 metres. The lithology intersected at the base of the borehole consisted of alluvium composed of stiff clay and clasts of weathered basalt. The thickness of the transition zone averages approximately 10 m and forms Layer 4 of the groundwater model.

The Main Range Volcanics and Walloon Coal Measures variably underlie the Oakey Creek Alluvium and form Layer 5 in the groundwater model.

Contaminants of potential concern

PFOS, PFOA, 6:2 FtS and 8:2 FtS were previously nominated as the key CoPC for the Investigation Area, along with petroleum hydrocarbons on-Site.

Selected samples collected for this ESA were submitted for analysis for an extended suite of PFAS. The additional analytical testing indicates that the PFAS CoPC include some additional PFAS, particularly in the case of sediment and surface water samples. These additional PFAS detected include:

- Perfluorohexanoic acid (PFHxA)
- Perfluorohexane sulfonic acid (PFHxS)
- Perfluorobutane sulfonic acid (PFBS)
- Perfluorobutanoic acid (PFBA)
- Perfluoroheptanoic acid (PFHpA)
- Perfluoroheptane sulfonic acid (PFHpS)
- Perfluoropentane sulfonic acid (PFPeS)
- Perfluoropentanoic acid (PFPeA)
- Perfluorodecanoic acid (PFDcA or PFDA)
- Perfluorododecanoic acid (PFDoA or PFDoDA)
- Perfluorononanoic acid (PFNA)
- Perfluorotetradecanoic acid (PFTeA or PFTeDA)
- Perfluorotridecanoic acid (PFTriA or PFTrDA)
- Perfluoroundecanoic acid (PFUnA or PFUnDA)
- Perfluorooctane sulphonamide (PFOSA or FOSA).

A number of non-PFAS CoPC were detected in groundwater samples from monitoring wells on-Site, including TRH, Bis(2-ethylhexyl) phthalate, arsenic, chromium, copper, nickel and zinc. A number of groundwater samples exceeded the adopted criteria for copper, nickel and zinc, and one sample (MWA5) exceeded the adopted criterion for Bis(2-ethylhexyl) phthalate.

A number of non-PFAS CoPC were also detected in surface water samples from drainage lines, including toluene, total BTEX, TRH, Bis(2-ethylhexyl) phthalate, arsenic, copper, nickel and zinc. A number of surface water results exceeded the adopted criteria for copper and zinc. All other results were below the adopted criteria.

TRH exceeded the adopted criteria at four monitoring wells on the western and southern Site boundary over the three GMEs (MWA4-B-UA, MWA4-B_LA, MWA4-B-BB and MWG1-A-LA). For the most recent round of monitoring (May 2016), the maximum TRH result was 120 µg/L for TRH C_{16}-$C_{34,}$ close to the adopted guideline of 90 µg/L. This result was recorded at well MWA4-B-BB, a deep well on the southern Site boundary. It is noted that

TRH contamination exists on-Site, particularly near the C1 area carpark (refer to **Figure F2**), however TRH has not been detected in the groundwater on-Site in the vicinity of this well in area B5 (Coffey, 2011). It is considered that these TRH results could be related to naturally occurring organic matter in the groundwater (silica gel cleanup was not requested for these samples).

Elevated concentrations of copper, nickel and zinc detected at locations MWB3-A, MWA5-A-UA, MWA5-A-LA and MWG1-C-LA (in the central area of the Site and on the western and southern Site boundary) are considered likely to be naturally occurring. The results are consistent with groundwater data previously gathered by Coffey. Coffey (2011) stated '*concentrations of copper and zinc were reported above the nominated ILs* [Investigation Levels] *in the majority of monitoring wells. As the concentrations of metals identified were generally consistent across the AACO, including both up gradient and down gradient locations, they are considered to be representative of regional aquifer conditions'.* Arsenic was detected in surface water and groundwater at low concentrations, comparable to the LOR. The concentrations of copper, nickel and zinc detected by AECOM are comparable to the concentrations reported by Coffey (2011). Bis(2-ethylhexyl) phthalate was detected during sampling at one well (MWA5-A-UA) in November 2015, but was not detected in the two subsequent sampling rounds (February and May 2016), so is not considered to be of concern.

These results confirm that PFAS are the key CoPC for the Investigation Area, along with petroleum hydrocarbons on-Site.

PFAS behaviour

Where AFFF has been historically discharged, either at fire training areas or in an emergency response, PFAS accumulate in the soil profile or soaks into pavements. Rainwater leaching carries the highly soluble chemicals to the groundwater table, and surface water runoff dissolves PFAS and carries it to surface water drains.

While AFFF containing PFOS and PFOA as active ingredients is no longer used at the Site, residual PFAS concentrations in soil, in sediments in drains and from pavements have shown PFAS can leach to surface and groundwater.

Excavation and landfilling of PFAS impacted soil could also create additional source areas.

A numerical groundwater model has been developed based on multiple data sources including information from the Queensland Department of Natural Resources and Mines. The model has been used to evaluate potential historical and future groundwater and PFAS movement behaviour.

Groundwater impact

Collated data on PFAS impacted groundwater and the results of the solute transport modelling indicate the following:

- PFAS impacted groundwater has migrated off-Site from the multiple source areas on-Site in a west/south-westerly direction towards Oakey Creek. The extent and orientation of the plume is more southerly than would be expected based on the predominantly westerly groundwater flow direction beneath the Investigation Area
- In general, it appears PFAS concentrations in the Upper Oakey Creek Alluvium were greater than concentrations in the Lower Oakey Creek Alluvium. The presence of PFAS in the Lower Oakey Creek Alluvium shows that there is a degree of connectivity between the two aquifers
- The contaminant movement is interpreted to be influenced by:
    - groundwater pumping from bores drawing from the Oakey Creek Alluvium
    - migration of PFAS impacted surface water along southerly oriented unlined drains and Oakey Creek, and infiltration to groundwater
    - mobilisation of PFAS along Oakey Creek during periods of flow, and recharge of the solute from the stream flow into the groundwater system at considerable distances downstream of the Site
- Groundwater modelling predicts only minor further migration of the PFOS and PFOA groundwater plumes after 10 years. After 100 years, the PFOS and PFOA groundwater plumes are predicted to migrate further to the west, which is consistent with the general groundwater flow in the alluvium. The 100-year simulations also predict movement of contaminants in a south-westerly direction under Oakey Creek for approximately 2 km for all the modelled scenarios.

Surface water and sediment Impact, drainage lines

A total of 41 sediment samples have been collected from 20 locations in the four drainage lines. PFAS were detected in 38 of the 41 samples collected, with the maximum concentrations of PFOS and PFOA 3.68 mg/kg and 1.05 mg/kg, respectively. None of the samples analysed exceeded the adopted residential soil criteria. Two pore water samples were analysed from sediment samples collected from drainage lines (reported in the AECOM (2015e) investigation). These results indicated that concentrations of PFOS of 0.0645 mg/kg and 0.0580 mg/kg in sediment samples correlated to concentrations of PFOS in pore water of 2.48 µg/L and 3.10 µg/L, respectively.

Concentrations of PFAS were detected in all surface water samples collected from both on- and off-Site drainage lines. Five surface water samples from four locations in drainage lines have exceeded the adopted criteria since 2014. The highest result for PFOS was recorded at SW15 in drain 2 off-Site (3.04 µg/L in December 2014).The highest result for PFOA was recorded at SW21 in drain 3, near the fire training facility (15.5 µg/L in August 2015).

In addition, TRH concentrations were consistently reported in surface water samples collected from both on- and off-Site drain locations during all sampling events (no criteria are available for TRH in surface water). TRH concentrations were consistently reported in surface water samples collected from both on- and off-Site drain locations during all sampling events. Assessment criteria for the protection of freshwater ecosystems have not been established for TRH in surface water. However, a review of the detected TRH concentrations and their locations within the drain network on- and off-Site to the south indicated that the concentrations were generally highest in drain 2 at locations on, or near, the Site boundary. In the most recent sampling event in May 2016, TRH was detected at low concentrations (close to the limit of reporting (LOR)) in the most downstream sample (SW13), which was collected from drain 2 at the confluence with Oakey Creek.

Copper and zinc were also recorded in surface water samples collected from drains located both on- and off-Site – these concentrations are considered to be naturally occurring.

The data indicate:

- the highest concentrations of PFAS were detected in surface water and sediment in drainage lines on-Site, with concentrations declining down-gradient
- PFOS and PFOA were generally not the PFAS with the highest concentrations in surface water and sediment, with 6:2 FtS recording the highest PFAS result for surface water and 8:2 FtS the highest result for sediment.

These results indicate that the drainage lines represent both an ongoing source of contamination on- and off-Site and a pathway for migration of contamination from the Site.

Surface water and sediment impact, Oakey Creek and Doctor Creek

A total of 28 samples have been collected from Oakey Creek and Doctor Creek since 2014, with one sample exceeding the adopted criteria. This sample was collected from SW18, to the south of the Site near where drains 1 and 2 discharge to Oakey Creek.

A total of 30 sediment samples have been collected from 23 locations in Oakey Creek and Doctor Creek. The maximum PFOS concentration detected was 0.0094 mg/kg, collected to the south of the Site near where drains 1 and 2 discharge to Oakey Creek. PFOA was not detected in sediment samples from Oakey or Doctor Creek. None of the results exceeded the adopted criteria.

Soil impact

Review of the soil analytical results from the ESA together with the available historical data indicates:

- 149 soil samples (excluding QA samples) from 50 locations on-Site have been analysed for PFAS
- 25 soil samples from five locations off-Site have been analysed for PFAS
- of these samples, PFOS was detected in 59 samples on-Site and one sample off-Site (BHO-B surface sample, 0.0007 mg/kg)
- PFOA was detected in 22 samples on-Site. PFOA was not detected in soil samples analysed from off-Site locations
- eight soil samples have been analysed for the extended PFAS suite. PFHxA was detected in one sample and PFHxS was detected in two samples. Both of these samples were collected from BHA5 in the saturated zone, from depths of 15.5 and 18.5 m bgs, respectively

- one sample, N_G_0.8, recorded a concentration of 30 mg/kg of PFOS, which exceeded the adopted assessment criteria. This sample was collected from near the former fire training area during a previous investigation (Coffey, 2011). None of the other soil samples exceed the adopted assessment criteria, although it should be noted that the adopted residential soil criteria for on-Site soil samples may not be protective of groundwater or surface water quality, as low concentrations of PFAS in soil readily leach into groundwater and surface water
- PFAS detections in soil samples were generally recorded in samples collected from the top 0.5 m or from the saturated zone of the Oakey Creek Alluvium (typically around 15 to 20 m bgs), although PFAS were also detected in some samples analysed from depths of 0.5 to 3 metres.

Future Considerations

The results of the ESA provide an improved understanding of the nature, extent and potential migration of PFAS contamination within the Investigation Area based on data collected between 2014 and early 2016. It is understood Defence will undertake further assessment to address important limitations in the current understanding of PFAS contamination arising from AACO within the Investigation Area. It is understood the outcomes of this ESA will inform these further assessments and will also inform ongoing environmental monitoring and future management decisions in relation to PFAS contamination arising from AACO. The further assessments and ongoing monitoring programs of work will be developed in consultation with the Queensland Government.