NEWCASTLE SAND

APPENDIX 12. PFAS EXPOSURE PATHWAYS REVIEW

Williamtown Sand Syndicate – Review of Per- and Polyfluoroalkyl Substances Exposure Pathways

298 Cabbage Tree Road, Williamtown, New South Wales, 2318

20213676.001A

Date when final

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Subject: Williamtown Sand Syndicate – Review of Per- and Polyfluoroalkyl Substances Exposure Pathways
298 Cabbage Tree Road, Williamtown, New South Wales, 2318

Kleinfelder Australia were engaged by Wedgetail Project Consulting, on behalf of the Williamtown Sand Syndicate (WSS) to undertake a review of the 2020 quarrying activities and determine whether these activities have changed the potential for local residents to be exposed to per- and polyfluoroalkyl substances (PFAS). PFAS in the WSS quarry area. PFAS contamination is related to contamination at and from the Department of Defence (DoD) Williamtown Royal Australian Air Force Base ("the Base"). PFAS have been identified in sediment, surface water, groundwater and biota (terrestrial and aquatic) within and surrounding the Base.

The WSS quarry is located at 298 Cabbage Tree Road, Williamtown ("the Site") and is situated partially within the New South Wales Environment Protection Authority (EPA) defined Williamtown Management Area (WMA). The Site is located within the WMA broader management zone, defined as an area where PFAS could be identified at the current time and into the future. EPA precautionary advice to minimise PFAS exposure within the broader management zone includes avoiding the use of groundwater and surface water and consuming home-grown produce.

This report forms the requirement to Schedule 3 Condition 48 in the Development Consent SSD-6125 which requires an assessment of whether or not quarrying operations are increasing the risk of PFAS exposure for local residents and the environment.

Since 2007 the DoD have been investigating the PFAS presence in various media at and surrounding the Base. The investigations have included multiple rounds of soil, sediment, surface water and groundwater sampling within the EPA defined WMA. Additional off-Base PFAS surface water and groundwater PFAS fate and transport models and human and ecological health risk assessments have also been conducted. The human health risk assessment identified four "risk zones" designated as Zones A through D and corresponding with a risk hierarchy such that Zone A is the highest risk and Zone D is the lowest. Part of the Site is situated within the low risk zone C, with the north-eastern Site area located outside the defined risk zones. Zones C and D broadly correspond with the WMA broader management area.

A review of the available information, that includes the Site setting, PFAS sampling and analysis undertaken at the Site and those conducted by the DoD at the Base and surrounding area leads to the following conclusions:

- PFAS are not present in Site soil, surface water or groundwater.
- PFAS migration from primary or secondary Base sources are unlikely to result in PFAS migrating to the Site.
- The proposed quarry minimum extraction elevations are sufficiently above the maximum observed local water table and comply with conditions set out in the quarry licence.

The DoD-commissioned human health risk assessment determined that the Site is within PFAS Risk Zone C for impacts originating from the Base. The risk assessment review compared the upper exposure scenario (i.e., highest concentration) for risk zone C with potential exposures from the quarry and concluded:

- Quarrying operations will not increase the PFAS risk to residents because:
  - PFAS have not been identified in the tested Site media and are therefore unlikely to impact nearby residents at unacceptable levels.
  - The Base PFAS groundwater plumes will not intersect the eastern Site boundary prior to 2050, with the predicted PFAS concentrations unlikely to exceed human health drinking water criteria until significantly after 2050, if at all.
  - Quarrying operations may result in the establishment of a groundwater mound, however, this is unlikely to change the current groundwater flow regime.

Historical prevailing wind directions and dust mitigation measures undertaken by the quarry will not result in additional PFAS impacts to nearby residents.

1 INTRODUCTION & OBJECTIVES

Wedgetail Project Consulting commissioned Kleinfelder to undertake a review of DoD and the NSW EPA information regarding PFAS contamination that originated from the Williamtown Royal Australian Air Force (RAAF) Base ("the Base"). The Site is within the NSW EPA declared WMA.

The WMA was established by the NSW EPA following DoD commissioned testing of sediment, soil, groundwater, surface water and aquatic and terrestrial biota which identified a large area affected by PFAS contamination originally sourced from the Base (**Figure 1**). The EPA management area is comprised of three zones:

- Primary – high PFAS concentrations have been observed.
- Secondary – low PFAS concentrations have been identified.
- Broader – topography and hydrology are used to suggest that PFAS could be identified in the future.

The Site is within the broader management area where the Site's eastern boundary is 1.4 km from the Base's western boundary.

In accordance with Condition 48 of the quarry approval note an annual review of the current available PFAS information relating to PFAS exposure pathways for contamination originating from the Base is required to be conducted. The review is to assess if the quarrying activities have resulted in an increased PFAS exposure for local residents. Condition 48 states the following:

> *"In conjunction with preparation of each Annual Review, unless otherwise agreed with the Secretary, the Applicant shall engage a suitably qualified and experienced independent expert, approved by the Secretary, to review the currently available information on exposure pathways for PFAS contamination originating from the Williamtown RAAF Base, as may be applicable to local residents and the development. This report must assess whether or not quarrying operations are increasing the risk of PFAS exposure for local residents and/or the environment, to the satisfaction of the Secretary. The Applicant must ensure that the Review of PFAS Exposure Pathways reports are placed on its website and are available to the CCC and any interested person on request."*

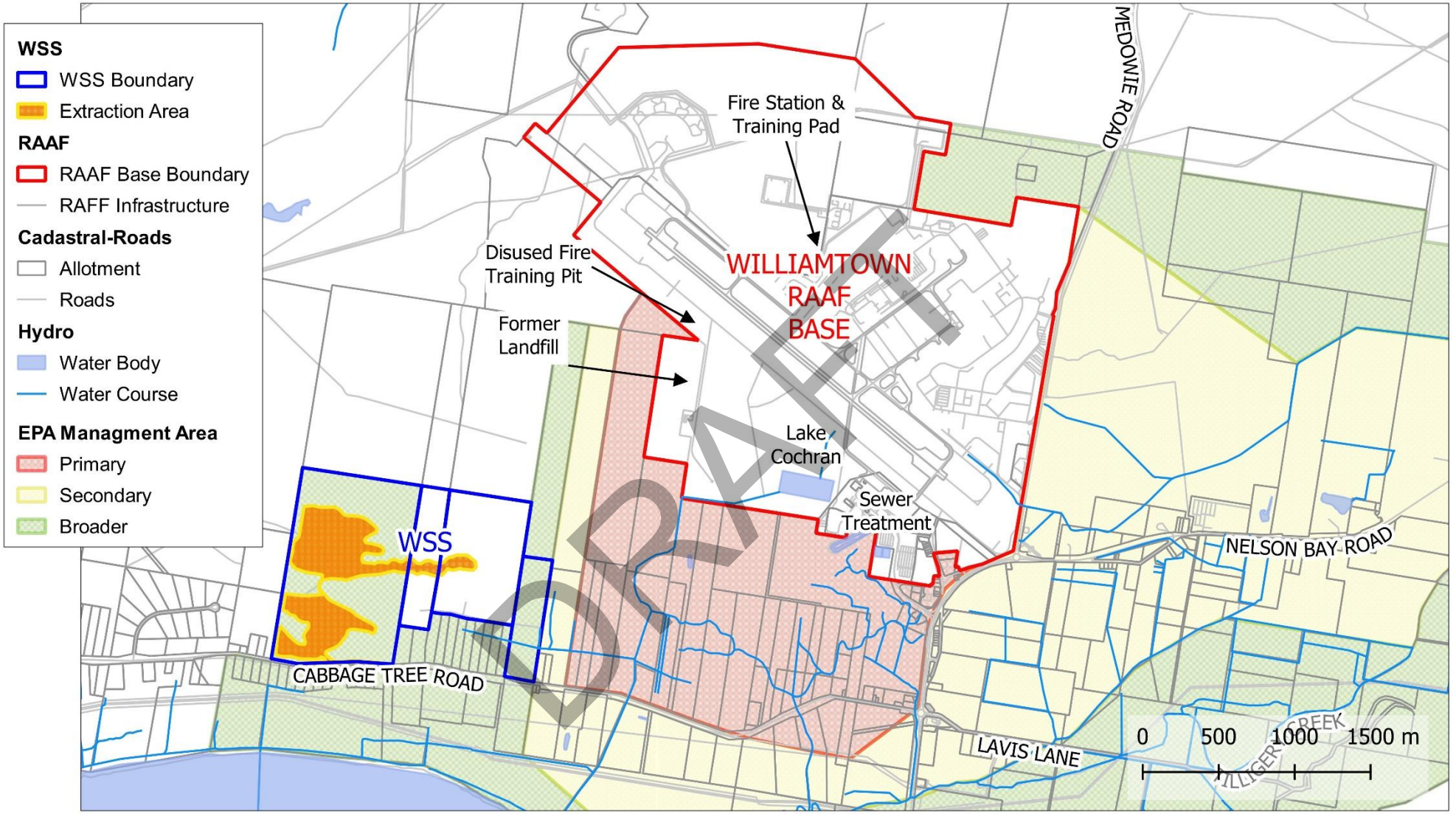

Figure 1. Site regional context

2 OBJECTIVE

The objective of this review is to assess if the quarrying activities have resulted in an increased PFAS exposure for local residents.

3 SITE SETTING

The site is located approximately 1.4 km to the southwest of the Base's western boundary. The general land use in the vicinity of the Site is large-lot residential and farming. Residential properties are located to the Site's west and south with larger allotments located along the eastern and northern boundaries. The Tilligerry Habitat Reserve forms part of the western and northern Site boundaries.

The Williamtown area receives a mean annual rainfall of 1,100 mm, with the highest rainfall months typically between January and June, where the monthly mean rainfall typically exceeds 100 mm. Mean monthly temperatures range between 17°C and 28°C, indicating the climate is warm temperate. The prevailing 9 AM wind directions at the Base are northwesterly (25%) and westerly (22%), i.e., away from the Site. Calm is the third most common observation (15%). Wind directions toward the Site are northeasterly (6%) and easterly (5%). Predominant 3 PM wind directions are southeasterly (24%) and southerly (16%). Afternoon wind directions toward the Site are easterly (14%) and northeasterly (8%).

Geologically the Site is located within the Tomago Sandbeds, a linear series of shallow sand dunes that cover approximately 200 km^2 between Newcastle and Lemon Tree Passage, that have a mean thickness of 20 metres. The beds were deposited from the Hunter and Karuah rivers during a period of high sea level and overlie clay and rock. The aquifer is the Tomago Sandbeds, with the underlying clay and rock generally acting as a barrier to vertical groundwater migration. The DoD 2019 groundwater hydraulic gradients indicates a potential southerly groundwater flow direction (**Figure 2**).

The Tomago Sandbed aquifer which forms an important water resource in the area. The low salinity groundwater combined with relatively shallow water table depth (mean depth 1.5 m below ground level) in the area have, historically resulted in the extensive use of the resource as a stock watering, irrigation and as a drinking water supply.

There is a well-developed man-made surface waterway network within the Williamtown area. Site surface water runoff may discharge to two unnamed surface water channels; one channel discharges directly to Fullerton Cove and the other joins Dawsons Drain, approximately 650 metres from the Site's eastern boundary. Within the Base Lake Cochran acts as a stormwater collection point which also discharges to the off-Base Dawsons Drain and ultimately Fullerton Cove to the South.

4 2020 QUARRYING ACTIVITIES SUMMARY

The quarry occupies four land titles and has an area of 175 hectares (ha), with the extractable sand resource occupying 43 ha. Approximately 3.25 megatonnes of sand is planned to be quarried from elevated areas over a period of 15 years. Sand will be excavated from an elevation of 24 mAHD to an elevation no less than 0.7 metres above the highest estimated water table elevation. The anticipated minimum excavation elevations are 3.8 mAHD in the north and 3.4 mAHD in the south.

Groundwater is not being extracted by the site operators for quarrying operations, which rely on water sourced from Hunter Water. WSS have commenced a comprehensive groundwater and surface water monitoring program to assist with potential migration of PFAS from the Site and to ensure that sand is not extracted from an elevation less than 0.7 metres above the maximum water table elevation.

Works that occurred during 2020 at the Site include:

- Completion of Site infrastructure construction.
- Beginning in May sand was quarried or exported from Sector 1 (see **Figure** 3).

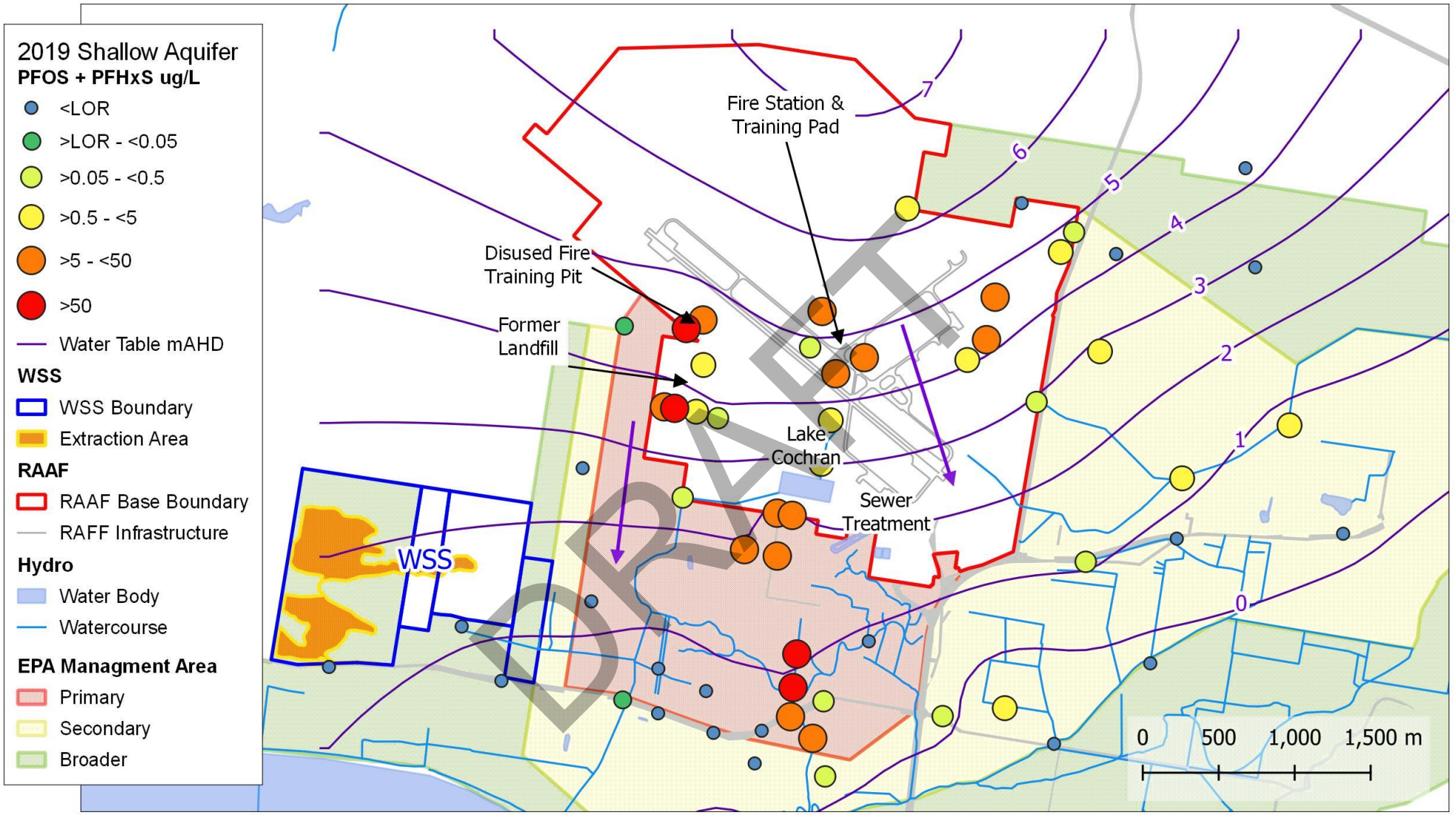

Figure 2. May 2019 water table elevations, potential groundwater flow direction and shallow groundwater sample PFOS + PFHxS concentrations.

5 SUMMARY OF PFAS INTESTIGATIONS IN THE WMA

PFAS contamination of surface water, groundwater, sediment and aquatic and terrestrial biota within and surrounding the Base has been reported by both the NSW EPA and DoD. A list of reports is available at www.defence.gov.au/environment/pfas/Williamtown/publications.asp.

The contamination is understood to have been the result of the use of aqueous film-forming foam used during firefighting and emergency response training. The known PFAS contamination sources at the Base are:

- Primary sources – Fire station, two landfills and a disused fire training pit.
- Secondary sources – Lake Cochran, the trade waste treatment plant (eastern Base area) and sewage treatment plant.
    - The trade waste treatment plant is not considered a possible source for PFAS contamination that may occur at the Site.

The surface soil samples collected outside the Base boundaries have been predominantly collected across the southern boundary, south of Lack Cochran and the sewerage treatment area. The PFOS + PFHxS concentrations, which generally make up approximately 90% of the total PFAS concentrations in the Williamtown Management Area, in the off-Base surface soil samples range between the laboratory limit of reporting (LOR), 0.2 and 375 micrograms per kilogram (µg/kg). Two soil samples were collected between the Site and the Base's western boundary. The PFOS + PFHxS concentrations in soil were 0.5 and 0.7 µg/kg, with the closest sample to the Site 350 metres northeast (1.3 km from the disused fire training pit (i.e., a primary PFAS source) and 1.1 km from a former landfill (i.e., a secondary PFAS source).

PFOS + PFHxS concentrations above the laboratory LOR (>0.2 to <10 µg/L) have been observed in all surface water samples collected from channels that receive discharge from the Base. Based on the local drainage network, surface water is not considered a likely pathway for PFAS from the Base to the Site

On- and off-Base PFAS groundwater investigations have focused on the Tomago Sandbed aquifer with shallow and deep groundwater samples collected and analysed. This review focusses on PFAS concentrations in the shallow aquifer.

The 2019 groundwater Base PFAS monitoring results are summarised in **Figure 2**. PFOS + PFHxS concentrations above the laboratory LOR were observed to the south of Lake Cochran, beneath the disused fire training burn-pit, former landfill and current fire station and training pad. From the data reviewed it is evident that there is a groundwater mound to the south of Lake Cochran, suggesting the lake is providing groundwater recharge and is consistent with high PFOS + PFHxS concentrations observed down-gradient from the Lake.

As shown on **Figure 2** the Site is not directly down-hydraulic gradient from any known primary or secondary Base PFAS source.

With regards to the Base groundwater fate and transport model four "unidentified" PFAS sources (surface water, soil and or groundwater) located to the Site's south were identified. It is possible that one of these sources, located near the Cabbage Tree Road Dawsons Drain bridge is associated with the Lake Cochran discharge. The three other low PFAS concentration occurrences are located to the Base's south and cannot be directly linked to the source at the Base. The three locations are:

- One Base groundwater monitoring well and three residential monitoring wells located on Cabbage Tree Road, directly south of the Site.
- Groundwater from a residential well located 550 metres to the Site' south.
- Groundwater from a residential bore located to the south of lot DP629503. It is noted PFAS were not present above the laboratory LOR in a 2019 groundwater sample from MW139 located approximately 75 metres up-hydraulic gradient from the residential well.

The PFAS groundwater fate and transport model estimated:

- The Base PFAS groundwater plume areas may expand through PFAS dispersion and diffusion.
- That by 2050:

- The disused fire training pit and former landfill plumes may merge, although it is noted that the merged plume is unlikely to intersect the Site's eastern boundary.
- The Lake Cochran PFAS plume should not intersect the Site's eastern boundary.

- The probable Lake Cochran sourced off-Base groundwater "unidentified" PFAS occurrence is beneath the Site's DP814078 parcel (eastern Site area) and has total PFAS concentrations between 0.01 and 0.07 µg/L.

6 SITE WATER TABLE ELEVATIONS AND PFAS

PFAS investigations commissioned by WSS at the Site have involved submission of soil, surface water and groundwater samples to a laboratory that has National Association of Testing Authorities (NATA) accreditation to determine PFAS concentrations in the submitted media.

6.1 Soil

Sixteen soil samples collected from 10 bore holes between 7 and 17 December 2016 were submitted for PFAS analysis. The samples were all collected from elevated Site areas where sand quarrying is proposed to be undertaken. All samples, including two samples collected within the eastern Site area, i.e., closest to the Base were reported to have total PFAS concentrations below the laboratory LOR.

6.2 Surface Water

Surface water is monitored at four Site locations.

Thirty surface water samples collected from three locations between January and December 2020 were submitted for PFAS analysis, with two locations dry in January 2020. The 2020 surface water results are summarised below:

- One surface water location (SW2) was dry during each monitoring event.
- PFOS was the only PFAS reported above or equal to the laboratory LOR (0.01 µg/L), with the concentrations in six samples ranging from 0.01 to 0.02 µg/L.
    - Five samples with PFOS concentrations above the laboratory LOR were collected from the SW4 location, with the other sample was collected from SW1.

During the 2019 monitoring two samples collected from SW4 were above the laboratory LOR (0.03 and 0.05 µg/L). SW4 is located at the Site's southeast corner of the eastern-most land parcel (DP814078), above the "unidentified" groundwater PFAS source. The data from the 2020 monitoring confirms there is a PFAS source located near the surface water sampling point.

The February 2020 SW1 water sample, collected from the Cabbage Tree Road – Site entry intersection was reported to have a PFOS concentration of 0.02 µg/L. PFAS were not above the laboratory LOR in the other eight samples collected from the location.

- The PFOS concentrations were below the National Medical Research Council (NHMRC) drinking water criteria of 0.07 µg/L.
- The SW4 location indicates there is a PFAS source near the sampling site.

6.3 Groundwater

Groundwater samples were collected using the HydraSleeve method, using high-density polyethylene HydraSleeves with the samples transferred directly into laboratory supplied PFAS containers. The method is considered suitable for the collection of water samples to assess for non-volatile chemicals[1].

Twelve groundwater monitoring bores have been installed and sampled at the Site (BH01 to BH12). Groundwater from MW239S, located within the DP629503 land parcel was installed during the DoD investigations. Groundwater from the well reported to have 0.03 µg/L PFOS in March 2017 and during the WSS monitoring has was sampled once in 2019 and five times in 2020. BH10 has been dry since installation, BH9 has had a water column of less than 0.5 m on two occasions (August and September 2020) since installation. Two wells have been decommissioned (BH3 and BH9) and BH9A was installed as a replacement for BH9 in September 2020.

[1] Environment Protection Authority Victoria, 2000. Groundwater sampling guidelines. Publication 669.

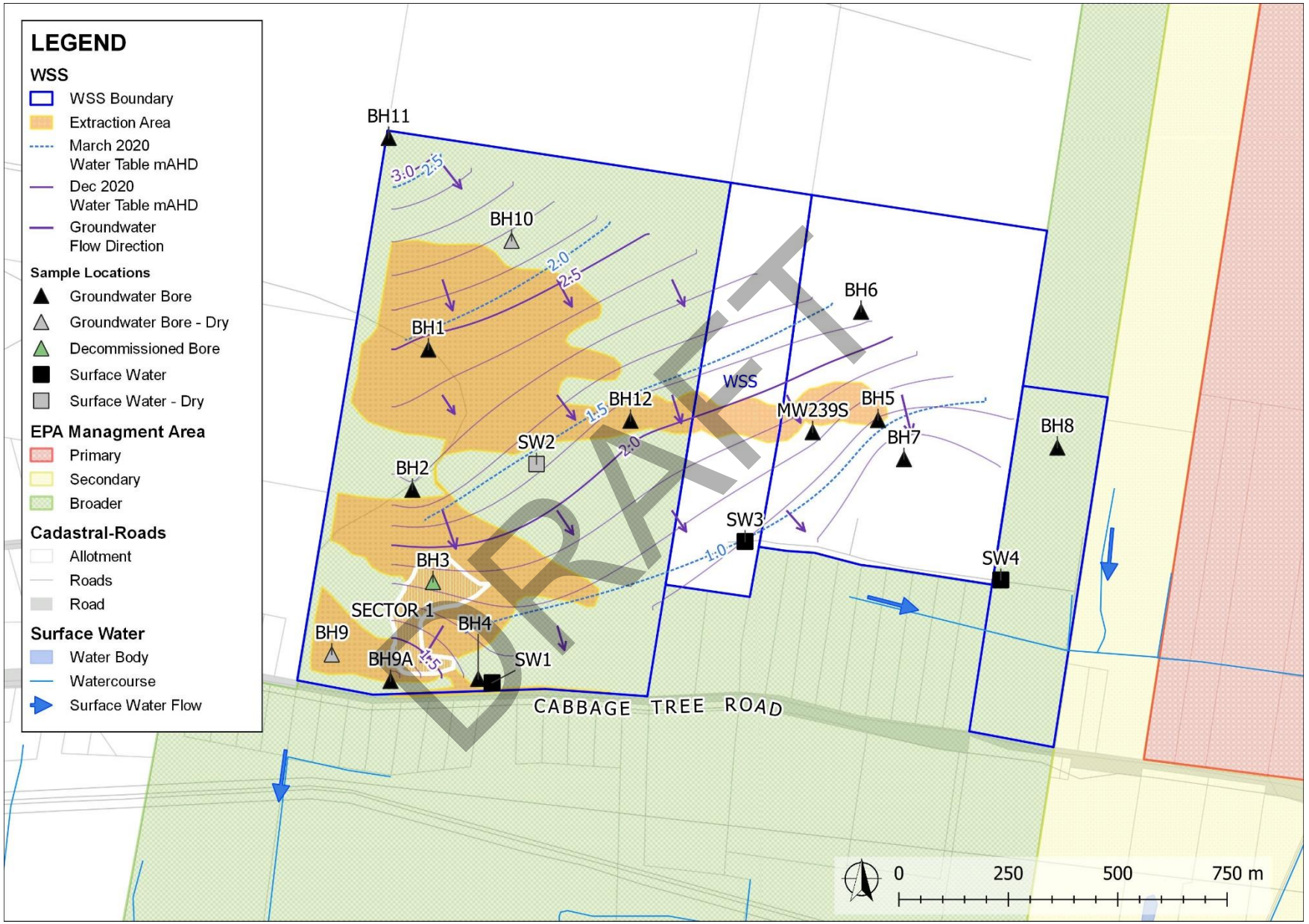

Figure 3. 2020 sampling locations and water table elevations

During the 2020 monitoring the majority of wells were sampled on a monthly basis, although BH2, BH11 and MW239S groundwater was sampled from August to December and BH12 groundwater was only sampled in August.

March and December 2020 water table elevations for the Site wells are provided on **Figure 3**, where it is evident that there is a close correspondence to the AECOM May 2019 measured water table elevations. Overall, during 2020 the water table at the Site varied by approximately 1 mAHD. during 2020, with the highest elevations generally occurring between August and December. The water table elevation contours indicate a southeasterly groundwater flow direction, consistent with the 2019 contours.

During the monitoring period the maximum water table elevation was 0.9 m below the proposed quarrying base in the north (3.8 mAHD; BH01 maximum water table elevation = 2.6 mAHD) and 1.3 m below the proposed base in the south (3.4 mAHD; BH04 maximum water table elevation = 2.1 mAHD). These maximum water table elevations are greater than 0.7 m below the proposed quarry base.

Groundwater rainfall recharge within the sands is likely to be relatively rapid. The removal of sand above the Site aquifer may result in groundwater mounding, due to increased infiltration and lower evapotranspiration although the mound would likely dissipate in the short-term due to the high effective porosity of the sands. If a groundwater mound does form beneath the quarried areas it would be unlikely to significantly change the groundwater flow direction and is more likely to result in producing a steeper off-Site hydraulic gradient. The likelihood that the quarrying would lead a change in groundwater flow direction and increased groundwater flow from the Base to the Site area is very low.

Seven groundwater samples were analysed for PFAS in 2016 and 2017 with all PFAS reported below the laboratory LOR. Between January and December 2020 groundwater samples from ten monitoring wells (total = 68 samples) were submitted to the laboratory for PFAS concentration determination.

One groundwater sample from BH9 (August) was reported to have a total PFAS concentration of 0.14 µg/L, with all other samples were below the laboratory LOR, with the PFAS reported 6:2 FTS (fluorotelomer sulfonate). 6:2 FTS is rarely above the laboratory LOR in the DoD groundwater samples (two samples out of 98 had low 6:2 FTS concentrations (<0.12 ug/L) during the 2019 DoD monitoring. The DoD monitoring wells with 6:2 FTS above the LOR are located to the Bases' northeast.

It is noted that from the 2019 WSS monitoring a low 6:2 FTS concentration (0.19 ug/L) was reported for BH6 groundwater and a low PFDS equal to the LOR 0.02 µg/L was reported for BH4 groundwater, however the concentrations were below the laboratory LOR in follow-up samples.

In summary:

- 2020 water table elevations and potential groundwater flow direction are consistent with the observed 2019 direction
- 6:2 FTS is not a COPC at the Base and is unlikely to represent PFAS migration from the Base.

7 DOD HUMAN HEALTH RISK ASSESSMENT REVIEW

In 2016 the DoD engaged AECOM to undertake an off-site human health risk assessment (HHRA). The off-Site HHRA was updated in 2017. A summary of the findings of the updated HHRA and relevance to the Site area are provided below.

The HHRA evaluated the potential health risks in the Williamtown area to residents (including recreational and commercial fishers and beef farmers) and non-residents (commercial fishers, council workers and visitors) from exposure to PFAS under both typical and upper exposure scenarios. The exposure scenarios are:

- Typical exposure scenario:
    - Representative of PFAS concentrations that a general or average receptor is likely to be exposed. This is applicable to the majority of the population.
- Upper exposure scenario:

- Calculated based on the PFAS concentration upper 95th percentile in the relevant media and is applicable for receptors that may be in close proximity to media with elevated PFAS concentrations within a localised area, such as a residential groundwater well. The upper exposure scenario is considered sufficient for quarry workers who would be exposed to a generally high risks though ingestion (incidental and through inhalation) or residents near the quarry.

Based on the Stage 2B investigation outcomes the HHRA divided the off-Base areas into zones based on the potential risk that PFAS posed. The Site's local area was designated risk zone C (low risk), with the risk zone encompassing the entire eastern Site area and the southern proposed extraction area. For reference the northern extraction area is not within an identified risk zone.

The HHRA determined risks for risk zone C upper exposure scenarios (pathways) are:

- Ingestion and contact with groundwater – acceptable.
- Dermal contact with soil and Ingestion of soil and dust – acceptable.
- Consumption of homegrown eggs – **elevated**.
- Consumption of locally grown fruit and vegetables – acceptable.
- Incidental ingestion of surface water – **elevated**.
- Surface water contact – acceptable.
- Incidental ingestion and contact with sediment – acceptable.
- Consumption of beef and milk – **elevated**.

7.1 Relevance of Potential On- and Off-Site Exposures

The HHRA determined potential exposure pathways listed above are considered suitable for off-Site residents and on-Site quarry personnel. For nearby residents and quarry personnel the comparison of the HHRA upper exposure scenario is considered conservative:

- For dust inhalation/soil ingestion because:
  - The prevailing wind directions in the area are not toward the residential areas.
  - PFAS have not been reported above the laboratory limit of reporting in soil samples.
  - Dust mitigation measures are required during quarrying activities.
- For groundwater exposure because:
  - The quarry base will not extend to a depth closer than 0.7 metres to the highest estimated water table elevation, hence groundwater management will not be required and groundwater discharge to surface water as a result of quarrying activities will not occur.
  - PFAS have essentially not been identified above the laboratory LOR in Site groundwater, hence PFAS present in groundwater from nearby residential wells is unlikely to have been sourced from the Site and may be diluted by Site derived groundwater.
  - The designation of risk zone C in the Site area was partially based on a very low PFOS concentration from one well, a concentration that was not subsequently repeated.
  - Groundwater migration from the Base is unlikely to reach the eastern property before 2050, by which time quarrying operations will have ceased and any complete PFAS migration pathways will be unlikely.
- For surface water because PFAS were not present above the laboratory LOR in surface water samples that drain from the Site.

The potential increased PFAS exposure to residents from quarrying activities is therefore considered unlikely.

8 CONCLUSIONS

A review of the currently available information regarding the PFAS contamination originating from the Base and assessed Site derived soil, groundwater and surface water data was undertaken to determine whether quarrying operations will increase the PFAS exposure to nearby residents.

During 2020 the final infrastructure construction was completed and sand quarrying activities at the Site commenced.

Considering the information reviewed the following is concluded:

- Base-sourced PFAS is, and has historically been unlikely to be transported to the Site via wind, surface water or groundwater – the Site does not appear to have received PFAS from the Base and does not appear to be acting as a local tertiary PFAS source because:
    - PFAS have not been reported within Site media (shallow and deep soil, surface water and groundwater) which is consistent with the results from the investigation undertaken by the DoD.
- It is understood that minor quarrying was performed in 2020. These work have not increased the potential for contaminated groundwater to flow toward the Site's local residential area. The most probable effect of quarrying will be the formation of a temporary groundwater mound due to increased rainwater infiltration and decreased evapotranspiration, with the local groundwater flow regime unlikely to be influenced for an extended time-period. The influence of quarrying on the groundwater flow regime is expected to decrease the risk of Base derived PFAS at the Site.

9 RECOMMENDATION

Development of a numerical groundwater flow model that allows for the effects of increased infiltration in the sand extraction areas to be quantitatively assessed should be considered.

If you require additional information or clarification, please contact the undersigned at (03) 9907 6000. This report should be read in conjunction with the Kleinfelder Statement of Limitations (attached).

Sincerely,

Kleinfelder Australia Pty Ltd

Stuart Graham (PhD – Geochemistry)

Associate Hydrogeologist

Attachments – Kleinfelder Statement of Limitations

KLEINFELDER STATEMENT OF LIMITATIONS

This report has been prepared by Kleinfelder Australia Pty Ltd (Kleinfelder) and may be used only by the Client and its designated representatives or relevant statutory authorities and only for the purposes stated for this specific engagement within a reasonable time from its issuance, but in no event later than two (2) years from the date of the report.

This work was performed in a manner consistent with that level of care and skill ordinarily exercised by other members of Kleinfelder's profession practicing in the same locality, under similar conditions and at the date the services are provided. Our conclusions, opinions, and recommendations are based on a limited number of observations and data. It is possible that conditions could vary between or beyond the data evaluated. Kleinfelder makes no other representation, guarantee, or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided.

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The findings and conclusions contained within this report are relevant to the conditions of the site and the state of legislation currently enacted in the relevant jurisdiction in which the site is located as at the date of this report.

Additionally, the findings and conclusions contained within this report are made following a review of certain information, reports, correspondence and data noted by methods described in this report including information supplied by the client or its assigns. Kleinfelder has designed and managed the program for this report in good faith and in a manner that seeks to confirm the information provided and test its accuracy and completeness. However, Kleinfelder does not provide guarantees or assurances regarding the accuracy, completeness and validity of information and data obtained from these sources and accepts no responsibility for errors or omissions arising from relying on data or conclusions obtained from these sources.

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