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NZDF PFAS Investigation – Summary Report: RNZAF Base Ohakea, Stage B

New Zealand Defence Force



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• Prepared for

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Executive Summary

This report documents Stage B of a sampling investigation undertaken on private properties adjacent to the Royal New Zealand Air Force (RNZAF) Base Ohakea ('the site') for the New Zealand Defence Force (NZDF) to investigate the potential for contamination relating to the use of per- and poly-fluoroalkyl substances (PFAS) at the site.

Based on the sample results from Stage A, the investigation area was expanded. This resulted in an increase of the number of groundwater samples analysed (26 in Stage A versus 74 in Stage B) as well as surface water samples (8 in Stage A versus 25 in Stage B). In addition to groundwater and surface water sampling, the Stage B investigation scope included sampling and analysis of soil, milk, eggs, cattle tissue, watercress and vegetables. A summary of Stage A is provided in a previous report (PDP, February 2018a).

Groundwater

Groundwater sampling was undertaken over four weeks, from 12 February to 9 March, 2017. Based on bore use information provided by the landowners, 22 of the sample locations are currently used for potable and/or drinking water supply.

Of the 74 groundwater samples collected:

- ∴ PFAS compounds were reported in 32 samples.
- ∴ Fifteen samples exceeded the interim drinking water guideline for the sum of total PFOS + PFHxS (MoH, 2017). Six of these samples are from bores identified as currently used for drinking water supply.
- ∴ Four samples exceeded the non-potable / recreation guideline for the sum of total PFOS + PFHxS.

Following the Stage A sampling, the Ministry for Primary Industries (MPI) provided site specific advice to landowners where groundwater samples exceeded the screening values developed by EnRisks (2017) for stock watering. For the Stage B results:

- ∴ Fifteen samples exceeded the Stock Watering and Fodder Irrigation Screening Value (SV) for home-grown beef consumption. This screening value is also applicable to home-grown sheep consumption.
- ∴ Eleven samples exceeded the Stock Watering Only SV for home-grown beef consumption. This screening value is also applicable to home-grown sheep consumption.
- ∴ Twenty-one samples exceeded the Stock Watering and Fodder Irrigation SV for home-grown milk consumption.

- ∴ Nineteen samples exceeded the Stock Watering Only SV for home-grown milk consumption.
- ∴ Ten samples exceeded the Stock Watering Only SV for home-grown egg consumption.

Comparing Stage B groundwater results to those collected from the same location during Stage A:

- ∴ Samples from eight locations show decreased total PFOS + PFHxS concentrations (Median drop = 8% | Median absolute drop = 0.018 µg/L);
- ∴ Samples from 11 locations show increased total PFOS + PFHxS concentrations (Median rise = 20% | Median absolute rise = 0.003 µg/L);
- ∴ Samples from five locations show no change (i.e. concentration has remained less than the LOR);
- ∴ Two sites were not re-sampled.

Surface Water

A total of 25 surface water samples were collected from stream and pond locations (compared to 8 samples collected during Stage A).

Of the 25 surface water samples collected:

- ∴ PFAS compounds were reported in 18 surface water samples.
- ∴ One sample exceeded the non-potable / recreation guideline, however water from this site is not used for non-potable / recreational purposes.
- ∴ Seventeen surface water samples exceeded the Stock Watering and Fodder Irrigation SV variously for home-grown beef, milk and/or eggs. Of these samples, 8 sites indicated water use for stock.

Soil

Of the twelve soil samples collected:

- ∴ PFAS compounds were reported in seven samples.
- ∴ Four exceeded the residential 10% human health screening value for the sum of total PFOS + PFHxS; however there are no residential dwellings in the vicinity of these samples.
- ∴ Seven samples exceeded the home grown beef consumption and the home grown milk consumption screening values. It is understood these sites are used for grazing beef cattle.

Plant Tissue

Nine samples were collected of plant tissue - five samples from a vegetable garden and four samples of watercress growing in roadside streams/drains.

- ∴ PFAS compounds were not detected in any of the vegetable samples.
- ∴ Three of the four watercress samples reported detections of one or more PFAS compounds.
- ∴ One watercress sample exceeded the all vegetables trigger point value (FSANZ, April 2017).

Animal Tissue

Two samples of frozen meat were collected from one farm, one beef, one pork. Both samples reported concentrations of total PFOS + PFHxS above the LOR but below the FSANZ trigger value. PFOA was not detected in either sample.

One chicken egg sample was collected. PFAS compounds were detected at concentrations above the LOR, yet below the FSANZ trigger value. PFOA was not detected in the sample.

No PFAS compounds were detected in the one goat milk sample.

Sediment

Five sediment samples were collected. PFAS was detected above the LOR in three samples (S1, S5 and S6). Currently there are no sediment quality guidelines to compare to.

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1.0 Introduction

Pattle Delamore Partners Ltd (PDP), in conjunction with a number of other Environmental Consultancies, has been engaged by the New Zealand Defence Force (NZDF) to undertake an external sampling campaign to investigate the potential for surface water and groundwater contamination by the use of per- and poly-fluoroalkyl substances (PFAS) at properties adjacent to the Royal New Zealand Air Force (RNZAF) Base Ohakea.

Stage A sample results, from sampling undertaken in December 2017, have been reported in a previous Summary Report (PDP, February 2018a). Based on the Stage A sample results, an expanded investigation area was proposed.

Stage B sampling has involved:

- ∴ Repeat sampling of those locations sampled during Stage A;
- ∴ Sampling at new surface water and groundwater locations identified within the expanded investigation area; and
- ∴ Sampling of additional media including soil, watercress, vegetables, milk, eggs and cattle tissue and pig tissue.

The Stage B sample results for landowners of adjacent properties from this expanded area have been reported in individual landowner reports, with recommendations regarding ongoing use of the water provided in those reports.

This summary report provides a summary of the Stage B sampling results in the context of the entire investigation area.

1.1 Project Objectives

The key project objectives for this sampling investigation were:

- ∴ To assess groundwater and surface water from sites adjacent to Base Ohakea and determine if PFAS compounds are present;
- ∴ To compare the concentrations of PFAS compounds present against interim drinking water guideline values and applicable screening values;
- ∴ To assess whether PFAS compounds are present in other sample media from sites adjacent to Base Ohakea where requested by the land owner; and
- ∴ Provide further data to update preliminary estimates of PFAS plume extent in groundwater made following the Stage A sampling.

1.2 Scope of Summary Report

The scope of this report involved:

- ∴ Collecting representative samples of groundwater, surface water, soil, plant and animal material from adjacent sites and analyses of these samples for PFAS.
- ∴ Comparison of the laboratory results to guideline and screening value criteria (where available).
- ∴ Update of the Ohakea Groundwater Model with the new results.

2.0 Background

PFAS compounds, such as perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) are a group of manufactured chemicals used since the 1950s. PFAS have been and continue to be used in a wide range of industrial and commercial products including aqueous film forming foam (AFFF) used for fighting fuel fires. Recently PFAS have gained increasing scientific and regulatory interest due to their widespread use, their environmental persistence and because some PFAS (primarily PFOS and PFOA) display bioaccumulative and toxic properties to humans and wildlife (CONCAWE, 2016).

PFAS are emerging contaminants. NZDF is investigating the potential for contamination of ground and water associated with the use and storage of AFFF containing PFAS at its camps and bases. Investigations at Ohakea have identified PFAS in the soil and water on the base.

Ohakea is surrounded by pastoral land predominantly used for grazing cattle and dairy farming. Shallow (and deep) groundwater is used relatively extensively on properties surrounding the base for water supply.

3.0 Methodology

Groundwater and surface water sampling was undertaken in groundwater supply wells and in surface water at selected locations adjacent to the base following the methodology outlined in the *Sampling Protocols for Monitoring Per and Polyfluorinated Compounds in Groundwater and Surface Water for New Zealand Defence Force* (PDP, February 2018b) and the guidance documents referenced therein.

Soil sampling was undertaken following the procedures outlined in *Sampling and Analysis Plan for Protocols for Polyfluorinated Compounds at RNZAF Ohakea* (PDP, 2017a).

Sampling of plant and animal tissue was undertaken following procedures developed by PDP.

Stage B Sampling was completed over four weeks, from 12 February to 9 March, 2018. All samples were sent to AsureQuality laboratories, Wellington under standard chain of custody procedures and were analysed for their PFAS suite.

4.0 Guidelines and Screening Values

The interim guidelines for drinking water and non-potable water / recreation currently used in New Zealand to compare with the water sample data collected during this project are presented in Table 1 along with additional screening criteria that have been prepared by NZDF consultants EnRisks. The soil guidelines used during this project are presented in Table 2. The screening criteria have been developed for water and soil and apply to animals/products grown and consumed at home (home-grown produce).

Plant and animal tissue samples are compared to the Food Standards Australia New Zealand's (FSANZ) trigger points (for further investigation); these are provided in Table 3.

Guidelines are provided for three PFAS compounds only. These compounds are known to be associated with certain types of AFFF. Henceforth results are discussed for these three compounds only. Results for the full analytical suite of 28 PFAS are available in the laboratory reports. These are provided in a separate electronic file.

Table 1: Environmental and Human Health Guidelines – Water					
Media	Sum of Total PFOS + PFHxS	PFOA	Total PFHxS	Total PFOS	Source
Drinking Water	0.07 µg/L	0.56 µg/L	-	-	MoH ¹ , AGDoH ²
Non-potable Water / Recreation	0.7 µg/L	5.6 µg/L	-	-	AGDoH ²
Stock Watering Only (home grown consumption)	-	Beef 150 µg/L	Beef 0.1 µg/L	Beef 0.1 µg/L	EnRisks ³
	-	Milk 30 µg/L	Milk 0.02 µg/L	Milk 0.02 µg/L	
	-	Eggs 4 µg/L	Eggs 0.2 µg/L	Eggs 0.09 µg/L	
Stock Watering and Fodder Irrigation (home grown consumption)	-	Beef 60 µg/L	Beef 0.06 µg/L	Beef 0.05 µg/L	EnRisks ³
	-	Milk 14 µg/L	Milk 0.008 µg/L	Milk 0.008 µg/L	
<p>Notes:</p> <ol style="list-style-type: none"> 1. Ministry of Health (MoH, 2017) Interim Guidance Level for Drinking Water, PFOA, PFOS and PFHxS. 2. Australian Government Department of Health (AGDoH, 2017) Health Based Guidance Values for PFAS for Use in Site Investigations in Australia. 3. Site specific screening values from Livestock Uptake Modelling and Screening Criteria Development for PFAS. EnRisks, November 2017. Screening values calculated using a scenario of 10% of the tolerable daily intake. This is the most conservative scenario developed. 					

Table 2: Environmental and Human Health Trigger Values – Soil					
Media	Sum of Total PFOS + PFHxS	PFOA	Total PFHxS	Total PFOS	Source
Soil (residential 10% with garden / accessible soil)	9 µg/kg	100 µg/kg	-	-	HEPA ^{1, 2}
Soil (public open space)	1,000 µg/kg	10,000 µg/kg	-	-	HEPA ^{1, 3}
Soil (home grown beef consumption)	-	550 µg/kg	1 µg/kg	1 µg/kg	EnRisks ⁴
Soil (home grown milk consumption)	-	160 µg/kg	0.2 µg/kg	0.2 µg/kg	EnRisks ⁴
Soil (home grown egg consumption)	-	1,200 µg/kg	50 µg/kg	25 µg/kg	EnRisks ⁴

Notes:

1. PFAS National Environmental Management Plan. Heads of EPAs Australia and New Zealand (HEPA), January 2018.
2. Assumes home-grown produce providing up to 10% of fruit and vegetable intake (no poultry). Does not include home-grown poultry/egg.
3. Assumes public open space such as parks, playgrounds, playing fields, secondary schools and footpaths.
4. Site specific screening values from Livestock Uptake Modelling and Screening Criteria Development for PFAS. EnRisks, November 2017. Screening values calculated using a scenario of 10% of the tolerable daily intake. This is the most conservative scenario developed.

Table 3: Human Health Trigger Points for Investigation – Plant and Animal Tissue					
Media	Sum of Total PFOS + PFHxS	PFOA	Total PFHxS	Total PFOS	Source
Meat Mammalian (all)	3.5 µg/kg	28 µg/kg	3.5 µg/kg	3.5 µg/kg	FSANZ ¹
Milk (all)	0.4 µg/kg	2.8 µg/kg	0.4 µg/kg	0.4 µg/kg	
Poultry eggs	11 µg/kg	85 µg/kg	11 µg/kg	11 µg/kg	
Vegetables (all)	1.1 µg/kg	8.8 µg/kg	1.1 µg/kg	1.1 µg/kg	
Notes: 1. Assessment of potential dietary exposure to perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS) occurring in foods sampled from contaminated sites – Table 8, Supporting Document 2. Food Standards Australia New Zealand (FSANZ), April 2017.					

5.0 Quality Assurance/Quality Control

Due to the very low detection limits of PFAS required for this investigation, a robust quality assurance/quality control (QA/QC) programme was required.

5.1 Project Data Quality Objectives

The project data quality objectives (DQOs) were to:

1. Determine the presence or absence (less than 0.005 µg/L) of PFASs in groundwater from groundwater bores.
2. Determine the presence or absence (less than 0.005 µg/L) of PFASs in surface water.
3. Determine the presence or absence (less than 9 µg/kg) of PFASs in soil.
4. Determine the presence or absence (less than 1.1 µg/kg) of PFASs in plant tissue.
5. Determine the presence or absence (less than 0.4 µg/kg) of PFASs in animal tissue.

To determine if the DQOs were met, the internal QA/QC function ('QAChecker'), in the environmental database software ESdat, was used to calculate relative percent differences between sample duplicates and to check for detections of PFAS in blanks.

The results of the QA/QC check indicate that all samples meet the DQOs. This is with the exception of three rinsate blanks and two trip blanks. In general, these samples had very low concentrations ($<0.0025 \mu\text{g/L}$) of PFOS and PFHxS detected. These concentrations are close to the limit of reporting (LOR) for these compounds, therefore applying the estimated measurement uncertainty to the results, the numerical values are not considered to be statistically significantly different from the LOR. Slightly higher concentrations of the compound 6:2 FTS were also detected. 6:2 FTS is not one of the target compounds for this investigation.

Three duplicate samples were found to have relative percent differences $>70\%$ for the compounds PFBA and PFOS. The reason for these differences is currently unknown.

6.0 Results Summary and Comparison to Guidelines

A total of 74 groundwater samples, 25 surface water samples, 12 soil samples, five sediment samples and four watercress samples were collected.

In addition, two meat, nine vegetable, one goat milk and one egg sample were collected.

6.1 Groundwater

A summary of the groundwater sample results is presented below along with a comparison of the results to the interim drinking water guidelines, the non-potable guidelines, and the screening values for stock watering and fodder irrigation developed by EnRisks (2017). Screening values defined for beef would also be conservative for the consumption of home-grown sheep meat (EnRisks, 2017). Currently there is no information of the applicability of these screening values to the consumption of home-grown goat meat.

6.1.1 Drinking Water Guideline

Of the 74 groundwater samples collected:

- ∴ PFAS compounds were detected in 32 samples.
- ∴ Fifteen samples exceeded the interim drinking water guideline for the sum of total PFOS + PFHxS (MoH, 2017).
- ∴ Seventeen samples returned concentrations of the sum of total PFOS + PFHxS above the LOR but below the interim drinking water guideline (MoH, 2017).
- ∴ Forty-two samples were reported as less than the LOR for the sum of total PFOS + PFHxS.

- ∴ PFOA was reported in 27 samples, however no samples were found to exceed the interim drinking water guideline for PFOA.

6.1.2 Non-potable, Stock Watering and Fodder Irrigation Screening Values

- ∴ Four of the 74 groundwater samples exceeded the non-potable / recreation guideline for the sum of total PFOS + PFHxS.
- ∴ Fifteen samples exceeded the Stock Watering and Fodder Irrigation Screening Value (SV) for home-grown beef consumption.
- ∴ Eleven samples exceeded the Stock Watering Only SV for home-grown beef consumption.
- ∴ Twenty-one samples exceeded the Stock Watering and Fodder Irrigation SV for home-grown milk consumption.
- ∴ Nineteen samples exceeded the Stock Watering Only SV for home-grown milk consumption.
- ∴ Ten samples exceeded the Stock Watering Only SV for home-grown egg consumption.

6.1.3 Groundwater Results Summary

A summary of the groundwater results compared to the relevant drinking water and non-potable guidelines, and the stock watering and fodder irrigation screening values is provided in Table 4. It is noted that changes in the numbers, and percentages of samples found to exceed guideline or screening values must be considered in the context of the greater number of samples that were obtained during the Stage B sampling event, compared to the Stage A sampling event (74 in Stage B vs 26 in Stage A). The number of previous exceedances from Stage A sampling is provided in brackets.

Table 4: Guideline and Screening Value Exceedences – Groundwater Samples (n=74)			
Guideline	Number Exceeding the Relevant Guideline	Percent Exceeding the Relevant Guideline	Source
Interim Drinking Water	15 (previously 13)	20% (previously 50%)	MoH ¹ , AGDoH ²
Non-potable Water / Recreation	4 (previously 5)	5% (previously 19%)	AGDoH ²
Site Specific Screening Value – Beef Consumption (home grown)			
Stock Watering and Fodder Irrigation	15 (previously 12)	20% (previously 46%)	EnRisks ³
Stock Watering Only	11 (previously 10)	15% (previously 38.5%)	EnRisks ³
Site Specific Screening Value – Milk Consumption (home grown)			
Stock Watering and Fodder Irrigation	21 (previously 16)	28% (previously 61.5%)	EnRisks ³
Stock Watering Only	19 (previously 15)	26% (previously 58%)	EnRisks ³
Site Specific Screening Value – Egg Consumption (home grown)			
Stock Watering Only	10 (previously 9)	13.5% (previously 35%)	EnRisks ³
<p><i>Notes:</i></p> <ol style="list-style-type: none"> 1. Ministry of Health (MoH, 2017) Interim Guidance Level for Drinking Water, PFOA, PFOS and PFHxS. 2. Australian Government Department of Health (AGDoH, 2017) Health Based Guidance Values for PFAS for Use in Site Investigations in Australia. 3. Site specific screening values from Livestock Uptake Modelling and Screening Criteria Development for PFAS. EnRisks, November 2017. 			

6.2 Surface Water

A summary of the surface water sample results is presented below. Based on information of water use collected during the Stage B sampling round, surface water sampled within the investigation area is not understood to be used for drinking water. Therefore results have been compared to the non-potable /

recreation guideline and the stock watering and fodder irrigation screening values.

6.2.1 Non-potable, Stock Watering and Fodder Irrigation Screening Values

Of the 25 surface water samples collected:

- ∴ One sample exceeded the non-potable / recreation guidelines for the sum of total PFOS + PFHxS.
- ∴ Fourteen samples exceeded the Stock Watering and Fodder Irrigation SV for home-grown beef consumption.
- ∴ Ten samples exceeded the Stock Watering Only SV for home-grown beef consumption.
- ∴ Seventeen samples exceeded the Stock Watering and Fodder Irrigation SV for home-grown milk consumption.
- ∴ Seventeen samples exceeded the Stock Watering Only SV for home-grown milk consumption.
- ∴ Ten samples exceeded the Stock Watering Only SV for home-grown egg consumption.

6.2.2 Surface Water Results Summary

A summary of the surface water results compared to the relevant non-potable guidelines, stock watering and fodder irrigation screening values, is provided in Table 5.

Table 5: Guideline and Screening Value Exceedences – Surface Water Samples (n=25)			
Guideline	Number Exceeding the Relevant Guideline	Percent Exceeding the Relevant Guideline	Source
Non-potable Water / Recreation	1 (previously 2)	4% (previously 25%)	AGDoH ²
Site Specific Screening Value – Beef Consumption (home grown)			
Stock Watering and Fodder Irrigation	14 (previously 4)	56% (previously 50%)	EnRisks ³
Stock Watering Only	10 (previously 2)	40% (previously 25%)	EnRisks ³
Site Specific Screening Value – Milk Consumption (home grown)			
Stock Watering and Fodder Irrigation	17 (previously 8)	68% (previously 100%)	EnRisks ³
Stock Watering Only	17 (previously 7)	68% (previously 87.5%)	EnRisks ³
Site Specific Screening Value – Egg Consumption (home grown)			
Stock Watering Only	10 (previously 3)	40% (previously 37.5%)	EnRisks ³
Notes: <ol style="list-style-type: none"> 1. Ministry of Health (MoH, 2017) Interim Guidance Level for Drinking Water, PFOA, PFOS and PFHxS. 2. Australian Government Department of Health (AGDoH, 2017) Health Based Guidance Values for PFAS for Use in Site Investigations in Australia. 3. Site specific screening values from Livestock Uptake Modelling and Screening Criteria Development for PFAS. EnRisks, November 2017. 4. PFAS National Environmental Management Plan. Heads of EPAs Australia and New Zealand (HEPA), January 2018. 			

6.3 Soil

A summary of the soil sample results is presented below. Soil samples are compared to the human health screening values and the screening values developed by EnRisks for the consumption of home-grown beef, milk and eggs.

6.3.1 Human Health Screening Values

Of the 12 soil samples collected:

- ∴ Four samples exceeded the residential 10% human health screening value for the sum of total PFOS + PFHxS.
- ∴ No samples exceed the residential 10% human health screening value for PFOA.
- ∴ No samples exceed the public open space human health screening value for the sum of total PFOS + PFHxS or for PFOA.

6.3.2 Beef, Egg and Milk Screening Values

Of the 12 soil samples collected:

- ∴ Seven samples exceeded the home grown beef consumption screening value.
- ∴ Seven samples exceeded the home grown milk consumption screening value.
- ∴ No samples exceeded the home grown egg consumption screening value.

Table 6: Screening Value Exceedences – Soil Samples (n=12)		
Human Health Screening Value	Number Exceeding the Relevant Criteria	Source
Soil (residential 10% with garden / accessible soil)	4	HEPA ¹
Soil (public open space)	0	HEPA ¹
Site Specific Screening Values		
Soil (home grown beef consumption)	7	EnRisks ²
Soil (home grown milk consumption)	7	EnRisks ²
Soil (home grown egg consumption)	0	EnRisks ²
Notes: 1. PFAS National Environmental Management Plan. Heads of EPAs Australia and New Zealand (HEPA), January 2018. 2. Site specific screening values from Livestock Uptake Modelling and Screening Criteria Development for PFAS. EnRisks, November 2017.		

6.4 Plant Tissue

Nine samples were collected of plant tissue - five samples from a vegetable garden and four samples of watercress growing in roadside streams/drains. Of the nine samples collected:

- ∴ PFAS compounds were not detected in any of the vegetable samples.
- ∴ Three of the four watercress samples reported detections of one or more PFAS compounds – note total PFOS + PFHxS was only detected in one of these samples.
- ∴ One watercress sample reported a total PFOS + PFHxS concentration of 1.2 µg/kg which exceeds the all vegetables trigger point for investigation value of 1.1 µg/kg for total PFOS + PFHxS (FSANZ, April 2017).

6.5 Animal Tissue

6.5.1 Cattle Meat

Two samples of frozen meat were collected from one farm. Both samples reported concentrations of total PFOS + PFHxS above the LOR (0.28 µg/kg and 0.38 µg/kg). However, neither sample exceeded the FSANZ trigger value of 3.5 µg/kg. PFOA was not detected in either sample.

6.5.2 Egg

One chicken egg sample was collected. PFAS compounds were detected at above the LOR, however the concentrations of total PFOS + PFHxS (3.6 µg/kg) did not exceed the FSANZ trigger point value of 11 µg/kg. PFOA was not detected in the sample.

6.5.3 Goats Milk

No PFAS compounds were detected in the one goat milk sample.

6.6 Sediment

Five sediment samples were collected. PFAS was detected above the LOR in three samples. Currently there are no sediment quality guidelines to compare to.

7.0 Ohakea Groundwater Assessment

The Stage B sample results have been used to produce an interpreted plume extent of total PFOS + PFHxS concentration $\geq 0.07 \mu\text{g/L}$ within the shallow groundwater system at Ohakea. The interpreted plume was developed based on the returned groundwater and surface water sample results as well as qualitative use of the previously developed 3D numerical groundwater flow model (PDP, 2017b).

Of the 74 groundwater bore locations, 29 bores have information on bore depth, which has been used to assume a sample depth. Nineteen bores have a depth less than 20 m below ground level (bgl) and 10 bores have a recorded depth greater than 20 m bgl. For the remaining 45 bores without depth information, it has been assumed that these samples are from shallow bores <20 m bgl. It should be noted that the 'shallow' groundwater system at Ohakea as a whole, is considered to extend to ~50 m bgl. Sample depth is a very important aspect for interpreting the results. This is due to the hydrogeological understanding that shallow groundwater is likely to contain higher concentrations of PFAS than deeper groundwater. Surface water is also a very important aspect as there is a significant degree of groundwater – surface water interaction within the Ohakea system.

The results from Stage B have been used to refine the estimated shallow groundwater plume extent for total PFOS + PFHxS that was developed following completion of Stage A.

In summary:

- ∴ The estimated plume extent remains an overall similar shape and area to that produced for the Stage A (December 2017) sample data.
- ∴ The plume has been extended along surface water lines of the Makowhai Stream and its primary tributaries due to the addition of further afield surface water samples.
- ∴ Surface water monitoring returned concentrations of total PFOS + PFHxS $> 0.07 \mu\text{g/L}$ at over 4 km downstream (south-west) from Base Ohakea.
- ∴ A groundwater sample approximately 2.3 km downstream (south-west), is the furthest groundwater sample from the base with a concentration of total PFOS + PFHxS $> 0.07 \mu\text{g/L}$.
- ∴ The southern/south-western extent of the plume i.e. the region between Speedy Rd, Taylor Rd and further south to Makowhai Stream is not well delineated by field sampling. There are a number of bore samples, with many showing non-detect, however the majority of these bores are either deep ($> 100 \text{ m bgl}$) or of unknown depth. Consequently, uncertainty remains on the shallow groundwater PFAS concentrations in this direction.

- ∴ The eastern extent of the plume has been extended slightly eastward from the Stage A estimate – nevertheless, non-detect surface water samples, along with non-detect or below <0.07 µg/L shallow groundwater concentrations, have enabled reasonable delineation in this direction based on the Stage B data.
- ∴ The western extent of the plume remains essentially unchanged from the Stage A estimate i.e. does not extend across (west of) the Rangitikei River. Four bores on the western side of the Rangitikei River were sampled, as well as samples from the river itself; which all returned non-detect.
- ∴ The northern-north eastern extent of the plume has, for the time being, remained unchanged from the Stage A estimate. However, detectable concentrations of PFAS within four shallow bores used for the Bulls township water supply across (north of) the Rangitikei River have been observed within the Stage B monitoring results. The source area for these is subject to a separate investigation. Dependant on the results of this additional investigation, the plume extent in this direction may need to be altered.

Summary statistics for off-site sample locations of the Stage A (December 2017) and Stage B (February 2018) monitoring rounds are provided below:

For groundwater samples only:

- ∴ Samples from eight locations show decreased total PFOS + PFHxS concentrations (Median drop = 8% | Median absolute drop = 0.018 µg/L);
- ∴ Samples from 11 locations show increased total PFOS + PFHxS concentrations (Median rise = 20% | Median absolute rise = 0.003 µg/L);
- ∴ Samples from five locations show no change (i.e. concentration has remained less than the LOR);
- ∴ Two sites were not re-sampled.

Some notable changes between the Stage A and Stage B sampling events with respect to individual groundwater bores were:

- ∴ One bore was below the drinking water guideline for total PFOS + PFHxS (0.037 µg/L), but is now above guideline (0.082 µg/L);
- ∴ One bore was less than the LOR, but is now showing detectable concentrations of total PFOS + PFHxS (0.022 µg/L);
- ∴ One bore was above guideline for total PFOS + PFHxS (0.073 µg/L), but is now below guideline (0.052 µg/L).

8.0 Discussion

This section discusses groundwater, surface water and soil results, and watercress on public land only. Further assessment and discussion of the plant and animal tissue results is outside the scope of this report.

8.1 Groundwater Users

8.1.1 Drinking Water

Results from this surface water and groundwater sampling investigation indicate that the 'plume' of PFAS contaminated groundwater extends for a distance of at least 3 to 3.5 km from the boundary of Base Ohakea in a general south to south west direction.

Based on information gathered during Stage B, 22 groundwater bores have been confirmed as being used for drinking/potable water supply. A further two groundwater samples were previously used for drinking water or are used as back-up supplies. Six of these 22 bores contain concentrations of total PFOS + PFHxS that exceed the interim drinking water guideline. All these bores are located south of the Base, at distances ranging from approximately 600 m to 2 km from the Base boundary.

Four bores used for potable supply reported concentrations of total PFOS + PFHxS above the LOR, but below the drinking water guideline. These bores are located to the north and west of Base Ohakea. As mentioned above in Section 7.0, the sample from of these bores collected during Stage A exceeded the interim drinking water guideline.

Twelve bores used for potable supply reported concentrations of total PFOS + PFHxS below the LOR. These bores are located to the west and southwest of the site. As with the Stage A sampling round, a bore located approximately 800 m to the west of the Base did not contain PFAS at reportable concentrations, despite being approximately 400 m down gradient of a number of bores with concentrations of PFAS above the drinking water guideline. This may be due to the depth of this bore (57 m) and that PFAS is currently restricted to shallower groundwater.

8.1.2 Non-potable, Stock Watering and Fodder Irrigation

Sample results have been compared to the non-potable guidelines (AGDoH, 2017) and the site specific screening values (EnRisks, 2017) (refer Table 1). The EnRisk screening values are used to assess the risk of on-farm consumption of farm grown products (e.g. homekill) only (which are assumed to drink groundwater), which is a more conservative exposure pathway given the potential for consumption of larger quantities of beef, milk or eggs from a single animal. These screening values are not relevant for produce supplied to the

general market. Screening values defined for beef would also be conservative for the consumption of sheep meat (EnRisks, 2017).

Four samples exceeded the non-potable guideline for the sum of PFOS + PFHxS. Of these, two of which indicated water was used for non-potable / recreation purposes.

Twenty-one samples exceeded the screening value for home-grown milk consumption and fifteen samples exceeded the screening value for home-grown beef consumption. Of these samples, 16 sites indicated water use for stock, one site indicated water use for irrigation only and two indicated water use for stock and irrigation.

Ten samples exceeded the screening value for home-grown eggs. However, none of the sites where these samples were collected indicated water was used for chickens.

8.1.3 Site Specific Advice from MPI

Following the results of the Stage A sampling, the MPI provided independent site specific advice to landowners of 16 bores located on twelve properties where concentrations of PFAS in groundwater were found to exceed some or all of the screening values developed by EnRisks. Fourteen of the bores MPI provided specific advice for in Stage A are included in the samples discussed above in Section 8.1.2.

8.2 Surface Water Users

PFAS compounds have been reported in 18 of the 25 surface water samples collected. One of these samples exceeded the non-potable guideline for the sum of PFOS + PFHxS. However water from this site was not indicated as being used for non-potable / recreation purposes. Seventeen samples exceeded the screening value for home-grown milk consumption and fourteen samples exceeded the screening value for home-grown beef consumption. Of these samples, 8 sites indicated water use for stock.

In general, the surface water samples are located on streams that have been identified as the main stormwater discharge points for Base Ohakea (e.g. samples SW13 and SW20 in the south and samples SW11 and SW12 in the west). An exception to this are the four surface water samples collected from ponds in the southwest of the investigation area (SW14, SW17, SW18 and SW19). These samples are approximately 3 km from the Base boundary and contain elevated concentrations of total PFOS and PFHxS. Groundwater samples collected up gradient returned concentrations below the LOR suggesting the pond water is not sourced from groundwater. At the time of sampling the overland flow path feeding these ponds was dry. Most PFAS are not volatile; hence the elevated

concentrations recorded here may be a result of concentrated PFAS in the remaining pond water following evaporation of pond water.

8.3 Soil

PFAS compounds were reported in 7 of the 12 soil samples collected. Four of these samples exceeded the residential 10% human health screening value for the sum of total PFOS + PFHxS; however there are currently no residential dwellings in the vicinity of these samples.

All seven of the above samples were found to exceed the home grown beef consumption and the home grown milk consumption screening values. Based on information collected during Stage B, these sites are used for grazing beef cattle.

8.4 Watercress

Three of the four watercress samples reported detections of one or more PFAS compounds and one sample reported a total PFOS + PFHxS concentration exceeding the all vegetables trigger point for investigation value for total PFOS + PFHxS (FSANZ, April 2017). These samples were collected from watercourses on public land. The extent to which watercress is collected from public land and used for consumption in this area is currently unknown.

8.5 Results Interpretation Limitations

Due to their physiochemical properties, the fate and transport of PFAS is complicated and poorly understood. As such, extrapolation of these results, particularly to locations down-gradient, is uncertain and may not represent the actual conditions present. On this basis, any assessment of risk to receptors located outside the current investigation area is limited.

9.0 References

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