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NZDF PFAS Investigation – Summary Report: RNZAF Base Auckland (Whenuapai)

New Zealand Defence Force

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✦ Prepared for

New Zealand Defence Force

✦ October 2018



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Quality Control Sheet

TITLE NZDF PFAS Investigation – Summary Report: RNZAF Base Whenuapai

CLIENT New Zealand Defence Force

VERSION Final – Version 2

ISSUE DATE 01 October 2018

JOB REFERENCE A02386808

SOURCE FILE(S) A02386808R001_WHP_SummaryReport_final.docx

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Executive Summary

This report documents a sampling investigation undertaken adjacent to the Royal New Zealand Air Force (RNZAF) Base Auckland (“Whenuapai Airbase”) for the New Zealand Defence Force (NZDF) to investigate the potential for off-site contamination relating to historic use of products that contain per- and poly-fluoroalkyl substances (PFAS) on Whenuapai Airbase.

To understand the occurrence of PFAS in the investigation area, and to address potential concerns regarding consumption of natural resources (i.e. fish and shellfish), a programme of sampling was conducted in selected groundwater wells, streams and drains bordering Whenuapai and in the littoral zone in the adjacent Upper Waitematā Harbour.

For comparison, sediment and biota samples were also collected from the littoral zone at a control site, being Wenderholm Regional Park which is located outside the Waitematā Harbour approximately 29 km to the north east of Whenuapai Airbase.

Sampling was completed on non-consecutive days between 26 July and 30 August 2018.

Groundwater

Of the six groundwater samples collected, PFAS compounds were reported above the laboratory limit of reporting (LOR), but below the interim drinking water guideline, in three samples. All three of these samples were from shallow monitoring wells located to the south west of the base. No PFAS compounds were detected in samples collected from deeper groundwater bores.

Surface Water

Of the twelve surface water samples collected, PFAS compounds were detected in nine samples. Two samples exceeded the recreational water guidelines for the sum of total PFOS + PFHxS (AGDoH, 2017), and the 95% Ecological Protection guideline for Total PFOS (HEPA, 2018).

Sediment

Of the 48 sediment samples collected (44 samples collected in the vicinity of Whenuapai Airbase, and 4 samples collected from the Wenderholm control site), PFAS compounds were detected in ten sediment samples collected from the vicinity of Whenuapai Airbase. No sample had PFAS compounds that exceeded the ecological screening criteria. PFAS compounds were not detected in the sediment samples collected from the control site.

Fish

One bully (*Gobiomorphus cotidianus*) and one eel (*Anguilla sp*), were collected from a freshwater environment. Two Parore (*Girella tricuspidata*), one Yellow-eyed mullet (*Aldrichetta forsteri*) and 4 Yellowbelly flounder (*Rhombosolea leporine*) samples were collected from the marine environment of the upper Waitematā Harbour, in the vicinity of Whenuapai Airbase. PFAS were detected above the LOR in all samples. Of these, the bully and eel samples, and one flounder sample, contained concentrations exceeding the Food Safety Australia New Zealand (FSANZ) trigger point for investigation.

A further 2 flounder samples, collected from the control site at Wenderholm Regional Park, did not contain concentrations of PFAS above the LOR.

Macroinvertebrates

Twenty-eight macroinvertebrate samples were collected from ten sample locations (including the control site at Wenderholm Regional Park). Macroinvertebrate samples were composited for analysis according to species. Eight mollusc species and one crab species were sampled.

PFAS compounds were detected above the LOR in all species sampled from the vicinity of Whenuapai Airbase. None of the samples exceeded the FSANZ trigger point for investigation.

PFAS were detected in two mollusc samples from the control site at Wenderholm Regional Park, seven macroinvertebrate samples were collected.

Table of Contents

SECTION	PAGE
Executive Summary	ii
1.0 Introduction	1
1.1 Project Objectives	1
1.2 Scope of Summary Report	1
2.0 Background	2
3.0 Methodology	2
4.0 Guidelines and Screening Values	3
4.1 Water	3
4.2 Sediment	3
4.3 Biota	4
5.0 Quality Assurance/Quality Control	4
5.1 Project Data Quality Objectives	4
5.2 PFAS Concentrations at the Limit of Reporting	5
6.0 Results Summary and Comparison to Guidelines	5
6.1 Groundwater	6
6.2 Surface Water	6
6.3 Sediment	7
6.4 Biota	7
7.0 Discussion	9
7.1 Groundwater	9
7.2 Surface Water	9
7.3 Sediment	10
7.4 Biota	10
8.0 Conclusions	11
8.1 Results Interpretation Limitations	12
9.0 References	13

Table of Tables

Table 1: Environmental and Human Health Guidelines – Water	3
Table 2: Environmental Screening Criteria – Sediment	4
Table 3: Human Health Trigger Points for Investigation – Finfish, Crustaceans and Molluscs	4

Appendices

Appendix A: Sediment Quality Guidelines

Appendix B: Quality Assurance / Quality Control Check

Appendix C: Summary Sample Results Table

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, sediment, groundwater and biota contamination relating to historic use of products that contain per- and poly-fluoroalkyl substances (PFAS) at the Royal New Zealand Air Force (RNZAF) Base Auckland (“Whenuapai Airbase”). The investigation comprised sampling of groundwater and surface water at properties adjacent to Whenuapai Airbase, and sampling of sediment and biota in freshwater and coastal marine areas to address potential concerns regarding consumption of natural resources (i.e. fish and shellfish).

For comparison, sediment and biota samples were also collected from the littoral zone at a control site, being Wenderholm Regional Park which is located approximately 29 km to the north east of Whenuapai Airbase. This location was selected for use as a control site because of the undeveloped nature of the catchment with limited industrial activity.

Sample results for landowners of adjacent properties have been reported in individual landowner reports, with recommendations regarding ongoing use of water and biota consumption. This summary report provides a summary of the 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, surface water, sediment and biota from sites adjacent to Whenuapai Airbase and determine if PFAS compounds are present.
- ∴ To compare the concentrations of any PFAS compounds present against applicable guideline values and screening values.

1.2 Scope of Summary Report

The scope of this report involved:

- ∴ Collecting representative samples of groundwater, surface water (from streams and drains), sediment (from streams and in the littoral zone), and biota (from the littoral zone) at sites adjacent to Whenuapai Airbase and analysis of these samples for PFAS compounds.
- ∴ Collecting representative samples of sediment, and biota from the control site at Wenderholm Regional Park; and analysis of these samples for PFAS compounds.
- ∴ Comparison of the laboratory results to applicable guideline and screening value criteria.

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), which is 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 water, sediment and aquatic biota associated with the use and storage of AFFF which contains PFAS (and any other potential PFAS sources) at its camps and bases. Investigations at Whenuapai Airbase have identified PFAS in the surface water and groundwater on the base.

Whenuapai Airbase is predominantly surrounded by rural residential properties, beyond which, to the west, north and east, lie the upper Waitematā Harbour and its tributaries. An area of high density housing has been constructed to the west of Whenuapai Airbase in recent years. Searches of the Auckland Council resource consent database have shown that groundwater and surface water abstraction does not occur extensively as the majority of properties are on reticulated water supply provided by the Auckland Council.

3.0 Methodology

Groundwater and surface water sampling was undertaken in those groundwater supply and monitoring wells that were identified, and in surface water at selected locations adjacent to the base following the methodology outlined in the *Sampling Protocols for Monitoring Per and Poly-fluorinated Compounds in Groundwater and Surface Water for New Zealand Defence Force* (PDP, 2018a) and the guidance documents referenced therein.

Sediment and biota sampling was undertaken following the procedures outlined in the *Sampling and Analysis Plan for Protocols for Monitoring Per and Poly-fluorinated Compounds in Biota, Sediment, Surface and Groundwater, Adjacent to the RNZAF Base Whenuapai* (PDP, 2018b).

The external sampling campaign was completed on non-consecutive days between 26 July and 30 August 2018. All samples were sent toASUREQuality laboratories, Wellington under standard chain of custody procedures and were analysed for a standard suite of 28 PFAS compounds.

4.0 Guidelines and Screening Values

4.1 Water

The interim guidelines for drinking water, recreational water quality (derived to be protective of human health), and ecological protection (derived to be protective of the health of ecological receptors) that are currently used in New Zealand, and to which the water sample data collected during this project have been compared are presented in Table 1.

Guidelines are provided for three PFAS compounds only. These compounds are known to be associated with certain types of AFFF, and they are currently the only compounds for which suitable guidelines are available.

Table 1: Environmental and Human Health Guidelines – Water				
Media	Sum of Total PFOS + PFHxS	PFOA	Total PFOS	Source
Drinking Water	0.07 µg/L	0.56 µg/L	-	MoH ¹ , AGDoH ²
Recreational Water	0.7 µg/L	5.6 µg/L	-	AGDoH ²
Ecological Freshwater Guideline - 95% ecosystem protection ³	-	220 µg/L	0.13 µg/L	HEPA ⁴

Notes:

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. The 95% ecosystem protection level is not protective for bioaccumulation in organisms.
4. PFAS National Environmental Management Plan. Heads of EPAs Australia and New Zealand (HEPA), January 2018.
5. '-' denotes no guideline value.

4.2 Sediment

Currently there are no ANZECC guidelines for PFAS in sediment. The Norway Sediment Quality Guidelines developed by Bakke *et al.* (2010) have guidelines for PFOS only. These guidelines are relevant to aquatic ecosystem health rather than human health. There are currently no human health sediment guidelines for PFAS used in New Zealand. It is important to note that these guidelines have been derived using a theoretical relationship and have not been validated by ecotoxicological data; consequently these guidelines are considered 'low reliability guideline values' (see Appendix A). For this reason the Norwegian guidelines have been applied as initial screening criteria, to classify if a site is either low risk or high risk. The sediment screening criteria are reproduced below in Table 2.

Table 2: Environmental Screening Criteria – Sediment		
Media	Total PFOS	Source
Sediment Quality Guidelines – Toxic Effects Following Chronic Exposure	0.22 mg/kg	NSQG ¹
Sediment Quality Guidelines – Toxic Effects Following Short Term Exposure	0.63 mg/kg	
<i>Notes:</i> <ol style="list-style-type: none"> Norway Sediment Quality Guidelines. Obtained from Bakke, T., Kailquist, T., Ruus, A., Breedveld, G. and Huylland, K. (2010). <i>Journal of Soils and Sediment</i>, 10, pp 172-178. 		

4.3 Biota

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. These trigger points have been derived to indicate that further investigation is required to determine if human health may be adversely affected in the event that the animal tissue is consumed.

Table 3: Human Health Trigger Points for Investigation – Finfish, Crustaceans and Molluscs				
Media	Sum of Total PFOS + PFHxS	PFOA	Total PFOS	Source
Finfish (all)	5.2 µg/kg	41 µg/kg	5.2 µg/kg	FSANZ ¹
Crustaceans and Molluscs - proposed trigger points for investigation ²	65 µg/kg	520 µg/kg	65 µg/kg	
<i>Notes:</i> <ol style="list-style-type: none"> 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. Occasionally consumed food, trigger points for investigation for crustaceans applied to molluscs due to small number of consumers of molluscs. 				

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:

- 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 0.5 µg/kg) of PFASs in animal tissue (fish, molluscs and crustaceans).
4. Determine the presence or absence (less than 0.001 mg/kg) of PFASs in sediment.

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 Checker indicated that there were no detections in the blanks collected. The relative percent difference (RPD) was also analysed for field and lab duplicates. Three RPD's exceeding the DQOs were reported by the software, however these were for samples that were either below the limit of reporting (LOR) or were non reportable¹ and therefore do not reflect a true high RPD between the duplicate samples. Based on the results of the QAChecker, the sample results meet the DQOs and are considered to be acceptable for this investigation.

A summary of the QA/QC check is provided in Appendix B. Additional information relating to the QA/QC results can be provided upon request.

5.2 PFAS Concentrations at the Limit of Reporting

Where low detections (i.e. sum of total PFHxS + PFOS < 0.005 µg/L) have been reported in groundwater and surface water samples, this may not represent a real presence of PFAS in the sampled water but may reflect uncertainty of measurement or sampling and/or analysis error.

6.0 Results Summary and Comparison to Guidelines

The following samples were collected during the external sampling campaign:

- ∴ 6 groundwater samples.
- ∴ 12 surface water samples.
- ∴ 48 sediment samples.
- ∴ 28 macroinvertebrate samples.
- ∴ 11 fish samples.

¹ Non reportable is used by the laboratory to indicate a sample result that does not meet the laboratories internal quality control criteria and therefore the accuracy of the result is not reliable.

These include control samples (i.e. samples that were obtained from outside of the investigation area) that were collected at Wenderholm Regional Park.

Summary tables for groundwater, surface water, sediment and biota are provided in Appendix C.

An electronic file containing the laboratory reports for all samples is appended in a separate electronic file.

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 and the recreational water guidelines. Groundwater results for samples reporting PFOS, PFOA and PFHxS concentrations above the LOR are provided in Table C-1, Appendix C. Groundwater results for all compounds reported above the LOR are provided in Table C-6.

6.1.1 Drinking Water and Recreational Water Quality Guidelines

Three of the six groundwater samples taken during the external sampling campaign reported PFAS compounds. No samples exceeded the drinking water guidelines (MoH, 2017) or the recreational water guidelines (AGDoH, 2017) for the total sum of PFOS + PFHxS or PFOA.

6.2 Surface Water

A summary of the surface water sample results is presented below. Based on water use information collected during this investigation, which indicated that surface water is not used for drinking water, surface water results have been compared to the recreational water quality guidelines (AGDoH, 2017) and the ecological freshwater guidelines. Surface water results for samples reporting PFOS, PFOA and PFHxS concentrations above the LOR are provided in Table C-2, Appendix C. Surface water results for all compounds reported above the LOR are provided in Table C-7.

6.2.1 Recreational Water Quality Guidelines and Ecological Guidelines

Of the 12 surface water samples collected, PFAS compounds were detected in nine samples. Two of these samples exceeded the recreational water guideline (AGDoH, 2017) for the sum of total PFOS + PFHxS, and in these same samples, the 95% Ecological Protection guideline for Total PFOS (HEPA, 2018) was exceeded. No samples exceeded the recreational water guideline (AGDoH, 2017) or the ecosystem protection guideline for PFOA.

6.3 Sediment

A total of 48 sediment samples (from 24 locations i.e. a surface and shallow sample was collected at each location) were collected. Of this total, 44 were collected from the immediate vicinity of Whenuapai Airbase. The four remaining sediment samples were collected from Wenderholm Regional Park as control samples to compare with the samples taken at Whenuapai. A summary of the sediment sample results for samples reporting select PFAS concentrations above the LOR is provided in Table C-3, Appendix C. Sediment results for all compounds reported above the LOR are provided in Table C-8.

A summary of the sediment sample results is presented below. The sediment results were compared to the Norway Sediment Quality Guidelines (Bakke et al., 2010).

Of the 44 sediment samples collected at Whenuapai, PFAS was detected in 10 samples. No samples exceeded the sediment quality guidelines (Bakke et al., 2010). PFAS was not detected above the LOR in any of the sediment samples collected at Wenderholm Regional Park (and therefore these results have not been tabulated).

6.4 Biota

A summary of the biota sample results is presented below. The results were compared to trigger values developed by Food Standards Australia New Zealand (FSANZ, 2017). Fish and macroinvertebrates were collected at locations in the vicinity of Whenuapai Airbase, and at the Wenderholm Regional Park control site. A summary of the biota results compared to the relevant trigger values (FSANZ, 2017) is provided in Appendix C, Tables C-4 and C-5.

6.4.1 Fish

A total of 11 fish samples were collected during the sampling campaign; nine were collected from Whenuapai and two were collected from the control site. The fish species caught during the sampling campaign included the following:

- ∴ Yellowbelly flounder (*Rhombosolea leporine*).
- ∴ Parore (*Girella tricuspidata*).
- ∴ Yellow-eyed mullet (*Aldrichetta forsteri*).
- ∴ Eel (*Anguilla dieffenbachii*).
- ∴ Bully (*Giomorphus cotidianus*).

The eel and the bully samples were collected in freshwater.

The fish samples analysed from Whenuapai consisted of eight samples of individual fish (with at least one of each of the species above being sampled), and one composite sample which consisted of three individual flounder.

Of the nine fish samples analysed from Whenuapai:

- ✦ PFAS compounds were detected in all samples.
- ✦ The sum of Total PFOS + PFHxS was reported above the LOR for all samples with three exceeding the guideline (FSANZ, 2017).
- ✦ Concentrations of Total PFOS were also reported above the LOR for all samples with three exceeding the guideline (FSANZ, 2017).
- ✦ PFOA was detected above the LOR in two samples, none of which exceeded the guideline (FSANZ, 2017).
- ✦ Five samples contained one or more PFAS compounds for which there are currently no guidelines.

Both of the two fish samples collected and analysed from Wenderholm Regional Park returned concentrations of PFAS below the LOR.

6.4.2 Macroinvertebrates

A total of 28 macroinvertebrate samples were collected during the sampling campaign. All macroinvertebrate samples were composite samples and consisted of the following species:

- ✦ Mud crab (*Helice crassa*).
- ✦ Oyster (*Crassostrea gigas*).
- ✦ Horn shell (*Zeacumantus lutulentus*).
- ✦ Harbour top shell (*Diloma subrostrata*).
- ✦ Mud whelk (*Cominella glandiformis*).
- ✦ Cockle (*Austrovenus stutchburyi*).
- ✦ Mud snail (*Potamopyrgus* sp.).
- ✦ Cats eye (*Turbo smaragdus*).

(Note that composites were created from sub-samples of the same species.)

A total of 21 macroinvertebrate samples were collected at Whenuapai, of these samples:

- ✦ PFAS compounds were detected in 15 samples.
- ✦ No samples exceeded the guideline value for either Total PFOS or for the sum of Total PFHxS + PFOS (FSANZ, 2017).
- ✦ PFOA was detected in nine samples, none of which exceeded the guideline value (FSANZ, 2017).
- ✦ Seven samples contained one or more other PFAS compounds for which there are currently no guidelines.

Seven macroinvertebrate samples were collected at Wenderholm Regional Park, of these samples:

- ∴ PFAS compounds (including Total PFOS and Total PFHxS) were detected in two samples.
- ∴ No samples exceeded the guideline value for Total PFOS or for the sum of Total PFHxS + PFOS (FSANZ, 2017).
- ∴ PFOA was not detected in any of the samples.

7.0 Discussion

This section discusses the groundwater, surface water, sediment, fish and macroinvertebrate results with respect to sample location.

7.1 Groundwater

PFAS compounds were detected in groundwater samples from three bores located down hydraulic gradient of potential on-base sources identified in the Preliminary Site Investigation (PSI) (Coffey, 2018). Water use information and bore construction details indicate that the bores are shallow and used as monitoring wells for Watercare. The interim drinking water guideline (MoH, 2017) was not exceeded in any of the three bores.

No other samples reported PFAS concentrations above the LOR. The remaining three groundwater bores, where PFAS was not detected above the LOR, are recorded as being installed to 200 to 300 m below ground level (bgl), and cased to a depth of 50 – 100 m bgl. These results indicate that PFAS is not present in the deeper groundwater at the locations sampled.

7.2 Surface Water

PFAS was detected in nine samples collected from sites in freshwater streams that receive runoff/discharge from Whenuapai Airbase. Seven of these sites had low concentrations of the sum of Total PFHxS + PFOS with concentrations at or below 0.01 µg/L.

The remaining two sites exceed the recreational water quality guideline for the sum of Total PFHxS + PFOS (AGDoH, 2017) and the 95% ecological protection guideline for Total PFOS. These sites are located downstream of an on-base fire training area / former foam testing area and a possible on-base source related to light aircraft crashes (Coffey, 2018). Water from the sampled streams ultimately discharges in to the upper Waitematā Harbour. Water at one of the sites runs through a paddock where pigs are raised, and the pigs have access to the waterway. MPI have been advised of the sample results and will provide specific advice to the resident if they consider it necessary.

At two sample locations which are both receiving environments of stormwater which emanates from the southeast of the Whenuapai Airbase, the compounds 6:2 FTS, PFBA, PFHpA, PFHxA and PFPeA were detected, however PFOS and PFHxS were not.

7.3 Sediment

Sediment was collected at nine sites in the vicinity of Whenuapai Airbase, ten samples from three sample sites reported PFAS compounds above the LOR. The highest concentration of Total PFOS was in the surface sediment sample collected at SD09. This sample was also the only sediment sample that reported a detection of 6:2 FTS. SD09 was collected at the freshwater-marine water mixing zone of Rarawaru Stream. This area receives runoff from the northwest of the Whenuapai Airbase, including the small gully adjacent to the on-base fire training area and former foam testing area (Coffey, 2018). Surface water sample SW02 (which reported a concentration of the sum of Total PFHxS + PFOS exceeding the recreation guideline) was also collected at this location.

PFOS was detected in all six of the estuarine sediment samples collected in the Rarawaru Inlet downstream of SD09 (being samples SD06.1, SD06.2, and SD06.3). The six sediment samples were collected from three sediment cores spaced approximately 50 metres apart. At each core site, a surface (0-2cm deep) and a deeper (8-10cm deep) sample was collected. PFOS concentrations in the three surface sediment sample results were found to decrease with distance downstream from the base; however concentrations were variable with depth. No PFAS compounds other than PFOS were detected in these samples.

PFOS was also detected at low concentrations (just above the LOR) in both the surface sample and the deeper sample from sediment core SD04.2 in the Te Turerenga Inlet (one of three cores collected at this location). This site is downstream from a former fire training area identified in the PSI (Coffey, 2018).

PFAS compounds were not detected above the LOR in the two samples from the control site at Wenderholm Regional Park.

7.4 Biota

7.4.1 Fish

PFAS compounds were detected in all fish samples collected in the vicinity of Whenuapai Airbase. Three of these samples reported PFAS concentrations above the food safety trigger value (FSANZ, 2017). These were individual samples of flounder, eel and bully.

Sample numbers FS04.1 (Eel) and FS04.2 (Bully) were collected from Rarawaru Creek (the same location as SW02 and SD09), downstream from an on-base fire training area and former foam testing area (Coffey, 2018). These samples were more than three times the trigger value (FSANZ, 2017) for the sum of total PFHxS + PFOS.

Flounder sample FS03.2, collected further downstream within the Rarawaru Inlet (the same location as BT05 and SD06) was also found to exceed the trigger (FSANZ, 2017). Three other fish collected at the same location (FS03.1, FS03.3 and FS03.4) reported detectable PFAS compounds; however none of these samples exceeded the trigger (FSANZ, 2017).

PFAS compounds were not detected above the LOR in the samples from the control site at Wenderholm Regional Park.

7.4.2 Macroinvertebrates

PFAS compounds were detected in 15 samples. All samples were below the trigger value (FSANZ, 2017). Oysters and mud crabs were collected at each site. The presence of the remaining species varied at each site. With the exception of one site, oysters were the only samples that did not contain PFAS compounds above the LOR.

PFAS concentrations were found to be significantly higher in horn shells compared to other molluscs living in the same environment. Horn shells were found at three sites, BT02, BT03 and BT04. The highest concentrations of PFAS in horn shells were found in samples from BT02 and BT03 which were collected at Waiarohia Inlet and Te Turerenga Inlet respectively. These sites are downstream from known former fire training areas identified in the PSI (Coffey, 2018). The concentration of PFAS in samples BT02 and BT03 were significantly higher than the concentrations detected in the horn shells collected at BT04, which is located in the near-shore environment downstream from the Kotukutuku Creek.

The highest concentration of the sum of Total PFHxS + PFOS in horn shells was in sample BT02.3, which was collected at Waiarohia Inlet, in the same location as sediment samples SD03. No PFAS compounds were detected in the sediment samples collected at SD03.

PFAS compounds were detected in low concentrations in both the horn shell and cats eye samples from the control site at Wenderholm Regional Park. No other samples from the control site were found to contain PFAS.

8.0 Conclusions

Sampling at locations adjacent to the Whenuapai Airbase has confirmed the presence of PFAS compounds at some locations, in various media.

PFAS compounds were detected at low concentrations (below the interim drinking water guideline) in shallow groundwater to the south west of the base; however samples collected from deeper groundwater (> 50 m bgl) did not contain concentrations of PFAS above the LOR. The shallow groundwater at those sample sites where PFAS was detected is not used for any purpose.

All surface water samples collected from locations north and east of Whenuapai Airbase were found to contain PFAS compounds. These locations drain stormwater from Whenuapai Airbase. The highest concentrations of PFAS found in surface water were from samples located downstream of areas within Whenuapai Airbase that have been identified as being used for fire training (Coffey, 2018).

Sediment, fish and macroinvertebrate samples collected from Rarawaru Creek and Inlet were found to contain higher concentrations of PFAS compounds compared to samples from other locations in the vicinity of Whenuapai Airbase. Three of the six fish samples collected from Rarawaru Creek and Inlet exceeded the FSANZ human health trigger point for investigation.

8.1 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 not recommended.

9.0 References

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- MoH, 2017. *Poly-fluoroalkyl substances (PFASs), also called perfluoroalkyl substances (PFASs) draft*, Ministry of Health November 2017.
- PDP, 2018a. *Sampling Protocols for Monitoring Per and Poly-fluorinated Compounds in Groundwater and Surface Water for New Zealand Defence Force*. Pattle Delamore Partners Ltd. 2018.
- PDP, 2018b. *Sampling and Analysis Plan for Protocols for Monitoring Per and Poly-fluorinated Compounds in Biota, Sediment, Surface and Groundwater, Adjacent to the RNZAF Base Whenuapai*. Pattle Delamore Partners Ltd. July 2018.

Appendix A

Sediment Quality Guidelines

Appendix A: Sediment Quality Guidelines

To establish the degree of risk to sediment-dwelling organisms, the results of sediment sampling are normally compared to sediment quality guidelines. However, neither the Australian and New Zealand Environmental Conservation Council (ANZECC) nor PFAS National Environmental Management Plan (HEPA, 2018) has derived any sediment quality guideline values for the protection of aquatic ecosystems. The Norwegian Pollution Control Authority have developed Predicted No Effect Concentrations (PNECs) for sediment based on expected background concentration levels and using equilibrium partitioning relationships² with seawater to calculate $PNEC_{\text{sediment}}$ based on water quality toxicity data (Bakke et al, 2010).

At sediment concentrations less than the Norwegian $PNEC_{\text{sediment}}$ trigger values (concentrations which are either within the range of categories I or II) are unlikely to cause adverse effects in aquatic organisms. However, concentrations above this range represent a possible effects range but do not necessarily mean that adverse effects will actually occur. This is for four reasons:

- i. The Norwegian $PNEC_{\text{sediment}}$ are have been derived using a theoretical relationship between sediment concentration and water quality concentration based on a partitioning co-efficient (K_{oc}).
- ii. No actual sediment toxicity data is available for use in validating these predictions so these guidelines are considered to be ‘low reliability guidelines’³.
- iii. PNEC are values designed to predict no effect rather than the onset of toxicity. PNEC values are, therefore, considered to be poor predictors of likely toxicity as toxic effects may occur at significantly higher concentrations than the PNEC values.

² PFAS compounds are emerging contaminants, therefore there is a lot of uncertainty in the data and relationship used to calculate the $PNEC_{\text{sediment}}$ trigger values. It is likely that as more data becomes available, and the scientific uncertainty regarding the behaviour of these compounds reduces, these trigger values could change and the risks may need to be re-assessed in the future.

³ For the purpose of this report, water and sediment quality guidelines can be assessed as being high reliability, moderate reliability or low reliability. High reliability guidelines are based off a species sensitive distribution of a sufficient robust eco-toxicological dataset. Moderate reliability guidelines have been derived using a dataset which includes a smaller number of eco-toxicological data from at least three different species (ANZECC (2000) sediment quality guidelines are an example of a moderate reliability sediment quality guideline). Low reliability guidelines do not have datasets which meet the above requirements. Low reliability guidelines have been calculated from insufficient datasets and, therefore, provide less confidence that aquatic ecosystems will be protected. For this report, it was considered preferable to have low-reliability guidelines than no guidelines to assess the data. However, a reassessment of the data should be undertaken once higher reliability sediment guidelines become available.

- iv. Site-specific factors such as the concentration of organic matter, iron oxides and the clay content of the sediment may all modify the toxicity of PFAS compounds at a specific site.

Given these limitations, values below the PNECs for these chemicals do not guarantee that the concentrations are safe either but they provide an indication of likely risk and allow ranking of sampling locations. Also, PFAS compounds are known to bio-accumulate in organisms and bio-magnify up the food-chain. The Norwegian PNEC guidelines do not account for bioaccumulation – they are based on direct toxicity for aquatic organisms in water, adjusted to account for the characteristics of sediments. Therefore, the Norwegian PNEC guidelines are designed to be trigger values to indicate which sites may warrant closer investigation. They do not assess the risk to aquatic organisms from dietary borne toxicity nor do they assess the potential for a compound to bio-accumulate up the food chain.

Appendix B

Quality Assurance / Quality Control Check

ESDAT QA Checker

Project:A02386_RNZAF Base Whenuapai

Filter: SDG in('A02386808')

Overview Summary

[Count of Samples](#)

[Count of Results](#)

Holding Times

Blanks

[Field Blanks](#)

Detects in Lab Blanks (0)

Duplicates

[All Field Duplicates \(108\)](#)

All Field Inter-lab Duplicates (0)

[Field Duplicates with high RPDs \(1\)](#)

Field Inter-lab Duplicates with high RPDs (0)

[Lab Duplicates with high RPDs \(2\)](#)

Lab Control Samples

SDG's without a Laboratory Control Sample (0)

Laboratory Control Samples, Error > 25% (0)

Certified and Standard Reference Materials

Certified Reference Materials - Error > 25% (0)

Matrix Spikes

Trip Spikes with invalid Control Sample (0)

Matrix Spike Recoveries outside lab LCL or UCL (0)

Inorganic

Other

OriginalChemNames Requiring Validation (0)

Samples with no Results (0)

[Contents](#)

Field Duplicates with high RPDs

SDG	Matrix_Type	Dupe_Field_ID	Parent_Field_ID	Depth	Sampled_Date-Time	Method_Name	Compound	Parent_Result	Dupe_Result	Result_Unit	EQL	RPD
A02386808	Water	WHP_ADJ_SWAAB_1_260718	WHP_ADJ_SW08_1_260718		26/07/2018	DX-PFCS01, 03-SUITE_B - AsureQuality Method (LC-MS/MS)	PFTeDA	<0.1	-999.0	µg/L	0.001 µg/L	0

[Contents](#)

Lab Duplicates with high RPDs

SDG	Lab_Report_Number	Matrix_Type	Lab_Duplicate	Field_ID	Depth	Sampled_Date-Time	Method_Name	Compound	Parent_Result	Dupe_Result	Result_Unit	EQL	RPD
A02386808	1206458	Water	1206458_18-198210-7	WHP_ADJ_SW03_1_300718		30/07/2018	DX-PFCS01, 03-SUITE_B - AsureQuality Method (LC-MS/MS)	PFTTrDA	-999	<0.1	µg/L		0
A02386808	1206458	Water	1206458_18-198210-7	WHP_ADJ_SW03_1_300718		30/07/2018	DX-PFCS01, 03-SUITE_B - AsureQuality Method (LC-MS/MS)	PFTeDA	-999	<0.1	µg/L		0

Appendix C

Summary Sample Results Table

Table C-1: Groundwater Sampling Results - Per- and Poly-Fluoroalkyl Substances (PFAS) Detections Only ¹

PFAS In Groundwater				Guideline Values	
Sample Name	WHP_ADJ_GW07_1_030818	WHP_ADJ_GW08_1_030818	WHP_ADJ_GW09_1_030818	Interim Guidance Level for Drinking Water ²	Recreational Water Guideline ³
Sample Location	GW07	GW08	GW09		
Laboratory	AsureQuality	AsureQuality	AsureQuality		
Lab Report Number	1206454	1206454	1206454		
Date Sampled	3/08/2018	3/08/2018	3/08/2018		
Sample Results ³					
Total Perfluorohexanesulfonic acid (T-PFHxS) ⁴	0.0062	0.0061	<LOR	-	-
Total Perfluorooctanesulfonic acid (T-PFOS) ⁴	0.0081	0.0065	0.0013	-	-
Sum of Total PFOS & PFHxS	0.014	0.013	0.0013	0.07	<u>0.7</u>
Perfluorooctanoic acid (PFOA)	0.0044	0.0074	<LOR	0.56	<u>5.6</u>

Notes:

1. Values in µg/L (parts per billion).
2. Interim Guidance Level for Drinking Water, Ministry of Health 2017. Adopted from Australian Government Department of Health - Health Based Guidance Values for PFAS accessed 01/06/2017 ([https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/\\$File/fs-Health-Based-Guidance-Values.pdf](https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/fs-Health-Based-Guidance-Values.pdf)).
2. Australian Government Department of Health - Health Based Guidance Values for PFAS accessed 01/06/2017 ([https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/\\$File/fs-Health-Based-Guidance-Values.pdf](https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/fs-Health-Based-Guidance-Values.pdf)).
3. Only compounds relevant to the applicable guidelines are included in this table.
4. Total PFOS, PFHxS are calculated by summing monoethyl, dimethyl and linear isomers.
5. Summations are made by adding compounds Total PFOS (7), Total PFHxS (3) together. Where one compound is below detection, it is not included in the summation.

-	No guideline available
<LOR	Less than the laboratory limit of reporting.
0.75	Exceeds the Interim Drinking Water Guideline.
<u>0.75</u>	Exceeds the Interim Drinking Water Guideline and the Recreational Water Quality Guideline.

Table C-2: Surface Water Sampling Results - Per- and Poly-Fluoroalkyl Substances (PFAS) Detections Only ¹

Sample Name	PFAS In Surface Water							Guideline Values	
	WHP_ADJ_SW02_1_090818	WHP_ADJ_SW03_1_300718	WHP_ADJ_SW04_1_300718	WHP_ADJ_SW05_1_300718	WHP_ADJ_SW07_1_010818	WHP_ADJ_SW10_1_010818	WHP_ADJ_SW12_1_170818	Recreational Water Quality Guideline ²	Ecological Freshwater Guidelines - 95% Ecosystem Protection ³
Sample Location	SW02	SW03	SW04	SW05	SW07	SW10	SW12		
Laboratory	AsureQuality								
Lab Report Number	1212180	1206458	1206219	1205834	1230590	1205829	1216460		
Date Sampled	9/08/2018	30/07/2018	30/07/2018	30/07/2018	1/08/2018	1/08/2018	17/08/2018		
Sample Results ⁴									
Total Perfluorohexanesulfonic acid (T-PFHxS) ⁵	0.38	0.0051	0.33	0.0052	0.0044	0.006	0.0053	-	-
Total Perfluorooctanesulfonic acid (T-PFOS) ⁵	0.37	0.0041	0.5	0.0045	<LOR	0.0044	0.01	-	0.13
Sum of Total PFOS & PFHxS ⁶	0.75	0.0092	0.83	0.0097	0.0044	0.01	0.015	0.7	-
Perfluorooctanoic acid (PFOA)	0.081	0.0026	0.012	<LOR	0.0012	0.0026	0.0041	5.6	220

- Notes:
1. Values in µg/L (parts per billion).
 2. Australian Government Department of Health - Health Based Guidance Values for PFAS accessed 01/06/2017 ([https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/\\$File/fs-Health-Based-Guidance-Values.pdf](https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/fs-Health-Based-Guidance-Values.pdf)).
 3. Heads of EPAs Australia and New Zealand - PFAS National Environmental Management Plan, January 2018.
 4. Only compounds relevant to the applicable guidelines are included in this table.
 5. Total PFOS is calculated by summing monoethyl, dimethyl and linear isomers. Where an isomer is below the detection limit it is not added to the summation. This is following the method in the reported lab results.
 6. Summations are made by adding compounds Total PFOS (7), Total PFHxS (3) together. Where one compound is below detection, it is not included in the summation.

-	No Guideline Available.
<LOR	Less than the laboratory limit of reporting.
0.75	Exceeds the Contact Recreational Guideline.
0.13	Exceeds the 95% Ecosystem Protection Guideline.

Table C-3: Sediment Sampling Results - Per- and Poly-Fluoroalkyl Substances (PFAS) Detections Only ¹

PFAS In Sediment							Guideline Values			
Sample Name	WHP_ADJ_SD04.2_1_300718	WHP_ADJ_SD04.2_2_300718	WHP_ADJ_SD06.1_1_260718	WHP_ADJ_SD06.1_2_260718	WHP_ADJ_SD06.2_1_260718	WHP_ADJ_SD06.2_2_260718	Sediment Quality Guidelines - Toxic Effects Following Chronic Exposure ³	Sediment Quality Guidelines - Toxic Effects Following Short Term Exposure ³		
Sample Location ²	SD04.2 - BT02 - FS01	SD04.2 - BT02 - FS01	SD06.1 - BT05 - FS02	SD06.1 - BT05 - FS02	SD06.2 - BT05 - FS02	SD06.2 - BT05 - FS02				
Sample Depth (cm)	2	10	2	10	2	10				
Laboratory	AsureQuality	AsureQuality	AsureQuality	AsureQuality	AsureQuality	AsureQuality				
Lab Report Number	1205398	1205398	1201816	1201816	1201816	1201816				
Date Sampled	30/07/2018	30/07/2018	26/07/2018	26/07/2018	26/07/2018	26/07/2018				
Sample Results ⁴										
Total Perfluorohexanesulfonic acid (T-PFHxS) ⁵	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	-	-		
Total Perfluorooctanesulfonic acid (T-PFOS) ⁵	0.001	0.0011	0.0032	0.0018	0.0032	0.0022	0.22	0.63		
Sum of Total PFOS & PFHxS ⁶	0.001	0.0011	0.0032	0.0018	0.0032	0.0022	-	-		
Perfluorooctanoic acid (PFOA)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	-	-		

PFAS In Sediment					Guideline Values			
Sample Name	WHP_ADJ_SD06.3_1_260718	WHP_ADJ_SD06.3_2_260718	WHP_ADJ_SD09_1_090818	WHP_ADJ_SD09_2_090818	Sediment Quality Guidelines - Toxic Effects Following Chronic Exposure ³	Sediment Quality Guidelines - Toxic Effects Following Short Term Exposure ³		
Sample Location ²	SD06.3 - BT05 - FS02	SD06.3 - BT05 - FS02	SD09 - SW02	SD09 - SW02				
Sample Depth (cm)	2	10	2	10				
Laboratory	AsureQuality	AsureQuality	AsureQuality	AsureQuality				
Lab Report Number	1201816	1201816	1213365	1213365				
Date Sampled	26/07/2018	26/07/2018	9/08/2018	9/08/2018				
Sample Results ⁴								
Total Perfluorohexanesulfonic acid (T-PFHxS) ⁵	<LOR	<LOR	<LOR	<LOR	-	-		
Total Perfluorooctanesulfonic acid (T-PFOS) ⁵	0.0025	0.0015	0.0049	0.0032	0.22	0.63		
Sum of Total PFOS & PFHxS ⁶	0.0025	0.0015	0.0049	0.0032	-	-		
Perfluorooctanoic acid (PFOA)	<LOR	<LOR	<LOR	<LOR	-	-		

- Notes:
1. Values in mg/kg dry weight (parts per million).
 2. The sample location is accompanied by the surface water sample location or biota sample location sharing the same location.
 3. Norway Sediment Quality Guidelines. Obtained from Bakke, T., Kailquist, T., Ruus, A., Breedveld, G. and Huylland, K. (2010). Journal of Soils and Sediment, 10, pp 172-178.
 4. Only select PFAS compounds are reported on rather than the entire suite of 28 compounds reported by the laboratory.
 5. Total PFOS, PFHxS are calculated by summing monoethyl, dimethyl and linear isomers. Where an isomer is below the detection limit it is not added to the summation. This is following the method in the reported lab results.
 6. Summations are made by adding compounds Total PFOS (7), Total PFHxS (3) together. Where one compound is below detection, it is not included in the summation.

<LOR	Result is less than the limit of reporting.
-	No guideline value available.
0.22	Shaded - Exceeds one or more guidelines.

Table C-4: Biota Sampling Results - Per- and Poly-Fluoroalkyl Substances (PFAS) All Samples - Fish ¹

PFAS In Fish								Guideline Values
Sample Name	WHP_ADJ_FS01.1_160818	WHP_ADJ_FS01.2_160818	WHP_ADJ_FS02.1_030818 ⁷	WHP_ADJ_FS03.1_160818	WHP_ADJ_FS03.2_160818	WHP_ADJ_FS03.3_160818	WHP_ADJ_FS03.4_160818	Human Health Trigger Points for Investigation - Finfish (all) ³
Sample Location ²	FS01 - BT02 - SD03	FS01 - BT02 - SD03	FS02 - BT03 - SD04	FS03 - BT05 - SD06				
Species	Yellowbelly Flounder	Yellow-eyed mullet	Yellowbelly Flounder	Yellowbelly Flounder	Yellowbelly Flounder	Parore	Parore	
Laboratory	AsureQuality	AsureQuality	AsureQuality	AsureQuality	AsureQuality	AsureQuality	AsureQuality	
Lab Report Number	1220903	1220903	1209486	1220955	1220955	1220955	1220955	
Date Sampled	16/08/2018	16/08/2018	3/08/2018	16/08/2018	16/08/2018	16/08/2018	16/08/2018	
Sample Results ⁴								
Total Perfluorohexanesulfonic acid (T-PFHxS) ⁵	<LOR	<LOR	<LOR	<LOR	0.82	<LOR	<LOR	-
Total Perfluorooctanesulfonic acid (T-PFOS) ⁵	0.31	0.75	0.88	2.3	6.9	1.2	1.8	5.2
Sum of Total PFOS & PFHxS ⁶	0.31	0.75	0.88	2.3	7.7	1.2	1.8	5.2
Perfluorooctanoic acid (PFOA)	<LOR	<LOR	<LOR	<LOR	0.33	<LOR	<LOR	41

PFAS In Fish					Guideline Values
Sample Name	WHP_ADJ_FS04.1_170818	WHP_ADJ_FS04.2_170818	WND_CTL_FS06.1_300818	WND_CTL_FS06.2_300818	Human Health Trigger Points for Investigation - Finfish (all) ³
Sample Location ²	FS04 - SD09 - SW02	FS04 - SD09 - SW02	FS06 - SD10 ⁸	FS06 - SD10 ⁸	
Species	Eel	Bully	Yellowbelly Flounder	Yellowbelly Flounder	
Laboratory	AsureQuality	AsureQuality	AsureQuality	AsureQuality	
Lab Report Number	1220954	1220954	1233329	1233329	
Date Sampled	17/08/2018	17/08/2018	30/08/2018	30/08/2018	
Sample Results ⁴					
Total Perfluorohexanesulfonic acid (T-PFHxS) ⁵	1.5	<LOR	<LOR	<LOR	-
Total Perfluorooctanesulfonic acid (T-PFOS) ⁵	28	17	<LOR	<LOR	5.2
Sum of Total PFOS & PFHxS ⁶	30	17	<LOR	<LOR	5.2
Perfluorooctanoic acid (PFOA)	0.35	<LOR	<LOR	<LOR	41

Notes:

1. Values in µg/kg (parts per billion).
2. Sample names of other samples collected from this location are shown.
3. Australian Government Department of Health - Perfluorinated chemicals in food accessed 16/07/2018 ([http://www.health.gov.au/internet/main/publishing.nsf/content/2200FE086D480353CA2580C900817CDC/\\$File/Consolidated-report-perfluorinated-chemicals-food.pdf](http://www.health.gov.au/internet/main/publishing.nsf/content/2200FE086D480353CA2580C900817CDC/$File/Consolidated-report-perfluorinated-chemicals-food.pdf)).
4. Only compounds relevant to the applicable guidelines are included in this table.
5. Total PFOS, PFHxS are calculated by summing monoethyl, dimethyl and linear isomers.
6. Summations are made by adding compounds together.
7. Composite sample of three Yellowbelly Flounder.
8. Control site - Wenderholm Regional Park.

<LOR	Result is less than the limit of reporting.
-	No guideline value available.
0.22	Exceeds the Finfish (all) Human Health Trigger Point.

Table C-5: Biota Sampling Results - Per- and Poly-Fluoroalkyl Substances (PFAS) All samples - Macroinvertebrates ^{1,2}

PFAS In Macroinvertebrates									Guideline Values
Sample Name	WHP_ADJ_BT01.1_090818	WHP_ADJ_BT01.2_090818	WHP_ADJ_BT01.7_090818	WHP_ADJ_BT02.1_090818	WHP_ADJ_BT02.2_090818	WHP_ADJ_BT02.3_090818	WHP_ADJ_BT02.5_090818	WHP_ADJ_BT02.6_090818	Human Health Trigger Points for Investigation - Crustaceans and Molluscs (all) ⁴
Sample Location ³	BT01 - SD02			BT02 - FS01 -SD03					
Species	Mud crab	Oyster	Mud snail	Mud crab	Oyster	Horn shell	Mud whelk	Cockle	
Laboratory	AsureQuality								
Lab Report Number	1213209	1213209	1213209	1213211	1213211	1213211	1213211	1213211	
Date Sampled	9/08/2018	9/08/2018	9/08/2018	9/08/2018	9/08/2018	9/08/2018	9/08/2018	9/08/2018	
Sample Results ⁵									
Total Perfluorohexanesulfonic acid (T-PFHxS) ⁶	<LOR	<LOR	<LOR	<LOR	<LOR	14	<LOR	<LOR	-
Total Perfluorooctanesulfonic acid (T-PFOS) ⁶	0.45	<LOR	0.6	0.33	<LOR	12	0.45	0.31	65
Sum of Total PFOS & PFHxS ⁷	0.45	<LOR	0.6	0.33	<LOR	26	0.45	0.31	65
Perfluorooctanoic acid (PFOA)	0.35	<LOR	<LOR	0.55	<LOR	3	<LOR	<LOR	250

PFAS In Macroinvertebrates									Guideline Values
Sample Name	WHP_ADJ_BT03.1_300718	WHP_ADJ_BT03.2_300718	WHP_ADJ_BT03.3_300718	WHP_ADJ_BT03.4_300718	WHP_ADJ_BT04.1_090818	WHP_ADJ_BT04.2_090818	WHP_ADJ_BT04.3_090818	Left blank for formatting purposes	Human Health Trigger Points for Investigation - Crustaceans and Molluscs (all) ⁴
Sample Location ³	BT03 - FS02 - SD04				BT04 - SD04				
Species	Mud crab	Oysters	Horn shell	Harbour top shell	Mud crab	Oyster	Horn shell		
Laboratory	AsureQuality								
Lab Report Number	1205395	1205395	1205395	1205395	1213213	1213213	1213213		
Date Sampled	30/07/2018	30/07/2018	30/07/2018	30/07/2018	9/08/2018	9/08/2018	9/08/2018		
Sample Results ⁵									
Total Perfluorohexanesulfonic acid (T-PFHxS) ⁶	<LOR	<LOR	2.8	<LOR	<LOR	<LOR	0.81	-	
Total Perfluorooctanesulfonic acid (T-PFOS) ⁶	0.56	<LOR	17	0.44	0.57	<LOR	2.8	65	
Sum of Total PFOS & PFHxS ⁷	0.56	<LOR	20	0.44	0.57	<LOR	3.6	65	
Perfluorooctanoic acid (PFOA)	0.41	<LOR	3.3	0.38	0.4	<LOR	0.36	250	

PFAS In Macroinvertebrates								Guideline Values
Sample Name	WHP_ADJ_BT05.1_260718	WHP_ADJ_BT05.2_260718	WHP_ADJ_BT06.1_090818	WHP_ADJ_BT06.2_090818	WHP_ADJ_BT06.7_090818	WHP_ADJ_BT07.1_260718	Left blank for formatting purposes	Human Health Trigger Points for Investigation - Crustaceans and Molluscs (all) ⁴
Sample Location ³	BT05 -FS02 - SD06		BT06 - SD07		BT07 - SD08			
Species	Mud Crab	Oyster	Mud crab	Oyster	Mud snail	Mud crab		
Laboratory	AsureQuality	AsureQuality	AsureQuality	AsureQuality	AsureQuality	AsureQuality		
Lab Report Number	1201811	1201811	1214137	1214137	1214137	1201810		
Date Sampled	26/07/2018	26/07/2018	9/08/2018	9/08/2018	9/08/2018	26/07/2018		
Sample Results ⁵								
Total Perfluorohexanesulfonic acid (T-PFHxS) ⁶	0.37	<LOR	<LOR	<LOR	<LOR	<LOR	-	
Total Perfluorooctanesulfonic acid (T-PFOS) ⁶	1.6	0.4	<LOR	<LOR	0.54	2	65	
Sum of Total PFOS & PFHxS ⁷	2	0.4	<LOR	<LOR	0.54	2	65	
Perfluorooctanoic acid (PFOA)	0.99	<LOR	<LOR	<LOR	<LOR	<LOR	250	

PFAS In Macroinvertebrates								Guideline Values	
Sample Name	WND_CTL_BT08.1_300818	WND_CTL_BT08.2_300818	WND_CTL_BT08.3_300818	WND_CTL_BT08.4_300818	WND_CTL_BT08.5_300818	WND_CTL_BT08.6_300818	WND_CTL_BT08.8_300818	Left blank for formatting purposes	Human Health Trigger Points for Investigation - Crustaceans and Molluscs (all) ⁴
Sample Location ³	BT08 - SD10 -FS06 ⁸								
Species	Mud crab	Oyster	Horn shell	Harbour top shell	Whelk	Cockle	Cats eye		
Laboratory	AsureQuality	AsureQuality	AsureQuality	AsureQuality	AsureQuality	AsureQuality	AsureQuality		
Lab Report Number	1233329	1233329	1233329	1233329	1233329	1233329	1233329		
Date Sampled	30/08/2018	30/08/2018	30/08/2018	30/08/2018	30/08/2018	30/08/2018	30/08/2018		
Sample Results ⁵									
Total Perfluorohexanesulfonic acid (T-PFHxS) ⁶	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	-	
Total Perfluorooctanesulfonic acid (T-PFOS) ⁶	<LOR	<LOR	0.41	<LOR	<LOR	<LOR	0.67	65	
Sum of Total PFOS & PFHxS ⁷	<LOR	<LOR	0.41	<LOR	<LOR	<LOR	0.67	65	
Perfluorooctanoic acid (PFOA)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	250	

- Notes:
1. Values in µg/kg (parts per billion).
 2. All samples are composite samples.
 3. Sample names of other samples collected from this location are shown.
 4. Australian Government Department of Health - Perfluorinated chemicals in food accessed 16/07/2018 ([http://www.health.gov.au/internet/main/publishing.nsf/content/2200FE086D480353CA2580C900817CDC/\\$File/Consolidated-report-perfluorinated-chemicals-food.pdf](http://www.health.gov.au/internet/main/publishing.nsf/content/2200FE086D480353CA2580C900817CDC/$File/Consolidated-report-perfluorinated-chemicals-food.pdf)).
 5. Only compounds relevant to the applicable guidelines are included in this table.
 6. Total PFOS, PFHxS are calculated by summing monoethyl, dimethyl and linear isomers.
 7. Summations are made by adding compounds together.
 8. Control site - Wenderholm Regional Park

<LOR	Result is less than the limit of reporting.
-	No guideline value available.
0.22	Exceeds the Crustaceans and Molluscs (all) Human Health Trigger Point.

Table C-6: Groundwater Sampling - Per- and Poly-Fluoroalkyl Substances (PFAS) All Detects ¹

Sample Name	WHP_ADJ_GW07_1_030818	WHP_ADJ_GW08_1_030818	WHP_ADJ_GW09_1_030818
Location	GW07	GW08	GW09
Laboratory	AsureQuality	AsureQuality	AsureQuality
Lab Report Number	1206454	1206454	1206454
Sample Date	3/08/2018	3/08/2018	3/08/2018
Sample Results ²			
L-PFHxS (1)	0.0062	0.0061	-
Total PFHxS (3)	0.0062	0.0061	-
L-PFOS (5)	0.0042	0.0032	0.0013
mono-PFOS (5)	0.0039	0.0033	-
Total PFOS (7)	0.0081	0.0065	0.0013
Sum PFHxS+PFOS (1)	0.014	0.013	0.0013
NEtFOSAA	-	0.0014	-
6:2 FTS	0.0033	0.0055	0.015
PFOA	0.0044	0.0074	-
PFHpA	0.0014	0.0019	-
PFHxA	0.0085	0.008	-
PFPeA	0.0036	0.0086	-

Notes:

1. Values in µg/L (parts per billion).
2. Only detected compounds are shown in the table.
3. Total PFHxS (3) and Total PFOS (3) is calculated by summing monoethyl, dimethyl and linear isomers. Where an isomer is below the detection limit it is not added to the summation. This is following the method in the reported lab results.
6. Summations are made by adding compounds Total PFOS (7), Total PFHxS (3) together. Where one compound is below detection, it is not included in the summation.

- Result is less than the limit of reporting or is not reportable

Table C-7: Surface Water Sampling - Per- and Poly-Fluoroalkyl Substances (PFAS) All Detects ¹

Sample Name	WHP_ADJ_SW02_1_090818	WHP_ADJ_SW03_1_300718	WHP_ADJ_SW04_1_300718	WHP_ADJ_SW05_1_300718	WHP_ADJ_SW06_1_310718	WHP_ADJ_SW07_1_010818	WHP_ADJ_SW08_1_260718	WHP_ADJ_SW10_1_010818	WHP_ADJ_SW12_1_170818
Location	SW02	SW03	SW04	SW05	SW06	SW07	SW08	SW10	SW12
Laboratory	AsureQuality								
Lab Report Number	1212180	1206458	1206219	1205834	1205839	1230590	1200331	1205829	1216460
Sample Date	9/08/2018	30/07/2018	30/07/2018	30/07/2018	31/07/2018	1/08/2018	26/07/2018	1/08/2018	17/08/2018
Sample Results ²									
mono-PFHxS (1)	0.051	-	0.039	-	-	-	-	-	-
L-PFHxS (1)	0.33	0.0051	0.29	0.0052	-	0.0044	-	0.006	0.0053
Total PFHxS (3) ³	0.38	0.0051	0.33	0.0052	-	0.0044	-	0.006	0.0053
mono-PFOS (5)	0.14	0.0017	0.2	0.0019	-	-	-	0.0015	0.0032
L-PFOS (5)	0.22	0.0024	0.29	0.0026	-	-	-	0.0029	0.0071
di-PFOS (5)	0.012	-	0.012	-	-	-	-	-	-
Total PFOS (7) ³	0.37	0.0041	0.5	0.0045	-	-	-	0.0044	0.01
Sum PFHxS+PFOS (1) ⁴	0.75	0.0092	0.83	0.0097	-	0.0044	-	0.01	0.015
8:2 FTS	0.018	-	-	-	-	-	-	-	-
6:2 FTS	1.2	0.017	-	-	-	-	0.0035	0.017	-
PFOA	0.081	0.0026	0.012	-	-	0.0012	-	0.0026	0.0041
PFBA	0.1	0.022	-	-	-	-	-	0.023	0.0059
PFBS	0.016	-	0.0033	-	-	-	-	-	-
PFHpA	0.14	0.01	0.0043	0.0015	0.0012	0.0021	0.0015	0.01	0.0066
PFHpS	0.02	-	0.028	-	-	-	-	-	-
PFHxA	0.34	0.057	0.021	0.0052	0.0024	0.0033	0.0037	0.063	0.013
PFNA	0.02	-	0.0088	-	-	-	-	-	0.0016
PFPeA	0.48	0.1	0.0057	0.0081	0.0028	0.0057	0.005	0.11	0.019
PFPeS	0.028	-	0.0066	-	-	-	-	-	-
PFPrS	0.0076	-	-	-	-	-	-	-	-

Notes:

1. Values in µg/L (parts per billion).
2. Only detected compounds are shown in the table.
3. Total PFHxS (3) and Total PFOS (3) is calculated by summing monoethyl, dimethyl and linear isomers. Where an isomer is below the detection limit it is not added to the summation. This is following the method in the reported lab results.
6. Summations are made by adding compounds Total PFOS (7), Total PFHxS (3) together. Where one compound is below detection, it is not included in the summation.

- Result is less than the limit of reporting or is not reportable

Table C-8: Sediment Sampling - Per- and Poly-Fluoroalkyl Substances (PFAS) All Detects ¹

Sample Name	WHP_ADJ_SD04.2_1_300718	WHP_ADJ_SD04.2_2_300718	WHP_ADJ_SD06.1_1_260718	WHP_ADJ_SD06.1_2_260718	WHP_ADJ_SD06.2_1_260718	WHP_ADJ_SD06.2_2_260718	WHP_ADJ_SD06.3_1_260718	WHP_ADJ_SD06.3_2_260718	WHP_ADJ_SD09_1_090818	WHP_ADJ_SD09_2_090818
Location	SD04.2	SD04.2	SD06.1	SD06.1	SD06.2	SD06.2	SD06.3	SD06.3	SD09	SD09
Laboratory	AsureQuality	AsureQuality	AsureQuality							
Lab Report Number	1205398	1205398	1201816	1201816	1201816	1201816	1201816	1201816	1213365	1213365
Sample Date	30/07/2018	30/07/2018	26/07/2018	26/07/2018	26/07/2018	26/07/2018	26/07/2018	26/07/2018	9/08/2018	9/08/2018
Sample Results ²										
mono-PFOS (5)	-	-	-	-	-	-	-	-	0.001	-
L-PFOS (5)	0.001	0.0011	0.0032	0.0018	0.0032	0.0022	0.0025	0.0015	0.0039	0.0032
Total PFOS (7)	0.001	0.0011	0.0032	0.0018	0.0032	0.0022	0.0025	0.0015	0.0049	0.0032
Sum PFHxS+PFOS (1)	0.001	0.0011	0.0032	0.0018	0.0032	0.0022	0.0025	0.0015	0.0049	0.0032
6:2 FTS	-	-	-	-	-	-	-	-	0.0026	-

Notes:

1. Values in µg/L (parts per billion).
2. Only detected compounds are shown in the table.
3. Total PFHxS (3) and Total PFOS (3) is calculated by summing monoethyl, dimethyl and linear isomers. Where an isomer is below the detection limit it is not added to the summation. This is following the method in the reported lab results.
6. Summations are made by adding compounds Total PFOS (7), Total PFHxS (3) together. Where one compound is below detection, it is not included in the summation.

- Result is less than the limit of reporting or is not reportable