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PATTLE DELAMORE PARTNERS LTD

New Zealand Defence Force
PFAS Investigation: Waitematā Harbour

New Zealand Defence Force

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Prepared for

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Executive Summary

This report provides a summary of investigations into the accumulation of Per- and Poly-Fluorinated Substances (PFAS) in biota and sediment in the Waitematā Harbour relating to the historical use and storage of aqueous film forming foams (AFFF) at HMNZS Devonport Naval Base and the Royal New Zealand Air Force (RNZAF) Base Auckland (Whenuapai), collectively referred to as "the sites". Biota and sediment samples were collected from multiple locations within the receiving environments of the sites at Ngataringa Bay at Devonport (PDP, 2018a) and the Waitematā Harbour at Whenuapai (PDP, 2018b). Surface water and sediment samples collected on-site and off-site have determined elevated levels of PFAS discharging from the sites into the Waitematā Harbour (Golder Associates (NZ) Limited, 2016; Coffey; 2018; PDP, 2018a; PDP, 2018b).

The results of these four investigations have been summarised in this report.

Invertebrates

Multiple invertebrate samples were collected from Ngataringa Bay and the Upper Waitematā Harbour downgradient of Whenuapai. Samples were also collected from reference sites[1] within urban and rural catchments at Hellyers Creek in the Waitematā Harbour and Wenderholm Regional Park.

Of the 33 invertebrate samples collected (excluding reference sites):

- Twenty-five (75%) samples had concentrations of one or more PFAS compound above the limit of reporting (LOR).
- Seven samples (21%) exceeded the avian wildlife diet guideline (Environment and Climate Change Canada, 2018).
- The highest concentrations observed in the invertebrate samples were found in the horn shell and cats eyes samples. The concentration of PFOS in horn shells was significantly higher in comparison to other invertebrate samples.

PFOS concentrations were above the LOR in horn shell and cats eyes samples from the reference site at Wenderholm Regional Park however at much lower concentrations. This is also true for the horn shells collected at the reference site in Hellyers Creek (no cats eyes were collected from this site).

Fish

Fish samples were also collected from Ngataringa Bay and the Upper Waitematā Harbour downgradient of Whenuapai. Samples were also collected from both reference sites at Wenderholm Regional Park and Hellyers Creek.

[1] Reference or control sites are locations that are not likely to be impacted by the source of PFAS being investigated.

Of the eleven fish samples collected (excluding reference sites):

- All samples had concentrations of one or more PFAS compound greater than the LOR.
- No fish samples exceeded the recreational fish consumption guideline (MPI, 2018). One sample, flounder collected from the harbour near Whenuapai, exceeded the trigger point for investigation (FSANZ, 2017).
- No fish samples exceeded the avian wildlife diet guideline (Environment and Climate Change Canada, 2018).
- The highest concentrations of PFOS observed were from samples collected from the Rarawaru Inlet near Whenuapai. The remaining fish samples had PFOS concentrations that did not exceed 1 µg/kg.

PFOS concentrations in the flounder sample collected from the reference site in Hellyers Creek were similar to the concentrations found at Ngataringa Bay. No PFAS compounds were above the LOR in the flounder samples collected from Wenderholm Regional Park.

Sediment

Marine sediment samples were collected from the same location as the biota samples (PDP, 2018a; PDP, 2018b) and along the border of the Devonport Naval Base targeting the Seamanship Safety Training Squadron (SSTS) stormwater outfalls (Golder Associates (NZ) Limited, 2016).

Of the 74 samples collected:

- Twenty-five (34%) samples had concentrations of one or more PFAS compounds above the LOR.
- No samples exceeded the interim sediment quality screening criteria (Bakke *et al.,* 2010).
- Of the sediment samples collected, PFAS was present above the LOR in areas downgradient of the historical and current firefighting training areas (FTA) of Whenuapai Airbase and Devonport Naval Base.

Eight sediment samples were collected from the reference sites at Wenderholm Regional Park and Hellyers Creek. No PFAS compounds were above the LOR in these samples.

Freshwater sediment samples were also collected from streams on-site and off-site at Whenuapai. Of the nine samples, four had concentrations of one or more PFAS compound above the LOR. No sediment samples exceeded the interim sediment quality screening criteria (Bakke *et al.,* 2010).

Surface Water

Surface water (freshwater) samples were collected from multiple on-site and off-site locations at Whenuapai which drain to the Upper Waitematā Harbour.

Of the 19 samples collected:

- Fourteen (74%) samples had concentrations of one or more PFAS compound above the LOR.
- Seven samples exceeded the ANZECC 95% ecosystem protection guideline (HEPA, 2018). All samples collected on-site (five samples) exceeded this guideline.

International Context

International studies were reviewed to provide context to the results obtained in the Waitematā Harbour. Studies pertaining to AFFF impacted sites and urban harbours with multiple PFAS sources were reviewed. Of the studies reviewed, samples were collected from generally greater distances from known PFAS sources and therefore may not be directly comparable. Some studies also included the collection of samples that were not related to a specific PFAS source. In general, PFOS was the most commonly reported compound both in the Waitematā Harbour and in the international studies reviewed.

We note that:

- PFOS concentrations in sediment collected immediately below the stormwater outfalls from the historical firefighting training area at Devonport Naval Base were the highest recorded amongst the limited number of studies reviewed. However, the sediment samples in the other studies reviewed were generally collected from a greater distance from a known PFAS source.
- Sediment samples that were located further from the point sources in Waitematā Harbour had similar PFOS concentrations to the sediment samples collected in San Francisco Bay, Sydney Harbour, and other AFFF impacted sites such as Williamtown (New South Wales, Australia).
- Of the invertebrate (with the exception of worms) samples collected from the Waitematā Harbour, and the AFFF impacted sites at Garden Island (Western Australia*)* and Williamtown (New South Wales, Australia), the sample with the highest PFOS concentration was collected from Ngataringa Bay. The invertebrate samples consisted of varying species and were collected from varying distances from known PFAS point sources.

- The dataset of fish sampled from the Waitemata Harbour was very small, it is possible that a larger sampling programme could yield a greater range of results. However, of the samples collected, the concentration of PFOS in fish samples collected from the Waitematā Harbour was lower than the fish samples collected in other urban environments such as San Francisco Bay and other AFFF impacted sites such as Williamtown.

The investigations summarised above have shown that the bio-accumulation of PFAS in biota has been found in multiple sample locations within the Waitematā Harbour. PFAS compounds are very common in urban environments, which is likely the case for the Waitematā Harbour which may have been exposed to other urban sources of PFAS, such as (but not limited to) urban stormwater, wastewater and/or landfill leachate.

With the limited information available it is not possible to fully characterise the extent of, and effects of, PFAS in marine biota within the harbour.

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1.0 Introduction

Pattle Delamore Partners Limited (PDP) has been engaged by the New Zealand Defence Force (NZDF) to prepare a summary report of the contamination of per- and poly-fluoroalkyl substances (PFAS) in biota and sediment sampled from the Waitematā Harbour, Auckland. NZDF have completed multiple sampling campaigns investigating the potential for PFAS contamination across various media arising from the use and storage of Aqueous Film Forming Foam (AFFF) at NZDF sites around New Zealand. Investigations in the Waitematā Harbour (PDP, 2018a; PDP, 2018b) have revealed PFAS in marine invertebrates and fish adjacent to the Royal New Zealand Air Force (RNZAF) Base Auckland (Whenuapai) and Royal New Zealand Navy (RNZN) HMNZS Devonport (referred to collectively as 'the sites'). In light of this, NZDF have commissioned a report detailing this information within the greater context of the Waitematā Harbour.

1.1 Objectives

The objectives of this investigation were:

- Compare sampling results from previous marine biota investigations in the Waitematā Harbour; and
- Discuss results observed in the Waitematā Harbour in the context of literature on other international urban environments where marine biota has been exposed to PFAS.

1.2 Scope

The scope of work completed to fulfil the project objectives was to:

- Collate and compare sampling results from previous PFAS investigations conducted for NZDF in the Waitematā Harbour.
- Assess results against applicable guideline values and compare to samples collected from reference sites.
- Undertake a literature review to identify international investigations of PFAS concentrations in marine sediment and biota in two urban harbours and two marine environments located near to sources of PFAS associated with military firefighting training.
- Discuss the results obtained in the Waitematā Harbour and control sites with reference to results obtained in the reviewed literature.

2.0 Background

PFAS compounds, such as perfluorooctane sulfonate (PFOS) and perfluorohexane sulphonate (PFHxS) are a group of manufactured chemicals used since the 1950s. PFAS are 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 bio accumulative properties (CONCAWE, 2016).

Due to the widespread use of PFAS, it has become ubiquitous in the environment and has been found throughout the world's coastal environments (CONCAWE, 2016). PFAS compounds are used in various commercial products with water and grease repelling properties such as food packaging, non-stick cookware, textiles etc. The use of these products results in the accumulation of PFAS compounds in wastewater treatment plants and landfill leachate and potentially domestic wastewater disposal systems such as septic tanks. PFAS are not removed by traditional wastewater treatment processes, meaning that PFAS may be present in treated discharges from wastewater treatment plants and landfills (ITRC, 2017).

Industries such as the textile and chrome-plating industries are also common sources of PFAS. Smaller amounts of PFAS are also known to accumulate in urban stormwater. These sources are commonly associated with urban areas and commonly act as diffuse sources into waterbodies adjacent to urban centres (CONCAWE, 2016).

PFAS are considered to be emerging contaminants. NZDF is investigating the potential for contamination in biota associated with the use and storage of AFFF containing PFAS at its camps and bases.

2.1 Bio-Accumulation of PFAS

The uptake of PFAS into marine organisms has been documented in numerous studies and reviews. These chemicals are known to bio-accumulate in individual organisms and bio-magnify with increasing trophic levels. Bio-accumulation of PFAS compounds varies amongst compounds. PFOS and PFOA commonly bio-accumulate in aquatic species (PDP, 2018c). These compounds are commonly associated with historical AFFF use and storage. Due to the persistence of these compounds they can remain in the environment for many years, as is the case of the receiving environments of AFFF use and storage areas at Devonport and Whenuapai. A number of different aquatic species tested in New Zealand have shown that aquatic organisms have the ability to bio-accumulate PFAS compounds.

Bio-accumulation of PFAS compounds in lower order trophic levels could result in the bio-magnification (accumulation of PFAS through diet) of these compounds in apex predators (PDP, 2018c). For the marine environment adjacent to Whenuapai and Devonport these apex predators include predatory fish and coastal and wading birds.

Although bio-accumulation and bio-magnification has been observed in gill-breathing organisms such as fish, bio-magnification is more obvious in air breathing organisms. Increased depuration (elimination) of PFAS has been observed in organisms that respire via gills or gill-like organs in comparison to air breathing organisms (PDP, 2017).

3.0 Site Description

The Waitematā Harbour is a large urban harbour located on the eastern coastline of the Auckland Isthmus. The land use adjacent to the harbour includes a combination of low to high density residential, industrial and commercial areas.

The Devonport Naval Base (Figure 1) is an operating naval base located on the eastern side of the Waitematā Harbour near the harbour entrance. The Naval Base is adjacent to Ngataringa Bay to the north and Stanley Bay and the Waitematā Harbour to the south. AFFF containing PFAS was historically used for firefighting training at the Seamanship Safety Training Squadron (SSTS), located on the shores of Ngataringa Bay (Figure 2). Previous investigations have identified the SSTS as the principal source of PFAS from the Naval Base to the marine environment (PDP, 2018a).

The Whenuapai Airbase (Figure 1) is located near the upper northern reaches of the Waitematā Harbour and is in close proximity to many tributaries of the harbour. This area of the Waitematā Harbour is very popular for recreational activities such as fishing and water activities. Previous investigations have identified several potential sources of PFAS from activities at Whenuapai Airbase:

- Firefighting training was historically conducted in the north-west of the airbase.
- The 6 Squadron Hangar contains an AFFF based fire suppressant system hangar in the south-west of the base. These activities were potential sources of PFAS to soil and water on the base and ultimately to the Upper Waitematā Harbour.
- A historical NZDF landfill is located on Kauri Rd.

These activities were potential sources of PFAS to soil and water on the base and ultimately to the Upper Waitematā Harbour.

A detailed assessment of potential sources and pathways of PFAS from each base is provided in PDP (2018a) and Coffey (2018a).

3.1 Marine Ecology

3.1.1 Devonport

Ngataringa Bay, which borders the North Yard and Seamanship Safety Training Squadron (SSTS) of the Devonport Naval Base, is identified as a Significant Ecological Area Marine 1 and Marine 2 in the Auckland Unitary Plan (AUP [OP], 2019). The Unitary Plan describes the several factors of ecological value in Ngataringa Bay such as the varied habitat including salt marsh and mangrove communities, these areas of saline vegetation offer a good habitat to secretive coastal fringe birds such as the banded rail (AUP [OP], 2019). The intertidal zone is an important wading bird feeding ground due to the close proximity of Shoal Bay which has extensive roosting and feeding grounds. Many New Zealand and migratory birds that are threatened or at risk commonly feed at Ngataringa Bay and nearby Shoal Bay (Forest & Bird, 2016), these species include:

- Caspian Tern
- Pied Shag
- Northern New Zealand Dotterel
- Variable Oystercatcher
- South Island Pied Oystercatcher
- Pied Stilt
- Wrybill
- Bar Tailed Godwit
- Banded Dotterel.

The South Yard of the Naval Base borders the lower Waitematā Harbour. The marine environment adjacent to the South Yard is extensively modified with wharves and jetties that are part of the Naval Base. The Ports of Auckland are also located directly opposite of the South Yard. Nevertheless, such areas typically support a variety of tolerant marine species.

3.1.2 Whenuapai

The Waitematā Harbour at Whenuapai is also identified as a Significant Ecological Area Marine 2 in the Auckland Unitary Plan. This area is fed by many mangrove-lined inlets and has high diversity and productivity of flora and fauna including extensive shellfish beds and large abundances of birds and fish (AUP [OP], 2019). The mangroves and saline vegetation are also an important habitat for threatened secretive costal fringe birds such as the banded rail. These areas also provide important habitat for avian species such as black shag, kingfisher and

white fronted tern. The freshwater influence of the area also provides important pathways for migration of native freshwater fish.

3.2 Other PFAS Sources in the Waitematā Harbour

There are multiple historical landfills located adjacent to the Waitematā Harbour, such as the historical landfill in Devonport. As landfill leachate is a known source of PFAS landfills with waste deposited after PFAS became widely used (> 1950's) have the potential to act as diffuse sources of PFAS into the Waitematā Harbour. Other potential sources of PFAS in the Waitematā Harbour (historic and current) could include: septic tanks (e.g. in the upper reaches of the Waitematā Harbour), industrial tradewaste, urban stormwater and AFFF use and storage at non-NZDF sites i.e. AFFF use associated with historic and/or current bulk fuel storage.

4.0 Summary of Results

A summary of all biota samples collected from the Waitematā Harbour and analysed for PFAS is provided below. The sample locations are shown in Figures 2-5. A summary of the estuarine sediment sample results from the locations biota samples were collected, and of surface water and sediment samples from streams that lead into the Waitematā Harbour from the sites is also provided.

The sampling methods, guidelines and trigger values are discussed in Appendix A along with a detailed discussion of the sample results. The full results are tabulated in Appendix B.

4.1 Invertebrates

Multiple invertebrate samples were collected from Ngataringa Bay and Whenuapai. The species collected included mud crabs (*Helice crassa*), oysters (*Crassostrea gigas*), horn shells (*Zeacumantus lutulentus*), harbour top shells (*Diloma subrostrata*), mud whelks (*Cominella glandiformis*), cockles (*Austrovenus stutchburyi*), mud snails (Amphibolidae sp) and cats eyes (*Turbo smaragdus*). Samples were also collected from reference sites[2] with urban and rural catchments at Hellyers Creek in the Waitematā Harbour and Wenderholm Regional Park.

Of the 33 invertebrate samples collected (excluding reference sites):

- Twenty-five (75%) samples had concentrations of one or more PFAS compound above the limit of reporting (LOR).
- Seven samples (21%) exceeded the avian wildlife diet guideline (Environment and Climate Change Canada, 2018).

[2] Reference or control sites are locations that are not likely to be impacted by the source of PFAS being investigated.

- The PFOS concentration range for all invertebrates collected from Ngataringa Bay and Whenuapai was <LOR – 120 µg/kg.
- The highest concentrations observed in the invertebrate samples were found in the horn shell and cats eyes samples. The concentration of PFOS in horn shells was significantly higher in comparison to other invertebrate samples. The highest PFOS concentration in horn shells was in the samples collected from Ngataringa Bay.

PFOS concentrations were above the LOR in horn shell and cats eyes samples from the reference site at Wenderholm Regional Park however at much lower concentrations. This is also true for the horn shells collected at the reference site in Hellyers Creek (no cats eyes were collected from this site). PFAS concentrations were below the LOR in all other invertebrate samples collected from the reference sites.

4.2 Fish

Fish samples were also collected from Ngataringa Bay and the Upper Waitematā Harbour downgradient of Whenuapai. The species collected were flounder (*Rhombosolea leporina*), parore (*Girella tricuspidata*) and yellow-eyed mullet (*Aldrichetta forsteri*). Flounder samples were also collected from both reference sites at Wenderholm Regional Park and Hellyers Creek.

Of the eleven fish samples collected (excluding reference sites):

- All samples had concentrations of one or more PFAS compound greater than the LOR.
- No fish samples exceeded the recreational fish consumption guideline (MPI, 2018). One sample, flounder collected from the harbour near Whenuapai, exceeded the trigger point for investigation (FSANZ, 2017).
- No fish samples exceeded the avian wildlife diet guideline (Environment and Climate Change Canada, 2018).
- The PFOS concentration range for all fish collected from Ngataringa Bay and Whenuapai was 0.31 – 6.9 µg/kg.
- The highest concentrations of PFOS observed were from samples collected from the Rarawaru Inlet near Whenuapai. The remaining fish samples had PFOS concentrations that did not exceed 1 µg/kg.

PFOS concentrations in the flounder sample collected from the reference site in Hellyers Creek were similar to the concentrations found at Ngataringa Bay. No PFAS compounds were above the LOR in the flounder samples collected from Wenderholm Regional Park.

4.3 Sediment

Marine sediment samples were collected from the same location as the biota samples (PDP, 2018a; PDP, 2018b) and along the border of the Devonport Naval Base targeting the Seamanship Safety Training Squadron (SSTS) stormwater outfalls (Golder Associates (NZ) Limited, 2016).

Of the 74 samples collected:

- Twenty-five (34%) samples had concentrations of one or more PFAS compounds above the LOR.
- No samples exceeded the interim sediment quality screening criteria (Bakke *et al.,* 2010).
- The presence of PFAS above the LOR in sediment was limited to areas downgradient of historical and current firefighting training areas (FTA) of Whenuapai Airbase and Devonport Naval Base.

Eight sediment samples were collected from the reference sites at Wenderholm Regional Park and Hellyers Creek. No PFAS compounds were above the LOR in these samples.

Freshwater sediment samples were also collected from streams on-site and off-site at Whenuapai. Of the nine samples, four had concentrations of one or more PFAS compound above the LOR. These samples were taken from the Rarawaru Creek which is downstream of the historical firefighting training area at the site. No sediment samples exceeded the interim sediment quality screening criteria (Bakke *et al.,* 2010).

4.4 Surface Water

Surface water (freshwater) samples were collected from multiple on-site and off-site locations at Whenuapai which drain to the Upper Waitematā Harbour.

Of the 19 samples collected:

- Fourteen (74%) samples had concentrations of one or more PFAS compound above the LOR.
- Seven samples exceeded the ANZECC 95% ecosystem protection guideline (HEPA, 2018). All samples collected on-site (five samples) exceeded this guideline.
- The concentration of the Sum of PFHxS + PFOS in these samples ranged from <LOR – 15.3 µg/L.
- The highest concentrations of PFOS and PFHxS were found in the Rarawaru Creek, downstream of the historical firefighting training area.

5.0 Discussion

5.1 Waitematā Harbour

The datasets for the investigations conducted for NZDF in the Waitematā Harbour are very small and this should be considered with respect to any conclusions about the data and its applicability to the wider harbour.

5.1.1 Invertebrates

The highest concentrations of PFAS in invertebrates collected in the Waitematā Harbour (Whenuapai, Ngataringa Bay and Hellyers Creek) were found in the horn shell and cats eyes samples. Significantly higher concentrations of PFOS in horn shells were observed in the samples collected from Ngataringa Bay in comparison to the samples collected from Whenuapai. No cats eyes samples were collected from Whenuapai. Higher PFHxS concentrations were also observed in the samples collected from Ngataringa Bay.

PFOS was present in the control samples of horn shells from Hellyers Creek and horn shells and cats eyes from Wenderholm Regional Park however these concentrations were much lower than the primary samples of the corresponding studies. PFOS concentrations in horn shells from Wenderholm Regional Park were also significantly lower than those found at Hellyers Creek. PFOA and PFHxS were present in the horn shell sample collected from Hellyers Creek but were below the LOR for the horn shell and cats eye samples collected from Wenderholm Regional Park. No cats eyes sample was collected at Hellyers Creek.

The source of PFAS in horn shells collected from Hellyers Creek is unknown (no PFAS compounds were reported above the LOR in co-located sediment samples), however due to the urban setting of the site and the ubiquitous nature of PFAS it is not unexpected that PFAS compounds are present at this location. The concentration of PFOS in the horn shell sample collected from Wenderholm Regional Park was an order of magnitude lower than the sample collected from Hellyers Creek. No PFAS compounds were reported in the co-located sediment samples from Wenderholm Regional Park. The source of the small amount of PFOS detected at Wenderholm is unknown but is indicative of the numerous sources and the ubiquitous nature of PFAS in the environment.

From the results of the biota sampling undertaken for NZDF in the Waitematā Harbour, the marine gastropods (e.g. horn shells) appear to bioaccumulate compounds more strongly than bivalve species (e.g. oysters) however it is difficult to make a direct comparison as the different taxa have not been collected at all sampling sites.

Of all the invertebrate samples collected at Ngataringa Bay, the highest concentrations of PFAS (particularly PFOS) were in samples collected in quadrats two and three (Figure 2). These locations were located the closest to the current

and historical stormwater outfalls of the SSTS. Samples from Quadrat_1 had lower concentrations of the invertebrate samples collected however less species were also collected from this location.

5.1.2 Fish

PFAS compounds were found in all fish samples collected in the Waitematā Harbour. The two control samples collected from Wenderholm Regional Park did not have PFAS compounds with concentrations above the LOR.

Of the fish samples collected from Devonport and Whenuapai, the highest PFOS concentrations were found in the samples collected from Rarawaru Inlet. These were flounder and parore samples. The PFOS concentration in fish from this location ranged from 1.2 - 6.9 µg/kg. The highest PFOS concentrations were in the flounder samples (2.3 and 6.9 µg/kg). The parore samples had lower PFOS concentrations in comparison to the flounder samples collected from Rarawaru Inlet. The PFOS concentrations in the two parore samples were very similar to each other (1.2 and 1.8 µg/kg). Higher PFAS concentrations have been observed in benthic and/or predatory fish species in comparison to pelagic and/or prey fish species as described by Sedlak *et al.,* (2018).Parore are pelagic fish and are herbivores that typically feed on seaweed and algae, whereas flounder are a benthic predatory species, that feed on molluscs, worms, crustaceans and small fish and are therefore exposed to PFAS accumulation in their prey.

All fish samples (with the exception of DNB_NGA_FS3.1_1_010318) collected from Ngataringa Bay and Hellyers Creek were composite samples of similar sized fish. The sample collected from Hellyers Creek had a PFOS concentration 0.7 µg/kg which was very close to the highest concentration collected from Ngataringa Bay (0.73 µg/kg). The flounder collected from Hellyers Creek sample were bigger in size, and therefore possibly older in age compared to the sample from Ngataringa Bay with the highest PFOS concentration. It is not possible to draw any conclusions based on a single sample, the fish caught in Hellyers Creek could have been exposed to point sources of PFAS from AFFF, such as discharges from Whenuapai Airbase, similarly the fish could have been exposed to other potential sources of PFAS within the Waitematā Harbour.

5.1.3 Avian Wildlife

Ngataringa Bay is a feeding ground for wading and coastal birds. Due to the presence of PFAS in invertebrates and fish, the predatory birds in this area have the potential to be exposed to PFAS through their diet. The invertebrates collected in this area were collected on the basis of assessing the risk to human health from a food safety perspective and may not be reflective of the avian wildlife diet in the area.

The knowledge of feeding behaviour of wading birds in New Zealand is limited, although it is known that diets can change depending on the location and the

prey species present. Smaller invertebrates such as crustaceans (shrimps and amphipods), worms (nemertea and polychaetes) and plankton are commonly consumed by birds (Batley *et al.,* 2005; Keeley, 2005). No worms were sampled in the Waitematā Harbour however polychaete worms have been collected and analysed for PFAS from Garden Island (RPS, 2018) and Williamtown (Aecom, 2018). Elevated PFOS concentrations were observed in both areas with concentrations ranging from <LOR – 3,100 µg/kg. It is noted that this range includes a combination of wet weights (Aecom, 2018) and dry weights (RPS, 2018). These concentrations would not be directly comparable to the worm species present in the Waitematā Harbour as there are different species and PFAS sources present but do illustrate that marine worms have the potential to accumulate PFAS.

Larger wading birds have the ability to eat some of the invertebrates sampled. Bivalves are a common group of invertebrates targeted by birds however as discussed in Appendix A, bio-accumulation of PFAS in bivalves appears to be limited. These larger birds can eat mud crabs such as the species *Helice crassa* (Batley *et al.,* 2005; Keeley, 2005) and gastropods, dependent on the size. Small gastropod mollusc species could be targeted by wading birds (Piersma *et al.,* 1998) in the absence of worm and/or bivalve species. The gastropod mollusc species collected at Ngataringa Bay and Whenuapai include mud whelks, harbour top shells, cats eyes, mud snails and horn shells. These species would be less desirable to avian wildlife due to the digestive processes associated with a hard shell.

Mud crabs and gastropods described as above are known to have elevated PFOS concentrations in both Ngataringa Bay and Whenuapai. The horn shell and cats eyes samples from Quadrats 2 and 3 in Ngataringa Bay exceeded the avian wildlife diet guideline (Environment and Climate Change Canada, 2018). The mud whelk sample collected from Quadrat 3 also exceeded this guideline along with two horn shell samples collected from Whenuapai. It is noted that this guideline was derived from data on terrestrial and freshwater avian species (Environment and Climate Change Canada, 2018).

There is potential for avian scavenger species such as gulls in the Waitematā Harbour to be exposed to PFAS. Due to their foraging behaviour, it is possible that gulls in the Ngataringa Bay and Whenuapai areas can consume the larger invertebrates sampled. Gulls could also be exposed via consumption of PFAS impacted fish carcasses. Although the fish species collected during the PFAS investigations were adults and unlikely to be consumed by birds, it is possible that juveniles of the same species could be consumed. This could also provide a pathway for PFAS accumulation in birds as PFAS is known to transfer from adult females to fish eggs as observed in the investigation by PDP (2019).

That being said, the investigations in the Waitematā Harbour were intended to establish the presence, or absence, of PFAS in the media sampled and not the

extent of impact. Therefore, the areal extent of PFAS impacted invertebrates in the Harbour adjacent to the two NZDF source sites is unknown. However, the lower PFAS concentrations observed in sample locations further away from a point source (stormwater outfalls) in Ngataringa Bay indicate it is likely to be limited. It is likely that the feeding area of these foraging birds would be larger than the PFAS impacted area and would include areas that are not affected within Ngataringa Bay as well as areas outside of Ngataringa Bay.

In addition, some species are resident in the harbour only for part of the year. Migratory birds in the Waitematā Harbour migrate to the arctic to breed. It is very common for these birds to feed at intertidal mudflats off the coast of Asian countries such as China during their northward migration. In some cases, these birds feed in mudflats adjacent to heavily urbanised and industrialised areas which could also have PFAS impacted biota and/or sediment. New Zealand birds such as oystercatchers, wrybills and dotterels generally breed in rural areas of the South Island where PFAS sources could be fewer. Gulls are also widely distributed around New Zealand in rural and urban areas and therefore any bio-accumulation of PFAS in these species could come from multiple sources, particularly as gulls are known to forage at landfills which can be an important source of PFAS.

In summary, whilst birds foraging in or near point sources of PFAS are likely to be exposed to PFAS through their diet, they may also be exposed from other sources with the Waitematā Harbour and/or elsewhere within New Zealand or even international sites (for migratory birds).

5.1.4 Surface Water

All samples collected on-site at RNZAF Base Auckland (Whenuapai) contained elevated PFAS concentrations which exceeded the 95% ecosystem protection guideline (HEPA, 2018). The highest concentrations of the Sum of PFHxS + PFOS (15.3 µg/L and 11.5 µg/L) were observed in the two on-site samples taken from a tributary of the Rarawaru Creek, downstream of the historical firefighting training area. The remaining onsite samples had much lower concentrations which ranged from 0.25 - 0.44 µg/L for the Sum of PFHxS + PFOS. The results indicate that the firefighting training area at Whenuapai is a source of PFAS into the Rarawaru Creek tributary and ultimately the Rarawaru Inlet in the Waitematā Harbour.

Multiple sites along the Rarawaru Creek and tributary were sampled, the concentration of PFOS and PFHxS decreased with distance from the base. The off-site sample collected from Rarawaru Creek showed an order of magnitude decrease in PFOS concentration (0.37 µg/L) from the next upstream sample which was collected on-site from the Rarawaru Creek Tributary (downstream of the firefighting training area). It is noted that these samples were taken at different times of the year, the on-site samples were taken during March 2018

while the off-site sample was taken during August 2018. The concentration of PFAS in surface water is known to fluctuate seasonally in response to water levels and rainfall. This sample location was also in an area of tidal influence however the sample was collected at low tide.

The PFOS concentrations in the Rarawaru Creek tributary exceeded the typical concentrations of urban stormwater in the San Francisco Bay. Urban stormwater would be considered a diffuse source. The typical PFOS concentration in urban stormwater in the San Francisco Bay area can range from 0.01-0.99 µg/L of PFOS (Houtz and Sedlak, 2012; Sedlak et *al.,* 2017). The downstream Rarawaru Creek water sample had a PFOS concentration in this range.

5.1.5 Sediment

Sediment samples were collected in Whenuapai from streams that flow through the base and into the harbour. These samples were down stream of historical firefighting training areas (WHP_FFL_SD3, WHP_NWD_SD5 and WHP_ADJ_SD09) and the aircraft hangars (WHP_HGR_SD1 and WHP_ NWD_SD4). See Figure 3 and Figure 4 for sample locations. These sites all have the same receiving environment in the harbour (Rarawaru Inlet). PFOS concentrations decreased with distance from the base, particularly in the Rarawaru Creek tributary downstream of the historical firefighting training area. PFAS were not detected above the LOR in the samples collected from WHP_HGR_SD1 and WHP_ NWD_SD4 which targeted the aircraft hangars.

The decrease in PFOS concentrations observed in the sediment samples was also observed in the surface water samples collected at each site. All surface sediment samples had PFOS concentrations higher than all marine sediment samples collected downstream in Rarawaru Creek (WHP_ADJ_SD06) however the deeper sediment sample collected at WHP_ADJ_SD09 had the same concentration as the highest PFOS concentrations of the surface marine samples downstream.

Marine sediment was collected from Ngataringa Bay during two previous investigations (Golder Associates (NZ) Limited, 2016; PDP, 2018a). The sediment samples were collected near the historical and present STSS outfall locations (see figure 2). Both surface samples collected from the two SSTS outfall sites had very elevated PFOS concentrations (0.066 – 0.109 mg/kg) in comparison to the other sediment samples collected from the Waitematā Harbour. Elevated PFOS concentrations were also observed in the deeper samples (0.3 m) collected at the SSTS outfalls. The PFOS concentrations in the deeper samples (0.3 m) collected at both SSTS outfall sites were also higher than all samples collected from other sites in the Waitematā Harbour (0.0166 – 0.022 mg/kg). These observed concentrations in the deep sediment samples are likely a reflection of the historical use of PFOS at the SSTS.

PFOS was also present in the other Golder Associates (NZ) Limited (2016) sites downgradient of the two outfall locations. The one sample site with PFOS concentrations below the LOR (Mangrove 04) did have a higher LOR than the other samples. Other PFAS compounds such as PFHxS, 6:2 FTS, 8:2 FTS, PFBS, PFDS, PFHpA, PFHxA and PFOSA were also above the LOR in one or more samples.

Of the sediment samples collected by PDP (2018a), no PFAS compounds were above the LOR in all samples collected from Quadrat 1. Quadrat 2 had a total of eight out of ten samples with PFOS concentrations above LOR (0.0011-0.0022 mg/kg). One out of eight sediment samples collected from Quadrat 3 had concentrations of PFOS above the LOR (0.0014 mg/kg). As stated in section 5.1.1 the PFAS concentrations in invertebrates were higher in Quadrat 2 and 3. Species such as mud crabs, mud whelks and cats eyes had higher PFOS and PFHxS concentrations in the samples collected from Quadrat 3 however the concentration of PFOS and PFHxS was significantly higher in the horn shells collected from Quadrat 2.

Multiple studies have stated that sediment is a potential source of PFAS into the food chain (Larson *et al.,* 2018; Sedlak *et al.,* 2017; Martin *et al.,* 2004) however higher concentrations of PFAS in sediment have not consistently corresponded with higher PFAS concentrations in the benthic invertebrates collected. PFAS compounds have also been present in benthic invertebrates where no PFAS has been found in the sediment. PFAS was only been found in sediment downgradient of current and historical firefighting areas of the RNZAF Base Auckland (Whenuapai) and Devonport Naval Base. Rarawaru Creek, Rarawaru Inlet and Ngataringa Bay are the direct receiving environments for the current and historical firefighting training areas. PFAS concentrations were much lower in the sediment samples collected from Te Turerenga Inlet which receives stormwater from Whenuapai Airbase and is downgradient of historic firefighting training areas identified by Coffey (2018a).

5.2 International Context

Despite the global distribution of PFAS, its fate and transport, particularly in the marine environment, is poorly understood. There are only a limited number of studies relating to PFAS in the marine environment in Australasia. An extensive literature review into the impact of PFAS on ecosystems was completed using PFAS studies from around the world (PDP, 2018c). This information was reviewed, along with other available literature investigating PFAS in two urban harbours, San Francisco Bay (Sedlak *et al.,* 2017; Sedlak *et al.,* 2018) and Sydney Harbour (Thompson *et al.,* 2011), and investigations into marine environments adjacent to Australian Defence Force sites with fire training areas at Garden Island, Western Australia (RPS, 2018) and Williamtown, New South Wales (Aecom, 2018). The review is documented in Appendix C.

Results obtained during the investigations conducted for NZDF are discussed with reference to the results of investigations conducted internationally below. Whilst these studies illustrate the concentrations of PFAS observed in other locations, the differences in sources of PFAS, species and physical conditions between sites could affect the comparability of the results obtained in each study. Biota and sediment samples were also collected from varying distances from known sources, and in the case of the San Francisco Bay and Sydney Harbour, samples were not collected in association with point sources of PFAS. Of the AFFF impacted sites, samples collected from Garden Island were of comparable distances to the respective PFAS sources to that in Ngataringa Bay. The Garden Island investigation was not limited to AFFF use, but also targeted other sources of PFAS such as the wastewater treatment plant on the island. The distance of sample location in comparison to respective AFFF sources in Whenuapai varied. Although the sediment and biota samples collected at Williamtown were the marine receiving environments for AFFF impacted sites of the RAAF Base, the distance from the base was much higher in comparison to the samples collected in other studies.

5.2.1 Invertebrates

The range of PFOS concentrations in invertebrate samples collected from the Waitematā Harbour, Garden Island (RPS, 2018) and Williamtown (Aecom, 2018) are shown below. Different species were collected at each site and can accumulate PFOS at different rates. Worm samples collected from Williamtown and Garden Island were not included in the summary as no worm samples were collected from the Waitematā Harbour.

The highest PFOS concentration in an invertebrate sample (excluding worms) was collected from the Waitematā Harbour. This sample was a horn shell sample collected from Ngataringa Bay which had a PFOS concentration of 120 µg/kg. The number of invertebrate samples collected from the Waitematā Harbour was similar to the number of samples collected from Williamtown however more samples from Williamtown had concentrations of PFOS that were above the LOR. The percentage of samples with PFOS above the LOR was 47% for the Waitematā Harbour and 97% for Williamtown. Four samples were collected from Garden Island and only one was above the LOR.

Table 1: PFOS Concentration Range in Invertebrates[1,2]

Location	Concentration Range[1]	No. of Samples	No. of Samples >LOR
Waitematā Harbour	<LOR - 120	36	17
Garden Island[3,4]	<LOR - 6	4	1
Williamtown[5]	<LOR - 25	37	36

Notes:

1. *All values in µg/kg.*
2. *Information presented above excludes worm samples as no worm samples were collected in the Waitematā Harbour.*
3. *Information from RPS, 2018.*
4. *Dry weight results.*

Information from Aecom, 2018

5.2.2 Fish

PFOS concentration ranges in fish samples collected from the Waitematā Harbour (PDP, 2018a; PDP, 2018b), San Francisco Bay (Sedlak *et al.,* 2017), and Williamtown (Aecom, 2018) are shown in Table 2. The samples summarised below were also collected from fish from different trophic levels (i.e. prey and predator species) and therefore some fish samples may or may not have experienced bio-magnification of PFAS. The number of samples collected also varied between locations.

The maximum PFOS concentration was similar at San Francisco Bay and Williamtown. The maximum PFOS concentration in fish collected from the Waitematā Harbour was significantly lower than the maximum concentration from samples collected San Francisco Bay and Williamtown, however the number of samples collected in Waitematā Harbour is much lower than at the other sites.

Sixty-six percent of the fish collected from San Francisco Bay had concentrations of PFAS above the LOR. A portion of these samples were collected during periods when the analytical methods for analysing PFAS were not as precise in comparison to today's methods. The samples were also collected opportunistically and not associated with point sources in contrast to the samples collected from the Waitematā Harbour and Williamtown

All fish samples collected from the Waitematā Harbour and Williamtown had concentrations of PFOS above the LOR. The number of samples collected from Williamtown and in the Waitematā Harbour was much lower in comparison to San Francisco Bay and were collected as part of investigations targeting point sources from Australian and New Zealand Defence Force sites. Only samples included in the ecological risk assessment (Aecom, 2018) report were presented below.

No PFAS compounds were detected above the LOR in the fish samples collected from the reference site at Wenderholm Regional Park (PDP, 2018b). Due to its rural nature, Wenderholm Regional Park is more likely to have fewer potential sources of PFAS in comparison to the urban Waitematā Harbour. PFAS compounds were also below the LOR in a fish sample collected from another rural reference site in Tomales Bay, California. This sample was documented by Sedlak, *et al.,* (2018), and used to compare to fish samples collected in the San Francisco Bay. PFAS compounds may be less common in rural areas however they're presence should not be ruled out without further investigation.

Table 2: PFOS Concentration Range in Fish[1]

Location	Concentration Range[1]	No. of Samples	No. of Samples >LOR
Waitematā Harbour	0.31 – 6.9	12	12
San FranciscoBay[2]	<LOR – 241	77	51
Williamtown[3]	1 - 300	36	36

Notes:

1. *All values in µg/kg.*
2. *Information from Sedlak et al. 2018.*
3. *Information from Aecom 2018.*

The PFOS concentration range of benthic fish is also summarised in the table below. As discussed above and in Appendix A, higher PFOS concentrations have been observed in the samples from benthic-dwelling fish in most locations. Of the fish samples collected from the Waitematā Harbour and San Francisco Bay, the benthic-dwelling species had the highest PFOS concentration. The PFOS concentration in fish samples collected from the Waitematā Harbour were lower than most benthic and non-benthic fish samples collected from San Francisco Bay. However the PFOS concentration range in benthic-dwelling fish in Williamtown was much lower in comparison to the highest PFOS concentration in fish samples collected from the same location. The fish samples with the highest PFOS concentration collected from Williamtown was sea mullet (*Mugil cephalus)* which can feed on algae and detritus commonly ingesting large amounts of the substrate in the process (Rowling *et al.,* 2010).

Table 3: PFOS Concentration Range in Benthic Fish[1]

Location	Benthic Fish[1]	No. of Samples	No. of Samples >LOR
Waitematā Harbour	0.31 – 6.9	11	11
San Francisco Bay[2]	<LOR - 241	6	5
Williamtown[3]	13 - 16	2	2

Notes:
1. *All values in µg/kg.*
2. *Information from Sedlak et al. 2018.*
3. *Information from Aecom 2018.*

5.2.3 Sediment

PFOS concentrations in sediment collected from the Waitematā Harbour, Sydney Harbour (Thompson *et al.,* 2011), San Francisco Bay (Sedlak et *al.,* 2017) and Williamtown are summarised in table 4. The samples collected from Sydney Harbour and San Francisco Bay were not collected from areas with known point sources of PFAS and are more reflective of PFOS levels in sediment from diffuse sources in urban and industrial areas. The Williamtown samples were collected targeting the marine receiving environments of RAAF Base Williamtown. These sites are not as closely located to the base and/or potential sources in comparison to the Devonport Naval Base which directly borders Ngataringa Bay

Table 4: PFOS Range in Marine Sediment Samples

Location	Concentration Range[1]	No. of Samples	No. of Samples >LOR
Waitematā Harbour	<LOR – 0.109	76	25
Sydney Harbour[2]	0.0008 – 0.0062	10	10
San Francisco Bay[3]	<LOR – 0.00261	12	10
Williamtown[4]	<LOR – 0.03	106	85

Notes:
1. *All values in mg/kg (Dry Weight).*
2. *Information from Sedlak et al. 2017.*
3. *Information from Thompson et al. 2011.*
4. *Information from Aecom, 2018.*

Table 4 shows the number of samples varied between each site. Of the four sites summarised in Table 4, the Waitematā Harbour had the lowest percentage of samples that were greater than the LOR (33%). The majority of these samples

were collected from locations near discharges from current and historical firefighting training areas at NZDF sites.

The highest PFOS concentration was in a sediment sample collected from the Waitematā Harbour. This sample was collected directly under the outfall of the SSTS at Devonport, which is consistent with the concept of higher PFOS concentrations in sediment being closer to shore and / or sources, described by Sedlak *et al.* (2018). The remaining sediment samples collected further from the outfall sites in Ngataringa Bay have varying PFOS concentrations that are similar to sediment samples collected from Williamtown, San Francisco Bay and Sydney Harbour. This is consistent with the concept of higher PFOS concentrations in sediment being closer to shore and / or sources, described by Sedlak *et al.* (2018)

6.0 Summary and Conclusions

Sampling investigations in the Waitematā Harbour carried out by PDP (2018a and 2018b) and Golder Associates (NZ) Limited (2016) have confirmed the presence of per and poly-fluoroalkyl substances (PFAS) in biota and sediment within Ngataringa Bay and at Whenuapai within the Waitematā Harbour. PFAS was also present in invertebrate samples from two reference sites; one within the Waitematā harbour at Hellyers Creek and one in the Hauraki Gulf at Wenderholm Regional Park, however at much lower concentrations. The Coffey (2018b) and PDP (2018b) investigations also confirmed the presence of PFAS in surface water on-site at Whenuapai Airbase which discharges to the Waitematā Harbour.

A summary of these investigations is provided below along with a comparison to investigations conducted in other international urban and aqueous film forming foam impacted marine environments, including San Francisco Bay, Sydney Harbour, Williamtown (New South Wales, Australia) and Garden Island (Western Australia.

In general, PFOS was the most commonly reported compound both in the Waitematā Harbour and in the international studies reviewed.

Surface Water

- PFOS concentrations in all five surface water sites collected on-site at Whenuapai exceeded the 95% ecosystem protection guideline (HEPA, 2018).
- The highest PFOS concentrations in surface water samples were found directly downstream of the historical firefighting training area in the tributary of the Rarawaru Creek.
- After reasonable mixing, the concentration of PFOS in the furthest downstream sample collected from Rarawaru Creek was within the range of typical urban stormwater PFOS concentrations in the San Francisco Bay.

Sediment

- PFOS concentrations in sediment collected immediately below the Devonport Naval Base, Sea Safety Training Squadron (SSTS) outfalls downstream of the historical firefighting training area at Devonport were the highest recorded amongst the limited number of national and international studies reviewed.
- Of all the sediment samples collected from the Waitematā Harbour and the international studies reviewed, the sediment samples collected near the Devonport SSTS outfalls were the closest sediment samples collected to a known source of PFAS.
- Sediment samples that were located further from the point sources (i.e. NZDF firefighting training areas) in the Waitematā Harbour had similar PFOS concentrations to the sediment samples collected at other international sites such as San Francisco Bay, Sydney Harbour, and other AFFF impacted sites such as Williamtown.

Invertebrates

- In general, the concentration of PFAS compounds in invertebrates was higher in the samples collected from Ngataringa Bay in comparison to Whenuapai.
- Of the seven invertebrate samples collected in the Waitematā Harbour that exceeded the avian wildlife diet guideline, five (71%) were collected from Ngataringa Bay.
- Of the invertebrate samples (excluding worm samples) collected from the Waitematā Harbour, Garden Island and Williamtown, the sample with the highest PFOS concentration was collected from Ngataringa Bay.
- PFOS was reported in horn shell samples at both reference sites at Hellyers Creek and Wenderholm Regional Park. PFOS was also found in the cats eyes sample collected from Wenderholm Regional Park (cats eyes were not collected at Hellyers Creek). However, the concentrations in invertebrate samples was much lower than the concentrations in the same species samples collected near Whenuapai and Ngataringa Bay.
- PFOS concentrations were much lower in the invertebrate samples collected from Wenderholm Regional Park, which is located within a rural catchment, in comparison to the invertebrate sample collected from Hellyers Creek which is in an urban catchment.

Fish

- The dataset of fish sampled from the Waitemata Harbour was very small, with both a small number of samples and a small number of species sampled. On this basis, there is a higher degree of uncertainty around

the interpretation of results compared to the other international sites which have larger data sets. Of the samples collected, the concentration of PFOS in fish samples collected from the Waitematā Harbour were lower than the majority of fish samples collected in other urban environments such as San Francisco Bay and other AFFF impacted sites such as Williamtown.

- No fish samples collected in the Waitematā Harbour exceeded the consumption guidelines for recreational fish (MPI, 2018).
- No fish samples exceeded the avian wildlife diet guideline (Environment and Climate Change Canada, 2018).
- Of the fish samples collected from the Waitematā Harbour, the samples from Rarawaru Inlet had the highest PFOS concentrations in comparison to the other sample locations. The elevated levels of PFOS in the fish caught from this site also correspond with higher PFOS concentrations in surface water in the Rarawaru Creek downstream of the firefighting training area and sediment concentrations in the Rarawaru Inlet.
- With the exception of the fish samples collected from Rarawaru Inlet, the concentration of PFAS compounds in the fish samples collected were very similar, particularly for PFOS which did not exceed 1 µg/kg.

PFAS compounds are very common in urban environments. It is likely that there are many sources of PFAS to the Waitematā Harbour. Limited sampling has confirmed the presence of PFAS in biota and sediment both adjacent to known 'point sources' of PFAS (i.e. firefighting training areas at NZDF sites), and elsewhere within the harbour. The concentration of PFAS compounds in surface water, sediment and biota samples were higher with closer proximity to these 'point sources' at NZDF sites.

The investigations summarised above have shown that the bio-accumulation of PFAS in biota has been found in multiple sample locations within the Waitematā Harbour.

With the limited information available it is not possible to fully characterise the extent of, and effects of, PFAS in marine biota with the harbour.

7.0 References

AUP [OP], 2019. Auckland Unitary Plan (Operative in Part). Auckland Council. Updated May 2019.

AGDoH, 2017. *Final Health Based Guidance Values for PFAS for use in site investigations in Australia.* The Department of Health, Australian Government, Canberra, Australia. Sourced 15/05/2017 https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/fs-Health-Based-Guidance-Values.pdf

AECOM 2018. *Ecological Risk Assessment – RAAF Base Williamtown Stage 2B Environmental Investigation.* Report prepared from Australian Defence Force, September 2018.

Bakke, T., Kailquist, T., Ruus, A., Breedveld, G. and Huylland, K. 2010. *Norway Sediment Quality Guidelines.* Journal of Soils and Sediment, 10, pp 172-178.

Barghi, M. Jin, X., Lee, S., Jeong, Y., Yu, J., Paek, W, and Moon, H. (2018). *Accumulation and exposure assessment of persistent chlorinated and fluorinated contaminants in Korean birds*, Science of the Total Environment. Elsevier B.V., 645, pp. 220–228.

Battley, P., Melville, D., Schuckard, R., Balance, P., 2005. Quantitative Survey of the Intertidal Benthos of Farewell Spit, Golden Bay (Marine Biodiversity Report 7).

Coffey 2018a. *PFAS Specific Site Wide PSI RNZAF Base Auckland & Satellite Sites*. Report prepared for NZDF by Coffey Services (NZ) Ltd.

Coffey, 2018b. *PFAS Specific Site Wide PSI RNZAF Base Auckland & Satellite Sites – Sampling, Analytical and Quality Plan*. Draft report prepared for NZDF by Coffey Services (NZ) Ltd.

Environment and Climate Change Canada (2018). *Canadian Environmental Protection Act, 1999 Federal Environmental Quality Guidelines Perfluorooctane Sulfonate.* Environment and Climate Change Canada, June 2018.

Forest & Bird, 2016. Submission: *Ryman Retirement Home and Ngataringa Bay.* Forest & Bird North Shore Branch, 2016.

FSANZ, 2017. *Supporting Document 2: Assessment of potential dietary exposure to perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS) occurring in foods sampled from contaminated sites*. Food Standards Australia New Zealand, September 2017.

Giesy, J. P. and Kannan, K., 2001, Global Distribution of Perfluorooctane Sulfonate in Wildlife, Environmental science and technology, 35(7), pp. 1339-1342.

Golder Associates (NZ) Limited, 2016. *New Zealand Defence Force Seamanship Safety Training Squadron – Detailed Site Investigation.* Report prepared for New Zealand Defence Force, May 2016.

HEPA, 2018. *PFAS National Environmental Management Plan.* Heads of EPA Australia and New Zealand. January 2018.

HEPA, 2019. *PFAS National Environmental Management Plan (Version 2.0 Consultation Draft).* Heads of EPAs Australia and New Zealand, 2019.

Houde M, Martin JW, Letcher RJ, Solomon KR, Muir DCG. 2006. *Biological monitoring of polyfluoroalkyl substances: A review*. Environmental Science & Technology 40:3463-3473.

Houtz, E.F., Sedlak, D.L., 2012. *Oxidative Conversion as a Means of Detecting Precursors to Perfluoroalkyl Acids in Urban Runoff*. Environmental Science & Technology 46:9342-9349. September 2012.

ITRC, 2017. *History and Use of Per- and Polyfluoroalkyl Substances (PFAS).* Factsheet. Interstate Technology Regulatory Council. November 2017.

Kim, S.-K., Kannan, K., 2007. *Perfluorinated Acids in Air, Rain, Snow, Surface Runoff, and Lakes: Relative Importance of Pathways to Contamination of Urban Lakes*. Environ. Sci. Technol. 41, 8328e8334. November 2007.

Martin, J., Whittle, D., Muir, D., Mabury, S, 2004. *Perfluoroalkyl Contaminants in a Food Web from Lake Ontario*. Environ. Sci. Technol. 38,5379e5385.

MPI, 2018. *Consumption Guidelines to Minimise Food Safety Risk Due to PFOS in Recreational Catch Marine Finfish.* Ministry for Primary Industries New Zealand. Accessed March 2019 from: http://www.mfe.govt.nz/sites/default/files/media/Land/marine-freshwater-fin-fish-PFOS-thresholds.pdf

Murakami, M., Imamura, E., Shinohara, H., Kiri, K., Muramatsu, Y., Harada, A., Takada, H., 2008. *Occurrence and Sources of Perfluorinated Surfactants in Rivers in Japan*. Environ. Sci. Technol. 42, 6566e6572. August 2008.

Newsted, J., Jones, P., Coady, K. and Giesy, J. (2005). Avian toxicity reference values for perfluorooctane sulfonate, Environmental Science and Technology, 39(23), pp. 9357–9362.

Nguyen, V.T., Reinhard, M., Karina, G.Y., 2011. *Occurrence and Source Characterization of Perfluorochemicals in an Urban Watershed*. Chemosphere 82, 1277e1285. February 2011.

PDP, 2017. *Literature Review: Poly- and Per-Fluoroalkyl Substances (PFAS) in the Marine Environment.* Letter Report prepared for New Zealand Defence Force, 2017.

PDP, 2018a. *PFAS Detailed Site Investigation: Devonport Naval Base.* Report prepared for New Zealand Defence Force, December 2018.

PDP, 2018b. *NZDF PFAS Investigation – Summary Report: RNZAF Base Auckland (Whenuapai).* Report prepared for New Zealand Defence Force, September 2018.

PDP, 2018c. *Impact of Per and Poly Fluoroalkyl Substances on Ecosystems.* Report prepared for Ministry for the Environment, November 2018.

PDP, 2019. *NZDF PFAS Investigation – Summary Report: RNZAF Base Woodbourne Biota and Stream Sampling.* Report prepared for New Zealand Defence Force, March 2019.

RPS, 2018. *HMAS Stirling, Garden Island PFAS Investigation – Ecological Risk Assessment.* Report prepared for Australian Defence Force, September 2018.

Piersma, T., van Aelst, R., Kurk, K., Berkhoudt, H., Maas, L.R.M 1998. A new pressure sensory mechanism for prey detection in birds: the use of principles of seabed dynamics? *Proceedings of the Royal Society of London, B 265:* 1377-1383.

Rowling K, Hegarty A and Ives M (eds.), 2010 *Status of fisheries resources in NSW 2008/09*. Prepared for New South Wales Department of Primary Industries. pp 275-278. Accessed on 27/03/2019 from: https://www.dpi.nsw.gov.au/content/research/areas/fisheries-and-ecosystems/wild-fisheries/outputs/2010/1797/StatusOfFisheriesResourcesNSW2008-09.pdf

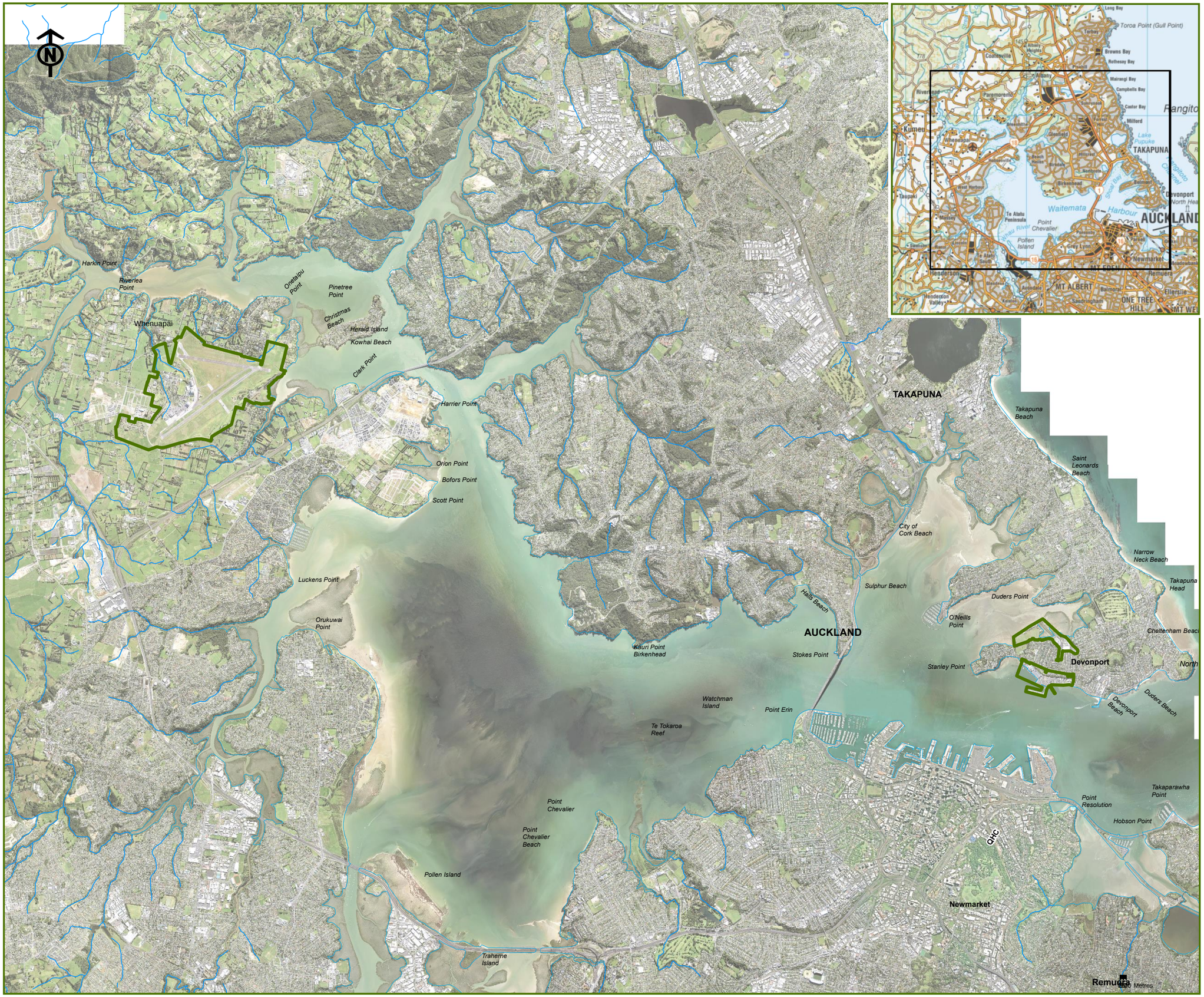
Sakurai, T., Serizawa, S., Isobe, T., Kobayashi, J., Kodama, K., Kume, G. 2010. *Spatial, Phase, and Temporal Distributions of Perfluorooctane Sulfonate* (PFOS) and Perfluorooctanoate (PFOA) in Tokyo Bay, Japan. June 2010.

Sedlak, M., Benskin, J., Wong, A., Grace, R., 2017. *Per- and Polyfluoroalkyl Substances (PFASs) in San Francisco Bay Wildlife: Temporal Trends, Exposure Pathways, and Notable Presence of Precursor Compounds.* April, 2017.

Sedlak, M., Sutton, R., Wong, A., Lin, D., 2018. *Per and Polyfluoroalkyl Substances (PFASs) in San Francisco Bay: Synthesis and Strategy.* Report Prepared for Regional Monitoring Program for Water Quality in San Francisco Bay. June 2018.

Thompson, J., Roach, A., Eaglesham., Bartkow, M., Edge, K., Mueller., J., 2011. *Perfluorinated Alkyl Acids in Water, Sediment, and Wildlife from Sydney Harbour and Surroundings*. December 2011.

Zushi, Y., Masunaga, S., 2009. *First-Flush Loads of Perfluorinated Compounds in Stormwater Runoff from Hayabuchi River Basin, Japan Served By Separated Sewerage System*. Chemosphere 76, 833e840.



New Zealand DEFENCE FORCE
Te Ope Kātua O Aotearoa

NAVY | NZ ARMY | AIR FORCE

KEY :

Base / Camp Boundary

River /Stream

SOURCE:
Aerial imagery flown 2017 supplied Auckland Council
Topographic information supplied by LINZ.
Cadastal information supplied by NZDF, dated 19/10/16.

NO.	REVISION HISTORY	DATE
A	ISSUE 1	JUN 19

PROJECT NAME:

WAITEMATŭ HARBOUR - NZDF PFAS INVESTIGATION

FIGURE TITLE:

SITE LOCATIONS

SCALE:		FIGURE NO.:	ISSUE NO.:
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New Zealand DEFENCE FORCE
Te Ope Kātua O Aotearoa

NAVY | NZ ARMY | AIR FORCE

KEY :

Sample Location

- Fish
- Macroinvertebrates
- Sediment
- Quadrat Investigation Area
- Base / Camp Boundary

SOURCE:
Aerial imagery flown 2017 supplied Auckland Council
Topographic information supplied by LINZ.
Cadastral information supplied by NZDF, dated 19/10/16.

NO.	REVISION HISTORY	DATE
A	ISSUE 1	JUN 19

pdp

PROJECT NAME:

WAITEMATŭ HARBOUR - NZDF PFAS INVESTIGATION

FIGURE TITLE:

SAMPLE LOCATIONS ï DEVONPORT NAVAL BASE

SCALE:		FIGURE NO.:	ISSUE NO.:
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New Zealand DEFENCE FORCE
Te Ope Kātua O Aotearoa
NAVY NZARMY AIR FORCE

KEY :

Sample Locations:

- Surface water
- Fish
- Macroinvertebrates
- Sediment
- RNZAF Base Auckland
- AC Rivers/Streams

SOURCE:
1. AERIAL IMAGERY (FLOWN 2017) PROVIDED UNDER LICENCE FROM AUCKLAND COUNCIL WHO MAKES NO CLAIMS AS TO ITS RELIABILITY, ACCURACY OR ADEQUACY FOR ANY PARTICULAR PURPOSE.
2. CADASTRAL INFORMATION AND INSET DERIVED FROM LINZ DATA.

NO.	REVISION HISTORY	DATE
A	ISSUE 1	JUN 19

PATTLE DELAMORE PARTNERS LTD
Auckland Tauranga Wellington Christchurch

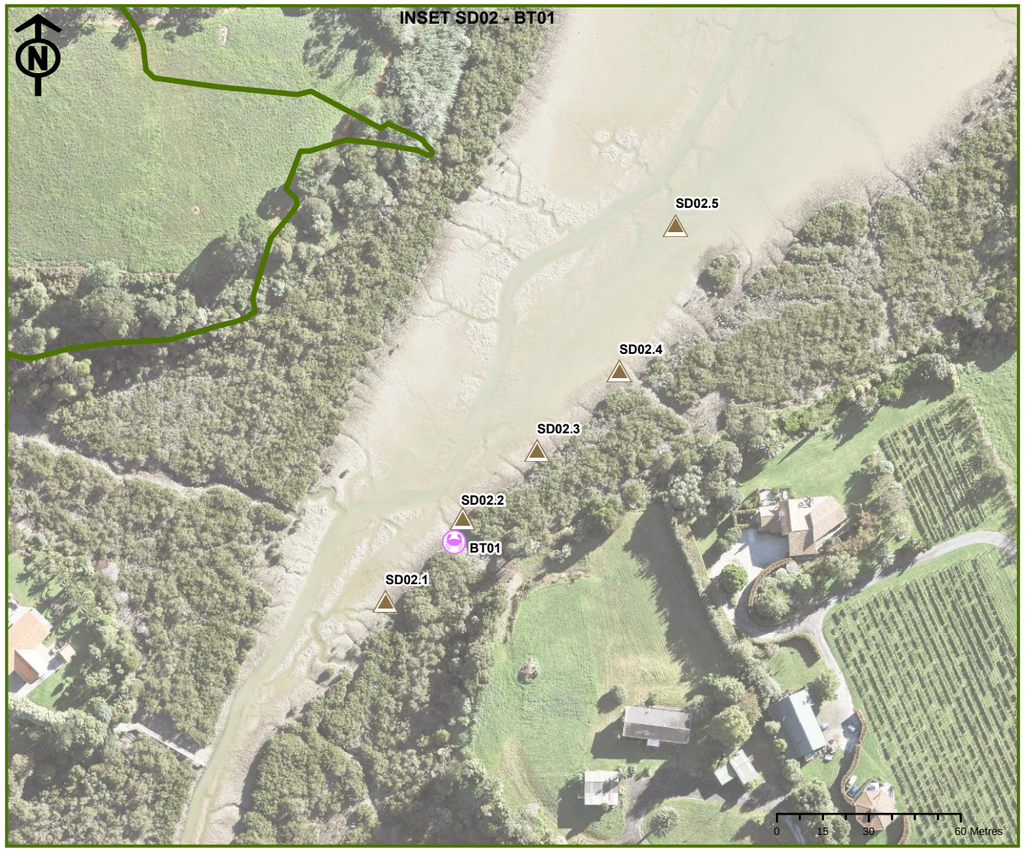
PROJECT NAME:

WAITEMATŭ HARBOUR - NZDF PFAS INVESTIGATION

FIGURE TITLE:

SAMPLE LOCATIONS - WHENUAPAI

SCALE:		FIGURE NO.:	ISSUE NO.:
1:15,000	(A3)	3	A



New Zealand DEFENCE FORCE
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NAVY NZARMY AIR FORCE

KEY :

Sample Locations:

- Surface water
- Fish
- Macroinvertebrates
- Sediment
- RNZAF Base Auckland
- AC Rivers/Streams

SOURCE:
1. AERIAL IMAGERY (FLOWN 2017) PROVIDED UNDER LICENCE FROM AUCKLAND COUNCIL WHO MAKES NO CLAIMS AS TO ITS RELIABILITY, ACCURACY OR ADEQUACY FOR ANY PARTICULAR PURPOSE.
2. CADASTRAL INFORMATION AND INSET DERIVED FROM LINZ DATA.

NO.	REVISION HISTORY	DATE
A	ISSUE 1	JUN 19

PATTLE DELAMORE PARTNERS LTD
Auckland Tauranga Wellington Christchurch

PROJECT NAME:

WAITEMATŭ HARBOUR - NZDF PFAS INVESTIGATION

FIGURE TITLE:

SAMPLE LOCATIONS - WHENUAPAI CONTINUED

SCALE:	FIGURE NO.:	ISSUE NO.:
AS SHOWN (A3)	4	A

A02386808Z104_WHP_SummaryReport_Mar19Inset.mxd

New Zealand DEFENCE FORCE
Te Ope Kātua O Aotearoa
NAVY NZARMY AIR FORCE

KEY :

Sample Locations:

- Fish
- Macroinvertebrates
- Sediment
- AC Rivers/Streams

SOURCE:
Aerial imagery flown 2017, supplied by Auckland Council.
Topographic information supplied by LINZ.
Rivers and streams information supplied by Auckland Council, dated Dec 2015.

NO.	REVISION HISTORY	DATE
A	ISSUE 1	JUN 19

PATTLE DELAMORE PARTNERS LTD
Auckland Tauranga Wellington Christchurch

PROJECT NAME:

WAITEMATŭ HARBOUR - NZDF PFAS INVESTIGATION

FIGURE TITLE:

CONTROL SAMPLE LOCATIONS ï WENDERHOLM REGIONAL PARK

SCALE:		FIGURE NO.:	ISSUE NO.:
1:6,000	(A3)	5	A

A02386808Z105_WHP_ControlSiteSampling_SumRepMar19.mxd

Appendix A

Summary of NZDF Sampling Investigation Methodology and Results

1.0 Methodology

All methodologies of sample collection from Whenuapai and Devonport can be found in the *PFAS Detailed Site Investigation: Devonport Naval Base* (PDP, 2018a) and *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).

Surface water and sediment samples were also collected on-site at Whenuapai Airbase by Coffey Services (NZ) Ltd following the *PFAS Specific Site Wide CSI RNZAF Base Auckland & Satellite Sites. Sampling, Analytical and Quality Plan* (Coffey, 2018b) draft report prepared for NZDF. These results will also be discussed in this report. Sediment samples were also collected by Golders Associates (New Zealand) Limited (2016) from the receiving environment of the SSTS at Devonport. These results will also be discussed below.

1.1 Guidelines

1.1.1 Biota

Fish and invertebrate tissue samples have been compared to the trigger points for further investigation developed by Food Standards Australia and New Zealand (FSANZ, 2017). FSANZ (2017) provides investigation trigger point values for PFOS + PFHxS and PFOA. The "trigger points" are the maximum concentration level of these chemicals that could be present in individual foods or food groups so that even high consumers of these foods would not exceed the relevant TDI [tolerable daily intake]" (FSANZ, p.2, 2017). The trigger points are based on consumption by a child 2 – 6 years old of 73 g per day of fish or 2 g per day of molluscs or crustaceans.

Invertebrate and fish samples have also been compared to the Canadian Environmental Quality guideline for avian wildlife diet (freshwater biota) has been provisionally applied in the absence of specific marine guidelines for the protection of birds consuming marine aquatic biota (Environment and Climate Change Canada, 2018). This guideline value has been included in the draft HEPA (2019) PFAS National Environmental Management Plan Version 2.0 (NEMP 2.0).

Table A-1: Biota Guidelines – Human and Environmental Health

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	
Avian Wildlife Diet [3]	-	-	8.2 µg/kg	Environment and Climate Change Canada [4]

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.*
2. *Occasionally consumed food, trigger points for investigation for crustaceans applied to molluscs due to small number of consumers of molluscs.*
3. *The avian wildlife diet guideline is intended to protect avian species that consume aquatic biota. It is the concentration of PFOS in the aquatic biota food item, expressed on whole body, wet weight basis that could be eaten by avian wildlife.*
4. *Accessed 26/02/2019 from https://www.canada.ca/content/dam/eccc/documents/pdf/pded/feqg-pfos/20180620-PFOS-EN.pdf*

The fish samples were also compared to the consumption guidelines for recreational catch marine finfish produced by the Ministry for Primary Industries (MPI, 2018). These guidelines were developed to minimise the food safety risk associated with recreational catch marine finfish. The guidelines are based on the concentration of PFOS that would exceed the FSANZ tolerable daily intake calculated from standard adult (150 g) and child (100 g) serving sizes and consumption frequency.

The MPI guidelines are provided in the table below. It is noted that there are no current New Zealand guidelines for PFAS in fish that are applicable to ecological health. MPI advise that finfish should be thoroughly gutted prior to consumption as fish livers can accumulate higher concentrations of PFOS than other edible tissues (MPI, 2018).

Table A-2: Consumption Guidelines for Recreational Catch Marine Finfish[1]		
Average PFOS concentration[2]	**Child (2-10 years) (1 serving = 100g)**	**Adult (1 serving = 150g)**
<7.5	No advice necessary	No advice necessary
7.5-10	Limit of 3 servings/week	
10-15	Limit of 2 servings/week	
15-20		Limit of 3 servings/week
20-30	Limit of 1 serving/week	Limit of 2 servings/week
30-45	Limit of 3 servings/month	
45-60	Limit of 2 servings/month	Limit of 1 serving/week
60-90	Limit of 1 serving/month	Limit of 3 servings/month
90-125		Limit of 2 servings/month
125-250	**Do not consume**	Limit of 1 serving/month
>250		**Do not consume**

Notes:

1. *Ministry for Primary Industries. Accessed on 07/01/2019 from http://www.mfe.govt.nz/sites/default/files/media/Land/marine-freshwater-fin-fish-PFOS-thresholds.pdf on 07/01/2019.*
2. *Values in µg/kg.*

1.1.2 Surface Water Guidelines

The relevant water guidelines are presented in Table below. Surface water sample results were compared to the Australia and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC) PFAS guidelines published in the PFAS National Environmental Management Plan (HEPA, 2018). These guidelines consist of three ecosystem protection levels – 90%, 95% and 99% ecosystem protection.

Surface water sample results have been compared to the draft ANZECC guidelines for the protection of 95% of species. The 90 and 99% species protection guidelines have been included in Table A-3 below for completeness. While comparison to the 99% protection guidelines is recommended for bio-accumulative substances, any concentrations of PFOS above the laboratory limit of reporting would exceed the 99% ecosystem protection value[3]. The guidelines

[3] Currently the draft ANZECC/ANZGWQG are under revision, which is likely to result in the 99% ecosystem protection value being higher than the current draft 95% ecosystem protection value (Batley *et al.*, 2018). Therefore, the current draft 95% ecosystem protection value has been used in this assessment.

have been derived using a species sensitive distribution using chronic toxicity data.

Table A-3: Environmental and Human Health Guidelines - Water

Guideline	Sum of Total PFOS + PFHxS	PFOA	Total PFHxS	Total PFOS	Source
Ecological Freshwater Guideline – 99% ecosystem protection	-	19 µg/L	-	0.00023 µg/L	HEPA [2]
Ecological Freshwater Guideline - 95% ecosystem protection [3]	-	220 µg/L	-	0.13 µg/L	HEPA [2]
Ecological Freshwater Guideline - 90% ecosystem protection [3]	-	632 µg/L	-	2 µg/L	HEPA [2]

Notes:

1. *Australian Government Department of Health (AGDoH, 2017) Health Based Guidance Values for PFAS for Use in Site Investigations in Australia.*
1. *PFAS National Environmental Management Plan. Heads of EPAs Australia and New Zealand (HEPA), January 2018.*
2. *The 95% and 90% ecosystem protection level is not protective for bioaccumulation in organisms.*
3. *'-' denotes no guideline value.*

1.1.3 Sediment Guidelines

Currently there are no ANZECC guidelines for PFAS in sediment. The Norway Sediment Quality Guidelines (Bakke et *al.* 2010) have guidelines for PFOS only. These guidelines have been derived using a theoretical relationship and have not been validated by ecotoxicological data, therefore the Norwegian guidelines have been applied as initial screening criteria. The sediment quality guidelines are reproduced in the table below. The guidelines are expressed as a range of PFOS concentrations for a particular toxicity scenario. It is noted that the lower value the concentration range is compared to the sediment sample results as a conservative measure. The sediment sample results were only compared to the chronic exposure and short-term exposure guidelines, the remaining guideline values are provided for informational purposes only.

Table A-4: Norway Sediment Quality Guidelines [1,2]					
Compound	**Background Levels**	**No Toxic Effect**	**Toxic Effects Following Chronic Exposure**	**Toxic Effects Following Short Term Exposure**	**Severe Acute Toxic Effects**
PFOS	< 0.17	0.17 - 220	220 - 630	630 – 3,100	> 3,100

Notes:

1. *Sediment guidelines reported in µg/kg dry weight.*
2. *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.*

2.0 Results

A summary of all biota samples collected from the Waitematā Harbour and analysed for PFAS is provided below. A summary of the estuarine sediment sample results from the locations biota samples were collected is also provided. The biota results are summarised per species and include results from both Devonport and Whenuapai investigations (PDP, 2018a; PDP, 2018b). Surface water and sediment samples from streams that lead into the Waitematā Harbour from the sites are also summarised below. The summary includes the concentration range and the median concentration. It is noted that the median concentration is calculated for the samples above LOR only. Where there were less than three samples above the LOR, the median concentration was not calculated.

2.1 Invertebrates

A total of 33 invertebrate samples were collected from Whenuapai and Devonport. An additional ten control samples were collected from Hellyers Creek and Wenderholm Regional Park. The species of invertebrate collected and analysed for PFAS are as follows:

- 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 (Amphibolidae sp); and
- Cats eye (*Turbo smaragdus).*

All invertebrate samples were composite samples consisting of 10 – 15 individuals, although the oyster samples may have consisted of fewer individuals.

2.1.1 Mud Crabs

A total of 12 mud crab samples were collected during the Whenuapai and Devonport investigations. Of the 12 samples, a total of nine (75%) had concentrations of one or more PFAS compound above the limit of reporting (LOR). No samples exceeded the FSANZ trigger point for further information or the avian wildlife diet guideline. PFAS below the LOR in the two samples collected from the control (reference) sites.

Table A-5: Biota Sampling Results Summary – Mud Crabs

No. of Samples Analysed	Analyte	Concentration Range[1]	Median Concentration[2]	No. of Samples > LOR	Exceeds FSANZ Trigger Value[3]
12	PFOS	<0.25 - 7.5	1.6	9	0
12	PFHxS	<0.25 - 0.97	0.39	3	0
12	Sum of PFHxS + PFOS	<0.25 - 8.5	2	9	0
12	PFOA	<0.25 - 0.99	0.48	8	0

Notes:

1. *All values in µg/kg.*
2. *Median concentration calculated using samples above LOR only. Where there were less than three samples above the LOR the median concentration was not calculated.*
3. *https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consolidated-report-perflourianted-chemicals-food.pdf*

2.1.2 Oysters

A total of seven oyster samples were collected during the Whenuapai investigation. No oysters were collected from the Devonport area. A total of six oyster samples were collected from the Waitematā Harbour adjacent to RNZAF Base Whenuapai, and one control sample was collected from Wenderholm Regional Park. Of the seven samples, only one had concentrations of PFAS compounds above LOR. PFHxS was the only compound detected in this sample with a concentration of 0.4 µg/kg. This sample was collected from Rarawaru Creek (BT05). This sample did not exceed the FSANZ trigger point for further information or the avian wildlife diet guideline.

2.1.3 Horn Shells

A total of eight horn shell samples were collected during both the Whenuapai and Devonport investigations. Of the eight samples, seven (88%) had concentrations of one or more PFAS compound above the LOR.

The sample that was below the LOR had a high unusually high LOR (<8).

Comparatively elevated concentrations were exhibited in two samples (DPT_NGA_BT2.2_1_010318 and DPT_NGA_BT3.2_1_010318) collected from Ngataringa Bay which had elevated concentrations of both PFOS and PFHxS. The median concentration for both compounds was much lower than the maximum concentration which demonstrates the significant increase in concentration of these two samples, particularly in comparison to third sample also collected from Ngataringa Bay which was below LOR (DPT_NGA_BT1.3_1_010318).

Two samples exceeded the FSANZ trigger point for further investigation and four samples exceeded the avian wildlife guideline. The concentration of PFAS found in horn shell samples were much higher in comparison to other biota samples. PFAS concentrations were above the LOR in both control samples however they were much lower than the primary samples for each respective investigation. The control sample collected from Hellyers Creek had PFOS, PFHxS and PFOA concentrations above the LOR however PFOS was the only compound above the LOR in the control sample collected from Wenderholm Regional Park.

Table A-6: Biota Sampling Results Summary – Horn Shells

No. of Samples Analysed	Analyte	Concentration Range[1]	Median Concentration[2]	No. of Samples > LOR	Exceeds FSANZ Trigger Value[3]
8	PFOS	0.41 - 120	12	7	0
6	PFHxS	<0.25 - 180	8.4	6	0
8	Sum of PFHxS + PFOS	0.41 - 300	20	7	2
8	PFOA	<0.25 - 10	3.1	6	0

Notes:

1. *All values in µg/kg.*
2. *Median concentration calculated using samples above LOR only. Where there were less than three samples above the LOR the median concentration was not calculated.*
3. *https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consolidated-report-perflourianted-chemicals-food.pdf*

2.1.4 Harbour Top Shells

A total of four harbour top shell samples were collected, these samples consist of one primary and control sample collected in both investigations. Of the four samples, two (50%) samples had concentrations above the LOR for one or more PFAS compound. The concentration of PFAS was below the LOR in both control samples. PFOS and PFOA concentrations were above the LOR in the sample collected from Whenuapai. Conversely, the PFOA concentration in the sample from Ngataringa Bay was below the LOR, although this sample had a higher LOR than the remaining samples at <2. No samples had concentrations of PFHxS that

exceeded the LOR. No samples exceeded the FSANZ trigger point for further investigation or the avian wildlife diet guideline.

Table A-7: Biota Sampling Results Summary – Harbour Top Shells

No. of Samples Analysed	Analyte	Concentration Range[1]	Median Concentration[2]	No. of Samples > LOR	Exceeds FSANZ Trigger Value[3]
4	PFOS	<0.25 - 4.3	NC	2	0
4	PFHxS	<0.25 - <2	NC	0	0
4	Sum of PFHxS + PFOS	<0.25 - 4.3	NC	2	0
4	PFOA	<0.25 – 0.38	NC	1	0

Notes:

1. *All values in µg/kg.*
2. *Median concentration calculated using samples above LOR only. Where there were less than three samples above the LOR the median concentration was not calculated.*
3. *https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consolidated-report-perflourianted-chemicals-food.pdf*

'NC' – Not calculated

2.1.5 Mud Whelks

A total of five mud whelk samples were collected, inclusive of one control sample collected from Wenderholm Regional Park. Of the four samples, three (75%) samples had PFOS concentrations above the LOR. PFOS was the only compound with concentrations above LOR. PFAS concentrations were below the LOR in the control sample collected from Wenderholm Regional Park. One sample collected from Ngataringa Bay exceeded the avian wildlife guideline however no samples exceeded FSANZ trigger value for further investigation.

Table A-8: Biota Sampling Results Summary – Mud Whelks

No. of Samples Analysed	Analyte	Concentration Range[1]	Median Concentration[2]	No. of Samples > LOR	Exceeds FSANZ Trigger Value[3]
5	PFOS	<0.25 - 12	NC	3	0
5	PFHxS	<0.25 - <1	NC	0	0
5	Sum of PFHxS + PFOS	<0.25 - 12	NC	3	0
5	PFOA	<0.25 – <1	NC	0	0

Notes:

1. *All values in µg/kg.*
2. *Median concentration calculated using samples above LOR only. Where there were less than three samples above the LOR the median concentration was not calculated.*
3. *https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consolidated-report-perflourianted-chemicals-food.pdf*

'NC' – Not calculated

2.1.6 Cockles

Cockle samples were only collected from two locations, one at Whenuapai and one at Wenderholm Regional Park. Of the two samples, only the sample collected from Whenuapai had concentrations of PFAS above the LOR. PFOS was the only compound present in concentrations above the LOR for this sample. The concentration of PFOS was 0.31 µg/kg. This concentration did not exceed the FSANZ trigger value for further investigation or the avian wildlife diet.

Table A-9: Biota Sampling Results Summary – Cockles

No. of Samples Analysed	Analyte	Concentration Range[1]	Median Concentration[2]	No. of Samples > LOR	Exceeds FSANZ Trigger Value[3]
2	PFOS	<0.25 - 0.31	NC	1	0
2	PFHxS	<0.25 - <0.25	NC	0	0
2	Sum of PFHxS + PFOS	<0.25 - 0.31	NC	1	0
2	PFOA	<0.25 - <0.25	NC	0	0

Notes:

1. *All values in µg/kg.*
2. *Median concentration calculated using samples above LOR only. Where there were less than three samples above the LOR the median concentration was not calculated.*
3. *https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consolidated-report-perflourianted-chemicals-food.pdf*

'NC' – Not calculated

2.1.7 Mud Snails

A total of two mud snail samples were collected during both investigations. These samples were both collected from Whenuapai. Of the two samples, both (100%) had concentrations of PFOS above the LOR. No other compound had concentrations above the LOR. The FSANZ trigger values for further investigation or the avian wildlife diet were not exceeded.

Table A-10: Biota Sampling Results Summary – Mud Snail

No. of Samples Analysed	Analyte	Concentration Range[1]	Median Concentration[2]	No. of Samples > LOR	Exceeds FSANZ Trigger Value[3]
2	PFOS	0.54 - 0.6	NC	2	0
2	PFHxS	<0.25 - <0.25	NC	0	NA
2	Sum of PFHxS + PFOS	0.54 - 0.6	NC	2	0
2	PFOA	<0.25 - <0.25	NC	0	0

Notes:

1. *All values in µg/kg.*
2. *Median concentration calculated using samples above LOR only. Where there were less than three samples above the LOR the median concentration was not calculated.*
3. *https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consoldiated-report-perflourianted-chemicals-food.pdf*

'NC' – Not calculated
'NA' – Not applicable

2.1.8 Cats Eyes

A total of three cats eye samples collected from Ngataringa Bay and Wenderholm Regional Park. All three samples had concentrations of one or more PFAS compound above the LOR. Comparatively elevated concentrations of PFOS and PFHxS were present in the samples collected from Ngataringa Bay. The concentration of PFOS for these two samples ranged from 33 µg/kg – 38 µg/kg. These two samples exceeded the avian wildlife diet guideline however only one sample exceeded the FSANZ trigger value for further investigation.

PFOS concentrations were significantly lower in the control sample collected from Wenderholm Regional Park (0.67 µg/kg). PFHxS and PFOA were not present in concentrations above the LOR in this sample.

Table A-11: Biota Sampling Results Summary – Cats Eyes

No. of Samples Analysed	Analyte	Concentration Range[1]	Median Concentration[1, 2]	No. of Samples > LOR	Exceeds FSANZ Trigger Value[3]
3	PFOS	0.67 - 38	33	3	1
3	PFHxS	<0.25 - 30	NC	2	NA
3	Sum of PFHxS + PFOS	0.67 - 68	56	3	0
3	PFOA	<0.25 - 1.1	NC	0	0

Notes:

1. *All values in µg/kg.*
2. *Median concentration calculated using samples above LOR only. Where there were less than three samples above the LOR the median concentration was not calculated.*
3. *https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consolidated-report-perflourianted-chemicals-food.pdf*

'NC' – Not calculated
'NA' – Not applicable

2.2 Fish

A total of 11 samples were collected from Whenuapai and Devonport. Three control samples were also caught from reference sites Hellyers Creek and Wenderholm Regional Park. The species of fish collected and analysed for PFAS are as follows:

- Flounder (*Rhombosolea leporina*);
- Parore (*Girella tricuspidata*); and
- Yellow-eyed mullet (*Aldrichetta forsteri*).

2.2.1 Flounder

A total of 11 flounder samples were collected from Devonport, Whenuapai and the two control sites. Five of these samples were composite samples consisting of three or more fish. Of the 11 samples, PFAS concentrations were above the LOR in nine (82%) samples. The two samples with PFAS concentrations below the LOR were control samples collected from Wenderholm Regional Park. One sample exceeded the trigger point for further investigation (from the harbour in the vicinity of Whenuapai), however no samples exceeded the consumption guidelines for recreational marine catch (MPI, 2018).

The consumption guidelines are based on the average PFOS concentration at a site. The average PFOS concentrations of flounder per site are shown in Table A-12. Concentrations of PFOS in composite samples of three or more fish have been treated as an average concentration for a site. The location with the

highest average PFOS concentration in flounder was WHP_ADJ_FS03 which was collected at Rarawaru Creek. The average concentration was not calculated for a location where only one fish was collected. There was a total of two locations where only one flounder was collected and analysed for PFAS (FS01 and NET_3). Both samples collected from these locations had a PFOS concentration of less than 1 µg/kg and were well below 7.5 µg/kg, which is the lowest concentration level of the consumption guideline.

Table A-12: Biota Sampling Results Summary – Flounder

No. of Samples Analysed	Analyte	Concentration Range[1]	Median Concentration[1,2]	No. of Samples > LOR	Exceeds FSANZ Trigger Value[3]
11	PFOS	<0.25 - 6.9	0.7	9	1
11	PFHxS	<0.25 - 0.82	NC	1	NA
11	Sum of PFHxS + PFOS	<0.25 - 7.7	0.7	9	1
11	PFOA	<0.25 - 0.33	NC	1	0

Notes:

1. *All values in µg/kg.*
2. *Median concentration calculated using samples above LOR only. Where there were less than three samples above the LOR the median concentration was not calculated.*
3. *https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consolidated-report-perflourianted-chemicals-food.pdf*

'NC' – Not calculated
'NA' – Not applicable

TableA-13: Average PFOS Concentrations – Flounder

Location	Local Name	No. of Fish Collected	Concentration Range[1]	Average Concentration[1,2]
WHP_ADJ_FS01	Waiarohia Inlet	1	0.31	NC
WHP_ADJ_FS02[3]	Te Turerenga Inlet	3	0.88	0.88
WHP_ADJ_FS03	Rarawaru Inlet	2	2.3 - 6.9	4.6
DPT_NET_5_HC[3]	Hellyers Creek	4	0.73	0.73
DPT_NET_3	Ngataringa Bay	1	0.36	NC
DPT_NET_4[3]	Ngataringa Bay	14	0.61 – 0.7	0.62
WND_CTL_FS06	Wenderholm Regional Park	2	<0.25	<0.25

Notes:

1. *All values in µg/kg.*
2. *Average concentration calculated for locations where two or more flounder were collected. Where only one flounder was collected the average concentration was not calculated.*

'NC' – Not calculated

2.2.2 Parore

A total of two parore samples were collected and analysed for PFAS. Both samples had PFAS concentrations above the LOR. These samples were collected from Rarawaru Inlet at Whenuapai (FS03). No samples exceeded the trigger value for further investigation. The average PFOS concentration of both samples was 1.5 µg/kg which was significantly lower than the consumption guideline (MPI, 2018).

Table A-14: Biota Sampling Results Summary – Parore

No. of Samples Analysed	Analyte	Concentration Range[1]	Median Concentration[1,2]	No. of Samples > LOR	Exceeds FSANZ Trigger Value[3]
2	PFOS	1.2 – 1.8	NC	2	0
2	PFHxS	<0.25	NC	0	NA
2	Sum of PFHxS + PFOS	1.2 – 1.8	NC	2	0
2	PFOA	<0.25	NC	0	0

Notes:

1. *All values in µg/kg.*
2. *Median concentration calculated using samples above LOR only. Where there were less than three samples above the LOR the median concentration was not calculated.*
3. *https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consolidated-report-perflourianted-chemicals-food.pdf*

'NC' – Not calculated
'NA' – Not applicable

2.2.3 Yellow-Eyed Mullet

One yellow-eyed mullet sample was collected at Whenuapai and analysed for PFAS. PFOS was the only compound with concentrations above the LOR. The PFOS concentration in this sample was 0.75 µg/kg. This concentration did not exceed the FSANZ trigger value for further investigation. In order to compare this sample to the consumption guidelines an average PFOS concentration must be used. As only one sample of this species was collected the average of all fish collected from this location (FS01) was calculated and is discussed below.

2.2.4 Site Average PFOS Concentrations

There were two sites where more than one fish species was caught and analysed for PFAS. These sites were the Rarawaru Creek (FS03) and Waiarohia Inlet (FS01) at Whenuapai. These two sites will have different site averages compared to the sites where only flounder were collected. The site average for these two sites is calculated in Table A-15 below. These values have been calculated for all species caught at each site. At FS01, Waiarohia Inlet, the site average PFOS concentration was 0.53 µg/kg, which did not exceed the consumption guideline. The average PFOS concentration of all fish collected from FS03, Rarawaru Creek, (Flounder and Parore) was 3.05 µg/kg, which also did not exceed the consumption guideline. FS03 had the highest PFOS concentration.

Table A-15: Site Average PFOS Concentrations – All Species				
Location	**Local Name**	**No. of Fish Collected**	**Concentration Range[1]**	**Average Concentration[1]**
WHP_ADJ_FS01	Waiarohia Inlet	2	0.31 – 0.75	0.53
WHP_ADJ_FS03	Rarawaru Creek	4	1.2 - 6.9	3.05

Notes:
1. *All values in µg/kg.*

2.3 Surface Water

A total of 19 surface water samples were collected from multiple locations on-site and off-site at Whenuapai, these results are summarised in the table below. Due to environmental conditions at the time of sampling, no surface water samples were collected at Devonport.

Of the surface water samples collected from Whenuapai, 14 samples (74%) had PFAS concentrations above the LOR for one or more compound. The maximum concentration for the Sum of PFHxS + PFOS was 15.3 µg/L, this sample was collected from the Rarawaru Stream tributary downstream of the historical firefighting training area. All surface water samples collected on-site had concentrations of PFOS that exceeded the ANZECC 95% ecosystem protection guideline. Two samples collected off-site also exceeded the guideline, one site was at Rarawaru Creek and the second was collected near Kotukutuku Creek to the north of the runway. Of the on-site samples PFOA was only present in the samples downstream of the former firefighting training area. Other PFAS compounds (PFHxA, PFBA, PFPeA, PFPeS) were also present in the surface water samples collected both on-site and off-site, in most cases the two on-site samples taken at Rarawaru Creek had the highest concentrations. 8:2 FTS was also only present in the samples downstream of the former firefighting training area.

Table A-16: Surface Water Sampling Results Summary

No. of Samples Analysed	Analyte	Concentration Range[1]	Median Concentration[1,2]	No. of Samples > LOR	Exceeds ANZECC 95% Guideline[3]
19	PFOS	<0.001 – 11	0.15	13	7
19	PFHxS	<0.001 - 4.3	0.0066	14	NA
19	Sum of PFHxS + PFOS	<0.001 - 15.3	0.15	14	NA
19	PFOA	<0.001 – 1.1	0.012	13	0

Notes:

1. *All values in µg/L.*
2. *Median concentration calculated using samples above LOR only.*
3. *95% ecosystem protection guideline: HEPA, 2018. PFAS National Environmental Management Plan. Heads of EPA Australia and New Zealand. January 2018.*

'NC' – Not calculated
'NA' – Not applicable

2.4 Sediment

Freshwater and estuarine sediment samples were also collected from multiple locations at Whenuapai and Devonport. The freshwater sediment samples were collected from the same locations as the surface water samples summarised in the section above. No freshwater sediment samples were collected at Devonport. The freshwater and estuarine sediment samples are summarised in seperate sections below.

2.4.1 Freshwater Sediment

The freshwater sediment samples are summarised in the table below. A total of nine samples were taken at Whenuapai from locations both on-site and off-site. Of the nine samples, four (45%) samples had concentrations of PFOS above the LOR. The median conentration of PFOS was 0.0085 mg/kg (dry weight). Only one sample had a PFHxS concentration above the LOR. This sample was collected on-site downstream of the historical firefighting training area. This sample also had the highest PFOS and Sum of PFHxS + PFOS concentrations. All four samples that were above the LOR were collected downstream of the historical firefighting training area. No samples had concentrations of PFOA above the LOR and no samples exceeded the sediment quality screening criteria.

Table A-17: Sediment Sampling Results Summary - Freshwater

No. of Samples Analysed	Analyte	Concentration Range[1]	Median Concentration[1,2]	No. of Samples > LOR	Exceeds Screening Criteria[3]
9	PFOS	<0.001 – 0.95	0.0085	4	0
9	PFHxS	<0.001 – 0.006	NC	1	NA
9	Sum of PFHxS + PFOS	<0.001 – 0.101	0.0085	4	NA
9	PFOA	<0.001 - <0.005	NC	0	NA

Notes:

1. *All values in mg/kg (Dry Weight).*
2. *Median concentration calculated using samples above LOR only. Where there were less than three samples above the LOR the median concentration was not calculated.*
3. *Exceeds 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.*

'NC' – Not calculated
'NA' – Not applicable

2.4.2 Marine Sediment

The marine sediment samples are summarised in the table below. Surface and subsurface sediment samples were collected from each site where biota was collected. Marine sediment samples were also collected during a previous investigation by Golder Associates (NZ) Limited (2016) at the receiving environment of the SSTS at Devonport. A total of 82 sediment samples were collected inclusive of eight control samples. Of the 82 samples, 24 (29%) samples had concentrations of one or more PFAS compound. PFOS was the most common compound and was in all 24 samples that had concentrations above the LOR. PFHxS and PFOA were only found in the samples collected downstream of the SSTS at Devonport. The highest concentration of the compounds PFOS, PFHxS, PFOA and the Sum of PFHxS + PFOS were from the same sample collected downstream of the SSTS. The maximum PFOS concentration was 0.109 mg/kg (dry weight) which did not exceed the sediment quality screening criteria. PFAS concentrations did not exceed the LOR in the control samples collected from Hellyers Creek and Wenderholm Regional Park.

Table A-18: Sediment Sampling Results Summary - Estuarine

No. of Samples Analysed	Analyte	Concentration Range[1]	Median Concentration[1,2]	No. of Samples > LOR	Exceeds Guideline[3]
82	PFOS	0.0006 - 0.109	0.0017	24	0
82	PFHxS	<0.0002 - 0.0052	0.0019	6	NA
82	Sum of PFHxS + PFOS	0.0004 - 0.114	0.0016	4	NA
82	PFOA	0.0006 - <0.005	NC	1	NA

Notes:

1. *All values in mg/kg (Dry Weight).*
2. *Median concentration calculated using samples above LOR only. Where there were less than three samples above the LOR the median concentration was not calculated.*
3. *Exceeds 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.*

'NC' – Not calculated
'NA' – Not applicable

Appendix B

Result Summary Tables

Table B-1: Macroinvertebrate Per-and Poly-Fluoroalkly Substances (PFAS) Sampling - Mud Crabs [1,2]

	PFAS In Mud Crabs																																		
	mono-PFHxS (1)	L-PFHxS (1)	di-PFHxS (1)	Total PFHxS (3) [5]	mono-PFOS (5)	L-PFOS (5)	di-PFOS (5)	Total PFOS (7) [5]	Sum PFHxS+PFOS (1) [6]	4:2 FTS	6:2 FTS	8:2 FTS	PFOA	PFBA	PFBS	PFDA	PFDoDA	PFDS	PFHpA	PFHpS	PFHxA	PFNA	PFNS	PFOSA	PFPeA	PFPeS	PFPrS	PFTeDA	PFTrDA	PFUnDA	NEtFOSAA	NEtFOSA-M	NEtFOSE-M	NMeFOSAA	NMeFOSA-M	NMeFOSE-M
Human Health Trigger Points for Investigation - Crustaceans and Molluscs [3]	-	-	-	-	-	-	-	65	65	-	-	-	520	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal Environment Quality Guidelines - Avian Wildlife Diet [4]	-	-	-	-	-	-	-	**8.2**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Sample Name	Site	Location	Sample Date	Matrix Description																																	
DPT_HC_BT4.1_1_020318	Hellyers Creek	Quadrat_1_HC	2/03/2018	Mud Crab	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<2.5	<0.25	<0.25	-	<2.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<2.5	<0.25	<2.5	-	-	<0.25	<0.5	<2.5	<2.5	<0.5	<2.5	<2.5
DPT_NGA_BT1.1_1_010318	Ngataringa Bay	Quadrat_1	1/03/2018	Mud Crab	<0.25	<0.25	<0.25	<0.25	<0.25	2.8	<0.25	2.8	2.8	<0.25	<0.25	<0.25	0.39	<2.5	<0.25	<0.25	-	<2.5	0.54	<0.25	<0.25	<0.25	<0.25	0.25	<2.5	<0.25	<2.5	-	-	<0.25	<0.5	<2.5	<2.5	<0.5	<2.5	<2.5
DPT_NGA_BT2.1_1_010318	Ngataringa Bay	Quadrat_2	1/03/2018	Mud Crab	<0.25	0.39	<0.25	0.39	<0.25	3.1	<0.25	3.1	3.5	<0.25	<0.25	<0.25	0.6	<2.5	<0.25	<0.25	0.33	-	<2.5	0.87	<0.25	0.35	<0.25	<0.25	<0.25	<2.5	<0.25	<2.5	-	-	0.25	<0.5	<2.5	<2.5	<0.5	<2.5	<2.5
DPT_NGA_BT3.1_1_010318	Ngataringa Bay	Quadrat_3	1/03/2018	Mud Crab	<0.25	0.97	<0.25	0.97	0.47	7	<0.25	7.5	8.5	<0.25	1.4	<0.25	0.63	<2.5	<0.25	<0.25	-	<2.5	1.2	<0.25	0.46	<0.25	<0.25	0.77	<2.5	<0.25	<2.5	-	-	<0.25	<0.5	<2.5	<2.5	<0.5	<2.5	<2.5
WHP_ADJ_BT01.1_090818	Whenuapai	BT01	9/08/2018	Mud Crab	<0.25	<0.25	<0.25	<0.25	<0.25	0.45	<0.25	0.45	0.45	<0.25	<0.25	<0.25	0.35	<0.5	<0.25	<0.25	0.26	<2.5	0.76	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.5	<0.25	<0.25	-	<0.25	<0.25	<0.25	<0.25	<0.25
WHP_ADJ_BT02.1_090818	Whenuapai	BT02	9/08/2018	Mud Crab	<0.25	<0.25	<0.25	<0.25	<0.25	0.33	<0.25	0.33	0.33	<0.25	<0.25	<0.25	0.55	<0.5	<0.25	<0.25	<0.25	<2.5	0.86	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.5	<0.25	<0.25	-	<0.25	<0.25	<0.25	<0.25	<0.25
WHP_ADJ_BT03.1_300718	Whenuapai	BT03	30/07/2018	Mud Crab	<0.25	<0.25	<0.25	<0.25	<0.25	0.56	<0.25	0.56	0.56	<0.25	<0.25	<0.5	0.41	<0.25	<0.25	<0.25	<12	<0.25	0.64	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	-	<12	<50	<0.25	<0.25	<0.5	<2.5	<0.25	<2.5	<2.5
WHP_ADJ_BT04.1_090818	Whenuapai	BT04	9/08/2018	Mud Crab	<0.25	<0.25	<0.25	<0.25	<0.25	0.57	<0.25	0.57	0.57	<0.25	<0.25	<0.25	0.4	<0.5	<0.25	<0.25	0.32	<0.25	0.31	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<50	<12	<0.25	<0.25	<0.25	<2.5	<0.25	<2.5	<2.5
WHP_ADJ_BT05.1_260718	Whenuapai	BT05	26/07/2018	Mud Crab	<0.25	0.37	<0.25	0.37	<0.25	1.6	<0.25	1.6	2	<0.25	0.49	<0.25	0.99	1.1	<0.25	<0.25	<12	<0.25	4.1	<0.25	-	0.27	<0.25	<0.25	0.68	<0.25	<0.25	<50	<50	<0.25	<0.25	<0.5	<2.5	<0.25	<2.5	<2.5
WHP_ADJ_BT06.1_090818	Whenuapai	BT06	9/08/2018	Mud Crab	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<50	<12	<0.25	<0.25	<0.25	<2.5	<0.25	<2.5	<2.5
WHP_ADJ_BT07.1_260718	Whenuapai	BT07	26/07/2018	Mud Crab	<0.25	<0.25	<0.25	<0.25	<0.25	2	<0.25	2	2	-	-	-	<0.25	<0.25	<0.25	<0.25	0.62	<12	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<50	<50	0.5	<0.25	<0.5	<2.5	<0.25	<2.5	<2.5
WND_CTL_BT08.1_300818	Wenderholm	BT08	30/08/2018	Mud Crab	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<5	<5	<0.25	<0.25	<2.5	<2.5	<0.25	<2.5	<2.5

Summary Statistics

Number of Results	12	12	12	12	12	12	12	12	12	11	11	11	12	12	12	12	8	12	12	12	11	12	12	12	12	12	12	8	8	12	12	10	12	12	12	12
Number of Detects	0	3	0	3	1	9	0	9	9	0	1	0	8	1	0	2	2	0	8	0	2	1	0	0	1	0	0	0	0	2	0	0	0	0	0	0
Number of Guideline Exceedances	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Minimum Concentration	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Maximum Concentration	<0.25	0.97	<0.25	0.97	0.47	7	<0.25	7.5	8.5	<0.25	1.4	<0.5	0.99	<2.5	<0.25	0.62	<12	<2.5	4.1	<0.25	0.46	0.27	<0.25	0.77	<2.5	<0.25	<2.5	<50	<50	0.5	<0.5	<2.5	<2.5	<0.5	<2.5	<2.5
Median Concentration [7]	NC	0.39	NC	0.39	NC	1.6	NC	1.6	2	NC	NC	NC	0.48	NC	NC	NC	NC	NC	0.87	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

Notes

1. All values in µg/kg.

2. All samples are composite of three or more individuals.

3. https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consoldiated-report-perflourianted-chemicals-food.pdf accessed 26/02/2019

4. Federal Environmental quality guidelines https://www.canada.ca/content/dam/eccc/documents/pdf/pded/feqg-pfos/20180620-PFOS-EN.pdf accessed 26/02/2019

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.

7. Median concentration calculated using samples above the limit of reporting only (LOR). Where there were less than three samples below the LOR the median concentration was not calculated.

-	No value available
<0.25	Less than the limit of reporting (LOR)
NA	Not applicable
NC	Not calculated

Table B-2: Macroinvertebrate Per- and Poly-Fluoroalkyl Substances (PFAS) Sampling - Oysters [1,2]

	PFAS In Oysters																																				
	mono-PFHxS (1)	L-PFHxS (1)	di-PFHxS (1)	Total PFHxS (3) [5]	mono-PFOS (5)	L-PFOS (5)	di-PFOS (5)	Total PFOS (7) [5]	Sum PFHxS+PFOS (1) [6]	4:2 FTS	6:2 FTS	8:2 FTS	PFOA	PFBA	PFBS	PFDA	PFDoDA	PFDS	PFHpA	PFHpS	PFHxA	PFNA	PFNS	PFOSA	PFPeA	PFPeS	PFPrS	PFTeDA	PFTrDA	PFUnDA	NEtFOSAA	NEtFOSA-M	NEtFOSE-M	NMeFOSAA	NMeFOSA-M	NMeFOSE-M
Human Health Trigger Points for Investigation - Crustaceans and Molluscs [3]	-	-	-	-	-	-	-	65	65	-	-	-	520	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal Environment Quality Guidelines - Avian Wildlife Diet [4]	-	-	-	-	-	-	-	**8.2**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Sample Name	Site	Location	Sample Date	Matrix Description																																		
WHP_ADJ_BT01.2_090818	Whenuapai	BT01	9/08/2018	Oyster	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<50	<12	<0.25	<0.25	<0.25	<2.5	<0.25	<2.5	<2.5
WHP_ADJ_BT02.2_090818	Whenuapai	BT02	9/08/2018	Oyster	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<50	<12	<0.25	<0.25	<0.25	<2.5	<0.25	<2.5	<2.5
WHP_ADJ_BT03.2_300718	Whenuapai	BT03	30/07/2018	Oyster	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<12	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	-	<0.25	<0.25	<12	<12	<0.25	<0.25	<0.5	<2.5	<0.25	<2.5	<2.5
WHP_ADJ_BT04.2_090818	Whenuapai	BT04	9/08/2018	Oyster	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<50	<12	<0.25	<0.25	<0.25	<2.5	<0.25	<2.5	<2.5
WHP_ADJ_BT05.2_260718	Whenuapai	BT05	26/07/2018	Oyster	<0.25	<0.25	0.4	<0.25	<0.25	<0.25	<0.25	<0.25	0.4	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<12	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<50	<12	<0.25	<0.25	<0.25	<2.5	<0.5	<2.5	<2.5
WHP_ADJ_BT06.2_090818	Whenuapai	BT06	9/08/2018	Oyster	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
WND_CTL_BT08.2_300818	Wenderholm	BT08	30/08/2018	Oyster	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<5	<5	<0.25	<0.25	<2.5	<2.5	<0.25	<2.5	<2.5

Number of Results	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	7	7	7	7	7	7	7	7	7	7	7	7
Number of Detects	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Guideline Exceedances	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Minimum Concentration	<0.25	0.37	<0.25	0.37	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Maximum Concentration	<0.25	<0.25	0.4	<0.25	<0.25	<0.25	<0.25	<0.25	0.4	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<12	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<50	<12	<0.25	<0.25	<2.5	<2.5	<0.5	<2.5	<2.5

Notes

1. All values in µg/kg.

2. All samples are composite of three or more individuals.

3. https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consoldiated-report-perflouriantes-chemicals-food.pdf accessed 26/02/2019

4. Federal Environmental quality guidelines https://www.canada.ca/content/dam/eccc/documents/pdf/pded/feqg-pfos/20180620-PFOS-EN.pdf accessed 26/02/2019

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.

-	No value available
<0.25	Less than the limit of reporting (LOR)
NA	Not applicable

Table B-3: Macroinvertebrate Per-and Poly-Fluoroalkly Substances (PFAS) Sampling - Hornshells [1,2]

	PFAS In Hornshells																																		
	mono-PFHxS (1)	L-PFHxS (1)	di-PFHxS (1)	Total PFHxS (3) [5]	mono-PFOS (5)	L-PFOS (5)	di-PFOS (5)	Total PFOS (7) [5]	Sum PFHxS+PFOS (1) [6]	4:2 FTS	6:2 FTS	8:2 FTS	PFOA	PFBA	PFBS	PFDA	PFDoDA	PFDS	PFHpA	PFHpS	PFHxA	PFNA	PFNS	PFOSA	PPPeA	PPPeS	PPPrS	PFTeDA	PFUnDA	PFTrDA	NEtFOSAA	NEtFOSA-M	NEtFOSE-M	NMeFOSAA	NMeFOSA-M	NMeFOSE-M
Human Health Trigger Points for Investigation - Crustaceans and Molluscs [3]	-	-	-	-	-	-	-	65	65	-	-	-	520	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal Environment Quality Guidelines - Avian Wildlife Diet [4]	-	-	-	-	-	-	-	**8.2**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sample Name	**Site**	**Location**	**Sample Date**	**Matrix Description**																																	
WHP_ADJ_BT02.3_090818	Whenuapai	BT02	9/08/2018	Horn Shell	0.36	14	<0.25	14	1.6	10	<0.25	**12**	26	<0.25	4.7	<0.25	3	<0.5	<0.25	<0.25	<0.25	<0.25	1.3	0.74	<0.25	0.6	<0.25	<0.25	<0.25	0.32	<0.25	<50	<2.5	<12	<0.25	<0.25	<0.25	<2.5	<0.25	<2.5
WHP_ADJ_BT03.3_300718	Whenuapai	BT03	30/07/2018	Horn Shell	<0.25	2.8	<0.25	2.8	1.8	15	<0.25	**17**	20	<0.25	6.1	<0.25	3.3	<0.25	<0.25	0.48	<12	<0.25	0.43	0.63	<0.25	1.2	<0.25	<0.25	<0.25	<0.25	<0.25	<50	<2.5	<12	<0.25	<0.25	<0.25	<2.5	<0.25	<2.5
WHP_ADJ_BT04.3_090818	Whenuapai	BT04	9/08/2018	Horn Shell	<0.25	0.81	<0.25	0.81	0.45	2.3	<0.25	2.8	3.6	<0.25	1.4	<0.25	0.36	<0.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<50	<2.5	<12	<0.25	<0.25	<0.25	<2.5	<0.25	<2.5
WND_CTL_BT08.3_300818	Wenderholm	BT08	30/08/2018	Horn Shell	<0.25	<0.25	<0.25	<0.25	<0.25	0.41	<0.25	0.41	0.41	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<0.25	<5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<5	<0.25	<5	<0.25	<0.25	<0.25	<2.5	<2.5	<2.5
DPT_HC_BT4.3_1_020318	Hellyers Creek	Quadrat_1_HC	2/03/2018	Horn Shell	<0.25	1.8	<0.25	1.8	0.79	7.9	<0.25	8.7	10	<0.25	2.3	<0.25	2.1	<2.5	<0.25	0.43	-	<2.5	<0.25	0.37	<0.25	0.65	<0.25	0.35	<0.25	<0.25	<0.25	-	<0.25	-	<2.5	<2.5	-	-	-	-
DPT_NGA_BT1.3_1_010318	Ngataringa Bay	Quadrat_1	1/03/2018	Horn Shell	<8	<8	<8	<8	<8	<8	<8	<8	<8	<8	33	<8	<8	<80	<8	<8	-	<80	<8	<8	<8	<8	<8	<8	<8	<8	<8	-	<8	-	<80	<80	-	-	-	-
DPT_NGA_BT2.2_1_010318	Ngataringa Bay	Quadrat_2	1/03/2018	Horn Shell	<4	180	<4	180	13	110	<4	**120**	300	<4	150	<4	10	<10	<4	<4	-	<10	<4	9.2	<4	<4	<4	<4	<4	<4	<4	<4	-	<4	-	<10	<10	-	-	-	-
DPT_NGA_BT3.2_1_010318	Ngataringa Bay	Quadrat_3	1/03/2018	Horn Shell	0.92	58	<0.5	59	6.2	68	<0.5	**74**	130	0.69	200	1.3	3.2	<5	<0.5	<0.5	-	<5	1.3	3.4	<0.5	0.79	<0.5	<0.5	<0.5	1.3	<0.5	-	<0.5	-	<5	<5	-	-	-	-
Summary Statistics																																							
Number of Results					8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	4	8	8	8	8	8	8	8	8	8	8	4	8	4	8	8	4	4	4	4
Number of Detects					2	6	0	6	6	7	0	7	7	1	7	1	6	0	0	2	0	0	3	5	0	4	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0
Number of Guideline Exceedances					NA	NA	NA	NA	NA	NA	NA	4	2	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Minimum Concentration					<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.41	0.41	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<5	<0.25	<5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Maximum Concentration					<8	180	<8	180	13	110	<8	120	300	<8	200	<8	10	<80	<8	<8	<8	<80	<8	<8	<8	<8	<8	<8	<8	<8	<8	<50	<8	<12	<80	<80	<2.5	<2.5	<2.5	<2.5
Median Concentration [7]					NC	8.4	NC	8.4	1.7	10	NC	12	20	NC	6.1	NC	3.1	NC	NC	NC	NC	NC	1.3	0.74	NC	0.72	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

Notes

1. All values in µg/kg.

2. All samples are composite of three or more individuals.

3. https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consoldiated-report-perflourianted-chemicals-food.pdf accessed 26/02/2019

4. Federal Environmental quality guidelines https://www.canada.ca/content/dam/eccc/documents/pdf/pded/feqg-pfos/20180620-PFOS-EN.pdf accessed 26/02/2019

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.

7. Median concentration calculated using samples above the limit of reporting only (LOR). Where there were less than three samples above the LOR the median concentration was not calculated.

-	No value available
<0.25	Less than the limit of reporting (LOR)
8.5	Eceeds avian wildlife diet guideline
66	Exceeds trigger point for further investigation (human health)
NA	Not applicable
NC	Not calculated

Table B-4: Macroinvertebrate Per-and Poly-Fluoroalkly Substances (PFAS) Sampling - Harbour Top Shells [1,2]

	PFAS In Harbour Top Shells																																			
	mono-PFHxS (1)	L-PFHxS (1)	di-PFHxS (1)	Total PFHxS (3) [5]	mono-PFOS (5)	L-PFOS (5)	di-PFOS (5)	Total PFOS (7) [5]	Sum PFHxS+PFOS (1) [6]	4:2 FTS	6:2 FTS	8:2 FTS	PFOA	PFBA	PFBS	PFDA	PFDoDA	PFDS	PFHpA	PFHpS	PFHxA	PFNA	PFNS	PFOSA	PFPeA	PFPeS	PFPrS	PFTeDA	PFUnDA	PFTrDA	NEtFOSAA	NEtFOSA-M	NEtFOSE-M	NMeFOSAA	NMeFOSA-M	NMeFOSE-M
Human Health Trigger Points for Investigation - Crustaceans and Molluscs [3]	-	-	-	-	-	-	-	65	65	-	-	-	520	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal Environment Quality Guidelines - Avian Wildlife Diet [4]	-	-	-	-	-	-	-	**8.2**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Sample Name	Site	Location	Sample Date	Matrix Description																																	
WHP_ADJ_BT03.4_300718	Whenuapai	BT03	30/07/2018	Harbour Top Shell	<0.25	<0.25	<0.25	<0.25	<0.25	0.44	<0.25	0.44	0.44	<0.25	<0.25	<0.25	0.38	<0.25	<0.25	<0.25	<12	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<50	<2.5	<12	<0.25	<0.25	<2.5	<2.5	<2.5
WND_CTL_BT08.4_300818	Wenderholm	BT08	30/08/2018	Harbour Top Shell	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<5	<2.5	<5	<0.25	<2.5	<2.5	<0.25	<2.5	<2.5
DPT_HC_BT4.2_1_020318	Hellyers Creek	Quadrat_1_HC	2/03/2018	Harbour Top Shell	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<2.5	<0.25	<0.25	-	<2.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	-	<0.25	-	<2.5	<2.5	-	-	-	-
DPT_NGA_BT3.6_1_010318	Ngataringa Bay	Quadrat_3	1/03/2018	Harbour Top Shell	<2	<2	<2	<2	<2	4.3	<2	4.3	4.3	<2	<2	<2	<2	<20	<2	<2	-	<20	<2	<2	<2	<2	<2	<2	<2	<2	<2	-	<2	-	<20	<20	-	-	-	-

Summary Statistics

Number of Results	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4	4	4	4	4	4	4	4	4	4	2	4	2	4	4	2	2	2	2
Number of Detects	0	0	0	0	0	2	0	2	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Guideline Exceedances	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Minimum Concentration	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<5	<0.25	<5	<0.25	<0.25	<2.5	<0.25	<2.5	<2.5
Maximum Concentration	<2	<2	<2	<2	<2	4.3	<2	4.3	4.3	<2	<2	<2	<2	<20	<2	<2	<12	<20	<2	<2	<2	<2	<2	<2	<2	<2	<2	<50	<2	<12	<20	<20	<2.5	<0.25	<2.5	<2.5

Notes

1. All values in µg/kg.

2. All samples are composite of three or more individuals.

3. https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consoldiated-report-perflourianted-chemicals-food.pdf accessed 26/02/2019

4. Federal Environmental quality guidelines https://www.canada.ca/content/dam/eccc/documents/pdf/pded/feqg-pfos/20180620-PFOS-EN.pdf accessed 26/02/2019

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.

-	No value available
<0.25	Less than the limit of reporting (LOR)
NA	Not applicable

Table B-5: Macroinvertebrate Per-and Poly-Fluoroalkyl Substances (PFAS) Sampling - Mud Whelks [1,2]

														PFAS In Mud Whelks																											
								mono-PFHxS (1)	L-PFHxS (1)	di-PFHxS (1)	Total PFHxS (3) [5]	mono-PFOS (5)	L-PFOS (5)	di-PFOS (5)	Total PFOS (7) [5]	Sum PFHxS+PFOS (1) [6]	4:2 FTS	6:2 FTS	8:2 FTS	PFOA	PFBA	PFBS	PFDA	PFDoDA	PFDS	PFHpA	PFHpS	PFHxA	PFNA	PFNS	PFOSA	PFPeA	PFPeS	PFPrS	PFTeDA	PFTrDA	PFUnDA	NEtFOSAA	NEtFOSA-M	NEtFOSE-M	NMeFOSAA	NMeFOSA-M	NMeFOSE-M
Human Health Trigger Points for Investigation - Crustaceans and Molluscs [3]								-	-	-	-	-	-	-	65	65	-	-	-	520	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal Environment Quality Guidelines - Avian Wildlife Diet [4]								-	-	-	-	-	-	-	**8.2**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sample Name	**Site**	**Location**	**Sample Date**	**Matrix Description**																																				
WHP_ADJ_BT02.5_090818	Whenuapai	BT02	9/08/2018	Mud Whelk	<0.25	<0.25	<0.25	<0.25	<0.25	0.45	<0.25	0.45	0.45	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<50	<12	<2.5	<0.25	<0.25	<0.25	<2.5	<0.25	<2.5
WND_CTL_BT08.5_300818	Wenderholm	BT08	30/08/2018	Mud Whelk	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<5	<5	<2.5	<0.25	<0.25	<2.5	<2.5	<0.25	<2.5
DPT_NGA_BT1.2_1_010318	Ngataringa Bay	Quadrat_1	1/03/2018	Mud Whelk	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	<1	<1	-	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	<1	<10	<10	-	-	-	-
DPT_NGA_BT2.3_1_010318	Ngataringa Bay	Quadrat_2	1/03/2018	Mud Whelk	<0.5	<0.5	<0.5	<0.5	<0.5	0.74	<0.5	0.74	0.74	<0.5	<0.5	<0.5	<0.5	<5	<0.5	<0.5	-	<5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	<0.5	<5	<5	-	-	-	-
DPT_NGA_BT3.3_1_010318	Ngataringa Bay	Quadrat_3	1/03/2018	Mud Whelk	<0.5	<0.5	<0.5	<0.5	1	11	<0.5	**12**	12	<0.5	2	0.56	<0.5	<5	<0.5	<0.5	-	<5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	<0.5	<5	<5	-	-	-	-
Summary Statistics																																								
Number of Results					5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	2	5	5	5	5	5	5	5	5	5	5	5	2	2	5	5	5	2	2	2	2
Number of Detects					0	0	0	0	1	3	0	3	3	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Guideline Exceedances					NA	NA	NA	NA	NA	NA	NA	1	0	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Minimum Concentration					<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Maximum Concentration					<1	<1	<1	<1	1	11	<0.25	12	12	<1	2	0.56	<1	<10	<1	<1	<5	<10	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<50	<12	<2.5	<10	<10	<2.5	<2.5	<0.25	<2.5
Median Concentration [7]					NC	NC	NC	NC	NC	0.74	NC	0.74	0.74	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

Notes

1. All values in µg/kg.

2. All samples are composite of three or more individuals.

3. https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consoldiated-report-perflourianted-chemicals-food.pdf accessed 26/02/2019

4. Federal Environmental quality guidelines https://www.canada.ca/content/dam/eccc/documents/pdf/pded/feqg-pfos/20180620-PFOS-EN.pdf accessed 26/02/2019

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.

7. Median concentration calculated using samples above the limit of reporting only (LOR). Where there were less than three samples above the LOR the median concentration was not calculated.

-	No value available
<0.25	Less than the limit of reporting (LOR)
8.5	Eceeds avian wildlife diet guideline
NA	Not applicable
NC	Not calculated

Table B-6: Macroinvertebrate Per-and Poly-Fluoroalkly Substances (PFAS) Sampling - Cockles [1,2]

						PFAS In Cockles																																
						mono-PFHxS (1)	L-PFHxS (1)	di-PFHxS (1)	Total PFHxS (3) [5]	mono-PFOS (5)	L-PFOS (5)	di-PFOS (5)	Total PFOS (7) [5]	Sum PFHxS+PFOS (1) [6]	4:2 FTS	6:2 FTS	8:2 FTS	PFOA	PFBA	PFBS	PFDA	PFDoDA	PFDS	PFHpA	PFHpS	PFHxA	PFNA	PFNS	PFOSA	PFPeA	PFPeS	PFPrS	PFTeDA	PFUnDA	PFTrDA	NEtFOSAA	NEtFOSA-M	NEtFOSE-M	NMeFOSAA	NMeFOSA-M	NMeFOSE-M
Human Health Trigger Points for Investigation - Crustaceans and Molluscs [3]						-	-	-	-	-	-	-	65	65	-	-	-	520	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal Environment Quality Guidelines - Avian Wildlife Diet [4]						-	-	-	-	-	-	-	**8.2**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sample Name	**Site**	**Location**	**Sample Date**	**Matrix Description**																																			
WHP_ADJ_BT02.6_090818	Whenuapai	BT02	9/08/2018	Cockle		<0.25	<0.25	<0.25	<0.25	<0.25	0.31	<0.25	0.31	0.31	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<50	<12	<0.25	<0.25	<0.25	<2.5	<0.25	<2.5	<2.5
WND_CTL_BT08.6_300818	Wenderholm	BT08	30/08/2018	Cockle		<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<5	<5	<0.25	<0.25	<2.5	<2.5	<0.25	<2.5	<2.5
Summary Statistics																																							
Number of Results						2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Number of Detects						0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Guideline Exceedances						NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Minimum Concentration						<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<5	<5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Maximum Concentration						<0.25	<0.25	<0.25	<0.25	<0.25	0.31	<0.25	0.31	0.31	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<50	<12	<0.25	<0.25	<2.5	<2.5	<0.25	<2.5	<2.5

Notes

1. All values in µg/kg.

2. All samples are composite of three or more individuals.

3. https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consoldiated-report-perflourianted-chemicals-food.pdf accessed 26/02/2019

4. Federal Environmental quality guidelines https://www.canada.ca/content/dam/eccc/documents/pdf/pded/feqg-pfos/20180620-PFOS-EN.pdf accessed 26/02/2019

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.

-	No value available
<0.25	Less than the limit of reporting (LOR)
NA	Not applicable

Table B-7: Macroinvertebrate Per-and Poly-Fluoroalkly Substances (PFAS) Sampling - Mud Snails [1,2]

	PFAS In Mud Snails																																			
	mono-PFHxS (1)	L-PFHxS (1)	di-PFHxS (1)	Total PFHxS (3) [5]	mono-PFOS (5)	L-PFOS (5)	di-PFOS (5)	Total PFOS (7) [5]	Sum PFHxS+PFOS (1) [6]	4:2 FTS	6:2 FTS	8:2 FTS	PFOA	PFBA	PFBS	PFDA	PFDoDA	PFDS	PFHpA	PFHpS	PFHxA	PFNA	PFNS	PFOSA	PFPeA	PFPeS	PFPrS	PFTeDA	PFUnDA	PFTrDA	NEtFOSAA	NEtFOSA-M	NEtFOSE-M	NMeFOSAA	NMeFOSA-M	NMeFOSE-M
Human Health Trigger Points for Investigation - Crustaceans and Molluscs [3]	-	-	-	-	-	-	-	65	65	-	-	-	520	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal Environment Quality Guidelines - Avian Wildlife Diet [4]	-	-	-	-	-	-	-	**8.2**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Sample Name	Site	Location	Sample Date	Matrix Description																																		
WHP_ADJ_BT01.7_090818	Whenuapai	BT01	9/08/2018	Mud snail	<0.25	<0.25	<0.25	<0.25	<0.25	0.6	<0.25	0.6	0.6	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<50	<0.25	<12	<0.25	<0.25	<2.5	<0.25	<2.5	<2.5
WHP_ADJ_BT06.7_090818	Whenuapai	BT06	9/08/2018	Mud snail	<0.25	<0.25	<0.25	<0.25	<0.25	0.54	<0.25	0.54	0.54	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<50	<0.25	<12	<0.25	<0.25	<2.5	<0.25	<2.5	<2.5

Summary Statistics																																						
Number of Results	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Number of Detects	0	0	0	0	0	2	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Guideline Exceedances	NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Minimum Concentration	<0.25	<0.25	<0.25	<0.25	<0.25	0.54	<0.25	0.54	0.54	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<50	<0.25	<12	<0.25	<0.25	<2.5	<0.25	<2.5	<2.5
Maximum Concentration	<0.25	<0.25	<0.25	<0.25	<0.25	0.6	<0.25	0.6	0.6	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<50	<0.25	<12	<0.25	<0.25	<2.5	<0.25	<2.5	<2.5

Notes

1. All values in µg/kg.

2. All samples are composite of three or more individuals.

3. https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consoldiated-report-perflourianted-chemicals-food.pdf accessed 26/02/2019

4. Federal Environmental quality guidelines https://www.canada.ca/content/dam/eccc/documents/pdf/pded/feqg-pfos/20180620-PFOS-EN.pdf accessed 26/02/2019

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.

-	No value available
<0.25	Less than the limit of reporting (LOR)
NA	Not applicable

Table B-8: Macroinvertebrate Per-and Poly-Fluoroalkly Substances (PFAS) Sampling - Cats Eyes [1,2]

					PFAS In Cats Eyes																																	
					mono-PFHxS (1)	L-PFHxS (1)	di-PFHxS (1)	Total PFHxS (3) [5]	mono-PFOS (5)	L-PFOS (5)	di-PFOS (5)	Total PFOS (7) [5]	Sum PFHxS+PFOS (1) [6]	4:2 FTS	6:2 FTS	8:2 FTS	PFOA	PFBA	PFBS	PFDA	PFDoDA	PFDS	PFHpA	PFHpS	PFHxA	PFNA	PFNS	PFOSA	PFPeA	PFPeS	PFPrS	PFTeDA	PFTrDA	PFUnDA	NEtFOSAA	NEtFOSA-M	NEtFOSE-M	NMeFOSAA	NMeFOSA-M	NMeFOSE-M
Human Health Trigger Points for Investigation - Crustaceans and Molluscs [3]					-	-	-	-	-	-	-	65	65	-	-	-	520	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal Environment Quality Guidelines - Avian Wildlife Diet [4]					-	-	-	-	-	-	-	**8.2**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sample Name	**Site**	**Location**	**Sample Date**	**Matrix Description**																																		
WND_CTL_BT08.8_300818	Wenderholm	BT08	30/08/2018	Cats Eye	<0.25	<0.25	<0.25	<0.25	<0.25	0.67	<0.25	0.67	0.67	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<5	<2.5	<5	<0.25	<0.25	<2.5	<2.5	<0.25	<2.5
DPT_NGA_BT2.4_1_010318	Ngataringa Bay	Quadrat_2	1/03/2018	Cats Eye	3.4	20	<0.25	23	5.7	27	0.32	**33**	56	<0.25	<0.25	<0.25	0.78	<2.5	0.47	0.39	<2.5	<2.5	0.48	0.62	<0.25	0.38	<0.25	<0.25	<2.5	1.6	<0.25	-	-	<0.25	<0.5	<2.5	<2.5	<0.5	<2.5	<2.5
DPT_NGA_BT3.5_1_010318	Ngataringa Bay	Quadrat_3	1/03/2018	Cats Eye	4.7	25	<0.25	30	7.8	30	0.44	**38**	68	<0.25	0.72	0.31	1.1	<2.5	0.62	0.4	-	<2.5	0.6	0.71	0.43	0.53	<0.25	0.26	<2.5	2	<0.25	-	-	<0.25	<0.5	<2.5	<2.5	<0.5	<2.5	<2.5
Summary Statistics																																						
Number of Results					3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	1	1	3	3	3	3	3	3	3
Number of Detects					2	2	0	2	2	3	2	2	3	0	1	1	2	0	2	2	0	0	2	1	1	2	0	1	0	2	0	0	0	0	0	0	0	0	0	0
Number of Guideline Exceedances					NA	NA	NA	NA	NA	NA	NA	2	2	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Minimum Concentration					<0.25	<0.25	<0.25	<0.25	<0.25	0.67	<0.25	0.67	0.67	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<2.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<5	<2.5	<2.5	<0.25	<0.25	<2.5	<0.5	<0.25	<2.5
Maximum Concentration					4.7	25	<0.25	30	7.8	30	0.44	38	68	<0.25	0.72	0.31	1.1	<2.5	0.62	0.4	<5	<2.5	0.6	0.71	0.43	0.53	<0.25	0.26	<2.5	1.6	<0.25	<5	<2.5	<5	<0.5	<2.5	<2.5	<2.5	<0.25	<2.5
Median Concentration [7]					NC	NC	NC	NC	NC	27	NC	33	56	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

Notes

1. All values in µg/kg.

2. All samples are composite of three or more individuals.

3. https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consoldiated-report-perflourianted-chemicals-food.pdf accessed 26/02/2019

4. Federal Environmental quality guidelines https://www.canada.ca/content/dam/eccc/documents/pdf/pded/feqg-pfos/20180620-PFOS-EN.pdf accessed 26/02/2019

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.

7. Median concentration calculated using samples above the limit of reporting only (LOR). Where there were less than three samples above the LOR the median concentration was not calculated.

-	No value available
<0.25	Less than the limit of reporting (LOR)
8.5	Eceeds avian wildlife diet guideline
66	Exceeds trigger point for further investigation (human health)
NA	Not applicable
NC	Not calculated

Table B-9: Fish Per- and Poly-Fluoroalkyl Substances (PFAS) Sampling - Flounder [1]

	PFAS In Flounder																																				
	mono-PFHxS (1)	L-PFHxS (1)	di-PFHxS (1)	Total PFHxS (3) [2]	mono-PFOS (5)	L-PFOS (5)	di-PFOS (5)	Total PFOS (7) [2]	Sum PFHxS+PFOS (1) [3]	4:2 FTS	6:2 FTS	8:2 FTS	PFOA	PFBA	PFBS	PFDA	PFDoDA	PFDS	PFHpA	PFHpS	PFHxA	PFNA	PFNS	PFOSA	PFPeA	PFPeS	PFPrS	PFTeDA	PFTrDA	PFUnDA	NEtFOSAA	NEtFOSA-M	NEtFOSE-M	NMeFOSAA	NMeFOSA-M	NMeFOSE-M
Human Health Trigger Points for Investigation - Finfish (all) [4]	-	-	-	-	-	-	-	5.2	5.2	-	-	-	41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal Environment Quality Guidelines - Avian Wildlife Diet [5]	-	-	-	-	-	-	-	**8.2**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sample Name	**Site**	**Location**	**Sample Date**	**Matrix Description**																																		
WHP_ADJ_FS01.1_160818	Whenuapai	FS01	16/08/2018	Yellowbelly Flounder	<0.25	<0.25	<0.25	<0.25	<0.25	0.31	<0.25	0.31	0.31	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<2.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5
WHP_ADJ_FS02.1_030818 [6]	Whenuapai	FS02	3/08/2018	Yellowbelly Flounder	<0.25	<0.25	<0.25	<0.25	<0.25	0.88	<0.25	0.88	0.88	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	0.41	<0.25	<2.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.5	<0.25	<0.25	<0.25	-	<0.25	<0.25	<0.25
WHP_ADJ_FS03.1_160818	Whenuapai	FS03	16/08/2018	Yellowbelly Flounder	<0.25	<0.25	<0.25	<0.25	0.34	2	<0.25	2.3	2.3	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	0.48	0.34	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<2.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5
WHP_ADJ_FS03.2_160818	Whenuapai	FS03	16/08/2018	Yellowbelly Flounder	<0.25	<0.25	0.82	0.82	1.1	5.8	<0.25	6.9	7.7	<0.25	<0.25	<0.25	0.33	<0.5	<0.25	0.36	0.31	<0.25	<0.25	<0.25	<0.25	0.38	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<2.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5
WND_CTL_FS06.1_300818	Wenderholm	FS06	30/08/2018	Yellowbelly Flounder	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<5	<5	<2.5	<0.25	<0.25	<2.5	<2.5	<0.25	<2.5
WND_CTL_FS06.2_300818	Wenderholm	FS06	30/08/2018	Yellowbelly Flounder	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<5	<5	<2.5	<0.25	<0.25	<2.5	<2.5	<0.25	<2.5
DPT_HC_FS1.1_1_020318 [6]	Hellyers Creek	NET_5_HC	1/03/2018	Yellowbelly Flounder	<0.25	<0.25	<0.25	<0.25	<0.25	0.73	<0.25	0.73	0.73	<0.25	<0.25	<0.5	<0.25	<0.5	<0.25	0.33	<5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	-	-	<0.25	<0.5	<2.5	<2.5	<0.5	<2.5	<2.5
DPT_NGA_FS3.1_1_010318	Ngataringa Bay	NET_3	1/03/2018	Yellowbelly Flounder	<0.25	<0.25	<0.25	<0.25	<0.25	0.36	<0.25	0.36	0.36	<0.25	<0.25	<0.5	<0.25	<0.5	<0.25	<0.25	<5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	-	-	<0.25	<0.5	<2.5	<2.5	<0.5	<2.5	<2.5
DPT_NGA_FS4.1_1_010318 [6]	Ngataringa Bay	NET_4	1/03/2018	Yellowbelly Flounder	<0.25	<0.25	<0.25	<0.25	<0.25	0.54	<0.25	0.54	0.54	<0.25	<0.25	<0.5	<0.25	<0.5	<0.25	<0.25	<5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	-	-	<0.25	<0.5	<2.5	<2.5	<0.5	<2.5	<2.5
DPT_NGA_FS4.2_1_010318 [6]	Ngataringa Bay	NET_4	1/03/2018	Yellowbelly Flounder	<0.25	<0.25	<0.25	<0.25	<0.25	0.7	<0.25	0.7	0.7	<0.25	<0.25	<0.5	<0.25	<0.5	<0.25	<0.25	<5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	-	-	<0.25	<0.5	<2.5	<2.5	<0.5	<2.5	<2.5
DPT_NGA_FS4.3_1_010318 [6]	Ngataringa Bay	NET_4	1/03/2018	Yellowbelly Flounder	<0.25	<0.25	<0.25	<0.25	<0.25	0.61	<0.25	0.61	0.61	<0.25	<0.25	<0.5	<0.25	<0.5	<0.25	<0.25	<5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	-	-	<0.25	<0.5	<2.5	<2.5	<0.5	<2.5	<2.5
Summary Statistics																																							
Number of Results					11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	6	6	11	11	11	10	11	11	11
Number of Detects					0	0	1	1	2	9	0	9	9	0	0	0	1	0	0	4	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Guideline Exceedances					NA	NA	NA	NA	NA	NA	NA	1	1	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Minimum Concentration					<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Maximum Concentration					<0.25	<0.25	0.82	0.82	1.1	5.8	<0.25	6.9	7.7	<0.25	<0.25	<0.5	0.33	<0.5	<0.25	0.48	<5	<2.5	<0.25	<0.25	<0.25	0.38	<0.25	<0.25	<0.25	<0.25	<0.25	<5	<5	<2.5	<0.5	<2.5	<2.5	<2.5	<2.5	<2.5
Median Concentration [7]					NC	NC	NC	NC	NC	0.7	NC	0.7	0.7	NC	NC	NC	NC	NC	NC	0.39	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

Notes

1. All values in µg/kg.

2. 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.

3. 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.

4. https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consoldiated-report-perflouranted-chemicals-food.pdf accessed 26/02/2019

5. Federal Environmental quality guidelines https://www.canada.ca/content/dam/eccc/documents/pdf/pded/feqg-pfos/20180620-PFOS-EN.pdf accessed 26/02/2019

6. Composite sample of three or more individuals.

7. Median concentration calculated using samples above the limit of reporting only (LOR). Where there were less than three samples above the LOR the median concentration was not calculated.

-	No value available
<0.25	Less than the limit of reporting (LOR)
NA	Not applicable
NC	Not calculated

Table B-10: Fish Per- and Poly-Fluoroalkyl Substances (PFAS) Sampling - Parore [1]

										PFAS In Parore																													
										mono-PFHxS (1)	L-PFHxS (1)	di-PFHxS (1)	Total PFHxS (3) [4]	mono-PFOS (5)	L-PFOS (5)	di-PFOS (5)	Total PFOS (7) [4]	Sum PFHxS+PFOS (1) [5]	4:2 FTS	6:2 FTS	8:2 FTS	PFOA	PFBA	PFBS	PFDA	PFDoDA	PFDS	PFHpA	PFHpS	PFHxA	PFNA	PFNS	PFOSA	PFPeA	PFPeS	PFPrS	PFTeDA	PFTrDA	PFUnDA	NEtFOSAA	NEtFOSA-M	NEtFOSE-M	NMeFOSAA	NMeFOSA-M	NMeFOSE-M
Human Health Trigger Points for Investigation - Finfish (all) [2]										-	-	-	-	-	-	-	5.2	5.2	-	-	-	41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal Environment Quality Guidelines - Avian Wildlife Diet [3]										-	-	-	-	-	-	-	**8.2**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sample Name	**Site**	**Location**	**Sample Date**	**Matrix Description**																																							
WHP_ADJ_FS03.3_160818	Whenuapai	FS03	16/08/2018	Parore	<0.25	<0.25	<0.25	<0.25	<0.25	1.2	<0.25	1.2	1.2	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<2.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25
WHP_ADJ_FS03.4_160818	Whenuapai	FS03	16/08/2018	Parore	<0.25	<0.25	<0.25	<0.25	<0.25	1.8	<0.25	1.8	1.8	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<2.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25
Summary Statistics																																									
Number of Results					2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Number of Detects					0	0	0	0	0	2	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Guideline Exceedances					NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Minimum Concentration					<0.25	<0.25	<0.25	<0.25	<0.25	1.2	<0.25	1.2	1.2	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<2.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25
Maximum Concentration					<0.25	<0.25	<0.25	<0.25	<0.25	1.8	<0.25	1.8	1.8	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<2.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25

Notes

1. All values in µg/kg.

2. https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consoldiated-report-perflourianted-chemicals-food.pdf accessed 26/02/2019

3. Federal Environmental quality guidelines https://www.canada.ca/content/dam/eccc/documents/pdf/pded/feqg-pfos/20180620-PFOS-EN.pdf accessed 26/02/2019

4. 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.

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 value available
<0.25	Less than the limit of reporting (LOR)
NA	Not applicable

Table B-11: Fish Per- and Poly-Fluoroalkyl Substances (PFAS) Sampling - Yellow-eyed Mullet [1]

								PFAS In Yellow-eyed Mullet																																
								mono-PFHxS (1)	L-PFHxS (1)	di-PFHxS (1)	Total PFHxS (3) [4]	mono-PFOS (5)	L-PFOS (5)	di-PFOS (5)	Total PFOS (7) [4]	Sum PFHxS+PFOS (1) [5]	4:2 FTS	6:2 FTS	8:2 FTS	PFOA	PFBA	PFBS	PFDA	PFDoDA	PFDS	PFHpA	PFHpS	PFHxA	PFNA	PFNS	PFOSA	PFPeA	PFPeS	PFPrS	PFTeDA	PFTrDA	PFUnDA	NEtFOSAA	NEtFOSA-M	NEtFOSE-M	NMeFOSAA	NMeFOSA-M	NMeFOSE-M
Human Health Trigger Points for Investigation - Finfish (all) [2]								-	-	-	-	-	-	-	5.2	5.2	-	-	-	41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Federal Environment Quality Guidelines - Avian Wildlife Diet [3]								-	-	-	-	-	-	-	**8.2**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sample Name	**Site**	**Location**	**Sample Date**	**Matrix Description**																																							
WHP_ADJ_FS01.2_160818	Whenuapai	FS01	16/08/2018	Yellow-eyed mullet	<0.25	<0.25	<0.25	<0.25	<0.25	0.75	<0.25	0.75	0.75	-	-	-	<0.25	<0.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<2.5	<0.25	<0.25	<0.25	<0.25	<0.25	<0.5	<0.25
Summary Statistics																																										
Number of Results					1	1	1	1	1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Number of Detects					0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Guideline Exceedances					NA	NA	NA	NA	NA	NA	NA	0	0	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes

1. All values in µg/kg.

2. https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/Consoldiated-report-perflourianted-chemicals-food.pdf accessed 26/02/2019

3. Federal Environmental quality guidelines https://www.canada.ca/content/dam/eccc/documents/pdf/pded/feqg-pfos/20180620-PFOS-EN.pdf accessed 26/02/2019

4. 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.

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 value available
<0.25	Less than the limit of reporting (LOR)
NA	Not applicable

Table B-12: Per- and Poly-Fluoroalkyl Substances (PFAS) Sampling Results - Surface Water [1]

	PFAS In Sur ace Water																																				
	mono-PFHxS (1)	di-PFHxS (1)	L-PFHxS (1)	Total PFHxS (3) [4]	mono-PFOS (5)	di-PFOS (5)	L-PFOS (5)	Total PFOS (7) [4]	Sum PFHxS+PFOS (1) [5]	4:2 FTS	6:2 FTS	8:2 FTS	PFOA	PFBA	PFBS	PFDA	PFDoDA	PFDS	PFHpA	PFHpS	PFHxA	PFNA	PFNS	PFOSA	PFPeA	PFPeS	PFPrS	PFTeDA	PFTrDA	PFUnDA	NEtFOSAA	NEtFOSA-M	NEtFOSE-M	NMeFOSAA	NMeFOSA-M	NMeFOSE-M
ANZECC 90% Species Protection - Technical Draft Default Guideline Values [2]	-	-	-	-	-	-	-	*2*	-	-	-	-	*632*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ANZECC 95% Species Protection - Technical Draft Default Guideline Values [2]	-	-	-	-	-	-	-	**0.13**	-	-	-	-	**220**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Sample Name	Site	Location	Sample Date																																		
WHP_FFL_SW3_1_28032018	Whenuapai	FFL_SW3	28/03/2018	-	-	-	4.3	-	-	-	***11***	15.3	0.02	9.2	0.23	1.1	1.1	0.2	0.02	<0.01	<0.01	1.6	0.43	4	0.25	-	<0.05	7	0.38	-	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
WHP_HGR_SW1_1_28032018	Whenuapai	HGR_SW1	28/03/2018	-	-	-	0.15	-	-	-	**0.29**	0.44	<0.01	<0.05	<0.01	0.02	<0.05	0.02	<0.01	<0.01	<0.01	0.06	<0.01	0.1	<0.01	-	<0.05	0.14	0.02	-	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
WHP_HGR_SW2_1_28032018	Whenuapai	HGR_SW1	28/03/2018	-	-	-	0.11	-	-	-	**0.14**	0.25	<0.01	<0.05	<0.01	0.02	<0.05	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	0.09	<0.01	-	<0.05	0.13	<0.01	-	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
WHP_NWD_SW4_1_28032018	Whenuapai	NWD_SW4	28/03/2018	-	-	-	0.11	-	-	-	**0.18**	0.29	<0.01	<0.05	<0.01	0.02	<0.05	0.01	<0.01	<0.01	<0.01	0.04	<0.01	0.08	<0.01	-	<0.05	0.12	0.01	-	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
WHP_NWD_SW5_1_28032018	Whenuapai	NWD_SW5	28/03/2018	-	-	-	3.6	-	-	-	***7.9***	11.5	<0.01	9.5	0.17	0.83	0.95	0.16	0.01	<0.01	<0.01	1.4	0.34	3.5	0.19	-	<0.05	5.1	0.29	-	<0.01	<0.01	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
SW1	Whenuapai	SW1	10/08/2018	0.0021	<0.001	0.013	0.015	0.0046	<0.001	0.005	0.0096	0.025	<0.001	<0.001	<0.001	0.011	0.019	<0.001	<0.001	<0.001	<0.001	0.025	<0.001	0.055	0.0018	<0.001	<0.001	0.083	<0.001	<0.001	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SW4	Whenuapai	SW4	10/08/2018	0.0028	<0.001	0.019	0.022	0.011	<0.001	0.017	0.028	0.05	<0.001	<0.001	<0.001	0.011	0.015	0.0012	<0.001	<0.001	<0.001	0.019	<0.001	0.038	0.0027	<0.001	<0.001	0.056	0.0013	<0.001	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
WHP_ADJ_SW01_1_310718	Whenuapai	SW01	31/07/2018	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.025	<0.001	<0.001	-	-	<0.001	-	-
WHP_ADJ_SW02_1_090818	Whenuapai	SW02	9/08/2018	0.051	<0.001	0.33	0.38	0.14	0.012	0.22	**0.37**	0.75	-	1.2	0.018	0.081	0.1	0.016	<0.001	<0.001	<0.001	0.14	0.02	0.34	0.02	<0.001	<0.001	0.48	0.028	0.0076	-	<0.001	<0.001	<0.001	-	-	<0.001	-	-
WHP_ADJ_SW03_1_300718	Whenuapai	SW03	30/07/2018	<0.001	<0.001	0.0051	0.0051	0.0017	<0.001	0.0024	0.0041	0.0092	<0.001	0.017	<0.001	0.0026	0.022	<0.001	-	-	<0.001	0.01	<0.001	0.057	<0.001	<0.001	-	0.1	<0.001	<0.001	-	-	-	-	-	-	-	-	-	-
WHP_ADJ_SW04_1_300718	Whenuapai	SW04	30/07/2018	0.039	<0.001	0.29	0.33	0.2	0.012	0.29	**0.5**	0.83	<0.001	<0.001	<0.001	0.012	<0.005	0.0033	<0.001	-	<0.001	0.0043	0.028	0.021	0.0088	<0.001	-	0.0057	0.0066	<0.001	-	-	<0.001	<0.001	-	-	<0.001	-	-
WHP_ADJ_SW05_1_300718	Whenuapai	SW05	30/07/2018	<0.001	<0.001	0.0052	0.0052	0.0019	<0.001	0.0026	0.0045	0.0097	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	-	<0.001	0.0015	<0.001	0.0052	<0.001	<0.001	-	0.0081	<0.001	<0.001	-	-	-	<0.001	-	-	<0.001	-	-
WHP_ADJ_SW06_1_310718	Whenuapai	SW06	31/07/2018	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	0.0012	<0.001	0.0024	<0.001	<0.001	<0.001	0.0028	<0.001	<0.001	-	<0.025	<0.001	<0.001	-	-	<0.001	-	-
WHP_ADJ_SW07_1_010818	Whenuapai	SW07	1/08/2018	<0.001	<0.001	0.0044	0.0044	<0.001	<0.001	<0.001	<0.001	0.0044	<0.001	<0.001	<0.001	0.0012	<0.005	<0.001	<0.001	<0.025	<0.001	0.0021	<0.001	0.0033	<0.001	<0.001	<0.001	0.0057	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SW08_1_260718	Whenuapai	SW08	26/07/2018	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0035	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	0.0015	<0.001	0.0037	<0.001	<0.001	<0.001	0.005	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SW09_1_300718	Whenuapai	SW09	30/07/2018	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.1	<5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<5	<5	<0.1	<0.1	<0.1	<1	<0.1	<1	<1
WHP_ADJ_SW10_1_010818	Whenuapai	SW10	1/08/2018	<0.001	<0.001	0.006	0.006	0.0015	<0.001	0.0029	0.0044	0.01	<0.001	0.017	<0.001	0.0026	0.023	<0.001	<0.001	<0.025	<0.001	0.01	<0.001	0.063	<0.001	<0.001	<0.001	0.11	<0.001	<0.001	-	<0.025	<0.001	<0.001	-	-	<0.001	-	-
WHP_ADJ_SW11_1_070818	Whenuapai	SW11	7/08/2018	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
WHP_ADJ_SW12_1_170818	Whenuapai	SW12	17/08/2018	<0.001	<0.001	0.0053	0.0053	0.0032	<0.001	0.0071	0.01	0.015	<0.001	<0.001	<0.001	0.0041	0.0059	<0.001	<0.001	<0.025	<0.001	0.0066	<0.001	0.013	0.0016	<0.001	<0.001	0.019	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005

Statistical Summary																																					
Number of Results	14	14	14	19	14	14	14	19	19	18	19	19	19	19	19	18	16	19	19	19	19	19	14	16	19	19	14	9	11	17	18	12	7	13	7	7
Number of Detects	4	0	9	14	8	2	8	13	14	1	6	3	13	8	7	2	0	0	16	4	16	7	0	0	16	7	1	0	0	0	0	0	0	0	0	0
Minimum Concentration	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Maximum Concentration	<0.1	<0.1	0.33	4.3	0.2	<0.1	0.29	11	15.3	<0.1	9.5	0.23	1.1	1.1	0.2	<0.1	<5	<0.1	1.6	0.43	4	0.25	<0.1	<0.1	7	0.38	<0.1	<5	<5	<0.1	<0.1	<0.1	<1	<0.1	<1	<1
Number of Guideline Exceedances	NA	NA	NA	NA	NA	NA	NA	7	0	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Geometric Average [6]	0.0104	NC	0.016	0.0575	0.0083	NC	0.0127	0.0901	0.1261	NC	0.2176	NC	0.0184	0.0554	0.017	NC	NC	NC	0.0192	0.0951	0.0489	0.0131	NC	NC	0.0661	0.0245	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Median Concentration [6]	0.0209	NC	0.006	0.066	0.0039	NC	0.0061	0.14	0.15	NC	0.6085	NC	0.012	0.0225	0.016	NC	NC	NC	0.0145	0.184	0.056	0.0088	NC	NC	0.0915	0.02	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

Notes:

1. All values are in µg/L.
2. Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Technical Draft Default Guideline Values. Referenced in HEPA, 2018. PFAS National Environmental Management Plan. Heads of EPA Australia and New Zealand. January 2018.
3. www.health.gov.au/internet/main/publishing.nsf/content/A12B57E41EC9F326CA257BF0001F9E7D/$Fil e/PFAS-interim-health-reference-values-june2016.pdf.
4. 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.
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.
6. Only samples above the LOR have been included in calculation. Where there were less than three samples below the LOR the geometric average and median were not calculated.

2.5	Italics - Exceeds or equal to ANZECC 90% Species Protection
0.15	Bolded - Exceeds or equal to ANZECC 95% Species Protection
0.22	Shaded - Exceeds or equal to Recreational Water Quality Guideline
-	No value available
<0.001	Below the limit of reporting
NA	Not applicable
NC	Not calculated

Table B-13: Per- and Poly-Fluoroalkyl Substances (PFAS) Sampling Results - Sediment (Freshwater)[1]

	PFAS In Sediment (Freshwater)																																			
	mono-PFHxS (1)	di-PFHxS (1)	L-PFHxS (1)	Total PFHxS (3)[3]	mono-PFOS (5)	di-PFOS (5)	L-PFOS (5)	Total PFOS (7)[3]	Sum PFHxS+PFOS (1)[4]	4:2 FTS	8:2 FTS	6:2 FTS	PFOA	PFBA	PFBS	PFDA	PFDoDA	PFDS	PFHpA	PFHpS	PFHxA	PFNA	PFNS	PFPeA	PFPeS	PFPrS	PFTeDA	PFTrDA	PFUnDA	PFOSA	NEtFOSAA	NEtFOSA-M	NEtFOSE-M	NMeFOSAA	NMeFOSA-M	NMeFOSE-M
Sediment Quality Guidelines - Toxic Effects Following Short Term Exposure	-	-	-	-	-	-	-	**0.63**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sediment Quality Guidelines - Toxic Effects Following Chronic Exposure [2]	-	-	-	-	-	-	-	0.22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sample Name	**Location**	**Date**	**Sample Depth (m bgl)**																																			
WHP_ADJ_SD01_1_260718	SD01	26/07/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD01_2_260718	SD01	26/07/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD09_1_090818	SD09	9/08/2018	0.02	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.0039	0.0049	0.0049	<0.001	<0.001	0.0026	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005
WHP_ADJ_SD09_2_090818	SD09	9/08/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0032	0.0032	0.0032	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005
WHP_FFL_SD3_0.1_28032018	SD3	28/03/2018	0.1	-	-	-	0.0056	-	-	-	0.095	0.1006	-	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	<0.005	<0.005	-	<0.005	-	-	<0.005	-
WHP_HGR_SD1_0.1_28032018	SD1	28/03/2018	0.1	-	-	-	<0.005	-	-	-	<0.005	<0.005	-	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	<0.005	<0.005	-	<0.005	-	-	<0.005	-
WHP_HGR_SD2_0.1_28032018	SD1	28/03/2018	0.1	-	-	-	<0.005	-	-	-	<0.005	<0.005	-	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	<0.005	<0.005	-	<0.005	-	-	<0.005	-
WHP_NWD_SD4_0.1_28032018	SD4	28/03/2018	0.1	-	-	-	<0.005	-	-	-	<0.005	<0.005	-	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	<0.005	<0.005	-	<0.005	-	-	<0.005	-
WHP_NWD_SD5_0.1_28032018	SD5	28/03/2018	0.1	-	-	-	<0.005	-	-	-	0.012	0.012	-	-	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	<0.005	<0.005	-	<0.005	-	-	<0.005	-
Statistical Summary																																						
Number of Results				4	4	4	9	4	4	4	9	9	4	4	4	9	9	9	9	9	9	9	9	9	4	9	9	4	9	9	9	9	4	9	4	4	9	4
Number of Detects				0	0	0	1	1	0	2	4	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Minimum Concentration				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005
Maximum Concentration				<0.001	<0.001	<0.001	0.0056	0.001	<0.001	0.0039	0.095	0.1006	<0.001	<0.001	0.0026	<0.005	<0.005	<0.005	<0.005	<0.025	<0.005	<0.005	<0.005	<0.005	<0.001	<0.005	<0.005	<0.001	<0.025	<0.1	<0.005	<0.005	<0.001	<0.005	<0.005	<0.001	<0.005	<0.005
Number of Guideline Exceedances				NA	NA	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Geometric Average [5]				NC	NC	NC	NC	NC	NC	NC	0.012	0.012	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC
Median Concentration [5]				NC	NC	NC	NC	NC	NC	NC	0.0085	0.0085	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC

Notes:

1. All values are in mg/kg (Dry weight).

2. 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. Accessed 16/02/19.

3. 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.

4. 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.

5. Only samples above the Limit of Reporting (LOR) were inlcuded in the calculations. Geometric Average and Median concentration were not calculated when there were less than three samples above the LOR.

<0.001	Result is less than the limit of reporting
-	Value unavailable
0.63	Bolded - Exceeds Sediment Quality Guidelines - Toxic Effects Following Short term Exposure
0.22	Shaded - Exceeds Sediment Quality Guidelines - Toxic Effects Following Chronic Exposure
NA	Not applicable
NC	Not calculated

Table B-14: Per- and Poly-Fluoroalkyl Substances Sampling Results - Marine Sediment [1]

PFAS In Marine Sediment

Sample Name	Location	Sample Date	Sample_Depth (m bgl)	mono-PFHxS (1)	L-PFHxS (1)	di-PFHxS (1)	Total PFHxS (3) [3]	mono-PFOS (5)	L-PFOS (5)	di-PFOS (5)	Total PFOS (7) [3]	Sum PFHxS+PFOS (1) [4]	6:2 FTS	4:2 FTS	8:2 FTS	PFOA	PFBA	PFBS	PFDA	PFDoDA	PFDS	PFHpA	PFHpS	PFHxA	PFNA	PFNS	PFPeA	PFPeS	PFPrS	PFTeDA	PFTrDA	PFUnDA	PFOSA	NEtFOSAA	NEtFOSA-M	NEtFOSE-M	NMeFOSAA	NMeFOSA-M	NMeFOSE-M
Sediment Quality Guidelines - Toxic Effects Following Short Term Exposure [2]				-	-	-	-	-	-	-	**0.63**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sediment Quality Guidelines - Toxic Effects Following Chronic Exposure [2]				-	-	-	-	-	-	-	0.22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mangrove 01-0.1	Mangrove 01	18/04/2016	0.1	-	-	-	<0.0002	-	-	-	0.0016	0.0016	<0.0005	-	<0.001	<0.005	-	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-	<0.0002	<0.0002	-	-	-	-	<0.001	<0.0002	<0.0002	<0.0002	-	<0.001	<0.001	-	<0.001	<0.001
Mangrove 01-0.3	Mangrove 01	18/04/2016	0.3	-	-	-	<0.0002	-	-	-	0.0057	0.0057	<0.0005	-	<0.001	<0.005	-	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-	<0.0002	<0.0002	-	-	-	-	<0.001	<0.0002	<0.0002	<0.0002	-	<0.001	<0.001	-	<0.001	<0.001
Mangrove 02-0.1	Mangrove 02	18/04/2016	0.1	-	-	-	0.002	-	-	-	0.06	0.062	0.008	-	0.002	<0.005	-	<0.0002	<0.0002	<0.0002	0.0004	0.0006	-	0.001	<0.0002	-	-	-	-	<0.001	<0.0002	<0.0002	0.0009	-	<0.001	<0.001	-	<0.001	<0.001
Mangrove 02-0.3	Mangrove 02	18/04/2016	0.3	-	-	-	0.0021	-	-	-	0.022	0.025	0.008	-	<0.001	<0.005	-	<0.0002	<0.0002	<0.0002	<0.0002	0.0008	-	0.0017	<0.0002	-	-	-	-	<0.001	<0.0002	<0.0002	0.0002	-	<0.001	<0.001	-	<0.001	<0.001
Mangrove 03-0.1	Mangrove 03	18/04/2016	0.1	-	-	-	0.0052	-	-	-	0.109	0.114	0.024	-	0.004	0.0006	-	0.0005	<0.0002	<0.0002	0.0058	0.0007	-	0.001	<0.0002	-	-	-	-	<0.001	<0.0002	<0.0002	0.0023	-	<0.001	<0.001	-	<0.001	<0.001
Mangrove 03-0.3	Mangrove 03	18/04/2016	0.3	-	-	-	0.0018	-	-	-	0.0166	0.0184	0.007	-	<0.001	<0.005	-	<0.0002	<0.0002	<0.0002	<0.0002	0.0004	-	0.008	<0.0002	-	-	-	-	<0.001	<0.0002	<0.0002	<0.0002	-	<0.001	<0.001	-	<0.001	<0.001
Mangrove 04-0.1	Mangrove 04	18/04/2016	0.1	-	-	-	0.0004	-	-	-	<0.005	0.0004	<0.0005	-	<0.001	<0.005	-	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	-	<0.0002	<0.0002	-	-	-	-	<0.001	<0.0002	<0.0002	<0.0002	-	<0.001	<0.001	-	<0.001	<0.001
Mangrove 04-0.3	Mangrove 04	18/04/2016	0.3	-	-	-	0.0005	-	-	-	0.0006	0.0011	<0.0005	-	<0.001	<0.005	-	0.0003	<0.0002	<0.0002	<0.0002	<0.0002	-	<0.0002	<0.0002	-	-	-	-	<0.001	<0.0002	<0.0002	<0.0002	-	<0.001	<0.001	-	<0.001	<0.001
DPT_NGA_SD1.1_1_010318	SD1	1/03/2018	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD1.1-1.10_1_010318	SD1	1/03/2018	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.1	<0.001	<0.001	<0.001	<0.005	<0.025	<0.001	<0.005	<0.025
DPT_NGA_SD1.11_1_010318	SD1	1/03/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD1.11-1.20_010318	SD1	1/03/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.1	<0.001	<0.001	<0.001	<0.005	<0.025	<0.001	<0.005	<0.025
DPT_NGA_SD1.14_1_010318	SD1	1/03/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD1.2_1_010318	SD1	1/03/2018	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD1.4_1_010318	SD1	1/03/2018	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD1.8_1_010318	SD1	1/03/2018	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD2.1_1_010318	SD2	1/03/2018	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	0.0022	<0.001	0.0022	0.0022	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD2.11_1_010318	SD2	1/03/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	0.0015	<0.001	0.0015	0.0015	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD2.11-2.20_1_010318	SD2	1/03/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	0.0012	<0.001	0.0012	0.0012	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.1	<0.001	<0.001	<0.001	<0.005	<0.025	<0.001	<0.005	<0.025
DPT_NGA_SD2.1-2.10_1_010318	SD2	1/03/2018	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	0.0014	<0.001	0.0014	0.0014	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.1	<0.001	<0.001	<0.001	<0.005	<0.025	<0.001	<0.005	<0.025
DPT_NGA_SD2.19_1_010318	SD2	1/03/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD2.2_1_010318	SD2	1/03/2018	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.002	0.002	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD2.20_1_010318	SD2	1/03/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD2.3_1_010318	SD2	1/03/2018	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	0.0014	<0.001	0.0014	0.0014	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD2.7_1_010318	SD2	1/03/2018	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	0.0013	<0.001	0.0013	0.0013	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD2.9_1_010318	SD2	1/03/2018	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	0.0011	<0.001	0.0011	0.0011	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD3.1_1_010318	SD3	1/03/2018	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	0.0014	<0.001	0.0014	0.0014	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD3.10_1_010318	SD3	1/03/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD3.11-3.20_1_010318	SD3	1/03/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.1	<0.001	<0.001	<0.001	<0.005	<0.025	<0.001	<0.005	<0.025
DPT_NGA_SD3.1-3.10_1_010318	SD3	1/03/2018	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.1	<0.001	<0.001	<0.001	<0.005	<0.025	<0.001	<0.005	<0.025
DPT_NGA_SD3.15_1_010318	SD3	1/03/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD3.19_1_010318	SD3	1/03/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD3.2_1_010318	SD3	1/03/2018	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DPT_NGA_SD3.3_1_010318	SD3	1/03/2018	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
DNB_HC_SD4.11-4.20_1_020318	SD4	2/03/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.1	<0.001	<0.001	<0.001	<0.005	<0.025	<0.001	<0.005	<0.025
DNB_HC_SD4.1-4.10_1_020318	SD4	2/03/2018	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.1	<0.001	<0.001	<0.001	<0.005	<0.025	<0.001	<0.005	<0.025
DPT_HC_SD4.11-4.20_1_020318	SD4	2/03/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.1	<0.001	<0.001	<0.001	<0.005	<0.025	<0.001	<0.005	<0.025
DPT_HC_SD4.1-4.10_1_020318	SD4	2/03/2018	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.1	<0.001	<0.001	<0.001	<0.005	<0.025	<0.001	<0.005	<0.025
WHP_ADJ_SD02.1_1_090818	SD02.1	9/08/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD02.1_2_090818	SD02.1	9/08/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD02.2_1_090818	SD02.2	9/08/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD02.2_2_090818	SD02.2	9/08/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD02.3_1_090818	SD02.3	9/08/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD02.3_2_090818	SD02.3	9/08/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD02.4_1_090818	SD02.4	9/08/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD02.4_2_090818	SD02.4	9/08/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD02.5_1_090818	SD02.5	9/08/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD02.5_2_090818	SD02.5	9/08/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD03.1_1_090818	SD03.1	9/08/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD03.1_2_090818	SD03.1	9/08/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD03.2_1_090818	SD03.2	9/08/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD03.2_2_090818	SD03.2	9/08/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD03.3_1_090818	SD03.3	9/08/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD03.3_2_090818	SD03.3	9/08/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005
WHP_ADJ_SD03.4_1_090818	SD03.4	9/08/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005
WHP_ADJ_SD03.4_2_090818	SD03.4	9/08/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005
WHP_ADJ_SD03.5_1_090818	SD03.5	9/08/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005
WHP_ADJ_SD03.5_2_090818	SD03.5	9/08/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005
WHP_ADJ_SD04.1_1_300718	SD04.1	30/07/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD04.1_2_300718	SD04.1	30/07/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD04.2_1_300718	SD04.2	30/07/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD04.2_2_300718	SD04.2	30/07/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	0.0011	<0.001	0.0011	0.0011	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD04.3._2_300718	SD04.3	30/07/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD04.3_1_300718	SD04.3	30/07/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD05.1_1_090818	SD05.1	9/08/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005
WHP_ADJ_SD05.1_2_090818	SD05.1	9/08/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005
WHP_ADJ_SD05.2_1_090818	SD05.2	9/08/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005
WHP_ADJ_SD05.2_2_090818	SD05.2	9/08/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005
WHP_ADJ_SD06.1_1_260718	SD06.1	26/07/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	0.0032	<0.001	0.0032	0.0032	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD06.1_2_260718	SD06.1	26/07/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	0.0018	<0.001	0.0018	0.0018	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD06.2_1_260718	SD06.2	26/07/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	0.0032	<0.001	0.0032	0.0032	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD06.2_2_260718	SD06.2	26/07/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	0.0022	<0.001	0.0022	0.0022	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD06.3_1_260718	SD06.3	26/07/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	0.0025	<0.001	0.0025	0.0025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD06.3_2_260718	SD06.3	26/07/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	0.0015	<0.001	0.0015	0.0015	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD07_1_090818	SD07	9/08/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005
WHP_ADJ_SD07_2_090818	SD07	9/08/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005
WHP_ADJ_SD08_1_260718	SD08	26/07/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WHP_ADJ_SD08_2_260718	SD08	26/07/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.025	<0.1	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WND-CTL-SD10.1-1-300818	SD10.1	30/08/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WND-CTL-SD10.1-2-300818	SD10.1	30/08/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005

PFAS In Marine Sediment

	Location	Sample Date	Sample_Depth (m bgl)	mono-PFHxS (1)	L-PFHxS (1)	di-PFHxS (1)	Total PFHxS (3) [3]	mono-PFOS (5)	L-PFOS (5)	di-PFOS (5)	Total PFOS (7) [3]	Sum PFHxS+PFOS (1) [4]	6:2 FTS	4:2 FTS	8:2 FTS	PFOA	PFBA	PFBS	PFDA	PFDoDA	PFDS
Sediment Quality Guidelines - Toxic Effects Following Short Term Exposure [2]				-	-	-	-	-	-	-	**0.63**	-	-	-	-	-	-	-	-	-	-
Sediment Quality Guidelines - Toxic Effects Following Chronic Exposure [2]				-	-	-	-	-	-	-	0.22	-	-	-	-	-	-	-	-	-	-
Sample Name	**Location**	**Sample Date**	**Sample_Depth (m bgl)**																		
WND-CTL-SD10.2-1-300818	SD10.2	30/08/2018	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001
WND-CTL-SD10.2-2-300818	SD10.2	30/08/2018	0.1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.001	<0.025	<0.001
Statistical Summary																					
Number of Results				82	82	82	82	82	82	82	82	82	82	82	82	82	82	82	82	82	82
Number of Detects				0	0	0	6	0	17	0	24	25	4	0	2	1	0	2	0	0	2
Minimum Concentration				<0.001	<0.001	<0.001	<0.0002	<0.001	<0.001	<0.001	0.0006	0.0004	<0.0005	<0.001	<0.001	0.0006	<0.001	<0.0002	<0.0002	<0.0002	<0.0002
Maximum Concentration				<0.001	<0.001	<0.001	0.0052	<0.001	0.0032	<0.001	0.109	0.114	0.024	<0.001	0.004	<0.005	<0.005	<0.001	<0.001	<0.025	0.0058
Number of Guideline Exceedances				NA	NA	NA	NA	NA	NA	NA	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Geometric Average [5]				NC	NC	NC	0.0014	NC	0.0017	NC	0.0028	0.0027	0.0102	NC	NC	NC	NC	NC	NC	NC	NC
Median Concentration [5]				NC	NC	NC	0.0019	NC	0.0015	NC	0.0017	0.0016	0.008	NC	NC	NC	NC	NC	NC	NC	NC

	PFHpA	PFHpS	PFHxA	PFNA	PFNS	PFPeA	PFPeS	PFPrS	PFTeDA	PFTrDA	PFUnDA	PFOSA	NEtFOSAA	NEtFOSA-M	NEtFOSE-M	NMeFOSAA	NMeFOSA-M	NMeFOSE-M
Sediment Quality Guidelines - Toxic Effects Following Short Term Exposure [2]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sediment Quality Guidelines - Toxic Effects Following Chronic Exposure [2]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sample Name																		
WND-CTL-SD10.2-1-300818	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
WND-CTL-SD10.2-2-300818	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	<0.025	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001	<0.005	<0.005
Statistical Summary																		
Number of Results	82	82	82	82	82	82	82	82	78	82	82	82	82	82	82	82	82	82
Number of Detects	4	0	4	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
Minimum Concentration	<0.0002	<0.001	<0.0002	<0.0002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0002	<0.0002	<0.0002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Maximum Concentration	<0.001	<0.001	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.1	<0.1	<0.001	0.0023	<0.001	<0.005	<0.025	<0.001	<0.005	<0.025
Number of Guideline Exceedances	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Geometric Average [5]	0.0006	NC	0.0019	NC	NC	NC	NC	NC	NC	NC	NC	0.0008	NC	NC	NC	NC	NC	NC
Median Concentration [5]	0.0007	NC	0.0014	NC	NC	NC	NC	NC	NC	NC	NC	0.0009	NC	NC	NC	NC	NC	NC

Notes:

1. All values are in mg/kg (Dry weight).
2. 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. Accessed 16/02/19.
3. 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.
4. 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.
5. Only samples above the Limit of Reporting (LOR) were inlcuded in the calculations. Geometric average and median concentration was not calculated when there were less than three samples above LOR.

<0.001	Result is less than the limit of reporting
-	No value available
0.64	Bolded - Exceeds Sediment Quality Guidelines - Toxic Effects Following Short term Exposure
0.23	Shaded - Exceeds Sediment Quality Guidelines - Toxic Effects Following Chronic Exposure
NC	Not calculated
NA	Not applicable

Appendix C

Literature Review: PFAS in Other Marine Environments

1.0 Studies in Other Marine Environments

Studies of PFAS impacted biota in urban harbours have been undertaken in San Francisco Bay (Sedlak *et al.,* 2017; Sedlak *et al.,* 2018) and Sydney Harbour (Thompson *et al.,* 2011) and the receiving marine environment for two Australian Defence Force sites (Aecom2018; RPS, 2018). These studies have been selected for review to provide context to the results of the NZDF investigations in Waitematā Harbour.

In the San Francisco Bay study samples were collected of multiple media from one site adjacent to industrial facilities and petroleum refineries and two sites adjacent to wastewater treatment plant discharge sites, airports and former military facilities. Historical landfills are also present at multiple locations around the San Francisco Bay. The information from this study was also included in Sedlak *et al.* (2018) which summarises PFAS sample data from the San Francisco Bay since 2004.

In the Thompson *et al.* (2011) study, multiple media across five locations in the Sydney Harbour were sampled and analysed for PFAS. These locations were adjacent to urban/industrial areas of the upper reaches of the Sydney Harbour and Parramatta River estuary. No point sources were identified in this study.

1.1 PFAS in Wastewater Treatment Effluent

Wastewater treatment effluent is a known PFAS source in urban areas. Effluent samples were collected from three sites in the Central and South San Francisco Bay (Sedlak *et al.,* 2017). Multiple PFAS compounds were detected in the effluent samples however the concentration of the different compounds varied between sites. PFOS was present in all samples collected, however PFOS had the highest mean concentration for one site only. PFHxA had the highest mean concentration of the samples collected from the second site and PFPeA had the highest mean concentration from the third site. The range of mean PFOS concentrations from the three sites was 0.00502 – 0.0423 µg/L.

1.2 PFAS in Stormwater

Urban stormwater can also be a PFAS source for urban coastal receiving environments. Houtz and Sedlak (2012) found PFOS concentrations stormwater runoff into the San Francisco Bay in ranged from 0.002 – 0.026 µg/L. PFOS has also been detected in urban stormwater from places such as Japan, Singapore and the US (Kim and Kannan, 2007; Murakami et al., 2008; Zushi and Masunaga, 2009; Nguyen et al., 2011).

1.3 Sediment

Despite their relatively high water solubility, sorption of PFAS to sediment does occur and is related to a number of factors including the sediment properties (grain size and composition), the presence of organic carbon and the length of the carbon chain for the PFAS (PDP, 2018c).

PFOS was the most common PFAA in sediment collected in sediment samples from San Francisco Bay (Sedlak *et al.,* 2017) and Sydney Harbour (Thompson *et al,*. 2017). PFOS was detected in all samples collected in the Sydney Harbour with a range of concentrations from 0.0008 – 0.0062 mg/kg (dry weight).

PFOS was detected in all sediment samples collected from San Francisco Bay with concentrations ranging from 0.0006 – 0.00261 mg/kg (dry weight) in the South Bay. In the Central Bay Area, PFOS was concentrations ranged from < LOR to 0.00024 mg/kg (dry weight). PFOS concentrations in sediment in the San Francisco Bay are considered typical of other urbanised estuaries and lakes (Sedlak *et al.,* 2018). Higher PFOS concentrations in sediment are known to be closer to shore and/or potential sources (Sedlak *et al.,* 2018).

An extensive study of Tokyo Bay sediments (Sakurai *et al*., 2010) revealed a median PFOS concentration of 0.00061 mg/kg.

Sediment samples were also collected from two marine areas adjacent to Royal Australian Air Force (RAAF) Base Williamtown (Aecom, 2018). The range of PFOS concentrations in sediment samples collected from these sites was <LOR – 0.03 mg/kg.

1.4 Invertebrates

Sydney Rock Oysters (*Saccostrea commercialis*) were collected from five locations within the Sydney Harbour and analysed for PFAS. PFOS and perfluorododecanoic acid PFDoDa were detected in all samples. PFDoDa had the highest mean concentration of 3.0 ± 1.8 µg/kg with concentrations ranging from 1.2 – 5.8 µg/kg. PFOS had the second highest mean concentration of 1.2 ± 0.54 µg/kg and a range of 0.60 2.3 µg/kg.

Other bivalves (*Geukensia demissa*) were also collected from San Francisco Bay. Of the thirteen samples, only two had concentrations of PFOS above the LOR. These samples were both collected in the South Bay. One sample had a significantly higher concentration of PFOS (76.3 µg/kg). This sample also had a PFHxS concentration of 5.48 µg/kg. The authors were unsure as to the source of this elevated sample result. A sediment sample collected in this area had a low PFOS concentration of 0.00072 mg/kg (dry weight) and PFHxS was not detected above the LOR. PFASs concentrations in bivalves have shown to be low in multiple studies across the world and are not recommended as a PFAS bio-accumulation indicator (Sedlak *et al.* 2018).

Invertebrates were collected and analysed for PFAS from intertidal areas adjacent to Royal Australian Naval (RAN) base HMAS Stirling on Garden Island in Western Australia (RPS, 2018). Intertidal infauna such as segmented worms (Oligochaeta sp.) and epifauna such as crabs, molluscs (including bivalves) and chitons were collected from areas adjacent to the fire training area, demolition ground, wastewater treatment plants and other areas of base HMAS Stirling. Infauna (worms) was collected from five sites on Garden Island. The concentration range of PFOS in the infauna ranged from <LOR – 3,100 µg/kg. Epifauna were collected from three sites, two of which were control sites. PFOS was above the LOR in only one epifauna sample which had a concentration of 6 µg /kg. No PFOS was found above the LOR in the epifauna collected from the control sites. The concentrations from the Garden Island study are reported for dry weight samples and should not be directly compared with wet weight sample results.

PFAS was also found in marine invertebrates collected from two areas adjacent to RAAF Base Williamtown (Aecom, 2018). Crustaceans, molluscs (gastropods and bivalves) and polychaete worms were collected from two marine areas adjacent to Base Williamtown. The range of PFOS in all invertebrate samples (i.e. including worms) was <LOR – 900 µg/kg. The range of PFOS in invertebrates only was <LOR – 25 µg/kg. The invertebrate samples from Williamtown predominantly consisted of crustaceans (i.e. crabs), however bivalves and gastropods were also collected.

1.5 Fish

For fish samples collected in both the San Francisco Bay and the Sydney harbour, PFOS was found to have the highest concentration of the perfluorinated alkyl acids (PFAAs). The concentration of PFOS in Sea Mullet (*Mugil cephalus*) muscle collected from the Sydney Harbour ranged from 0.80 – 4.9 µg/kg. PFAS tend to accumulate in the body by attaching to proteins. This occurs mainly in blood and organs which accumulate blood (liver and kidneys). The concentration range of PFOS in fish liver from the same fish was 44 – 107 µg/kg.

Multiple prey fish studies have been conducted in San Francisco Bay (Sedlak *et al.,* 2017; Sedlak *et al.,* 2918). During 2009, Topsmelt (*Atherinops affinis*) and Mississippi Silverdale (*Menidia audens*) fish were collected and analysed for PFAS from ten intertidal and subtidal locations in the North and Central San Francisco Bay. The range of PFOS concentrations of these samples was 5.7 – 80 µg/kg. PFAS were not detected in samples collected from a control site in Tomales Bay (Sedlak *et al.* 2018).

The geometric mean of PFOS concentrations in all prey fish samples from the San Francisco Bay collected from 2012 – 2013 as discussed by Sedlak *et al.* (2017), was 11.8 µg/kg. This was across multiple species including yellowfin gobies (*Acanthogobius flavimanus*), chameleon/cheekspot gobies (*Tridentiger*

trigonocephalus/Ilypnus gilbert), northern anchovy (*Engraulis mordax*), shiner surfperch (*Cymatogaster aggregate*) and staghorn sculpin (*Leptocottus armatus*). The lowest concentrations of PFOS in fish samples collected from San Francisco Bay were collected from the Central Bay area (Sedlak *et al.* 2017). The Central Bay sites were located near multiple industrial facilities and petroleum refineries. Higher PFOS concentrations were found in fish collected from the South Bay which were collected from sites near airports and former military facilities. Both the Central and South Bays have wastewater treatment facilities that discharge effluent into the harbour. It is noted that the Central Bay has a much higher degree of hydraulic flushing in comparison to the South Bay. The hydraulic residence time of the South Bay is also much higher.

Of the prey fish species sampled, the benthic-dwelling fish such as the pacific staghorn sculpin had the highest PFOS concentrations in the San Francisco Bay, these samples had a geometric mean of 23.2 µg/kg. The maximum PFOS concentration reported in a fish sample from the San Francisco Bay was 241 µg/kg, which was from a pacific staghorn sculpin in the South Bay (Sedlak *et al.,* 2018). It is possible that the higher concentrations of PFOS in these fish could be attributed to pacific staghorn sculpin eating at a higher trophic level than the other fish sampled as these fish are known to eat benthic organisms (Sedlak *et al.,* 2018). The pacific staghorn sculpin was much heavier than the other fish in the study and potentially older which could explain the elevated PFOS concentrations in comparison to the other fish (Sedlak *et al.,* 2018). Higher PFOS concentrations have also been detected in benthic-dwelling fish in studies of the Canadian Great Lakes (Martin *et al.* 2004). The higher PFOS concentrations found in benthic-dwelling organisms supports the idea of sediment contributing PFOS into the food web.

Perfluorooctane sulphonamide (PFOSA) was the second most frequently detected compound in prey fish collected from San Francisco Bay (Sedlak *et al.,* 2017). The concentration of PFOSA in prey fish collected from the San Francisco Bay ranged from below the LOR to 2.28 µg/kg. PFOSA is a precursor to PFOS. PFOSA was below the LOR in all fish samples collected from the Waitematā Harbour.

A combination of prey, predator pelagic and benthic fish species were collected from two areas adjacent to Royal Australian Air Force (RAAF) Base Williamtown and analysed for PFAS (Aecom, 2018). The PFOS concentration range in these samples was 1 – 300 µg/kg.

1.6 Avian Wildlife

PFAS bio-accumulate, particularly in protein-rich tissues such as eggs, liver, and blood. High trophic level animals (i.e., predators), including birds, have been found with higher concentrations of PFOS in their tissues than is contained in their food sources (Giesy and Kannan, 2001), indicating the bio-magnification of PFAS up the food chain. There is evidence of potentially harmful concentrations

of PFOS in some wild predatory birds (Barghi *et al.*, 2018). Barghi *et al.* (2018) found that PFOS was higher in predator birds than non-predator birds.

PFOS has a relatively short half-life of two to three weeks in birds (Houde *et al.,* 2006), therefore the frequent detection of PFOS in bird eggs suggests individuals are being continually exposed to PFOS. Alternatively, the detection of PFOS may be a result of the transformation of PFOS precursors (Sedlak *et al.,* 2018).

PFAS concentrations have been detected in the eggs of multiple bird species in both aquatic and terrestrial environments. PFAS was detected in the eggs of both Australian white ibis and silver gulls (Thompson *et al.,* 2011) with PFOS concentrations ranging from 12 – 114 µg/kg in the ibis eggs and 19 – 80 µg/kg in the gull eggs. These high PFOS concentrations are likely to be reflective of the birds foraging behaviours, these birds are also known to feed at nearby landfills. Of the two bird species the silver gull has a more marine dominant feeding pattern compared to the ibis which has a more terrestrial feeding pattern.

PFAS was detected in the eggs of double-crested cormorant (*Phalacrocorax auritus*) in San Francisco Bay. These birds are known to forage close to shore in shallow and open waters (Sedlak *et al.,* 2018). PFOS had the highest concentration of the PFAS compounds detected. The PFOS concentration in cormorant eggs was much higher in the samples collected from the South Bay (concentration range 570 – 654 µg/kg) and decreased further away from the South Bay and into the upper reaches of the harbour. PFOS concentrations in cormorant eggs in San Francisco Bay are amongst the highest recorded concentrations in the world (Sedlak *et al.,* 2018).