Queensland Ambient PFAS Monitoring Program

2019–2020

Queensland Government

Prepared by: Water Quality and Investigations, Department of Environment and Science

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Executive Summary

This report summarises the ambient per- and poly-fluoroalkyl substances (PFAS) data collected by the Department of Environment and Science (DES) through an ambient monitoring program conducted throughout Queensland in 2019–2020. The primary objective of the monitoring program was to establish a baseline dataset of PFAS by collecting ambient surface water samples at 55 sites throughout Queensland every two months for one year, supplemented by sediment and biota samples at selected sites. The secondary objective was to collate and summarise existing ambient PFAS data (water, sediment, and biota) already collected in Queensland from other projects (grey literature). A total of 45 sites were collated from these projects.

The 55 sites selected for this ambient project primarily represented estuarine and some freshwater locations throughout five regions along the Queensland coast—the Wet Tropics, Mackay Whitsunday, Fitzroy, Burnett Mary and South East Queensland (SEQ) regions. The selected sites encompassed various land use types—conservation, agricultural (dryland and irrigated), forestry and grazing (native), and intensive uses (urban/industrial). Sites were chosen in locations at least 1km from known PFAS point sources such as wastewater treatment plants (WWTP), airports and ports. The first monitoring round for ambient surface waters commenced in May 2019 with the last monitoring round being finalised in March 2020. Sediment and water samples were collected during the last two monitoring rounds in 2020.

Although PFAS are chemical compounds considered to be very widely distributed throughout the environment, the results from this ambient monitoring program and the analysis of the grey literature indicate that this is not a completely valid statement for water, sediment and biota in Queensland. Of the 55 ambient sites monitored, no PFAS were reported in any water sample collected from eight sites (15% of total). At 21 of the 55 sites (38% of total), only Perfluorooctane sulfonate (PFOS) was found at around the limit of reporting (LOR) of 0.0001 µg/L. The highest concentrations and variety of PFAS were found at sites surrounded by urban and industrial land. These sites included locations in the Brisbane River, Logan River, Oxley Creek, Tingalpa Creek, and Caboolture River—all in the SEQ region—and Vines Creek in the Mackay Whitsunday region. The reported concentrations of PFAS were generally very low (close to the LOR) or below the LOR at sampling locations adjacent to conservation, agriculture, and forestry/grazing land use types. This is consistent with other studies in Australia and across the grey literature data collated from other projects in Queensland. Similarly, of the data collected from 45 sites in the grey literature, only 14 sites had PFAS reported, and these were generally in urban and industrial areas.

In urban and industrial areas, PFOS was reported at the highest concentration and was reported in most samples. The patterns of other PFAS depended upon the area, and presumably the source. Other PFAS compounds commonly reported were PFPeA, PFHpA, PFHxA, PFOA, PFBS and PFHxS. Sites at the mouth of two rivers had lower concentrations of PFAS compared to upstream sites, presumably due to flushing from sea or bay water. The Total Oxidisable Precursor Assay (TOP Assay) was undertaken on water samples from sites where PFAS had been reported, and results indicated there were no precursors or ‘unseen’ PFAS present in the samples.

Comparison of the PFAS concentrations in water from the urban/residential areas of Queensland with other studies in Australia found the reported concentrations of PFAS—in the most contaminated sites in the Brisbane River and Oxley Creek—were two to four times higher than the mean of those reported in the Parramatta River in New South Wales (Thompson *et al.* 2011). The maximum of all PFAS reported in the Brisbane River were consistently lower than the maximum concentrations reported by Sardiña *et al.* (2019) in Victoria, but were higher or equal to the Victorian estuarine results provided by Allinson *et al.* (2019).

In the SEQ region, where PFAS were reported at elevated concentrations compared with the other regions, seasonal patterns in total PFAS and proportions of PFAS were seen. Two sites that were close to WWTP (Caboolture River at Caboolture and the Brisbane River at Karana Downs) had lower concentrations of total PFAS after rainfall, and only PFOS was reported. The concentration of PFAS increased throughout the drier season. This may indicate a constant source or load of PFAS, which is diluted during high flow. In contrast, Oxley Creek and lower Brisbane River sites had the opposite pattern, with the highest total PFAS being

recorded in the wet season and decreasing in the dry season, which may indicate an upstream source/s of PFAS being washed into the waterways. At the two lower Brisbane River sites, a strong and significant correlation was found between turbidity and PFOS.

Sediment samples were analysed for PFAS at 26 sites, and PFAS were reported in only four sediment samples: at Oxley Creek, two Brisbane River sites and at Tingalpa Creek. PFOS was reported in all of these four samples and PFDA was reported only at Tingalpa Creek. No other compounds were reported in these sediment samples.

Biota sampling was targeted in areas where the highest concentrations of PFAS were reported, and hence the majority of samples were collected in the SEQ area. Biota was sampled to assess risk to wildlife, so whole samples were collected. Overall, PFOS was the predominant PFAS in biota in Queensland, with a tendency for longer-chained PFAS occurring in fish and shorter-chained PFAS in macroinvertebrates, but no PFAS were reported in oyster samples. Variation in PFAS levels in whole fish samples was high within species, between species and between locations. The fork-tailed catfish (*Arius graeffei*) tended to have the highest concentrations of PFAS and the most compounds reported.

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Acronyms

Acronym	Meaning
ALUMC	Australian Land Use and Management Classification Scheme
CAS	Chemical Abstract Service
EHMP	Ecosystem Health Monitoring Program
LOR	Limit of Reporting
NEMP	National Environmental Management Plan
OECD	Organisation for Economic Co-operation and Development
RPD	Relative Percentage Difference
SEQ	South East Queensland
PFAS	Per- and poly-fluoroalkyl substances
PFCA	Perfluoroalkyl carboxylic acids
PFSA	Perfluoroalkyl sulfonic acids
TOP Assay	Total Oxidisable Precursor Assay (TOPA)
Vic EPA	The Victorian Environment Protection Authority
WWTP	Wastewater Treatment Plant

List of PFAS

PFAS groups and chemical names	PFAS acronym	CAS number
Perfluoroalkyl carboxylic acids (PFCA)		
Perfluoropentanoic acid	PFBA	375-22-4
Perfluoropentanoic acid	PFPeA	2706-90-3
Perfluorohexanoic acid	PFHxA	307-24-4
Perfluoroheptanoic acid	PFHpA	375-85-9
Perfluorooctanoic acid	PFOA	335-67-1
Perfluorononanoic acid	PFNA	375-95-1
Perfluorodecanoic acid	PFDA	335-76-2
Perfluoroundecanoic acid	PFUnDA	2058-94-8
Perfluorododecanoic acid	PFDoDA	307-55-1
Perfluorotridecanoic acid	PFTrDA	72629-94-8
Perfluorotetradecanoic acid	PFTeDA	376-06-7
Perfluoroalkyl sulfonic acids (PFSA)		
Perfluoropropanesulfonic acid	PFPrS	423-41-6
Perfluorobutanesulfonic acid	PFBS	375-73-5
Perfluoropentanesulfonic acid	PFPeS	2706-91-4
Perfluorohexanesulfonic acid	PFHxS	335-46-4
Perfluoroheptanesulfonic acid	PFHpS	375-92-8
Perfluorooctanesulfonic acid	PFOS	1763-23-1
Perfluorononanesulfonic acid	PFNS	68259-12-1
Perfluorodecanesulfonic acid	PFDS	335-77-3
n:2 Fluorotelomer sulfonic acids (n:2 FTSA)		
1H.1H.2H.2H-perfluorohexanesulfonic acid	4:2 FTSA	757124-72-4
1H.1H.2H.2H-perfluorooctanesulfonic acid	6:2 FTSA	27619-97-2
1H.1H.2H.2H-perfluorodecanesulfonic acid	8:2 FTSA	39108-34-4
1H.1H.2H.2H-perfluorododecanesulfonic acid	10:2 FTSA	120226-60-0
Perfluoroalkyl sulfonamido substances		
2-(N-ethylperfluoro-1-octane sulfonamido)-ethanol	N-EtFOSE	1691-99-2
2-(N-methylperfluoro-1-octane sulfonamido)-ethanol	N-MeFOSE	24448-09-7
N-ethylperfluoro-1-octane sulfonamide	N-EtFOSA	4151-50-2
N-ethyl-perfluorooctanesulfonamidoacetic acid	N-EtFOSAA	2991-50-6
N-methylperfluoro-1-octane sulfonamide	N-MeFOSA	31506-32-8
N-methyl-perfluorooctanesulfonamidoacetic acid	N-MeFOSAA	2355-31-9
Perfluorooctane sulfonamide	FOSA	754-91-6

1 Introduction

Per- and poly-fluoroalkyl substances (PFAS) are a group of anthropogenic contaminants of global concern. The Organisation for Economic Co-operation and Development (OECD) has recently categorised 4,730 PFAS-related compounds by Chemical Abstract Service (CAS) number (OECD 2018). Of these, perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) have been listed in the Stockholm Convention for persistent organic pollutants (POPs) (UNEP n.d.).

PFAS have been used widely since the 1950s in numerous products, including firefighting foams, stain guard products for textiles/furniture, cookware coatings and food packaging, as well as a number of cosmetics and personal care products (Vedagiri *et al.* 2018; Z. Zhao *et al.* 2012; Gallen *et al.* 2014; Paul, Jones, and Sweetman 2009). Firefighting activities have been identified as a significant source of PFAS in the environment. Other sources include discharge of treated effluent into waterways, contamination of groundwater from disposal of waste to landfills (Gallen *et al.* 2014; Hirst, Lee, and Victoria EPA (unpublished) 2017) and stormwater runoff (Codling *et al.* 2020). Atmospheric deposition and oceanic transport has led to widespread global distribution of PFAS compounds (Yamashita *et al.* 2005; Toms *et al.* 2014; Z. Zhao *et al.* 2012). Australia does not manufacture PFAS and only small amounts are imported for direct use (Coggan *et al.* 2019 and references within). With a move toward phasing out these and other legacy compounds, alternate PFAS products, often containing shorter chain PFAS, are being used instead.

PFAS are persistent pollutants and can be toxic to wildlife (Wang *et al.* 2017; Conder *et al.* 2008). Further, PFAS are known to bioaccumulate in aquatic organisms and PFOS has been shown to bioaccumulate and biomagnify in organisms with lungs (e.g. mammals and birds) (Heads of EPAs Australia and New Zealand (HEPA) 2020). Short chain PFAS[1] are more mobile in water than longer chain compounds due to their physicochemical properties. Longer chain compounds are more likely to adsorb to sediment and suspended particles in water (Y. M. Lee *et al.* 2020; Chen *et al.* 2019). Within a contaminated site, shorter chain compounds tend to be found in water; longer chain compounds are observed in water and sediment and often also found to bioaccumulate in fish (Goodrow *et al.* 2020). Salinity has been shown to negatively affect the solubility of PFAS compounds (Yamashita *et al.* 2008; 2005) and hence the bioavailability of PFAS in marine environments is generally considered lower than in freshwater environments (Pignotti *et al.* 2017; Jeon *et al.* 2010; Z. Zhao *et al.* 2012). PFAS concentrations in water and sediments are also affected by pH, organic matter and dissolved and total organic carbon content (Bečanová *et al.* 2016; Zhang *et al.* 2013; Pignotti *et al.* 2017; Z. Zhao *et al.* 2012).

International studies have found the highest concentrations of PFAS near industrial and urbanised areas in major cities (Scott *et al.* 2009; Nakata *et al.* 2006; Yamashita *et al.* 2005; Rankin *et al.* 2016; J.-W. Lee *et al.* 2020). Historically, PFOA and PFOS are generally the most frequently reported PFAS in surface waters reported from studies outside of Australia (e.g. (Pignotti *et al.* 2017; Campo *et al.* 2015; Munoz, Budzinski, and Labadie 2017; Scott *et al.* 2009), although short chain perfluoroalkyl carboxylic acids (PFCA) and other novel compounds are becoming more prevalent (Pignotti *et al.* 2017; Feng *et al.* 2020; Lin *et al.* 2020; J. W. Lee *et al.* 2020; C. Zhao *et al.* 2020). In a review of Australian marine and coastal ecosystems, PFOS was

[1] The OECD define long chain PFAS as perfluoroalkyl carboxylic acids (PFCA) with ≥7 perfluorinated carbons and perfluoroalkane sulfonic acids (PFSA) with ≥6 perfluorinated carbons (OECD, 2018).

the most commonly reported PFAS in water, sediment and biota samples (Hirst, Lee, and Victoria EPA (unpublished) 2017).

The seasonal variability of PFAS in water is not clear, with some authors reporting no seasonal variability in total PFAS concentration (Pan *et al.* 2014), whereas other authors report lower concentrations of total PFAS in the wet season, coinciding with high rainfall and dilution (Z. Zhao *et al.* 2015; Pignotti *et al.* 2017; J. W. Lee *et al.* 2020).

PFAS bioaccumulate in aquatic organisms and some bioaccumulate in terrestrial biota (Heads of EPAs Australia and New Zealand, 2020). Although PFOS is known to bioaccumulate in aquatic biota, it does not appear to biomagnify in aquatic ecosystems, although it does biomagnify in biota with lungs (such as birds and mammals) (Heads of EPAs Australia and New Zealand, 2020). This means that birds and mammals that consume aquatic organisms are particularly at risk from aquatic contamination. PFOS is the most commonly reported contaminant in biota samples (Shi *et al.* 2010; Houde *et al.* 2011; Babut *et al.* 2017; Pan *et al.* 2018; Vedagiri *et al.* 2018; Kowalczyk *et al.* 2019; Mazzoni *et al.* 2020; Goodrow *et al.* 2020). Other contaminants found in biota tend to be longer chained compounds such as PFDA, PFUnDA and PFDoDA (Goodrow *et al.* 2020). Chain length appears to be related to bioaccumulation potential, and sulfonates are more likely to bioaccumulate than carboxylates (Goodrow *et al.* 2020 and references therein).

Even though PFAS compounds are of global concern, there has been little published work on the background or ambient concentrations of PFAS in waters in Australia. PFAS investigations have predominantly focused on contaminated areas, either as a result of an incident or to determine impacts from historically contaminated sites at a local scale. Furthermore, biota studies tend to be focused on potential human health risks. As PFAS are considered to be ubiquitous in the environment, there is a need to investigate the ambient concentrations of PFAS in Australia. This will allow for an understanding of the nationwide scale of the potential risk of these compounds to the environment and will assist in the management of PFAS contamination when an incident occurs.

The terms ‘ambient’ and ‘background’ are often used interchangeably in the literature. For the purposes of this report ambient waters are defined as all water generally of natural occurrence (e.g. lakes, rivers, wetlands, estuaries, oceans) (ANZG 2018) and *at least* 1 km downstream of known PFAS point sources such as WWTP (Stockholm Convention 2015a). The Australian Water Quality Guidelines (2018) refer to ‘natural background’ concentrations of contaminants when assessing water quality. As PFAS are not naturally occurring, there are no natural background concentrations of PFAS in the environment. To avoid confusion, the term background is not used further in this report.

To understand the ambient PFAS concentrations in the Queensland environment, the Queensland Government undertook a state-wide sampling program between May 2019 and March 2020, with water samples collected every two months at 55 sites covering the coast from the Wet Tropics to South East Queensland (SEQ). Sediment and biota were collected at a subset of sites in January 2020, and January and March 2020 respectively.

This report presents ambient PFAS data in three sections:

- Section 2 summarises published ambient data in Australia
- Section 3 reports on the Queensland Ambient Monitoring Program
- Section 4 summarises the grey literature for Queensland that was collected from investigations.

2 Summary of published ambient data in Australia

In Australia, a small but growing number of papers and reports summarising ambient concentrations of PFAS have been published (Thompson *et al.* 2011; Gallen *et al.* 2014; Munksgard *et al.* 2016; Allinson *et al.* 2019; Sardiña *et al.* 2019). Biota sampling for the purpose of assessing potential risk to human health has been fairly extensive in Australia (e.g. EPA New South Wales, 2020; EPA Victoria, 2020; Queensland Government, 2020a), but not for the purpose of assessing the risk to wildlife. The sampling undertaken for the Queensland Ambient Monitoring Program focused on potential risks to wildlife from the consumption of aquatic organisms. This entailed sampling of whole organisms rather than the edible portions (e.g. fish fillets) that are generally sampled for the purpose of protecting human health (Queensland Health 1994). Therefore, only studies that analysed whole organisms and eggs are summarised in this report.

Thompson *et al.* (2011) collected water, sediment and biota in the vicinity of Homebush Bay in New South Wales (NSW), which is in the upper reaches of the Parramatta River estuary that runs into Sydney Harbour. This estuary is surrounded by urban and industrial land use. PFOS was found to be the most dominant compound in water. PFOA and shorter chain PFAS (PFHxA, PFHpA, PFBS and PFHxS) were also reported at higher concentrations than other compounds (Table 1). In contrast, only PFUnDA and PFOS were reported in all sediment samples, PFDA was quantified (reported above the LOR) in 80% of sediment samples and PFOA, PFNA, PFTriDA, PFHxS, and PFDS were quantified in only 10-20% of sediment samples (Table 2). The long chain compounds PFDoDA, PFTriDA and PFOS were reported in oysters at all sites, with PFDoDA reported at the highest concentration (Table 3). PFUnDA was only quantified in oysters at one site, but was detected in oysters at all sites (Table 3).

PFAS were reported in the eggs of both Australian White Ibis and Silver Gull, with PFOS, PFHxS and PFDoDA being the dominant compounds in both species (Table 3). Thompson *et al.* (2011) found that the gull eggs were more contaminated than the ibis eggs around the Homebush Bay site in NSW, and attributed this to differing foraging habits, as the gull has a predominantly marine feeding pattern, whereas the ibis tends to feed from invertebrates in soil. In contrast, the ibis eggs at Mt Annan were the most contaminated and these birds were known to forage on a domestic waste tip (Thompson *et al.* 2011).

Gallen *et al.* (2014a) undertook PFAS sampling after a major flood in Brisbane in 2011. The authors found that PFOS and PFOA were the most commonly reported PFAS in waters during the flood, but that the shorter chain compounds PFHxA, PFHpA, PFBS and PFHxS were all commonly found in the urban areas (Table 1). It was suggested that flood waters may be an overlooked source of PFAS in the environment. The highest concentration of PFBS was reported in urban areas (0.030 µg/L). They also found that the mean total PFAS concentrations were at their highest in the downstream urban catchment areas.

Munksgaard *et al.* (2016) studied PFAS in sediment and biota in creeks around Darwin urban area and a reference area. They found concentrations of PFAS in sediment and biota to be higher in creeks around the Darwin urban area compared to the reference site nearby (Table 2 and Table 3), apart from PFAS in oysters and cockles, which were similar in both the urban and reference creeks (Table 3). In biota, PFOS was found at higher concentrations than other PFAS.

Allinson *et al.* (2019) undertook a snapshot survey of PFAS in two freshwater and five estuarine sites around Port Phillip Bay, Victoria, in September 2012. Of the 19 compounds in the analysis suite, results were reported for 18, with PFOS and PFHxS reported at higher concentrations than other PFAS at both freshwater and estuarine sites (Table 1), followed by PFOA and PFHxA.

Sardiña *et al.* (2019) looked at emerging and legacy contaminants, including PFAS, across a number of land-uses in Victoria. They found that in water, short and long chain length PFCAs and PFSAs were found in all water samples (Table 1), although the highest concentrations were found at residential and industrial sites. Detection frequencies were higher for short chain PFCAs, except for PFOA. Long chain PFSAs were also frequently reported, especially PFHxS and PFOS. In sediment, only long chain PFCAs and PFSAs, and 8:2 FTS were reported (Table 2). 8:2 FTS was found across a variety of land uses, whereas PFOS was primarily found at urban (residential and industrial) sites. They suggest the frequency and diversity of short chain compounds indicate that the effect of replacement PFAS are evident in Victorian waters.

A study on PFAS in the marine environment in the Adelaide area was conducted by the South Australia Environmental Protection Agency (Gaylard 2017). The main focus was the concentration of PFOS in dolphins; however, fish (liver and flesh) and water samples were also taken. The author found that PFOS, PFHxS and PFOA were the most commonly reported PFAS, and that PFNA, PFBA, PFPeA and 8:2 FTS were not reported in any samples. Only PFOS results were presented in the report (Table 1).

Table 1: Reported surface water concentrations (Australian studies) (µg/L). **Median**, **range**, average and frequency of detection (%) are reported where provided in literature.

	Queensland – Brisbane River Catchment[1]			NSW Parramatta River – Homebush Bay[2]	Victoria			South Australia – Adelaide[5]			
	Upstream dams (n=4)	Urban (n=14)	Moreton Bay (n=14)	Urban (n=20)	Freshwater[3] (n=2)	Estuarine[3] (n=5)	Urban and agricultural rivers and streams[4] (n=25)	Tidal creeks (n=6)	Outer harbour (n=17)	Port terminal (n=10)	Port river (n=12)
PFBA					**–** **0.0027-0.0088** 0.00058 100%	**0.0029** **0.0017-0.0111** 0.0057 100%	**–** **<LOR-0.07** 0.01 –				
PFPeA					**–** **0.0035-0.0097** 0.0066 100%	**0.0031** **0.0012-0.0097** 0.0045 100%	**–** **<LOR-0.04** 0.005 –				
PFHxA	**–** **0.00012-0.00017** **–** **100%**	**–** **0.0007-0.0062** **–** 100%	**–** **0.00006-0.00046** **–** 100%	**–** **0.0028-0.0032** 0.0029 100%	**–** **0.0024-0.0114** 0.0069 100%	**0.0021** **0.0015-0.0226** 0.0078 100%	**–** **<LOR-0.04** 0.006 –				
PFHpA	All <LOR	**–** **0.00031-0.0037** **–** 100%	**–** **<LOQ – 0.00024** **–** **43%**	**–** **0.0014-0.002** 0.0018 100%	**–** **0.0018-0.0060** 0.0039 100%	**0.0018** **0.0012-0.0089** 0.0041 100%	**–** **<LOR-0.03** 0.005 –				
PFOA	**–** **0.00027 – 0.00063** **–** 100%	**–** **0.00092-0.011** **–** 100%	**–** **0.00008-0.00066** **–** 100%	**–** **0.0042-0.0064** 0.0057 100%	**–** **0.0012-0.0145** 0.0079 100%	**0.0022** **0.0017-0.0092** 0.0048 100%	**–** **<LOR-0.02** 0.005 –				
PFNA	All <LOQ	**–** **<LOQ-0.0013** **–** 79%	<LOD-<LOQ	**–** **0.0006-0.002** 0.0012 100%	**–** **0.0001-0.0022** 0.0012 100%	**0.0012** **0.0002-0.0033** 0.0023 100%	**–** **<LOR-0.008** 0.001 –				
PFDA	**–** **<LOD-0.00012** **–** 25%	**<LOD-0.0012** **–** 64%	All <LOD	**–** **0.0008-0.0016** 0.0012 100%	**–** **0.0007-0.0042** 0.0025 100%	**0.0005** **0.0002-0.0017** 0.0008 100%	**–** **<LOR-0.005** 0.001 –				

	Queensland – Brisbane River Catchment[1]			NSW Parramatta River – Homebush Bay[2]	Victoria			South Australia – Adelaide[5]			
	Upstream dams (n=4)	Urban (n=14)	Moreton Bay (n=14)	Urban (n=20)	Freshwater[3] (n=2)	Estuarine[3] (n=5)	Urban and agricultural rivers and streams[4] (n=25)	Tidal creeks (n=6)	Outer harbour (n=17)	Port terminal (n=10)	Port river (n=12)
PFUnDA				– 0.0002- 0.0003 0.0002 100%	– 0.0002-0.0005 0.0004 100%	– 0.0002 0.0001-0.0011 0.0005 100%	– <LOR-0.01 0.001 –				
PFDoDA				– 0.0002- 0.0003 0.0002 100%	– 0.0001-0.0009 0.0005 100%	0.0002 <LOR-0.0011 0.0003 75%	<LOR				
PFTriDA				<LOD			<LOR				
PFTeDA				<LOD	– <LOR-0.0001 0.00005 50%	<LOR <LOR-0.0001 0.00003 (60%)	<LOR				
PFBS		– LOQ – 0.030 – 93%	NR	– 0.0012- 0.0015 0.0014 100%	– 0.0005-0.0026 0.0016 100%	0.0008 0.0004-0.0070 0.0031 100%	– <LOR-0.008 0.001 –				
PFPeS							– <LOR-0.006 0.0008 –				
PFHxS	– <LOD – 0.00013 – 50%	– 0.0017- 0.017 – 100%	– 0.0001- 0.0013 – 100%	– 0.0027- 0.0043 0.00037 100%	– 0.0029-0.0154 0.0092 100%	0.007 0.0030-0.0423 0.0172 100%	– <LOR-0.066 0.007 –				
PFHpS							– <LOR-0.002 0.0006 –				

	Queensland – Brisbane River Catchment[1]			NSW Parramatta River – Homebush Bay[2]	Victoria			South Australia – Adelaide[5]			
	Upstream dams (n=4)	Urban (n=14)	Moreton Bay (n=14)	Urban (n=20)	Freshwater[3] (n=2)	Estuarine[3] (n=5)	Urban and agricultural rivers and streams[4] (n=25)	Tidal creeks (n=6)	Outer harbour (n=17)	Port terminal (n=10)	Port river (n=12)
PFOS	**–** **<LOQ – 0.00020** **–** **50%**	**–** **<LOQ – 0.034** **–** **93%**	**–** **<LOQ – 0.0053** **–** **86%**	**–** **0.0075-0.021** 0.014 100%	**–** **0.0065-0.0452** 0.0259 100%	**0.0139** **0.0039-0.0749** 0.0343 (100%)	**–** **<LOR-0.1** 0.01 **–**	**–** **0.0037-0.010** **–** **–**	**–** **<LOR-0.0035** **–** **–**	**–** **0.0042-0.0082** **–** **–**	**–** **0.0015-0.0046** **–** **–**
PFDS				<LOD	**–** **<LOR-0.0001** 0.00005 50%	**0.001** **<LOR-0.0001** 0.00005 (80**%)**	<LOR				
6:2 FTS							**–** **<LOR-0.003** 0.0006 **–**				
10:2 FTS							**–** **<LOR-0.001** 0.0006 **–**				
FOSA					**–** **<LOR-0.001** 0.0005 50%	**0.0001** **<LOR-0.0003** 0.0001 75%					
N-EtFOSA					<LOD	<LOD	**–** **<LOR-0.008** 0.001 **–**				
N-EtFOSAA					**–** **0.0001-0.0019** 0.001 100%	**0.0003** **0.0002-0.0015** 0.0045 100%					

[1] Gallen *et al.* 2014; [2] Thompson, et.al., 2011; [3] Allinson *et al.* 2019; [4] Sardiña *et al.* 2019; [5] Gaylard 2017

LOD: limit of detection – the lowest concentration of an analytical parameter in a sample that can be detected, but not necessarily quantified (NATA 2018)

LOR: limit of reporting – the lowest concentration of an analytical parameter that can be determined with acceptable precision and accuracy (NATA 2018)

LOQ: level of quantitation – see LOR

NR: Analyte was included in analysis suite, but not reported.

Blank cells: Analyte not included in analysis suite.

Table 2: Sediment concentrations (mg/kg dry weight) reported in Australian studies. **Median**, **range**, average and frequency of detection (%) are reported where provided in the literature.

Location	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnDA	PFDoDA	PFTriDA	PFTeDA	PFBS	PFHxS	PFOS	PFDS	8:2 FTS
Northern Territory – Darwin Creeks[1]																
Urban (n=12)	**0.00016** **<LOR–0.00042** 0.00017 67%	**0.00004** **<LOR–0.00031** 0.00007 25%	**0.00003** **<LOR–0.00065** 0.00013 42%	**0.00002** **<LOR–0.00023** 0.00004 33%	**0.00011** **0.00005–0.00084** 0.00019 100%	**0.00003** **<LOR–0.0011** 0.00014 33%	**0.00002** **<LOR–0.00028** 0.00005 75%	**0.00004** **<LOR–0.00019** 0.00006 25%	**0.00005** **<LOR–0.00054** 0.00017 50%	NR	NR	**0.00005** **<LOR–0.00009** 0.00005 8%	**0.00013** **<LOR–0.0018** 0.00040 50%	**0.00185** **0.00026–0.028** 0.00577 100%	All <LOR	NR
Reference creek (n=3)	All <LOR	All <LOR	All <LOR	All <LOR	**0.00004** **0.00004–0.00005** 0.00004 100%	All <LOR	All <LOR	All <LOR	All <LOR	NR	NR	All <LOR	All <LOR	**0.00009** **0.00004–0.0001** 0.00008 100%	All <LOR	NR
New South Wales – Homebush Bay, Parramatta River (Sydney) [2]																
Urban (n=10)	NR	NR	<LOD	<LOQ	**–** **<LOQ-0.00016** 0.00003 20%	**–** **<0.000010-0.000011** 0.00004 10%	**–** **<LOD-0.00081** 0.00026 80%	**–** **0.00010-0.00061** 0.00022 100%	**–** **<0.0001-0.00027** 0.00007 20%	**–** **<0.0001-0.00027** 0.00007 20%	<LOD	<LOD	**–** **<0.0001-0.0001** 0.00004 20%	**–** **0.0008-0.0062** 0.0021 100%	**–** **<0.00010-0.0002** 0.00006 20%	
Victoria[3]																
Urban and agricultural rivers and streams (n=25)	<LOR	<LOR	<LOR	<LOR	<LOR	**–** **<LOR – 0.0053** 0.00069 **–**	<LOR	**–** **<LOR-0.0034** 0.0011 **–**	<LOR	<LOR	<LOR	<LOR	**–** **<LOR – 0.0015** 0.00054 **–**	**–** **<LOR-0.004** 0.00131 **–**	<LOR	**–** **<LOR-0.0079** 0.069 **–**

[1] Munksgaard *et al.* 2016; [2] Thompson, et.al., 2011; [3] Sardiña *et al.* 2019

LOD: limit of detection – the lowest concentration of an analytical parameter in a sample that can be detected, but not necessarily quantified (NATA 2018)

LOR: limit of reporting – the lowest concentration of an analytical parameter that can be determined with acceptable precision and accuracy (NATA 2018)

LOQ: level of quantitation – see LOR

NR: Analyte was included in analysis suite, but not reported

Table 3: Whole biota for ecological assessment reported in Australian studies (mg/kg wet weight). **Median, range**, average and frequency of detection (%) are reported where provided in the literature.

Location type and sample type.	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnDA	PFDoDA	PFTriDA	PFTeDA	PFBS	PFHxS	PFOS	PFDS
Northern Territory – Darwin Creeks[1]															
Urban Gastropods (n=36)	**0.00052** **0.00014–0.0017** 0.00072 100%	**0.00004** **<LOR–0.00026** 0.00007 28%	**0.00003** **<LOR–0.00069** 0.00009 11%	**0.00014** **<LOR–0.0033** 0.00047 58%	**0.00235** **0.00015–0.047** 0.00529 100%	**0.00055** **<LOR–0.0041** 0.00109 62%	**0.00001** **<LOR–0.00045** 0.00007 33%	**0.00004** **<LOR–0.00017** 0.00006 25%	**0.000025** **<LOR–0.00083** 0.00009 14%	NR	NR	**0.00005** **<LOR–0.00023** 0.00006 11%	**0.00025** **<LOR–0.0048** 0.00106 72%	**0.00285** **0.00017–0.035** 0.00684 100%	All <LOR
Urban Bivalves (n=3)	All <LOR	All <LOR	All <LOR	All <LOR	All <LOR	All <LOR	All <LOR	All <LOR	All <LOR	NR	NR	All <LOR	All <LOR	**0.00013** **0.00008–0.00028** 0.00016 100%	All <LOR
Reference creek Gastropods (n=10)	**0.00023** **<LOR–0.00058** 0.00024 80%	All <LOR	All <LOR	**0.00002** **<LOR–0.00022** 0.00002 20%	**0.00002** **0.00006–0.00073** 0.00021 100%	**0.00004** **<LOR–0.00037** 0.00008 20%	All <LOR	All <LOR	All <LOR	NR	NR	All <LOR	All <LOR	**0.00002** **<LOR–0.00008** 0.00003 20%	All <LOR
Reference creek Bivalves (n=5)	**0.00005** **<LOR–0.00054** 0.00017 40%	All <LOR	All <LOR	**0.00002** **<LOR–0.00003** 0.00002 20%	**0.00002** **<LOR–0.00006** 0.00003 20%	All <LOR	All <LOR	All <LOR	All <LOR	NR	NR	All <LOR	All <LOR	All <LOR	All <LOR
New South Wales – Homebush Bay, Parramatta River (Sydney)[2]															
Urban Industrial – Oysters Soft tissue (n=10)	NR	NR	<LOD	<LOD	LOQ	<LOD	**–** **<0.0006-0.0007** 0.00033 30%	**–** **<0.0007-0.0008** 0.0004 20%	**–** **0.0012-0.0058** 0.003 100%	**–** **<0.0006-0.0011** 0.00072 70%	<LOQ	<LOD	<LOD	**–** **0.0006-0.0023** 0.0012 100%	<LOQ

Location type and sample type.		**PFBA**	**PFPeA**	**PFHxA**	**PFHpA**	**PFOA**	**PFNA**	**PFDA**	**PFUnDA**	**PFDoDA**	**PFTriDA**	**PFTeDA**	**PFBS**	**PFHxS**	**PFOS**	**PFDS**
	Silver Gull Eggs (n=8)	NR	NR	<LOQ	<LOQ	**–** **<0.0006-0.0026** 0.0011 50%	**–** **<0.0009-0.0022** 0.00088 38%	**–** **0.0014-0.0049** 0.0025 100%	**–** **0.0017-0.0028** 0.0022 100%	**–** **0.0024-0.011** 0.0066 100%	**–** **0.0007-0.035** 0.0024 100%	**–** **<0.0006-0.0037** 0.0012 75%	<LOD	**–** **0.00012-0.0068** 0.0032 100%	**–** **0.019-0.085** 0.039 100%	**–** **<0.0006-0.0029** 0.00095 75%
	Australian White Ibis. Mt Annan Eggs (n=10)	NR	NR	<LOD	<LOD	<LOQ	<LOQ	<LOQ	**–** **<0.0007-0.0007** 0.00024 17%	**–** **<LOQ-0.0016** 0.00053 33%	**–** **<LOQ-0.0007** 0.00015 17%	<LOQ	<LOD	**–** **<0.0005-0.0016** 0.0011 83%	**–** **0.012-0.082** 0.030 100%	<LOD
	Australian White Ibis. Homebush Eggs.	NR	NR	<LOD	<LOQ	**–** **<0.006-0.008** 0.0004 10%	**–** **<0.0009-0.0009** 0.0005 40%	**–** **0.0009-0.0032** 0.0018 100%	**–** **<0.0007-0.0012** 0.00065 60%	**–** **0.0013-0.0043** 0.0031 100%	**–** **<0.0005-0.0008** 0.00029 20%	**–** **<LOQ-0.0007** 0.00022 20%	<LOD	**–** **0.0006-0.0068** 0.0024 100%	**–** **0.013-0.114** 0.053 100%	**–** **<LOQ-0.0006** 0.00012 10%

[1] Munksgaard, Lambrinidis, Gibb, Jackson, Grant, Braeunig and Mueller, 2016; [2] Thompson, Eaglesham and Mueller, 2011

LOD: limit of detection – the lowest concentration of an analytical parameter in a sample that can be detected, but not necessarily quantified (NATA 2018)

LOR: limit of reporting – the lowest concentration of an analytical parameter that can be determined with acceptable precision and accuracy (NATA 2018)

LOQ: level of quantitation – see LOR

NR: Analyte was included in analysis suite, but not reported

3 Queensland Ambient Monitoring Program

3.1 Sample collection

Surface water samples were collected at 55 sites across five regions within Queensland (Section 3.3), every two months for one year. The first monitoring round was undertaken in May 2019 and last was undertaken in March 2020. At estuarine sites, samples were collected on an outgoing tide. Samples were taken in accordance with guidance in the Queensland Monitoring and Sampling Manual (2018; available at https://environment.des.qld.gov.au/water/monitoring/sampling-manual/), and in accordance with PFAS sampling protocols provided by CRC Care (CRC CARE, n.d.) and sampling protocols provided by the Western Australian Department of Environment Regulation 2016.

Particular emphasis was placed on reducing possibilities of cross-contamination during the sampling from sources such as clothing, food wrappers, detergents, markers, sunscreens, and insect repellents. Sample bottles, bags, transport blanks and rinsate waters were provided by the testing laboratory. In order to minimise contamination, new eskies were purchased for PFAS samples, and bottles were double bagged (before and after sampling). Samples were stored in a ‘PFAS Only’ freezer (surface water, biota), or a ‘PFAS Only’ fridge (sediment) until transport to the laboratory for analysis.

Field blanks and transport blanks were also collected by each sampling team. Duplicate samples were taken to check for intra-lab and inter-lab comparisons. Duplicate samples were only used as a quality check and have not been reported. Quality control results and criteria are detailed in Appendix A.

Surface water samples were collected for the total oxidisable precursor (TOP) assay at 25 of the 55 sites in November 2019 (Tables 4–8). These 25 were chosen as sites where PFOS had been reported in the previous three sampling rounds. TOP Assay is an analytical method used to indirectly measure PFAS precursor in a sample. Of the 4,730 compounds categorised as PFAS (OECD, 2018), only 28 to 30 compounds are routinely reported in Australia. This means many other compounds may be present but not included in the analysis suites, and therefore, they are considered ‘unseen’ PFAS. TOP Assay uses a strong oxidation process to convert precursor PFAS to end-point PFAS compounds (such as PFOS, PFOA and shorter chained PFCAs). This allows assessment of the presence of ‘unseen’ PFAS.

Sediment samples were collected and analysed for PFAS at 26 of the 55 sampling sites in January 2020 (Tables 4-8). These 26 were chosen as the sites with the highest reported concentrations of PFAS in water. Sediment samples were taken from the banks near the water sample collection site. For each site, five individual samples approximately 10 m apart were collected from the top 10 cm of sediment using a stainless-steel spoon and homogenised to form a composite sample prior to placing in laboratory-supplied jars. Some sites had no accessible sediment banks (e.g. deep water with rocks), and at these sites a Van Veen Grab was used to collect the composite samples from the bottom sediments.

Biota samples were collected at 11 locations on nine waterways (Tables 6,9,11,14) during the January and March 2020 monitoring rounds. Sites were selected where the highest concentrations of PFAS had been reported in previous rounds. These were Vines Creek in Mackay Whitsundays, Caboolture River, Brisbane River (at Indooroopilly), Oxley Creek, Tingalpa Creek and Logan River. Biota samples from two extra sites on the Brisbane River were also analysed – Brisbane River at Karana Downs and Brisbane River at Yeronga. Opportunistic sampling was also undertaken at sites in the Fitzroy, Burnett and Burrum rivers. Biota samples were collected using lines, gill nets, and crab pots. The biota samples were analysed as whole samples. Whole fish were blended, and subsamples of the whole blend were analysed. The skull bones of fork-tailed catfish were not blended due to the very hard material. For this species, the tissue was scraped from the skull and added to the blended material of the samples. Very small specimens were composited to meet the minimum weight required for analysis by the laboratory. In total, 137 samples from

23 species were analysed. These included 16 species of fish and seven species of invertebrates. A summary of type and number of species is presented in Appendix B.

3.2 Sample analysis

Water samples were analysed by Eurofins, Brisbane, with inter-laboratory duplicates sent to be analysed by Australian Laboratory Services (ALS), Brisbane. Sediment and biota samples were analysed by Queensland Health, Brisbane. These laboratories are accredited by the National Association of Testing Authorities (NATA). Analytes reported by each laboratory and the limit of reporting for each matrix are summarised in Appendix C. For this report, where a compound has been referred to as 'reported', it means that the laboratory has reported it above the respective LOR (see Glossary).

3.3 Sites sampled, results and discussion

A total of 55 sampling locations were chosen based on three criteria:

1. Sites to be one of the long-term state monitoring sites from the Ecosystem Health Monitoring Program (EHMP) and South East Queensland Loads Monitoring Program (SEQ Loads).
2. Sites were at least 1 km from potential point sources of PFAS (e.g. airports, fire stations, etc) as recommended in the Stockholm Convention Guidance on the global monitoring plan for persistent organic pollutants (Stockholm Convention, 2015). Major known point sources were mapped as part of the selection process.
3. Sites were selected to represent adjacent major land use classes across the state. These are conservation, forestry/grazing, agricultural (dryland and irrigated), intensive uses (urban/industrial), and water.

Some larger rivers were allocated up to three sampling sites to get a better representation of the river system. The sampling locations for this report are grouped by the following Natural Resource Management (NRM) regions (Figure 1):

- Wet Tropics—6 sites
- Mackay Whitsunday—7 sites
- Fitzroy—5 sites
- Burnett Mary—13 sites
- South East Queensland (SEQ)—24 sites.

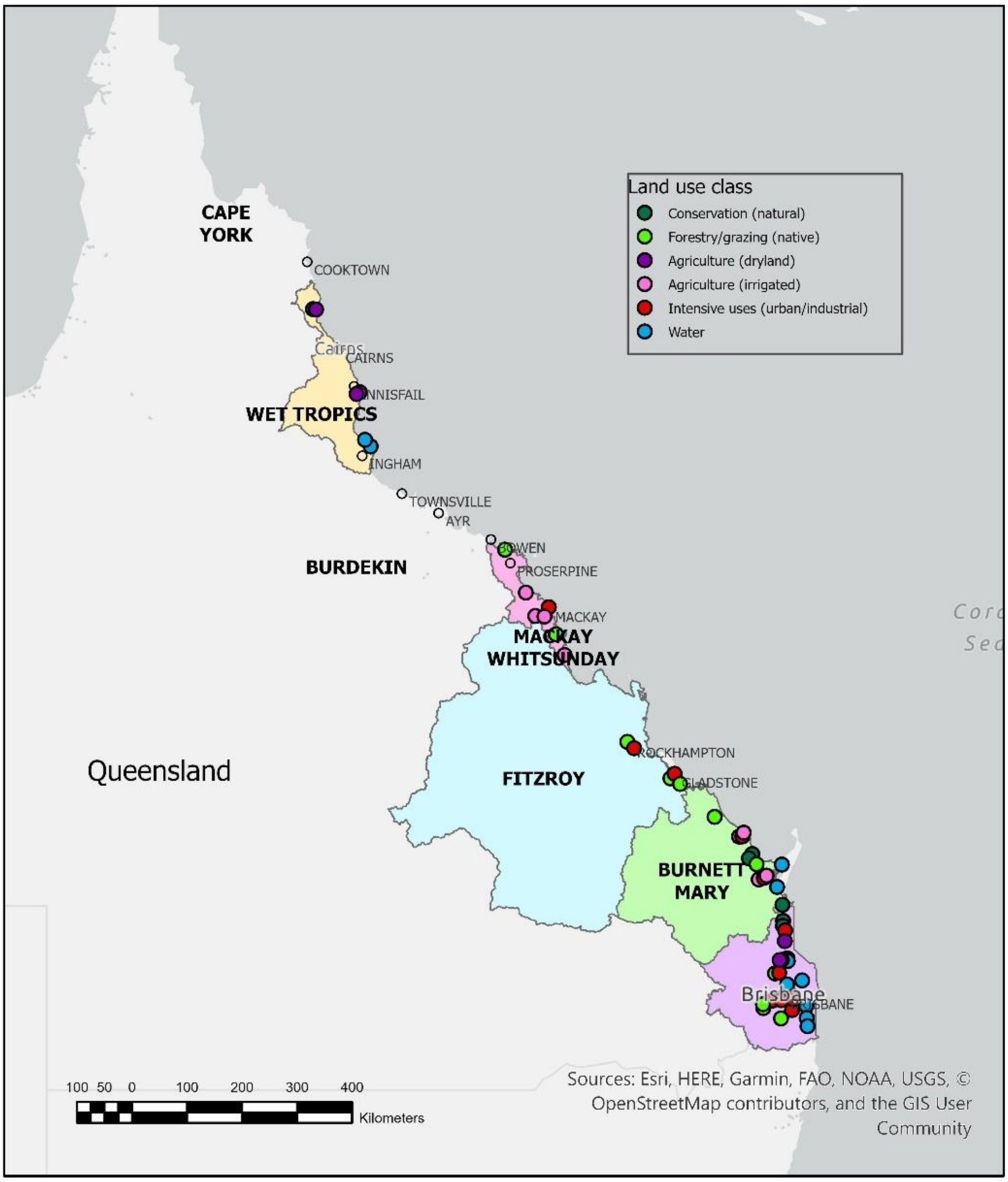

Figure 1: Map of ambient sampling locations within the five NRM regions.

3.3.1 Wet Tropics region

3.3.1.1 Site details

The Wet Tropics region lies between Townsville and Cape Melville and includes large areas that are within the UNESCO World Heritage area. This region features tropical rainforests and includes large areas of national parks, nature refuges and conservation areas. There are seven sub-basins in this region: Daintree, Barron, Herbert, Mulgrave–Russell, Johnstone, Tully, and Murray. The annual rainfall is approximately 2,000 mm, mostly falling from November to April. Cyclones also affect this part of the Wet Tropics, often causing flooding in the region. The population for this region is about 240,000 (Tropics Healthy Waterways Partnership, 2020). The sampling locations (Figure 2, Table 4) include the following waterways:

- **Daintree River** (Two sites)—mainly freshwater river that flows about 140 km through mountain ranges and rainforest. The upstream site is close to conservation areas while the downstream site is bordered by agricultural land.

- **Moresby River** (One site)—the top of the catchment is heavily surrounded by agriculture land (dryland) and is bordered by mangroves towards the mouth. Aquaculture is present in the river.
- **Armit Creek** (One site)—is a small estuarine tributary of the Moresby River – near the mouth. Agricultural land (dryland) is present at the top of the catchment.
- **Hinchinbrook Channel** (Two sites)—this channel is bordered by mangrove forests between mainland Australia and Hinchinbrook Island National Park.

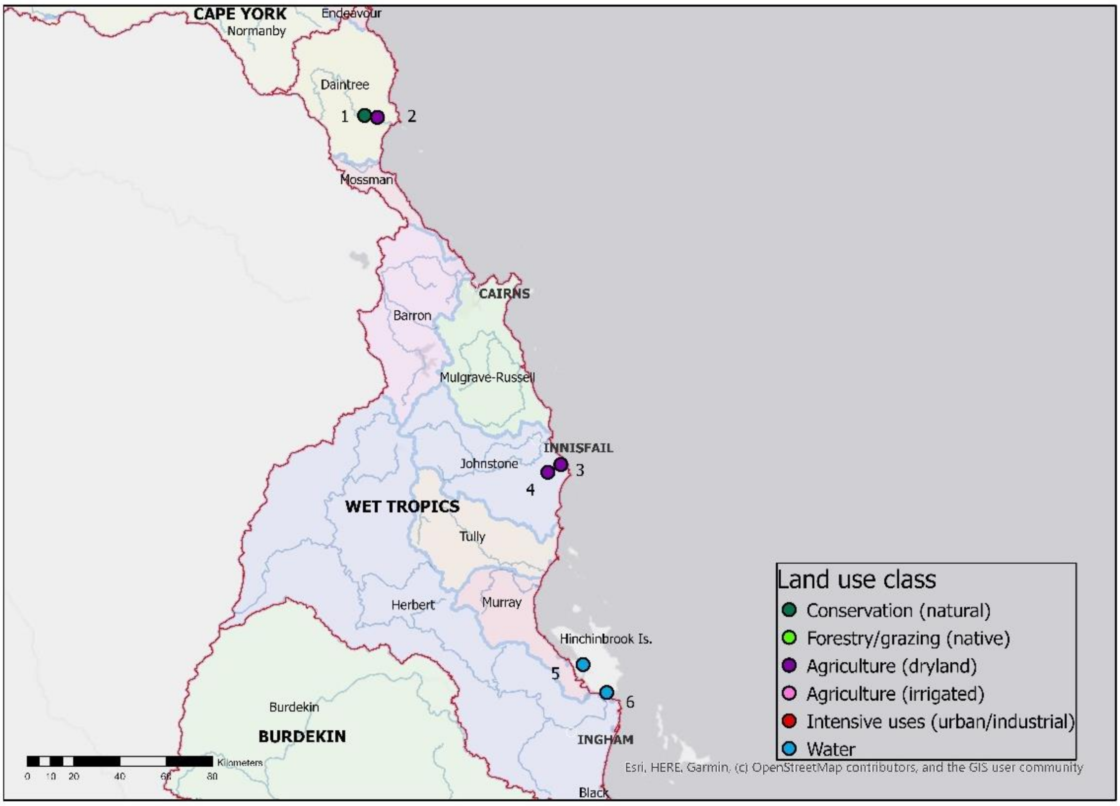

Figure 2: Map of ambient sampling locations within the Wet Tropics region.

Table 4: Ambient sampling locations and samples collected within the Wet Tropics region.

Sampling location	Latitude	Longitude	Water Type[1]	Land Use[2]	Samples	Map Reference
Daintree River (Kimberley)	-16.2517	145.34806	Middle estuary	Conservation (natural)	Water (including TOP Assay), sediment	1
Daintree River (Daintree)	-16.2592	145.39806	Middle estuary	Agriculture (dryland)	Water	2
Armit Creek	-17.6081	146.11089	Middle estuary	Agriculture (dryland)	Water	3
Moresby River	-17.6382	146.06025	Middle estuary	Agriculture (dryland)	Water	4
Hinchinbrook Channel (Northern end)	-18.3856	146.19694	Enclosed coastal waters	Water	Water	5
Hinchinbrook Channel (Southern end)	-18.4942	146.28889	Enclosed coastal waters	Water	Water	6

[1] Water type as described in the Environmental Protection (Water and Wetland Biodiversity) Policy 2019.
[2] Dominant adjacent land use class as designated by ALUMC (https://www.agriculture.gov.au/abares/aclump/land-use/alum-classification).

3.3.1.2 Results and discussion

Overall, there were no or very low concentrations (Table 5) of PFAS reported from the six sites in the Wet Tropics. None of the sites are in intensive land use areas. Only PFOS was reported at or just above the LOR in at least one monitoring round at every sampling location (Figure 3, Table 5). The highest PFOS concentration was reported at the northern end of the Hinchinbrook Channel in September 2019 (Figure 3) at 0.0004 µg/L (Table 5). The only other PFAS reported from this region was PFUnDA in one water sample from the northern end of the Hinchinbrook Channel at 0.002 µg/L (Table 5). The concentrations of PFOS and other PFAS in the Wet Tropics were too low to discern whether there were any seasonal trends.

TOP Assay was undertaken on a water sample collected from the Daintree River (Kimberley) sampling location. No PFAS were reported above the LOR, indicating that no precursors were present above the LOR. Sediment was also collected at this site and the reported concentrations for PFAS were below the LOR (0.001 mg/kg). No biota samples were collected in the Wet Tropics region.

Table 5: PFAS concentrations (µg/L) in water samples collected in the Wet Tropics. **Median**, **range**, geometric average and frequency of detection are reported (%). In cases where concentrations were below the LOR, half the LOR was used for the calculation of the geometric average and median values.

Wet Tropics	PFUnDA (LOR=0.001)	PFOS (LOR=0.0001)
Daintree River (Kimberley) (n=6)	<LOR	**0.0001, <LOR–0.0001** 0.0001 (17%)
Daintree River (Daintree) (n=6)	<LOR	**0.0001, <LOR–0.0001** 0.0001 (17%)
Armit Creek (n=6)	<LOR	**0.0001, <LOR–0.0001** 0.0001 (17%)
Moresby River (n=6)	<LOR	**0.0001, <LOR–0.0002** 0.0001 (33%)
Hinchinbrook Channel (Northern end) (n=6)	**0.0005, <LOR–0.002** 0.0006 (17%)	**0.0001, <LOR–0.0004** 0.0001 (17%)
Hinchinbrook Channel (Southern end) (n=5)	<LOR	**0.0001, <LOR–0.0001** 0.0001 (20%)

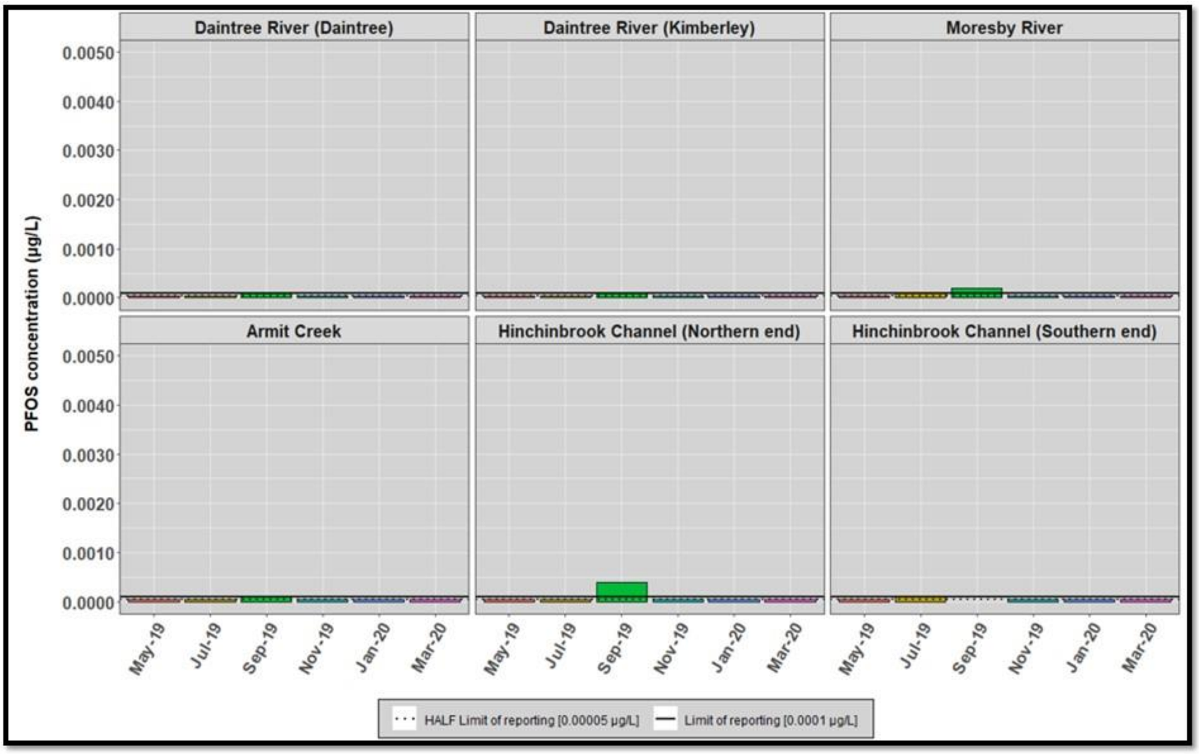

Figure 3: Reported concentrations of PFOS in the Wet Tropics region over the six monitoring rounds (May 2019–March 2020). Note: no bar indicates sample not collected

3.3.2 Mackay Whitsunday region

3.3.2.1 Site details

The Mackay Whitsunday region encompasses three local government areas (Isaac, Mackay, and Whitsunday) and lies between Bowen in the north and the Styx River in the south. The main land uses are grazing and conservation. This area has four major coastal sub-basins including Proserpine, O'Connell, Pioneer, and Plane. The climate is tropical, with cyclones, usually between December and April, which can result in heavy rain and flooding. The annual rainfall is about 1,500 mm. The population is about 170,000 (Australian Bureau of Statistics 2020). The sampling locations (Figure 4, Table 6) include the following waterways:

- **Gregory River** (One site)—the catchment starts at Dryander National Park flowing through grazing land before entering Edgecumbe Bay.
- **St Helens Creek** (One site)—runs from Eungella National Park, through agriculture land (irrigated) and out to St Helen Bay.
- **Vines Creek** (One site)—this small estuary creek is surrounded by intensive land use (urban/industrial) near the mouth of Pioneer River.
- **Sandy Creek** (Two sites)—the top of the catchment starts near a state forest before entering agriculture land (irrigated) and exiting the mouth near Sandringham Bay Conservation Park.
- **Rocky Dam Creek** (One site)—a number of tributaries contribute to Rocky Dam Creek from the top of the catchment. This area is surrounded by forestry and grazing land before entering Llewellyn Bay.
- **Carmila Creek** (One site)—the top of the catchment is bordered by state forest before flowing towards agriculture land (irrigated) and on to the mouth.

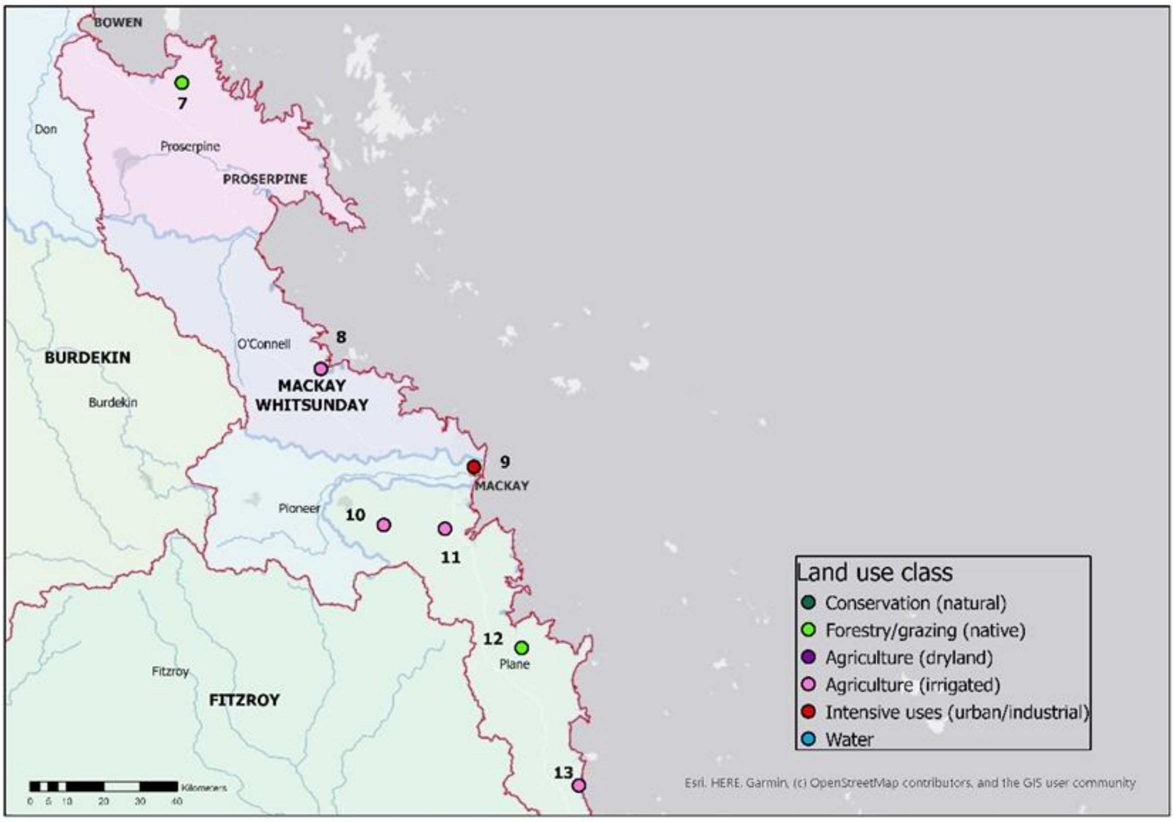

Figure 4: Map of ambient sampling locations within the Mackay Whitsunday region.

Table 6: Ambient sampling locations and samples collected within the Mackay Whitsunday region.

Sampling location	Latitude	Longitude	Water Type[1]	Land Use[2]	Samples	Map Reference
Gregory River (Cape Gloucester)	-20.1804	148.48233	Middle estuary	Forestry/ grazing (native)	Water	7
St Helens Creek	-20.8803	148.82265	Middle estuary	Agriculture (irrigated)	Water	8
Vines Creek (Mackay)	-21.1200	149.19736	Middle estuary	Intensive uses (urban/industrial)	Water (including TOP Assay), sediment, biota	9
Sandy Creek (Eton)	-21.2620	148.97667	Pioneer River and Plane Creek basins fresh waters	Agriculture (irrigated)	Water	10
Sandy Creek (Sandiford)	-21.2712	149.1266	Middle estuary	Agriculture (irrigated)	Water	11
Rocky Dam Creek	-21.5628	149.31455	Middle estuary	Forestry/ grazing (native)	Water	12
Carmila Creek	-21.8990	149.45466	Middle estuary	Agriculture (irrigated)	Water	13

[1] Water type as described in the Environmental Protection (Water and Wetland Biodiversity) Policy 2019
[2] Dominant adjacent land use class as designated by ALUMC (https://www.agriculture.gov.au/abares/aclump/land-use/alum-classification)

3.3.2.2 Results and discussion

Very few PFAS were reported in the Mackay Whitsunday region. Of the seven sites sampled, no PFAS were reported in any samples collected at the Gregory River, St Helens Creek, Rocky Dam Creek or Carmila Creek (Table 7). At the other three sites (Vines Creek, Sandy Creek at Eton and Sandy Creek at Sandiford), PFOS was reported most frequently (Table 7). PFOS was reported at or above the LOR in five of the six monitoring rounds in Vines Creek, in three monitoring rounds at Sandy Creek (Eton) and in and one monitoring round at Sandy Creek (Sandiford) (Figure 5). The highest PFOS concentration was reported at Vines Creek (0.0047 µg/L), which is next to an industrial area, whereas the PFOS concentrations at the two Sandy Creek sites (Eton and Sandiford) were 10 times lower at 0.0004 µg/L and 0.0006 µg/L, respectively) (Table 7).

A seasonal trend was apparent at Vines Creek, with water samples having higher PFOS concentrations in the months following rainfall (May 2019, January and March 2020) than the drier months of July, September and November (Figure 5, Figure 6). This may indicate that runoff from adjacent contaminated industrial areas (either through surface erosion or discharge through groundwater) are responsible for the pattern.

Other PFAS reported just above the LOR in the Mackay Whitsunday region (Table 7) were PFHxA, PFOA and PFHxS from Vines Creek, which were all reported in 50% of samples but at lower concentrations than PFOS, and PFBS from Sandy Creek (Sandiford) (Table 7).

TOP Assay was undertaken on water samples collected from Vines Creek. All results were below the LOR indicating no precursor PFAS were present above the LOR. A sediment sample was also collected at Vines Creek and all PFAS was reported at concentrations below the LOR (0.001 mg/kg).

Six species of fish and two of invertebrates were collected in Vines Creek (Table 8). PFOS was the only compound reported above the LOR, and was present in five of the six fish species sampled and in all the prawn samples (Table 8). Sea mullet (n=5, max: 0.003 mg/kg, geometric average: 0.0019 mg/kg) had the highest concentration of PFOS, while no PFOS was reported above the LOR in whiting and oyster samples.

Table 7: PFAS concentrations (µg/L) in water samples collected in the Mackay Whitsunday region. **Median**, **range**, geometric average and frequency of detection are reported. In cases where concentrations were below the LOR, half the LOR was used for the calculation of the geometric average and median values.

Mackay Whitsunday	PFHxA (LOR=0.001)	PFOA (LOR=0.001)	PFBS (LOR=0.001)	PFHxS (LOR=0.001)	PFOS (LOR=0.0001)
Gregory River (Cape Gloucester) (n=6)	<LOR	<LOR	<LOR	<LOR	<LOR
St Helens Creek (n=6)	<LOR	<LOR	<LOR	<LOR	<LOR
Vines Creek (n=6)	**0.0008** **<LOR–0.002** 0.0008 50%	**0.0008** **<LOR–0.002** 0.0008 50%	<LOR	**0.0008** **<LOR–0.001** 0.0007 50%	**0.0022** **<LOR–0.0047** 0.001 83%
Sandy Creek (Eton) (n=6)	<LOR	<LOR	<LOR	<LOR	**0.0001** **<LOR–0.0004** 0.0001 50%
Sandy Creek (Sandiford) (n=6)	<LOR	<LOR	**0.0005** **<LOR–0.001** 0.0006 17%	<LOR	**0.0001** **<LOR–0.0006** 0.0001 33%
Rocky Dam Creek (n=6)	<LOR	<LOR	<LOR	<LOR	<LOR
Carmila Creek (n=6)	<LOR	<LOR	<LOR	<LOR	<LOR

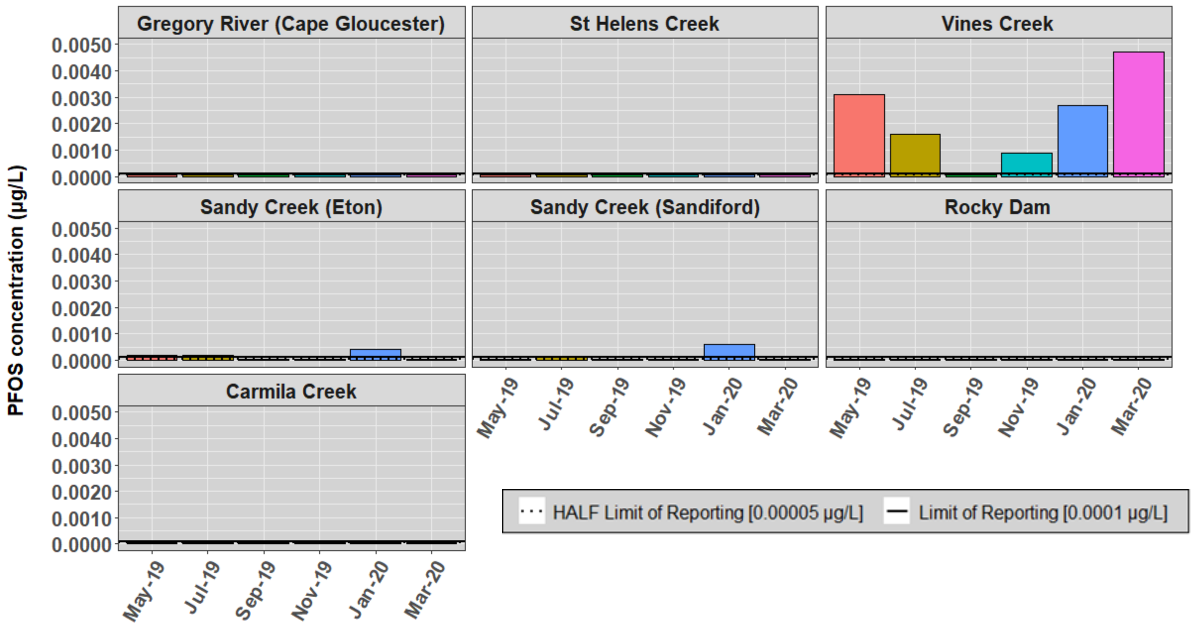

Figure 5: Reported concentrations of PFOS in the Mackay Whitsunday region over the six monitoring rounds (May 2019–March 2020).

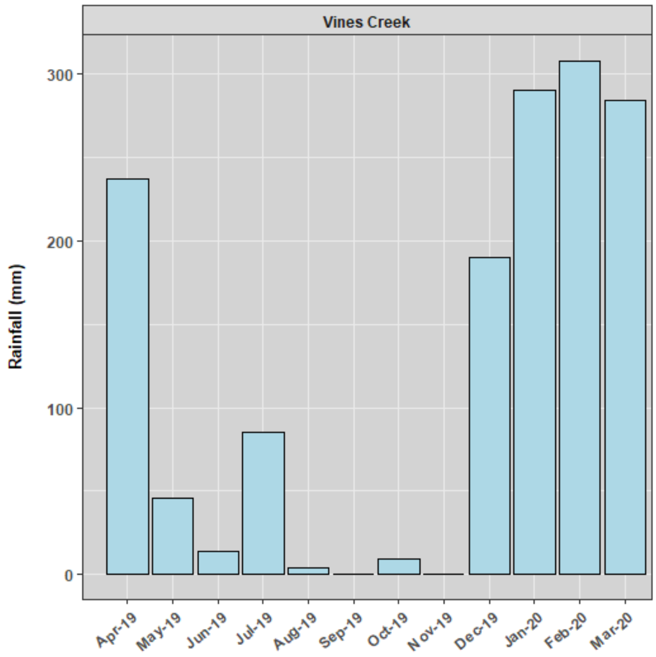

Figure 6: Rainfall by month in the Mackay Whitsunday region (April 2019−March 2020).

Table 8: PFOS concentrations (mg/kg ww) in biota samples collected in Vines Creek. **Range**, geometric average, and frequency of detection (%) are reported. In cases where concentrations were below the LOR, half the LOR was used for the calculation of the geometric average values. The LOR for PFOS was 0.001 mg/kg (adjusted to 0.0009 mg/kg in some instances).

PFAS	PFOS (LOR=0.0009–0.001)
Fish	
Yellowfin bream (n=5)	**<LOR–0.001** 0.0006 (20%)
Sea mullet (n=5)	**0.001–0.003** 0.0019 (100%)
Ponyfish (n=5)	**<LOR–0.003** 0.0014 (80%)
Silverbiddy (n=5)	**LOR–0.003** 0.0009 (40%)
Southern Herring (n=5)	**<LOR–0.001** 0.0007 (60%)
Whiting (n=5)	<LOR
Invertebrates	
Macrobrachium (n=5)	**0.001–0.002** 0.0013 (100%)
Oyster (n=1)	<LOR

3.3.3 Fitzroy region

3.3.3.1 Site details

The Fitzroy region encompasses more than 155,000 square kilometres between the Styx River and Gladstone, and includes seven major sub-basins: Isaac River, Theresa Creek, Nogoa River, Comet River, Mackenzie River, Dawson River and Fitzroy River. A large proportion of this region’s land use is grazing and extractive operations. The region experiences high rainfall during summer (about 700 mm annually) and dry periods in winter. The population is about 230,000 (Fitzroy Basin Association 2020). The sampling locations (Figure 7, Table 9) include the following waterways:

- **Fitzroy River** (Two sites)—the catchment begins at the Expedition and Carnarvon Range before forming into two large tributaries (Mackenzie and Dawson). The Fitzroy River starts near the small town of Duaringa, flowing near a national park and a state forest before entering the city of Rockhampton. One site is upstream of the barrage at Rockhampton and is freshwater. The second is downstream of Rockhampton and is surrounded by intensive urban and industrial areas. The Fitzroy catchment is predominantly a grazing catchment.
- **Auckland Creek** (One site)—this is the main creek in Gladstone, which is surrounded by intensive urban and industrial areas before exiting the mouth into Port Curtis.
- **Calliope River** (One site)—top of the catchment starts near a state forest before continuing 80 km towards Gladstone.
- **Boyne River** (One site)—main watercourse from Awoonga Dam that flows about 22 km downstream towards the mouth and is bordered by forestry and grazing.

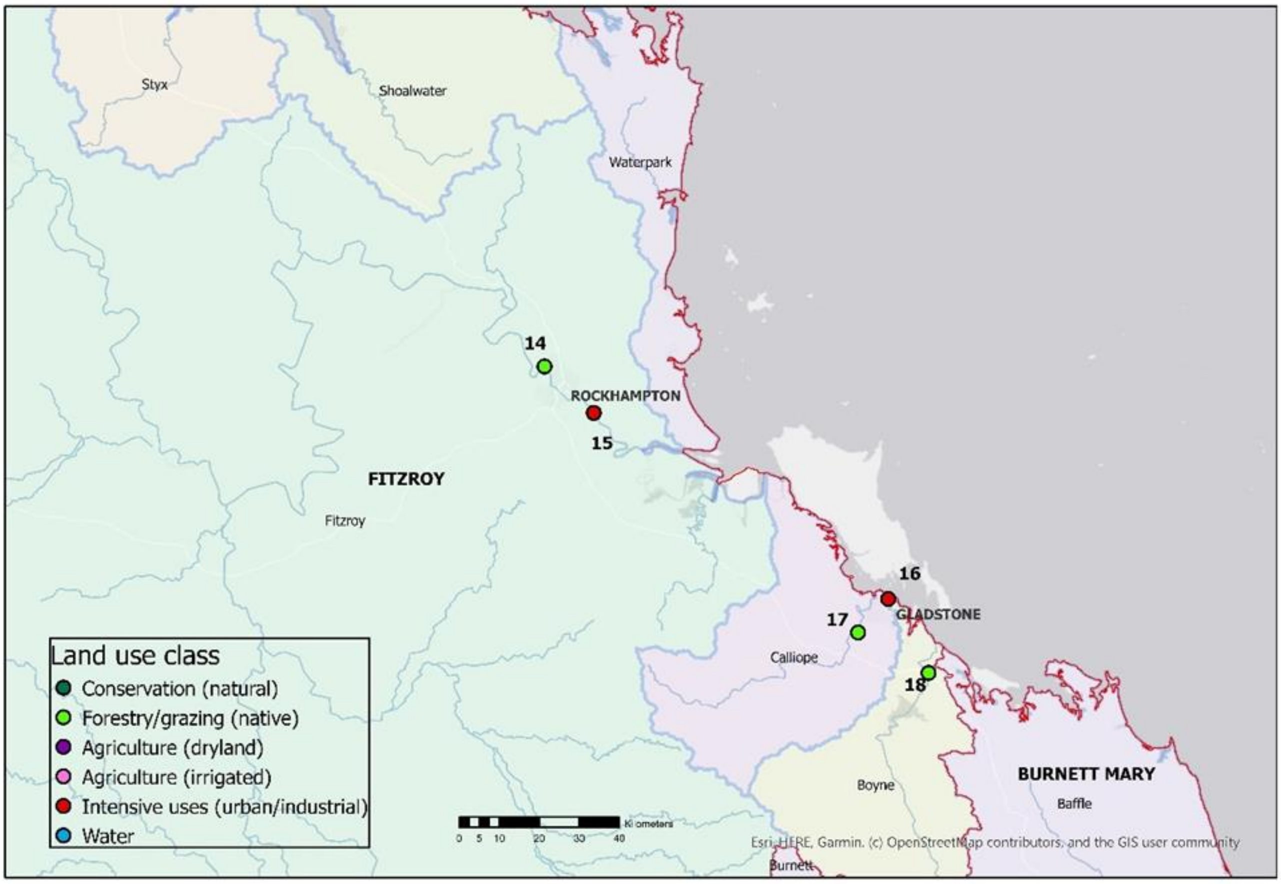

Figure 7: Map of ambient sampling locations within the Fitzroy region.

Table 9: Ambient sampling locations and samples collected within the Fitzroy region.

Sampling location	Latitude	Longitude	Water Type[1]	Land Use[2]	Samples	Map Reference
Fitzroy River (Barrage)	-23.3168	150.47934	Lakes/reservoirs	Forestry/ grazing (native)	Water, biota	14
Fitzroy River (Nerimbera)	-23.4209	150.58995	Middle estuary	Intensive uses (urban/industrial)	Water	15
Auckland Creek	-23.8384	151.25065	Lower estuary	Intensive uses (urban/industrial)	Water (including TOP Assay), sediment	16
Calliope River	-23.9137	151.183	Middle estuary	Forestry/ grazing (native)	Water (including TOP Assay), sediment	17
Boyne River	-24.0044	151.34098	Middle estuary	Forestry/ grazing (native)	Water (including TOP Assay), sediment	18

[1] Water type as described in the Environmental Protection (Water and Wetland Biodiversity) Policy 2019.
[2] Dominant adjacent land use class as designated by ALUMC (https://www.agriculture.gov.au/abares/aclump/land-use/alum-classification).

3.3.3.2 Results and discussion

No PFAS were reported in water samples in the Fitzroy region apart from PFOS. All reported concentrations of PFOS were around the LOR (Table 10, Table 5). PFOS was most frequently reported at the Calliope River site (67%) and least frequently at the Fitzroy River (Barrage) site (33%) (Table 10). The highest PFOS concentration for this region was reported at Auckland Creek (0.0005 µg/L), which is near industrial areas (Table 10, Figure 8).

TOP Assay was undertaken on a water samples collected from Auckland Creek and the Boyne and Calliope rivers. All results were below the LOR, indicating no precursor PFAS were present above the LOR at any of the sites. Sediment samples were also collected at these sites. All reported concentrations for PFAS were below the LOR (0.001 mg/kg).

Three fork-tailed catfish were collected in the Fitzroy River, and PFOS was reported in two of the three samples (0.001 mg/kg and 0.002 mg/kg). No other PFAS were reported.

Table 10: PFAS concentrations (µg/L) in water samples collected in the Fitzroy region. **Median, range**, geometric average and frequency of detection are reported. In cases where concentrations were below the LOR, half the LOR was used for the calculation of the geometric average and median values.

Fitzroy Region	PFOS (LOR=0.0001)
Fitzroy River (Barrage) (n=6)	**0.0001, <LOR–0.0002** 0.0001 (33%)
Fitzroy River (Nerimbera) (n=6)	**0.0001, <LOR–0.0002** 0.0001 (50%)
Auckland Creek (n=6)	**0.0001, <LOR–0.0005** 0.0001 (50%)
Calliope River (n=6)	**0.0003, <LOR–0.0003** 0.0002 (67%)
Boyne River (n=6)	**0.0001, <LOR–0.0004** 0.0001 (50%)

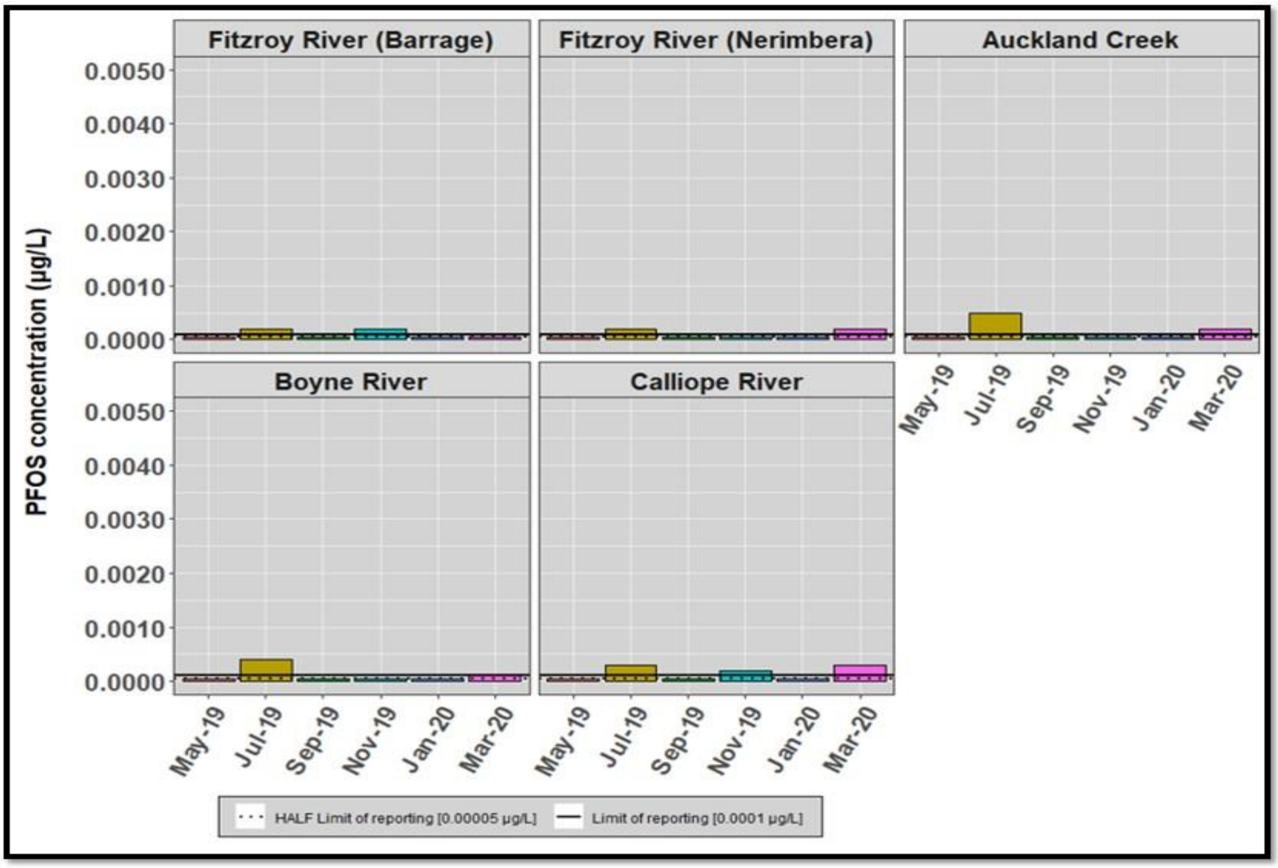

Figure 8: Reported concentrations of PFOS in the Fitzroy region over the six monitoring rounds (May 2019–March 2020).

3.3.4 Burnett Mary region

3.3.4.1 Site details

The Burnett Mary region covers more than 50,000 square kilometres between Miriam Vale and Gympie and includes the southern Great Barrier Reef Marine Park, the Great Sandy StraitWorld Heritage Area, and the Great Sandy Marine Park. The climate is subtropical and the main land uses are agricultural, grazing, forestry and areas of conservation. The annual rainfall is about 800 mm. The major sub-basins in this region are the Baffle and Kolan creeks, Burnett, Burrum and Mary rivers. The population is about 300,000 (Burnett Mary Regional Group, 2020). The sampling locations (Figure 9; Table 11) include the following waterways:

- **Baffle Creek** (One site)—the main watercourse in Baffle basin that is surrounded by forestry and grazing before entering the mouth at Rules Beach.
- **Burnett River** (Three sites)—is a large river that rises from the Burnett and Great Dividing Range that flows through several towns before reaching city of Bundaberg. This area is surrounded by agriculture land (irrigated) and intensive urban/industrial areas before continuing to the Coral Sea.
- **Gregory River** (One site)—the top of the catchment starts in a state forest before travelling through agriculture land and flowing through a national park near the mouth.
- **Isis River** (One site)—begins north of a state forest before flowing east to join the Burrum River and flowing out to the Coral Sea.
- **Burrum River** (One site)—begins at Lake Lenthall after gathering water from several other smaller waterways before passing the town of Howard and joining the Isis River downstream near the mouth.
- **Great Sandy Strait** (Two sites)—located between mainland Australia and Fraser Island (National Park and World Heritage Area). The strait runs from Hervey Bay to Inskip Point.

- **Mary River** (Three sites)—is a large river near the Sunshine Coast hinterland flowing from several tributaries through several towns before draining into the Great Sandy Strait Marine Park.
- **Tin Can Inlet** (One site)—the inlet stretches about 22 km into mainland Australia from south of Fraser Island and is surrounded by a national park and residential areas (Cooloola Cove and Tin Can Bay).

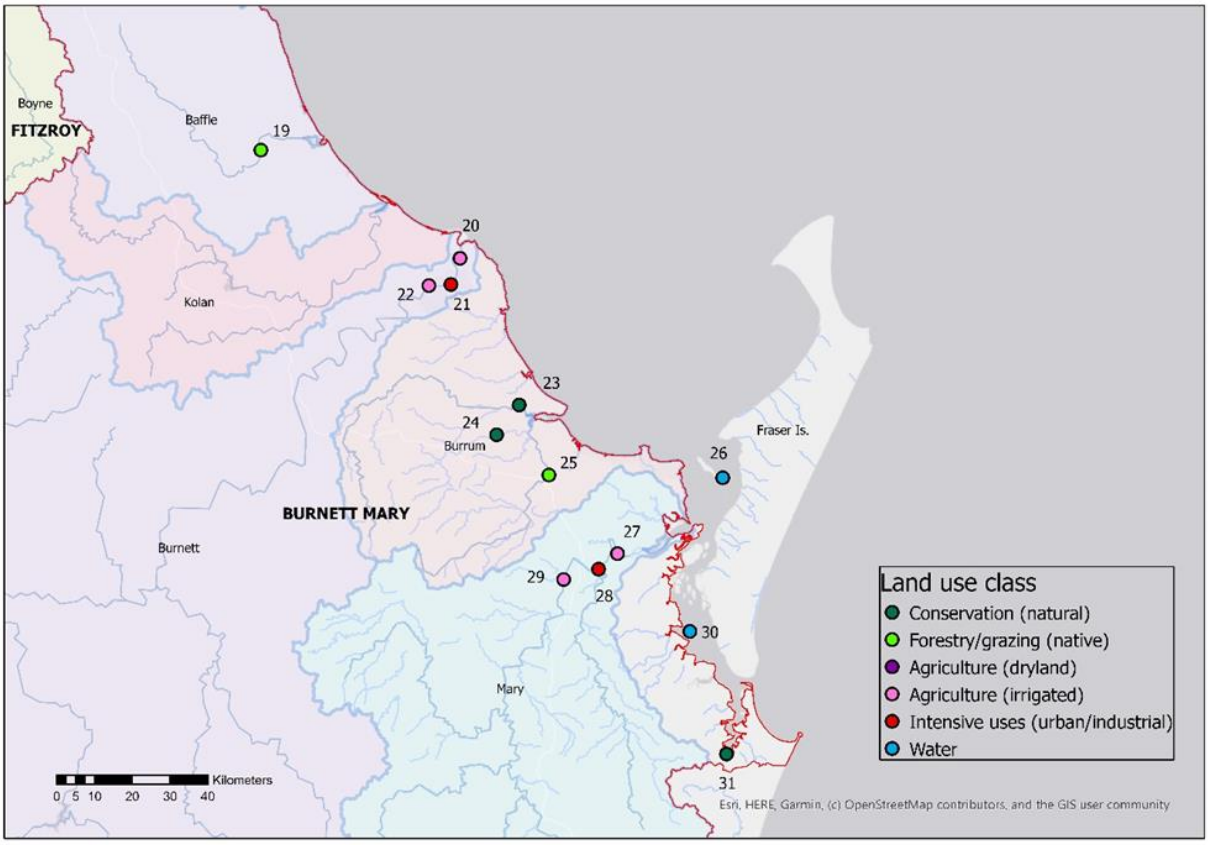

Figure 9: Map of ambient sampling locations within the Burnett Mary region.

Table 11: Ambient sampling locations and samples collected within the Burnett Mary region.

Sampling location	Latitude	Longitude	Water Type[1]	Land Use[2]	Samples	Map Reference
Baffle Creek	-24.5423	151.90452	Middle estuary	Forestry/ grazing (native)	Water	19
Burnett River (Fairymead)	-24.7996	152.37811	Middle estuary	Agriculture (irrigated)	Water	20
Burnett River (Bundaberg)	-24.8617	152.3564	Middle estuary	Intensive uses (urban/industrial)	Water (including TOP Assay), sediment	21
Burnett River (Oakwood)	-24.8644	152.30405	Middle estuary	Agriculture (irrigated)	Water (including TOP Assay), sediment, biota	22
Gregory River (Woodgate)	-25.1483	152.51861	Middle estuary	Conservation (natural)	Water	23
Isis River	-25.2192	152.46494	Middle estuary	Conservation (natural)	Water	24
Burrum River	-25.3149	152.5893	Middle estuary	Forestry/ grazing (native)	Water, biota	25
Great Sandy Strait (Northern End)	-25.3214	153.00262	Lower estuary	Water	Water	26
Mary River (Prawle)	-25.5018	152.7524	Middle estuary	Agriculture (irrigated)	Water (including TOP Assay)	27
Mary River (Maryborough)	-25.5388	152.7074	Middle estuary	Intensive uses (urban/industrial)	Water (including TOP Assay), sediment	28
Mary River (Grahams Creek)	-25.5633	152.62437	Middle estuary	Agriculture (irrigated)	Water, sediment	29
Great Sandy Strait (Southern End)	-25.6867	152.92455	Lower estuary	Water	Water	30
Tin Can Inlet (Cooloola)	-25.9783	153.01157	Lower estuary	Conservation (natural)	Water	31

[1] Water type as described in the Environmental Protection (Water and Wetland Biodiversity) Policy 2019
[2] Dominant adjacent land use class as designated by ALUMC (https://www.agriculture.gov.au/abares/aclump/land-use/alum-classification)

3.3.4.2 Results and discussion

Very few PFAS were reported in the Burnett Mary region, apart from PFOS at low concentrations (close to the LOR). PFOS was reported at or just above the LOR in water samples collected at eight of the 13 sampling locations (Table 12, Figure 10). PFOS was most frequently reported at the Burnett River (Bundaberg) (100% of monitoring rounds) and two sites in the Mary River (Maryborough and Grahams Creek, both 83% of monitoring rounds) (Table 12). No PFOS were reported above the LOR during the six monitoring rounds in the Gregory River (Woodgate), Isis River, Great Sandy Strait (Northern and Southern locations) and the Tin Can Inlet (Cooloola). PFPeA was reported from one sample collected at the Isis River (0.003 µg/L; Table 12). The highest PFOS concentration was reported from the Mary River (Maryborough) in November 2019 (0.021 µg/L; Table 12, Figure 10), which is around 100 times higher than the median concentration at this site. This elevated value was investigated[2] and although the site is adjacent to an urban area, the high PFOS concentration could not be explained further.

TOP Assay was undertaken on water samples collected at two sites on the Mary River and two sites on the Burnett River (Table 11). All results were below the LOR, indicating no precursor PFAS were present above the LOR at any of the sites. Sediment samples were also collected at two sites on the Mary River and two sites on the Burnett River, and all PFAS were below the LOR (0.001 mg/kg).

[2] A duplicate sample was analysed by the laboratory which confirmed an elevated level of PFOS (0.03µg/L)

Five species of fish were collected in the Burnett River. PFOS was only reported in one sample of fork-tailed catfish (0.001 mg/kg) and one sample of whiting (0.002 mg/kg; Table 13).). The only other PFAS reported was PFHxS in the same sample of whiting (0.003 mg/kg; Table 13). No PFOS or other PFAS were reported above the LOR in any of the other samples.

Single individuals of two species of fish (sea mullet and barred javelin) and one prawn were collected in the Burrum River. No PFAS was found in the biota samples from this location.

Table 12: PFAS concentrations (µg/l) in water samples collected in the Burnett Mary region. **Median**, **range**, geometric average and frequency of detection are reported. In cases where concentrations were below the LOR, half the LOR was used for the calculation of the geometric average and median values.

Burnett Mary	**PFPeA (LOR=0.001)**	**PFOS (LOR=0.0001)**
Baffle Creek (n=6)	<LOR	**0.0001, <LOR–0.0004** 0.0001 (17%)
Burnett River (Fairymead) (n=6)	<LOR	**0.0001, <LOR–0.0001** 0.0001 (67%)
Burnett River (Bundaberg) (n=5)	<LOR	**0.0003, 0.0002–0.0004** 0.0003 (100%)
Burnett River (Oakwood) (n=6)	<LOR	**0.0003, <LOR–0.0005** 0.0002 (83%)
Gregory River (Woodgate) (n=6)	<LOR	<LOR
Isis River (n=6)	**0.0005, <LOR–0.003** 0.0007 (17%)	<LOR
Burrum River (n=6)	<LOR	**0.0001, <LOR–0.0008** 0.0001 (33%)
Great Sandy Strait(Northern end) (n=6)	<LOR	<LOR
Mary River (Prawle) (n=6)	<LOR	**0.0001, <LOR–0.0003** 0.0001 (50%)
Mary River (Maryborough) (n=6)	<LOR	**0.0002, <LOR–0.021** 0.0003 (83%)
Mary River (Grahams Creek) (n=6)	<LOR	**0.0003, <LOR–0.0004** 0.0002 (83%)
Great Sandy Strait(Southern end) (n=6)	<LOR	<LOR
Tin Can Inlet (Cooloola) (n=6)	<LOR	<LOR

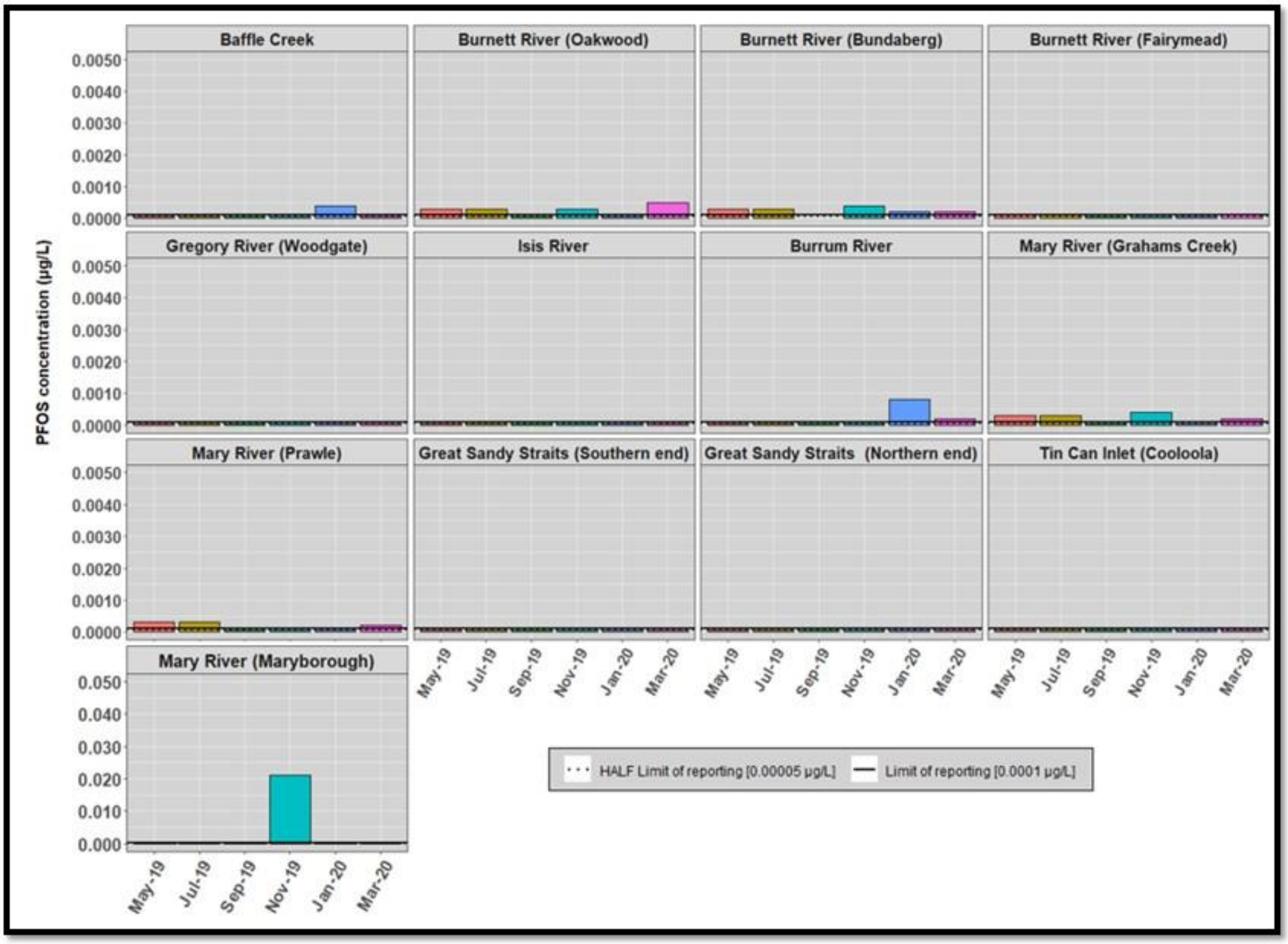

Figure 10: Reported concentrations of PFOS in water in the Burnett Mary region over the six monitoring rounds (May 2019–March 2020). No bar indicates sample not collected. NOTE: Mary River (Maryborough) site is on a different scale to allow for the results to be seen at the other sites within this region.

Table 13: PFAS concentrations (mg/kg ww) in fish samples collected in the Burnett River. **Range**, geometric average, and frequency of detection are reported. In cases where concentrations were below the LOR, half the LOR was used for the calculation of the geometric average values.

Burnett River	PFHxS (LOR=0.002)	PFOS (LOR=0.001)
Yellowfin bream (n=5)	<LOR	<LOR
Barred Javelin (n=1)	<LOR	<LOR
Fork-tailed catfish (n=5)	<LOR	**<LOR–0.001** 0.0005 (20%)
Silver Javelin (n=1)	<LOR	<LOR
Whiting (n=2)	**<LOR–0.003** 0.002 (50%)	**<LOR–0.002** 0.001 (50%)

3.3.5 South East Queensland region

3.3.5.1 Site details

The South East Queensland (SEQ) region is the most populated region of Queensland, with 11 local government areas (City of Brisbane, Moreton Bay, Logan City, City of Ipswich, Redland City, Scenic Rim, Somerset, Lockyer Valley, City of Gold Coast, Sunshine Coast, Toowoomba and Shire of Noosa). The climate is subtropical, and the land use is predominantly intensive use (urban and industrial). The annual rainfall is about 1,000mm and the population about 3.6 million (Queensland Government 2020b). The sampling locations (Figure 11, Table 14) include the following waterways:

- **Noosa River** (Three sites)—this freshwater river starts in a national park is linked to multiple lakes (Lake Cooloola, Lake Como, Lake Cootharaba, Lake Cooroibah and Lake Weyba) then exiting at the mouth, were it is mainly bordered by residential areas.
- **Maroochy River** (One site)—starting in the Blackall Range and forming two branches of the estuary, North Maroochy, and South Maroochy, before joining into the main Maroochy River at Yandina (urban area) then passing through agriculture land (dryland) and exiting the mouth at Maroochydore.
- **Bells Creek** (One site)—small tributary off Pumicestone Passage surrounded by agricultural land at the top of the catchment before exiting at the mouth, which is mainly bordered by residential areas.
- **Back/Coochin Creek** (Two sites)—small tributaries off Pumicestone Passage surrounded mostly by residential and agricultural land. One site is in Back Creek and another further downstream in Coochin Creek.
- **Pumicestone Passage** (One site)—a channel between mainland Australia and Bribie Island. This channel runs from Caloundra to Deception Bay, bordered by state forest and national park at the middle of the channel, and residential areas at both ends of the channel.
- **Caboolture River** (Two sites)—receives runoff from D’Aguilar Range north of Brisbane before it flows eastwards and joins two minor tributaries. The river continues through residential areas before exiting at Deception Bay and Moreton Bay.
- **Bremer River** (One site)—a large river that starts at a national park before flowing about 70 km northeast towards the Brisbane River draining several Scenic Rim Valleys. The confluence of Warrill Creek and Bremer River is bordered by Amberly RAAF airbase.
- **Warrill Creek** (One site)—large tributary of Bremer River that flows from Lake Moogerah at the top of the catchment surrounded by a national park and agriculture land before connecting with Bremer River in Amberly, where the RAAF airbase is located, and then with the Brisbane River.
- **Brisbane River** (Three sites)—longest river in South East Queensland receiving water from the Great Dividing Range. The river flows south through Lake Somerset and continuing into Lake Wivenhoe. Downstream of Lake Wivenhoe lies the heavily urban/industrial area of Brisbane. The Brisbane River enters Moreton Bay at the Port of Brisbane.
- **Oxley Creek** (One site)—tributary of Brisbane River collecting water from the low hills of Scenic Rim Region down its 70 km length before connecting with the Brisbane River near Indooroopilly. The region around this creek is heavily occupied by residential areas, an airport, WWTP, waste disposal and landfill facilities.
- **Tingalpa Creek** (One site)—starts at Venman Bushland National Park before continuing down to Tingalpa Reservoir, then exiting the dam into Tingalpa Creek and entering Moreton Bay at the mouth near Mooroondu Point. Most of the creek is bordered by industrial and residential land.
- **Logan River** (Two sites)—this river flows south of Scenic Rim before flowing north-east and eventually bordered by residential areas near the mouth before entering Moreton Bay.

- **Moreton Bay** (Three sites)—which is east of Brisbane, receives water from numerous rivers such as Brisbane River, Caboolture River and Pine River. Moreton Bay is a state Marine Park and also neighbours national parks and protected areas such as Moreton Island, Stradbroke Island and Bribie Island, which are made up of national parks, state forest and conservation areas.
- **Gold Coast Broadwater** (Two sites)—large shallow estuary bordered by residential areas and islands on the Gold Coast.

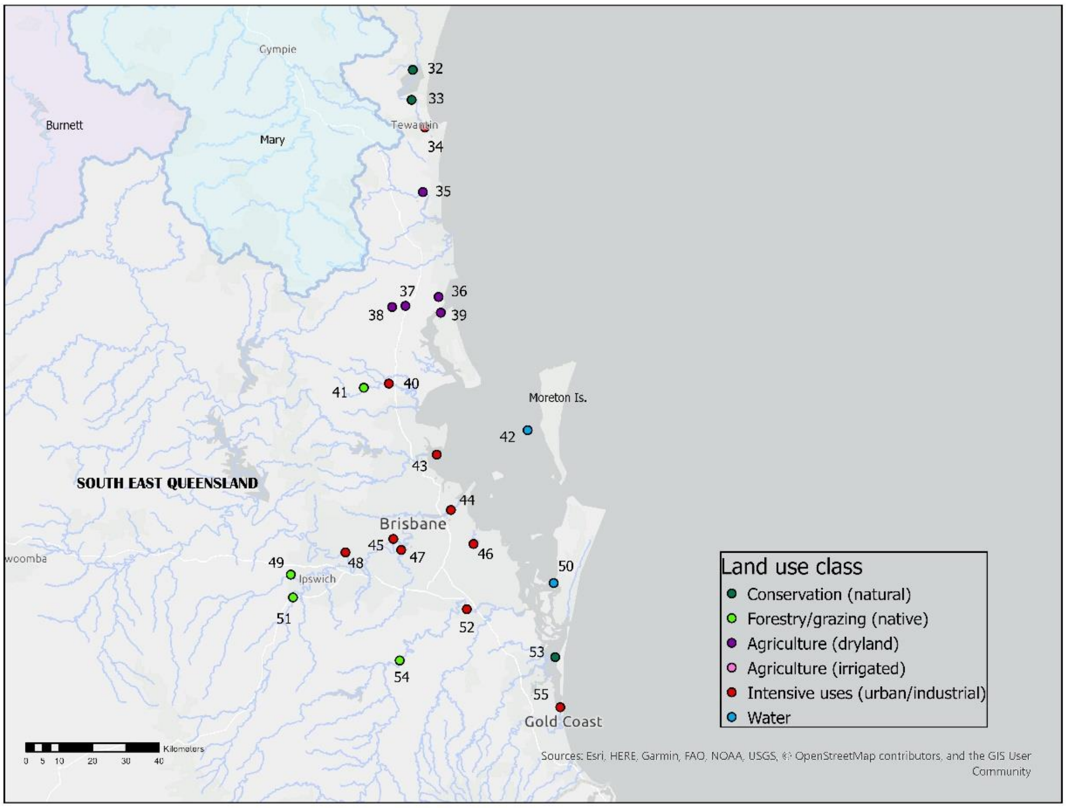

Figure 11: Map of ambient sampling locations within the South East Queensland region.

Table 14: Ambient sampling locations and samples collected within the South East Queensland region.

Sampling Location	Latitude	Longitude	Water Type[1]	Land Use[2]	Samples	Map Reference
Noosa River (Lake Cootharaba)	-26.2406	153.0231	Upper estuary	Conservation (natural)	Water, sediment	32
Noosa River (Cooroibah)	-26.3215	153.02003	Upper estuary	Conservation (natural)	Water	33
Noosa River Noosaville	-26.3960	153.05557	Lower estuary	Intensive uses (urban/industrial)	Water	34
Maroochy River	-26.5702	153.05042	Middle estuary	Agriculture (dryland)	Water (including TOP Assay), sediment	35
Bells Creek	-26.8531	153.09281	Middle estuary	Agriculture (dryland)	Water (including TOP Assay), sediment	36
Coochin Creek	-26.8771	153.0034	Lowland streams	Agriculture (dryland)	Water (including TOP Assay), sediment	37
Back Creek	-26.8802	152.96739	Lowland streams	Agriculture (dryland)	Water (including TOP Assay), sediment	38
Pumicestone Passage	-26.8955	153.09866	Middle estuary	Agriculture (dryland)	Water (including TOP Assay), sediment	39
Caboolture River (Caboolture)	-27.0868	152.95863	Upper estuary	Intensive uses (urban/industrial)	Water (including TOP Assay), sediment, biota	40
Caboolture River (Upper Caboolture)	-27.0979	152.8911	Lowland streams	Forestry/ grazing (native)	Water (including TOP Assay), sediment	41
Moreton Bay (Near Moreton Is)	-27.2125	153.33308	Open coastal	Water	Water	42
Moreton Bay (Bramble Bay)	-27.2784	153.08771	Enclosed coastal	Intensive uses (urban/industrial)	Water (including TOP Assay), sediment	43
Brisbane River (Lytton)	-27.4278	153.12607	Middle estuary	Intensive uses (urban/industrial)	Water (including TOP Assay), sediment	44
Brisbane River (Indooroopilly)	-27.5058	152.97069	Middle estuary	Intensive uses (urban/industrial)	Water (including TOP Assay), sediment, biota	45
Tingalpa Creek	-27.5194	153.18698	Middle estuary	Intensive uses (urban/industrial)	Water (including TOP Assay), sediment, biota	46
Oxley Creek	-27.5355	152.99189	Middle estuary	Intensive uses (urban/industrial)	Water (including TOP Assay), sediment, biota	47
Brisbane River (Karana Downs)	-27.5421	152.84143	Upper estuary	Intensive uses (urban/industrial)	Water (including TOP Assay), sediment, biota	48
Bremer River[3]	-27.6020	152.694	Lowland streams	Forestry/ grazing (native)	Water (including TOP Assay), sediment	49
Moreton Bay (N of Russell Is)	-27.6247	153.4033	Enclosed coastal	Water	Water	50
Warrill Creek	-27.6635	152.7	Lowland streams	Forestry/ grazing (native)	Water (including TOP Assay)	51
Logan River (Eden's Landing)	-27.6954	153.16886	Middle estuary	Intensive uses (urban/industrial)	Water (including TOP Assay), sediment, biota	52
Northern Broadwater (Couran Cove)	-27.8246	153.40738	Lower estuary	Conservation (natural)	Water	53
Logan River (Glenlogan)	-27.8336	152.98778	Lowland streams	Forestry/ grazing (native)	Water (including TOP Assay), sediment	54
Northern Broadwater (Southport)	-27.9597	153.4211	Lower estuary	Intensive uses (urban/industrial)	Water	55

[1] Water type as described in the Environmental Protection (Water and Wetland Biodiversity) Policy 2019
[2] Dominant adjacent land use class as designated by ALUMC (https://www.agriculture.gov.au/abares/aclump/land-use/alum-classification)

3.3.5.2 Results and discussion

In the SEQ region, surface water was sampled at 24 locations. Ten sites were between Noosa and Caboolture (Figure 12), 10 in the Greater Brisbane and Moreton Bay (Figure 16), and four in the Logan and Gold Coast (Broadwater) area (Figure 23).

3.3.5.2.1 Noosa to Caboolture subregion

Very few PFAS were reported in the waterways between Noosa and Caboolture, with only PFOS reported at seven of the 10 sites (Table 15, Figure 13).

PFHxA and PFOA were both reported occasionally in the Maroochy River (in 33% and 17% of samples respectively). PFOS was reported at 83% of samples in the Maroochy River. The samples from the site at the Caboolture River (Caboolture) had the highest PFOS concentrations (0.0007–0.0033 µg/L) and were reported in 100% of samples. As well as PFOA and PFOS, two short chain PFCAs (PFPeA, PFHxA), one short chain PFSA (PFBS), one long chain PFCA (PFHpA) and two long chain PFSAs (PFHxA and PFNS) were reported at this site during all six monitoring rounds (Table 15).

A seasonal pattern was evident in the PFAS results from the Caboolture River (Caboolture). In May 2019 and March 2020 only PFOS was reported in water samples at 0.001 µg/L and 0.0016 µg/L, respectively. These sampling dates followed rain and an increased flow in the Caboolture River (Figure 14). In the drier months of July, September and November 2019 and January 2020, various PFAS were reported (Figure 15) with the Total PFAS rising from 0.0027 µg/L in July 2019 to 0.02 µg/L in January 2020; Figure 15), and the number of PFAS reported increased from one in the wet months to eight in the January 2020 monitoring round (Figure 15, Figure 14). The electrical conductivity increased during these months, from being freshwater after rain to brackish in January 2020 (Table 16), most likely as a consequence of tidal mixing over time as this is an estuarine site. The decrease of total PFAS over the wetter periods may indicate dilution into the estuary during higher flow, which also may explain why only PFOS was reported above the LOR during these periods. The site is about one kilometre upstream from a WWTP discharge point and is likely influenced by tidal movement that would take discharge water upstream.

Water samples were collected for TOP Assay at six sites between Noosa and Caboolture. All results were below the LOR, indicating no precursor PFAS were present above the LOR at any of the sites. Sediments were collected at eight sites – from the Noosa River (Lake Cootharaba), Maroochy River, Pumicestone Passage, Bells Creek, Coochin Creek, Back Creek, and the two Caboolture River sites. PFAS in all samples were below the LOR (0.001 mg/kg).

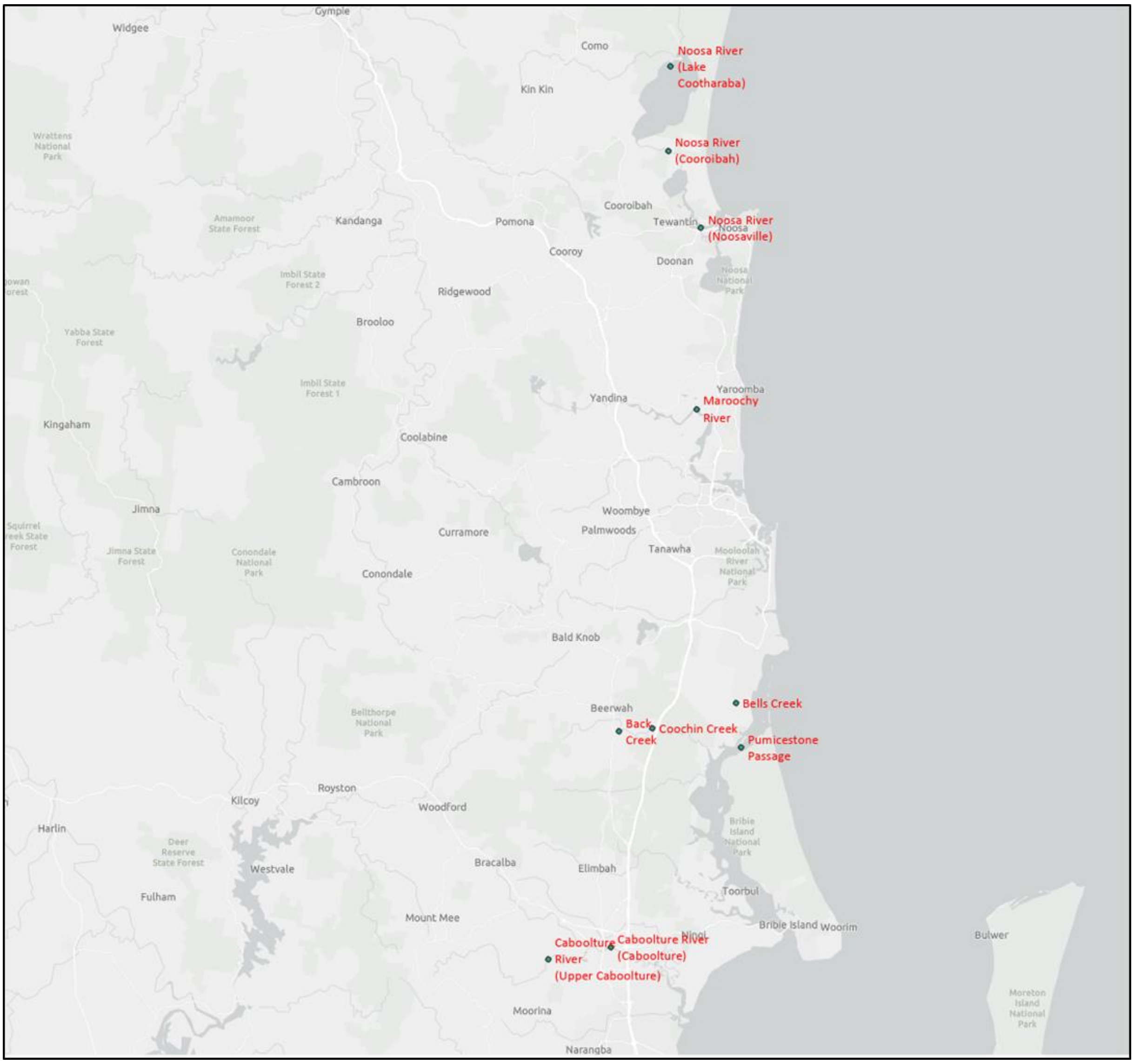

Figure 12: Noosa to Caboolture sampling sites.

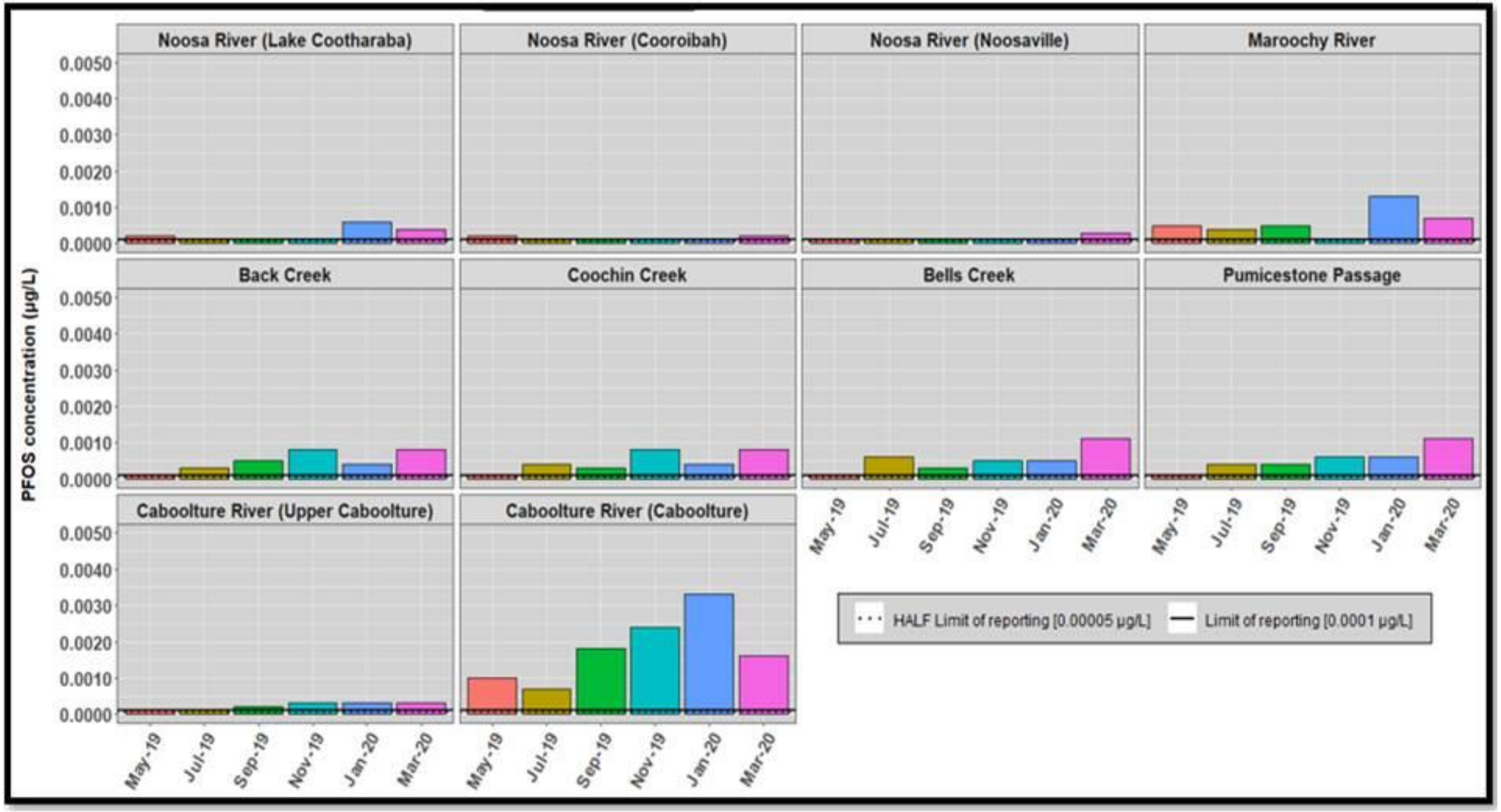

Figure 13: Reported concentrations of PFOS in the South East Queensland region (Noosa to Caboolture) over the six monitoring rounds (May 2019–March 2020)

Table 15: PFAS concentrations (µg/L) in water samples collected in the South East region, between Noosa and Caboolture. **Median**, **range**, geometric average and frequency of detection (%) are reported. In cases where concentrations were below the LOR, half the LOR was used for the calculation of the geometric average and median values. All LORs are 0.001 µg/L, except PFOS (LOR=0.0001 µg/L).

	PFPeA	PFHxA	PFHpA	PFOA	PFBS	PFHxS	PFOS	PFNS	PFDS
Noosa River (Lake Cootharaba) (n=6)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	**0.0002** **<LOR–0.0006** 0.0002 (67%)	<LOR	**0.0005** **<LOR–0.001** 0.0006 (17%)
Noosa River (Cooroibah) (n=6)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	**0.0001** **<LOR–0.0002** 0.0001 (50%)	<LOR	<LOR
Noosa River (Noosaville) (n=6)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	**0.0001** **<LOR–0.0003** 0.0001 (50%)	<LOR	<LOR
Maroochy River (n=6)	<LOR	**0.0005** **<LOR–0.001** 0.0006 (33%)	<LOR	**0.0005** **<LOR–0.001** 0.0006 (17%)	<LOR	<LOR	**0.0005** **<LOR–0.0013** 0.0004 (83%)	<LOR	<LOR
Bells Creek (n=6)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	**0.0005** **<LOR–0.0011** 0.0004 (83%)	<LOR	<LOR
Coochin Creek (n=6)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	**0.0004** **<LOR–0.0008** 0.0003 (83%)	<LOR	<LOR
Back Creek (n=6)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	**0.0005** **<LOR–0.0008** 0.0004 (83%)	<LOR	<LOR
Pumicestone Passage (n=6)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	**0.0005** **<LOR–0.0011** 0.0004 (83%)	<LOR	<LOR
Caboolture River (Caboolture) (n=6)	**0.0025** **<LOR–0.006** 0.0017 (67%)	**0.003** **<LOR–0.008** 0.0019 (67%)	**0.0005** **<LOR–0.001** 0.0006 (33%)	**0.0018** **<LOR–0.004** 0.0013 (50%)	**0.0005** **<LOR–0.001** 0.0006 (17%)	**0.0005** **<LOR–0.001** 0.0006 (33%)	**0.0017** **0.0007–0.0033** 0.0016 (100%)	**0.0005** **<LOR–0.001** 0.0006 (17%)	<LOR
Caboolture River (Upper Caboolture) (n=6)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	**0.0003** **<LOR–0.0003** 0.0002 (83%)	<LOR	<LOR

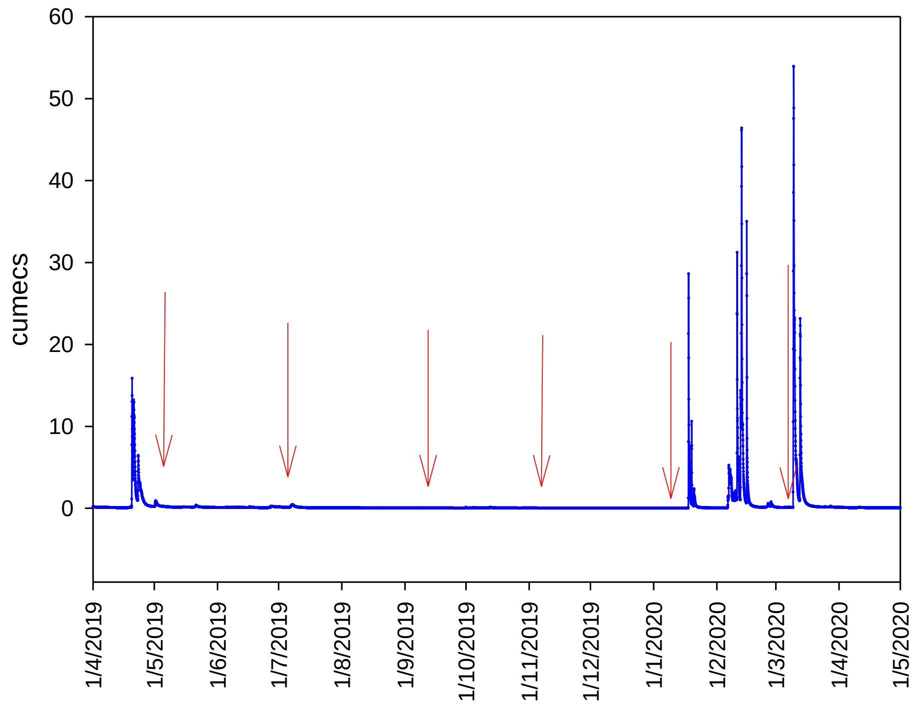

Figure 14: Caboolture River flow from Guaging Station 142001A – Caboolture River at Upper Caboolture. Note: red arrows indicate sample collection date. Cumecs are cubic metres per second.

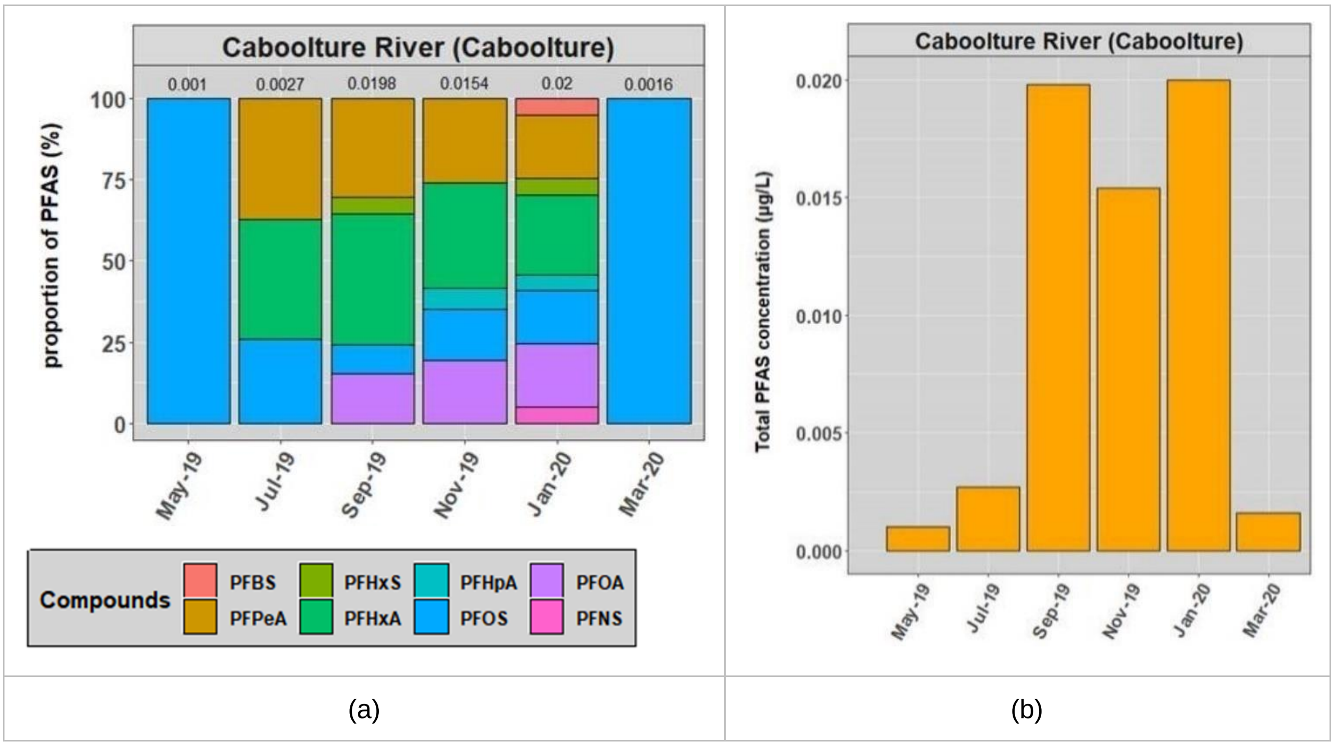

Figure 15: (a) Proportion of PFAS (%) reported in the Caboolture River (Caboolture). Total PFAS concentration (µg/L) presented at the top of each bar (b) total PFAS in the Caboolture River (Caboolture) for each monitoring round.

Table 16: In situ parameters collected each month from Caboolture River (Caboolture).

Month	Temp	DO (mg/L)	EC (µS/cm)	pH	Turbidity (NTU)	Salinity
May-19	21.91	8.13	210	7.46	8.4	0.1
Jul-19	17.41	7.3	1590	7.35	3.45	0.81
Sep-19	21.23	6.01	19460	7.32	2.86	11.61
Nov-19	26.87	9.66	13660	7.66	6.8	7.86
Jan-20	29.46	7.06	25110	7.52	8.3	15.2
Mar-20	25.33	6.15	250	7.27	6.6	0.12

Five species of fish and two of invertebrates were collected in the Caboolture River. The fish were collected in January 2020 and the invertebrates between January (Prawn) and March 2020 (Worm). PFOS was reported in all samples (Table 17). The lowest concentration of PFOS in biota from the Caboolture River was reported in sea mullet (n=5, 0.002 mg/kg). The highest concentration of PFOS in biota at this location was reported in fork-tailed catfish (n=1, 0.039 mg/kg). The only other PFAS reported in samples from this location were PFDA in one sample of fork-tailed catfish (0.005 mg/kg) and PFBA in two of three samples of worm (0.002 and 0.003 mg/kg) (Table 17). PFDA and PFBA were not reported in any of the water samples in the Caboolture River. No other PFAS reported in water samples (Table 15) were found in the biota samples.

Table 17: PFAS concentrations (mg/kg ww) in biota samples collected in the Caboolture River. **Range**, geometric average and frequency of detection (%) are reported. In cases where concentrations were below the LOR, half the LOR was used for the calculation of the geometric average values.

	PFBA (LOR=0.002)	PFDA (LOR=0.005)	PFOS (LOR=0.0009–0.001)
Fish			
Australian Bass (n=1)	<LOR	<LOR	0.009 (100%)
Fork-tailed Catfish (n=1)	<LOR	0.005 (100%)	0.039 (100%)
Glassfish (n=2)	<LOR	<LOR	**0.012–0.013** 0.0125 (100%)
Sea mullet (n=5)	<LOR	<LOR	**0.002–0.006** 0.0040 (100%)
Mozambique Tilapia (n=1)	<LOR	<LOR	0.003 (100%)
Invertebrates			
Worm (n=3)	**<LOR–0.003** 0.002 (67%)	<LOR	**0.014–0.025** 0.0173 (100%)
Prawn (n=5)	<LOR	<LOR	**0.007–0.013** 0.0096 (100%)

3.3.5.2.2 Greater Brisbane and Moreton Bay subregion

Of all the sampling sites in Queensland, PFAS were reported at the highest concentration, the greatest frequency and with the largest variety in the Greater Brisbane subregion (Figure 17, Table 18). PFAS were reported from all sample sites (Table 18). Only PFOS was reported in Bramble Bay, which is at the mouth of the Pine River, the two Moreton Bay sites, and Warrill Creek. The reported concentrations of PFOS were highest in the Brisbane River at Indooroopilly (0.01–0.037 µg/L), followed by Oxley Creek (0.012–0.03 µg/L), and the Brisbane River at Karana Downs (0.009–0.018 µg/L) (Table 18, Figure 17). Thirteen PFAS other than PFOS were reported at the sampling locations in the Greater Brisbane area (Table 18). These were the short chain PFCAs (PFBA, PFPeA, PFHxA), the long chain PFCAs (PFHpA, PFOA, PFNA, PFDA), short chain PFSAs (PFPrS, PFBS, PFPeS), long chain PFSAs (PFHxS, PFHpS) and the fluorotelomer 8:2 FTS (Figure 18).

PFHpA was reported in samples at a frequency of 83% with a median 0.003 µg/L at the Brisbane River (Indooroopilly) and Oxley Creek sites. PFDA was reported in 33% of samples at Oxley Creek and 67% of samples at the Brisbane River (Indooroopilly) with a maximum concentration of 0.002 µg/L at both sites.

PFPeS was reported in the majority of months at the Brisbane River Indooroopilly and Karana Downs sites, and Oxley Creek sites (with a maximum of 0.003 µg/L). PFPrS was reported in one sample in each of the Oxley Creek and Brisbane River at Indooroopilly sites at 0.002 and 0.001 µg/L, respectively. The Brisbane River site at Lytton had a similar pattern to the other two Brisbane River sites (Indooroopilly and Karana Downs), but at a lower concentration. This site is close to the mouth of the river and would experience greater flushing from Moreton Bay.

The other site in the Greater Brisbane subregion with elevated PFAS, Tingalpa Creek, had a similar signature to the three Brisbane River sites, but no PFPeS was reported and 8:2 FTS was reported in one sample. Only one of the three sites in Moreton Bay had any PFAS, with PFOS reported in 100% of samples at Bramble Bay, which is near the mouth of the Pine River.

The PFAS signature for the different compounds in the Bremer River stands out, with a predominance of PFBA in all months apart from March 2020 (Figure 18). Heavy rainfall in February 2020 caused the Bremer River to flow (Figure 19). In the March 2020 monitoring round, the concentration of total PFAS decreased 10 to 20 times from previous months, and only PFOS was reported at the site (Figure 18). The site in the Bremer River is adjacent to the northern boundary of the RAAF Base Amberley, and may be affected by the known contamination at this site.

Two distinct seasonal trends are apparent in the Brisbane River. Flow data is not available for the Brisbane River estuary and so assessment was made using rainfall records. The upstream site of the Brisbane River (Karana Downs) has the lowest concentrations of total PFAS in the wet season, with the concentration increasing during the drier months (Figure 20, Figure 21). This site is about one kilometre upstream of a WWTP, and tidal movement still occurs in this area. In contrast, the total PFAS at the Brisbane River at Indooroopilly and Oxley Creek sites increase in the wet season and decrease somewhat during the drier months (Figure 20). The Brisbane River (Indooroopilly) and Oxley Creek sites are relatively close together and are tidally influenced by each other. The pattern is less pronounced at the Brisbane River at Lytton (Figure 20). Nonetheless, the highest concentration of PFAS at Brisbane River (Indooroopilly) was found in March 2020 after the month of heavy rainfall. This increase in total PFAS after rainfall may indicate surface run-off and upstream sources of PFAS at these sites.

Strong and significant correlations (Pearson's) were found between PFOS and turbidity at Brisbane River Indooroopilly ($r=0.88$, $p=0.021$) and Brisbane River Lytton ($r=0.89$, $p=0.016$) (Figure 22). As the highest turbidity at these sites was associated with the March 2020 sampling round, this may indicate the elevated Total PFAS occurs because contaminated sediment becomes resuspended in the water after rainfall or because contaminated soil is washed into the river and transported downstream. PFOS was reported in sediment in the Brisbane River at Indooroopilly, one of the few sites where it was reported. No seasonal trend was apparent at Tingalpa Creek (Figure 17).

Water samples were collected for TOP Assay at six sites in the Greater Brisbane and Moreton Bay area – Moreton Bay, Warrill Creek, Bremer River, Brisbane River, Oxley Creek and Tingalpa Creek. Only samples from four sites had detectable levels of PFAS compounds after the TOP Assay. They were two sites in the Brisbane River, and one site in each of the Oxley and Tingalpa creeks (Appendix D). There was no evidence of precursors in the sample, as the total concentrations of PFAS were lower in the post-TOP Assay results than the pre-TOP Assay results; differences are likely associated with method uncertainty.

Among the seven sites where sediment samples were collected within this area, PFOS was reported at 0.001 mg/kg at Brisbane River (Karana Downs), Brisbane River (Indooroopilly), and Oxley Creek, and at Tingalpa Creek (0.002 mg/kg) (Appendix E). PFDA was also reported at 0.001 mg/kg at Tingalpa Creek (Appendix E). No other PFAS compounds were reported in sediment samples at these sites. No PFAS compounds were reported above the LOR (0.001 mg/kg) in the sediment samples collected at the remaining sites (Bremer River, Moreton Bay – Bramble Bay, and Brisbane River – Lytton).

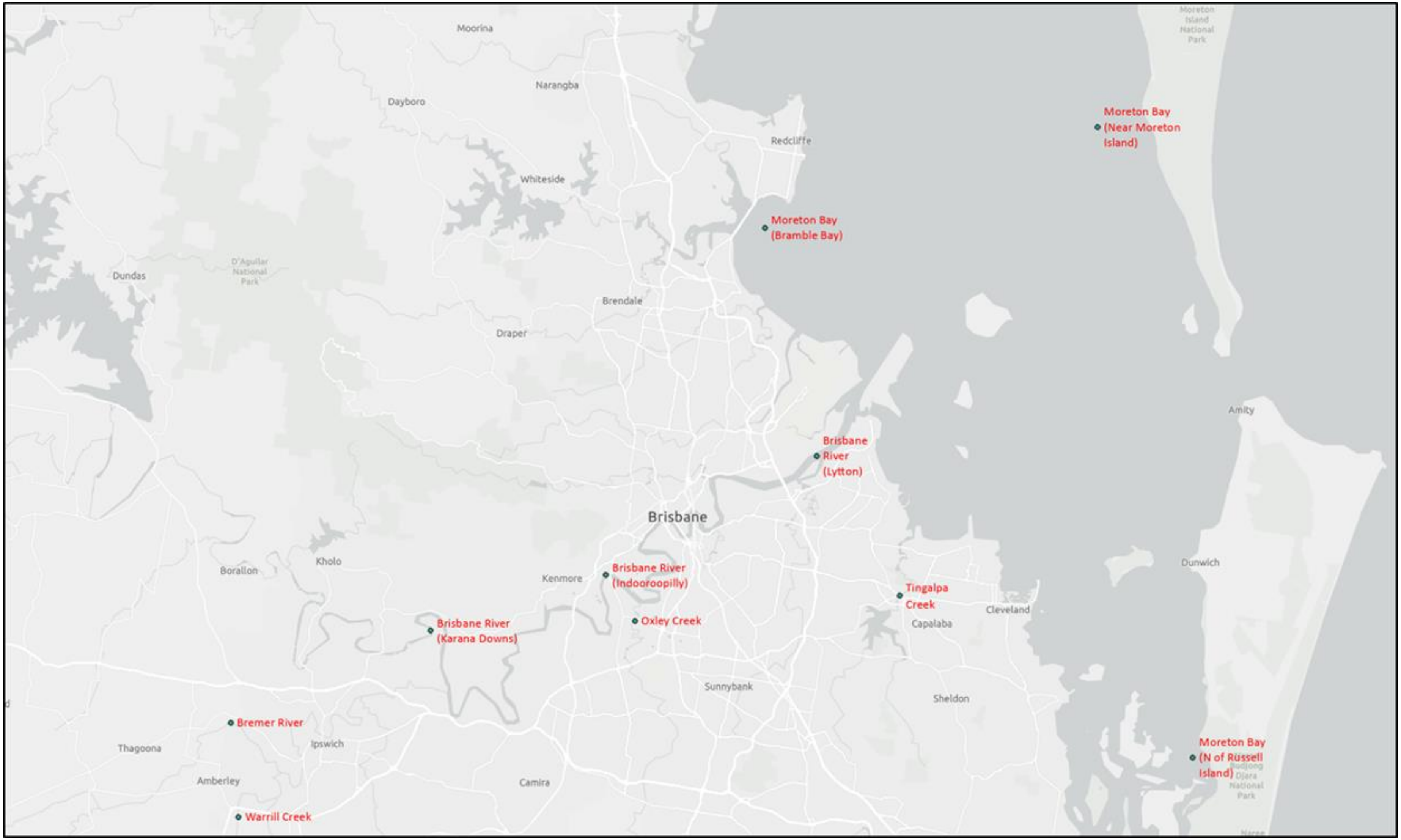

Figure 16: Greater Brisbane and Moreton Bay sampling sites.

Table 18: PFAS concentrations (µg/L) in water samples collected in the South East region, for the Greater Brisbane area and Moreton Bay. **Median**, **range**, geometric average and frequency of detection are reported. In cases where concentrations were below the LOR, half the LOR was used for the calculation of the geometric average and median values. All LORs were 0.001 µg/L, with the exception of PFOS (0.0001 µg/L) and 8:2 FTS (0.005 µg/L).

Greater Brisbane	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFPrS	PFBS	PFPeS	PFHxS	PFHpS	PFOS	8:2 FTS
Warrill Creek (n=6)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	**0.0003** **<LOR–** **0.0006** 0.0002 83%	<LOR
Bremer River (n=6)	**0.01** **<LOR–0.012** 0.0081 83%	**0.0005** **<LOR–** **0.001** 0.0006 17%	**0.002** **<LOR–** **0.002** 0.0014 83%	**0.0005** **<LOR–** **0.001** 0.0006 17%	**0.0005** **<LOR–** **0.001** 0.0006 33%	<LOR	<LOR	<LOR	<LOR	<LOR	**0.0005** **<LOR–** **0.001** 0.0006 17%	<LOR	**0.0026** **0.0011–** **0.0035** 0.0023 100%	<LOR
Brisbane River (Karana Downs) (n=6)	**0.0025** **<LOR–0.006** 0.0033 33%	**0.0055** **0.002–** **0.009** 0.0047 100%	**0.006** **0.002–0.01** 0.0055 100%	**0.002** **<LOR–** **0.003** 0.0016 83%	**0.003** **0.001–** **0.005** 0.0027 100%	<LOR	<LOR	<LOR	**0.002** **<LOR–** **0.004** 0.0014 67%	**0.0015** **<LOR–** **0.003** 0.0013 67%	**0.011** **0.005–** **0.019** 0.0097 100%	<LOR	**0.0125** **0.009–** **0.018** 0.013 100%	<LOR
Oxley Creek (n=6)	**0.0038** **<LOR–0.006** 0.0037 33%	**0.0075** **0.006–** **0.012** 0.0078 100%	**0.009** **0.008–0.01** 0.0089 100%	**0.003** **<LOR–** **0.004** 0.0024 83%	**0.005** **0.004–** **0.006** 0.0051 100%	**0.0005** **<LOR–** **0.001** 0.0006 17%	**0.0008** **<LOR–** **0.002** 0.0009 50%	**0.0005** **<LOR–** **0.002** 0.0007 17%	**0.002** **0.002–** **0.004** 0.0024 100%	**0.0015** **<LOR–** **0.003** 0.0012 67%	**0.0105** **0.008–** **0.017** 0.0112 100%	**0.0005** **<LOR–** **0.0003** 0.0007 17%	**0.0165** **0.012–0.03** 0.0182 100%	<LOR
Brisbane River (Indooroopilly) (n=6)	**0.0038** **<LOR–0.006** 0.0036 50%	**0.0065** **0.004–** **0.01** 0.0064 100%	**0.01** **0.008–** **0.012** 0.0098 100%	**0.003** **<LOR–** **0.004** 0.0022 83%	**0.006** **0.004–** **0.006** 0.0052 100%	<LOR	**0.001** **<LOR–** **0.002** 0.001 67%	**0.0005** **<LOR–** **0.001** 0.0006 20%	**0.002** **0.001–** **0.003** 0.0019 100%	**0.001** **<LOR–** **0.002** 0.001 67%	**0.009** **0.008–** **0.018** 0.01 100%	**0.0005** **<LOR–** **0.003** 0.0007 17%	**0.017** **0.01–0.037** 0.019 100%	<LOR
Brisbane River (Lytton) (n=6)	<LOR	**0.001** **<LOR** **0.002** 0.001 83%	**0.001** **<LOR–** **0.002** 0.001 83%	<LOR	**0.0005** **<LOR–** **0.001** 0.0006 33%	<LOR	<LOR	<LOR	<LOR	<LOR	**0.0015** **<LOR–** **0.004** 0.0013 67%	<LOR	**0.0024** **0.0012–** **0.0062** 0.0025 100%	<LOR
Tingalpa Creek (n=6)	<LOR	**0.0035** **<LOR–** **0.01** 0.0024 67%	**0.005** **<LOR–** **0.009** 0.0037 83%	**0.002** **<LOR–** **0.003** 0.0015 83%	**0.005** **<LOR–** **0.006** 0.0034 83%	<LOR	**0.0005** **<LOR–** **0.001** 0.0006 17%	<LOR	**0.001** **<LOR–** **0.002** 0.0008 67%	<LOR	**0.003** **<LOR–** **0.004** 0.0024 83%	<LOR	**0.0047** **0.0004–** **0.0095** 0.0033 100%	**0.0005** **<LOR–** **0.004** 0.0007 17%
Moreton Bay (Bramble Bay) (n=6)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	**0.0012** **0.0003–** **0.0018** 0.0012 100%	<LOR
Moreton Bay (Near Moreton Island) (n=5)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	**0.0001** **<LOR –** **0.0002** 0.0001 60%	<LOR
Moreton Bay (N of Russell Island) (n=6)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	**0.0001** **<LOR –** **0.0003** 0.0001 50%	<LOR

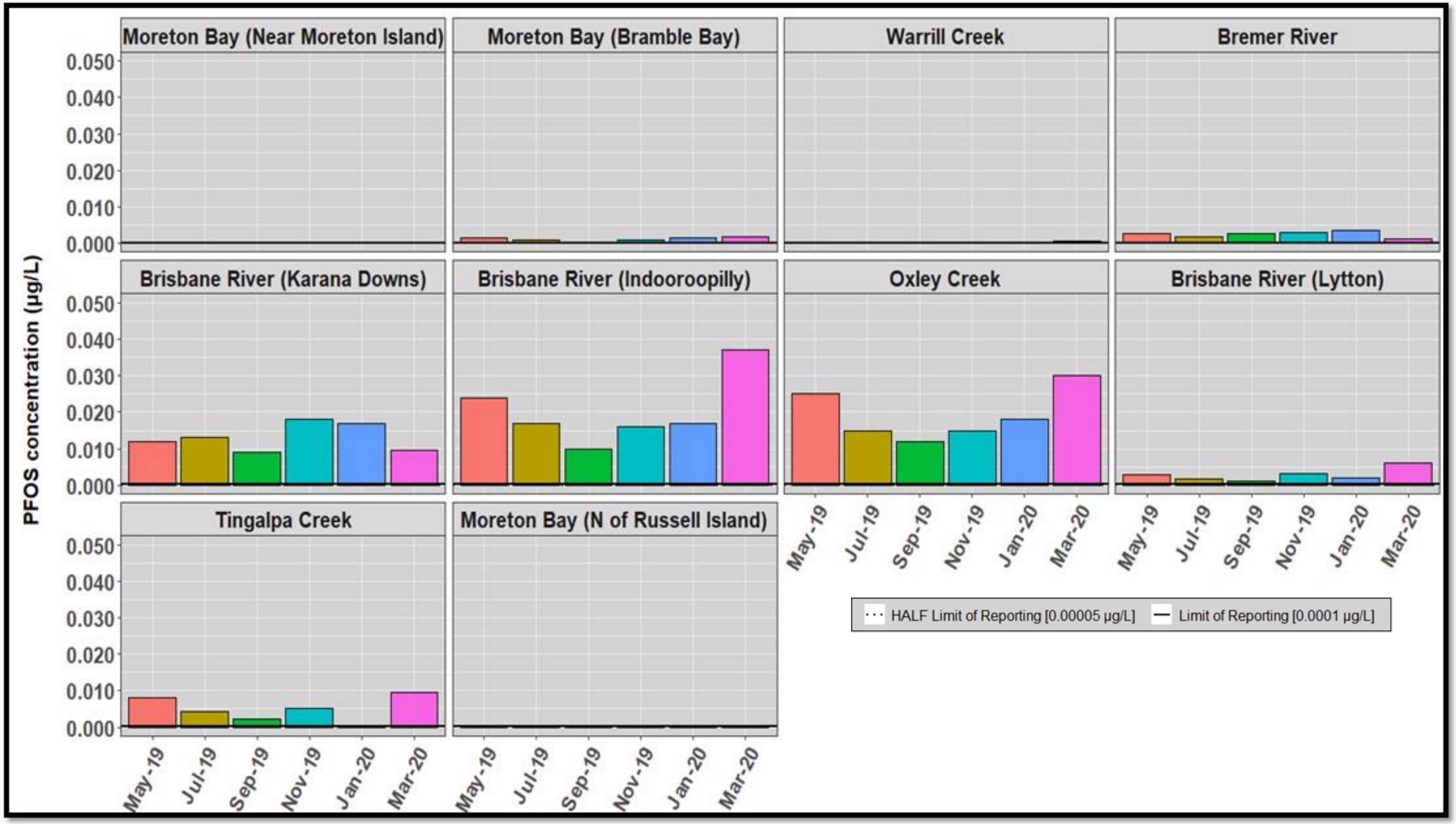

Figure 17: Reported concentrations of PFOS in water in the South East Queensland region (Greater Brisbane and Moreton Bay) over the six monitoring rounds (May 2019–March 2020.

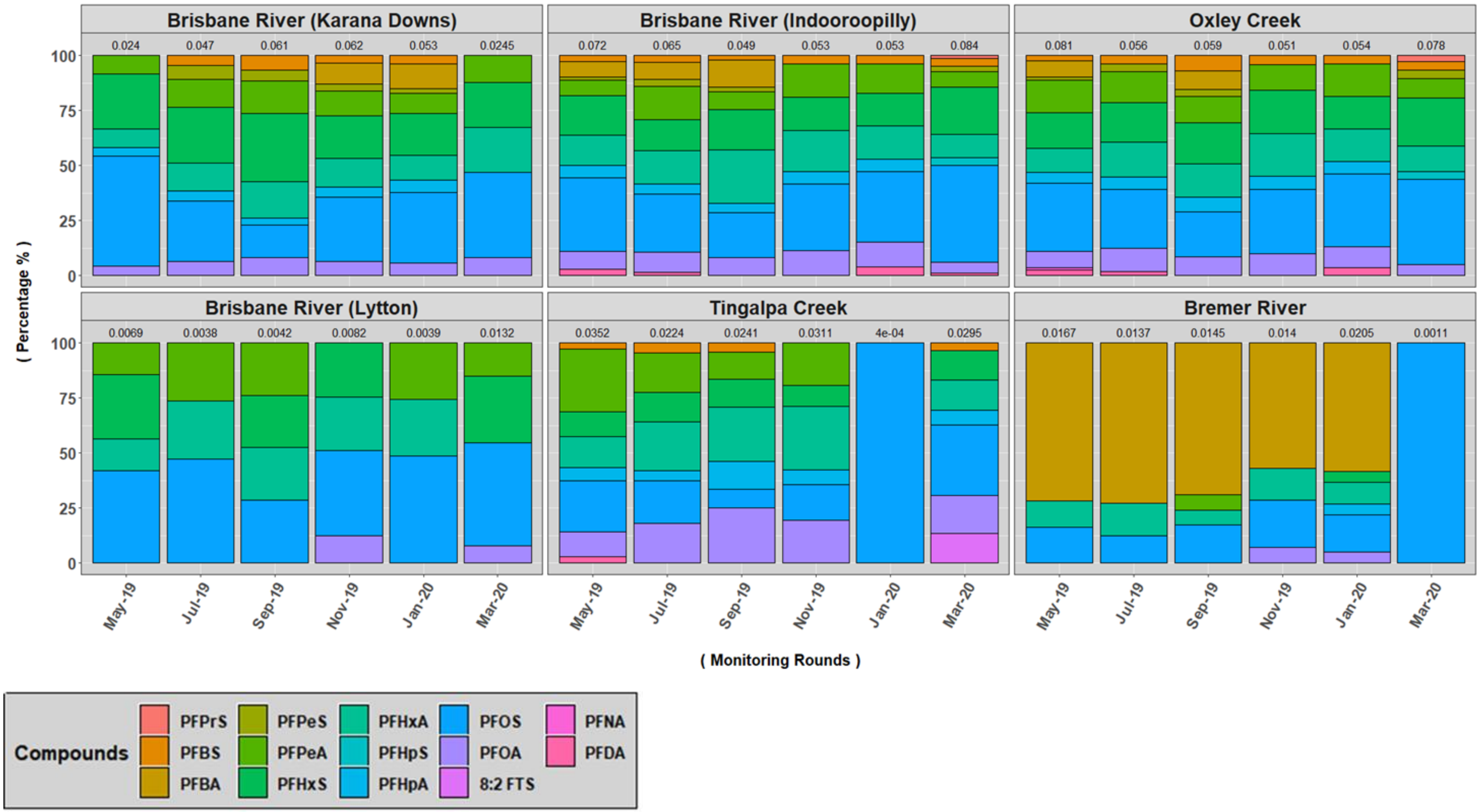

Figure 18: Proportion of PFAS (%) reported in water in the South East Queensland region (Greater Brisbane area). Total PFAS concentration (µg/L) presented at the top of each bar.

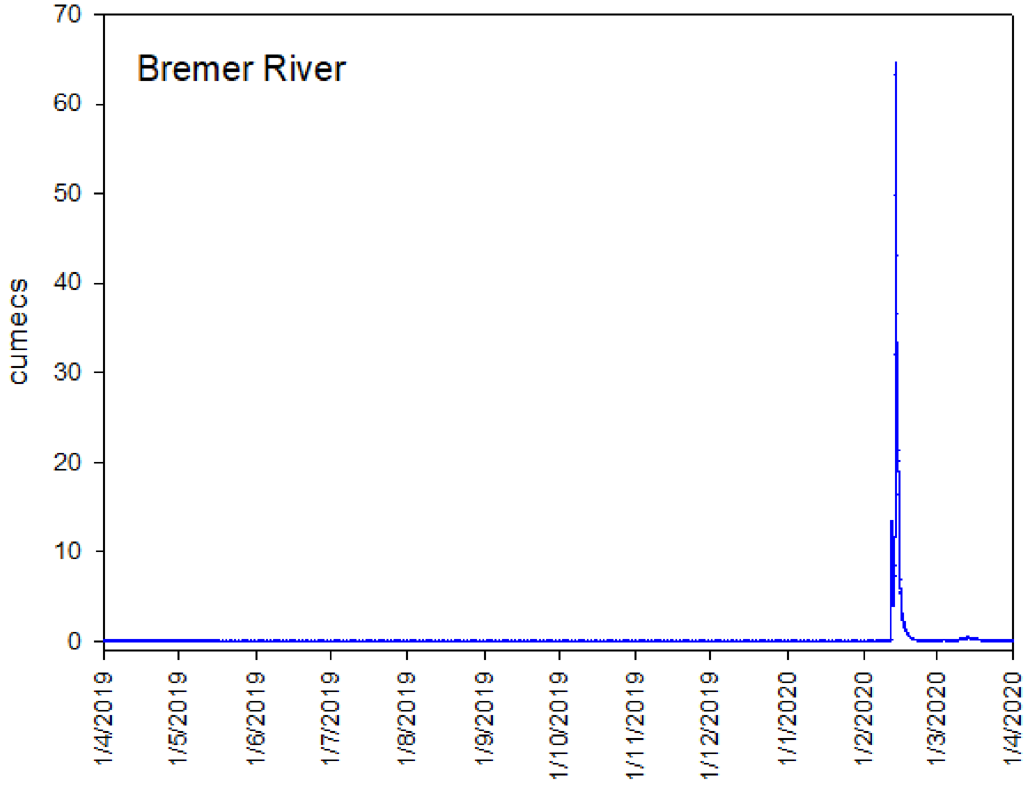

Figure 19: Flow at Bremer River at Walloon (Gauging Station 143107A). Cumecs are cubic metres per second.

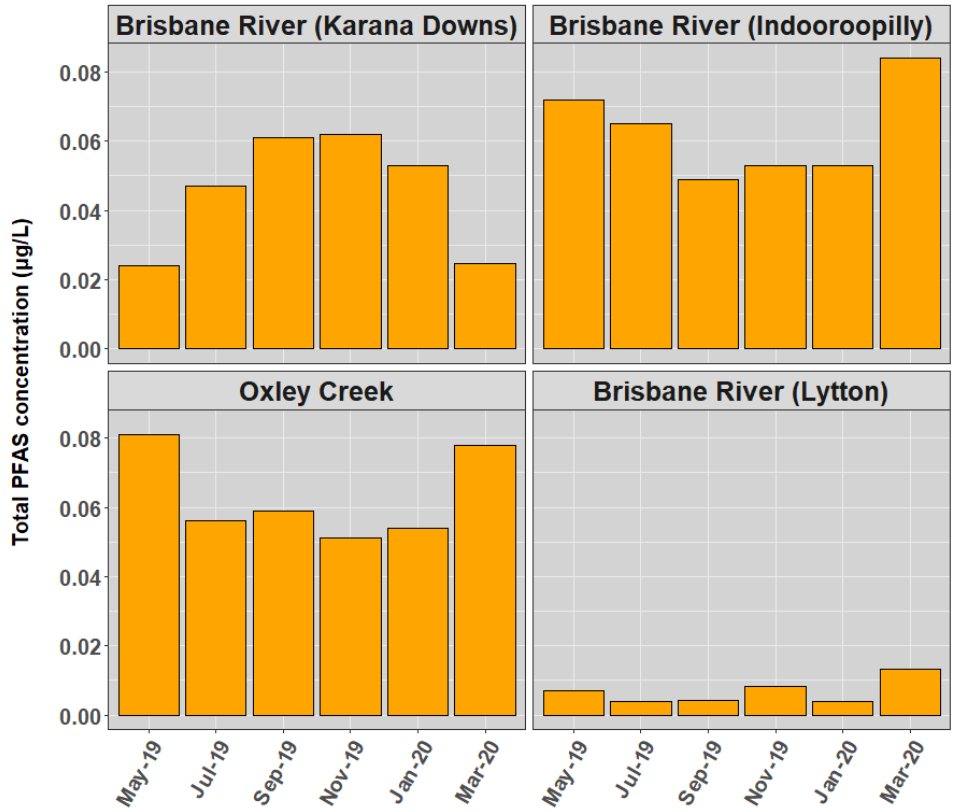

Figure 20: Total PFAS reported in water in the Brisbane River and Oxley Creek in the South East Queensland region (Greater Brisbane area).

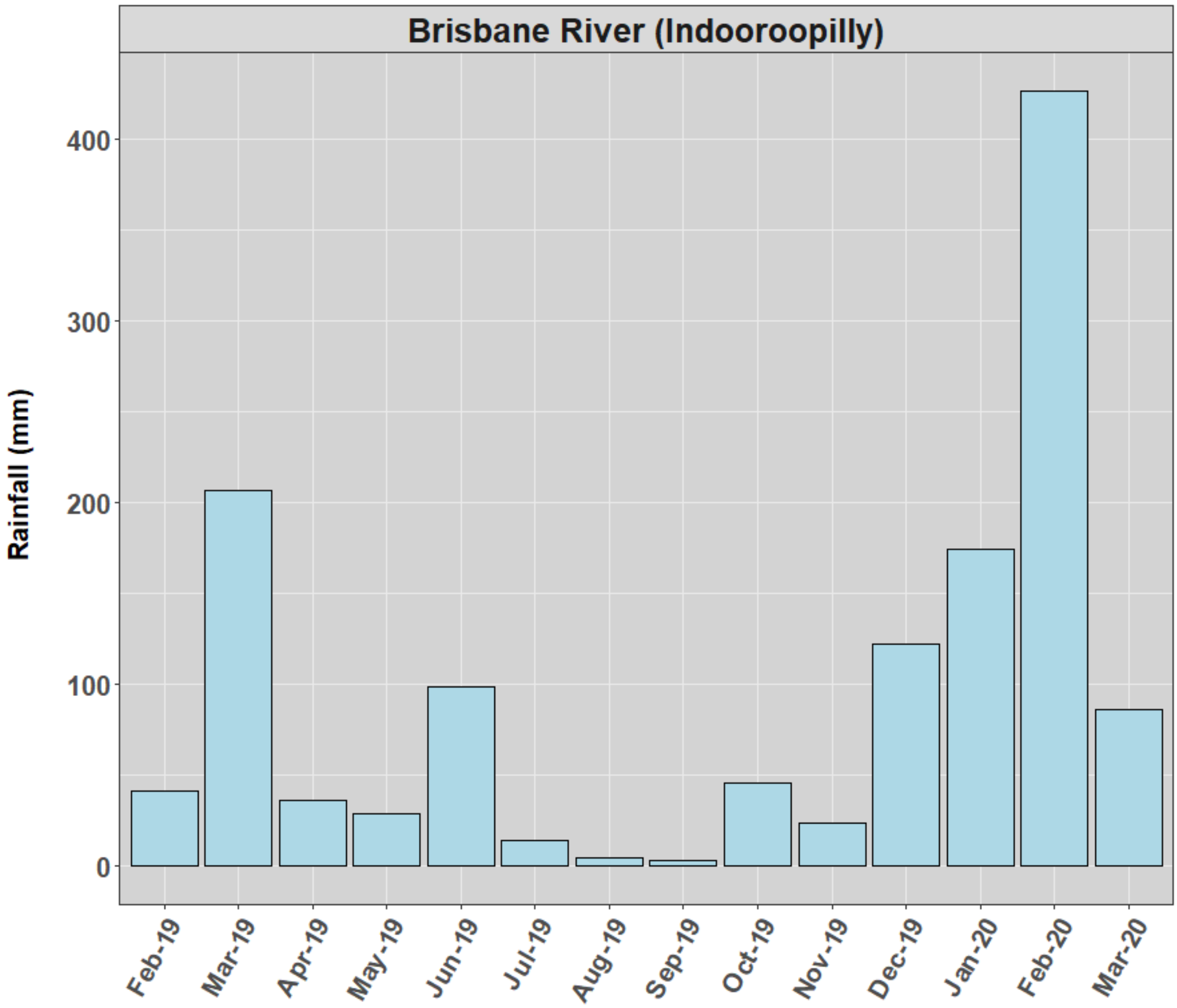

Figure 21: Rainfall by month in the Brisbane Area (February 2019–March 2020).

Figure 22: Pearson's correlation between PFOS and Turbidity in the Brisbane River and Oxley Creek sites.

Across the three sample sites in the Brisbane River (Karana Downs, Indooroopilly and Yeronga), nine species (seven fish and two invertebrates) were collected (Table 19). Fish were collected in December 2019 and invertebrates in March 2010. PFOS was reported in 91% of all samples. The highest level of PFOS for the Brisbane River was reported in fork-tailed catfish from Karana Downs (0.12 mg/kg) (Table 20). In Oxley Creek, three species of fish and one invertebrate species were collected in December 2019 (Table 20). PFOS was reported in all samples, and the highest concentration was reported in fork-tailed catfish (0.3 mg/kg). This concentration was higher than in the fork-tailed catfish samples from the Brisbane River, and the highest overall for all locations sampled.

Other PFAS reported in biota samples from Brisbane River and Oxley Creek included PFHxS, PFDA, PFTrDA, PFDoDA, FOSA and PFHpS. PFHxA was only reported in invertebrate samples from the Brisbane River (Table 19), PFUnDA, FOSA and PFHpS were only reported in fish samples from the Brisbane River (Table 19), and PFHpA was only reported in invertebrate samples from Oxley Creek (Table 20).

PFHxA, PFHpA, PFDA, PFHxS and PFHpS were reported in both surface water and biota samples, whereas PFUnDA, PFDoDA, PFTrDA and FOSA were only reported in biota samples.

Table 19: PFAS concentrations (mg/kg ww) in biota samples collected in the Brisbane River (Karana Downs[1], Indooroopilly[2] and Yeronga[3]). **Range**, geometric average, and frequency of detection (%) are reported. In cases where concentrations were below the LOR, half the LOR was used for the calculation of the geometric average values. Note: Yeronga site was part of an ad hoc survey.

Brisbane River	PFHxA (LOR=0.0009-0.001)	PFDA (LOR=0.005)	PFUnDA (LOR=0.002)	PFDoDA (LOR=0.005)	PFTrDA (LOR = 0.002)	PFHxS (LOR =0.002)	PFOS (LOR=0.0009-0.001)	FOSA (LOR=0.002)
Fish								
Barred Javelin[2] (n=1)	<LOR	<LOR	<LOR	<LOR	0.002	<LOR	0.005	0.002
Bony Bream[1] (n=2)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	**0.013–0.02** 0.0161 100%	<LOR
Yellowfin Bream[1,2,3] (n=5)	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	**<LOR–0.004** 0.0009 60%	<LOR
Fork-tailed catfish (n=3)	<LOR	<LOR	<LOR	<LOR	<LOR	**<LOR–0.003** 0.002 67%	**0.063–0.12** 0.0883 100%	<LOR
Glassfish[1](n=2)	<LOR	**<LOR–0.005** 0.0038 50%	<LOR	<LOR	<LOR	<LOR	**0.04–0.071** 0.0533 100%	<LOR
Pike Eel[1] (n=1)	<LOR	0.007	0.002	0.006	0.002	<LOR	0.03	<LOR
River Perch[2,3] (n=3)	<LOR	<LOR	**0.003–0.004** 0.0033 100%	**0.005–0.008** 0.0067 100%	**0.002–0.003** 0.0023 100%	<LOR	0.0446 100%	<LOR
Invertebrates								
Fiddler crab[2] (n=1)	0.001	<LOR	<LOR	<LOR	<LOR	<LOR	0.002	<LOR
Furry clawed crab[2] (n=4)	**<LOR–0.002** 0.001 100%	<LOR	<LOR	<LOR	<LOR	<LOR	**0.002–0.003** 0.0035 100%	<LOR

Table 20: PFAS concentrations (mg/kg ww) in biota samples collected in Oxley Creek. **Range**, geometric average, and frequency of detection are reported. In cases where concentrations were below the LOR, half the LOR was used for the calculation of the geometric average and median values.

Oxley Creek	PFHpA (LOR=0.002)	PFDA (LOR =0.005)	PFDoDA (LOR =0.005)	PFTrDA (LOR =0.002)	PFHxS (LOR =0.002)	PFOS (LOR=0.001)
Fish						
Yellowfin bream (n=2)	<LOR	<LOR	<LOR	<LOR	<LOR	**0.003** 0.003 (100%)
Fork-tailed catfish (n=5)	<LOR	**<LOR–0.014** 0.0049 (60%)	**<LOR–0.007** 0.0031 (20%)	**<LOR–0.002** 0.0011 (20%)	**<LOR–0.005** 0.0014 (20%)	**0.027–0.3** 0.0821 (100%)
Sea mullet (n=5)	<LOR	<LOR	<LOR	<LOR	<LOR	**0.01–0.013** 0.0117 (100%)
Invertebrates						
Furry clawed crab (n=4)	**<LOR–0.004** 0.0019 (50%)	<LOR	<LOR	<LOR	<LOR	**0.007–0.009** 0.0077 (100%)

Three species of fish and two species of invertebrates were collected in Tingalpa Creek (Table 21). PFOS was reported in all fish samples, and one of the invertebrate samples (fiddler crab). The highest concentration of PFOS from Tingalpa Creek was reported in a fork-tailed catfish sample (0.036 mg/kg). PFDA (0.007 mg/kg) and PFDoDA (0.006 mg/kg) were also reported in the fork-tailed catfish (Table 21). One invertebrate species (Mangrove worm) had no reported PFAS.

Table 21: PFAS concentrations (mg/kg ww) in biota samples collected in Tingalpa Creek. **Range**, geometric average, and frequency of detection are reported. In cases where concentrations were below the LOR, half the LOR was used for the calculation of the geometric average values.

Tingalpa Creek	PFDA (LOR=0.005)	PFDoDA (LOR=0.005)	PFOS (LOR=0.001)
Fish			
Silverbiddy (n=1)	<LOR	<LOR	0.002
Fork-tailed catfish (n=1)	0.007	0.006	0.036
Sea mullet (n=2)	<LOR	<LOR	**0.004** 0.004 (100%)
Invertebrates			
Fiddler crab (n=3)	<LOR	<LOR	**<LOR–0.001** 0.0006 (33%)
Mangrove worm (n=1)	<LOR	<LOR	<LOR

3.3.5.2.3 Logan and Gold Coast (Broadwater) subregion

PFOS was reported at or around the limit of reporting in the majority of samples at three out of the four sites sampled in the Logan and Gold Coast area (Figure 23, Figure 24, Table 22, Table 23), with no other PFAS reported. However, six PFAS were reported above the LOR in water samples at the Logan River at Eden's Landing, (Figure 24, Table 23). In contrast to other sites, the median PFOS concentration (0.0032 µg/L) was similar to other PFAS reported at this site (PFPeA, PFHxA, PFHpA, PFOA, PFHxS) with median concentrations ranging between 0.001 µg/L and 0.004 µg/L.

No seasonal trend was evident at this site. Water samples were collected for TOP Assay at one site in the Logan River. Detectable levels of PFAS compounds were present after the TOP Assay but were lower than the results from the pre-TOP Assay, indicating that no precursors were present above the LOR in the sample. All PFAS compounds were below the LOR (0.001 mg/kg) in the sediment samples collected at the two Logan River sites.

Three species of fish and two species of invertebrates were sampled in the Logan River (Eden's Landing) (Table 23). PFOS was the only compound reported and was present in all species. The highest concentration of PFOS was reported in fork-tailed catfish (0.018 mg/kg).

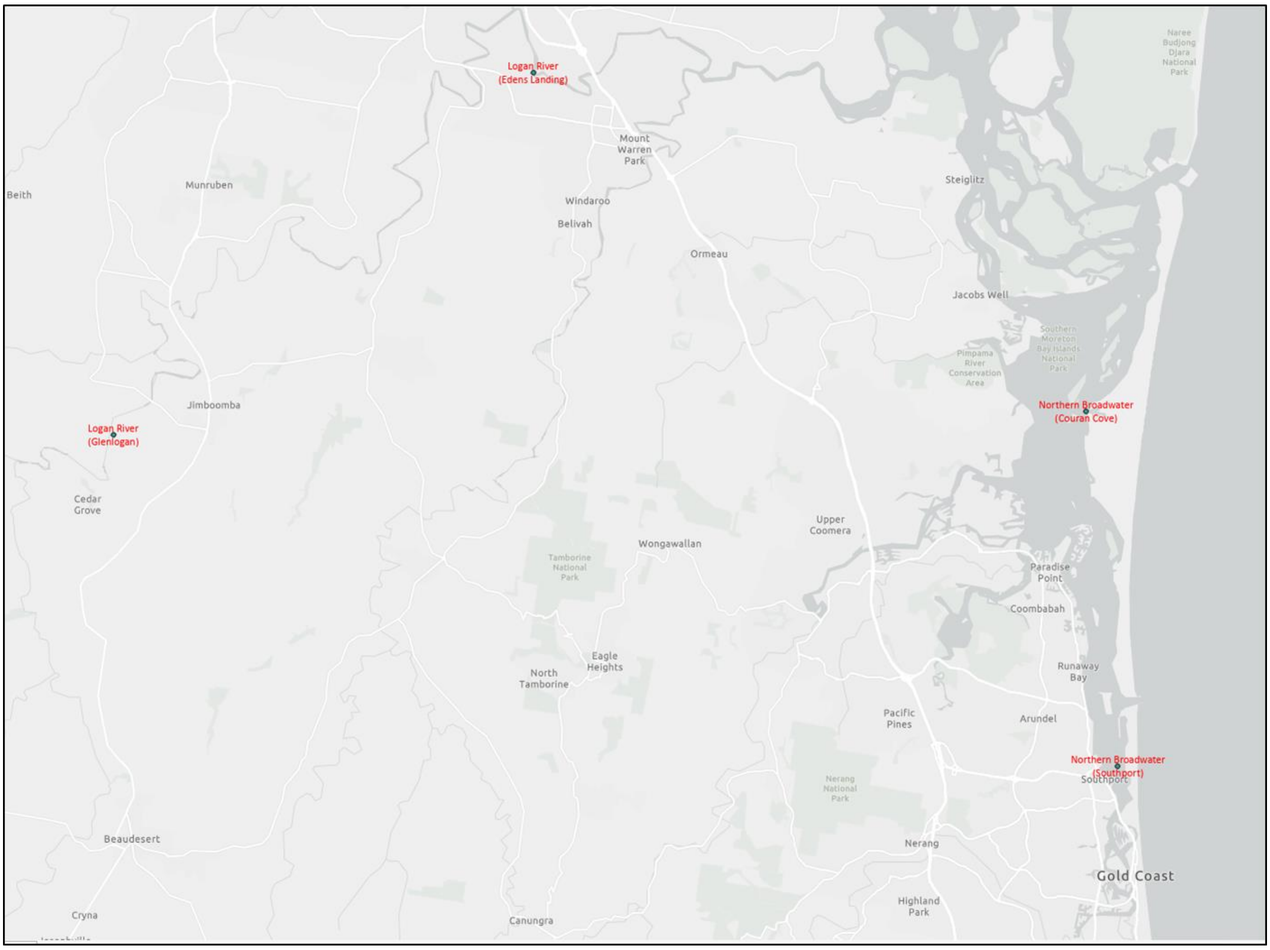

Figure 23: Sampling sites, Logan to Gold Coast.

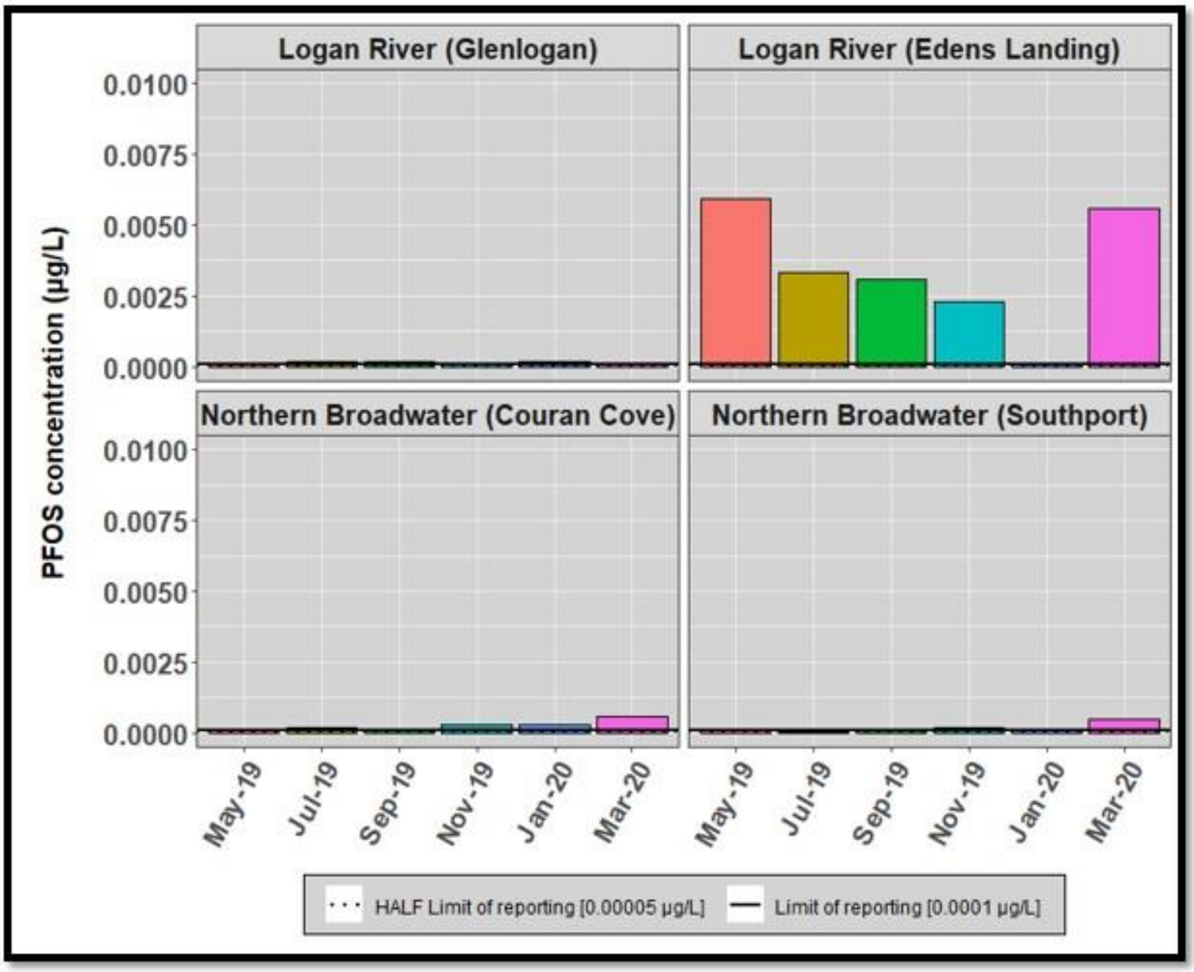

Figure 24: Reported concentrations of PFOS in water in the South East Queensland region (Logan and Gold Coast) over the six monitoring rounds (May 2019–March 2020).

Table 22: PFAS concentrations (µg/L) in water samples collected in the South East region, Logan and the Gold Coast (Broadwater). **Median**, **range**, geometric average, and frequency of detection (%) are reported. In cases where concentrations were below the LOR, half the LOR was used for the calculation of the geometric average and median values.

Logan and Gold Coast	PFPeA (LOR=0.001)	PFHxA (LOR=0.001)	PFHpA (LOR=0.001)	PFOA (LOR=0.001)	PFHxS (LOR=0.001)	PFOS (LOR=0.0001)
Logan River (Glenlogan) (n=6)	<LOR	<LOR	<LOR	<LOR	<LOR	**0.0001** **<LOR–0.0002** 0.0001 50%
Logan River (Edens Landing) (n=6)	**0.004** **<LOR–0.005** 0.0021 67%	**0.003** **<LOR–0.006** 0.0025 83%	**0.001** **<LOR–0.001** 0.0008 67%	**0.003** **<LOR–0.004** 0.0020 83%	**0.002** **<LOR–0.002** 0.0013 67%	**0.0032** **<LOR–0.0059** 0.0018 83%
Northern Broadwater (Couran Cove) (n=6)	<LOR	<LOR	<LOR	<LOR	<LOR	**0.0003** **<LOR–0.0006** 0.0002 67%
Northern Broadwater (Southport) (n=6)	<LOR	<LOR	<LOR	<LOR	<LOR	**0.0001** **<LOR–0.0005** 0.0002 50%

Table 23: PFOS concentrations (mg/kg ww) in biota samples collected in the Logan River. **Range**, geometric average, and frequency of detection (%) are reported. In cases where concentrations were below the LOR, half the LOR was used for the calculation of the geometric average values.

Logan River	**PFOS (LOR=0.001)**
Fish	
Yellowfin bream (n=3)	**<LOR–0.001** 0.0006 33%
Fork-tailed catfish (n=5)	**0.002–0.018** 0.0075 100%
Longfinned eel (n=1)	0.012
Invertebrates	
Furry clawed crab (n=3)	**0.002–0.003** 0.0023 100%
Prawn (n=5)	**0.004–0.005** 0.0046 100%

4 Summary of grey literature

Other data were collated from reports relating to investigations into potential PFAS contamination, undertaken by private and public entities in Queensland. Within the information collected, only data from ambient sites were selected for inclusion in this report. Where quality control data were provided, these were reviewed prior to including data in this summary. The sources of these collated data cannot be referenced as they were provided confidentially. Samples were collected between 2017 and 2019, and some sites were sampled on more than one date. The LORs for PFAS compounds vary between laboratories and according to the analyses conducted. Where possible, a LOR range has been included to provide a perspective on the data summarised. For biota, only whole samples were included in the summary. The data reviewed includes composite and single samples. Where a sample from a specimen (i.e. flesh) was taken and the carcass was analysed separately, the carcass sample was considered as whole sample and included in this summary. This allowed for comparisons between different sites.

4.1 Cape York

Four ambient sampling sites from the grey literature are in this region, all in the vicinity of Weipa (Andoom Creek, North Pine River Bay, Mission River, Hey River). Water and sediment samples were collected at all sites and no PFAS were reported. These sites are adjacent to predominantly conservation and forestry/grazing land use types.

4.2 Wet Tropics

Four ambient sampling locations for water have been reported in the grey literature from this region (Smiths Creek in Cairns, the Barron River at Myola, the Johnstone River at Coquette Point, and the Tully River at Euramo). The Smiths Creek site is adjacent to an urban/ industrial area, whereas the remaining sites are in forestry/grazing, or agricultural land use types. PFOS was reported at 0.0006 µg/L at Smiths Creek. No other PFAS were reported. There were no PFAS reported in water samples for the three remaining sampling locations.

Fish and invertebrate samples from two sampling sites in Smiths Creek in Cairns were included in this report. The results for these sites were pooled as the two sites were close to each other (<3 km). The available data shows up to eight PFAS were reported in fish (51 samples of 27 phyla as listed in the source material) and invertebrates (15 samples of 6 phyla as listed in the source material) (Table 24). The highest PFOS concentration in fish was from a sample of queenfish at 0.011 mg/kg, and 0.015 mg/kg in a sample of sea lice

4.3 Burdekin

Six ambient water sampling locations with one site each are reported in the grey literature in this region (Bohle and Ross rivers in Townsville, Barratta Creek at Northcote, Burdekin River at Home Hill, Bonnie Doon Creek at Strathalbyn and the Bowen River at Myuna). PFOS was reported in water samples at the Bohle and Ross rivers in Townsville which are located in an urban/ industrial areas (Table 24). Ten PFAS were reported in the Bohle River, which were PFPeA, PFHxA, PFHpA, PFOA, PFDA, PFBS, PFPeS, PFHxS, PFHpS, and PFOS. No PFOS was reported from the Ross River, and the PFAS were dominated by short chained compounds (PFBA, PFPeA, PFHxA, PFBS and PFPeS) as well as PFHxS and PFOSA (Table 24). There were no PFAS reported in water samples for the four remaining sampling locations (Barratta Creek at Northcote, Burdekin River at Home Hill, Bonnie Doon Creek at Strathalbyn, Bowen River at Myuna). These sites are all near forestry/grazing and agricultural land use types.

4.4 Mackay Whitsunday

Seven ambient water sampling locations are reported in the grey literature in this region: the O'Connell River at Staffords Crossing, Proserpine River at Glen Isla (both near forestry/grazing and agricultural areas), Barnes Creek, Vines Creek and three sites in the Basset Basin in Mackay (near urban/industrial areas). No PFAS were reported at any sites, apart from Vines Creek where PFOS was reported at 0.0007 µg/L and PFHxS at 0.0008 µg/L. No other PFAS were reported at this site.

Sediment samples were collected at five of these sampling locations (Vines Creek, Barnes Creek, and the three sites in the Basset Basin in Mackay). PFAS were reported in a field duplicate collected at one site in the Basset Basin (PFOA 0.0002 mg/kg, and PFHxA 0.0003 mg/kg); however, these were reported below the LOR in the other sample. No other PFAS were reported at concentrations above the LOR in the sediment samples.

Six samples of mud crab from one sampling site in Vines Creek were included in this report. Three PFAS (PFHpA, PFOS and PFOA) were reported (Table 24). PFAS was reported above the LOR in one of the six samples (17%), with concentrations of the three compounds being relatively similar (between 0.001 and 0.002mg/kg).

Table 24: Concentrations of PFAS in invertebrates from the Mackay Whitsunday Region in mg/kg reported in the grey literature. **Median**, **range**, geometric average, and frequency of detection (%) are reported. In cases where concentrations were below the LOR, half the LOR was used for the calculation of the geometric average and median values. All samples were collected in Vines Creek.

Mackay Whitsunday	PFHpA	PFOA	PFOS
Mud crab (n=6)	**0.0005** **<0.001–0.001** 0.0006 17%	**0.0005** **<0.001–0.002** 0.0006 17%	**0.0005** **<0.001–0.002** 0.0006 17%

4.5 Burnett Mary

Two ambient water sampling locations are reported in the grey literature in this region (Gregory River at Leesons and a tributary of Snapper Creek adjacent to the Wide Bay Training Area). Sites are in agricultural land use and conservation areas respectively. Only PFOS was reported from Snapper Creek at low levels (0.0005 ug/L). No PFAS were reported from Gregory River at Leesons site.

4.6 Condamine

Three ambient water sampling sites are reported in the grey literature in this region, including two at Oakey Creek, and one at Kogan. These sites are near forestry/grazing and agricultural land use areas. No PFAS were reported at these sites.

4.7 South East Queensland

Results for water samples from 14 ambient sampling locations were available in the grey literature in this region, with PFAS reported above the LOR in water samples at eight of the 14 sites (Table 26). These eight sites are near predominantly urban/industrial areas. PFOS was reported in all samples, and had a maximum concentration of 0.0082 µg/L in a sample from Yebri Creek at Petrie, a tributary of the North Pine River. Ten PFAS were reported above the LOR at this site. The location with the most PFAS was also in the North Pine River at a site near Bald Hills, with 13 different PFAS reported in water samples (Table 26), which is upstream of a known contaminated site and a WWTP. As well as PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, and PFOS (which were typically found at other sites), longer chain PFCAs and PFSAs (PFDS, PFNA, PFDA, PFUnDA, PFDoDA and PFTrDA) were also reported in the water in the North Pine River. The PFOS concentration was approximately twice as high as other PFAS. The concentration of

PFAS found at the mouth of the North Pine River were much lower than that of upstream sites, indicating flushing with water from Moreton Bay was diluting the concentration of PFAS.

Sediment samples were collected at five of these 14 sampling locations (North Pine River at Joyner and Yebri Creek at Petrie, and two sites in the North Pine River). No PFAS were reported (LOR 0.0001–0.0005 mg/kg).

Fish and invertebrate samples from 10 ambient sampling sites in South East Queensland were available in the grey literature. In the Noosa to Caboolture area, fish samples were available for the Maroochy River and Pumicestone Passage. PFOS was reported in all samples. Two other PFAS (PFDoDA and PFDA) were reported above the LOR from biota samples from the Maroochy River, but not the Pumicestone Passage.

In the Greater Brisbane Area, biota samples were available for two sites in the North Pine River, one site in Yebri Creek (tributary of the North Pine River), and one site each in Cabbage Tree Creek, Tingalpa Creek, the Bremer River and Warrill Creek. The available data showed 10 PFAS that were reported in fish and four PFAS that were reported in invertebrates (Table 27). PFOS was reported in all biota samples. The highest PFOS concentration was 0.059 mg/kg in fish (Purple-Spotted Gudgeon from Yebri Creek), and 0.0038 mg/kg in invertebrates (mangrove crabs collected in the North Pine River). In fish samples, PFDA (maximum: 0.0076 mg/kg) and PFDoDA (maximum: 0.013 mg/kg) were reported relatively frequently (42% and 36%, respectively). Other PFAS were reported in less than 15% of the fish samples. Invertebrate samples from South East Queensland had three other PFAS other than PFOS reported above the LOR (PFHxA, PFHpA and PFOA) at an equal detection frequency of 50% in mangrove crabs.

Table 25 Summary of PFAS concentrations (µg/L) in water samples collected in the Burdekin region at other ambient locations reported in the grey literature. **Range**, geometric average, and frequency of detection (%) are reported. In cases where concentrations were below the LOR, half the LOR was used for the calculation of the geometric average values. Note: the LOR varies due to different laboratories used.

Burdekin Region	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFDA	PFBS	PFPeS	PFHxS	PFHpS	PFOS	PFOSA
Bohle (Townsville) (n=1)	<0.002	0.0045	0.0051	0.0013	0.0069	0.0018	0.0237	0.0011	0.0085	0.0005	0.035	<0.0005
Ross River (Townsville)(n=3)	**0.0063–0.0071** 0.0067 100%	**0.0022–0.003** 0.0025 100%	**0.0014–0.0016** 0.0015 100%	<0.001	<0.001	<0.001	**0.0029–0.003** 0.0029 100%	<0.001	**0.0012–0.0016** 0.0013 100%	<0.001	<0.002	**<0.001–0.0036** 0.0010 50%
Barratta Creek at Northcote (n=1)	<0.01	<0.007	<0.005	<0.005	<0.007	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.04
Burdekin River at Home Hill (n=1)	<0.01	<0.007	<0.005	<0.005	<0.007	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.04
Bonnie Doon Creek at Strathalbyn (n=1)	<0.01	<0.007	<0.005	<0.005	<0.007	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.04
Bowen River at Myuna (n=1)	<0.01	<0.007	<0.005	<0.005	<0.007	<0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.04

Table 26: Summary of PFAS concentrations (µg/L) in water samples collected in the SEQ region at other ambient locations reported in the grey literature. **Median**, **range**, average and frequency of detection (%) are reported. In cases where concentrations were below the LOR, half the LOR was used for the calculation of the average and median values.

SEQ	Stream type	Land use	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnDA	PFDoDA	PFTrDA	PFBS	PFHxS	PFOS	PFDS
Noosa to Caboolture																
Marcoola Marsh (n=1)	Wallum stream	Conservation (natural)	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.0005**	**0.003**
Southern Drain (n=1)	Wallum stream	Intensive use (urban/industrial)	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.0008**	<0.001
Marcoola Drain (Maroochy River) (n=1)	Wallum stream	Conservation (natural)	<0.005	**0.002**	**0.002**	<0.001	**0.003**	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	**0.0017**	<0.001
Coochin Creek (n=3)	Lowland stream	Agriculture (dryland)	<0.01	<0.007	<0.005	<0.005	<0.007	<0.007	<0.01	<0.01	<0.02	<0.05	<0.005	<0.005	<0.005	<0.02
Back Creek (n=3)	Lowland stream	Agriculture (dryland)	<0.01	<0.007	<0.005	<0.005	<0.007	<0.007	<0.01	<0.01	<0.02	<0.05	<0.005	<0.005	<0.005	<0.02
Caboolture River (Upper Caboolture) (n=3)	Lowland stream	Forestry/ grazing (native)	<0.01	<0.007	<0.005	<0.005	<0.007	<0.007	<0.01	<0.01	<0.02	<0.05	<0.005	<0.005	<0.005	<0.02
Greater Brisbane																
Yebri Creek (Petrie) (n=1)	Coastal stream	Intensive use (urban/industrial)	<0.005	**0.002**	**0.002**	**0.002**	**0.004**	<0.001	**0.001**	<0.001	**0.001**	**0.001**	**0.001**	**0.004**	**0.0082**	<0.001
North Pine River (Joyner) (n=1)	Lowland stream[a]	Intensive use (urban/industrial)	<0.005	**0.002**	**0.002**	**0.001**	**0.002**	<0.001	**0.002**	<0.001	<0.001	<0.001	**0.001**	<0.001	**0.0035**	<0.001
North Pine River (Bald Hills) (n=2)	Middle estuary	Intensive use (urban/industrial)	**<0.005–0.008** 0.0045 50%	**0.002–0.003** 0.0024 100%	**0.002–0.003** 0.0024 100%	**<0.001–0.001** 0.0007 50%	**0.001–0.004** 0.002 100%	**<0.001–0.001** 0.0007 50%	**<0.001–0.002** 0.001 50%	**<0.001–0.002** 0.001 50%	**<0.001–0.001** 0.0007 50%	**<0.001–0.003** 0.0012 50%	<0.001	**<0.001–0.001** 0.0007 50%	**0.0024–0.0058** 0.0037 100%	**<LOR–0.002** 0.001 50%
North Pine River (Mouth) (n=1)	Enclosed coastal	Intensive use (urban/industrial)	<0.005	**0.002**	**0.002**	<0.001	**0.002**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.004**	<0.001
Bremer River near Walloon (n=3)	Lowland stream	Intensive use (urban/industrial)	<0.01	<0.007	<0.005	<0.005	<0.007	<0.007	<0.01	<0.01	<0.02	<0.05	<0.005	<0.005	<0.005	<0.02
Warrill Creek at Purga (n=2)	Lowland stream	Forestry/ grazing (native	<0.01	<0.007	<0.005	<0.005	<0.007	<0.007	<0.01	<0.01	<0.02	<0.05	<0.005	<0.005	<0.005	<0.02
Logan and Gold Coast																
Logan River (Glenlogan) (n=3)	Lowland stream	Intensive use (urban/industrial)	<0.01	<0.007	<0.005	<0.005	<0.007	<0.007	<0.01	<0.01	<0.02	<0.05	<0.005	<0.005	<0.005	<0.02
Cobaki Broadwater	Estuarine	Intensive use	<0.01	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	**0.001** **<LOR–**	**0.001** **<LOR–**	<0.002

SEQ	Stream type	Land use	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnDA	PFDoDA	PFTrDA	PFBS	PFHxS	PFOS	PFDS
(Gold Coast) (n=22)		(urban/in dustrial)												**0.003** 0.0011 4%	**0.003** 0.0012 29%	

a This site is classified as lowland stream, but is under tidal influence, as noted in source material.

Table 27: Concentrations of PFAS in fish and invertebrates from SEQ in mg/kg reported in the grey literature. **Range**, average and frequency of detection (%) are reported. In cases where concentrations were below the LOR, half the LOR was used for the calculation of the average values.

Region	Biota	PFHxA	PFHpA	PFOA	PFDA	PFUnDA	PFDoDA	PFTrDA	PFTeDA	PFHxS	PFOS	PFDS	NEtFOSA	FOSA
Noosa to Caboolture														
Maroochy River	**Gambusia (n=1)**	<0.001	<0.001	<0.001	<0.001	<0.002	0.009	<0.002	<0.005	<0.001	0.006	<0.001	NT	NT
	Empire Gudgeon (n=1)	<0.001	<0.001	<0.001	0.002	<0.002	0.01	<0.002	<0.005	<0.001	0.006	<0.001	NT	NT
	Platy (n=1)	<0.001	<0.001	<0.001	<0.001	<0.002	0.006	<0.002	<0.005	<0.001	0.005	<0.001	NT	NT
Pumicestone Passage	**Flathead (n=2)**	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	**<0.001–0.0025** 0.0011 (50%)	<0.0005	<0.0005	<0.0005
	Whiting (n=2)	<0.0005	<0.00065	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	**<0.005–0.0008** 0.0014 (50%)	<0.0005	<0.0005	<0.0005
	Bream (n=2)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005–<0.005	<0.0005	<0.0005	<0.0005
Greater Brisbane and Moreton Bay														
Fish														
Yebri Creek	**Purple spotted gudgeon (n=1)**	<0.0005	<0.0005	<0.0005	0.0076	0.0035	0.013	0.005	0.0085	<0.0005	0.059	<0.0005	<0.0005	0.0007
	Swordtail (n=1)	<0.005	<0.005	<0.005	0.0068	0.0025	0.0063	<0.005	<0.005	<0.005	0.055	<0.005	<0.005	<0.005
North Pine River	**Tiger Mullet (n=1)**	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	0.0004	<0.0005	<0.0005	<0.0005
	Silver Biddy (n=2)	<0.0005	<0.0005	<0.0005	**0.0007** 0.0007 (100%)	<0.0005	**<0.0005–0.0006** 0.0004 (50%)	<0.0005	<0.0005	<0.0003	**0.0038–0.0044** 0.0041 (100%)	<0.0005	<0.0005	<0.0005
	Yellowfin Bream (n=3)	<0.0005	<0.0005	<0.0005	**<0.0005–0.0017** 0.0005 (33%)	<0.0005	**<0.0005–0.0006** 0.0003 (33%)	<0.0005	<0.0005	<0.0003	**0.0004–0.0097** 0.0014 (100%)	<0.0005	<0.0005	**<0.0005–0.0005** 0.0003 (33%)
	Bony Herring (n=1)	<0.0005	<0.0005	0.0005	0.0007	<0.0005	<0.0005	<0.0005	<0.0005	0.0004	0.012	<0.0005	<0.0005	<0.0005
Cabbage Tree Creek	**Mullet (n=1)**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001

Region	Biota	PFHxA	PFHpA	PFOA	PFDA	PFUnDA	PFDoDA	PFTrDA	PFTeDA	PFHxS	PFOS	PFDS	NEtFOSA	FOSA
Bremer River	**Eel-tailed catfish (n=1)**	<0.0005	<0.0005	<0.0003	0.001	<0.0005	<0.0005	<0.0005	0.0005	0.0006	0.032	<0.0005	<0.0005	<0.0005
Warrill Creek	**Australian bass (n=2)**	<0.0005	<0.0005	<0.0003	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	**0.002–0.0044** 0.0030 (100%)	<0.0005	**<LOR–0.0019** 0.0007 (50%)	<0.0005
	Sea mullet (n=1)	<0.0005	<0.0005	<0.0003	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	0.0042	0.0016	<0.0005	<0.0005
	Eel-tailed catfish (n=1)	<0.0005	<0.0005	<0.0003	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	0.01 (100%)	<0.0005	<0.0005	<0.0005
Tingalpa Creek	**Mullet (n=2)**	<0.0005	<0.0005	<0.0005	**0.0009–0.001** 0.0009 (100%)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	**0.003–0.004** 0.0035 (100%)	<0.0005	<0.0005	<0.0005
Invertebrates														
Yebri Creek	**Water snails (n=1)**	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0015	<0.005	<0.005	<0.005
North Pine River	**Small mussels (n=1)**	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	0.0011	<0.0005	<0.0005	<0.0005
	Mangrove crabs (n=2)	**<0.0005–0.0007** 0.0004 (50%)	**<0.0005–0.0012** 0.0005 (50%)	**<0.0005–0.0006** 0.0004 (50%)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	**0.0007–0.0038** 0.0016 (100%)	<0.0005	<0.0005	<0.0005
Warrill Creek	**Macroinvertebrates (n=1)**	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	0.0007	<0.0005	<0.0005	<0.0005

5 Summary and discussion

Although PFAS are considered to be ubiquitous compounds, the results from this ambient monitoring program and the analysis of the grey literature indicate that this is not a completely valid statement for water, sediment and biota in Queensland. Fifty-five sites were sampled six times during the ambient monitoring program and no PFAS were reported in water collected from eight sites (15% total) in any of the six rounds. Of the remaining 47 sites, PFOS was the only PFAS found at 21 sites (38% of total) with a median value of ≤0.0003 µg/L (≤3xLOR) at these sites.

The highest concentrations and variety of PFAS were found at sites surrounded by urban and industrial land, which is consistent with other studies (Scott *et al.* 2009; Nakata *et al.* 2006; Yamashita *et al.* 2005; Rankin *et al.* 2016; Sardiña *et al.* 2019; J.W. Lee *et al.* 2020). In this ambient monitoring program, PFAS were reported close to the LOR at sites in the agricultural and conservation areas of the Wet Tropics, Fitzroy and Burnett Mary regions, and in the Mackay Whitsunday region, with the exception of Vines Creek in Mackay, which is next to an industrial area. PFAS were reported in the highest concentrations in the SEQ region, with the most compounds also being reported in urban/industrial areas. A review of the grey literature found that PFAS was reported at only 14 of the 45 ambient sites. No PFAS were reported in water samples collected at the sites in the Cape York, Burnett Mary, and Condamine regions. In the Wet Tropics, Burdekin and Mackay Whitsundays, PFAS were reported at a small number of sites in urban and industrial areas. As with the ambient program results, in the grey literature the highest concentrations of PFAS were found in the SEQ region.

In urban and industrial areas, PFOS was reported at the highest concentration of all PFAS and reported above the LOR in most samples. The patterns of other PFAS depended upon the area, and presumably the source. Similar to this study, Thompson *et al.* (2011) found PFOS to be the dominant PFAS in water, with PFOA, PFHxA, PFHpA, PFBS and PFHxS reported at higher concentrations than other compounds. Overall, the concentrations of PFAS reported in the most contaminated sites in the Brisbane River and Oxley Creek, were two to four times higher than the mean of those reported in the Parramatta River by Thompson *et al.* (2011). It should be noted that Thompson *et al.* (2011) was a study of a single river and may not be representative of other areas in NSW (i.e. was not designed as an ambient study). When comparing PFAS concentrations to those reported in Victoria, the maximum of all PFAS reported in the Brisbane River were consistently lower than the maximum concentrations reported by Sardiña *et al.* (2019), but were higher or equal to the Victorian estuarine results provided by Allinson *et al.* (2019). The PFOS concentrations reported in South Australia were lower than those found in the Brisbane River area. A similar pattern of PFAS was found by Allinson *et al.* (2019) in their estuarine sites, with PFOS and PFHxS reported in the highest concentrations at both freshwater and estuarine sites, followed by PFOA and PFHxA.

The TOP Assay was undertaken on water samples at sites where PFAS had been reported above the LOR, and results indicated that there were generally no precursors or 'unseen' PFAS reported above the LOR in the samples for this ambient program.

The seasonal variability of PFAS in water is not clear, with some authors reporting no seasonal variability in PFAS concentration, and others reporting lower concentrations in the wet season, coinciding with high rainfall and dilution. In the SEQ area, where PFAS were reported at elevated concentrations, seasonal patterns in total PFAS and proportions of PFAS were observed. Two sites that were close to WWTPs (Caboolture River at Caboolture and the Brisbane River at Karana Downs) had lower concentrations of Total PFAS after rainfall, and only PFOS was reported. The concentration of PFAS increased throughout the drier season. This may indicate a constant source of PFAS, with dilution during higher river flow. In contrast, the site at Oxley Creek and two Brisbane River sites (Indooroopilly and Lytton) had the opposite pattern, with the highest total PFAS being recorded in the wet season and decreasing in the dry season, which may indicate an upstream source of PFAS that is washed into the waterways after wet season rainfall. At two lower Brisbane River sites (Indooroopilly and Lytton), a strong and significant correlation was found between turbidity and PFOS, and turbidity was highest after rainfall.

Comparison of PFAS data to flood data in the Brisbane River catchment (urban areas) presented by Gallen *et al.* (2014) indicates that maximum concentrations of PFOS, PFOA and PFBS during the flood were higher than that reported during the ambient program, but that PFHxA, PFHpA, PFNA, PFDA and PFHxS in the Gallen *et al.* (2014b) study were similar to the ambient program. This may indicate that a different source or higher load of PFAS contamination was present during the floods. A seasonal trend was also observed at Vines Creek, in an industrial land use area, with water samples having higher PFOS concentrations in the wetter months, indicating runoff from contaminated areas is occurring.

Sediment samples were analysed for PFAS at 26 sites, including those sites with elevated reported levels of PFAS in the water. PFAS was only reported in four sediment samples (all close to the LOR) – Oxley Creek, two Brisbane River sites (Indooroopilly and Karana Downs) and Tingalpa Creek. PFOS was reported in the four samples and PFDA was only reported at Tingalpa Creek. Overall, fewer compounds were reported in sediment for this program than were reported in Victoria (Sardiña *et al.* 2019), Homebush Bay, NSW (Thompson *et al.* 2011), and urban creeks in Darwin (Munksgaard *et al.* 2016). The PFOS reported in sediment in the Brisbane River and Oxley Creeks was a quarter of the maximum concentration reported in Victoria (Sardiña *et al.* 2019), one sixth that reported from Homebush Bay (Thompson *et al.* 2011), and one twentieth of that found in Darwin (Munksgaard *et al.* 2016).

Biota sampling for the purpose of assessing potential risk to human health has been undertaken extensively in Australia, however, there have been limited studies looking at potential risk to wildlife. This report focused predominantly on whole fish and invertebrates, which were not reported in other ambient studies. Biota sampling was targeted in areas where elevated levels of PFAS in water were reported, and hence, the majority of samples were collected in the SEQ region.

As with the water samples, PFOS was found at the highest concentration and the highest frequency in the biota. However, the findings of this study indicate that the long chain PFAS tended to accumulate in biota and short chain PFAS (commonly found in water samples collected from urban/industrial sites) generally did not. The short chain compounds were also reported more often in invertebrates then they were in fish. A number of PFAS found with the highest frequencies and concentrations in water were not measured in fish. For example, in the samples from the Brisbane River and Oxley Creek, PFPeA and PFHxA, which are short chain PFAS and reported in 100% of water samples at those sites where biota samples were collected, were not reported in the fish, with PFHxA only reported in crabs at the Indooroopilly site. PFHpA was reported in 83% of the water samples in the area, but only was reported in crabs in Oxley Creek. PFHxS is relatively absent from the biota (only found in two fork-tailed catfish), despite being at elevated concentrations and similar frequencies to that of PFOS in water.

Conversely, neither PFDoDA nor PFTrDA, which are long chain PFAS, were reported in any water samples but were reported in biota. The measurement of long chained PFCAs in biota but not water samples is consistent with other studies (Goodrow *et al.* 2020). For example, in the samples from Tingalpa Creek, the long chained PFCAs (PFDA and PFDoDA) were reported in a fork-tailed catfish sample, with only PFDA being reported in one sample in water from this location. Similarly, the long chain PFCA (PFDA) was reported in one sample of fork-tailed catfish and PFBA was reported in two out of three mangrove worms at the Caboolture River (Caboolture). Neither of these compounds were reported in water samples collected at any time at this site.

PFOS was also the dominant PFAS reported in fish in the grey literature from the SEQ area, with long chain PFAS (e.g. PFDA, PFUnDA and PFDoDA) and FOSA being reported in fish and invertebrates from urban and industrial areas. As with other sites, the shorter chained PFAS (PFHxA, PFHpA), and PFOA were reported in invertebrates (mangrove crabs) more often than they were in fish.

Similar to patterns observed in the SEQ samples, PFOS was the predominant PFAS in biota in areas outside of SEQ, with the highest frequency of detections being at the Vines Creek site which is near an industrial area. PFOS was reported in most fish and all prawns at the site, but none of the whiting or the oyster samples. Of note, Munksgaard *et al.* (2016) found the PFAS in oysters and cockles to be similar in both urban and reference sites in Darwin creeks, with very low concentration of PFAS reported in these organisms. Similarly, in this study PFOS was not reported above the LOR in the oyster nor in oyster samples described in the grey literature.

Variation in PFAS levels in whole fish samples was high within species, between species and between locations. The fork-tailed catfish (*Arius graeffei*) tended to have the highest concentrations of PFAS (particularly PFOS), and the most compounds reported, and could be useful as a sentinel species in further studies.

6 Conclusions

Key conclusions from this monitoring program are:

- PFAS cannot be considered to be ubiquitous compounds in Queensland.
- The reported concentrations of PFAS were generally very low (close to the respective LOR), or below the LOR at sampling locations adjacent to conservation, agriculture and forestry /grazing land use types.
- PFAS were highest, and found in the greatest variety in urban and industrial areas. Compared to other PFAS, PFOS was reported at comparatively high concentrations (<LOR – 0.037 µg/L) and was reported in most samples in these areas. The patterns of other PFAS depended upon the area, and presumably the source. Other PFAS compounds commonly reported in water samples in urban and industrial areas were PFPeA, PFHpA, PFHxA, PFOA, PFBS and PFHxS.
- Sites at river mouths had lower reported concentrations of PFAS compared to sites further upstream, presumably due to flushing from sea or bay water.
- The TOP Assay was undertaken for water samples collected at sites where PFAS had been reported, and results indicated there were no detectable precursors or 'unseen' PFAS present above the LOR in the samples.
- Out of all the sampling sites in Queensland, PFAS were reported at the highest concentration, the greatest frequency and with the largest variety in the Greater Brisbane subregion (SEQ region).
- In the SEQ region, where PFAS were reported at elevated concentrations in water samples, seasonal patterns in total PFAS and proportions of PFAS were observed.
- The Caboolture River (Caboolture) and the Brisbane River (Karana Downs) sites both had lower concentrations of total PFAS after rainfall, and only PFOS was reported. The concentration of PFAS increased throughout the drier season. This may indicate a constant source of PFAS with dilution during higher river flow. Both sites are in close proximity to a WWTP.
- In contrast, total PFAS concentrations in Oxley Creek and two Brisbane River sites (Indooroopilly and Lytton) were highest in the wet season, decreasing in the dry season, which may indicate PFAS being washed into the waterways from an upstream source.
- At two Brisbane River sites (Indooroopilly and Lytton), a strong and significant correlation was found between turbidity and PFOS. Turbidity was also highest after rainfall here.
- Sediment samples were analysed for PFAS at 26 sites, and PFAS was reported in only four sediment samples. PFOS was reported in all four of these samples and PFDA was reported in one sample.
- Overall, PFOS was the predominant PFAS in biota in Queensland, with a tendency for longer chained PFAS to be reported in fish and shorter chained PFAS to be reported in invertebrates. No PFAS were reported in oyster samples. Of the fish, fork-tailed catfish tended to have the highest concentrations of PFAS and the most compounds.
- The measurement of long chain PFCAs in biota but not water samples is consistent with other findings in the literature.
- Due to the nature of PFAS, and the ability for these compounds to be transported large distances (especially from contaminated areas), many sampling sites adjacent to intensive land use areas have the potential to be impacted by multiple sources that can be hard to identify. This is particularly the case in estuaries with tidal flushing where impacts can come from upstream or downstream.

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Glossary

Ambient:

All water generally of natural occurrence (e.g. lakes, rivers, wetlands, estuaries, oceans).

Bioaccumulation:

The accumulation of a substance within an organism.

Biomagnification:

The accumulation of a substance in organisms via the food chain.

Biotransformation:

The change of a substance within an organism.

Carboxylates:

Carbon atom bonding with two oxygen atoms creating a functional group.

Effluent:

Wastewater that is released back into the natural environment after treatment.

Grey literature:

Any data that has not been published, or published in a peer reviewed journal.

Legacy compounds:

Molecules containing perfluoroalkyl sulfonic acids or perfluoroalkyl carboxylic acids.

Limit of detection (LOD)

The lowest concentration of an analytical parameter in a sample that can be detected, but not necessarily quantified.

Limit of quantitation (LOQ)

The smallest amount of analyte that can be reliably identified and quantified with a certain degree of reliability.

Limit of reporting (LOR)

The limit of reporting (also known as the 'limit of quantitation') is defined as the lowest concentration of an analytical parameter that can be determined with acceptable precision and accuracy. In practice, the limit of reporting is frequently taken to be five to ten times the limit of detection.

Stockholm Convention:

International treaty to protect human health and the environment from persistent organic pollutants.

Appendix A: Quality control

Overview

Field, trip and intra-lab and inter-lab duplicates were collected according to the Queensland Monitoring and Sampling Manual (2018). A summary of the quality control samples that were collected for each sampling round are presented Table A1-1.

Table A1-1: Summary of number of quality control samples taken for each sampling round.

Monitoring round	Field Blank	Trip Blank	Duplicates (intra-lab)	Triplicates (inter-lab)
May	7	7	6	
July	6	6	8	
September[3]	6	5	8	
November[4]	7	7	6	3
January	6	6	9	3
March	6	6	9	4

Field and trip blanks

The reported concentrations of PFAS in transport blanks were below the LOR in all instances. The reported concentrations of PFAS in field blanks collected in May, July and September 2019, and March 2020 were below the LOR. In November 2019 the reported concentration of PFOS in a field blank collected at Rocky Dam was 0.035 µg/L (Table A1-2). The sample was analysed a second time, and a concentration of 0.024 µg/L was reported. The cause of the high concentration in the field blank is not known. However, the environmental sample collected at the same site had a reported PFOS concentration below the LOR (0.0001 µg/L), indicating the contamination was either not widespread or the positive result was due to laboratory error. A second field blank collected in November 2019 appeared to have contamination. PFTrDA was reported at 0.002 µg/L (LOR of 0.001 µg/L) at Warrill Creek, however no PFTrDA was reported above the LOR when the sample was analysed a second time, and no PFTrDA was reported above the LOR in the environmental sample collected at this site. This field blank result was treated as an outlier.

In January 2020 low concentrations of PFOS (0.0002 µg/L, LOR 0.0001 µg/L) were reported in the field blank collected at Tin Can Inlet, however the reported PFOS concentration was not higher than the LOR in the environmental sample collected at this site, indicating the result may be due to laboratory error. In the same month, the reported concentration of PFOS (0.0002 µg/L, LOR 0.0001 µg/L), in the field blank collected at the Burnett River site was lower than the concentration reported in the environmental sample collected at this site (0.0004 µg/L). Results for PFOS concentrations at 0.0002 µg/L or lower collected by this field team in January 2020 were adjusted to account for the potential contamination (subtracted from reported concentrations).

Duplicates (intra-laboratory)

For intra-laboratory (intra-lab) duplicates, the relative percentage difference (RPD) was calculated. Allowable RPD limits were set for the following ranges:

- reported concentration 1–10 times the LOR: 100%
- reported concentration greater than 10 times the LOR: 30%.

The RPDs were within acceptance criteria for all intra-lab duplicate samples collected in May, July and November 2019, as well as March 2020.

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[3] Quality control results from the September 2019 indicated internal quality issues. Samples were re-analysed by the laboratory after these issues had been addressed. Only the results of the second analysis are presented in this report.

[4] The November monitoring round were analysed twice by the primary laboratory as an additional quality control measure due to the issues that occurred in the September monitoring round.

In September 2019, the RPDs were outside the acceptance criteria for Oxley Creek (PFOS: 32%, PFHxS: 32% and PFBS: 120%) and Logan River (PFOS: 64%) (Table A1-3). In January 2020, the duplicates samples collected at Tingalpa Creek had a RPD for PFOS of 120%, the reported results however were between 0.0004 µg/L and below the LOR (Table A1-3). Although the acceptance criteria were not met for these samples, it is known there is more uncertainty with PFAS as methods (particularly at concentrations close to the LOR) are still being adjusted as part of ongoing improvements.

Table A1-2: Summary of data for field blanks where PFAS concentrations were reported >LOR. All concentrations are µg/L.

Monitoring round	Location	Monitoring Zone	Comments/LOR	PFOS	PFTrDA
			LOR	**0.0001**	**0.001**
November	Warrill Creek	South East Queensland	Run 1	<0.0001	**0.002**
			Run 2	<0.0001	<0.001
	Rocky Dam Creek	Mackay Whitsundays	Run 1	**0.035**	<0.001
			Run 2	**0.024**	<0.001
January	Tin Can Inlet	Mary – Burnett Region	–	**0.0002**	<0.001
	Burnett River [Bundaberg]		–	**0.0002**	<0.001

Table A1-3: Summary of data for duplicates (intra-lab) where PFAS concentrations were reported >LOR. All concentrations are µg/L.

Monitoring round	Location	Monitoring Zone		PFOS	PFTrDA	PFBS
			LOR	**0.0001**	**0.001**	**0.001**
September	Logan River (Edens Landing)	South East Queensland		**0.0031**		
				0.0016		
			RPD	**64**		
September	Oxley Creek			**0.012**	**0.011**	**0.004**
				0.0087	**0.008**	**0.001**
			RPD	**32**	**32**	**120**
January	Tingalpa Creek	South East Queensland		**0.0004**		
				<0.0001		
			RPD	**120**		

Duplicates (inter-laboratory)

Three inter-lab duplicates were analysed in November 2019 and January 2020 and four in March 2020. For the inter-lab duplicates, the RPD was calculated and compared against the same acceptable criteria as the intra-lab duplicates. Where the LOR of the primary and secondary laboratories differed, the more conservative LOR was used to set the acceptance criteria. No RPD was calculated if one of the laboratories reported an analyte below the LOR. In all exceedance cases, the primary laboratory was under-reporting the PFAS concentrations compared to the secondary laboratory.

The following PFAS had exceedances of RPD ranges for inter-lab samples:

- Perfluorohexane sulfonic acid (PFHxS) in one sample in November 2019 (42%) and two samples in March 2020 (47% and 35%); the results of these samples were within 10–30 times the LOR (Table A1-4).
- Perfluorobutane sulfonic acid (PFBS) for two samples collected in January 2020 (107% and 111%) (Table A1-4) the results of these samples were within 1–10 times the LOR.

The failure of inter-laboratory results to meet acceptance criteria has led to further investigations that are ongoing. It is accepted that there is uncertainty surrounding PFAS results as methods are still being adjusted as part of on-going improvements.

Table A1-4: Summary of data for duplicates (inter-lab) where PFAS concentrations were reported >LOR. All concentrations are µg/L.

Monitoring round	Location	Monitoring Zone	Compound	PFHxS	PFBS
			LOR (1st Lab)	**0.001**	**0.001**
			LOR (2nd Lab)	**0.0005**	**0.0005**
November	Brisbane River (Karana Downs)	South East Queensland	–	**0.012**	0.002
			–	**0.0184**	<0.0005
			RPD (%)	**42**	NA
January	Brisbane River (Indooroopilly)	South East Queensland	–	0.008	**0.002**
			–	0.0083	**0.0066**
			RPD (%)	4	**107**
	Oxley Creek	South East Queensland	–	0.008	**0.002**
			–	0.0088	**0.007**
			RPD (%)	10	**111**
March	Brisbane River (Indooroopilly)	South East Queensland	–	0.018	0.003
			–	0.0291	0.0054
			RPD (%)	**47**	57
	Oxley Creek	South East Queensland	–	**0.017**	0.003
			–	**0.0243**	0.0043
			RPD (%)	**35**	36

TOP Assay

Quality assurance measures for TOP Assay ((Heads of EPAs Australia and New Zealand (HEPA) 2020) include:

- The total PFAS concentration post-TOP Assay should be greater or equal to the total PFAS concentration pre-TOP Assay,
- The sum of PFCA post-TOP Assay should be equal to or greater than the sum of PFCA pre-TOP Assay, which signifies any precursors being converted to PFCA products.
- The sum of PFSA post-TOP Assay should approximate the sum of PFSA pre-TOP Assay, signifying that precursors did not convert to PFSA products
- No PFAA precursors (e.g. 6:2 FtS, FOSA) are detectable post oxidation, signifying complete oxidation.
- Greater leniency may be applied for samples where PFAS were reported ≤10 times LOR.

For this study, all results post-TOP Assay were around the TOP Assay LOR and so these quality control guidelines were not applicable.

Appendix B: Summary of type and number of species of aquatic biota collected

Table A2-1: Number of biota samples by species collected and analysed at each location.

Species	Vines Creek	Fitzroy River [Barrage]	Burnett River [Oakwood]	Burrum River	Caboolture River [Caboolture]	Brisbane River [Karana Downs]	Brisbane River [Indooroopilly]	Brisbane River [Yeronga]	Oxley Creek	Tingalpa Creek	Logan River [Edens Landing]
Australian Bass *Macquaria novemaculeata*	–	–	–	–	1	–	–	–	–	–	–
Barred Javelin *Pomadasys kaakan*	–	–	1	1	–	–	1[i]	–	–	–	–
Bony Bream *Nematalosa erebi*	–	–	–	–	–	2	–	–	–	–	–
Yellowfin Bream *Acanthopagrus australis*	5	–	5	–	–	1	2[i]	2	2[j]	–	3
Fork-tailed Catfish *Neoarius graeffei*	–	3	5	–	1	3[i]	–	–	5[i]	1	5
Fiddler crabs *Tubuca coarctata*	–	–	–	–	–	–	1	–	–	3	–
Worm Annelida	–	–	–	–	3[a]	–	–	–	–	–	–
Longfinned eel *Anguilla reinhardtii*	–	–	–	–	–	–	–	–	–	–	1
Furry clawed crab *Australoplax tridentata*	–	–	–	–	–	–	4[b]	–	4[c]	–	3[d]
Glassfish *Ambassis sp.*	–	–	–	–	2[e]	2[f]	–	–	–	–	–
River Perch *Johniops vogleri*	–	–	–	–	–	–	2[i]	1[i]	–	–	–
Freshwater prawn *Macrobrachium sp.*	5	–	–	–	–	–	–	–	–	–	–
Mangrove worm *Teredo navalis*	–	–	–	–	–	–	–	–	–	1[f]	–
Sea mullet *Mugil cephalus*	5	–	–	1	5	–	–	–	5[i]	2	–
Oyster *Sacostrea cucullata*	1[h]	–	–	–	–	–	–	–	–	–	–
Pike Eel *Muraenesox bagio*	–	–	–	–	–	–	1	–	–	–	–
Ponyfish *Leiognathus equulus*	5	–	–	–	–	–	–	–	–	–	–
Prawn *Penaeus sp.*	–	–	–	1	5	–	–	–	–	–	5

Species	Vines Creek	Fitzroy River [Barrage]	Burnett River [Oakwood]	Burrum River	Caboolture River [Caboolture]	Brisbane River [Karana Downs]	Brisbane River [Indooroopilly]	Brisbane River [Yeronga]	Oxley Creek	Tingalpa Creek	Logan River [Edens Landing]
Silver Javelin *Pomadasys argenteus*	–	–	1	–	–	–	–	–	–	–	–
Silverbiddy *Gerres subfasciatus*	5	–	–	–	–	–	–	–	–	1	–
Southern Herring *Herklotsichthys castelnaui*	5	–	–	–	–	–	–	–	–	–	–
Mozambique Tilapia *Oreochromis mossambicus*	–	–	–	–	1	–	–	–	–	–	–
Whiting *Sillago sp.*	5	–	2	–	–	–	–	–	–	–	–
Total	36	3	14	3	18	8	11	3	16	8	17

a Three composite samples of six specimens each

b Four composite samples of seven to eight specimens each

c Four composite samples of nine to eleven specimens each

d Three composite samples of four to five specimens each

e One composite of 5 specimens, one composite of 15 specimens

f Two composite samples of five specimens each

g Composite of two specimens

h Composite of five specimens

i These specimens were analysed whole, however a flesh sample was previously taken from each specimen for a separate investigation

j These two specimens were analysed whole, however a flesh sample was previously taken from one specimen for a separate investigation

Appendix C: Summary of each PFAS reported in each matrix and the LOR for each matrix

PFAS compounds	Water (µg/L)	Biota (mg/kg)	Sediment (mg/kg)
Perfluoroalkyl carboxylic acids (PFCA)			
PFBA	0.005	0.002	0.004-0.005
PFPeA	0.001	0.04	0.002
PFHxA	0.001	0.001	0.0009-0.001
PFHpA	0.001	0.002	0.0009-0.001
PFOA	0.001	0.005	0.002
PFNA	0.001	0.002	0.0009-0.001
PFDA	0.001	0.005	0.0009-0.001
PFUnDA	0.001	0.002	0.002
PFDoDA	0.001	0.005	0.002
PFTrDA	0.001	0.002	0.006-0.007
PFTeDA	0.001	0.04	0.009-0.01
Perfluoroalkyl sulfonic acids (PFSA)			
PFPrS	0.001	-	-
PFBS	0.001 0.001	0.001	0.0009-0.001
PFPeS	0.001	0.001	0.0009-0.001
PFHxS	0.001	0.002	0.0009-0.001
PFHpS	0.001	0.001	0.0009-0.001
PFOS	0.0001	0.0009-0.0001	0.0009-0.001
PFNS	0.01	0.002	0.0009
PFNS (trace)	0.001	-	-
PFDS	0.001	0.002	0.002
PFDoS	-	0.04	0.0009-0.001
n:2 Fluorotelomer sulfonic acids (n:2 FTSA)			
4:2 FTSA	0.001	0.01	0.002
6:2 FTSA	0.005	0.005	0.018-0.02
8:2 FTSA	0.001	0.01	0.004-0.005
10:2 FTSA	0.001	0.01	0.0009-0.001
Perfluoroalkyl sulfonamido substances			
N-EtFOSE	0.005	0.04	0.004-0.005
N-MeFOSE	0.005	0.04	0.004-0.005
N-EtFOSA	0.005	0.005	0.004-0.005
N-EtFOSAA	0.005	0.04	0.004-0.005
N-MeFOSA	0.005	0.005	0.004-0.005
N-MeFOSAA	0.005	0.005	0.004-0.005
FOSA	0.005	0.002	0.009-0.01

Appendix D: TOP Assay Results (µg/L)

	PFAS pre-TOPA									PFAS post-TOPA			
	PFBS	PFPeS	PFHxS	PFOS	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFOS TOPA	PFHxS TOPA	TOPA	PFPeA TOPA
Brisbane River [Indooroopilly]	**0.002**	<0.001	**0.008**	**0.016**	<0.005	**0.008**	**0.01**	**0.003**	**0.006**	**0.02**	<0.01	**0.01**	**0.01**
Brisbane River [Karana Downs]	**0.002**	**0.002**	**0.012**	**0.018**	**0.006**	**0.007**	**0.008**	**0.003**	**0.004**	**0.02**	**0.01**	**0.01**	<0.01
Oxley Creek	**0.002**	<0.001	**0.01**	**0.015**	<0.005	**0.006**	**0.01**	**0.003**	**0.005**	**0.02**	<0.01	**0.02**	<0.01
Logan River [Edens Landing]	<0.001	<0.001	<0.001	**0.0023**	<0.005	**0.004**	**0.006**	<0.001	**0.003**	<0.01	<0.01	**0.01**	<0.01
Tingalpa Creek	<0.001	<0.001	**0.003**	**0.0051**	<0.005	**0.006**	**0.009**	**0.002**	**0.006**	<0.01	<0.01	**0.01**	<0.01

Note: Only compounds that were reported above the LOR are presented in this table. Other data are available on request.

Appendix E: Sediment Results (mg/kg)

Monitoring round	Location	Monitoring Zone	Compound	PFOS	PFDA
			LOR	0.001	0.001
January 2020	Brisbane River (Karana Downs)	South East Queensland	-	0.001	-
	Brisbane River (Indooroopilly)		-	0.001	-
	Oxley Creek		-	0.001	-
	Tingalpa Creek		-	0.002	0.001

Note: Only compounds that were reported above the LOR are presented in this table. Other data are available on request.