PFAS risks in drinking-water.

Expert commentary prepared for Watercare.

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1. Background

This report has been prepared at the request of Watercare following detections of per- and poly-fluoroalkyl substances (PFAS) compounds in drinking-water source wells and treated water at the Onehunga water treatment plant. The information supplied regarding these detections is presented inTable 1.

Table 1: PFOS and PFHxS values reported from Watercare

Sum (PFHxS + PFOS)					
Sample Date	Pearce Street Well	Rowe Street Well	Onehunga WTP Treated	Units	Taumata Arowai DWS MAV
10/07/2019	**0.098**	**0.106**	**0.103**	µg/L	0.07
30/03/2021	0.030	0.032	0.033		
31/03/2021	0.050	0.043	0.033		
1/04/2021	**0.09**	0.010	0.008		
2/04/2021	0.007	**0.09**	0.006		
8/06/2022	**0.091**	**0.124**	**0.119**		

PFHxS: perfluorohexane sulfonic acid, PFOS: perfluorooctane sulfonate

Per- and polyfluoroalkyl substances (PFAS) have not historically been regulated in New Zealand drinking-water. However, a revised version of the drinking-water standards will apply as of November 2022 [1], and these include Maximum Acceptable Values (MAV) for PFAS as follows:

PFHxS + PFOS 0.00007 mg/L (0.07 µg/L)

PFOA 0.00056 mg/L (0.56 µg/L).

It is clear from the data provided from Watercare that the detections in treated water exceeded the new MAV value on both 10/07/2019 and 8/6/2022. There have also been intermittent detections in the source water for this supply which suggests further monitoring and possible action is required. ESR has been requested to provide expert commentary on the potential public health risk of the PFAS detections in the treated drinking-water both to provide certainty to the community and also to assist with future management decisions.

2. PFAS IN DRINKING-WATER

PFAS are a group of several thousand different chemical substances that contain carbon-fluorine bonds [2]. This makes them very stable and has led to their common nickname "forever chemicals". The chemicals have been used for a number of commercial purposes including as water and stain resistant coatings, in electronics, food processing and as components of fire-fighting foams. Due to their persistence in the environment they are known to contaminate water sources and have been detected in drinking-waters internationally [3]. In addition to drinking-water, potential exposure routes include consumption of contaminated food, particularly fish from contaminated waterways, ingestion of contaminated soil or dust, and possibly ongoing contact with consumer products containing PFAS chemicals [4]. Perfluorooctane sulfonic acid (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS) are the PFAS for which the most toxicological information is available and for which drinking-water standards have been developed [3].

Data from human exposure studies support the conclusion that there is very low risk of acute (short-term) toxicity from these compounds [3]. One study in humans showed no significant toxicity from PFOA at levels up to 2.3 mg/kg bw/day. This is supported by rodent studies which show low acute toxicity. The US Agency for Toxic Substance and Disease Registry (ATSDR) did not consider that there was adequate information to set an acute oral minimal risk level (MRL) [2].

The main health concerns for PFOS, PFHxS and PFOA are related to chronic exposures. The most robust evidence links PFAS exposure to decreased immune responses, dyslipidemia, decreased birth weight and impacts on liver enzymes [5]. Other studies have suggested there may be a myriad of potential adverse health outcomes including an increased risk of kidney, testicular and breast cancer, pre-eclampsia, thyroid disease and ulcerative colitis [5]. The scientific data around the impacts of exposure are still being developed and is challenged by the large number of compounds within the group and the range of effects these chemicals have been associated with. To date, the evidence for a role of PFAS in any of these adverse health effects falls short of establishing a causal relationship.

While the pharmacokinetics of these compounds is variable between compounds and between species there is evidence that the biological half-life is in the region of days to years [3] and that clearance occurs in a biphasic manner with a rapid uptake phase followed by a slower accumulation [2]. This suggests that accumulation of the compounds will occur over time and multiple possible exposure routes will be relevant to calculating the total body burden and possible health risks. PFAS will cross the placenta and will pass into breast milk posing a risk for the foetus and infant [2].

Several expert organisations have established health-based guidance values (HBGV; tolerable exposure limits) for selected PFAS.

For intermediate oral exposure (over a period of 15-364 days), MRLs have been set by ATSDR at 3 ng/kg bw/day for PFOA, 20 ng/kg bw/day for PFHxS and 2 ng/kg bw/day for PFOS [2]. Minimal risk levels (MRL) have not been determind by ATSDR for either acute or chronic exposure to PFOS, PFHxS or PFOA due to inadequate study data.

Food Standards Australia New Zealand (FSANZ) established a substantially higher tolerable daily intake (TDI) for PFOS of 20 ng/kg bw/day, while the European Food Safety Authority (EFSA) a lower limit, expressed as a tolerable weekly intake (TWI) of 4.4 ng/kg bw/week (0.6 ng/kg bw/day) of combined PFAS (PFOA, PFOS, PFNA and PFHxS) [6]. In the calculation of the US drinking-water guidance the Environmental Protection Agency used a PFOS reference dose (RfD) of 0.7 ng/kg bw/day, which is similar to the EFSA value.

3. RISK CALCULATIONS

The possible exposures to PFAS due to their presence in drinking-water were calculated for both a toddler and an adult for the highest concentration of PFOS+PFHxS detected in the drinking-water from Onehunga WTP (0.119 µg/L).

Equation 1:

Toddler: estimated body weight 15 kg and 1 L daily water intake [7].

0.119 µg/L x 1 L / 15 kg = 0.00790 µg/kg bw/day (8 ng/kg bw/day).

Equation 2:

Adult: estimated body weight 70 kg and 2 L daily water intake [7].

0.119 µg/L x 2 L / 70 kg = 0.003 µg/kg bw/day (3 ng/kg bw/day).

These values both exceed the ATSDR intermediate oral exposure guideline value for PFOS of 2 ng/kg bw/day and the EFSA TWI, but not the FSANZ TDI of 20 ng/kg bw/day, or the ATSDR guideline of 20 ng/kg bw/day for PFHxS.

Repeating this exercise for the values of PFAS in Onehunga WTP drinking-water (Table 2) indicates that the levels reported would equate to exposure equalling or exceeding the ATSDR PFOS MRL on 4 out of 6 occasions for toddlers and 2 out of 6 occasions for the adults. This indicates that there may be cause for concern based on the ASTDR values for intermediate (15-364 days) oral exposure. Four of the 6 PFAS measurements would also equate to exposure in exceedance of the EFSA tolerable weekly intake of 4.4 ng/kg bw/week.

Table 2: Estimated exposure for all PFOS+PFHxS values supplied

Sum (PFHxS + PFOS)						
Sample Date	Onehunga WTP Treated	Toddler	Adult	Units	EFSA TWI	ATSDR MRL(PFOS)
10/07/2019	**0.103**	6.9	2.9	ng/kg bw/day	4.4 ng/kg bw/week (0.6 ng/kg bw/day)	2 ng/kg bw/day
30/03/2021	0.033	2.2	0.9			
31/03/2021	0.033	2.2	0.9			
1/04/2021	0.008	0.5	0.2			
2/04/2021	0.006	0.4	0.2			
8/06/2022	**0.119**	7.9	3.4			

PFHxS: perfluorohexane sulfonic acid, PFOS: perfluorooctane sulfonate

A 2018 report from the Ministry for Primary Industries suggested that the New Zealand population was at low risk of PFAS exposure from food [8]. This conclusion was based on a lack of detections in the food samples analysed. However, the low frequency of detection of PFAS may have been due to insufficiently low limits of detection. A calculation presuming that PFOS was present at the limit of detection suggested that intake could possibly reach

2.2 ng/kg bw/day for a toddler and 0.9 ng/kg bw/day in adults. This was determined to be low risk as the dietary exposure estimates were compared to the FSANZ TDI for PFOS of 20 ng/kg bw/day [9].

A 2013 screening study of blood levels of PFHxS, PFOS and PFOA in New Zealand adults showed that PFOS had the highest concentrations (4.23 ng/mL), followed by PFOA (2.98 ng/mL) and PFHxS (1.82 ng/mL) [10]. For all compounds male non-Māori had the highest reported levels. Recently released clinical guidelines suggest that individuals with combined PFAS levels (PFOS + PFOA + PFHxS) above 2 ng/mL should be encouraged to reduce their potential exposure, particularly if a source of contamination has been identified [5]. Pregnant persons were noted as a population subset that should be particularly alerted to the possible risks [5].

3.1 ADDITIONAL INFORMATION (ADDED 21/10/2022)

The full dataset of analyses for PFOS+PFHxS was subsequently provided to ESR (Figure 1). Calculations for all detections were repeated using equation 1 and equation 2 above.

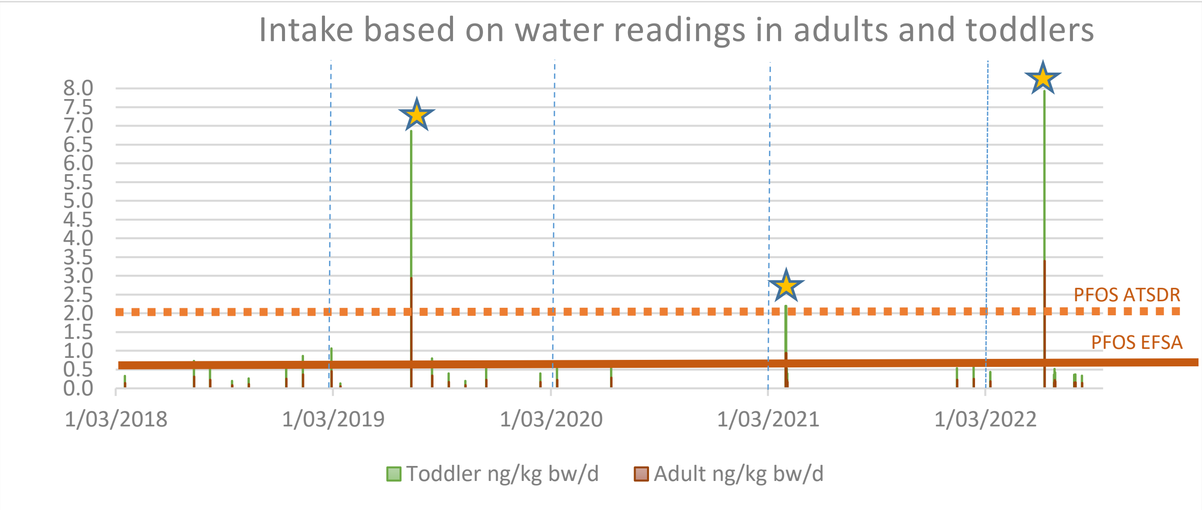

Figure 1: Estimated daily intake of PFOS/PFHxS based on water readings. The blue lines indicate 365-day periods. The orange lines denote different regulatory levels. The stars indicate readings from Table 2.

In each 365-day period, there is no more than one exceedance of the guideline ATSDR value, based on point estimates of PFAS exposure. The risk is higher for toddlers as they exceed both the ATSDR and EFSA guidelines on multiple occasions (see Table 3). This poses a potential risk as some of the elevated readings seem to persist for a month or more (e.g. 9/01/2019-26/02/2019). Given that ATSDR is an intermediate guideline value (15-364 days) it is reasonable to refer to the ATSDR reference for this pattern of exposure. The data shows that the ATSDR guideline is not being exceeded for multiple consecutive months. Furthermore, the average yearly exposures (Table 4) do not exceed the ATSDR guideline value. However, it should be noted that the maximum number of measurements reported in a year is nine and some years had only three. Based on this data, while the intermittent elevations need to be addressed, they are unlikely to cause immediate adverse health effects.

Table 3: Individual exposure calculations from reported values. Zero and blank values have been removed as it was unclear if these were samples below the detection level or where no analysis had been performed on the treatment plant sample. Values exceeding the ASTDR guideline value of 2 ng/kg bw/day are highlighted in orange.

Sample Date	Estimated PFAS exposure, ng/kg bw/day	
	Toddler	Adult
16/03/2018	0.3	0.1
10/07/2018	0.7	0.3
6/08/2018	0.5	0.2
12/09/2018	0.2	0.1
10/10/2018	0.3	0.1
12/12/2018	0.6	0.3
9/01/2019	0.9	0.4
26/02/2019	1.1	0.5
13/03/2019	0.1	0.1
10/07/2019	6.9	3.0
14/08/2019	0.8	0.3
11/09/2019	0.4	0.2
9/10/2019	0.2	0.1
13/11/2019	0.5	0.2
12/02/2020	0.4	0.2
11/03/2020	0.5	0.2
10/06/2020	0.7	0.3
30/03/2021	2.2	0.9
31/03/2021	2.2	0.9
1/04/2021	0.5	0.2
2/04/2021	0.4	0.2
12/01/2022	0.5	0.2
9/02/2022	0.6	0.3
9/03/2022	0.4	0.2
8/06/2022	8.0	3.4
24/06/2022	0.4	0.2
25/06/2022	0.5	0.2
26/06/2022	0.4	0.2
28/07/2022	0.4	0.2
30/07/2022	0.4	0.2
10/08/2022	0.3	0.1

Table 4: Yearly average exposure values for Onehunga Water Treatment Plant. Zero and blank values were removed prior to analysis as it was unclear if these were samples below the detection level or where no analysis had been performed on the treatment plant sample. The timeframe is determined by the date of the first sample.

Year	Number of reported measurements (31 total)	Number of zero/blank measurements removed	Average Estimated PFAS exposure, ng/kg bw/day	
			Toddler	Adult
March 2018 to March 2019	9	1	0.5	0.2
March 2019 to March 2020	7	4	1.4	0.6
March 2020 to March 2021	3	0	1.7	0.7
March 2021 to March 2022	5	11	0.5	0.2
March 2022 to Sept 2022	7	10	1.2	0.6

CONCLUSION

The interpretation of the supplied analytical data is complicated by the combined nature of the analytical results (sum of PFHxS + PFOS) and the variety of exposure limits set by regulatory agencies. Nevertheless, the intermittent exceedances of the upcoming New Zealand MAVs across a two-year period warrant further investigation.

Overall, the exposures from the contamination events detected to date within the Onehunga water supply are unlikely to have contributed to any major health effects in the population. However, as the information on possible dietary exposure to these compounds in New Zealand is uncertain and the (limited) data showing the PFAS burden in New Zealanders is sufficiently high to warrant reduction in exposure, it is recommended that this water contamination is investigated further.

GLOSSARY

ATSDR	Agency for Toxic Substances and Disease Registry
EFSA	European Food Safety Agency
FSANZ	Food Standards Australia and New Zealand
LOAEL	Lowest Observed Adverse Effect Level
MAV	Maximum Acceptable Level
MRL	Minimal Risk Level
PFAS	Perfluoroalkyl and polyfluoroalkyl substances
PFHxS	Perfluorohexane sulfonate
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonic acid

REFERENCES

1. Government, N.Z., *Water Services (Drinking Water Standards for New Zealand) Regulations 2022*, D. Department of Internal Affairs, Editor. 2022.
2. Agency for Toxic Substances and Disease Registry, A., *Toxicological Profile for Perfluoroalkyls*. 2021.
3. World Health Organization, W., *PFOS and PFOA in Drinking-Water Background Document for development of WHO Guidelines for Drinking-water Quality DRAFT version for public review*. 2022, World Health Organization.
4. Agency, E.P. *Our current understanding of the human health and environmental risks of PFAS*. 2022 11/10/22]; Available from: https://www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas.
5. Medicine, N.A.o.S.E.a., *Guidance on PFAS Exposure, Testing and Clinical Follow-Up*. 2022: National Academies of Sciences.
6. European Food Safety Authority, E., *Risk to human health related to the presence of perfluoroalkyl substanes in food.* EFSA Journal, 2020. **18**: p. 6223.
7. Ministry of Primary Industries, M., *2016 New Zealand Total Diet Study*. 2018, New Zealand Government: Wellington.
8. Ministry for Primary Industries, M., *Per- and Poly- Fluorinated Alkyl Substanes (PFAS) in selected New Zealand Foods*, N.Z.F. Safety, Editor. 2018.
9. Food Safety Australia New Zealand, F. *Perfluorinated Compounds*. 2021 11/10/22]; Available from: https://www.foodstandards.gov.au/consumer/chemicals/Pages/Perfluorinated-compounds.aspx.
10. (CPHR), C.f.P.H.R., *Concentrations of Selected Persistent Organic Pollutants (POPs) in the Serum of New Zealanders*. 2013.

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