Division of Water Resources Identification of Select Emerging PFAS Compounds in Public Water Supply Reservoirs of Jordan Lake (2023)

NORTH CAROLINA DEPARTMENT OF ENVIRONMENTAL QUALITY
DIVISION OF WATER RESOURCES
WATER SCIENCES SECTION

THIS REPORT HAS BEEN APPROVED FOR RELEASE

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DATE: March 12, 2024

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Introduction

In response to the rising interest in the public health effects associated with per- and polyfluoroalkyl substances (PFAS) and 1,4-Dioxane in drinking water sources, the Intensive Survey Branch (ISB) conducted a special study alongside our Ambient Lakes Monitoring Program to characterize the presence and concentrations of these emerging compounds (EC) in public drinking water supply reservoir Jordan Lake. Beginning in January of 2023, ISB staff collected surface water samples for 1,4-Dioxane and 47 different per- and polyfluoroalkyl substances at three sampling locations at Jordan Lake (Appendix 1). Analytical results indicated the presence of at least eight PFAS analytes above the laboratory practical quantitation limit (PQL) at each site during the 2023 sampling season. Of the 1,4-Dioxane samples collected during this study period, three were detected above the PQL (1.0 µg/l). It is important to note that all analytical data presented in this document reflect levels of target analytes detected in untreated surface waters, as opposed to finished drinking water.

Methods

Selected sites were sampled in conjunction with regularly scheduled sampling events as part of ALMP monitoring. Samples were collected in accordance with ISB's Standard Operating Procedures Manual: Physical and Chemical Monitoring v2.1, Dec. 2013 and Ambient Lakes Quality Assurance Project Plan v2.0, March 2014, as well as ISB's Draft Standard Operating Procedures Manual: Per- and Polyfluorinated Alkyl Substances (PFAS) - Field Collection Method. Physical parameters were collected at surface (0.15 m) using an In-Situ multiparameter hydrosonde. Chemical samples were collected as surface grab samples. All PFAS and 1,4-Dioxane samples were analyzed by the DWR central laboratory in Raleigh, NC. Appropriate QA/QC samples were collected during each sampling event including trip blanks, field blanks, duplicates, matrix spikes and matrix spike duplicates. Guidance on acceptable supplies, equipment, and personal care products is provided within the ISB Draft Standard Operating Procedures Manual: Per- and Polyfluorinated Alkyl Substances (PFAS) - Field Collection Method. Full PFAS sampling results are shown below in Table 1, with PFAS sums displayed in the graph in Figure 2.

Results

PFAS analysis was conducted by DWR at the Central Laboratory in Raleigh, NC. Of the 47 PFAS compounds selected for this study, the following 28 compounds were found above the PQL on at least one occasion: 11 Cl-PF3OUdS, 4:2 FTS, 6:2 FTS, 8:2 FTS, 9 Cl-PF3ONS, ADONA, GenX, N-EtFOSAA, N-MeFOSAA, PFBA, PFBS, PFDA, PFDoA, PFDoS, PFDS,PFHpA, PFHpS, PFHxA, PFHxS, PFNA, PFNS, PFOA, PFOS, PFPeA, PFPeS, PFTA, PFTriA, and PFUnA. One or more of these compounds were found at all three sites during the 2023 sampling period (January – December). These results demonstrate the widespread distribution of detectable PFAS in public water supply reservoirs.

1,4- dioxane was found above the PQL (1 µg/L) in three samples taken from Jordan Lake. 1,4-Dioxane was found only at station CPF055CSUR on July 24th (4.7 µg/L), August 9th (2.2 µg/L J2), and on October 11th (1.1 µg/L).

Summary

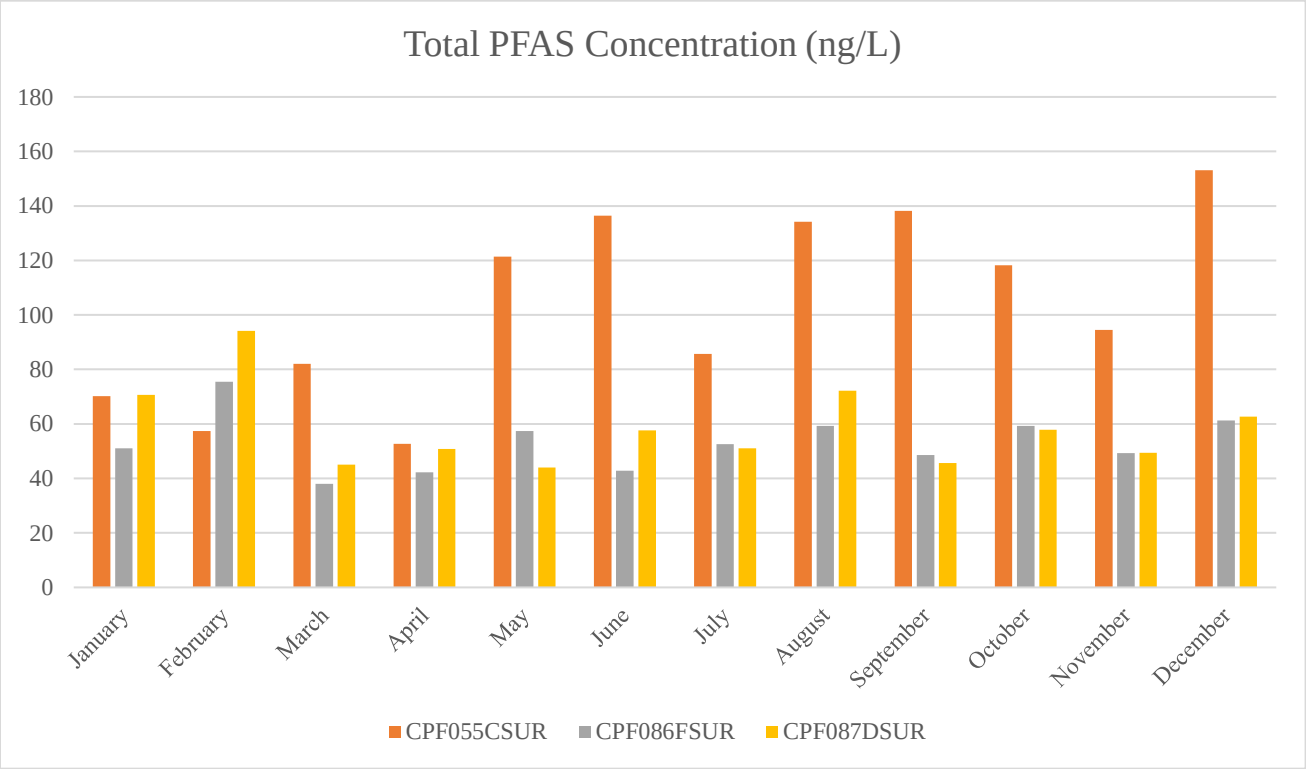
Evaluation of physical and chemical results from this study suggest that while there are detectable levels of target analytes at the public water supply reservoir, Jordan Lake, additional long-term monitoring would need to be conducted to evaluate persistence of these compounds and their associated effects on drinking water. Station CPF055CSUR exhibited the highest total single event PFAS concentration (138.2 ng/L) in September of 2023. The most prevalent compounds that were detected at every site were PFOS, PFPeA, PFHxA, PFOA, PFHxS, PFBA, PFBS, PFHpA. The compounds with the highest detected values were PFHpS (44 and 35 ng/L), PFPeA (30 ng/L), and PFBS (27 ng/L).

Appendix 1. *Station ID, Description, and coordinates of sampled sites.*

Station	Station Description	Latitude	Longitude
CPF055CSUR	ABOVE STINKING CK NR PITTSBORO NC	35.69131	-79.0791
CPF087DSUR	MOUTH WHITE OAK CK NR SEAFORTH NC	35.73864	-79.0242
CPF086FSUR	NEAR FARRINGTON NC	35.79700	-79.0108

Figure 1. *Map of Jordan Lake with Stations.*

Figure 2. *Graph showing total PFAS concentration.*



Appendix 2. *List of PFAS Compounds.*

Abbreviation	Name	CAS #
HFPO-DA (GenX)	Perfluoro-2-methyl-3-oxahexanoic acid	13252-13-6
PFOS	Perfluorooctanesulfonic acid	1763-23-1
PFUnA	Perfluoroundecanoic acid	2058-94-8
N-MeFOSAA	2-(N- Methylperfluorooctanesulfonamido)acetic acid	2355-31-9
PFPeA	Perfluoropentanoic acid	2706-90-3
PFPeS	Perfluoropentanesulfonic acid	2706-91-4
6:2 FTS	6:2 Fluorotelomer sulfonic acid	27619-97-2
N-EtFOSAA	2-(N- Ethylperfluorooctanesulfonamido)acetic acid	2991-50-6
PFHxA	Perfluorohexanoic acid	307-24-4
PFDoA	Perfluorododecanoic acid	307-55-1
PFOA	Perfluorooctanoic acid	335-67-1
PFDA	Perfluorodecanoic acid	335-76-2
PFDS	Perfluorodecanesulfonic acid	335-77-3
PFHxS	Perfluorohexanesulfonic acid	355-46-4
PFBA	Perfluorobutanoic acid	375-22-4
PFBS	Perfluorobutanesulfonic acid	375-73-5
PFHpA	Perfluoroheptanoic acid	375-85-9
PFHpS	Perfluoroheptanesulfonic acid	375-92-8
PFNA	Perfluorononanoic acid	375-95-1
PFTeDA	Perfluorotetradecanoic acid	376-06-7

8:2 FTS	8:2 Fluorotelomer sulfonic acid	39108-34-4
PFNS	Perfluorononanesulfonic acid	68259-12-1
PFTrDA	Perfluorotridecanoic acid	72629-94-8
9Cl-PF3ONS	9-chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	756426-58-1
4:2 FTS	4:2 Fluorotelomer sulfonic acid	757124-72-4
11Cl-PF3OUdS	11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	763051-92-9
PFDoS	Perfluorododecane sulfonic acid	79780-39-5
ADONA	4,8-Dioxa-3H-perfluorononanoicacid	919005-14-4
PFEESA/PES	Perfluoro(2-ethoxyethane)sulphonic acid	113507-82-7
PMPA	Perfluoro-2-methoxypropanoic acid	13140-29-9
PFECA B or NFHDA	Perfluoro-3,6-dioxaheptanoic acid	151772-58-6
R-PSDA (Nafion Byproduct 4)	Perfluoro-4-(2-sulfoethoxy)pentanoic acid	2416366-18-0
Hydrolyzed PSDA (Nafion Byproduct 5)	2-fluoro-2-[1,1,2,3,3,3-hexafluoro-2-(1,1,2,2-tetrafluoro-2-sulfoethoxy)propoxy]-acetic acid	2416366-19-1
R-PSDCA (Nafion Byproduct 6)	1,1,2,2-tetrafluoro-2-[1,2,2,3,3-pentafluoro-1-(trifluoromethyl)propoxy] ethanesulfonic acid	2416366-21-5
R-EVE	4-(2-carboxy-1,1,2,2-tetrafluoroethoxy)-2,2,3,3,4,5,5,5-octafluoro-pentanoic acid	2416366-22-6
PEPA	Perfluoro-2-ethoxypropanoic acid	267239-61-2
PFESA-BP1 (Nafion Byproduct 1)	Perfluoro-3,6-dioxa-4-methyl-7-octenesulfonic acid	29311-67-9
PFO2HxA	Perfluoro (3,5-dioxahexanoic) acid	39492-88-1
PFO3OA	Perfluoro (3,5,7-trioxaoctanoic) acid	39492-89-2
PFO4DA	Perfluoro (3,5,7,9-tetraoxadecanoic) acid	39492-90-5
PFO5DA	Perfluoro(3,5,7,9,11-pentaoxadodecanoic) acid	39492-91-6
PFMOAA	Perfluoro-2-methoxyacetic acid	674-13-5
EVE Acid	2,2,3,3-tetrafluoro-3-({1,1,1,2,3,3-hexafluoro-3-[(1,2,2-trifluoroethenyl)oxy]propan-2- yl}oxy)propionic acid	69087-46-3
PFESA-BP2 (Nafion Byproduct 2)	7H-Perfluoro-4-Methyl-3,6-Dioxaoctanesulfonic Acid	749836-20-2
Hydro-EVE Acid	2,2,3,3-Tetrafluoro-3-{[1,1,1,2,3,3-hexafluoro-3-(1,2,2,2-tetrafluoroethoxy)propan-2-yl]oxy}propanoic acid	773804-62-9
NVHOS	Perfluoroethoxysulfonic acid	801209-99-4
PFECA G	4-(Heptafluoroisopropoxy)hexafluorobutanoic acid	801212-59-9

Table 1. *Values of detected PFAS compounds and detection date for sites with values above PQL.*

Station	Date	Analytes Detected	Analyte	Result (ng/L)	PFAS Sum (ng/L)
CPF055CSUR	01/10/2023	8	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA	18 Q2 6.1 Q2 8.4 Q2 9.6 Q2 5.9 Q2 4.3 Q2 13 Q2 4.9 Q2	70.2
CPF086FSUR	01/10/2023	9	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA PFHpS	5.3 Q2 7.0 Q2 8.1 Q2 4.0 Q2 2.5 Q2 6.3 Q2 12 Q2 2.8 Q2 3.1 Q2	51.1
CPF087DSUR	01/10/2023	9	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA PFHpS	7.8 Q2 11 Q2 12 Q2 5.8 Q2 3.5 Q2 8.3 Q2 12 Q2 4.3 Q2 6.0 Q2	70.7
CPF055CSUR	02/08/2023	8	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFHpA PFHpS	17 Q2 5.9 Q2 8.0 Q2 9.8 Q2 5.7 Q2 4.0 Q2 4.8 Q2 2.2 Q2	57.4
CPF086FSUR	02/08/2023	9	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA PFHpS	4.6 Q2 5.5 Q2 6.9 Q2 3.3 Q2 2.3 Q2 5.7 J2, Q2 10 Q2 2.2 Q2 35 Q2	75.5

Station	Date	Analytes Detected	Analyte	Result (ng/L)	PFAS Sum (ng/L)
CPF087DSUR	02/08/2023	26	GenX	2.0	94.1
			PFOS	7.1	
			PFUnA	2.0	
			N-MeFOSAA	2.0	
			PFPeA	9.9	
			PFPeS	2.0	
			6:2 FTS	2.0	
			N-EtFOSAA	2.0	
			PFHxA	11	
			PFDoA	2.0	
			PFOA	5.4	
			PFDA	2.0	
			PFDS	2.0	
			PFHxS	3.2	
			PFBA	7.5	
			PFBS	5.6	
			PFHpS	4.1	
			PFNA	2.3	
			8:2 FTS	2.0	
			PFNS	2.0	
			PFTriA	2.0	
			9 Cl-PF3ONS	2.0	
			4:2 FTS	2.0	
			11 Cl-PF3OUdS	2.0	
			PFDoS	2.0	
			ADONA	2.0	
CPF055CSUR	03/16/2023	8	PFOS	20	82.1
			PFPeA	10	
			PFHxA	13	
			PFOA	12	
			PFHxS	6.6	
			PFBA	5.8 J2	
			PFBS	8.3	
			PFHpA	6.4	
CPF086FSUR	03/16/2023	9	PFOS	5.0	38
			PFPeA	5.4	
			PFHxA	6.4	
			PFOA	3.7	
			PFHxS	2.5	
			PFBA	5.5 J2	
			PFBS	5.1	
			PFHpA	2.3	
			PFHpS	2.1	

Station	Date	Analytes Detected	Analyte	Result (ng/L)	PFAS Sum (ng/L)
CPF087DSUR	03/16/2023	8	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA	6.5 8.3 8.8 4.6 2.6 6.5 J2 4.5 3.3	45.1
CPF055CSUR	04/12/2023	9	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA PFHpS	16 3.5 4.8 9.1 4.3 3.0 6.3 3.1 2.6	52.7
CPF086FSUR	04/12/2023	8	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA	5.5 5.9 6.7 4.3 2.5 6.1 J2 8.8 2.4	42.2
CPF087DSUR	04/12/2023	9	PFOS N-MeFOSAA PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA	7.3 J2 2.0 J2 7.8 J2 8.9 J2 5.6 J2 3.1 J2 6.1 J2 6.8 J2 3.2 J2	50.8
CPF055CSUR	05/24/2023	10	PFOS PFPeA PFPeS PFHxA PFOA PFHxS PFBA PFBS PFHpA PFHpS	23 Q2 17 Q2 2.1 Q2 18 Q2 16 Q2 7.0 Q2 11 Q2 16 Q2 7.8 Q2 3.5 Q2	121.4

Station	Date	Analytes Detected	Analyte	Result (ng/L)	PFAS Sum (ng/L)
CPF086FSUR	05/24/2023	9	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA PFHpS	6.5 Q2 6.1 Q2 5.7 Q2 4.4 Q2 2.9 Q2 6.4 Q2 11 Q2 2.4 Q2 12 Q2	57.4
CPF087DSUR	05/24/2023	8	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA	7.3 Q2 6.1 Q2 6.6 Q2 5.1 Q2 2.8 Q2 6.2 Q2 7.2 Q2 2.7 Q2	44
CPF055CSUR	06/08/2023	9	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA PFHpS	24 25 24 14 7.5 9.5 19 9.7 3.7	136.4
CPF086FSUR	06/08/2023	8	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA	6.4 5.7 6.3 4.8 2.9 7.0 J2 7.0 2.7	42.8
CPF087DSUR	06/08/2023	9	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA PFHpS	9.1 7.4 7.3 6.2 3.2 9.4 7.4 3.1 4.5	57.6

Station	Date	Analytes Detected	Analyte	Result (ng/L)	PFAS Sum (ng/L)
CPF055CSUR	07/24/2023	9	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA PFHpS	19 12 12 12 5.9 6.1 J1 11 5.2 2.5	85.7
CPF086FSUR	07/24/2023	9	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA PFHpS	7.6 7.6 7.3 5.0 3.0 6.2 J1 4.0 5.7 6.2	52.6
CPF087DSUR	07/24/2023	8	PFOS PFPeA PFHxA PFOA PFHxS PFBS PFHpA PFHpS	9.6 8.4 8.5 6.8 3.6 4.9 3.5 5.8	51.1
CPF055CSUR	08/09/2023	9	PFOS PFPeA PFPeS PFHxA PFOA PFHxS PFBA PFBS PFHpA	25 24 1.8 22 15 8 7.1 J1 23 8.3	134.2
CPF086FSUR	08/09/2023	9	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA PFHpS	9.2 8.5 7.8 6.2 3.6 5.7 J1 8.7 3.8 5.8	59.3

Station	Date	Analytes Detected	Analyte	Result (ng/L)	PFAS Sum (ng/L)
CPF087DSUR	08/09/2023	17	PFOS PFUnA PFPeA N-EtFOSAA PFHxA PFDoA PFOA PFDS PFHxS PFBA PFBS PFHpA PFHpS PFTA PFTriA 11 Cl-PF3OUdS PFDoS	9.4 1.9 8.4 1.8 V2 9.1 2.7 6.3 2.1 3.6 5.5 J1 5.2 3.5 3.7 2.5 2.4 2.2 1.9 J13	72.2
CPF055CSUR	09/12/2023	9	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA PFHpS	17 25 22 12 6.1 26 J1 18 9.7 2.4	138.2
CPF086FSUR	09/12/2023	8	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA	8.6 7.7 7.8 5.8 2.5 6.3 J1 6.9 3.0	48.6
CPF087DSUR	09/12/2023	8	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA	7.5 8.4 8 5.3 2.7 6.7 J1 4.1 2.9	45.6

Station	Date	Analytes Detected	Analyte	Result (ng/L)	PFAS Sum (ng/L)
CPF055CSUR	10/11/2023	8	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA	16 Y 25 Y 24 Y 12 Y 6.0 Y 9.9 J1, Y 17 Y 8.3 Y	118.2
CPF086FSUR	10/11/2023	9	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA PFHpS	7.6 11 13 6.1 2.7 8.1 J1 4.5 3.4 2.9	59.3
CPF087DSUR	10/11/2023	9	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA PFHpS	10 9.7 9.8 6.8 3.5 6.5 J1 5.8 3.8 2.0	57.9
CPF055CSUR	11/07/2023	8	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA	12 20 18 9.7 4.3 8.0 J1 16 6.5	94.5
CPF086FSUR	11/07/2023	8	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA	6.3 Y 9.7 Y 9.4 Y 5.3 Y 2.4 Y 7.0 J1, Y 6.1 Y 3.1 Y	49.3

Station	Date	Analytes Detected	Analyte	Result (ng/L)	PFAS Sum (ng/L)
CPF087DSUR	11/07/2023	8	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA	8.2 9.2 8.5 5.8 2.5 6.4 J1 5.5 3.3	49.4
CPF055CSUR	12/11/2023	10	PFOS PFPeA PFHxA PFOA PFDA PFHxS PFBA PFBS PFHpA PFNA	26 Y 26 Y 26 Y 13 Y 2.2 Y 5.8 Y 16 Y 27 Y 9 Y 2.1 Y	153.1
CPF086FSUR	12/11/2023	8	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA	6.3 13 13 6.0 2.5 9.3 J1 7.5 3.7	61.3
CPF087DSUR	12/11/2023	9	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS PFHpA PFHpS	8.8 Y 11 Y 11 Y 6.3 Y 2.7 Y 7.0 J1, Y 8.8 Y 4.2 Y 2.9 Y	62.7

Data Qualifier Codes:

J1 – Surrogate recovery limits have been exceeded.

J2 – The reported value failed to meet the established quality control criteria for either precision or accuracy.

J13 – Standards used for this analyte are from an uncertified source. These are the only standards currently available for this analyte.

Q2 – Holding time exceeded following receipt by lab.

V2 – The analyte was detected in both the sample and the field blank.

Y – Elevated PQL due to insufficient sample size.