Division of Water Resources Identification of Select Emerging Compounds in Public Reservoirs and Lakes of the Little Tennessee, Hiwassee, Roanoke, and White Oak River Basins (2024)

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:_____

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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 (ALMP) to characterize the presence and concentrations of these emerging compounds (EC) in public reservoirs and lakes of the Little Tennessee, Hiwassee, Roanoke, and White Oak River basins. Beginning in June of 2024, ISB staff collected surface water samples for 47 different PFAS substances (Appendix 2) and 1,4-Dioxane at 21 ambient lakes monitoring stations, six of which are North Carolina public water supply reservoirs (Appendix 1). Analytical results indicated the presence of at least one PFAS analyte above the laboratory practical quantitation limit (PQL) in each sampled waterbody of the Roanoke and White Oak River basins during the 2024 sampling season. PFAS was only detected on Appalachia Lake, Santeetlah Lake, Lake Sequoyah, and Thorpe Reservoir in the Hiwassee and Little Tennessee River basins. 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 2013, 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.

Appendix 1. *Station ID, description, and coordinates of 2024 ALMP sampled sites.*

WATERBODY NAME	STATION ID	LATITUDE	LONGITUTDE
LAKE CHATUGE	HIW000F	35.01652	-83.79100
HIWASSEE RESERVOIR	HIW009G	35.15712	-84.16280
APPALACHIA LAKE	HIW012	35.16770	-84.29344
LAKE SEQUOYAH*	LTN008E	35.06660	-83.22445
NANTAHALA LAKE	LTN013D	35.19015	-83.65351
BEAR CREEK RESERVOIR	LTN015D	35.24142	-83.07095
WOLF CREEK RESERVOIR	LTN015A1	35.22162	-82.99725
THORPE RESERVOIR	LTN015R	35.19541	-83.15704
LAKE FONTANA*	LTN031J	35.45619	-83.80479
LAKE CHEOAH	LTN032F	35.44853	-83.93526
SANTEETLAH LAKE	LTN037E	35.37582	-83.87662
CALDERWOOD LAKE	LTN041	35.49397	-83.97915
JOHN H. KERR RESERVOIR*	ROA037B	36.43779	-78.36103
BELEWS LAKE	ROA009H	36.31873	-80.02798
FARMER LAKE*	ROA027L	36.38634	-79.36263
LAKE ROXBORO	ROA030DE	36.34569	-79.15423
LAKE ISAAC WALTON*	ROA031C	36.42289	-79.01519
ROANOKE RAPIDS LAKE*	ROA039E	36.48232	-77.68777
LAKE GASTON	ROA039B	36.50321	-77.83114
CATFISH LAKE	WOK026D	34.93023	-77.09430
GREAT LAKE	WOK026H	34.86336	-77.03702

*North Carolina Public Drinking Water Reservoir

Results

PFAS analysis was conducted by DWR at the Central Laboratory in Raleigh, NC. Of the 47 PFAS compounds selected for this study (Appendix 2), the following 18 compounds were found above the PQL on at least one occasion: PFOS, PFOA, PFPeA, PFHxA, PFHxS, PFBA, PFBS, PFHpS, R-EVE, N-MeFOSAA, N-EtFOSAA, PFDoA, PFDS, PFTA, PFTriA, 11Cl-PF3OUdS, PFDoS, and PFUnA. These results demonstrate the widespread distribution of detectable PFAS in public lakes and reservoirs. Values of detected compounds and the associated detection dates for sites with compounds above the PQL are listed in Table 1 below.

1,4-Dioxane was not detected above the PQL (1.0 µg/L) at any of the collection sites listed in Appendix 1 throughout the sampling period.

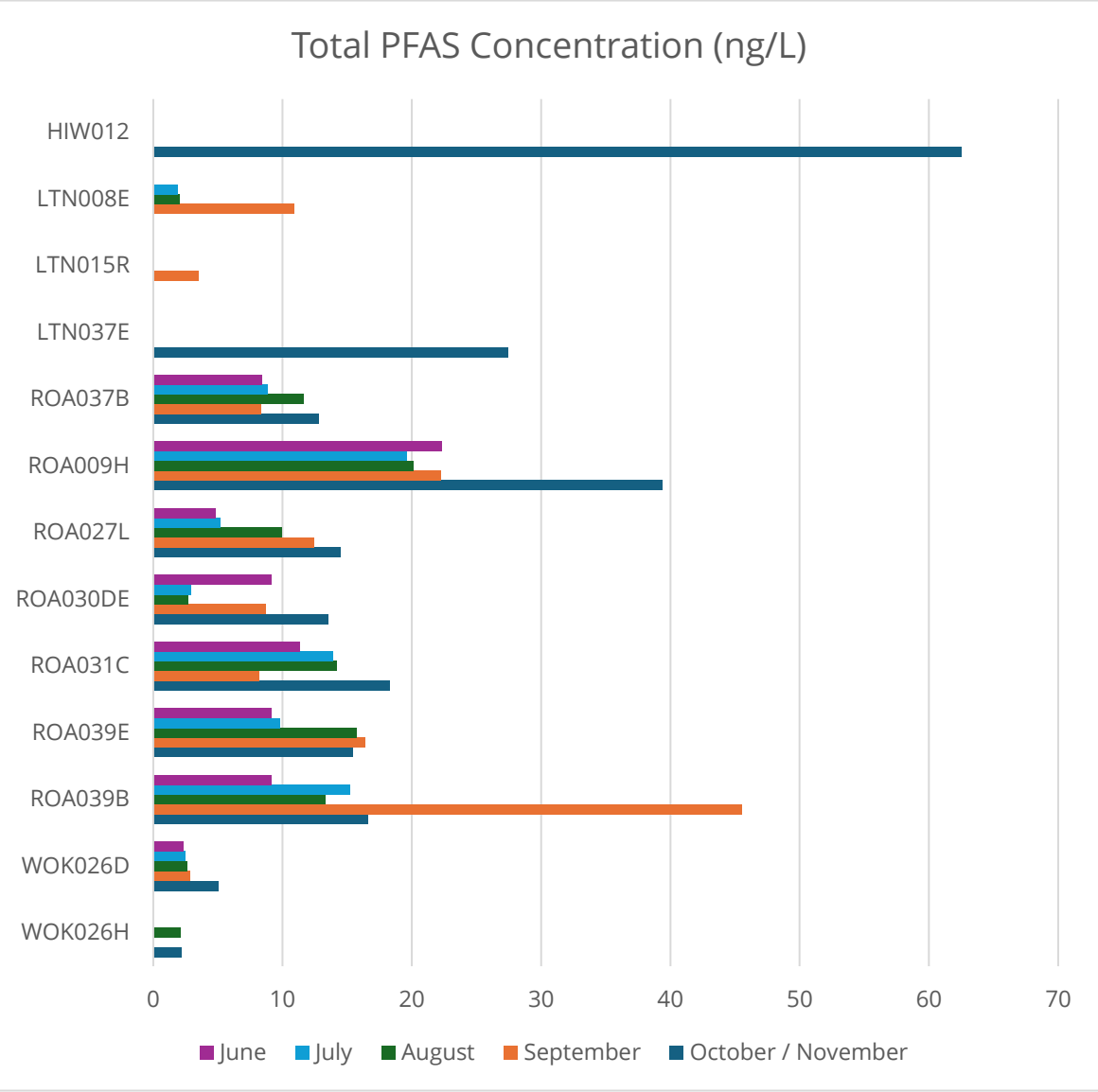
Summary

Evaluation of chemical results from this study suggest that while there are detectable levels of target PFAS analytes in all river basins sampled, additional long-term monitoring would

need to be conducted to evaluate persistence of these compounds and their associated effects on surface water. The graph in Figure 1 shows total PFAS concentration values for each month of the sampling period.

Apalachia Lake (HIW012) displayed the greatest diversity of target analytes (n=9) as well as the highest PFAS concentration (62.5 ng/L) out of any lakes sampled on 11/05/2024. This sampling event occurred post Hurricane Helene, which could have been a contributing factor to this observation. Throughout the sampling season Belews Lake (ROA009H) consistently had the highest monthly total PFAS concentrations which ranged from 19.6 ng/L on 07/30/2024 to 39.4 ng/L on 10/15/2024.

Figure 1. *Graph showing total PFAS concentrations per site per month.*



Appendix 2. *List of PFAS compounds sampled for.*

ABBREVIATION	CAS #
HFPO-DA (GenX)	13252-13-6
PFOS	1763-23-1
PFUnA	2058-94-8
N-MeFOSAA	2355-31-9
PFPeA	2706-90-3
PFPeS	2706-91-4
6:2 FTS	27619-97-2
N-EtFOSAA	2991-50-6
PFHxA	307-24-4
PFDoA	307-55-1
PFOA	335-67-1
PFDA	335-76-2
PFDS	335-77-3
PFHxS	355-46-4
PFBA	375-22-4
PFBS	375-73-5
PFHpA	375-85-9
PFHpS	375-92-8
PFNA	375-95-1
PFTA	376-06-7
8:2 FTS	39108-34-4
PFNS	68259-12-1
PFTriA	72629-94-8
9Cl-PF3ONS	756426-58-1
4:2 FTS	757124-72-4
11Cl-PF3OUdS	763051-92-9
PFDoS	79780-39-5
ADONA	919005-14-4
PFEESA/PES	113507-82-7
PMPA	13140-29-9
PFECA B or NFHDA	151772-58-6
R-PSDA (Nafion Byproduct 4)	2416366-18-0
Hydrolyzed PSDA (Nafion Byproduct 5)	2416366-19-1
R-PSDCA (Nafion Byproduct 6)	2416366-21-5
R-EVE	2416366-22-6
PEPA	267239-61-2
PFESA-BP1 (Nafion Byproduct 1)	29311-67-9

PFO2HxA	39492-88-1
PFO3OA	39492-89-2
PFO4DA	39492-90-5
PFO5DA	39492-91-6
PFMOAA	674-13-5
EVE Acid	69087-46-3
PFESA-BP2 (Nafion Byproduct 2)	749836-20-2
Hydro-EVE Acid	773804-62-9
NVHOS	801209-99-4
PFECA G	801212-59-9

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

Station	Date	Analytes Detected	Analyte	Result (ng/L)	PFAS Sum (ng/L)
ROA037B **JOHN H. KERR RESERVOIR**	06/05/2024	2	PFOS PFOA	5.0 Q2 3.4 Q2	8.4
ROA009H **Belews Lake**	06/25/2024	7	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS	4.0 J1 2.6 J1 3.1 J1 3.4 J1 3.5 J1 2.4 3.3 J1	22.3
ROA027L **Farmer Lake**	06/26/2024	2	PFOS PFHpS	2.6 J1 2.2 J1	4.8
ROA030DE **LAKE ROXBORO**	06/20/2024	4	PFOS PFOA PFBS PFHpS	3.1 1.9 J1 2.1 2.0	9.1
ROA031C **LAKE ISAAC WALTON**	06/03/2024	3	PFOS PFOA PFBA	5.9 Q2 2.9 Q2 2.5 J1, Q2	11.3
ROA039E **ROANOKE RAPIDS LAKE**	06/03/2024	2	PFOS PFOA	5.7 Q2 3.4 Q2	9.1
ROA039B **LAKE GASTON**	06/04/2024	2	PFOS PFOA	5.5 Q2 3.6 Q2	9.1
WOK026D **CATFISH LAKE**	06/04/2024	1	PFBA	2.3 J1, Q2	2.3

Station	Date	Analytes Detected	Analyte	Result (ng/L)	PFAS Sum (ng/L)
LTN008E **LAKE SEQUOYAH**	07/11/2024	1	PFOS	1.9 Q2	1.9
ROA037B **JOHN H. KERR RESERVOIR**	07/23/2024	2	PFOS PFOA	5.5 J2, Q2 3.3 Q2	8.8
ROA009H **Belews Lake**	07/30/2024	7	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS	3.5 J2, Q2 2.3 Q2 2.7 Q2 2.9 Q2 2.8 Q2 2.5 J1, Q2 2.9 Q2	19.6
ROA027L **Farmer Lake**	08/01/2024	2	PFOS PFHpS	2.5 2.7	5.2
ROA030DE **LAKE ROXBORO**	07/18/2024	1	PFOS	2.9 J2, Q2	2.9
ROA031C **LAKE ISAAC WALTON**	07/29/2024	4	PFOS PFOA PFBA PFHpS	5.7 J2, Q2 2.6 Q2 2.7 J1, Q2 2.9 Q2	13.9
ROA039E **ROANOKE RAPIDS LAKE**	07/31/2024	2	PFOS PFOA	6.2 J2, Q2 3.6 Q2	9.8
ROA039B **LAKE GASTON**	07/15/2024	4	PFOS PFHxA PFOA PFBA	7.1 1.9 4.1 2.1 J1	15.2
WOK026D **CATFISH LAKE**	07/31/2024	1	PFBA	2.5 J1	2.5

Station	Date	Analytes Detected	Analyte	Result (ng/L)	PFAS Sum (ng/L)
LTN008E **LAKE SEQUOYAH**	08/06/2024	1	PFOS	2.0	2.0
ROA037B **JOHN H. KERR RESERVOIR**	08/28/2024	3	PFOS R-EVE PFOA	5.3 3.2 J1, J13 3.1	11.6
ROA009H **Belews Lake**	08/20/2024	7	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS	3.6 J2 2.2 2.8 2.9 3.1 2.4 J1 3.1	20.1
ROA027L **Farmer Lake**	08/28/2024	3	PFOS R-EVE PFBA	2.7 5.3 J1, J13 1.9 J1	9.9
ROA030DE **LAKE ROXBORO**	08/06/2024	1	PFOS	2.7	2.7
ROA031C **LAKE ISAAC WALTON**	08/20/2024	3	PFOS PFOA PFBA	9.1 J2 2.9 J1 2.2 J1	14.2
ROA039E **ROANOKE RAPIDS LAKE**	08/22/2024	4	PFOS R-EVE PFOA PFBA	6.5 3.1 J1, J13 3.9 2.2 J1	15.7
ROA039B **LAKE GASTON**	08/22/2024	3	PFOS PFOA PFBA	7.4 J2 3.9 2.0 J1	13.3
WOK026D **CATFISH LAKE**	08/27/2024	1	PFBA	2.6 J1	2.6

Station	Date	Analytes Detected	Analyte	Result (ng/L)	PFAS Sum (ng/L)
WOK026H **GREAT LAKE**	08/27/2024	1	PFOS	2.1 V1	2.1
LTN008E **LAKE SEQUOYAH**	09/12/2024	2	PFOS PFBS	2.3 Q2 8.6 Q2	10.9
LTN015R **THORPE RESERVOIR**	09/12/2024	1	PFBS	3.5 Q2	3.5
ROA037B **JOHN H. KERR RESERVOIR**	09/19/2024	2	PFOS PFOA	5.1 Q2 3.2 J1, Q2	8.3
ROA009H **Belews Lake**	09/24/2024	7	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS	3.8 2.7 J1, J2 2.8 J1 3.1 3.3 3.3 J1 3.2	22.2
ROA027L **Farmer Lake**	09/18/2024	3	PFOS PFBA PFHpS	2.9 J1, Q2 4.0 Z2 5.5 J1, Q2	12.4
ROA030DE **LAKE ROXBORO**	10/02/2024	3	PFOS PFOA PFBA	3.6 2.2 J1 2.9 J1	8.7
ROA031C **LAKE ISAAC WALTON**	09/23/2024	2	PFOS PFOA	5.7 Q2 2.5 J1, Q2	8.2
ROA039E **ROANOKE RAPIDS LAKE**	09/19/2024	3	PFOS PFOA PFBA	6.8 Q2 3.8 Q2 5.8 J1, Q2	16.4

Station	Date	Analytes Detected	Analyte	Result (ng/L)	PFAS Sum (ng/L)
ROA039B **LAKE GASTON**	09/18/2024	8	PFOS N-MeFOSAA N-EtFOSAA PFDoA PFOA PFDS PFBA PFTA PFTriA 11Cl-PF3OUdS PFDoS	6.1 Q2, Y 3.7 Q2, V2, Y 5.2 Q2, V2, Y 3.8 Q2, V2, Y 3.0 J1, Q2, Y 3.0 Q2, V2, Y 3.3 J1, Q2, Y 4.4 Q2, V2, Y 4.8 Q2, V2, Y 3.6 Q2, V2, Y 4.6 Q2, V2, Y	45.5
WOK026D **CATFISH LAKE**	09/24/2024	1	PFBA	2.8 J1, Q2, Y	2.8
ROA037B **JOHN H. KERR RESERVOIR**	10/07/2024	3	PFOS PFOA PFBA	5.8 3.5 3.5 J1	12.8
ROA009H **Belews Lake**	10/15/2024	7	PFOS PFPeA PFHxA PFOA PFHxS PFBA PFBS	3.6 2.2 J1 2.4 J1 2.7 2.8 23 J1 2.7	39.4
ROA027L **Farmer Lake**	10/09/2024	4	PFOS PFPeA PFOA PFBA	3.0 4.5 J1 2.3 J1 4.7 J1	14.5
ROA030DE **LAKE ROXBORO**	10/22/2024	4	PFOS PFPeA PFOA PFBA	3.4 4.1 J 2.4 J1 3.6 J1	13.5
ROA031C **LAKE ISAAC WALTON**	10/23/2024	5	PFOS PFPeA PFOA PFBA PFHpS	6.0 4.1 J1 2.6 J1 2.9 J1 2.7	18.3

Station	Date	Analytes Detected	Analyte	Result (ng/L)	PFAS Sum (ng/L)
ROA039E **ROANOKE RAPIDS LAKE**	10/15/2024	4	PFOS PFPeA PFOA PFBA	5.7 3.0 J1 2.9 3.8 J1	15.4
ROA039B **LAKE GASTON**	10/08/2024	4	PFOS PFPeA PFOA PFBA	6.0 2.9 J1 3.6 4.1 J	16.6
WOK026D **CATFISH LAKE**	10/17/2024	2	PFBA PFBS	3.1 J1 1.9	5
WOK026H **GREAT LAKE**	10/17/2024	1	PFBA	2.2 J1	2.2
HIW012 **APALACHIA LAKE**	11/05/2024	9	PFUnA N-MeFOSAA N-EtFOSAA PFDoA PFDS PFTA PFTriA 11Cl-PF3OUdS PFDoS	2.7 5.6 7.5 V1 7.2 5.9 8.0 9.4 7.3 8.9 V1	62.5
LTN037E **SANTEETLAH LAKE**	11/07/2024	8	N-MeFoSAA N-EtFOSAA PFDoA PFDS PFTA PFTriA 11Cl-PF3OUdS PFDoS	2.8 V2 3.7 V1, V2 3.0 V2 2.4 V2 4.2 V2 4.2 V2 3.1 V2 4.0 V1, V2	27.4

Data Qualifier Codes:

J1 – Surrogate recovery limits have been exceeded.

J2 – The supported 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 the analyte.

Q2 – Holding time exceeded following receipt by the lab.

V1 – The analyte was detected in both the sample and the method blank.

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

Y – Elevated PQL due to insufficient sample size.

Z2 – The sample analysis/results are not reported due to questions concerning data reliability.