Virginia Per and Polyfluoroalkyl Substances (PFAS) in Drinking Water Sample Study Summary

Virginia Department of Health
Office of Drinking Water

VIRGINIA PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS) IN DRINKING WATER SAMPLE STUDY

SUMMARY OF RESULTS

SEPTEMBER 30, 2021

PFAS Sample Study Design

The Virginia Department of Health Office of Drinking Water (ODW), in conjunction with the Virginia Per and Poly Fluoroalkyl Substances (VA PFAS) work group, designed the sample study to prioritize sites for measuring Per and Poly Fluoroalkyl Substances (PFAS) concentrations in drinking water and major sources of water and generate statewide occurrence data, subject to the limitations in 2020 Acts of Assembly Chapter 611 (HB586).[1]

The process of selecting sample locations involved a combination of geospatial analysis and programmatic review in order to meet the requirements in HB586 and assess the potential public health implications for as many Virginians as possible within the scope of the legislation. The geospatial analysis utilized ArcMap 10.4.1 to overlay waterworks locations data and information about potential sources of PFAS contamination[2] from the Virginia Department of Environmental Quality (DEQ). The GIS project included information on the following:

- Waterworks size and population served;
- Known locations of potential PFAS contamination
- Military or commercial airports (from U.S. Geological Survey data);
- Unlined landfills;
- Virginia Pollutant Discharge Elimination System (VPDES) discharge locations;
- Discharge points for publicly owned treatment works (POTWs); and
- Major river networks in Virginia.

ODW selected the 17 largest waterworks in the state, which serve approximately 4.5 million consumers. This group represents 23 raw water sources, 21 water treatment plants, and 12 consecutive connections. ODW selected to monitor drinking water at the entry points to the distribution system, at the water treatment plants, and at consecutive connections at these 17 waterworks. All of these samples represent "finished water," which means the drinking water

[1] 2020 Acts of Assembly Chapter 611 states that in determining the current levels of PFAS contamination in public drinking water, "the Department of Health shall sample no more than 50 representative waterworks and major sources of water..."

[2] For purposes of the sample study, the term "potential sources of PFAS contamination" refers to facilities or locations that may be a source of PFAS based on historical use, existing literature, other available information (Standard Industrial Classification codes, Virginia Pollutant Discharge Elimination System permits, etc.), and/or the nature of the facility (airports, unlined landfills, etc.). This term is not meant to imply that these locations do in fact produce, use, or discharge PFAS, only that previous published work indicates the type of facility or activity may be associated with the production, use, or discharge of PFAS.

Further, the PFAS sample study does not determine the cause and effect relationship between potential sources of PFAS and PFAS found in drinking water or drinking water sources. The PFAS sample study and the sampling performed provide additional data regarding the occurrence of PFAS at waterworks in Virginia.

has gone through the treatment process before going into the waterworks' distribution system, i.e., the "entry point."

A significant portion of the peer-reviewed, published literature on PFAS contamination focuses on contamination resulting from the use of aqueous film-forming foam (AFFF), a product mandated for use by both the Federal Aviation Administration and the U.S. Department of Defense (DoD). AFFF that meets DoD specifications for use at military facilities is a common source of PFAS contamination and is frequently found at both military and large civilian airports, as well as many firefighting facilities. Other sources of PFAS associated with airports and the aeronautical industry include wire insulation and certain mechanical fluids. Given the number of products that can be found at airports that potentially contain PFAS, airports are considered a likely source of PFAS contamination. For the purpose of the geospatial analysis, ODW considered large airports (meaning the airport is large enough to be classified as a public-use airport). ODW did not attempt to identify whether the airports had either on-purpose or accidental releases of AFFF or if they conducted training with AFFF on-site.

Peer-reviewed, published research also indicates that landfills and landfill leachate may be a potential source of PFAS contamination. Landfill leachate likely obtains PFAS from the myriad of consumer products that include PFAS and are commonly placed in landfills. Consumer products, food contact packaging, cosmetics, and electronics are examples of PFAS-containing products commonly found in garbage. There are landfills in Virginia that were constructed before they had to meet the requirements in Subtitle D of the Resource Conservation and Recovery Act (RCRA), meaning they are unlined and more likely to have leachate that reaches groundwater sources. The Subtitle D criteria do not apply to landfill units if they did not receive waste after October 9, 1991. See 40 C.F.R. § 258.1(c). DEQ recommended focusing on landfills that did not have linings, leachate collection systems, or other waste disposal facilities.

ODW considered waterworks using a groundwater well located within 1.0 mile of an unlined landfill or airport as a potential risk for PFAS influence. ODW does not possess, and therefore did not consider, the following in evaluating potential risk for PFAS in groundwater waterworks/water sources:

- Data on PFAS levels in groundwater;
- Information on groundwater flow direction; or
- Information on water supply well recharge areas.

Based on the compilation of potential sources of PFAS contamination, ODW and the PFAS work group selected 11 waterworks that use groundwater as their water source and have a well or wells to withdraw groundwater within 1 mile of potential sources of PFAS contamination.

ODW also identified major surface water supplies for sampling based on potential sources of PFAS contamination that DEQ identified from SIC codes and information in VPDES permits. These included POTWs with significant industrial users, direct dischargers, and activities with potential to involve PFAS. The identified facilities potentially use and/or discharge PFAS; however, DEQ does not have effluent monitoring data for PFAS. DEQ noted that both current and historic discharges of PFAS could impact waterworks' surface water intakes. DEQ provided the Global Positioning System (GPS) coordinates for the discharge points to ODW. Using ArcGIS, ODW overlaid the discharge points to surface water bodies and

identified them as potentially impacted by PFAS discharges. ODW traced the surface water bodies downstream to identify waterworks with surface water intakes potentially impacted by the discharges. This procedure identified 45 drinking water intakes potentially impacted by the discharges. ODW prioritized these 45 intakes as follows:

- ODW excluded intakes associated with the 17 large waterworks because the entry point sampling addressed these intakes;
- ODW sorted remaining waterworks from the largest to the smallest population served;
- The PFAS work group recommended including at least one sample location from the New River, Clinch River, and Dan River;
- ODW selected impacted intakes starting with the largest population served, selecting two intakes on the river systems noted above; and
- ODW selected no more than one intake per waterworks.

Based on the limitation in HB586 of no more than 50 waterworks and major sources of water, ODW selected 22 major sources of water for sampling. Figures 1 and 2 show the locations of potential sources of PFAS contamination, surface water sources that are potentially impacted by PFAS, and associated surface water intake locations selected for monitoring as part of the sample study.

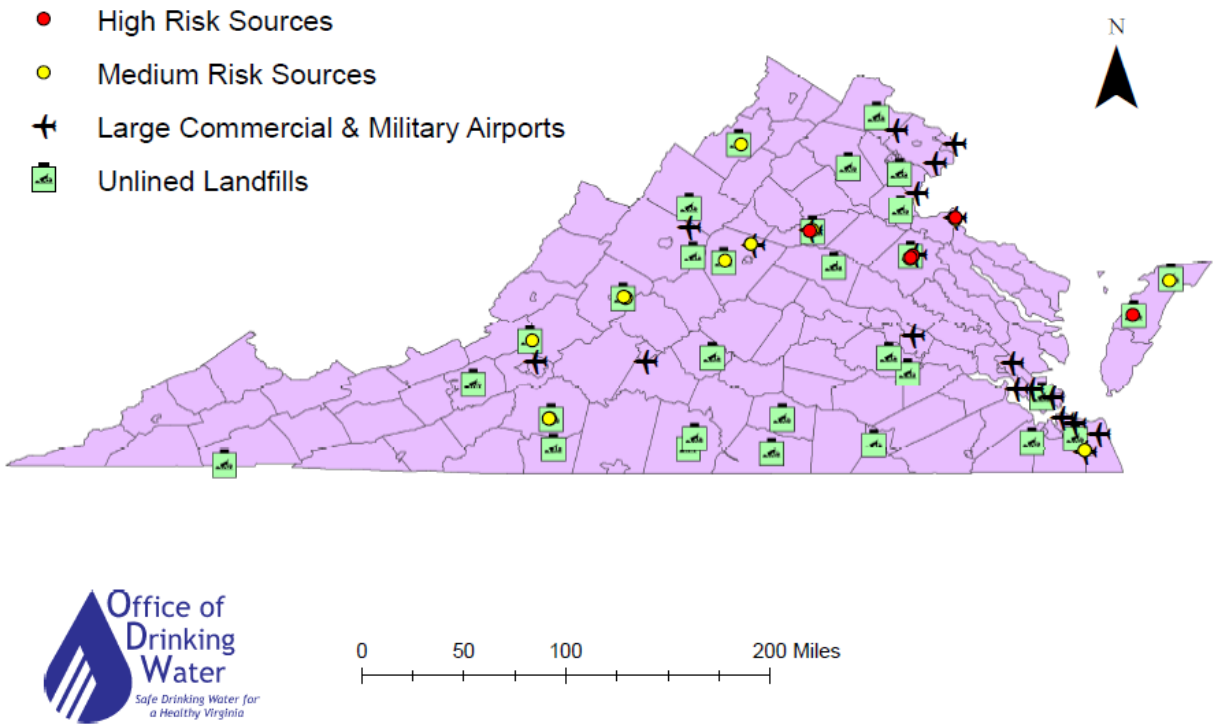

Figure 1 - Potential sources of PFAS contamination. High risk means the potential source of contamination is less than one-half mile from a waterworks. Medium risk means the potential source is between one-half and one mile from a waterworks.

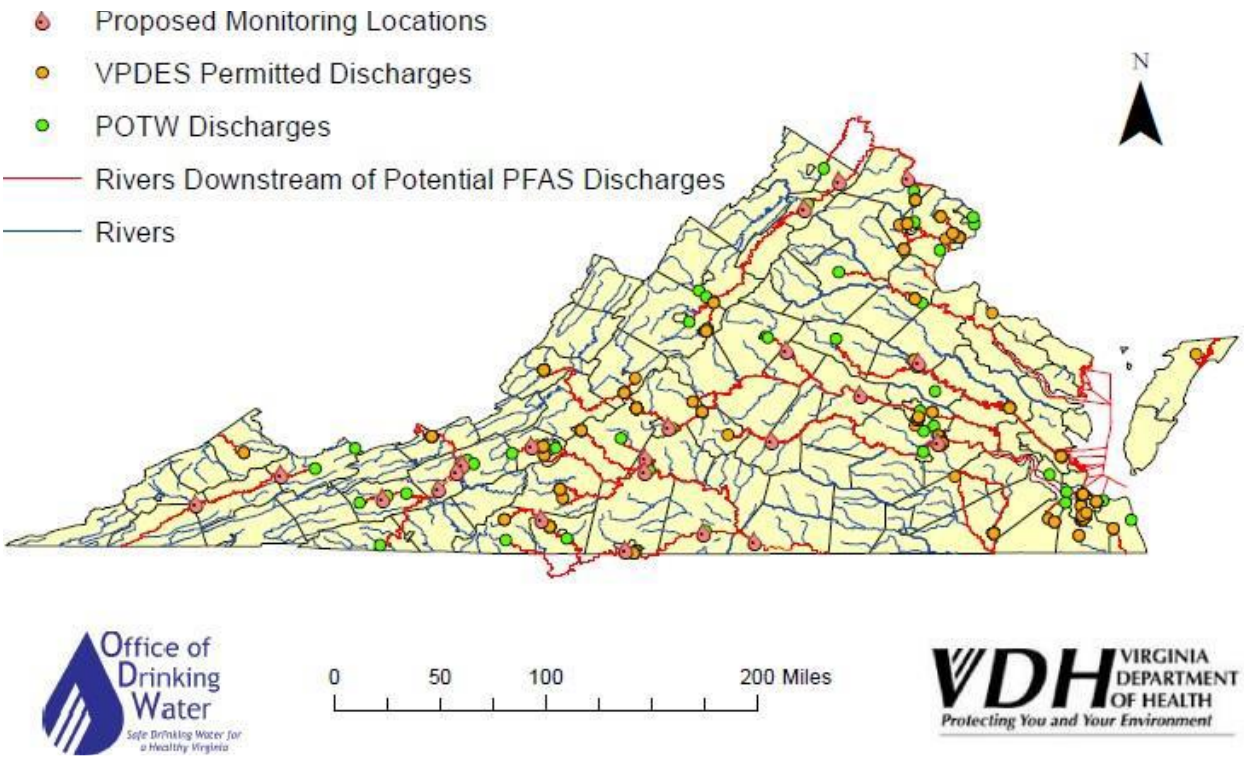

Figure 2 – River systems (blue) with intakes downstream of potential PFAS discharges (red), and proposed PFAS monitoring locations.

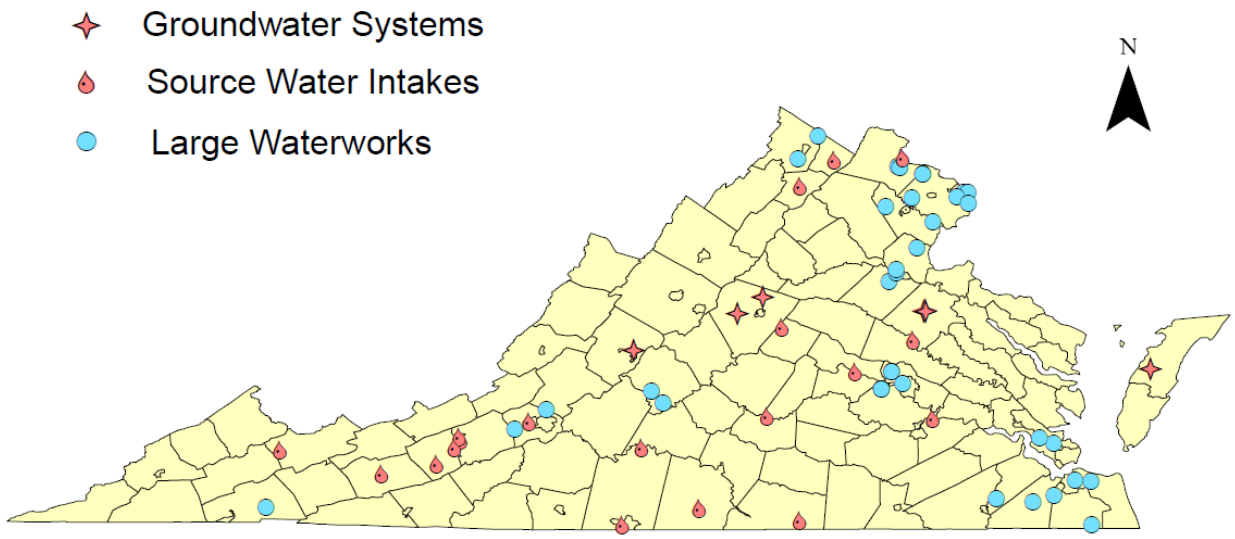

Figure 3 – PFAS monitoring locations.

Laboratory Analytical Services

HB586 requires ODW and the PFAS work group to study the occurrence of 6 specified PFAS[3] and others, "as deemed necessary," in the Commonwealth's public drinking water. ODW contracted with a laboratory that had the capability to analyze water samples for all 6 PFAS through a competitive bidding process. The scope of work included preparing sample kits, shipping the kits to the participating waterworks, providing return shipping labels, analyzing the samples, and returning results to ODW and the waterworks using EPA Method 533 for finished water samples and a comparable method for source (untreated) water samples. The laboratory had to meet accreditation and other requirements in ODW's Quality Assurance Project Plan, which EPA approved as a requirement for ODW to use a federal grant to pay for testing. The laboratory analyzed drinking water samples by EPA Method 533 because this method reports the analytes specified in HB586, whereas EPA Method 537.1 does not (it does not include perfluorobutyrate (PFBA)). Other related requirements included:

- The laboratory will report the complete list of 25 analytes (EPA Method 533 analytes).
- The laboratory will establish method reporting limits (MRLs) for each analyte based on the lowest concentration of standards used by the laboratory.
- The laboratory will meet National Environmental Laboratory Certification (NELAC) accreditation requirements.

The laboratory analyzed source water samples using a method employing solid phase extraction, liquid chromatograph/mass spectrometer/mass spectrometer (LC/MS/MS), and isotope dilution that met the requirements of Table B-15 of the DoD ELAP QSM (Environmental Laboratory Accreditation Program Quality Systems Manual). The laboratory had to analyze source water samples by another method since EPA Methods 537.1 and 533 are applicable only to drinking water. Other related requirements for source water analysis included:

- The laboratory will report the same analytes as EPA Method 533.
- The laboratory will use the same MRLs as EPA Method 533 or as agreed by ODW.
- The laboratory will hold accreditation for the DoD PFAS method by LC/MS/MS compliant with QSM 5.3 Table B-15.

PFAS Sample Study Results

Of the 50 waterworks identified in the VA PFAS Sample Study Design, 45 agreed to participate in the study (40 waterworks with surface water sources; 5 with groundwater sources). There are a total of 63 sample locations among the 45 waterworks because some waterworks have more than one treatment facility or water source. Figure 3 shows the locations of the 45 waterworks that participated in the Sample Study.

Waterworks received sample kits from the laboratory between May through July 2021. ODW and the laboratory provided training and specific instructions on sample collection so that operators at each of the participating waterworks could collect the samples. Waterworks staff

[3] The 6 PFAS specified in HB 586 are perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), perfluorobutyrate (PFBA), perfluoroheptanoic acid (PFHpA), perfluorohexane sulfonate (PFHxS), and perfluorononanoic acid (PFNA).

collected samples and returned them to the laboratory for analysis from late May through July 2021.

Quality Assurance/Quality Control (QA/QC) review of the preliminary results revealed data inconsistencies with four (4) samples, so ODW requested the waterworks resample from each of the four (4) locations. Data inconsistencies means the sample did not have any detected PFAS, but the field reagent blank (FRB), used for QA/QC purposes, had PFAS, which suggested the two were either switched or there was cross-contamination. Another data inconsistency occurred when both the sample and FRB had PFAS, which suggested a sample collection error, or another data qualifier was out of the specified range for the FRB.

Table 1 provides a summary of the sample results. Specified PFAS were found in quantities above the practical quantitation level[4] (PQL) at 15 of the 63 sample locations. The highest detected concentration of a compound was 57 ppt of hexafluoropropylene oxide-dimer acid (HPFO-DA), which is commonly known as GenX, a type of PFAS developed to replace use of perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS). All other detections were 20 ppt[5] or less. Resamples resolved QA/QC questions with the data irregularities.

- PFOA was measured above the 3.5 ppt practical quantitation limit (PQL) at four sample locations. Measured concentrations were between 4.2 and 5.5 ppt.
- PFOS was measured above the 3.5 ppt PQL at seven sample locations. Measured concentrations were between 3.9 and 7.1 ppt.
- Perfluorobutyrate (PFBA) was measured above the 3.5 ppt PQL at 10 sample locations. Measured concentrations were between 3.7 and 12 ppt.
- Perfluoroheptanoic acid (PFHpA) was measured above the 3.5 ppt PQL at three sample locations. Measured concentrations were between 4.1 and 5.5 ppt.
- Perfluorohexane sulfonate (PFHxS) was measured above the 3.5 ppt PQL at one sample location. The concentration was 4.9 ppt.
- Perfluorononanoic acid (PFNA) was not detected in any samples at a concentration above the PQL.
- Four (4) additional PFAS that are not listed in HB586 were measured above their respective PQLs in samples. They include HPFO-DA, PFHxA (perfluorohexanoic acid), PFPeA (perfluoropentanoic acid), and PFBS (perfluorobutanesulfonic acid).

All of the samples that had PFAS present above the PQL were from surface water sources and all, except one, were entry point samples. Neither ODW nor DEQ have collected additional samples to identify potential sources of PFAS contamination. A list of the 48 sample locations that did not have any PFAS detected above the PQL is in Table 2.

[4] Practical Quantification Limit (PQL) is the minimum concentration of an analyte than can be measured with high confidence, in this case, 99%.

[5] 20 ppt is significant since Massachusetts and Vermont established a maximum contaminant level (MCL) of 20 ppt for total PFAS, which differs from the approach of other states that established MCLs for individual PFAS analytes.

Ten samples from waterworks in the Northern Virginia region had at least one PFAS present in a quantity above the PQL, but none were above EPA's health advisory level of 70 ppt for PFOA and PFOS (individually or combined) and none exceeded any of the maximum contaminant levels (MCLs) established by other states, which range from 8 ppt to 14 ppt. Table 3 contains MCLs for other states and EPA's current lifetime health advisory.

Only one other waterworks outside of the Northern Virginia area had results indicating more than one PFAS was present in its finished water or source water samples above a PQL. Again, those levels were below EPA's health advisory level and all of the MCLs established by other states. (See Table 3.)

With respect to the presence of GenX in two sample locations, no other PFAS were detected above the PQL at either of the two locations. The only state that has an MCL for GenX is Michigan, which established an MCL of 370 ppt. ODW observed 51 ppt of GenX at one location and a resample observed 57 ppt. As a result, ODW is reporting the average of the two samples, 54 ppt, for this location. The levels of GenX detected at the two sample locations, 54 ppt and 4 ppt, were below the Michigan MCL.

Conclusions

There are approximately 2,800 waterworks in the Commonwealth of Virginia. HB586 specified that in determining the current levels of PFAS contamination in public drinking water, "the Department of Health shall sample no more than 50 representative waterworks and major sources of water..." Of the 50 waterworks and major sources of water identified in the VA PFAS Sample Study Design, 45 agreed to participate in the study and they provided a total of 63 samples (some waterworks have more than one treatment facility or water source). PFAS were found in quantities above the PQL at 15 of the 63 sample locations. All the samples were below the U.S. Environmental Protection Agency's lifetime health advisory level of 70 ppt and all of the current maximum contaminant limits established by individual states. Samples from 48 sample locations did not contain any PFAS above the PQL. The Sample Study was a one-time sampling event and was limited to the 45 waterworks. It is not a comprehensive evaluation of the extent or nature of PFAS contamination across the state, nor is it indicative of the sources of PFAS contamination when it was detected at a waterworks. The General Assembly appropriated $60,000 in fiscal year 2022 for the Virginia Department of Health to continue its study of the occurrence of perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), and other perfluoroalkyl and polyfluoroalkyl substances (PFAS) in the Commonwealth's public drinking water and to develop recommendations for specific maximum contaminant levels for PFOA, PFOS, and other PFAS for inclusion in regulations of the Board of Health applicable to waterworks.

Table 1

Samples with analytes above the Practical Quantification Limit (PQL)

All results are parts per trillion (ppt)

Waterworks Name	**Virginia American Water Co. - Alexandria District**		**Arlington County**	**Fairfax County Water Authority**		**Loudoun Water - Central System**		**Stafford County Utilities**		**Prince William County Service Authority - East**	**City of Newport News**		**Town of Altavista**	**Western Virginia Water Authority**	**Washington County Service Authority**
City/County	City of Alexandria		Arlington County	Fairfax County		Loudoun County		Stafford County		Prince William County	City of Newport News		Campbell County	Roanoke County	Washington County
Sample Location	From Fairfax Water		From Washington Aqueduct	Griffith WTP	From Washington Aqueduct	Trap Rock WTP	From Fairfax County Water Authority	Smith Lake WTP	Lake Mooney WTP	From Fairfax County Water Authority	Harwoods Mill WTP	Lee Hall WTP	Staunton River + Reed Creek	Spring Hollow WTP	Middle Fork Water Treatment Plant
Water Type	Finished	Finished	Finished	Finished	Finished	Finished	Finished	Finished	Finished	Finished	Finished	Finished	Raw Intake	Finished	Finished
PFOA (ppt)	*	4.2	*	5.5	*	*	4.5	*	*	5.5	*	*	*	*	*
PFOS (ppt)	*	3.9	*	5.1	*	*	*	6.4	*	4.1	7.1	4.4	*	*	5.2
PFBA (ppt)	7.7	9.2	*	7.7	4.3	4.0	4.6	*	5.9	12	4.3	4.3	*	*	*
PFHpA (ppt)	*	*	*	4.4	*	*	5.5	*	*	4.1	*	*	*	*	*
PFHxS (ppt)	*	*	*	*	*	*	*	*	*	*	4.9	*	*	*	*
PFNA (ppt)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
HPFO-DA (Gen-x)(ppt)	*	*	*	*	*	*	*	*	*	*	*	*	4.0	54[A]	*
PFHxA (ppt)	6.8	9.3	3.7	12	4.4	*	*	*	4.2	11	*	6.1	*	*	*
PFPeA (ppt)	7.4	10	4.1	14	4.2	*	*	*	5.5	12	*	4.5	*	*	*
PFBS (ppt)	*	4.2	*	5.6	*	*	*	*	*	4.8	*	*	*	*	*

*Results were below the Practical Quantitation Limit (PQL); PQL is the lowest level that can be reliably measured within specified limits of precision and accuracy during routine laboratory conditions.

[A] Average of two results, 51 ppt and 57 ppt

"Finished" means treated drinking water entering the distribution system.

"Raw Intake" means untreated water, before treatment.

"WTP" means water treatment plant.

Table 2
Samples with PFAS below the Practical Quantification Limit (PQL)

Water System Name	City/County	Water Type	Sampling Point
Earlysville Forest	Albemarle County	Finished	Combined Wells
Peacock Hill Subdivision	Albemarle County	Finished	Combined Wells
Pungoteague Elementary School	Accomack County	Finished	Well
Town of Bowling Green	Caroline County	Finished	Combined Wells
Mountain View Elementary School	Rockbridge County	Finished	Well
Frederick Water	Frederick County	Finished	James Diehl WTP
Frederick Water	Frederick County	Finished	James T. Anderson WTP
Western Virginia Water Authority	Roanoke County	Finished	Carvins Cove WTP
City of Chesapeake - Northwest River System	City of Chesapeake	Finished	Northwest River WTP
City of Chesapeake - Northwest River System	City of Chesapeake	Finished	Lake Gaston WTP
City of Norfolk	City of Norfolk	Finished	Moores Bridges WTP
City of Norfolk	City of Norfolk	Finished	Kristen M Lentz WTP
City of Portsmouth	City of Portsmouth	Finished	Lake Kilby WTP
City of Virginia Beach	City of Virginia Beach	Finished	From City of Norfolk
Chesterfield County Central Water System	Chesterfield County	Finished	Addison Evans WTP
Chesterfield County Central Water System	Chesterfield County	Finished	From City of Richmond
Chesterfield County Central Water System	Chesterfield County	Finished	From Appomattox River Water Authority
Henrico County Water System	Henrico County	Finished	Henrico WTP
Henrico County Water System	Henrico County	Finished	From City of Richmond
City of Richmond	City of Richmond	Finished	Richmond WTP
City of Lynchburg	City of Lynchburg	Finished	Abert Water Treatment Plan
City of Lynchburg	City of Lynchburg	Finished	College Hill WTP
Fairfax County Water Authority	Fairfax County	Finished	Corbalis WTP
Prince William County Service Authority - West	Prince William County	Finished	City of Manassas WTP
Prince William County Service Authority - West	Prince William County	Finished	Fairfax County Water Authority
Spotsylvania County Utilities	Spotsylvania County	Finished	Ni River WTP
Spotsylvania County Utilities	Spotsylvania County	Finished	Motts Run WTP
NRV Regional Water Authority	Montgomery County	Raw Intake	New River
Radford Army Ammunition Plant	Montgomery County	Raw Intake	New River
Pulaski County Public Service Authority	Pulaski County	Raw Intake	Claytor Lake
Town of Richlands	Tazwell County	Raw Intake	Clinch River
Town of Wytheville	Wythe County	Raw Intake	Reed Creek
City of Radford	City of Radford	Raw Intake	New River
Town of Berryville	Clarke County	Raw Intake	Shenandoah River

Water System Name	City/County	Water Type	Sampling Point
Lake Monticello	Fluvanna County	Raw Intake	Rivanna River
Town of Front Royal	Warren County	Raw Intake	South Fork Shenandoah River
City of Salem	City of Salem	Raw Intake	Roanoke River
VA American Water Co., Hopewell District	City of Hopewell	Raw Intake	Appomattox River
James River Correctional Center	Goochland County	Raw Intake	James River
Hanover Suburban Water System	Hanover County	Raw Intake	North Anna River
Roanoke River Service Authority	Mecklenburg County	Raw Intake	Lake Gaston
Town of Farmville	Prince Edward County	Raw Intake	Appomattox River
City of Danville	City of Danville	Raw Intake	Dan River
Halifax County Service Authority - Leigh St Plant	Halifax County	Raw Intake	Dan River
Town of Leesburg	Loudoun County	Raw Intake	Potomac River

"Finished" means treated drinking water entering the distribution system.

"Raw Intake" means untreated source water, sampled at a water treatment plant.

"WTP" means water treatment plant.

"Well" means water from one well, after treatment, if provided.

"Combined Wells" means water from two or more wells, after treatment, if provided.

"From" indicates finished water purchased from a waterworks.

The PQL is the lowest level that can be reliably measured within specified limits of precision and accuracy during routine laboratory conditions.

Table 3
State and Federal limits on PFAS

	CA	CT	Mass.	MI	MN	NH	NJ	NY	VT	Virginia	EPA
	Notice Level*	Action Level	MCL	MCL	Health Advisory	MCL	MCL	MCL	MCL	MCL	Health Advisory
PFOA	5.1	✓	✓	8	35	12	14	10	✓	Study /estab.	✓
PFOS	6.5	✓	✓	16	15	15	13	10	✓	Study /estab.	✓
PFNA		✓	✓	6		11	13		✓	Study	
PFHxS		✓	✓	51	47	18			✓	Study	
PFHpA		✓	✓						✓	Study	
PFDA			✓								
PFBS				420	2,000						
PFHxA				400,000							
Gen X				370							
PFBA					7,000					Study	
SUM		70	20						20		70

All values are parts per trillion (ppt, 1×10^{-9}, which is equivalent to nanograms per liter).

* California requires waterworks to take a source out of service if a chemical is present in drinking water at a concentration greater than the notification level – this is referred to as the "response level." For PFOA and PFOS, California has lowered the response levels from 70 ppt combined to 10 ppt for PFOA and 40 ppt for PFOS based on a running four-quarter average.

Action Levels and Health Advisories are not enforceable limits.

"Study" indicates the specific PFAS is included among those in HB586. "Study/etab." Means that the State Board of Health will be required to establish an MCL for PFOA and PFOS when the amendments to Code of Virginia § 32.1-169 become effective on January 1, 2022.

Check marks indicate which PFAS are included in a limit that is a sum of chemicals.