Establishing Regulatory Limits for PFAS, Chromium (VI), and 1,4-Dioxane in Virginia Drinking Water

To

The Chairmen of
the Senate Committee on Education and Health

and

the House Committee on Health, Welfare, and Institutions

Submitted By

Office of
Drinking
Water
Safe Drinking Water for
a Healthy Virginia

Virginia Department of Health

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Table of Contents

GLOSSARY AND ACRONYMS

“AFFF” means aqueous film-forming foam. AFFF is a fire suppressant used to extinguish flammable liquid fires such as fuel fires. Perfluorooctane sulfonic acid (PFOS) was used in AFFF. Other PFAS may be present as a result of the manufacturing process or as breakdown products.

“Board” means the State Board of Health.

“Community waterworks” (CWS) means a waterworks that serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents. Examples include municipal water systems, authorities, and residential subdivisions with their own water supplies.

“DEQ” means the Virginia Department of Environmental Quality.

“Entry point” means the place where water from the source after application of any treatment is delivered to the distribution system.

“EPA” means the U.S. Environmental Protection Agency.

“Finished water” means water that is introduced into the distribution system of a waterworks and is intended for distribution and consumption without further treatment, except as treatment is necessary to maintain water quality in the distribution system (e.g., booster disinfection).

“GAC” means granular activated carbon, a water treatment technology that can be used for PFAS removal. Powdered activated carbon (PAC) is a variant of GAC.

“GenX” is a trade name for a technology that is used to make high performance fluoropolymers (e.g., some nonstick coatings) without the use of perfluorooctanoic acid (PFOA).

“HA” means a health advisory. “Under the Safe Drinking Water Act, EPA may publish HAs for contaminants that are not subject to any national primary drinking water regulation. SDWA section 1412(b)(1)(F) [42 U.S.C. § 300g-1(b)(1)(F)]. EPA develops HAs to provide information on … exposure [and] health effects … for drinking water contaminants. HAs describe concentrations of drinking water contaminants at which adverse health effects are not anticipated to occur over specific exposure durations (e.g., one-day, ten-days, and a lifetime). HAs serve as informal technical guidance to assist federal, state and local officials, as well as managers of public or community water systems in protecting public health. They are not regulations and should not be construed as legally enforceable federal standards. HAs may change as new information becomes available.” https://www.regulations.gov/document/EPA-HQ-OW-2014-0138-0037

“HPFO-DA” means hexafluoropropylene oxide-dimer acid, a replacement chemical for PFOA that is associated with GenX.

“IX” means ion exchange treatment, another treatment technology capable of removing PFAS from water.

“LHA” means lifetime health advisory. The LHA is the concentration of a chemical in drinking water that is not expected to cause any adverse noncarcinogenic effects for a lifetime of exposure, incorporating a drinking water relative source contribution factor of contaminant-specific data or a default of 20% of total exposure from all sources. The LHA is based on exposure of a 70-kg adult consuming 2 liters of water per day.

“MDL” means method detection limit. The MDL is defined as the minimum measured concentration of a substance that can be reported with 99% confidence that the measured concentration is distinguishable from method blank results. 40 C.F.R. Part 136, Appendix B.

“MCL” means maximum contaminant level. The MCL is the maximum permissible level of a contaminant in potable water that is delivered to any consumer of a waterworks.

“MCLG” means the the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, allowing an adequate margin of safety. 42 USC § 300 g-1(b)(4)(A).

“ng/L” means nanograms per liter. 1 ng/L is equivalent to 1 part per trillion (ppt).

“Nontransient noncommunity waterworks” (NTNC) means a waterworks that is not a CWS, that regularly serves at least 25 of the same people at least six months of the year. Examples include schools, factories, and hospitals that have their own water supplies.

“ODW” means the Office of Drinking Water, a functional unit within the Virginia Department of Health with responsibility for regulating waterworks in Virginia.

“One-day health advisory” means the concentration of a chemical in drinking water that is not expected to cause any adverse noncarcinogenic effects for up to one day of exposure. The one-day health advisory is intended to protect a 10-kg child consuming 1 liter of water per day.

“PFAS” means per- and polyfluoroalkyl substances and refers to a broad class of chemical compounds that includes PFOA, PFOS, PFBA, PFHpA, PFHxS, PFNA, HPFO-DA, and thousands of others.

“PFBA” means perfluorobutyrate.

“PFBS” means perfluorobutane sulfonic acid, a replacement chemical for PFOS.

“PFHpA” means perfluoroheptanoic acid.

“PFHxS” means perfluorohexane sulfonate.

“PFNA” means perfluorononanoic acid.

“PFOA” means perfluorooctanoic acid.

“PFOS” means perfluorooctane sulfonic acid.

“POTW” means publicly owned treatment works. This includes any devices and systems used in the storage, treatment, recycling and reclamation of municipal sewage or industrial wastes of a liquid nature.

“ppb” means parts per billion. 1 ppb is equivalent to 1 microgram per liter (µg/L).

“ppm” means parts per million. 1 ppm is equivalent to 1 milligram per liter (mg/L).

“ppt” means parts per trillion. 1 ppt is equivalent to 1 nanogram per liter (ng/L).

“PQL” means practical quantitation level. The PQL is the lowest level that can be reliably measured within specified limits of precision and accuracy during routine laboratory conditions. In general, the MDL < PQL.

“SDWA” means the Safe Drinking Water Act.

“SIC” means Standard Industrial Classification code. A SIC code describes the primary business activity of a company.

“Ten-day health advisory” means the concentration of a chemical in drinking water that is not expected to cause any adverse noncarcinogenic effects for up to ten days of exposure. The ten day health advisory is also intended to protect a 10-kg child consuming 1 liter of water per day.

“Transient noncommunity waterworks” (TNC) means a waterworks that is not a CWS, but serves transient customers in non-residential settings, such as campgrounds, motels, and restaurants that have their own water supplies. A TNC serves at least 25 persons daily for at least 60 days out of the year.

“µg/L” means micrograms per liter. 1 µg/L is equivalent to 1 part per billion (ppb).

“UCMR3” means EPA’s Third Unregulated Contaminant Monitoring Rule.

“VAPA” means the Virginia Administrative Process Act, Chapter 40 (§ 2.2-4000 et seq.) of Title 2.2 of the Code of Virginia. The VAPA is the basic law conferring authority on agencies either to make regulations or case decisions as well as standardizing court review thereof.

“VDH” means the Virginia Department of Health.

“VPDES” means Virginia Pollutant Discharge Elimination System.

“Waterworks” means a system that serves piped water for human consumption to at least 15 service connections or 25 or more individuals for at least 60 days out of the year. EPA and some other states refer to a waterworks as a “public water system.”

1. EXECUTIVE SUMMARY

The third enactment clause of 2020 Acts of Assembly Chapter 1097 (HB1257) requires the Virginia Department of Health (VDH) to submit a final report to the Chairmen of the Senate Committee on Education and Health and the House Committee on Health, Welfare and Institutions by October 1, 2021, detailing the maximum contaminant level (MCL) regulations established for per- and polyfluoroalkyl substances (PFAS), chromium (VI), and 1,4-dioxane. This report provides information about the work VDH is doing to establish the MCLs, which includes evaluating:

- PFAS contamination in drinking water (based on preliminary results from the study being performed under 2020 Acts of Assembly Chapter 611 (HB586));
- MCLs adopted by other states; treatment technologies; toxicological data and research other states and the federal government have used as the basis for limits on PFAS; and
- Requirements VDH must follow to promulgate regulations.

HB1257 required this report before the amendment to Code of Virginia § 32.1-169 (adding subsection B, which requires the Board of Health to adopt regulations establishing MCLs for PFAS, chromium (VI), and 1,4-dioxane) becomes effective on January 1, 2022, and before VDH's PFAS work group, established pursuant to HB586, concludes its work. Hence, there is insufficient information and authority at the time of this report for VDH and the Board of Health to establish MCLs, consistent with the Public Water Supplies Law, specifically Code of Virginia § 32.1-169 B., and the Virginia Administrative Process Act (VAPA), Code of Virginia § 2.2-4000 et seq., for PFAS, chromium (VI), and 1,4-dioxane. VDH will start the process required pursuant to the VAPA to adopt regulations establishing MCLs for PFAS, chromium (VI), and 1,4-dioxane as soon as HB1257 takes effect on January 1, 2022.

VDH's Office of Drinking Water (ODW) has provided administrative support and technical guidance to the PFAS work group, which planned, designed, and conducted the PFAS sample study required by HB586 (See Appendix 1 for a list of PFAS work group members). Information about PFAS contamination in drinking water in Virginia, which comes from the sample study, will inform the development and implementation of MCLs under Code of Virginia § 32.1-169 B. and the VAPA. The PFAS work group will need to conclude its work by September 2021 to meet the report deadline in HB586. As a result, the PFAS work group has not finalized key observations and recommendations for this report.

HB586 limited the PFAS sample study to no more than 50 waterworks or major sources of supply. With this limitation, the Department of Planning and Budget (DPB) concluded VDH could absorb the costs to form the PFAS work group, perform a literature survey, discuss results and data needed to drive regulatory decisions, and perform environmental sampling.[1] The PFAS

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[1] See Department of Planning and Budget 2020 Fiscal Impact Statement for HB586ER, item #8 at: https://lis.virginia.gov/cgi-bin/legp604.exe?201+oth+HB586FER122+PDF.

sample study focused on the largest waterworks in Virginia and waterworks and major sources of supply near potential sources of PFAS contamination given the legislative and financial limitations. VDH collaborated with the Virginia Department of Environmental Quality (DEQ) to identify potential sources of PFAS contamination and select waterworks for the voluntary sample study. The PFAS work group reviewed the methodology and selection process and offered guidance on improving the sample study. A few waterworks that VDH identified for inclusion in the voluntary sample study declined to participate, citing ongoing construction or other maintenance projects as reasons to not participate.

Forty-five (45) waterworks participated in the sample study. They collected a total of 63 water samples from one or more locations because, in certain cases, there were multiple water sources or entry points. Preliminary results from the sample study found PFAS in quantities above the practical quantitation level (PQL) at 15 of 63 sample locations. Samples from 48 sample locations did not contain any PFAS above the PQL.

The preliminary results indicate that PFAS are present in drinking water produced from the Potomac River and Occoquan Reservoir, two major sources of water for waterworks in Northern Virginia. The amount and specific types of PFAS in both sources are unknown because the sample study only tested finished water. Ten (10) samples from waterworks in the Northern Virginia region had at least one (1) PFAS present in a quantity above the PQL, but none were above the U.S. Environmental Protection Agency's (EPA) health advisory level of 70 ng/L for PFOA and PFOS (individually or combined) and none exceeded any of the MCLs established by other states.

The highest detected concentration of a compound was 51 ng/L of HPFO-DA (hexafluoropropylene oxide-dimer acid), which is commonly known as Gen-X, a type of PFAS used in place of PFOA (perfluorooctanoic acid) and PFOS (perfluorooctane sulfonic acid). This was one of only two GenX detections in all of the samples tested in the PFAS sample study (the other was 4.0 ng/L). No other PFAS were detected above the PQL at the two locations with Gen-X detections.

All other PFAS detections were 14 ng/L or less. Information about PFAS contamination of drinking water in Virginia, which came from the sample study conducted pursuant to HB586, will inform the development and implementation of MCLs required by HB1257. However, with more than 1,050 community waterworks in Virginia, the majority of which are "small" (i.e., serving fewer than 3,300 consumers), the extent and level of PFAS contamination in drinking water from waterworks is still largely unknown. VDH does not know how many small waterworks use water that contains PFAS, what level is present, if any, or what the resulting implications would be for setting an MCL.

The Code of Virginia requires VDH to consider protection of public health and the financial impact of regulations in the rulemaking process. See Code of Virginia §§ 2.2-4007.04 and 32.1-170. The Safe Drinking Water Act (SDWA) also requires this evaluation. See 42 U.S.C. §

300g-1(b). If VDH establishes an MCL that would require a small waterworks to install treatment, the capital cost could be in the millions of dollars. Small waterworks could most acutely experience the impact of establishing a MCL if PFAS were found above an established MCL because they have a smaller customer base amongst whom they can spread the cost of compliance.

The occurrence of chromium (VI) and 1,4-dioxane in Virginia has been limited to testing done in 2014-2015 as part of the EPA's Third Unregulated Contaminant Monitoring Rule (UCMR3). VDH and waterworks in Virginia have not conducted additional testing or performed a public health risk assessment of these chemicals in drinking water. A literature review revealed limited data on the occurrence, toxicity, and treatment options for both compounds. VDH lacked resources to complete the PFAS sample study and perform rigorous analysis of chromium (VI) and 1,4-dioxane prior to the effective date of the amendment to Code of Virginia § 32.1-169.

ODW will conduct additional PFAS sampling in 2021 and 2022 using $60,000 that the 2021 General Assembly appropriated and funding from EPA in the 2022 Public Water System Supervision Grant to study emerging contaminants. The report of the PFAS work group, as required under HB586, will inform the nature of the studies and sampling for PFAS. VDH cannot quantify the extent and nature of chromium (VI) and 1,4-dioxane contamination in drinking water in Virginia without additional funding.

2. INTRODUCTION

2.1 Enabling Legislation

HB1257 (2020 Acts of Assembly Chapter 1097), sponsored by Delegate Sam Rasoul during the 2020 General Assembly session, reads as follows:

> An Act to amend and reenact § 32.1-169 of the Code of Virginia, relating to drinking water; maximum contaminant levels; perfluoroalkyl and polyfluoroalkyl substances, and other contaminants.
>
> Approved April 10, 2020
>
> Be it enacted by the General Assembly of Virginia:
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> 1. That § 32.1-169 of the Code of Virginia is amended and reenacted as follows:
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> § 32.1-169. Supervision by Board.
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> A. The Board shall have general supervision and control over all water supplies and waterworks in the Commonwealth insofar as the bacteriological, chemical, radiological, and physical quality of waters furnished for human consumption may affect the public health and welfare and may require that all water supplies be pure water. In exercising such supervision and control, the Board shall recognize the relationship between an owner's financial, technical, managerial, and operational capabilities and his capacity to comply with state and federal drinking water standards.
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> *B. The Board shall adopt regulations establishing maximum contaminant levels (MCLs) in all water supplies and waterworks in the Commonwealth for (i) perfluorooctanoic acid and perfluorooctane sulfonate, and for such other perfluoroalkyl and polyfluoroalkyl substances as the Board deems necessary; (ii) chromium-6; and (iii) 1,4-dioxane. Each MCL shall be protective of public health, including vulnerable subpopulations, including pregnant and nursing mothers, infants, children, and the elderly, and shall not exceed any MCL or health advisory for the same contaminant adopted by the U.S. Environmental Protection Agency. In establishing such MCLs, the Board shall review MCLs adopted by other states, studies and scientific evidence reviewed by such states, material in the Agency for Toxic Substances and Disease Registry of the U.S. Department of Health, and current peer-reviewed scientific studies produced independently or by government agencies.*
>
> 2. That the provisions of this act shall become effective on January 1, 2022.
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> 3. That the Department of Health shall report to the Chairmen of the Senate Committee on Education and Health and the House Committee on Health, Welfare and Institutions on the status of research related to MCLs, the review of which is required by subsection B of § 32.1-169 of the Code of Virginia, as amended by this act, by November 1, 2020, and shall submit a final report to the Chairmen of the Senate Committee on Education and Health and the House Committee on Health, Welfare and Institutions by October 1, 2021, detailing the MCL regulations established by the Department of Health.

2.2 Status Report

The report VDH submitted on the status of work related to MCLs (RD696, November 1, 2020) is available on the Legislative Information System website at: https://rga.lis.virginia.gov/Published/2020/RD696/PDF

HB586 became effective on July 1, 2020; HB1257 becomes effective January 1, 2022, but requires VDH to report to the Chairmen of the Senate Committee on Education and Health and the House Committee on Health, Welfare and Institutions on the status of research related to MCLs by November 1, 2020, and submit a final report by October 1, 2021, detailing the MCL regulations established by VDH.

3. PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)

3.1 History, Development, Use of PFAS, Presence in the Environment, and Health Effects

PFAS, a class of synthetic organic chemicals, entered the national spotlight because of the potential risk that they pose to human health and the environment. While public attention to PFAS is relatively new, the chemicals themselves have been manufactured and used worldwide since the 1940s. The chemical structures of PFAS vary widely but all contain at least one fully fluorinated carbon atom. Strong Carbon-Fluorine (C-F) bonds and other physical and chemical characteristics make PFAS highly stable, heat-resistant, and oil- and water-repellent. PFAS have been widely used in consumer products such as nonstick cookware, waterproof apparel, stain-resistant textiles and carpets, personal care products, cleaners, waxes, and food packaging materials. PFAS also have numerous industrial applications – for instance, PFAS are used in metal finishing operations, and as the primary ingredient in aqueous film-forming foam (AFFF), the class of firefighting foam used to extinguish high-hazard flammable liquid fires.

The unique properties that made PFAS desired chemicals in manufacturing also make them pervasive and persistent once released into the environment. PFAS easily migrate in the environment and cause contamination of soil, sediment, groundwater, and surface water. PFAS are known as “forever chemicals” because they are non-biodegradable and persistent in nature. As such, humans and animals can be exposed to PFAS through drinking water and eating contaminated fish and plants. There are various environmental exposure routes for humans and animals from the use of PFAS-containing consumer products and consumption of food packaged in PFAS-containing materials.

The existing body of scientific literature on PFAS in drinking water has focused on a limited number of PFAS, primarily PFOA and PFOS, but also includes information on GenX, PFBS (perfluorobutane sulfonic acid), and other PFAS named in HB586. Such literature linked the exposure of PFOA, PFOS, and GenX at certain levels to human health effects ranging from developmental effects in fetuses and infants to certain forms of cancer. Environmental concentrations of concern currently reach as low as the parts per trillion (ppt) range. Limited toxicity data is available for all of the more than 4,000 PFAS, so further study is necessary to understand potential health effects from PFAS.

3.2 PFAS in Virginia (prior to HB1257)

In the past few years, the U.S. Environmental Protection Agency (EPA) began assessing PFAS, primarily in drinking water. Between 2013 and 2015, large public water systems (i.e., waterworks) serving more than 10,000 individuals were required to test their finished drinking water for six specific PFAS, among other pollutants, under the Third Unregulated Contaminant Monitoring Rule (UCMR3) carried out according to the Safe Drinking Water Act (SDWA). In Virginia, 72 large community waterworks and 15 small waterworks[2] were tested for PFAS. Of 509 tests, only two reported any PFAS detections above EPA's reporting limit. Upon retesting, confirmation samples did not show the detection of PFAS.

Nationwide, between 2013 and 2015, under the UCMR3, 1.3% of large public water systems nationwide reported detections of at least one PFAS that exceeded the reference concentration of 70 ppt (or 70 ng/L). These systems were estimated to provide drinking water to approximately 5.5 million people. However, the reporting limits for PFOA and PFOS used in UCMR3 were high (20 ppt and 40 ppt) compared to current laboratory detection limits. The practical quantitation limit (PQL) for finished water samples analyzed in the HB586 sample study was generally 3.5 ng/L.

In Virginia, PFAS has been detected at military facilities in the Tidewater area and at NASA's Wallops Island facility (see https://www.nasa.gov/feature/background-latest-information-on-pfas-at-nasa-wallops/). In each of these cases, PFAS contamination is believed to be associated with the use of AFFF.

Another known site of PFAS contamination in Virginia is the DuPont Spruance Plant south of downtown Richmond. The groundwater constituents of potential concern identified include PFOA. EPA states the contaminated groundwater is not used for drinking water, and no downgradient users of off-site groundwater exist between the site boundary and the James River (see https://www.epa.gov/hwcorrectiveaction/hazardous-waste-cleanup-dupont-spruance-facility-richmond-va).

Other states have performed more extensive studies than Virginia to set limits on PFAS in for form of MCLs, action levels, response levels, or health advisories. The EPA is currently following requirements in the SDWA (see 42 U.S.C. § 300g-1(b)) to establish limits for PFOA and PFOS (see https://www.federalregister.gov/documents/2021/03/03/2021-04184/announcement-of-final-regulatory-determinations-for-contaminants-on-the-fourth-drinking-water).

3.3 House Bill 586 (2020)

HB586 (Acts of Assembly Chapter 611) requires VDH to convene a work group to study the occurrence of perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS),

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[2] "Small" in the context of UCMR3 means a waterworks serving ≤ 10,000 people. Large waterworks serve more than 10,000 people. See 77 FR 26072, May 12, 2012. https://www.govinfo.gov/content/pkg/FR-2012-05-02/pdf/2012-9978.pdf

perfluorobutyrate (PFBA), perfluoroheptanoic acid (PFHpA), perfluorohexane sulfonate (PFHxS), perfluorononanoic acid (PFNA), and other PFAS, as deemed necessary, in the Commonwealth's public drinking water. The legislation states that the work group: (i) shall (a) determine current levels of PFAS contamination in the Commonwealth's public drinking water (limiting sampling to no more than 50 representative waterworks and major sources of water); (b) where PFAS contamination is found, identify possible sources of such contamination; and (c) evaluate existing approaches to regulating PFAS in drinking water, including regulatory approaches adopted by other states and the federal government; and (ii) may develop recommendations for specific MCLs for PFOA, PFOS, PFBA, PFHpA, PFHxS, PFNA, and other PFAS, as deemed necessary, to be included in regulations of the Board of Health applicable to waterworks. The work group is required to report its findings and recommendations to the Governor and the Chairmen of the House Committees on Agriculture, Chesapeake and Natural Resources and Health, Welfare and Institutions, and the Senate Committees on Agriculture, Conservation and Natural Resources and Education and Health by December 1, 2021.

3.4 Virginia PFAS Work Group

The State Health Commissioner formed the Virginia PFAS work group in October 2020 to study the level of PFAS contamination in drinking water in Virginia; and may, based on sample results, formulate and make recommendations for the State Board of Health to establish MCLs for PFAS. Members of the PFAS work group represent the following stakeholders (see Appendix 1 for a list of members and the groups they represent):

1. Community waterworks that serve more than 50,000 persons.
2. Community waterworks that serve less than 50,000 persons.
3. Community waterworks that serve less than 1,000 persons.
4. An advocacy group that represents waterworks in Virginia.
5. A chemical manufacturer with chemistry experience.
6. A consumer of public drinking water.
7. Non-governmental environmental organizations.
8. The Virginia Department of Environmental Quality (DEQ).
9. A local health district.

The State Toxicologist and an ODW staff member also serve on the PFAS work group. The ODW Deputy Director is the PFAS work group leader.

3.4.1 Subgroups

PFAS work group members and members of the public serve in one or more of four (4) subgroups that focus on specific requirements of HB586. The subgroups include, Health and Toxicology, Occurrence and Monitoring, Policy and Regulations, and Treatment Technologies. The State Toxicologist leads the Health Toxicology subgroup; ODW staff lead and coordinate the other subgroups. Appendix 1 contains a list with members of each subgroup.

The Health and Toxicology Subgroup is assessing the public health risk of the six (6) PFAS specified in HB586, using a toxicological database that is evolving as more studies are done on PFAS – individually and as a suite of compounds. EPA and a number of states have assessed the risk of PFAS in drinking water to varying degrees. The toxicology subgroup considered the health and toxicological methodologies and models adopted by EPA, the states, and current peer reviewed studies. As the toxicology subgroup completes its evaluations for the PFAS work group, it will consider the need for additional experts in the field of toxicology and epidemiology to assist with these efforts. The toxicology subgroup may, based on the sampling results, propose a safe level for the PFAS found in Virginia public waterworks, conclude that more information is necessary to determine a safe level of PFAS in drinking water, or make recommendations for choosing to add or remove any specific PFAS ("as deemed necessary") from those studied.

The Monitoring and Occurrence Subgroup is evaluating how to best determine the occurrence of PFAS in drinking water, including approaches adopted by other states and the federal government. After ODW completes quality assurance/quality control review of the sample results collected pursuant to HB586, the monitoring and occurrence subgroup will collect and tabulate PFAS data from the sample study and other existing PFAS monitoring data. This subgroup is also evaluating current levels of PFOA, PFOS, PFBA, PFHpA, PFHxS, PFNA, and other PFAS as deemed necessary and to make recommendations to the PFAS work group regarding additional sampling.

The Policy and Regulations Subgroup is evaluating approaches to regulating PFOA, PFOS, PFBA, PFHpA, PFHxS, PFNA, and other PFAS as deemed necessary, in drinking water, including regulatory approaches adopted by other states and the federal government. As data and information about PFAS occurrence in Virginia becomes available, the policy subgroup, based on input from other subgroups, may develop recommendations for specific MCLs for PFOA, PFOS, PFBA, PFHpA, PFHxS, PFNA, and other PFAS as deemed necessary, to present to the PFAS work group for consideration. In particular, the subgroup will consider what methodology other states developed to regulate PFAS in drinking water. Based on the information and resources available in Virginia, the subgroup will consider which framework could be best suited to establishing MCLs in Virginia, and may recommend a path for moving forward with establishing MCLs within the limits of the enabling legislation, budget, timeframe to act, and extent of data that is or may be available.

The Treatment Technologies Subgroup is reviewing best available treatment technologies (BATT) for PFAS removal, including whether certain technologies are better for controlling PFOA, PFOS, PFBA, PFHpA, PFHxS, and PFNA. Subgroup members are reviewing design criteria and practical treatment goals and/or limits of treatment technology for each PFAS species, including capital and operating costs for each technology. The treatment technologies subgroup is considering whether pilot testing or other special considerations are necessary to dispose of waste streams from the treatment process. Some treatment technologies generate a concentrated PFAS waste stream/product that requires special considerations for handling and disposal.

3.4.2 PFAS Work Group Meetings

Since its inception in October 2020, the PFAS work group has met five (5) times: October 20, 2020 and January 19, March 4, April 29 and July 27, 2021.[3] Additional meetings are scheduled in September and October 2021. Subgroups have generally met monthly since December 2020.

In March 2021, the PFAS work group approved a PFAS Sample Study Design (Appendix 2). The PFAS work group recommended a hybrid approach to the sample study, which involved collecting water samples for testing from:

- The seventeen (17) largest waterworks in Virginia by population served;
- Eleven (11) waterworks that use groundwater as a primary source and are located within one mile of a potential source of PFAS, including unlined landfills and commercial and military airports where AFFF may have been used; and
- Twenty-two (22) waterworks (excluding the 17 largest waterworks) that have an intake in a major water supply downstream of potential high risk sources based on industrial use code (i.e., factories and other facilities that, based on the type of manufacturing or products produced, may have used compounds containing PFAS).

Of the 50 waterworks identified in the PFAS Sample Study Design, 38 waterworks agreed to participate in the sample study. ODW reached out to additional waterworks and ultimately 45 waterworks agreed to participate. More details on the sample study are in Section 3.5; the Sample Study Design is included in Appendix 2 of the report.

In April 2021, the PFAS work group helped VDH staff develop a "PFAS Communications Toolkit" for participating waterworks and the relevant health districts. The toolkit contains information about the legislative requirements, PFAS, the sample study, fact sheets, and communication templates. The PFAS Communication Toolkit is included in Appendix 3.

The PFAS work group received an update on preliminary results from the sample study at its July 2021 meeting and made plans to meet in September 2021 to begin the process of drafting and reviewing the report required by HB586.

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[3] Due to the coronavirus pandemic, all of the meetings prior to the July 27, 2021 PFAS work group meeting were conducted by electronic communication means pursuant to the General Assembly's allowance for electronic meetings during the Governor's declared State of Emergency. The PFAS work group and subgroups have followed the requirements in the budget bills to conduct meetings by electronic communication means. For the 2020-2022 biennium, see Item 4-0.01g of Chapter 552 of the 2021 Special Session I, https://budget.lis.virginia.gov/item/2020/1/HB30/Chapter/4/4-0.01/.

Meeting minutes are available on the Virginia Regulatory Town Hall website and ODW PFAS webpage at https://www.vdh.virginia.gov/drinking-water/pfas/.

3.4.3 Literature Review

The PFAS work group and VDH partnered with Old Dominion University to complete a literature review. VDH paid for the literature review using a grant from EPA to study emerging contaminants, which include PFAS. Old Dominion University is also compiling data and literature on chromium (VI) and 1,4-dioxane. The literature review was not complete when VDH prepared this report, but it will be included with the PFAS work group's report.

3.5 Monitoring and Occurrence Study, a.k.a. PFAS Sample Study

VDH, in conjunction with the PFAS work group, designed the sample study to prioritize sites for PFAS sampling and generate statewide occurrence data, subject to the limitations in HB586. VDH and the PFAS work group considered several factors in developing the sample study, including:

- The location of potential sources of PFAS contamination (developed in conjunction with the Virginia Department of Environmental Quality (DEQ));
- Known locations of PFAS contamination;
- The relative risk to consumers who receive water from waterworks that utilize source water that comes from areas that are near known or potential sources of PFAS contamination;
- Population served; and
- $40,000 in funding from a fiscal year 2021 EPA grant to study emerging contaminants that could be used to pay for sample analysis.

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. The Board of Health can use this information as part of the VAPA process to establish regulatory limits for PFAS pursuant to HB1257.

3.5.1 Sample Locations

The process of selecting sample locations involved a combination of geospatial analysis and programmatic review. The geospatial analysis included the creation of a Geographic Information System (GIS) project using ArcMap 10.4.1 that combined waterworks locations and information about potential sources of PFAS contamination. There are currently 2,811 waterworks in Virginia. They are classified based on the population they serve:

- Community Waterworks (CWS): Waterworks that serve at least 15 service connections used by year-round residents or regularly serve at least 25 year-round residents. Examples include municipal water systems, authorities, and residential subdivisions with their own water supplies.
- Nontransient Noncommunity Waterworks (NTNC): Waterworks that are not CWS, that regularly serve at least 25 of the same people at least six (6) months of the year. Examples include schools, factories, and hospitals that have their own water supplies.
- Transient Noncommunity Waterworks (TNC): Waterworks that are not CWS, but serve transient customers in non-residential settings, such as campgrounds, motels, and restaurants that have their own water supplies. A TNC serves at least 25 persons daily for at least 60 days out of the year.

ODW staff identified the largest waterworks in the state (based on population served) and plotted the locations of surface water intakes and groundwater wells used by CWS and NTNCs, potential discharge locations, including unlined landfills and airports, and major rivers in the state. ODW and the PFAS work group identified three (3) strategies for selecting sites to be part of the sample study:

- The potential high and/or medium risk groundwater systems based on the potential sources of PFAS contamination;
- The large CWS ("large" means the waterworks provides water to more than 10,000 persons); and
- The water sources/intakes with potential to receive water from upstream sources of PFAS contamination.

Consumers served by CWS and NTNCs have a higher risk of exposure from drinking, cooking, bathing and showering, and other water uses because of the regular consumption of water over long periods of time. For this reason, ODW limited the sample study to CWS and NTNCs. There are 1,093 CWS and 510 NTNCs, for a total initial sampling pool of 1,603 waterworks, which collectively provide drinking water from 2,626 sources (e.g. wells, springs, and surface water sources).

VDH prioritized the list of CWS and NTNCs based on relative risk, considering the waterworks' proximity to the potential sources of PFAS contamination. Using a Geographic Information System, VDH established several data layers containing locational and other information specific to the potential sources of PFAS contamination. These layers include the following industries and land uses:

- Military or commercial airports (from U.S. Geological Survey data);
- Unlined landfills (data from DEQ);
- VPDES discharge locations (from DEQ);
- Discharge points for publicly owned treatment works (POTWs) (data from DEQ);

- Major river networks in Virginia; and
- Waterworks size and population served data.

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 the Federal Aviation Administration (FAA). AFFF that meets U.S. Department of Defense (DoD) specifications for use at military facilities is a common source of PFAS and is frequently found at both military and large civilian airports. 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 and that potentially contain PFAS, airports are considered a likely source of PFAS contamination. For the purpose of the geospatial analysis, ODW staff only 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, specifically landfill leachate, are a source of PFAS contamination. Landfill leachate likely obtains PFAS from the myriad of consumer products that include PFAS and are commonly placed in the landfill. 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 criteria for municipal solid waste landfills do not apply to landfill units if they do 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.

VDH designated any waterworks using a groundwater well located within 0.5 miles of an unlined landfill or airport as a potential high risk for PFAS influence. VDH designated other waterworks using a groundwater well within 1 mile of a known unlined landfill or airport as a potential medium risk water source.

VDH does not possess, and therefore did not consider, the following in evaluating potential high or medium risk 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, VDH and the PFAS work group selected 11 waterworks that use groundwater wells within 1 mile of potential sources of

PFAS contamination. These waterworks have a total of 6 groundwater wells considered high risk and 13 groundwater wells that constitute a medium risk based on proximity to a potential source of PFAS contamination.

VDH also identified major surface water supplies 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 and direct dischargers.

DEQ identified the POTWs and VPDES discharges based on SIC codes for significant industrial users and 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 GIS, ODW connected 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 occurrence and monitoring subgroup 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, and the number of waterworks selected via the hybrid approach, VDH selected 22 major sources of water for sampling. Maps 2 and 4 in the PFAS Sample Study Design (Appendix 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.

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. All of these samples represent "finished water," which means the drinking water has gone through the waterworks treatment process before going into the distribution system.

3.5.2 Laboratory Analytical Services

VDH contracted with a laboratory through a competitive bidding process to prepare sample kits, ship them to the participating waterworks, provide return shipping, analyze the samples, and return results to VDH 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 VDH's Quality Assurance Project Plan, which EPA approved as a requirement for VDH to use the 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 PFBA). Other related requirements included:

- The laboratory will report the complete list of 25 analytes for Method 533.
- 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. 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 VDH.
- The laboratory will hold accreditation for the DoD PFAS method by LC/MS/MS compliant with QSM 5.3 Table B-15.

3.6 Preliminary PFAS Sample Study Results

Of the 50 waterworks identified, 38 agreed to participate in the study. ODW reached out to additional waterworks and ultimately 45 agreed to participate in the sample study (40 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. Examples include:

- Western Virginia Water Authority uses water from Carvins Cove and Spring Hollow Reservoir;
- Chesterfield County Water System uses water from the City of Richmond water treatment plant (source – James River), Lake Chesdin (from the Appomattox River Water Authority), and its own water treatment plant at the Swift Creek Reservoir;
- Fairfax Water operates the James J. Corbalis and Frank P. Griffith water treatment plants (treating water from the Potomac River and Occoquan Reservoir respectively); and
- Bowling Green, which uses three separate wells.

Table 1 provides a summary of the preliminary sample results.

Waterworks received sample kits from the laboratory in May and June 2021. Waterworks staff followed specific instructions provided by the laboratory to collect samples and return them to the laboratory from late May through early July 2021 for analysis.

Quality assurance/quality control (QA/QC) review of the preliminary results revealed data irregularities with four (4) samples, so ODW requested the waterworks resample from each of the four (4) locations. Data irregularities mean 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 (2) were switched. Another data irregularity 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.

Preliminary results from the sample study, Table 1, found PFAS in quantities above the practical quantitation level (PQL) at 15 of 63 sample locations. The highest detected concentration of a compound was 51 ppt of HPFO-DA, which is commonly known as GenX, a type of PFAS developed to replace use of PFOA and PFOS. All other detections were 20 ppt or less.[4] Samples from 48 sample locations did not contain any PFAS above the PQL. 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. There appeared to be a data irregularity with one sample that contained PFOA. Resampling indicated that PFOA was detected above the PQL.

PFOS was measured above the 3.5 ppt PQL at seven sample locations. Measured concentrations were between 3.9 and 7.1 ppt. There appeared to be a sampling error, possibly related to the sample location where the waterworks collected the water, with the result of 17.0 ppt. Resampling indicated that PFOS was below the detection limit at that location.

PFBA was measured above the 3.5 ppt PQL at 10 sample locations. Measured concentrations were between 3.7 and 12.0 ppt. There appeared to be a data irregularity with one sample that contained PFBA in a field reagent blank. Resampling showed PFBA below the PQL.

PFHpA was measured above the 3.5 ppt PQL at three sample locations. Measured concentrations were between 4.1 and 5.5 ppt.

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[4] 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.

	Alexandria EP Samples		**Arlington**	**Fairfax** EP Samples		**Loudoun** EP Samples		**Stafford** EP Samples		**PWCSA**	**Newport News** EP Samples		**Altavista**	**WVWA**	**WCSA**
	003	004	EP001	022	041	005	001	001	003	EP001-2	001	002	IN003	EP002	EP001
PFOA		4.2		5.5			4.5			5.5					
PFOS		3.9		5.1				6.4		4.1	7.1	4.4			5.2
PFBA	7.7	9.2		7.7	4.3	4.0	4.6		5.9	12.0	4.3	4.3			
PFHpA				4.4			5.5			4.1					
PFHxS											4.9				
PFNA															
HPFO-DA													4.0	51	
PFHxA	6.8	9.3	3.7	12.0	4.4				4.2	11.0		6.1			
PFPeA	7.4	10.0	4.1	14.0	4.2				5.5	12.0		4.5			
PFBS		4.2		5.6						4.8					

TABLE 1. Preliminary Results of PFAS Sample Study. All quantities shown are in ng/L (ppt) and represent all results > PQL. A blank cells mean the results were below the PQL. PFOA, PFOS, PFBA, PFHpA, PFHxS, and PFNA are the PFAS listed in HB586.

PWCSA = Prince William County Service Authority, WVWA = Western Virginia Water Authority, and
WCSA = Washington County Service Authority; EP = entry point to the distribution system; IN = intake.

PFHxS was measured above the 3.5 ppt PQL at one sample location. The concentration was 4.9 ppt.

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 in samples. They include HPFO-DA (hexafluoropropylene oxide-dimer acid, commonly referred to as GenX), PFHxA (perfluorohexanoic acid), PFPeA (perfluoropentanoic acid), and PFBS (perfluorobutanesulfonic acid). A sample that contained PFHxA, PFPeA, and PFBS was resampled. The resample also contained the chemicals in concentrations similar to the original sample.

All of the samples that had PFAS present above the PQL, except one, were entry point samples. Neither VDH nor DEQ have collected additional samples to identify potential sources of PFAS contamination.

At this time, the preliminary results from the PFAS sample study suggest that PFAS may be present in water from the Potomac River and Occoquan Reservoir in an undetermined quantity. Waterworks that use these as a source of drinking water employ treatment technologies as part of their regular treatment processes, and through those processes have a level of PFAS that is between the PQL and 10 to 12 ppt for certain PFAS. Other patterns or conclusions are not evident from the preliminary data at this time.

3.7 Treatment Technologies

Treatment processes that are most commonly employed by waterworks are not effective at removing PFAS, nor are some of the more "advanced technologies" that are sometimes used. These processes include coagulation-settling-filtration, chemical oxidation, and advanced oxidation processes, such as ultraviolet light oxidation. There are currently three major PFAS treatment technologies widely used and available: granular activated carbon, ion exchange, and membrane separation (reverse osmosis). These technologies are more expensive than conventional treatment processes. Descriptions of each technology, along with disadvantages and unintended consequences, are included below.

3.7.1 Granular Activated Carbon

Granular activated carbon (GAC) has been used historically in water treatment processes to reduce or remove various contaminants and is the most studied treatment for PFAS removal (EPA 2018). Activated carbon is typically used for its highly porous structure as well as its large surface area for contaminants to attach (ITRC 2020). Activated carbon is made from organic materials with high carbon contents typically in a granular form: wood, lignite, coal. Removing PFAS from the water via GAC uses a physical mass transfer process from the aqueous phase onto solid media and does not use or involve chemical degradation or transformation (ITRC 2020). In this treatment process, water is taken from the source and directed through the treatment system where adsorption occurs. Figure 1 shows a standard GAC treatment process.

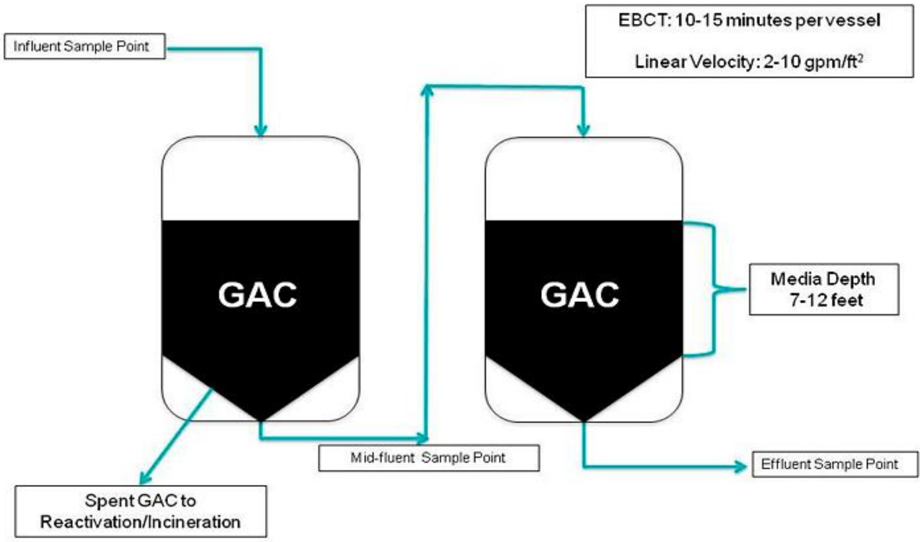

Figure 1. Typical GAC Treatment System Process Flow Diagram
Source: Calgon Carbon Corporation (within ITRC 2020, PFAS – Per- and Polyfluoroalkyl Substances Treatment Technologies)

GAC has been analyzed and examined in several pilot and field studies. Peer reviewed literature studies confirm that perfluorinated sulfonates are more readily adsorbed than perfluoroalkyl acids. Long-chain PFAS are more readily absorbed than shorted chain PFAS, and the presence of competing co-contaminants can harm performance.

The EPA Drinking Water Treatability Database (https://www.epa.gov/water-research/drinking-water-treatability-database-tdb) reported that GAC is effective in removing:

- Up to greater than 99 percent of PFBA, PFBS, PFHpA, PFNA, PFHxS, and PFHpS and
- 96 percent of PFNS from water.

Some disadvantages and unintended environmental consequences of GAC include:

- Not being as effective for short-chain PFAS surfactants (as long-chain homologues), particularly at low ppt target concentrations;
- The adsorption mechanism is not selective for PFAS surfactants and GAC can become loaded with other contaminants, reducing effectiveness for PFAS removal;
- There is modest overall capacity and slow kinetics for physical impurity adsorption compared with other technologies, which means larger physical site footprint and increased handling of contaminated GAC; and
- Production of GAC requires considerable energy input resulting in a large greenhouse gas (GHG) footprint for the material. Regeneration requires significant energy input and results in the loss of about 15% of the GAC to CO_2 emissions.

Powdered activated carbon (PAC) is a variant of GAC, in which the carbon granules are crushed to very fine particles, and fed to assist in a coagulation-settling-filtration process. The PAC absorbs the PFAS in the same way as in a GAC application, and can be very effective in removing some PFAS compounds (with the same performance characteristics and limitations as GAC). The major drawbacks of PAC applications include:

- The settled sludge may contain significant levels of PFAS, which limits the potential disposal methods for those solids;
- PAC can’t be regenerated, so it is a single-use option; and
- PAC is generally applied for PFAS removal as a short-term bridge, while a longer-term permanent solution is developed and implemented.

3.7.2 Ion Exchange

Ion exchange treatment (IX) is another treatment technology capable of removing PFAS from water. The resin beads used in IX consist of highly porous, polymeric materials which are acid, base, and water-insoluble, and are made from hydrocarbons. (EPA 2018). The IX resins are grouped into two groups, cationic and anionic, each serving a different purpose: cationic exchange resins (CER) remove positively charged contaminants, while anion exchange resins (AER) more effectively remove negatively charged contaminants, including PFAS (EPA 2018; ITRC 2020). The resins act as magnets, attracting contaminants as water passes through the system. There are two resin options for the treatment process, single-use or regenerable resins.

- *Single-use resins* are used until breakthrough, then removed and disposed of by high-temperature incineration or landfilling.
- *Regenerable resins* are used until breakthrough, then regenerated on-site with a specific solution to return resin to full exchange capacity.

Removing PFAS by ion exchange is a physical mass transfer process, similar to GAC, and does not involve chemical degradation or transformation (ITRC 2020). AER resins remove PFAS by forming ionic bonds with the sulfonic and carboxylic acid heads of PFOS and PFOA, while simultaneously the hydrophobic end of the PFAS structures adsorb onto the hydrophobic surfaces of the IX resins (ITRC 2020). Figure 2 shows a standard single-use resin ion exchange process.

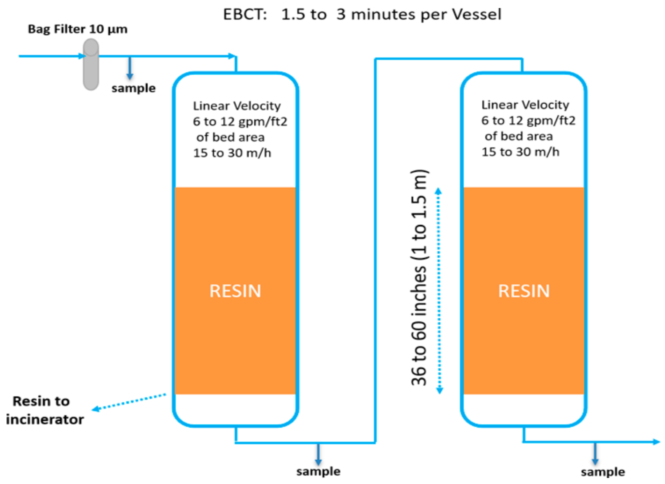

Figure 2. Single-use IX process flow diagram
Source: Purolite Corporation (within ITRC 2020 PFAS – Per- and Polyfluoroalkyl Substances Treatment Technologies)

While not as commonly used as GAC, ion exchange technology for PFAS removal is well established. Pilot and field studies have shown that single-use resin has a higher removal capacity than regenerable resin, and is more fully exhausted in a lead-lag vessel. In addition, IX treatment systems typically have a smaller physical footprint than GAC treatment systems. However, literature shows that the relative efficiency of single-use and regenerable reins depends upon PFAS and co-contaminant influent concentrations and treatment goals.

The EPA Drinking Water Treatability Database for IX reports similar findings to GAC, but includes additional PFAS:

- Up to 90 percent removal of PFPeA;
- Up to 90 percent removal of PFPeS;
- Up to greater than 99 percent removal of PFHxA; and
- Up to 97 percent removal of PFDA.

Some disadvantages of ion exchange include generally being more expensive than GAC for long-chain PFAS removal if not regenerated; short-chain PFAS removal has been reported to be decreased by elevated chloride concentrations; the technology is selective for PFAS and generally does not remove uncharged co-contaminants; and, depending on the displace counter ion (e.g., chloride), it may require attention to corrosion control. Unintended environmental consequences include the regenerative process generally involves lower costs but will lead to concentrated PFAS waste solutions in need of disposal; demonstrated recycle technologies require energy (greenhouse gas emissions) for distillation processes; and non-regenerative processes will require high temperature incineration of resin-bound PFAS resulting in greenhouse gas emissions (about 5 – 10% that of GAC regeneration).

3.7.3 Membrane Separation (Reverse Osmosis)

PFAS removal using membranes in processes such as reverse osmosis is effective. Reverse osmosis removes PFAS by pushing highly pressurized water through a semipermeable membrane (ITRC 2020). These membranes remove most organic and inorganic compounds, and new technology has increased efficiency while lowering operating pressures and costs. However, waste discharge (the concentrate or reject stream) from the reverse osmosis process will have concentrated levels of the various PFAS removed from the feed water, making disposal difficult (Appleman, 2014). Treated water passes through the membrane, and then the rejected water is collected for disposal or discharge. See Figure 3. Reverse osmosis has been combined with nanofiltration to increase PFAS removal (ITRC 2020). Nanofiltration provides high water flux at lower operating pressures, and combining it with reverse osmosis utilizes properties of both. Nanofiltration alone will not achieve PFAS removal equivalent to reverse osmosis.

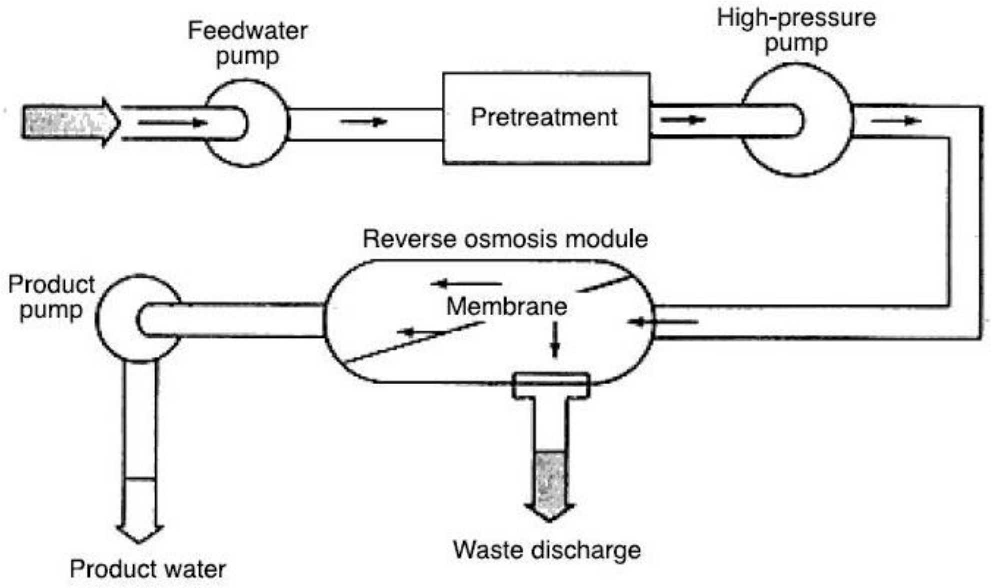

Figure 3. Reverse Osmosis Plant Simple Process
Source: RO Water Treatment Plant. Accessed from https://www.thewatertreatments.com/water-treatment-filtration/reverse-osmosis-plant-ro-desalination/

Removal of PFAS using reverse osmosis membrane separation is extremely effective. Pilot and field studies support that reverse osmosis (RO) membranes achieved PFAS removals up to greater than 99 percent.

The EPA Drinking Water Treatability Database (TDB) reports similar findings to GAC and ion exchange. See https://www.epa.gov/water-research/drinking-water-treatability-database-tdb.

3.7.4 Treatment Costs

EPA has compiled work breakdown structure-based models on the cost of adding granular activated carbon treatment, anion exchange treatment, and reverse osmosis treatment to drinking water facilities. While these models and documents are free to the public, they are not specific to PFAS or any other pollutant. The EPA also supplies Excel templates in which treatment facility specifications can be entered to determine the cost of adding said technology to the specific plant. All of the above information can be viewed and retrieved from the Drinking Water Treatment Technology Unit Cost Models at https://www.epa.gov/sdwa/drinking-water-treatment-technology-unit-cost-models.

3.8 Toxicology

The widespread use of PFAS in consumer products and its stability in the environment has resulted in PFAS being identified in the U.S. general population biomonitoring studies as early as 1999. (CDC 2021). Epidemiological studies, where PFAS were found in the environment and drinking water at relevant exposure levels, have examined possible relationships between levels of PFAS in blood and harmful health effects in people. Research involving humans suggests that high levels of certain PFAS may lead to the following: decrease in birth weight, decreased vaccine response in children, increased risk of high blood pressure or pre-eclampsia in pregnant women, increased cholesterol levels, changes in liver enzymes, and increased risk of kidney or testicular cancer. (ATSDR, 2021).

PFOA and PFOS were voluntarily phased out by its primary manufacturer and eight other major companies from global production starting in 2006. (EPA 2006a; EPA 2021b). These efforts and an increase in public awareness have resulted in a steady decline of PFAS in the U. S. population according to recent biomonitoring studies. (CDC 2021). After the phase out of PFOA, PFOS, and PFOA-related chemicals, other perfluoroalkyl substances have been developed or brought in as replacements for PFAS compounds. Replacements include using nonfluorinated chemicals, alternate technologies, and shorter chain PFAS. (ITRC 2020). However, several studies published show that replacement compounds may not be less hazardous than the traditionally used long-chain PFAS. One of these replacement compounds is GenX chemicals, trade name for a polymerization processing aid formulation that contains ammonium 2,3,3,3-tetrafluoro-2 (heptafluoropropoxy) propanoate. GenX is used as a replacement for PFOA, and since its usage, the EPA has completed a Toxicity Assessment that can be found at https://www.epa.gov/pfas/genx-toxicity-assessments-documents.

The persistent, bio-accumulative, and toxic nature of PFAS is unique among organic drinking water contaminants, causing concern about potential toxicological effects in humans. Possible exposure routes include ingestion, inhalation, and dermal absorption. The consumption of PFAS from drinking water is of increasing concern in the United States, as well as worldwide, because of their widespread detection in public water systems and private domestic wells. (U.S. EPA, 2021b). Infants are a sensitive subpopulation for the adverse effects of PFAS. Their exposures from contaminated water, either from prepared formula or via maternal transfer to breast milk, are much higher than in older individuals. (Post et al. 2017; Goeden et al. 2019).

The Health and Toxicology subgroup researched and evaluated animal and epidemiological studies and risk assessments for PFAS in drinking water, including PFOA, PFOS, PFBA, PFHpA, PFHxS, PFNA, and other PFAS. Old Dominion University's literature review (expected in the December 1, 2021 PFAS work group report) will have a table that summarizes current evidence on cancer, immunotoxicity, reproductive toxicity, developmental toxicity, and liver toxicity associated with exposures to PFAS.

3.8.1 Reference Doses

Nine states – California, New Jersey, New Hampshire, New York, Michigan, Washington, Minnesota, Vermont, and Massachusetts – have developed reference doses for PFOA and PFOS based on findings from animal studies. State reference doses for PFOA range from 1.5 to 18 nanograms per kilogram per day (ng/kg/d), while the EPA reference dose is 20 ng/kg/d. State references doses for PFOS range from 1.8 to 5 ng/kg/d. Toxicological information about other PFAS is more limited.

Details on how the states developed reference doses will be found in the forthcoming literature review from Old Dominion University.

3.8.2 Relative Source Contribution and Exposure Factors

The EPA default value for relative source contribution of PFAS in drinking water, as a portion of the overall daily dose, is 20%. In the absence of data to the contrary, this is the value that the Board of Health should consider in establishing MCLs as directed by HB1257.

With respect to exposure factors, in the past, EPA has used 70 kilograms (kg) for the body weight, and 2 liters (L) as the amount of drinking water consumed daily. Several states with PFAS MCLs still use these values. Current exposure factors used in assessing drinking water risk are 80 kg body weight and 2.4 L of water ingested daily. Mathematically, the difference between the new and old values is 0.03 L/kg-day and 0.028 L/kg-day, respectively, which is negligible. Many states with PFAS MCLs use the model for lactating women, which was developed by Minnesota and relies on the breastfed infant as the sensitive receptor.

3.8.3 Development of MCLs for PFAS

The minimum risk levels in the Agency for Toxic Substances Disease Registry's (ATSDR) final Toxicological Profile for Perfluoroalkyls (ATSDR, 2021), which includes PFOS, PFOA, PFBA, PFHpA, PFHxS, and PFNA, are meant as screening values and are not the same thing as MCLs. While other states have MCLs for PFBA, PFHpA, PFHxS, and PFNA, no other state has an MCL for PFBA.

Risk assessment metrics (critical study, uncertainty factors, point of departure, human equivalent dose, and relative source contribution) used by each state can be found in tables that will be included in Old Dominion University's literature review.

States with MCLs for PFOA and PFOS include Massachusetts, Michigan, New Hampshire, New Jersey, New York, and Vermont. Michigan has the lowest MCL for PFOA, 8 ppt, and New York has the lowest MCL for PFOS, 10 ppt. Massachusetts and Vermont have the highest MCLs, 20 ppt, because their MCL is the sum of six and five PFAS, respectively, so technically PFOA or

PFOS in drinking water in those states can be as high as 20 ppt if one is present but no other PFAS are detected.

All states used an animal study to develop their reference doses for PFOA and PFOS. For PFOA, Massachusetts and Vermont used a 2006 developmental study by Lau et. al (Lau, 2006); Michigan used a 2011 developmental study by Onishchenko et. al (Onishchenko, 2011) and a 2016 developmental study by Koskela et al. (Koskela, 2016); New York used a 2011 study by Macon et al. that reported increased liver weight (Macon, 2011); and New Jersey and New Hampshire used a 2006 study by Loveless et. al., that also evaluated increased liver weight (Loveless (2006). EPA used the 2006 study by Lau et al. and ATSDR used the 2016 study by Koskela et al. to develop a minimal risk level for PFOA. ATSDR is also cited by states as using the 2011 study by Onishchenko in conjunction with the Koskela study.

For PFOS, states either used a 2009 immune response study by Dong et al. (Dong, 2009), or a 2005 two-generation reproduction study by Luebker et al. New Hampshire also used a 2011 immune response study by Dong et al. Additionally, EPA and ATSDR used the Luebker et al. 2005 study to develop a reference dose and a minimal risk level, respectively.

PFHpA was included in MCLs developed by Massachusetts (sum of 6 PFAS not to exceed 20 ppt) and Vermont (sum of 5 PFAS not to exceed 20 ppt). No states have developed an MCL for PFHpA based on toxicity. Rather, states concluded that it would be equipotent to PFOA based on structural similarity.

Four (4) states have MCLs for PFHxS: Massachusetts (sum of 6 PFAS not to exceed 20 ppt), Vermont (sum of 5 PFAS not to exceed 20 ppt), Michigan (51 ppt) and New Hampshire (18 ppt). Massachusetts concluded that structural similarity between PFHxS, PFOS, and PFOA justified assigning a toxicity value to PFHxS similar to PFOS and PFOA. Michigan used a 2018 National Toxicology Program report that evaluated PFHxS effect on the thyroxin (T4) levels. Vermont also considered thyroid toxicity and behavioral outcomes in developing their MCL. New Hampshire used a study by Chang that evaluated effects on reproduction. (Chang, 2018).

Five (5) states had an MCL for PFNA. Michigan used a 2015 developmental study by Das. (Das, 2015). Massachusetts also considered the Das study and concluded that PFNA toxicity would be similar to PFOS and PFOA and could be "additive" resulting in an MCL that is 20 ppt for the sum of six compounds. New Jersey and New Hampshire used 2015 liver weight data from the Das study to develop their MCL. Vermont used changes in liver weight and developmental toxicity to develop their MCL for PFNA, which is the sum of five PFAS not to exceed 20 ppt.

The health and toxicology subgroup will continue to assess the methods other states used to assess health effects, the quality of the studies they based their decisions on, and information about PFAS occurrence in Virginia drinking water to guide any recommendations the PFAS work group makes regarding MCLs.

3.9 Establishing Regulatory Limits on PFAS – EPA

In May 2016, soon after the conclusion of the UCMR3 sampling, EPA issued a Lifetime Health Advisory (LHA) for levels of two specific PFAS in drinking water; PFOA and PFOS at 70 ng/L (70 ppt), either individually or combined. Per EPA guidelines, Virginia uses 70 ppt as the LHA for PFOA and PFOS in drinking water. The announcement of EPA's LHA, along with high-profile news reporting on PFAS contamination sites such as those in Parkersburg, West Virginia, Minneapolis-St. Paul, Minnesota, Portsmouth, New Hampshire, and Hoosick Falls, New York, caused many states to evaluate the PFAS levels detected in their public water systems and consider how best to address the possibility of contamination of public and private drinking water supplies. Hence, many state drinking water programs or environmental protection agencies began to address PFAS. In May 2018, EPA hosted a National Leadership Summit on PFAS. As a follow-up to the many concerns raised by states and stakeholder groups, EPA held Regional Community Engagement events in communities impacted by PFAS in drinking water and committed to prepare an action plan to address PFAS nationwide.

The March 3, 2021 Federal Register (86 FR 12272) included notice that EPA is making final determinations to regulate PFOS and PFOA, in drinking water and to not regulate six contaminants (1,1-dichloroethane, acetochlor, methyl bromide (bromomethane), metolachlor, nitrobenzene, and RDX). With the final Regulatory Determinations for PFOA and PFOS, EPA will move forward to implement the national primary drinking water regulation development process described above for these two PFAS. In addition, EPA has re-proposed the Fifth Unregulated Contaminant Monitoring Rule (UCMR 5) (86 FR 13846, March 11, 2021) to collect new data on PFAS in drinking water. As proposed, UCMR 5 would provide new data to improve EPA's understanding of the frequency that 29 PFAS are found in the nation's drinking water systems and at what levels. All public water systems serving more than 3,300 customers and an additional 800 representative small systems will participate in the sampling program if it goes forward as proposed. The public comment period ended May 10, 2021.

With its decision to regulate PFOA and PFOS in drinking water, the EPA will continue to follow the rulemaking process established in the SDWA. Information about the federal requirements for establishing an MCL or treatment technique is in Section 6.1.

3.10 Regulatory Limits on PFAS – States

As noted in the toxicology section above, several states have developed regulatory limits for PFOA, PFOS, and other PFAS that are lower than EPA's Lifetime Health Advisory of 70 ppt. These are summarized in Table 2.

Table 2. Limits on PFAS established by other states and EPA. All specified quantities are ppt.

	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				400000							
Gen X				370							
PFBA					7,000					Study	
SUM		70	20						20		70

*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.

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

“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.

4. CHROMIUM (VI)

4.1 Use, Presence in the Environment, and Health Effects

Chromium is a naturally occurring element found in rocks, animals, plants, and soil. It can exist in several different forms. Depending on the form it takes, it can be a liquid, solid, or gas. The most common forms are chromium (0), chromium (III), and chromium (VI), also known as hexavalent chromium. No taste or odor is associated with chromium compounds.

The metal chromium, which is the chromium (0) form, is used for making steel. Chromium (VI) and chromium (III) are used for chrome plating, dyes and pigments, leather tanning, and wood preserving.

EPA promulgated the national primary drinking water regulation that established the MCL for total chromium of 0.1 mg/l (100 ppb) in 1991. This includes all forms of chromium, including chromium (VI). EPA states that chromium (VI) and chromium (III) are covered under the total chromium drinking water standard because these forms of chromium can convert back and forth in water and in the human body, depending on environmental conditions. Measuring just one form may not capture all of the chromium that is present. In order to ensure that the greatest potential risk is addressed, EPA's regulation assumes that a measurement of total chromium is 100 percent chromium (VI), the more toxic form. See https://www.epa.gov/sdwa/chromium-drinking-water.

The SDWA requires EPA to periodically review the national primary drinking water regulation for each contaminant and revise the regulation, if appropriate. EPA reviewed total chromium as part of the second six-year review that was announced in March 2010. The EPA noted in March 2010 that it had initiated a reassessment of the health risks associated with chromium exposure and that they did not believe it was appropriate to revise the national primary drinking water regulation while that effort was in process.

In April 2019, EPA held a public meeting to discuss the systematic review of chromium (VI) for its Integrated Risk Information System (IRIS). EPA's Toxicological Review of Hexavalent Chromium dates back to 1998 and provides information that VDH and the Board of Health could use to assess and determine an appropriate chromium standard. EPA's efforts for the IRIS review would consider new and emerging science on chromium (VI) and serve as a foundation for decision making under the Safe Drinking Water Act. EPA has not completed its review, but is taking data from UCMR3 and studies completed since 1998 into consideration. When this human health assessment is finalized, EPA will carefully review the conclusions and consider all relevant information to determine if the current chromium standard should be revised.

4.2 Chromium (VI) in Virginia

To assess the levels of chromium-6 in drinking water, EPA required a selected number of waterworks to perform chromium-6 monitoring under UCMR3. EPA established a minimum reporting level (MRL) of 0.3 µg/l (0.3 ppb) for chromium (VI), but did not specify a reference concentration. The MRLs were based on the capability of the analytical method, not based on a level established as “significant” or “harmful.” In its Data Summary, EPA stated the “UCMR 3 MRLs are often below current ‘health reference levels’ (to the extent that HRLs have been established).” The reference concentrations were based on publicly-available health information found in the following EPA resources: 2012 Drinking Water Standards and Health Advisories, the Candidate Contaminate List (CCL) 4 Contaminant Information Sheets, the Human Health Benchmark for Pesticides (HHBPs), the Integrated Information Risk System (IRIS), or the 2014 Preliminary Regulatory Determinations for Contaminants on CCL 3. The Data Summary stated the reference concentration did “not represent an ‘action level’ (EPA requires no particular action based simply on the fact that UCMR monitoring results exceed draft reference concentrations), nor should the draft reference concentration be interpreted as any indication of an Agency intent to establish a future drinking water regulation for the contaminant at this or any other level.”

Results from 81 large (serving more than 10,000 persons) and small (serving fewer than 10,000 persons) waterworks in Virginia that provided samples for UCMR3 showed a total of 680 samples from 76 waterworks were above the minimum reporting level of 0.03 µg/l and 108 samples were characterized as “non-detect” because the result was less than 0.03 µg/l.

4.3 Treatment Technologies

California recognizes three treatment technologies, ion exchange, reverse osmosis, and filtration of the reduced chromium species, as the best available technology. Research to date has not identified additional evidence to support this conclusion or provide additional information about these or other treatment technologies for chromium (VI).

4.4 Establishing Regulatory Limits on Chromium (VI) – EPA and California

The MCL for total chromium that is in the Waterworks Regulations, 12VAC5-590-340, Table 340.1, is 0.1 mg/L (or 100 parts per billion), the same as EPA’s standard in the National Primary Drinking Water Regulations. California is the only state that has established a MCL for chromium (VI), following its review of public health goals for total chromium. California’s public health goals are comparable to EPA’s maximum contaminant level goals (see “Establishing Regulatory Limits - EPA” below). California established a public health goal for chromium (VI) of 0.02 µg/l. With a public health goal in place, California went on to set the MCL for chromium (VI) at 0.010 mg/L (10 µg/l) in July 2014. However, a court ruling in May 2017 invalidated the MCL because the state did not comply with the requirement to properly consider the economic feasibility of complying with the MCL. Rather than appealing the decision, the California State Water Resources Control Board (California Water Board) is going through the process of adopting an MCL. In February 2020, the California Water Board published the White Paper Discussion on Economic Feasibility in Consideration of a Hexavalent Chromium Maximum Contaminant Level. Preliminary occurrence data and treatment cost estimates were released in October and November 2020. The California Water Board is currently evaluating comments received regarding treatment technologies and cost estimating methodology and expected to publish a notice of proposed rulemaking by the summer of 2021. See https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/Chromium6.html. The notice was not available at the time of this report.

5. 1,4-DIOXANE

5.1 Use, Presence in the Environment, and Health Effects

1,4-Dioxane is a synthetic industrial chemical that is completely miscible in water (EPA 2006b; ATSDR 2012). It is found at many federal facilities because of its widespread use as a stabilizer in certain chlorinated solvents, paint strippers, greases and waxes. In the environment, it is short-lived in the atmosphere, may leach readily from soil to groundwater, migrates rapidly in groundwater and is relatively resistant to biodegradation in the subsurface.

Exposure may occur through ingestion of contaminated food and water, or dermal contact. Worker exposures may include inhalation of vapors. Short-term exposure to high levels of 1,4-dioxane may result in nausea, drowsiness, headache, and irritation of the eyes, nose and throat (ATSDR 2012; EPA 2013; NIOSH 2010; EU 2002); long-term exposure may cause kidney and liver damage. 1,4-Dioxane is readily absorbed through the lungs and gastrointestinal tract. Some 1,4-dioxane may also pass through the skin, but studies indicate that much of it will evaporate before it is absorbed. Distribution is rapid and uniform in the lung, liver, kidney, spleen, colon and skeletal muscle tissue.

The U.S. Department of Health and Human Services states that “1,4-dioxane is reasonably anticipated to be a human carcinogen based on sufficient evidence of carcinogenicity from studies in experimental animals.” (DHHS 2014). EPA classifies 1,4-dioxane as “likely to be carcinogenic to humans” by all routes of exposure.

Federal screening levels, state health-based drinking water guidance values, and federal occupational exposure limits have been established. EPA set a one-day health advisory of 4.0 milligrams per liter (mg/L) and a ten-day health advisory of 0.4 mg/L in drinking water for a 10-kilogram child, and a lifetime health advisory of 0.2 mg/L in drinking water (EPA 2012).

5.2 1,4-Dioxane in Virginia

To assess the levels of 1,4-dioxane in drinking water, EPA required a selected number of waterworks nationwide to perform 1,4-dioxane monitoring under UCMR3. In Virginia, 81 large (serving more than 10,000 persons) and small (serving ≤ 10,000 persons) waterworks provided samples. A a total of 22 samples from 11 waterworks were above the minimum reporting level of 0.07 µg/l (micrograms per liter, equivalent to parts per billion), but below the reference concentration of 0.35 µ/l. Only one result out of a total of 425 exceeded the reference concentration (0.51 µ/L).

5.3 Treatment Technologies

In general, 1,4-dioxane is challenging to remove from drinking water due to its physical and chemical properties. Many conventional unit processes involved with drinking water treatment are ineffective in 1,4-dioxane treatment.

Advanced oxidation processes are a group of technologies that use the highly reactive hydroxyl radical to destructively remove organic contaminants and are the only fully demonstrated technologies available for 1,4-dioxane treatment in drinking water and groundwater. Additionally, two (2) more water treatment processes, ozone (under some conditions), and reverse osmosis (RO) were found to remove 1,4-dioxane at various efficiencies in laboratory studies and full-scale plants. If a water treatment plant has an ozone or RO unit process, it is possible that 1,4-dioxane concentrations may be reduced in the treatment process.

1,4-Dioxane can also be removed by granular activated carbon (GAC), but the breakthrough occurs much faster than more hydrophobic VOCs. Therefore, it is possible to use GAC to treat 1,4-dioxane at low flow rates, including as a point-of-entry (POE) treatment approach, but the GAC's adsorption capacity is expected to be exhausted quickly if the flow rate is high. As with adsorption of other contaminants, the effectiveness of 1,4-dioxane adsorption can also be affected by the water quality matrix.

5.4 Establishing Regulatory Limits on 1,4-Dioxane – EPA and New York

EPA has not established a federal MCL for 1,4-dioxane in drinking water. New York is the first state in the nation to adopt an MCL for 1,4-dioxane and has set that standard at 1.0 ppb. Waterworks were required to monitor for PFOA, PFOS, and 1,4-dioxane beginning August 26, 2020.[5] Large waterworks (serving 10,000 or more people) had to start sampling by October 25; medium waterworks (serving between 3,300 and 9,999 people) were required to begin sampling by November 25, 2020; and small waterworks (serving less than 3,300 people) had to start sampling by February 25, 2021. New York approved an advanced oxidation process for 1,4-dioxane removal, which has been used successfully to treat a well in the Suffolk County Water Authority on Long Island since 2018.[6]

California established a drinking water notification level for 1,4-dioxane, which is currently 1 μg/L. Certain requirements and recommendations apply to a waterworks if it serves its customers drinking water containing a contaminant greater than its notification level. California's response level – that is, the level at which water systems must remove a source of water from service—is 35 μg/L.[7] The Florida Department of Health has established a health

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[5] See https://www.health.ny.gov/environmental/water/drinking/docs/water_supplier_fact_sheet_new_mcls.pdf and https://regs.health.ny.gov/volume-title-10/content/section-5-151-maximum-contaminant-levels-maximum-residual-disinfectant.

[6] See https://www.governor.ny.gov/news/governor-cuomo-announces-first-nation-drinking-water-standard-emerging-contaminant-14-dioxane.

[7] See https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/14-Dioxane.html.

advisory level for 1,4-dioxane of 0.35 μg/L.[8] Other states have groundwater screening levels, exposure guidelines, exposure levels, etc., but no other state has established a MCL.

6. THE STATE BOARD OF HEALTH WILL CONSIDER REGULATIONS

6.1 Establishing Regulatory Limits - EPA

The SDWA specifies the following three (3) requirements for making a Regulatory Determination regarding MCL development: 1) the chemical may have an adverse effect on the health of persons; 2) the chemical is known to occur or there is a substantial likelihood that it will occur in public water systems with a frequency and at levels of public health concern; and 3) in the sole judgment of the EPA administrator, regulating the contaminant presents a meaningful opportunity for health risk reductions for persons served by public water systems. EPA has done this for PFOA and PFOS.

After reviewing health effects data, EPA sets a maximum contaminant level goal (MCLG). The MCLG is the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, allowing an adequate margin of safety. 42 USC § 300 g-1(b)(4)(A). MCLGs are non-enforceable public health goals. MCLGs consider only public health and not the limits of detection and treatment technology effectiveness. When determining an MCLG, EPA considers the adverse health risk to sensitive subpopulations: infants, children, pregnant women, the elderly, and those with compromised immune systems and chronic diseases. For chemical contaminants that are carcinogens, EPA sets the MCLG at zero if both of these are the case: 1) there is evidence that a chemical may cause cancer; and 2) there is no dose below which the chemical is considered safe. If a chemical is carcinogenic and a safe dose can be determined, EPA sets the MCLG at a level above zero that is safe.

For chemical contaminants that are non-carcinogens but can cause adverse non-cancer health effects (for example, reproductive effects), the MCLG is based on the reference dose (RfD) - an estimate of the amount of a chemical that a person can be exposed to on a daily basis that is not anticipated to cause adverse health effects over a lifetime.

Once the MCLG is determined, EPA sets an enforceable standard – generally a maximum contaminant level (MCL) – the maximum level allowed of a contaminant in water which is delivered to any user of a public water system. When there is no reliable method that is economically and technically feasible to measure a contaminant at concentrations to indicate there is not a public health concern, EPA sets a “treatment technique” – an enforceable procedure or level of technological performance, which public water systems must follow to ensure control of a contaminant.

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[8] See http://www.floridahealth.gov/environmental-health/drinking-water/_documents/hal-list.pdf.

The MCL is set as close to the MCLG as feasible. Taking cost into consideration, EPA must determine the feasible MCL or treatment technique. This is defined by the SDWA as the level that may be achieved with use of the best available technology or treatment approaches, and other means which EPA finds are available (after examination for efficiency under field conditions, not solely under laboratory conditions). 42 U.S.C. § 300g-1(b)(4)(B) - (D). As a part of the rule analysis, the SDWA also requires EPA to prepare a health risk reduction and cost analysis (HRRCA) in support of any National Primary Drinking Water Regulation. For the HRRCA, EPA must analyze the quantifiable and non-quantifiable benefits that are likely to occur as the result of compliance with the proposed standard. EPA must also analyze certain increased costs that will result from the proposed drinking water standard.

Each national primary drinking water regulation, which establishes a MCL, shall list the technology, treatment techniques, and other means which are feasible to meet the MCL. For small systems, EPA (in consultation with the States) shall include in the list any technology that is affordable for waterworks serving between 10,000 and 3,300 persons, between 3,300 and 500 persons, and less than 500 persons. The technology must achieve compliance with the MCL or treatment technique, including packaged or modular systems and point-of-entry or point-of-use treatment units. However, EPA's regulations shall not require that any specified technology to meet the MCL. 42 U.S.C. § 300 g-1(b)(4)(E)(ii).

6.2 Establishing Regulatory Limits – Virginia

The amendments to Code of Virginia § 32.1-169, when they become effective on January 1, 2022, state that each MCL "shall be protective of public health, including of vulnerable subpopulations, including pregnant and nursing mothers, infants, children, and the elderly, and shall not exceed any MCL or health advisory for the same contaminant adopted by the U.S. Environmental Protection Agency." Further, the Board is to consider "MCLs adopted by other states, studies and scientific evidence reviewed by such states, material in the Agency for Toxic Substances and Disease Registry of the U.S. Department of Health, and current peer-reviewed scientific studies produced independently or by government agencies."

VDH and the Board of Health are required to follow the requirements in the Virginia Administrative Process Act (VAPA), Code of Virginia § 2.2-4000 et seq., to create, amend, or repeal a regulation. This involves three basic steps and typically takes about 18-24 months from start to finish.

Step 1 - Notice of Intended Regulatory Action (NOIRA)

The notice informs the public that a regulatory change is being considered, along with a description of the changes being considered. Once the NOIRA is published in The Virginia Register of Regulations, there is at least a 30-day period during which the agency receives comments from the public. The agency reviews these comments as it develops the proposed regulation.

Step 2 - Proposed regulation

This step includes publication of the following information: the proposed regulation; a statement explaining the basis, purpose, substance and issues, including economic impact on small businesses and local governments, of the regulatory action, i.e., the Agency Background Document; an Economic Impact Analysis (EIA) prepared by the Department of Planning and Budget (DPB); the agency response to the DPB EIA; and an agency contact person. A 60-day public comment period begins upon publication of the proposed regulatory action in the Virginia Register. The agency may make changes to the proposed regulation based on comments received during the public comment period.

Work done for the PFAS work group's report will inform parts of this step, particularly VDH's analysis of the economic impact on small businesses and local governments if they would have to install treatment at a waterworks to reduce levels of PFOA, PFOS, chromium (VI), and/or 1,4-dioxane below a specified MCL.

Step 3 - Final regulation

The new, amended, or repealed regulation is published in the Virginia Register. Any change to the text of the regulation since the proposed regulation was published is highlighted by brackets that surround the changed language. A 30-day final adoption period takes place before the regulation becomes effective.

The Governor may review the final regulation during this time and, if he objects, forward his objection to the Registrar of Regulations and the agency. In addition to or in lieu of filing a formal objection, the Governor may suspend the effective date of a portion or all of a regulation until the end of the next regular General Assembly session. The Governor's objection or suspension of the regulation, or both, will be published in the Virginia Register. If the Governor finds that changes made to the proposed regulation have substantial impact, he may require the agency to provide an additional 30-day public comment period on the changes.

The agency shall suspend the regulatory process for 30 days when it receives requests from 25 or more individuals to solicit additional public comment, unless the agency determines that the changes have minor or inconsequential impact.

VDH intends to publish a NOIRA, beginning the standard rulemaking process, when the amendments to Code of Virginia § 32.1-169 become effective on January 1, 2022. VDH and the Board of Health will use information from the study completed for HB586 to inform the rulemaking process.

VDH will also consider input from the PFAS work group and other stakeholders on the criteria for rulemaking in the VAPA, HB1257, and the SDWA, since EPA will follow requirements in the SDWA to establish MCLs for PFOS and PFOA. This is important because Virginia, through VDH and ODW, has primary enforcement authority for the SDWA. A condition of primacy is that Virginia's drinking water regulations must be no less stringent than the National Primary Drinking Water Regulations. With EPA moving to establish regulatory limits for PFOA and PFOS, stakeholders have expressed concerns about the possibility that Virginia establishes MCLs that are less restrictive (higher) than EPA's, forcing the Board of Health to lower Virginia's MCLs. Alternatively, if the Virginia standards are more restrictive (lower) than EPA's, it is possible that waterworks, local governments, and others would want the Board to change the standard to be the same as EPA's. Stakeholders have also raised concerns about the difference between the requirements EPA follows to establish an MCL compared to the VAPA process and the considerations specified in the amendment to Code of Virginia § 32.1-169.

7. CONCLUSIONS

VDH and the Virginia PFAS work group will continue to complete the requirements of HB586 to help inform the Board's decisions regarding MCLs for PFOA and PFOS. As VDH completes work to fulfill the requirements of HB586, the agency can shift resources to understanding the extent, nature, and health implications of chromium (VI) and 1,4-dioxane contamination in drinking water in Virginia. The PFAS work group was not tasked with, and thus did not consider, chromium (VI) and 1,4-dioxane as part of its evaluation.

The PFAS sample study required by HB586 provided 63 results from 45 waterworks. Samples from 48 sample locations did not contain any PFAS above the PQL. The preliminary results indicate that PFAS are present in drinking water produced from the Potomac River and Occoquan Reservoir, two major sources of water that waterworks in Northern Virginia use. The amount and specific types of PFAS in both sources is unknown because the PFAS sample study only tested finished water. Ten (10) 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 MCLs established by other states.

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 detection limit. Again, those levels were below EPA's health advisory level and all of the MCLs established by other states.

VDH and the Board of Health could adopt MCLs for PFOA and PFOS that are comparable to other states' MCL for the same compounds and, based on the preliminary results only, state that a significant portion of the people who drink water from waterworks in Virginia are drinking water that complies with the MCL. However, there are more than 1,050 community waterworks in Virginia and the majority of them are classified as "small," meaning they serve fewer than 3,300 persons. VDH does not know how many of these waterworks use water that contains PFAS, what level is present, if any, or what the implications would be for setting an MCL.

The Code of Virginia requires VDH to consider protection of public health and the financial impact of regulations in the rulemaking process. See Code of Virginia §§ 2.2-4007.04 and 32.1-170. The SDWA also requires this evaluation. See 42 U.S.C. § 300g-1(b). If the Board establishes a MCL that would require a small waterworks to install treatment, the cost could be in the millions of dollars. Small waterworks could most acutely experience the impact of establishing MCLs if PFAS were found above an established MCL because they have a smaller customer base amongst whom they can spread the cost of compliance. VDH and the Board need more sampling data and time to make an informed, reasonable decision regarding MCLs for all of the specified contaminants.

ODW will conduct additional PFAS sampling in 2021 and 2022 using $60,000 that the 2021 General Assembly appropriated and funding from EPA in the 2022 Public Water System Supervision Grant to study emerging contaminants. The PFAS work group's report will inform the nature of the studies and sampling for PFAS.

The occurrence of chromium (VI) and 1,4-dioxane in Virginia has been limited to testing done in 2014-2015 as part of the EPA's UCMR3. VDH and waterworks in Virginia have not conducted additional testing or performed a public health risk assessment of these chemicals in drinking water. A literature review revealed limited data on the occurrence, toxicity, and treatment options for both compounds. VDH lacked resources to complete the PFAS sample study and perform rigorous analysis of chromium (VI) and 1,4-dioxane prior to the effective date of the amendment to Code of Virginia § 32.1-169. Further, VDH cannot quantify the extent and nature of chromium (VI) and 1,4-dioxane contamination in drinking water in Virginia without additional funding.

This report does not address possible PFAS impacts to private drinking water/private wells, which rely on groundwater sources.

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APPENDIX 1 - PFAS Work Group Members.

1. Community waterworks that serve more than 50,000 persons.	Chris Harbin/Jillian Terhune	Norfolk Department of Public Utilities
	David Jurgens	City of Chesapeake Department of Public Utilities
	Jamie Bain Hedges	Fairfax Water
	Mike Hotaling	Newport News
	Michael McEvoy	Western Virginia Water Authority
	Jessica Edwards-Brandt	Loudoun Water
	Christian Volk, Ph.D.	Virginia American Water
	Russ Navratil	Henrico County
2. Community waterworks that serve less than 50,000 persons.	John J. Aulbach, P.E. / Dan Hingley, P.E.	Aqua Virginia
	Mark Estes	Halifax County PSA
3. Community waterworks that serve less than 1,000 persons.	Wendy Eikenberry	Augusta County Service Authority
4. Advocacy group that represents waterworks in Virginia.	Geneva Hudgins / Russ Navratil	Virginia Section American Water Works Association
	Andrea W. Wortzel	Mission H20
	Steve Herzog	Virginia Water Environment Association
5. Chemical manufacturer with chemistry experience.	Stephen P. Risotto	American Chemistry Council
	Henry Bryndza, Ph.D.	DuPont (retired)
6. A consumer of public drinking water.	Dr. William Mann	
7. Non-governmental environmental organizations.	Anna Killius	James River Association
	Phillip Musegaas	Potomac Riverkeeper Network
	Michael Town / Christopher Leyen	Virginia League of Conservation Voters
8. The Virginia Department of Environmental Quality (DEQ).	Jeff Steers / Benjamin Holland	
9. A local health district.	Dr. Noelle Bissell	Director, New River Health District
The State Toxicologist	Dwight Flammia, Ph.D.	
ODW staff member	Robert Edelman, P.E.	Director, ODW Division of Technical Services
PFAS work group leader	Tony Singh, Ph.D.	Deputy Director, ODW

APPENDIX 1 – SUBGROUP MEMBERS

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David Jurgens (City of Chesapeake)
Chris Leyen (Virginia League of Conservation Voters)
Paul Nyffeler (Chem Law)
Erin Reilly (James River Association)
Steve Risotto (American Chemistry Council)
Kelly Ryan (Virginia American Water)
Jillian Terhune (City of Norfolk)
Andrea Wortzel (Mission H2O)

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Mark Estes (Halifax County Service Authority)
Dwight Flammia (State Toxicologist)
Jamie Bain Hedges (Fairfax Water)
Jack Hinshelwood (VDH ODW)
David Jurgens (City of Chesapeake)
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Mike McEvoy (Western Virginia Water Authority)
Phillip Musegaas (Potomac Riverkeeper Network)
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Chris Harbin (City of Norfolk)
Jamie Bain Hedges (Fairfax Water)
Jack Hinshelwood (VDH ODW)
Mike Hotaling (Newport News Water Works)
Mike McEvoy (Western Virginia Water Authority)
Russ Navratil (Virginia Section American Water Works Association)
Kelly Ryan (Virginia American Water)

APPENDIX 2 – Virginia PFAS Sample Study Design

PFAS Sampling & Monitoring Study in Virginia Drinking Water

Virginia Department of Health - Office of Drinking Water

Developed in conjunction with the VA PFAS Workgroup

PFAS Sampling & Monitoring Study in Virginia Drinking Water

Virginia Department of Health
Office of Drinking Water

In conjunction with the
VA PFAS Workgroup

March 2021

TABLE OF CONTENTS

1. Introduction

Per- and poly fluoroalkyl substances (PFAS) are man-made, industrially produced compounds. Production of these chemicals began in the 1940s and there are now more than 5,000 different chemicals in the PFAS family. A wide variety of products, including stain resistant fabric coatings, non-stick coatings (Teflon), food packaging, and firefighting foam contain PFAS. Two of the most extensively produced and studied chemicals in the PFAS family are perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS).

PFOA/PFOS, and many other chemicals in the PFAS family, do not easily break down in the environment and are easily transportable in the atmosphere, surface water, soil, and groundwater. Exposure to humans can occur by eating, inhaling, or even touching the product. The U.S. Environmental Protection Agency (EPA) reports that scientists have found traces of one or more PFAS in the blood of nearly all the people they tested in the USA. Possible health effects associated with exposure to chemicals in the PFAS family include developmental effects to fetuses during pregnancy or to breastfed infants (e.g., low birth weight, accelerated puberty, skeletal variations), cancer (e.g., testicular, kidney), liver effects (e.g., tissue damage), immune effects (e.g., antibody production and immunity), thyroid effects, and other effects (e.g., cholesterol changes).

From 2013 to 2015, EPA evaluated the occurrence of PFOA, PFOS, and four other PFAS compounds at 4,920 public water systems (PWS; also referred to as "waterworks" in Virginia) across the U.S. as part of its "Third Unregulated Contaminant Monitoring Rule" (UCMR 3) evaluation. The data did not reveal significant occurrences of PFOA, PFOS, or other PFAS in Virginia; however, UCMR 3 had reporting limits of 20 parts per trillion (ppt) and 40 ppt for PFOA and PFOS, respectively. Two Virginia waterworks detected PFAS compounds, but follow-up sampling did not identify the source or an impact to drinking water supplies. EPA found that 1.3% of the public water systems monitored under the UCMR 3 had measured concentrations of PFOA and PFOS that were greater than the EPA's lifetime Health Advisory (70 parts per trillion (ppt)).

On May 16, 2016, EPA issued a Lifetime Health Advisory of 70 ppt for combined PFOA and PFOS and, on February 22, 2021, EPA announced it will move forward with final regulatory determinations (i.e., establish regulatory standards) for PFOA and PFOS under the Safe Drinking Water Act. However, since PFAS as a whole, or as individual compounds, are not subject to federally established regulatory limits at this time, there is scant monitoring data of PFAS occurrence in Virginia's waterworks and major sources of water.

House Bill (HB) 586 (2020 Acts of Assembly Chapter 0611) seeks to prevent adverse health effects and protect public health by studying the occurrence of PFAS in drinking water. The legislation requires the State Health Commissioner, who acts through the Virginia Department of Health (VDH), to convene a workgroup to study the occurrence of six specific PFAS (PFOA, PFOS, perfluorobutyrate (PFBA), perfluoroheptanoic acid (PFHpA), perfluorohexane sulfonate (PFHxS), perfluorononanoic acid (PFNA)) and other PFAS, as deemed necessary, that may be present in drinking water from waterworks, identify possible sources of such contamination, and evaluate approaches to regulating PFAS. The workgroup may recommend maximum contaminant levels (MCLs) for inclusion in regulations of the Board of Health applicable to waterworks. The workgroup will report its findings to the Governor and legislative committees by December 1, 2021. To determine the occurrence of PFAS contamination, the bill requires VDH to sample no more than 50 representative waterworks and major sources of water.

HB1257 (2020 Acts of Assembly Chapter 1097) directs the Board of Health to adopt regulations establishing MCLs for PFOA, PFOS, and other PFAS as it deems necessary. The effective date for HB1257 is January 1, 2022, so that the Board can consider the findings and recommendations that come from the work performed to satisfy the requirements in HB586.

To implement HB586, VDH, through its Office of Drinking Water (ODW), formed the Virginia (VA) PFAS Workgroup. In the October 20, 2020, kickoff meeting for the VA PFAS Workgroup, members accepted and formed four subgroups to focus on (1) PFAS Health and Toxicology, (2) PFAS Occurrence and Monitoring, (3) PFAS Policy and Regulations and (4) PFAS Treatment Technologies. These subgroups meet on a monthly basis and bring summaries of their findings and recommendations to the quarterly main VA PFAS Workgroup meetings.

2. Purpose

This document, the PFAS Sampling & Monitoring Study in Virginia Drinking Water (Sampling Plan), summarizes the approach VDH will follow to determine the occurrence of PFAS in drinking water and in major sources of water in Virginia. VDH developed the Sampling Plan in conjunction with the VA PFAS Workgroup.

As specified in the legislation, this study is limited to drinking water produced by waterworks and major water sources used by waterworks. It does not include water from private wells or other sources. “Waterworks” means a system that serves piped water for human consumption to at least 15 service connections or 25 or more individuals for at least 60 days out of the year. Code of Virginia § 32.1-167.

3. Objectives

The PFAS Occurrence and Monitoring Subgroup evaluated existing approaches to sample and monitor for PFAS chemicals in drinking water, including approaches adopted by other states and the federal government. Based on available data, funding, time limitations, and other states’ experience, the Subgroup recommend an approach (study design) for a limited sampling program to determine the occurrence of PFAS in Virginia by sampling no more than 50 representative waterworks and major sources of water. The Occurrence and Monitoring Subgroup met on January

13 and February 4, 2021 to develop and review its recommended approach and presented it to the VA PFAS Workgroup at a meeting on March 4, 2021. Members of the VA PFAS Workgroup could review a draft of the Sampling Plan prior to the meeting. At the meeting, they voted to support the recommended approach that is described in this Sampling Plan.

Upon implementing the Sampling Plan, VDH, through ODW, will coordinate sample collection from the representative waterworks and major sources of water. As results of analysis come in from the laboratory, ODW and the PFAS Occurrence and Monitoring Subgroup will tabulate PFAS data from the sampling program and other existing PFAS monitoring data that waterworks make available to VDH. The Subgroup will also evaluate the data to determine current levels of PFAS (PFOA, PFOS, PFBA, PFHpA, PFHxS, PFNA, and other PFAS as deemed necessary) contamination in the Commonwealth's public drinking water.

4. Methodology

The Sampling Plan is intended to prioritize sites for PFAS sampling and generate statewide occurrence data. VDH and the VA PFAS Workgroup considered several factors in developing the Sampling Plan, including:

- The location of potential sources of PFAS contamination;
- Known locations of PFAS contamination;
- The relative risk to consumers who receive water from waterworks that utilize source water that comes from areas that are near known or potential sources of PFAS contamination;
- Population served; and
- Available funding: $40,000.

> *It should be noted that, for the purpose of the Sampling Plan, 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 (SIC codes, VPDES 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 chemicals specifically, only that previous published work indicates the type of facility or activity may be associated with the production, use, or discharge of PFAS.*
>
> *It should be noted that implementation of the Sampling Plan is not intended to determine the causality between potential sources of PFAS and PFAS found in drinking water sources. The purpose of this plan and the sampling to be performed as a result of this plan is intended to provide additional data regarding the occurrence of PFAS in Virginia public drinking water.*

4.1 Sample collection costs/supplies

The sample collection costs and supplies are described in the Quality Assurance Program Plan (QAPP) VDH developed and submitted to EPA for approval and the responses to VDH's bid process for laboratories. The most recent QAPP is dated 10/30/20. VDH is in the process of revising the QAPP to reflect the selection of a lab to perform sample analyses.

4.2 Selection of Sample Locations

The process of selecting sample locations involved a combination of geospatial analysis and programmatic review. The geospatial analysis included the creation of a Geographic Information System (GIS) project using ArcMap 10.4.1 that combined waterworks locations and information about potential sources of PFAS contamination. There are currently 2,811 waterworks (also referred to as "public water systems" (PWSs)) in Virginia. Waterworks are classified based on the characteristics of the population they serve:

- **Community Water Systems (CWS):** A waterworks that provides water to the same population year-round. Examples are municipal water systems, authorities, and residential subdivisions with their own water supplies.
- **Nontransient Noncommunity (NTNC) Water Systems:** A waterworks that is not a CWS, but that regularly serves at least 25 of the same people at least six months of the year. Examples include schools, factories, and hospitals that have their own water supplies.
- **Transient Noncommunity (TNC) Water Systems:** A waterworks that serves transient customers in non-residential settings, such as campgrounds, motels, and restaurants that have their own water supplies.

The PFAS sampling sites selection is primarily based on the following considerations:

- Available funding ($40,000 for sample collection and PFAS analysis);
- HB586 limits sampling to no more than 50 waterworks and major sources of water;
- Relative potential for PFAS contamination in water that is used by waterworks as a source (either groundwater or surface water); and
- Maximum public health risk reduction (i.e., if there is PFAS, how many people are potentially consuming water that is contaminated – "large" waterworks serve more consumers, therefore if their source water is contaminated, they are potentially putting more people at risk). Large waterworks are defined as serving more than 50,000 persons. See 40 CFR § 141.2.

ODW staff identified the largest waterworks in the state (based on population served) and plotted the locations of surface water intakes and groundwater wells used by community and nontransient noncommunity water systems, potential discharge locations, including unlined landfills and airports, and major rivers in the state. Using three different strategies, described below, VDH and the VA PFAS Workgroup identified (1) potential high and/or medium risk groundwater systems based on the potential sources of PFAS contamination, (2) large community water systems, and (3) water sources/intakes with higher possibility of potential PFAS contamination.

Consumers served by CWSs and NTNCs have a higher risk of exposure from drinking, cooking, bathing and showering, and other water uses. For this reason, the Sampling Plan was limited to CWSs and NTNCs. There are 1,093 CWSs and 510 NTNCs, for a total initial sampling pool of 1,603 waterworks which collectively provide drinking water from 2,626 sources (e.g. wells, springs, and surface water sources).

VDH prioritized the list of waterworks based on relative risk, considering the waterworks proximity to the potential sources of PFAS contamination. Using the GIS system, VDH established several data layers containing locational and other information specific to the potential sources of PFAS contamination. These layers include the following industries and land uses:

- Military or commercial airports (from U.S. Geological Survey data)
- Unlined landfills (data from the Virginia Department of Environmental Quality (DEQ))
- Virginia Pollutant Discharge Elimination System (VPDES) discharge data
- Discharge points for Publicly Owned Treatment Works (POTWs)
- Waterworks size and population served data

4.2 Identification of Potential at-Risk Groundwater Waterworks

A significant portion of the peer-reviewed, published literature on PFAS contamination focuses on contamination resulting from the use of Aqueous Fire Fighting Foam (AFFF), a product mandated for use by the Federal Aviation Administration (FAA). AFFF that meets U.S. Department of Defense specifics for use at military facilities is a common source of PFAS and is frequently found at both military and civilian airports. 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 and that potentially contain PFAS, airports are considered a likely source of PFAS contamination. For the purpose of the geospatial analysis, ODW staff only 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.

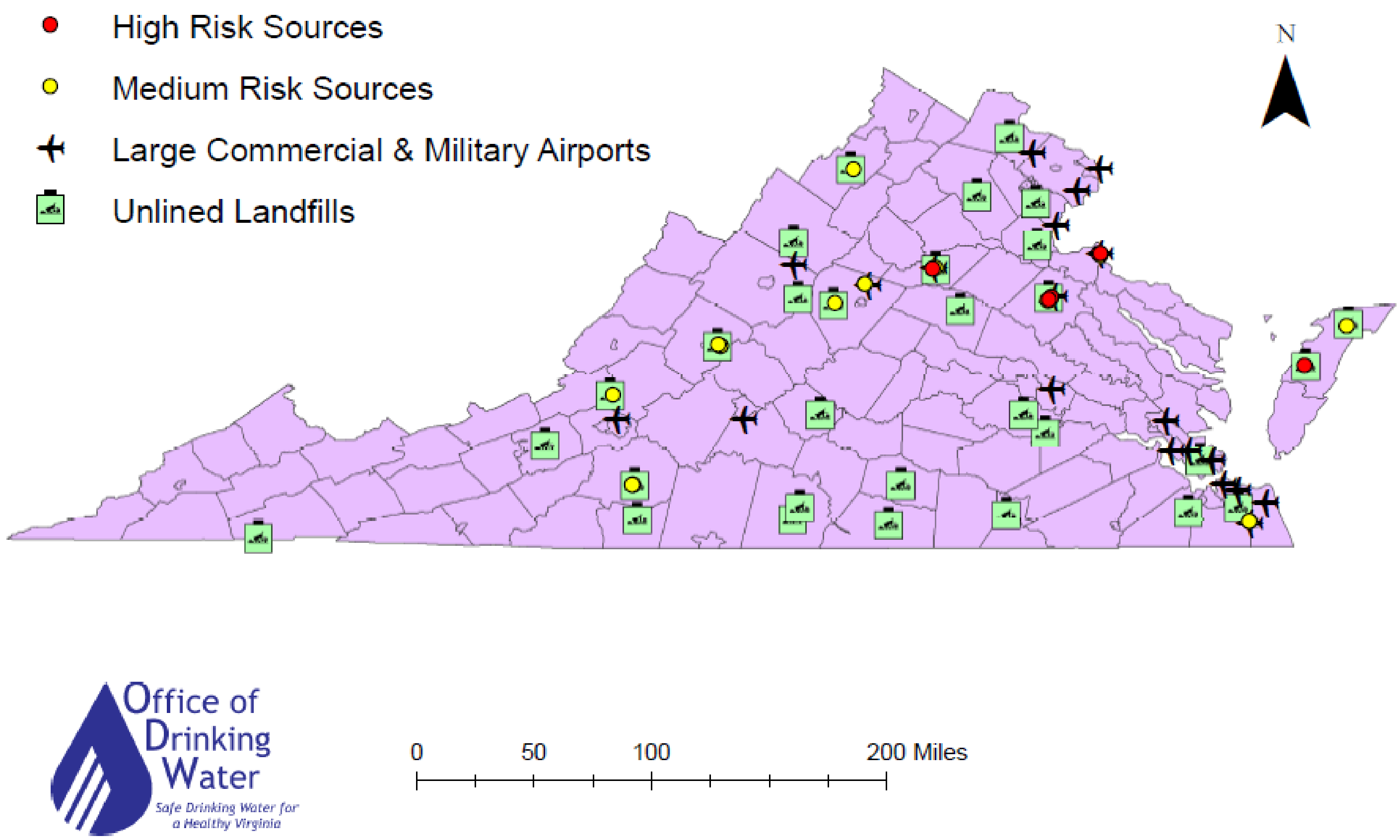
Peer-reviewed, published research also indicates that landfills, specifically landfill leachate, are a source of PFAS contamination. Landfill leachate likely obtains PFAS from the myriad of consumer products that include PFAS and are commonly placed in the garbage. Without going into the full list of likely consumer products, food contact packaging, cosmetics, and electronics are all examples of PFAS-containing products that can commonly be found in the 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. DEQ recommended focusing on these landfills over Subtitle D landfills (which are lined and have leachate collection systems) and other waste disposal facilities.

For purposes of the Sampling Plan and in order to minimize duplication of effort, VDH designated any waterworks using a groundwater well located within ½ mile of an unlined landfill or airport (potential sources of PFAS contamination) (as potential high risk water source. VDH designated waterworks using a groundwater well located within ½ mile to 1 mile of a known unlined landfill or airport as potential medium risk water source.

VDH did not consider the following in evaluating potential high or medium risk groundwater waterworks/water sources.

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

Based on the compilation of potential sources of PFAS contamination, VDH and the VA PFAS Workgroup selected 11 waterworks that use groundwater wells that are located within 1 mile of potential sources of PFAS contamination. These waterworks utilize a total of 6 groundwater wells that constitute a high risk and 13 groundwater wells that constitute a medium risk based on the proximity of the well to the potential source of PFAS contamination. See Figure 1 and Table 1.



Map 1. Groundwater Waterworks downstream of potential PFAS discharges

Table 1 . Potential high and medium risk Groundwater systems

System Name	PWSID	Facility Name	ID	System Type	Population Served	High or Medium
NAVAL SUPPORT FACILITY_ DAHLGREN	6099340	WELL 3 - BLDG 274A (RESERVOIR WELL)	WL003	C	11000	H
NAVAL SUPPORT FACILITY_ DAHLGREN	6099340	WELL 1 - BLDG 1288 (BRONSON WELL)	WL001	C	11000	H
BOWLING GREEN_ TOWN OF	6033550	WELL 4	WL004	C	1152	H
PUNGOTEAGUE ELEMENTARY SCHOOL	3001790	WELL	WL001	NTNC	610	H
RSA ROUTE 20	6137120	WELL #2 (MAY LANE)	WL002	C	387	H
FT A P HILL - HEADQUARTERS	6033251	WELL HQ #2 (PWAT 28)	WL028	C	180	H
NAVAL SUPPORT FACILITY_ DAHLGREN	6099340	WELL 2 - BLDG 1190 (CASKEY WELL)	WL002	C	11000	M
BOWLING GREEN_ TOWN OF	6033550	WELL 5	WL005	C	1152	M
BOWLING GREEN_ TOWN OF	6033550	WELL 1A	WL01A	C	1152	M
LONG HOLLOW	2163400	LHWDC WELL 1	WL001	C	578	M
LONG HOLLOW	2163400	LHWDC WELL 2	WL002	C	578	M
EARLYSVILLE FOREST	2003255	WELL 6	WL006	C	488	M
EARLYSVILLE FOREST	2003255	WELL 5	WL005	C	488	M
PEACOCK HILL SUBDIVISION	2003650	WELL 8	WL008	C	475	M
RSA ROUTE 20	6137120	WELL #1 (PORTER RD)	WL001	C	387	M
MOUNTAIN VIEW ELEM SCHOOL	2163560	MTN VIEW WELL	WL001	NTNC	250	M
ROANOKE CEMENT COMPANY	2023180	WELL - ROANOKE CEMENT COMPANY	WL001	NTNC	190	M
FT A P HILL - HEADQUARTERS	6033251	WELL HQ #1 (PWAT 29)	WL029	C	180	M
FRANKLIN COUNTY COMMERCE CENTER	5067137	WELL NO. 5	WL005	NTNC	103	M

**Note:* This establishes relative risk and is not exact. This approach identified wells and waterworks for monitoring in this study. Map 1 shows the distribution of large airports and unlined landfills across Virginia. *The list of waterworks sources identified within ½ mile of a potential source of PFAS contamination is subject to change as new information becomes available. Additional waterworks may be added or removed from the list.*

5. Identification of Potential at-Risk Surface Water Sources

ODW identified major surface water supplies based on potential sources of PFAS contamination that DEQ identified from industrial classification codes and information in discharge permits. These included::

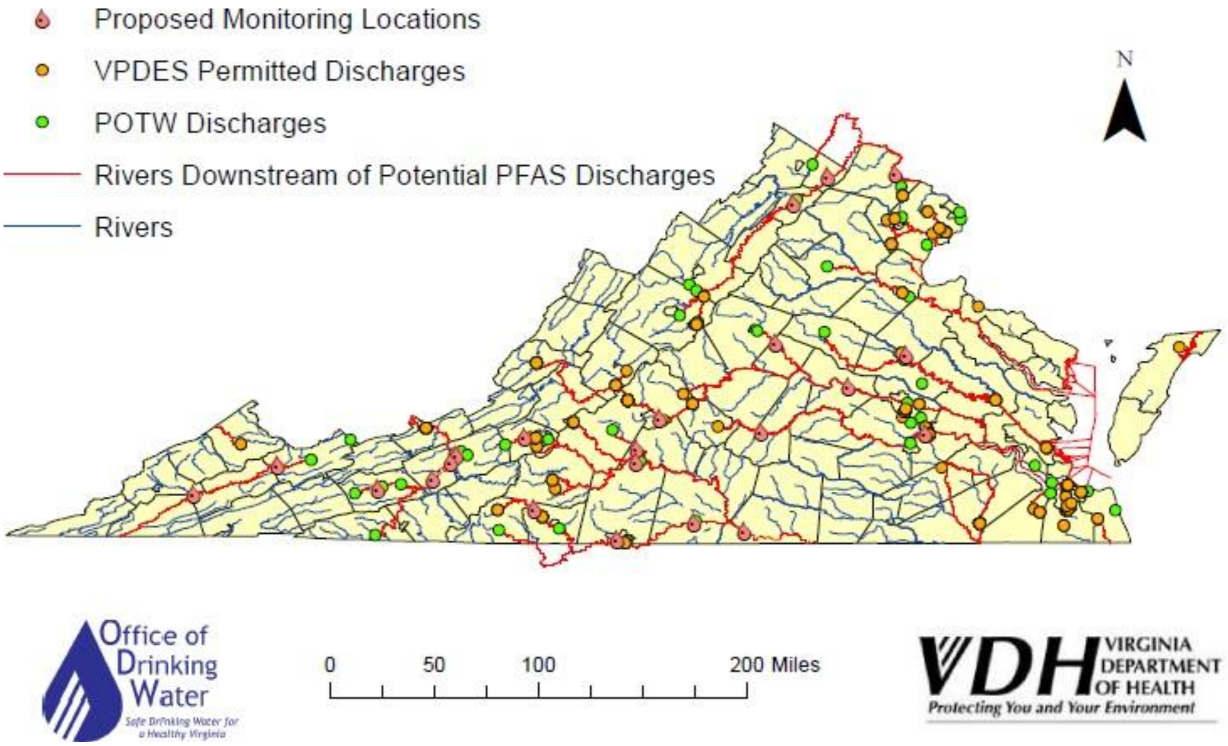
- Publicly Owned Treatment Works (POTWs) with Significant Industrial Users

- Virginia Pollution Discharge Elimination System (VPDES) discharge permits (direct dischargers)

DEQ identified the POTWs and VPDES discharges based on Standard Industrial Classification (SIC) codes for Significant Industrial Users and 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 past/historic discharges of PFAS could impact waterworks' surface water intakes. DEQ provided the GPS coordinates for the discharge points to ODW. Using GIS, , ODW connected 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 waterworks' drinking water intakes. ODW prioritized these 45 water intakes as follows:

- Excluded intakes associated with the 17 large waterworks because the entry point sampling addresses these intakes.
- Sorted remaining waterworks from largest to smallest population served.
- The Occurrence and Monitoring Subgroup recommended including at least one sample location that from each of the New River, Clinch River, and Dan River.
- Select impacted intakes starting with largest population served, selecting two intakes on the river systems noted above.
- Selected no more than one intake per waterworks.

Based on the limitation in the enabling legislation of no more than 50 waterworks and major sources of water and the number of waterworks selected in part 1 and 2 of the hybrid approach, VDH selected 22 major sources of water for this phase. Map 2 shows 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 Sampling Plan. Table 2 lists the associated waterworks.



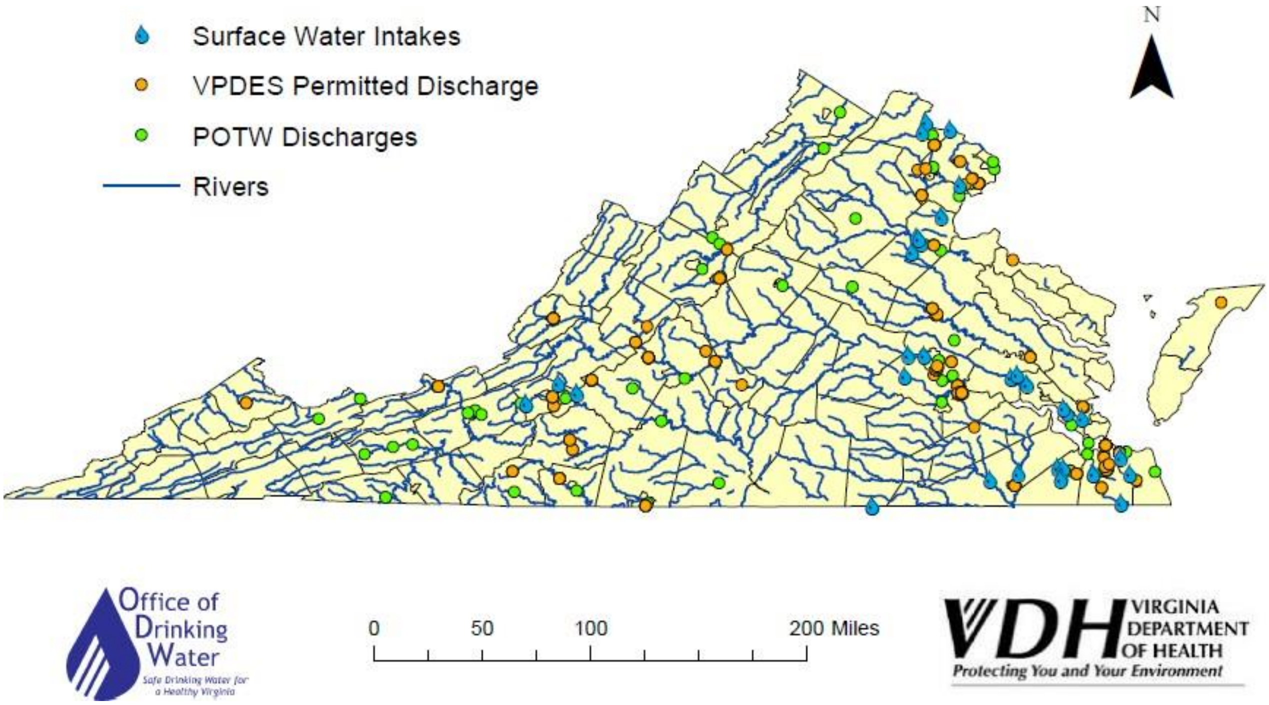
Map 2. Major Water Sources, consisting of surface water intakes.

Table 2. Major Water Sources - Waterworks Surface Water Intakes Identified for Sampling

PWSID	System	Facility
5680200	LYNCHBURG, CITY OF	JAMES RIVER-COLLEGE HILL
4085398	HANOVER SUBURBAN WATER SYSTEM	NORTH ANNA RWI
1121057	NRV REGIONAL WATER AUTHORITY	NEW RIVER (RAW WATER) PUMP STATION
6107300	LEESBURG_ TOWN OF	POTOMAC INTAKE
5590100	DANVILLE, CITY OF	DAN RIVER INTAKE
5089852	UPPER SMITH RIVER WATER SUPPLY	SMITH RIVER INTAKE
3670800	VIRGINIA-AMERICAN WATER CO.	APPOMATTOX RIVER
2775300	CITY OF SALEM WTP	ROANOKE RIVER
5031150	CAMPBELL COUNTY CENTRAL SYSTEM	BIG OTTER RIVER
1750100	RADFORD_ CITY OF	INTAKE ON NEW RIVER
2187406	FRONT ROYAL_ TOWN OF	SOUTH FORK SHENANDOAH RIVER
2065480	LAKE MONTICELLO	RIVANNA RIVER
1195900	WISE COUNTY REGIONAL WATER SYSTEM	CLINCH RIVER INTAKE
1155641	PULASKI COUNTY PSA	CLAYTOR LAKE
5780600	HCSA- LEIGH STREET PLANT	DAN RIVER INTAKE
5147170	FARMVILLE_ TOWN OF	APPOMATTOX RIVER
1197810	WYTHEVILLE_ TOWN OF	REED CREEK
4075735	JAMES RIVER CORRECTIONAL CTR	JAMES RIVER INTAKE
1185695	RICHLANDS_ TOWN OF	IN001 - CLINCH RIVER INTAKE
2043125	BERRYVILLE_ TOWN OF	SHENANDOAH RIVER
5031050	ALTAVISTA, TOWN OF	STAUNTON RIVER
5117310	CLARKSVILLE_ TOWN OF	KERR RESERVOIR INTAKE

6. Higher Public Health reduction - Largest waterworks in Virginia

This involves sampling at entry points and consecutive connections representative of the water entering the 17 largest waterworks in Virginia. The 17 largest waterworks provide water to more than half of Virginia residents. Maps 3 and 4 show the distribution of the intakes represented by this group of 17 waterworks. Several of the waterworks in this group have more than one surface water intake.



Map 3 Proposed 17 large waterworks in Virginia.

Table 3. Seventeen (17) large community waterworks in the Commonwealth of Virginia

PWSID	PWS name	City / County	Population	# EPs	# CCs
6059501	FAIRFAX COUNTY WATER AUTHORITY	FAIRFAX COUNTY	1074422	2	1
3810900	VIRGINIA BEACH, CITY OF	VIRGINIA BEACH	446067	0	1
3700500	NEWPORT NEWS, CITY OF	NEWPORT NEWS	407300	2	0
4041845	CHESTERFIELD CO CENTRAL WATER SYSTEM	CHESTERFIELD	320658	1	2

PWSID	**PWS name**	**City / County**	**Population**	**# EPs**	**# CCs**
4087125	HENRICO COUNTY WATER SYSTEM	HENRICO	292000	1	1
6107350	LOUDOUN WATER - CENTRAL SYSTEM	LOUDOUN	286202	1	1
3710100	NORFOLK, CITY OF	NORFOLK	234220	2	0
6013010	ARLINGTON COUNTY	ARLINGTON	215000	0	1
4760100	RICHMOND, CITY OF	RICHMOND CITY	197000	1	0
3550051	CITY OF CHESAPEAKE - NORTHWEST RIVER SYS	CHESAPEAKE	166704	2	0
2770900	WESTERN VIRGINIA WATER AUTHORITY	ROANOKE CITY	155000	2	0
6153600	PWCSA - EAST	PRINCE WILLIAM	153000	0	1
6510010	ALEXANDRIA, CITY OF	ALEXANDRIA	146970	0	2
6153251	PWCSA - WEST	PRINCE WILLIAM	130001	0	2
3740600	PORTSMOUTH, CITY OF	PORTSMOUTH	120400	1	0
6179100	STAFFORD COUNTY UTILITIES	STAFFORD	112285	2	0
6177300	SPOTSYLVANIA COUNTY UTILITIES	SPOTSYLVANIA	84390	2	0
Totals				19	12
Total Samples (EP + CC)				31	

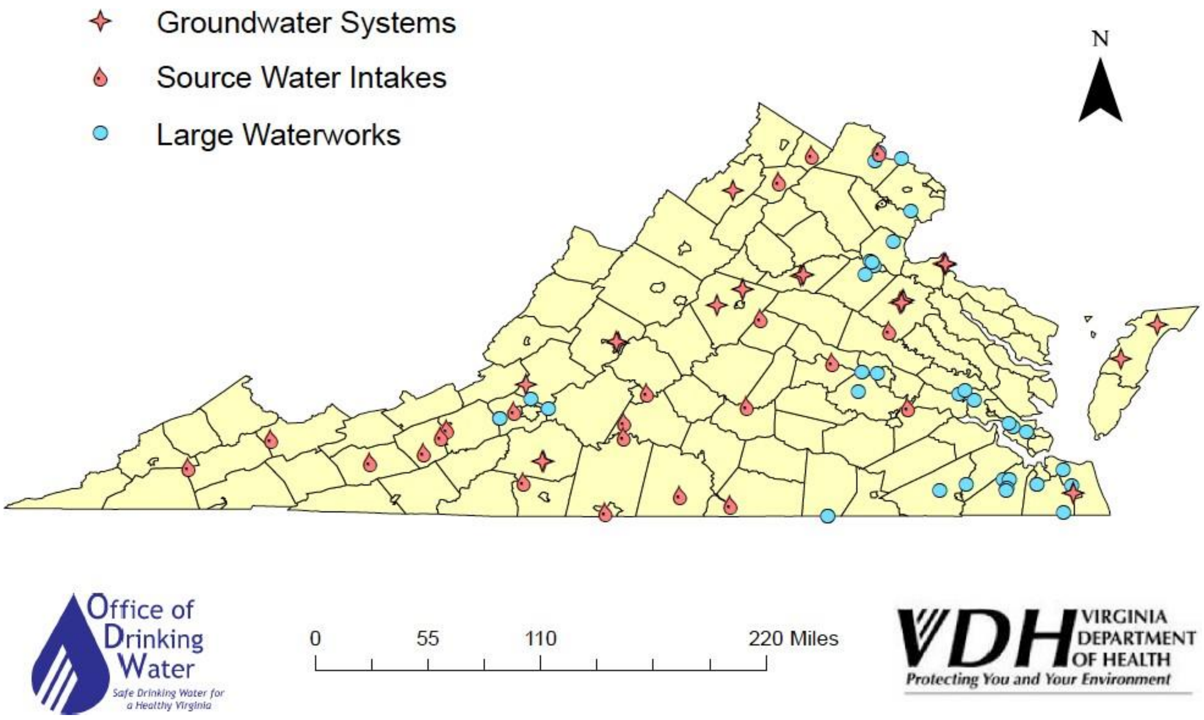
Population = Retail population, not including consecutive customers
EP = Entry point sample point, at a surface water treatment plant
CC = Consecutive Connection sample points
SWTP = Surface water treatment plant
Raw = untreated source water

7. Hybrid Approach Summary

The following table summarizes the numbers of waterworks, sample points, and population served for the hybrid PFAS sampling plan (Table 4 and map 4).

Table 4. Summary of the waterworks and water sources

	Sample Points	Waterworks	Population Served
17 Large Waterworks	31	17	4,541,619
Groundwater - High Risk	6	5	13,329
Groundwater - Medium Risk	13	6	2,084
Major Water Sources	22	22	536,322
Total	72	50	5,093,354



Map 4. The locations of proposed sampling sites for the PFAS Sampling study in Virginia Drinking Water

8. Sampling Approach

VDH intends to request waterworks identified in the Sampling Plan to collect samples for the PFAS study at specific locations. These locations include:

- Entry points (EP) – Locations where finished drinking water enters the distribution system (post treatment).
- Consecutive Connections (CC) – Locations where finished drinking water is transferred from one waterworks to another.
- Intakes – Locations where source water is withdrawn from the water source, such as a river, stream or reservoir, before any treatment.

9. Number of samples per location

The sampling program will take the following approach:

- One sample per location
- To be consistent with the EPA's sampling requirements for Method 533 (see Section 11 below), field reagent blanks (FRBs) will be submitted with each PFAS sample collected as part of the sampling study.
- Confirmation samples
    - A detection > Method Reporting Level (MRL) for a specific PFAS analyte may trigger the collection of a confirmatory sample
    - VDH has the goal of taking confirmation samples upon detection of PFAS; however, VDH may limit confirmation samples due to budget constraints.
    - VDH will prioritize confirmation samples based on:
        - Detection of specific PFAS analytes, such as the analytes in HB586, or detection of PFOS or PFOA, which have an EPA health advisory level.
        - Concentration of the analyte detected.
        - If the level of PFOS plus PFOA exceeds 70 ppt, which is the EPA lifetime Health Advisory Level.
        - Other published toxicity or health effects levels or information.

10. Sample Analysis and Logistics

VDH will utilize a contract laboratory for the PFAS analytical services. The laboratory will ship sample kits, along with sampling instructions, directly to the identified waterworks (sampling sites). VDH, in conjunction with the laboratory, will provide a training video on how to collect the samples. The waterworks staff will collect the samples and return the samples to the laboratory via prepaid shipping labels. The waterworks will not be required to pay for sample analysis or shipping as part of the Sampling Plan.

11. Analytical Method Selection

The laboratory will analyze drinking water samples by EPA Method 533. This method reports the analytes specified in HB586, whereas EPA Method 537.1 does not report all the analytes specified in HB586 because it does not include PFBA. Other related considerations include:

- The laboratory will report the complete list of 25 analytes for Method 533.
- 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 NELAC Accreditation requirements.

The laboratory will analyze source water samples using a method employing solid phase extraction, liquid chromatography/mass spectrometry/mass spectrometry (LC/MS/MS), and isotope dilution that will meet the requirements of Table B-15 of the DoD ELAP QSM. The laboratory must analyze source water samples by another method since EPA Method 537.1 and 533 are applicable only to drinking water. Other related considerations include:

- 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 VDH
- The laboratory will hold accreditation for the DoD PFAS method by LC/MS/MS compliant with QSM 5.3 Table B-15.

12. Collecting Existing PFAS Monitoring Data in Virginia Drinking Water

As part of the Sampling Plan, VDH will request waterworks to optionally share existing PFAS monitoring data. Criteria include:

- Sampled and analyzed in 2018 to date
- EPA Methods 533, 537.1, 537.1, a DoD method, proprietary commercial, proprietary commercial with DOD compliance, etc. Also submit the name of the lab and the reporting levels used.
- Samples at entry points, consecutive connection, or raw water
- Analytical work passes QA/QC

13. Modification of the Sampling Plan

VDH will retain flexibility to make minor modifications and amendments to the Sampling Plan as the agency implements it. Minor modifications could include specifying field reagent blanks for all samples, adding EPA's guidelines for responding to situations where PFAS levels (perfluorooctanoic acid (PFOA) + perfluorooctanesulfonic acid (PFOS)) exceed 70 ppt), and replacing one sampling site with another if a waterworks would decline the request to collect a sample or not be using a source or entry point that is currently identified in the plan. VDH will not make substantive changes to the Sampling Plan without informing the VA PFAS Workgroup.

Because there is very limited data on PFAS occurrence in Virginia, VDH may make adjustments as needed to carry out the Sampling Plan described herein. Adjustment could include changes to the sample locations, waterworks, intakes, sampling method and/or QA/QC samples (if needed). If VDH anticipates the need to make substantive changes to the Sampling Plan, due to factors such as budget, PFAS levels above EPA's Health Advisory Level in one or more locations (indicating a public health risk), or other unforeseen events, VDH will meet with the VA PFAS Workgroup before implementing substantive changes.

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Acronyms

AFFF – Aqueous Fire Fighting Foam
CWS – Community Water System
DEQ – Virginia Department of Environmental Quality
DoD ELAP QSM – Department of Defense Environmental Laboratory Accreditation Program Quality System Manual
VDH – Virginia Department of Health
EP – Entry Point
EP – Entry Point
EPA – U.S. Environmental Protection Agency GIS - Geographic Information System
MRL – Method Reporting Level
NTNC – Nontransient Noncommunity Water System
NELAC – National Environmental Laboratories Accreditation Conference
PFAS – Per- and polyfluoroalkyl substances
PFOA – Perfluorooctanoic acid
PFOS – Perfluorooctane sulfonate
PWS – Public Water System, aka, “waterworks”
SIC – Standard Industrial Classification system
TNC – Transient Noncommunity Water System
UCMR 3 – Unregulated Contaminant Monitoring Rule (3rd Round)

APPENDIX 3 – PFAS Communications Toolkit

Communication Toolkit for VA PFAS Sampling Study

Virginia Department of Health - Office of Drinking Water

Communication Toolkit for VA PFAS Sampling Study

Virginia Department of Health
Office of Drinking Water

In conjunction with the
Virginia PFAS Workgroup

May 2021

Introduction

House Bill (HB) 586 (2020 Acts of Assembly Chapter 0611) seeks to prevent potential adverse health effects and protect public health by studying the occurrence of per- and polyfluoroalkyl substances (PFAS) in drinking water. The legislation requires the State Health Commissioner, who acts through the Virginia Department of Health (VDH), to convene a workgroup to study the occurrence of six specific PFAS (perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), perfluorobutyrate (PFBA), perfluoroheptanoic acid (PFHpA), perfluorohexane sulfonate (PFHxS), perfluorononanoic acid (PFNA)[1]) and other PFAS, as deemed necessary, that may be present in drinking water from waterworks, identify possible sources of such contamination and evaluate approaches to regulating PFAS. The workgroup may recommend maximum contaminant levels (MCLs) for inclusion in regulations of the Board of Health applicable to waterworks. The workgroup will report its findings to the Governor and legislative committees by December 1, 2021. To determine the occurrence of PFAS contamination, the legislation requires VDH to sample no more than 50 representative waterworks and major sources of water.

HB1257 (2020 Acts of Assembly Chapter 1097) directs the Board of Health to adopt regulations establishing MCLs for PFOA and PFOS, as well as other PFAS as it deems necessary. The effective date for HB1257 is January 1, 2022, so that the Board can consider the findings and recommendations that come from the work performed to satisfy the requirements in HB586.

To implement HB586, VDH, through its Office of Drinking Water (ODW), formed the Virginia (VA) PFAS Workgroup. In the October 20, 2020, kickoff meeting for the VA PFAS Workgroup, members accepted and formed four subgroups to focus on (1) PFAS Health and Toxicology, (2) PFAS Occurrence and Monitoring, (3) PFAS Policy and Regulations and (4) PFAS Treatment Technologies. These subgroups meet on a monthly basis and provide summaries of their findings and recommendations to the VA PFAS Workgroup during its quarterly meetings.

The Communication Toolkit for VA PFAS Sampling Study consists of the following sections:

1. Purpose
2. PFAS Sampling Study: Data Review, Verification and Validation
3. PFAS Sampling Results: Guidelines for Publication
4. Drinking Water Assessment, Prevention and Response Toolbox for Waterworks
5. Expectations for Waterworks that Receive Results of PFOA + PFOS >70 ppt
6. Fact Sheets and Letter Templates
7. Additional Resources

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[1] Many PFAS can exist in various ionic states (for example, acids, anions, cations), which has important implications for their chemical and physical properties. House Bill 586 listed some PFAS in their acid form (PFOA - perfluorooctanoic acid) and others in their anionic form (PFOS – perfluorooctane sulfonate). This Toolkit uses the anionic form of a given PFAS name (e.g., PFOA – perfluorooctanoate; PFOS – perfluorooctane sulfonate), as this is the state in which most PFAS exist in the environment. See the List of Common PFAS in Appendix B and https://pfas-1.itrcweb.org/fact_sheets_page/PFAS_Fact_Sheet_Naming_Conventions_April2020.pdf.

1. Purpose

VDH, in collaboration with VA PFAS Workgroup, developed a VA PFAS Sampling Study (Sampling Study) to sample 50 select waterworks and major water sources in Virginia. VDH will conduct the sampling study between April and the end of June, 2021. In planning the sampling study, VA PFAS Workgroup members also felt the need to develop public awareness material on the presence of PFAS in drinking water. This document, the Communication Toolkit for VA PFAS Sampling Study, summarizes the approach VDH will follow to monitor, evaluate and release results and information from the Sampling Study. It also contains fact sheets, guidelines and other resources for waterworks and local health departments to use to interpret results and respond to inquiries about PFAS, testing and health concerns related to PFAS.

As specified in the legislation, the Sampling Study is limited to drinking water produced by waterworks and major water sources used by waterworks. It does not include water from private wells or other sources. “Waterworks” is defined in state law and means a system that serves piped water for human consumption to at least 15 service connections or 25 or more individuals for at least 60 days out of the year. Code of Virginia § 32.1-167.

2. PFAS Sampling Study: Data Review, Verification and Validation

Upon implementing the Sampling Study, VDH, through ODW, will coordinate sample collection from the representative waterworks and major sources of water. As results of analysis arrive from the contract laboratory, ODW will tabulate PFAS data from the Sampling Study and from other existing PFAS monitoring data that waterworks choose to share with VDH. The Monitoring and Occurrence subgroup will also evaluate the data to assess current levels of PFAS (PFOA, PFOS, PFBA, PFHpA, PFHxS, PFNA and other PFAS as deemed necessary) in the Commonwealth’s public drinking water.

ODW staff will review laboratory reports in accordance with the Quality Assurance Project Plan (QAPP) that the U.S. Environmental Protection Agency approved for the Sampling Study. The QAPP guides evaluation of the data to determine if the results are valid and usable. It also discusses strategies to evaluate data not meeting the quality control criteria in a way that does not result in unintended biases that may occur if combined with fully compliant data. The QAPP specifies that the Study Director is responsible for determining whether any data is usable as received, is usable after adding appropriate data qualifiers, or is incapable of meeting the applicable quality control criteria even if data qualifiers were employed.

Data review will begin with comparison of the laboratory reports (received as .pdf files) and Electronic Data Deliverable (EDD) files transmitted to ODW to confirm that both documents reflect equivalent data. In addition, ODW will review:

- Each sample report for data qualifiers indicating a data quality problem;
- The field reagent blanks associated with each water sample to confirm the field reagent blank is clean;
- The recovery of analytes near or at the Method Recovery Limit (MRL) to confirm results are within method limits;
- Chain of custody information in the data and compare it with the contents of the laboratory report to confirm sample location, sample collection time and date, and

evaluate sample hold times for compliance with the method requirements; and
- The case narrative for data qualifiers.

If any review identifies a data quality problem, ODW will initiate an in-depth review of the data for the affected water sample and related samples. In addition, ODW will conduct in-depth review of at least 5% of the water samples for quality assurance purposes.

The in-depth review will confirm that each analysis complied with the method requirements, including sample preservation and holding times, instrument performance checks, initial calibration, quality control samples, continuing calibration checks, field duplicates, blank samples, surrogate analyte recovery, internal standards, target analyte identification and quantification, and performance evaluation samples. Based on the in-depth review, ODW will determine if the reported results meet the method requirements and if the data is usable.

A checklist on the lab quality assurance/quality control (QA/QC) procedures is provided in Appendix A.

All water sample results will undergo data review before becoming public facing or sharing with the VA PFAS Workgroup and/or related subgroups.

3. PFAS Sampling Results: Guidelines for Publication

VDH plans to collect, perform QA/QC review and compile all of the data from the Sampling Study, develop a web-based method for sharing results and, in conjunction with the VA PFAS Workgroup, draft the required report for the legislature and Governor before posting the data on its website. VDH does not intend to post results from individual waterworks on its website upon receipt or immediately following review, verification and validation (as described in Section 2) so that the agency and VA PFAS Workgroup have an opportunity to review the dataset as a whole, assess the extent of PFAS in drinking water, complete the requirements in the legislation and, most importantly, provide appropriate context and resources for parties that are interested in the results and their implications for the Commonwealth.

VDH will provide a technical contact to assist waterworks that participate in the sampling with media inquiries. If VDH receives a request for records (i.e., sampling results) before making the data available to the public, under Virginia's Freedom of Information Act (FOIA), Code of Virginia § 2.2-3700 et seq., VDH is required to provide the records unless they are subject to an exemption. Because VDH does not anticipate that the sampling results will qualify for a recognized exemption, ODW will notify the associated waterworks as soon as practicable (typically within 24 hours) when a FOIA request is received so the waterworks can prepare, if necessary, a specific public comment.

4. Drinking Water Assessment, Prevention and Response Toolbox for Waterworks

This toolbox helps public water systems (waterworks) (a) assess per- and polyfluoroalkyl substances (PFAS) contamination, (b) guide responses to test results when compared to the U.S. Environmental Protection Agency's (EPA) drinking water lifetime health advisory level of 70 parts per trillion (ppt) for the concentration of perfluorooctanoate (PFOA) and perfluorooctane sulfonate (PFOS), individually or combined and (c) evaluate means that, depending on the source of contamination, water source(s) and waterworks capabilities, may prevent or reduce PFAS contamination.

4.1 Proactive tools for assessing and preventing PFAS contamination

- Use the Virginia Department of Health (VDH), Office of Drinking Water (ODW) PFAS website to understand basics and health risks of PFAS
- Assess risk to source water:
    - Proximity to potential sources of PFAS releases to the environment:
        - Industrial facilities that produce, process, or use PFAS chemicals or products in manufacturing or other activities (current or past)
        - Areas where PFAS-containing Class B firefighting foams are stored, used, or released such as airports, military bases and fire stations (current or past)
        - Waste management facilities, such as landfills
        - Wastewater treatment residuals and areas of biosolids production and application (elevated PFAS levels are more likely to be found in residuals and biosolids from wastewater treatment facilities that received wastewater from industrial sources)
    - Source water vulnerability to contamination based on proximity to known, suspected, or potential sources of PFAS contamination such as those listed above
    - If you need source water protection assistance, contact ODW's Division of Technical Services at (804) 864-7500
- Implement measures to reduce risk by:
    - Evaluating potential approaches with stakeholders
    - Raising awareness of PFAS contamination
    - Working with the Virginia Department of Environmental Quality to gain information about facilities with potential PFAS releases and PFAS use/storage/disposal for better understanding and ways to reduce risk
- Sample treated water and at risk sources for PFAS
    - Lab primer to help you find a lab, select a test method and collect a sample

4.2 Recommended response tools – treated water sample results with PFOA+PFOS ≤ 70 ppt

- Notify customers of test results (e.g., monthly bill, mailing, utility website, social media) and include results in the waterworks Consumer Confidence Report (i.e., when reporting 2021 water quality data)
    - Use the VDH letter template (Section 6.1) to help your customers understand that PFOA and PFOS concentrations were at or below the lifetime health advisory, PFAS that are not PFOA and PFOS (e.g., PFBA, PFHpA, PFHxS, PFNA) may have similar health effects and the concentrations associated with those risks are not well known at present, health info is still being developed, including risks for children and pregnant women (more information can be found here), and any next steps you have planned.

- Based on detectable concentrations, evaluate:
    - Risk to source water and implement best management practices (BMPs) (above)
    - Strategies on how to minimize exposure
    - Taking additional source and/or entry point samples
    - Removing any source with levels above the health advisory
- Contact ODW for assistance with activities listed above

4.3 Recommended response tools – treated water sample results with PFOA+PFOS > 70 ppt

- Notify ODW as soon as practicable. If it is after business hours or a weekend, please contact the **Waterworks Emergency After-Hours Call Center at 1-866-531-3068** to establish coordination on public notification, if deemed necessary by ODW and the waterworks, and follow up actions
- Resample to verify levels are above the lifetime health advisory
- Reduce exposure risk by notifying potentially affected customers using the VDH letter template (Section 6.2)
- Identify strategies for decreasing levels in water (e.g., operational, alternate sources, blending)
- Consider additional risk communications and holding a community meeting for potentially impacted residents. Possible resources include:
    - PFAS removal using household water treatment systems at the point-of-use (POU) or point-of-entry (POE)
    - In-home water filtration options
- Identify solutions for waterworks to consistently and reliably reduce PFAS below the lifetime health advisory level (e.g., treatment, removal/remediation of PFAS source)
    - Share in-home treatment options with residents
- Determine options for long term mitigation and treatment
    - Gather data to identify PFAS sources
    - Assess risk to source water and implement BMPs (as listed above)

4.4 Additional information

- EPA list of certified labs
- EPA: information on PFCs
- Agency for Toxic Substances and Disease Registry (ATSDR)
- Under sink treatment systems:
    - The Minnesota Study for point of use systems
    - New York guidance on point of use
- What's in my water: information about PFAS from the American Water Works Association

5. Expectations for Waterworks that Receive Results of PFOA + PFOS >70 ppt

In the event that results come back from a waterworks that indicate the amount of PFOA, PFOS, or PFOA and PFOS combined exceeds 70 parts per trillion (ppt), VDH expects the waterworks to respond in a way that is protective of public health and consistent with the U.S. Environmental Protection Agency's guidance associated with its lifetime health advisory level.

Background

To provide Americans, including the most sensitive populations, with a margin of protection from a lifetime of exposure to perfluorooctanoate (PFOA) and perfluorooctane sulfonate (PFOS) from drinking water, in 2016 EPA established a lifetime health advisory level of 70 parts per trillion (ppt). When both PFOA and PFOS are found in drinking water, the combined concentrations of PFOA and PFOS should be compared with the 70 ppt health advisory level.

Health advisories provide information on contaminants that can cause human health effects and are known or anticipated to occur in drinking water. EPA's health advisories are non-enforceable and non-regulatory and provide technical information to state agencies and other public health officials on health effects, analytical methodologies and treatment technologies associated with drinking water contamination. EPA's lifetime health advisory level for PFOA and PFOS offers a margin of protection for all Americans throughout their life from adverse health effects resulting from exposure to PFOA and PFOS in drinking water.

Virginia does not have a regulatory standard at this time. VDH will follow EPA's recommended actions for waterworks that receive results of PFOA and PFOS that exceed the lifetime health advisory level.

Assess Contamination

Waterworks are expected to conduct confirmation sampling. If results from implementation of the Sampling Plan indicate that drinking water (samples collected at the entry point to the distribution system) contains PFOA and PFOS at individual or combined concentrations greater than 70 ppt, VDH expects the waterworks to undertake additional sampling within two weeks of learning of the result to assess the level, scope and localized source of contamination to inform next steps.

Waterworks should promptly notify and perform confirmation sampling in coordination with the Department of Health (monitoring drinking water quality) and Department of Environmental Quality (identifying the source of contamination).

Inform Consumers

If the average of the initial result and the confirmation sample is greater than EPA's lifetime health advisory level, confirming that drinking water contains PFOA and PFOS at individual or combined concentrations greater than 70 parts per trillion, waterworks should also promptly provide consumers with information about the levels of PFOA and PFOS in their drinking water. This notice should include specific information on the risks to fetuses during pregnancy and breastfed and formula-fed infants from exposure to drinking water with an individual or combined concentration of PFOA and PFOS above EPA's lifetime health advisory level of 70 ppt. In addition, it should identify options that consumers may consider to reduce risk such as seeking an alternative drinking water source, or in the case of parents of formula-fed infants, using formula that does not require adding water.

Conduct Enhanced Monitoring

Following confirmation that PFOA and/or PFOS levels exceed the 70 ppt lifetime health advisory, waterworks should begin a program of monthly monitoring that continues until results are reliably and consistently below 70 ppt. “Reliably and consistently” means that though a waterworks detects contaminants in its water supply, it has sufficient knowledge of the source or extent of the contamination to predict that the lifetime health advisory level would not be exceeded in the future (i.e., wide variations in analytical results or an analytical result which is close to the lifetime health advisory are examples of situations where waterworks would not be reliably and consistently below the lifetime health advisory).

Evaluate and Take Steps to Limit Exposure

Depending on the source of contamination, water source(s) and waterworks capabilities, several options may be available to waterworks to lower concentrations of PFOA and PFOS in the drinking water supply. In some cases, waterworks may be able to reduce concentrations of perfluoroalkyl substances, including PFOA and PFOS, for example, by closing contaminated wells or changing the rates of blending of water sources, where the available quantity of drinking water is not compromised. Alternatively, waterworks can treat source water with activated carbon or high pressure membrane systems (e.g., reverse osmosis) to remove PFOA and PFOS from drinking water. These treatment systems are used by some waterworks today, but should be carefully designed and maintained to ensure that they are effective for treating PFOA and PFOS. In some communities, entities have provided bottled water to consumers while steps to reduce or remove PFOA or PFOS from drinking water or to establish a new water supply are completed.

Many home drinking water treatment units are certified by independent accredited third party organizations against American National Standards Institute (ANSI) standards to verify their contaminant removal claims. NSF International (NSF®) has developed a protocol for NSF/ANSI Standards 53 and 58 that establishes minimum requirements for materials, design and construction, and performance of point-of-use (POU) activated carbon drinking water treatment systems and reverse osmosis systems that are designed to reduce PFOA and PFOS in public water supplies. The protocol has been established to certify systems (e.g., home treatment systems) that meet the minimum requirements. The systems are evaluated for contaminant reduction by challenging them with an influent of 1.5±30% µg/L (total of both PFOA and PFOS) and must reduce this concentration by more than 95% to 0.07 µg/L or less (total of both PFOA and PFOS) throughout the manufacturer’s stated life of the treatment system. Product certification to this protocol for testing home treatment systems verifies that devices effectively reduces PFOA and PFOS to acceptable levels.

6. Fact Sheets and Letter Templates

Fact sheet 1 and 2 are presented in Appendix B and C respectively. These are intended for waterworks and local health departments to use to respond to inquiries from the media and/or consumers about PFAS, the Sampling Study and/or health risks associated with PFAS. Fact sheet 1 (Appendix B) contains more general information. Fact sheet 2 (Appendix C) contains more information about health effects. Select the appropriate fact sheet based on the nature of the inquiry and intended audience.

6.1 Letter Template for a Common Message (For PFAS concentration below 70 ppt):

The template is available for waterworks/localities to use to provide general information to consumers and/or the media in response to an inquiry (media or FOIA) about the sample result/results that came from the PFAS Sampling Study that are specific to the waterworks. If the sum of PFOA + PFOS exceeds the health advisory level, the waterworks should follow the guidelines in Section 5.

Thank you for inquiring about the results of the sampling for per- and polyfluoroalkyl substances (PFAS) in the drinking water at **LOCATION/WATERWORKS NAME**.

House Bill 586 (2020) initiated a study of PFAS from no more than 50 waterworks and/or water sources in Virginia. The Virginia Department of Health (VDH), through its Office of Drinking Water, and a work group with representatives from waterworks, advocacy groups and citizens, selected the waterworks and water sources to generate data that VDH could use to begin the process of establishing appropriate regulatory requirements for PFAS in drinking water. The goal of the study is to (1) protect public health and (2) begin to understand the extent and nature of PFAS contamination in drinking water to minimize risk. VDH is working closely with waterworks throughout the Commonwealth, including **WATERWORKS NAME,** to ensure water is safe, complies with all State and Federal drinking water standards and meets other recommended advisory levels for specified contaminants.

In [*month*], **WATERWORKS NAME** collected [*a sample / # samples*] of water and submitted [*it / them*] to a VDH-contracted laboratory. The laboratory used an analytical method approved by the U.S. Environmental Protection Agency (EPA) to analyze the sample[*s*] for the presence of 25 individual PFAS. Following analysis, the laboratory provided the results to VDH and **WATERWORKS NAME** for review. A copy of the results is attached.

EPA has not set a regulatory limit for any PFAS in drinking water. However, EPA has established a lifetime health advisory level of 70 parts per trillion (ppt) for two specific PFAS, perfluorooctanoate (PFOA) and perfluorooctane sulfonate (PFOS). The concentration of PFOA and PFOS found at **WATERWORKS NAME** during this study was **XXX** ppt, which is below the lifetime health advisory level. There is no immediate adverse health concern due to the presence of PFAS at the observed concentrations. [*The **XXXXX** City / County Government, along with*] **WATERWORKS NAME** and VDH continue to stress the importance of source water protection and our collaborative role in keeping drinking water supplies safe.

VDH is continuing to evaluate this issue to determine whether and how PFAS should be regulated in Virginia. Additionally, the Virginia Department of Environmental Quality (DEQ) is assessing potential environmental sources of PFAS in Virginia. Updates on the VDH and DEQ efforts can be found at the following websites:

https://www.vdh.virginia.gov/drinking-water/pfas/
https://www.deq.virginia.gov/get-involved/the-environment-you/per-and-polyfluoroalkyl-substances-pfas

Please feel free to contact me if you have any other questions.

Sincerely,

6.2 Letter Template for a Common Message (For PFAS concentration above 70 ppt):

The template is available for waterworks/localities to use to provide general information to consumers and/or the media in response to an inquiry (media or FOIA) about the sample result/results that came from the PFAS Sampling Study that are specific to the waterworks.

Thank you for inquiring about the results of the sampling for per- and polyfluoroalkyl substances (PFAS) in the drinking water at **LOCATION/WATERWORKS NAME**.

House Bill 586 (2020) initiated a study of PFAS from no more than 50 waterworks and/or water sources in Virginia. The Virginia Department of Health (VDH), through its Office of Drinking Water, and a work group with representatives from waterworks, advocacy groups and citizens, selected the waterworks and water sources to generate data that VDH could use to begin the process of establishing appropriate regulatory requirements for PFAS in drinking water. The goal of the study is to (1) protect public health and (2) begin to understand the extent and nature of PFAS contamination in drinking water to minimize risk. VDH is working closely with waterworks throughout the Commonwealth, including **WATERWORKS NAME,** to ensure water is safe, complies with all State and Federal drinking water standards and meets other recommended advisory levels for specified contaminants.

In [*month*], **WATERWORKS NAME** collected [*a sample / # samples*] of water and submitted [*it / them*] to a VDH-contracted laboratory. The laboratory used an analytical method approved by the U.S. Environmental Protection Agency (EPA) to analyze the sample[*s*] for the presence of 25 individual PFAS. Following analysis, the laboratory provided the results to VDH and **WATERWORKS NAME** for review. A copy of the results is attached.

EPA has not set a regulatory limit for any PFAS in drinking water. However, EPA has established a lifetime health advisory level of 70 parts per trillion (ppt) for two specific PFAS, perfluorooctanoate (PFOA) and perfluorooctane sulfonate (PFOS). The sum concentration of PFOA and PFOS found at **WATERWORKS NAME** during this study was **XXX** ppt, which is above EPA's 70 ppt lifetime health advisory level. Follow-up sampling confirmed the result.

Although EPA's health advisory level for PFOA and PFOS is not an enforceable regulatory standard, it offers a margin of protection for all Americans from adverse health effects resulting from a lifetime's exposure to PFOA and PFOS in drinking water. Out of an abundance of caution, **WATERWORKS NAME** has voluntarily decided to use EPA's lifetime health advisory as a basis for taking action to address the presence of PFOA and PFOS in the drinking water it provides. The initial actions **WATERWORKS NAME** will take, in coordination with [***XXXXX** City / County Government and*] VDH, include the following:

[*OPTIONS A WATERWORKS MAY TAKE IN RESPONSE TO PFOA/PFOS > 70 PPT - MODIFY LIST AS NEEDED TO REFECT ACTUAL CONDITIONS/SITUATION*]

- Collecting additional samples within two weeks of learning of the result to assess the level, scope and nature of contamination to inform next steps;
- Working with the Virginia Department of Environmental Quality to identify the source of contamination;
- Evaluating ways to reduce the level of PFOA and PFOS in drinking water we provide to consumers;
- Promptly providing consumers with information from VDH and EPA about the known health risks associated with PFOA and PFOS in their drinking water, including specific information on the risks to fetuses during pregnancy and breastfed and formula-fed infants from exposure to drinking water with an individual or combined concentration of PFOA and PFOS above EPA's lifetime health advisory level of 70 ppt (see https://www.epa.gov/pfas); and
- Conducting additional testing to monitor PFOA and PFOS levels in drinking water that will consider the current state of knowledge about risk and health effects.

Based on the results of VDH's PFAS study, EPA's lifetime health advisory and the development of any regulatory limits for PFOA, PFOS, or other PFAS, the **WATERWORKS NAME** response to this situation is likely to evolve over time.

[*Consumers / As a consumer, you*] may want to consider using an alternative water source that is free of PFAS for any activity in which [*they / you*] might ingest water. These activities include drinking, food preparation, brushing teeth and preparing infant formula. [*They / You*] might also consider an in-home filtration system. [*WATERWORKS MAY ADD A STATEMENT HERE ADDRESSING THE COST OF IN-HOME TREATMENT, IF IT WILL BE THE CONSUMER'S RESPONSIBILITY TO INSTALL/MAINTAIN OR IF THE WATERWORKS WILL PROVIDE FULL OR PARTIAL SUPPORT (AND FOR HOW LONG).*] Granular activated carbon filters or reverse osmosis water treatment devices are technologies that are capable of reducing the level of PFAS in drinking water. If a treatment is used, it is important to follow the manufacturer's guidelines for maintenance and operation. NSF International, an independent and accredited organization, certifies products proven effective for reducing PFOA and PFOS below the EPA lifetime health advisory level of 70 ppt, but they may not remove other types of PFAS. (http://info.nsf.org/Certified/DWTU/)

VDH is continuing to evaluate this issue to determine whether and how PFAS should be regulated in Virginia. Additionally, the Virginia Department of Environmental Quality (DEQ) is assessing potential environmental sources of PFAS in Virginia. Updates on the VDH and DEQ efforts can be found at the following websites:

https://www.vdh.virginia.gov/drinking-water/pfas/
https://www.deq.virginia.gov/get-involved/the-environment-you/per-and-polyfluoroalkyl-substances-pfas

Please feel free to contact me if you have any other questions.

Sincerely,

7. Additional Resources:

Technical Support

1. The VDH Local Health Districts can assist with local inquiries on PFAS and associated health risks. LHDs locations can be found at https://www.vdh.virginia.gov/health-department-locator/
2. The VDH Office of Drinking Water Regional Field Offices can assist with technical and engineering assistance. More information on the ODW's regional field offices is available at https://www.vdh.virginia.gov/content/uploads/sites/14/2020/04/ODW_Website_Map.pdf
3. PFAS resources for states are available at https://www.epa.gov/research-states/pfas-resources-states

Funding for Treating PFAS in Drinking Water

1. Waterworks interested in installing new treatment technologies can apply to use funding available through ODW's Drinking Water State Revolving Fund (DWSRF) program. More information on this can be found at https://www.vdh.virginia.gov/drinking-water/drinking-water-state-revolving-fund-program/

General Information on PFAS

1. EPA's PFAS webpage: https://www.epa.gov/pfas
2. Interstate Technology Regulatory Council (ITRC) PFAS webpage: https://pfas-1.itrcweb.org
3. ATSDR PFAS webpage: https://www.atsdr.cdc.gov/pfas/index.html

Other State Resources

1. The Association of State Drinking Water Administrators (ASDWA) provides a good overview of states' efforts on PFAs in drinking water: https://www.asdwa.org/pfas/
2. The Environment Council of States (ECOS) webpage with PFAS information: https://www.ecos.org/pfas/
3. Michigan: https://www.environmentalcouncil.org/pfas_in_michigan

Appendix - A

Table 1. Initial Demonstration of Capability (IDC) Quality Control Requirements*

Method Reference	Requirement	Specification and Frequency	Acceptance Criteria
Section 10.2.2	Establish retention times for branched isomers	Each time chromatographic conditions change	All isomers of each analyte must elute within the same MRM window.
Section 9.1.1	Demonstration of low system background	Analyze a Laboratory Reagent Blank (LRB) after the highest standard in the calibration range.	Demonstrate that the method analytes are less than one-third of the Minimum Reporting Level (MRL).
Section 9.1.2	Demonstration of precision	Extract and analyze 7 replicate Laboratory Fortified Blanks (LFBs) near the mid-range concentration.	Percent relative standard deviation must be ≤20%.
Section 9.1.3	Demonstration of accuracy	Calculate mean recovery for replicates used in Section 9.1.2.	Mean recovery within 70–130% of the true value.
Section 9.1.4	MRL confirmation	Fortify and analyze 7 replicate LFBs at the proposed MRL concentration. Confirm that the Upper Prediction Interval of Results (PIR) and Lower PIR meet the recovery criteria.	Upper PIR ≤150% Lower PIR ≥50%
Section 9.1.5	Calibration Verification	Analyze mid-level QCS.	Results must be within 70–130% of the true value.

Table 2. Ongoing Quality Control Requirements*

Method Reference	Requirement	Specification and Frequency	Acceptance Criteria
Section 10.3	Initial calibration	Use the isotope dilution calibration technique to generate a linear or quadratic calibration curve. Use at least 5 standard concentrations. Evaluate the calibration curve as described in Section 10.3.5.	When each calibration standard is calculated as an unknown using the calibration curve, analytes fortified at or below the MRL should be within 50–150% of the true value. Analytes fortified at all other levels should be within 70–130% of the true value.
Section 9.2.1	Laboratory Reagent Blank (LRB)	Include one LRB with each Extraction Batch. Analyze one LRB with each Analysis Batch.	Demonstrate that all method analytes are below one-third the Minimum Reporting Level (MRL) and that possible interference from reagents and glassware do not prevent identification and quantitation of method analytes.
Section 9.2.3	Laboratory Fortified Blank	Include one LFB with each Extraction Batch.	For analytes fortified at concentrations ≤2 x the MRL, the result must be within 50–150% of the true value; 70– 130% of the true value if fortified at concentrations greater than 2 x the MRL.
Section 10.4	Continuing Calibration Check (CCC)	Verify initial calibration by analyzing a low-level CCC (concentrations at or below the MRL for each analyte) at the beginning of each Analysis Batch. Subsequent CCCs are required after every tenth field sample and to complete the batch.	The lowest level CCC must be within 50–150% of the true value. All other levels must be within 70–130% of the true value.

Method Reference	**Requirement**	**Specification and Frequency**	**Acceptance Criteria**
Section 9.2.4	Isotope performance standards	Isotope performance standards are added to all standards and sample extracts.	Peak area counts for each isotope performance standard must be within 50–150% of the average peak area in the initial calibration.
Section 9.2.5	Isotope dilution analogues	Isotope dilution analogues are added to all samples prior to extraction.	50%–200% recovery for each analogue
Section 9.2.6	Laboratory Fortified Sample Matrix (LFSM)	Include one LFSM per Extraction Batch. Fortify the LFSM with method analytes at a concentration close to but greater than the native concentrations (if known).	For analytes fortified at concentrations ≤2 x the MRL, the result must be within 50–150% of the true value; 70– 130% of the true value if fortified at concentrations greater than 2 x the MRL.
Section 9.2.7	Laboratory Fortified Sample Matrix Duplicate (LFSMD) or Field Duplicate (FD)	Include at least one LFSMD or FD with each Extraction Batch.	For LFSMDs or FDs, relative percent differences must be ≤30% (≤50% if analyte concentration ≤2 x the MRL).
Section 9.2.8	Field Reagent Blank (FRB)	Analyze the FRB if any analyte is detected in the associated field samples.	If an analyte detected in the field sample is present in the associated FRB at greater than one-third the MRL, the results for that analyte are invalid.
Section 9.2.9	Calibration Verification using QCS	Perform a Calibration Verification at least quarterly.	Results must be within 70–130% of the true value.

*Source: USEPA Method 533 publication

APPENDIX B
FACT SHEET FOR CONSUMERS

Virginia Department of Health Office of Drinking Water

Per- and Polyfluoroalkyl Substances (PFAS) Fact Sheet

May 2021

What are Per- and Polyfluoroalkyl Substances (PFAS)?

Per- and polyfluoroalkyl substances (PFAS) are a large family of man-made chemicals that have been used worldwide, including the United States, in consumer products, industrial applications and in firefighting since the 1940s. There are between 6,000 and 10,000 different chemical compounds in the PFAS family and they are used to make products that resist heat, oil, stains, grease and water. Perfluorooctanoate (PFOA) and perfluorooctane sulfonate (PFOS) were the two most commonly produced PFAS historically and are currently the most studied chemicals in the PFAS family. PFOA and PFOS are no longer manufactured in the United States, but other types of PFAS have been developed to take their place. In general, chemicals in the PFAS family:

- are stable and many do not break down easily in the environment (they are persistent);
- do not occur naturally, yet are widespread in the environment because of their broad uses;
- may be found in people, wildlife and fish world-wide; and
- can build up in biological tissues over time (people, wildlife, fish) if exposure continues (they bioaccumulate).

Are PFAS harmful and how can PFAS affect people's health?

Human health effects from PFAS exposure are not completely understood because all of the individual chemicals in the PFAS family have not been examined to determine the health effects. Studies have shown that exposure to some PFAS may affect developmental stages (growth, learning, behavior) of infants and older children; lower a woman's chance of pregnancy; disrupt the body's hormones; increase cholesterol; and increase cancer risk. Some scientific studies suggest that certain PFAS may affect different systems in the body. However, although these same scientific studies have shown, for example, PFAS to be associated with increased cholesterol levels in humans, the studies have not, at this time, shown an association between the presence of these compounds and any increased risk of heart disease. Scientists are working to better understand how exposure to PFAS might affect people's health – especially how exposure to PFAS in water, food and other exposure pathways may be harmful. At this time, scientists are still learning about the health effects of exposures to mixtures of PFAS and need more time to study health effects of many distinct PFAS.

How can I be exposed to PFAS?

Because PFAS are man-made, they can be found near areas where they are (or were) manufactured; in some industrial applications, such as electroplating, textiles, pulp and paper; and/or in some manufactured products. Since PFOA and PFOS are no longer manufactured in the U.S., other types of PFAS have replaced PFOA and PFOS in some products. Many common consumer and industrial products still contain PFAS, including some:

- nonstick cookware
- food packaging (microwave popcorn bags, fast food wrappers, sliced cheese wrappers, pizza boxes)
- stain-resistant carpets, fabrics and water-resistant clothing
- paints, varnishes and sealants
- cosmetics, toothpaste and dental floss
- fire-fighting foams

Ingestion (swallowing) of food or water containing PFAS is the exposure route of primary concern. PFAS exposure by contact with PFAS-containing compounds through dermal absorption (touching and passing through the skin) and inhalation during showering/bathing are lesser human health concerns at this time.

How do PFAS get into drinking water?

A drinking water source may be contaminated by PFAS from a specific source such as a PFAS manufacturer, industrial user of PFAS, air emissions containing PFAS, wastewater discharges containing PFAS, landfill leachate containing PFAS and/or airports and firefighter training facilities that used firefighting foam containing PFAS. It is also possible for a drinking water source to become contaminated with PFAS due to precipitation, because of the presence of PFAS in the environment.

What is a Lifetime Health Advisory and what Lifetime Health Advisories have been established for PFAS?

A Lifetime Health Advisory (LHA) is just that, an advisory. It is not a primary drinking water standard (also called a Maximum Contaminant Level, or MCL) which is an enforceable regulatory standard under the Safe Drinking Water Act. The U.S. Environmental Protection Agency (EPA) has established a LHA for two types of PFAS, PFOA and PFOS, at 70 parts per trillion, individually or combined. The LHA is not a level that guarantees there will be no risk of harm from PFAS if a person stays below that level for their entire lives, nor is it a level that guarantees an increased risk of harm from PFAS if that level is exceeded. Current scientific data indicates that an LHA will be protective of most typical water users, including pregnant and nursing women, young children and the elderly. The LHA is based on long-term exposure, on the order of 70 years.

For perspective, one part per trillion is the equivalent of four grains of sugar in an Olympic sized swimming pool, or the equivalent of one second in 32,000 years. EPA has not established a short-term health advisory or a MCL for PFOA, PFOS, or other PFAS.

What is EPA doing about PFAS?

Through EPA's PFAS Action Plan, the Agency has made a final determination to regulate PFOA and PFOS and is moving forward with developing and implementing enforceable drinking water standards (MCLs) for these (and possibly other) PFAS. EPA also proposed preliminary groundwater remediation goals for PFOA and PFOS at 70 ppt (individually or combined) in areas where groundwater may be used for drinking water. EPA is also implementing a national sampling program between 2023 and 2025, called the Unregulated Contaminant Monitoring Rule 5, that will have waterworks collect and analyze samples to determine if 29 specified PFAS are present in drinking water and, if so, in what concentrations.

What is the Virginia Department of Health (VDH) doing about PFAS?

From 2013 to 2015, as part of EPA's national sampling program, Unregulated Contaminant Monitoring Rule 3, Virginia waterworks conducted testing for six (6) PFAS, including PFOA and PFOS, at all waterworks that served more than 10,000 persons and at some smaller waterworks randomly selected by EPA.

- Of 498 samples collected and analyzed, two (2) samples from two (2) waterworks returned detections of PFAS: one with perfluoroheptanoic acid (PFHpA) at 12 ppt; the other with PFOA at 22 ppt. None of the samples exceeded EPA's LHA of 70 ppt for PFOA and/or PFOS.
- Both waterworks collected follow-up samples, but neither detected PFAS in those samples.
- Advances in analytical capabilities are now able to detect lower levels of PFAS and more specific compounds within the broader family of PFAS.

While awaiting national guidance from EPA regarding MCLs or other enforceable regulatory limits for PFAS, Virginia has developed a multi-faceted strategy to begin to assess and address PFAS in drinking water. As part of this strategy, VDH has:

1. Convened a Virginia PFAS Workgroup with stakeholders from waterworks (small, medium and large), non-governmental environmental organizations, consumer advocacy groups, chemical manufacturers and other subject matter experts.
2. Planned a PFAS sampling study of 50 waterworks and major sources of drinking water that began in the second quarter of 2021 and includes:
   - The 17 largest community waterworks (by population served) which collectively serve over 50% of the State's residents;
   - Waterworks that use groundwater as their source and have well(s) less than a mile from a potential source of PFAS; and
   - Waterworks not among the 17 largest waterworks that have a surface water intake located in an area with higher vulnerability to potential PFAS sources.
3. With the drinking water study underway, VDH is actively working with stakeholder groups and the Virginia Department of Environmental Quality on studying and regulating PFAS, including recommendations for establishing enforceable regulatory limits for PFOA, PFOS and other chemicals and, if needed, what those limits should be.

How can I reduce my exposure to PFAS?

Because PFAS are present in so many consumer products and throughout our environment, one cannot reasonably expect to prevent PFAS exposure altogether. However, in addition to exercising consumer choices to minimize exposure, some steps can be taken to reduce exposure to PFAS in drinking water:

- Contact your drinking water provider to ask for information about PFAS levels in your drinking water.
- If your drinking water contains levels of PFOA or PFOS greater than the EPA LHA of 70 ppt, either individually or combined, consider using an alternative water source for any activity in which you might swallow water. These activities include drinking, food preparation, brushing teeth and preparing infant formula.
- Water with a PFOA and/or PFOS level greater than the LHA is understood to be safe for bathing, showering or washing clothes and cleaning.
- NSF approved activated carbon filtration or reverse osmosis membranes are effective in reducing PFOA and PFOS in water supplies (if the manufacturer's recommended usage instructions are followed).
- Read consumer product labels. If they include information about PFAS in the products, avoid using those with PFAS. Note that not all products have this information.

How can I learn more about PFAS?

U.S. Environmental Protection Agency	
- Basic Information about PFAS	https://www.epa.gov/pfas
- Drinking Water PFOA and PFOS Lifetime Health Advisory	https://www.epa.gov/ground-water-and-drinking-water/drinking-water-health-advisories-pfoa-and-pfos
- Technical Fact Sheet – PFOS and PFOA	https://www.epa.gov/sites/production/files/2017-12/documents/ffrrofactsheet_contaminants_pfos_pfoa_11-20-17_508_0.pdf
VDH Office of Drinking Water	https://www.vdh.virginia.gov/drinking-water/pfas
VA Dept. of Environmental Quality	https://www.deq.virginia.gov/get-involved/the-environment-you/per-and-polyfluoroalkyl-substances-pfas
U.S. Agency for Toxic Substances and Disease Registry	https://www.atsdr.cdc.gov/pfas/
CDC ATSDR PFAS page	https://www.cdc.gov/exposurereport/index.html

Food and Drug Administration	https://www.fda.gov/food/newsevents/constituentupdates/ucm479465.htm
National Toxicology Program	https://ntp.niehs.nih.gov/pubhealth/hat/noms/pfoa/index.html
Interstate Technology Regulatory Council (IRTC)	https://pfas-1.itrcweb.org/

List of Common PFAS and their Abbreviations

Abbreviation	Chemical Name (acid and anionic (salt) versions)
PFOS	Perfluorooctane sulfonic acid / Perfluorooctane sulfonate
PFOA (or C8)	Perfluorooctanoic acid / Perfluorooctanoate
PFNA	Perfluorononanoic acid / Perfluorononanoate
PFDA	Perfluorodecanoic acid / Perfluorononanoate
PFOSA (or FOSA)	Perfluorooctane sulfonamide
PFHxS	Perfluorohexane sulfonic acid / Perfluorohexane sulfonate
PFHpA	Perfluoroheptanoic acid / Perfluoroheptanoate
PFBA	Perfluorobutanoic acid

Virginia Department of Health Contacts

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APPENDIX C
ALTERNATIVE FACT SHEET FOR CONSUMERS

VDH Drinking Water Facts: May 2021

General Information re Per- and Polyfluoroalkyl Substances (PFAS) in Drinking Water

• Per- and polyfluoroalkyl substances (PFAS) are a family of chemicals with many commercial and industrial uses.
• Certain PFAS have been associated with a variety of adverse health effects in humans, but it has not been definitively established that PFAS cause these effects.
• Six states, including Michigan, Massachusetts and New Jersey, have established drinking water regulations for specific compounds within the PFAS family, including PFOA (perfluorooctanoate), PFOS (perfluorooctane sulfonate) and PFNA (perfluorononanoate). Virginia, through the State Board of Health and Virginia Department of Health (VDH), is conducting research through occurrence monitoring to determine levels of PFAS contamination in drinking water and major water sources. VDH formed a stakeholder workgroup to help assess the data and recommend whether and how to establish regulations for PFOA and PFOS in drinking water in Virginia, as directed by legislation that passed during the 2020 General Assembly Session.

What are PFAS?
Per- and polyfluoroalkyl substances (PFAS) are a complex family of manmade fluorinated organic chemicals which have been produced since the mid-20th century. It has been estimated that the PFAS family may include approximately 6,000 to 10,000 chemicals, with a recent inventory identifying more than 4,700 PFAS that could have been, or may be, on the global market. The unique physical and chemical properties of PFAS impart oil and water repellency, temperature resistance and friction reduction to a wide range of products used by consumers and industry. For example, PFAS, have been used in coatings for textiles, paper products and cookware, and to formulate some firefighting foams. They have a range of applications in the aerospace, photographic imaging, semiconductor, automotive, construction, electronics and aviation industries.

How can I be exposed to PFAS?
While consumer products and food (via packaging) are a common source of exposure to these chemicals for most people, drinking water can be an additional source of exposure in communities where these chemicals have contaminated water supplies. Such contamination is typically localized and associated with a specific facility, for example, an airfield at which these chemicals were used for firefighting or a facility where they were produced or used. PFAS can enter drinking water through industrial release to water, air, or soil; discharges from sewage treatment plants; land application of contaminated sludge; and use of fire-fighting foam. Recent scientific investigations have indicated that PFAS present in the atmosphere can also lead to PFAS contamination in precipitation.

Are PFAS harmful and how can PFAS affect people's health?
Research and information on the health effects of PFAS in humans and animals is continually becoming available. In animal testing, some PFAS have been found to cause developmental, immune, neurobehavioral, liver, endocrine and metabolic toxicity, generally at levels well above known human exposures. Some studies of the general population, communities with drinking water exposures to certain PFAS, and exposed workers suggest that PFAS increase the risk of a number of health effects. The most consistent human health effect findings for PFOA (perfluorooctanoate) – the most well-studied of the PFAS – include increases in serum cholesterol, some liver enzymes and uric acid levels. For PFOS (perfluorooctane sulfonate), another well-studied PFAS, the most consistently found human health effects include increased serum cholesterol and uric acid levels. PFOA and PFOS have also been associated with decreased antibody response following vaccination.

How can PFAS affect children?
In animal testing, some PFAS cause developmental effects. In humans, exposure to PFAS at elevated levels before birth or in early childhood may result in decreased birth weight, decreased immune responses and hormonal effects later in life. More research is needed to understand the role of PFAS in developmental effects.

Infants and children consume more water per body weight than older individuals, so their exposures may be higher than adults in communities with elevated levels of PFAS in drinking water. They may also be more sensitive to the effects of PFAS.

When PFAS are elevated in a drinking water supply, it is advisable to use alternative water sources to prepare infant formula for bottle-fed babies. Beverages for infants and children, such as juice made from concentrate, should also be prepared with water from alternate sources. PFAS have also been discovered in breast milk in some cases. Based on the scientific understanding at this time, since the benefits of breast-feeding are well-established, infants should continue to be breast-fed.

What is a Lifetime Health Advisory (LHA)? Are there LHAs for PFAS?
In 2016, the U.S. Environmental Protection Agency (EPA) issued Lifetime Health Advisories (LHA) for PFOA and PFOS in drinking water at 70 parts per trillion (ppt), individually or combined. A LHA is non-

enforceable guidance that identifies the concentration of a contaminant in drinking water at which EPA has concluded adverse health effects are not anticipated to occur during a person's lifetime. EPA began a process to establish enforceable regulatory limits for PFOA and PFOS in drinking water in 2021.

Some states have begun to establish their own limits for specific PFAS. For example, in 2018, New Jersey became the first state to establish a drinking water standard for a PFAS chemical when it set a Maximum Contaminant Level (MCL) for PFNA (perfluorononanoate) at 13 ppt. The New Jersey Department of Environmental Protection has also established enforceable MCLs for PFOA (14 ppt) and PFOS (13 ppt).

What is being done to address PFAS in drinking water in Virginia?

During the 2020 General Assembly Session, the Legislature passed and Governor Northam signed House Bill 586 (2020 Acts of Assembly Chapter 0611), making it effective on July 1, 2020. The legislation requires the State Health Commissioner to convene a workgroup to study the occurrence of PFAS in drinking water in Virginia. The workgroup is responsible for (1) determining current levels of PFAS in the Commonwealth's public drinking water based on samples from no more than 50 representative waterworks and major sources of water; (2) identifying possible sources of PFAS; (3) evaluating existing approaches to regulating PFAS in drinking water, including regulatory approaches adopted by other states and the federal government; and (4) at its discretion, developing recommendations for specific regulatory limits for PFAS, which the Board of Health may decide to incorporate in the Waterworks Regulations through the rulemaking process outlined in Virginia's Administrative Process Act.

In October 2020, the Virginia Department of Health (VDH) convened a Virginia PFAS Workgroup comprising of representatives from waterworks, advocacy groups, chemical manufacturers, non-governmental environmental organizations, subject matter experts and the general public. More details on this can be found at www.vdh.virginia.gov/drinking-water/pfas.

VDH, through the Office of Drinking Water (ODW) and the Virginia PFAS Workgroup, developed a plan to sample drinking water and major sources of water in Virginia. The PFAS Sampling & Monitoring Study in Virginia Drinking Water (Sampling Plan), identifies 50 waterworks and major sources of water for sampling based on factors including the population served, proximity to potential sources of PFAS contamination and geographic location. Implementation of the Sampling Plan enables VDH to begin to assess the scope of PFAS contamination in drinking water in the Commonwealth, subject to the limitations set by the General Assembly in the legislation.

VDH, in conjunction with the Virginia PFAS Workgroup, will compile and review the results from around the Commonwealth, ensuring they meet appropriate quality assurance/quality control guidelines. VDH and the Virginia PFAS Workgroup will use the results and other research required by the legislation to complete and submit a report to the Governor and General Assembly about the presence of PFAS in drinking water in Virginia by December 1, 2021.

A second bill, House Bill 1257 (2020 Acts of Assembly Chapter 1097) directs the Board of Health to adopt regulations establishing MCLs for PFOA and PFOS, as well as any other PFAS it deems necessary. The effective date for HB1257 is January 1, 2022, so that the Board can consider the findings and recommendations that come from the work performed to satisfy the requirements in House Bill 586.

How do I know if I have PFAS in my drinking water?

Large public waterworks in Virginia and the rest of the country, along with a subset of smaller waterworks, were required to test for some PFAS from 2013 to 2015 as part of the EPA Third Unregulated Contaminant Monitoring Rule implementation (UCMR3). In Virginia, two waterworks detected PFAS during UCMR3, but neither found concentrations above the reporting level and PFAS was not detected during follow-up sampling. In 2019, Congress passed a law requiring at least 29 PFAS to be included in the Fifth Unregulated

Contaminant Monitoring Rule implementation (UCMR5). UCMR5 sampling is scheduled to take place between 2023 and 2025.

VDH recently completed testing at 50 waterworks and major sources of water supply using an analysis method that detects 25 different types of PFAS in lower concentrations than UCMR3. These results will be available to the public on VDH's website. Additionally, this information can be obtained directly from the waterworks that serves your area if they participated in the study. If you use water from a private well, the only way to know whether it has PFAS is to have it tested. To find a laboratory certified to test, you can contact the Virginia Division of Consolidated Laboratory Services at (804) 648-4480 or at https://dgs.virginia.gov/division-of-consolidated-laboratory-services/certification-accreditation/find-a-lab/

What should I do if I am concerned about PFAS in my drinking water?
PFAS are not removed from water by boiling. If tap or well water is found to contain PFAS, people may choose to use home water filters or other alternate water sources for drinking and cooking to reduce exposure to PFAS. However, PFAS has been detected in some brands of bottled water and use of home filtering technologies does not guarantee that all PFAS will be removed from filtered water.

Granular activated carbon filters or reverse osmosis water treatment devices are technologies that are capable of reducing the level of PFAS in drinking water. If a treatment is used, it is important to follow the manufacturer's guidelines for maintenance and operation. NSF International, an independent and accredited organization, certifies products proven effective for reducing PFOA and PFOS below the EPA LHA of 70 ppt, but they may not remove other types of PFAS. (http://info.nsf.org/Certified/DWTU/).

What can blood testing for PFAS tell me?
Since 1999, the U.S. Centers for Disease Control (CDC) has measured several types of PFAS in the U.S. population as part of the National Health and Nutrition Examination Survey (NHANES). NHANES is a survey that measures the health and nutritional status of adults and children in the United States. With the decrease in production and use of some types of PFAS, the national levels of these types of PFAS have also dropped over time. From 1999 to 2014, blood PFOA and PFOS levels declined by more than 60% and 80%, respectively (www.cdc.gov/exposurereport). Nevertheless, the general U.S. population had average blood serum levels of 1.4-2.1 parts per billion (ppb) for PFOA and 4.3-6.3 ppb for PFOS between 2011–2018 (https://www.cdc.gov/exposurereport/pfas_early_release.html).

PFAS can be measured in your blood serum but this is not a routine test. While a blood test may indicate whether you have been exposed to PFAS, results cannot be used to predict your health effects nor can they be linked to specific health problems. Also, test results alone cannot be used to specifically identify sources of exposure, and there is no treatment to reduce levels of PFAS in blood. This information can be used to determine if the levels of PFAS in your blood are higher than national background levels. For example, if your concentration is higher than the 95th percentile, this means your blood serum concentration is higher than the concentration found in 95% of the U.S. population.

Additional Resources:

Basic Information about PFAS from EPA
https://www.epa.gov/pfas

EPA's Drinking Water PFOA and PFOS Lifetime Health Advisory
https://www.epa.gov/ground-water-and-drinking-water/drinking-water-health-advisories-pfoa-and-pfos

EPA's Technical Fact Sheet – PFOS and PFOA
https://www.epa.gov/sites/production/files/2017- 12/documents/ffrrofactsheet_contaminants_pfos_pfoa_11-

20-17_508_0.pdf

Virginia Department of Health PFAS website
https://www.vdh.virginia.gov/drinking-water/pfas

Centers for Disease Control and Prevention
https://www.atsdr.cdc.gov/pfas/

https://www.cdc.gov/exposurereport/index.html

Food and Drug Administration
https://www.fda.gov/food/newsevents/constituentupdates/ucm479465.htm

National Toxicology Program
https://ntp.niehs.nih.gov/pubhealth/hat/noms/pfoa/index.html

Interstate Technology Regulatory Council (IRTC)
https://pfas-1.itrcweb.org