Virginia PFAS Workgroup Meeting Minutes (Final)

July 27, 2021 – 1:00 pm. to 3:30 p.m.
In person meeting with WebEx, access
Virginia Department of Health (VDH) Office of Drinking Water (ODW)
109 Governor Street 6th Floor, Richmond, VA 23219

Workgroup Members /Alternate Attendees:

Chris Harbin (City of Norfolk, Dept. of Public Utilities, waterworks > 50,000 consumers)
Jamie Bain Hedges (DGM. Fairfax Water. Waterworks> 50,000 consumers)
Mike Hotaling (Newport News, waterworks > 50,000 consumers)
Jessica Edwards-Brandt (Loudoun Water, waterworks > 50,000 consumers)
Russ Navratil (Virginia Chapter, American Water Works Association, advocacy group)
Mark Estes (Halifax County PSA, Community Waterworks serving <50,000 consumers)
Dan Hingley (Aqua Virginia, Community Waterworks serving < 50,000 consumers)
Wendy Eikenberry (Augusta County Service Authority, waterworks < 1,000 consumers)
Steve Herzog (Hanover County, Advocacy Group)
Steve Rissoto (American Chemistry Council, manufacturer with chemical experience)
Paul Nyffeler (Chem Law, represents Waterworks, alternate)
Henry Bryndza (DuPont (retired), manufacturer with chemical experience)
Anna Killius (James River Association, environmental organization)
Phillip Musegaas (Potomac Riverkeeper, environmental organization)
Jeff Steers (Virginia Department of Environmental Quality)
Dr. William Mann (Consumer of Public Drinking Water)
Dwight Flammia, Ph.D. (VDH, State Toxicologist, Health & Toxicology Subgroup Lead)
Tony Singh (VDH, Office of Drinking Water, PFAS Workgroup Lead)

VDH Staff Supporting the Meeting:

Dwayne Roadcap (VDH Office of Drinking Water)
Leslie Holt (VDH, Office of Drinking Water, Sub for Robert Edelman)
Nelson Daniel (VDH Office of Drinking Water, Policy & Regulation Subgroup Lead)
Dan Horne (VDH, Office of Drinking Water, Treatment Technology Subgroup Lead)
Christine Latino (VDH Office of Drinking Water)
Jack Hinshelwood (VDH Office of Drinking Water)
Anthony Creech (VDH Office of Environmental Health Services)

Guest Speaker

Rebecca Warns (Natural Resources Planner, Maryland Department of the Environment (MDE) Water Supply Program**)**

1. Call to Order

Virginia Department of Health (VDH) Office of Drinking Water (ODW) Deputy Director, Tony Singh, Ph.D. called the meeting to order 1:03 p.m. The meeting was held in person at the Madison Building, 109 Governor Street, Richmond, VA and was available to Workgroup members and the public by electronic communication means due to the continued coronavirus threat. ODW recorded the meeting and posted minutes on the Town Hall website (https://townhall.virginia.gov). The recording will be available at the VDH-ODW PFAS webpage https://www.vdh.virginia.gov/drinking-water/pfas/

2. Meeting minutes from April 29, 2021

Workgroup members did not have any comments or corrections to the minutes from the April 29, 2021 meeting. ODW posted the April 29, 2021 meeting minutes as final on Town Hall.

3. Maryland PFAS Initiatives

Rebecca Warns is a Natural Resources Planner with the Maryland Department of the Environment's (MDE) Water Supply Program. She gave a presentation about understanding, communicating, and managing the risks of per- and polyfluoroalkyl substances (PFAS) in Maryland. A copy of the presentation follows the meeting minutes.

Formal study of PFAS in drinking water in Maryland began with sampling under EPA's Third Unregulated Contaminant Monitoring Rule (UCMR3) between 2012 and 2015. More recently, MDE implemented a multi-phased study to determine levels of PFAS in drinking water. MDE began by using geospatial information and GIS analysis to locate 2,000 potential sources of PFAS, drinking water supplies, and public water systems (waterworks) to assess the proximity of potential sources to drinking water supplies and the possibility of PFAS contamination. MDE then developed a risk-based approach to sampling over three phases. Phase 1 monitored 129 community waterworks that use surface water or groundwater from unconfined or semi-confined aquifers that are located within 1,000 feet of a potential source of PFAS. Phase 1 sampling began in September 2020 and ended in February 2021. Phase 2 was similar to Phase 1, but expanded the search radius from 1,000 feet to 1 mile. MDE completed sampling for Phase 2 in May 2021. Phase 3, which is expected to start in August or September of 2021, will include the remaining community waterworks.

Prior to implementing Phase 1, MDE also established a response plan. MDE based response on the concentration of perfluorooctanoate (PFOA) and/or perfluorooctane sulfonate (PFOS) detected, using EPA's health advisory level of 70 parts per trillion as the threshold for suggested action by an impacted waterworks. MDE recommended confirmation sampling and ongoing monitoring at lower levels of PFOA and/or PFOS (28 ppt and 35 ppt).

MDE released its report on Phase 1 on July 1, 2021. There were 2 community waterworks that had results above 70 ppt for PFOA + PFOS, 2 with PFOA + PFOS between 35 and 70 ppt, and 1 with PFOA + PFOS between 28 and 35 ppt. In the Phase 2 group, no samples to date have been above 70 ppt (PFOA + PFOS).

Workgroup members asked how MDE developed its list of potential sources of PFAS – MDE used SIC codes, military facilities, landfills, and criteria similar to what Virginia's Department of Environmental Quality used to help the Workgroup identify potential sources of PFAS in Virginia.

Workgroup members also asked about other PFAS – MDE did not establish any response levels for other PFAS because there are not any regulatory limits for them. Ms. Warns said there were other PFAS in the sample results, but most were non-detects. (MDE specified EPA method 537.1 for lab analysis).

4. VA PFAS Workgroup Updates:

Dr. Singh provided updates on ODW and Workgroup actions since the last meeting on April 29, 2021. Dr. Singh's presentation follows the meeting minutes. In addition to the information in the presentation, Dr. Singh discussed the following:

- <u>Literature Review</u>: Old Dominion University (ODU) has completed the literature review and provided a draft report to ODW. Staff are in the process of reviewing the report. ODW expects to share the draft report with Workgroup members in August. Dr. Singh asked Workgroup members to share any additional information, reports, etc. that they would like to Workgroup to consider – that is not included in the Literature Review.

- <u>Sampling Study</u>: The original Sample Study included 50 waterworks. Five declined to participate and others did not respond to the request to participate. ODW identified additional waterworks and asked them to participate, resulting in a total of 45 waterworks taking part in the Study.

  To date, 42 waterworks have returned samples to the lab for analysis. Remaining waterworks have sent samples to the lab for analysis. ODW is currently working with both the waterworks and the lab to perform quality assurance/quality control review of the provisional results. Based on QA/QC, ODW has asked 4 waterworks to collect re-samples. The sample data should be available to the Workgroup in August 2021.

  Provisional results had PFAS detections above 10 nanograms per liter (ng/L) at 6 sample locations. The detected compounds included PFOA, PFOS, and other PFAS. Dr. Singh said that ODW only intends to report results above the practical quantitation limit (PQL) with is 3 to 4 ng/L for most of the compounds.

- <u>Next Steps</u>: House Bill 586 (2020) requires the work group to report its findings to the General Assembly by December 1, 2021. Dr. Singh talked about the timeline to develop the report and the requirements/timeline for the report required by HB 1257 (2020) related to the development of maximum contaminant limits for PFOA, PFOS, 1,4-dioxane, and Chromium VI. Members of the Workgroup shared thoughts and concerns about both reports with Dr. Singh.

5. Subgroup Reports:

Subgroup leaders provided an update on activity since the last Workgroup meeting in April.

- <u>PFAS Health and Toxicology</u>: State Toxicologist, Dr. Dwight Flammia reported that in April the Subgroup requested ODU conduct a literary search to compile data regarding

PFAS and compounds related to this study and transfer data into an Excel spreadsheet for analysis. Members from the Subgroup analyzed data and reorganized tables to better serve the Subgroup's needs. The Subgroup then looked over the data determining the difference between chronic studies, chronic effects and uncertainty factors, and where the differences lie within each state – with the major focus being PFOS and PFOA and states that had already developed MCLs.

The Subgroup has looked at data and information from the Agency for Toxic Substances and Disease Registry (ATSDR), including the PFAS Exposure Assessment Technical Tools. They also looked at uncertainty factors, toxicology research on the other four PFAS specified in HB 586, and how states grouped compounds together for MCLs.

Dr. Flammia said the Subgroup needed input from the Workgroup and other Subgroups on what they need from the Toxicology Subgroup to help their work. Dr. Singh thought the Toxicology Subgroup – once results are available – could assess whether there is enough occurrence data for any PFAS that aren't specifically named in HB 586 to warrant further consider by the Workgroup and whether any research or data suggests the detected concentration(s) is more toxic for one compound than another, i.e., which would be of greater concern.

- PFAS Occurrence and Monitoring: There were not any updates from this Subgroup.

- PFAS Treatment Techniques: Dan Horne provided an update on the Treatment Technologies Subgroup activities. His presentation follows the meeting minutes. The Treatment Technologies Subgroup has focused on granulated activated carbon (GAC), ion exchange (IX), and reverse osmosis (RO) as the primary treatment technologies, focusing on the different aspects of each process with respect to cost and waste disposal.

  On July 22, 2021, Dr. Erik Rosenfeldt (Hazen & Sawyer) gave a presentation on treatment technologies. It covered cost, technological considerations, and provided case studies. A copy of Dr. Rosenfeldt's presentation follows the meeting minutes.

  The next step for the Subgroup is to prepare summaries and assessments of the major treatment technologies. The summaries should include information about cost, availability, overall effectiveness, effectiveness at removing some PFAS versus others (such as short-chain or long-chain), and waste product/treatment residue disposal.

  Workgroup members discussed presentation of different treatment options in the report required by HB 586. They noted that treatment determinations will need to be on a case-by-case basis. They also talked about the need to do pilot testing, and expressed concerns about waste disposal, particularly if EPA classifies PFAS as toxic substances.

- PFAS Policy and Regulations: Nelson Daniel provided an update on the Policy and Regulation Subgroup activities. His presentation follows the meeting minutes.

  The Policy Subgroup met on May 17 and June 21. In May, they worked on the Communications Toolkit and, at both meetings, focused on legislative and regulatory actions in other states.

  The next steps are to develop state summaries, consider input and recommendations from other subgroups, and think about how the Subgroup can contribute to the Workgroup's objectives. Once sampling results are available, the Subgroup can focus on the policy implications related to the presence or lack of PFAS in drinking water in Virginia, within the scope and limitations of the Sampling Study.

6. Public Comment:

Dr. Singh invited members of the public who were at the meeting to provide comments. No one commented.

7. Conclude Meeting:

Following the public comment period, Dr. Singh discussed the next meeting of the Workgroup and suggested that it should be in September, instead of October, so that Workgroup members could make recommendations for and provide feedback on the report to the General Assembly. Workgroup members discussed meeting in early September or in conjunction with the Virginia Section of the American Water Works Association's WaterJAM (September 13-16, 2021 in Virginia Beach). Dr. Singh will poll Workgroup members for their availability.

Dr. Singh concluded the meeting at 3:30.

Virginia PFAS Workgroup Meeting

Hosted by
the Virginia Department of Health (VDH) - Office of Drinking Water 109
Governor Street, Richmond, VA 23219

In-Person & WebEx (Virtual) Thursday, July 27, 2021
1:00 p.m. – 3:30 p.m.

DRAFT AGENDA

Subject	Time
Connect to WebEx and Meeting Instructions	12:50 – 1:00 PM
Call To Order Meeting minutes from April 29, 2021 Meeting Overview of Agenda	1:00 – 1:10 PM
Other State Perspective on the PFAS Sampling – Maryland PFAS Sampling study Rebecca Warns, Maryland Department of the Environment	1:10 – 1:40 PM
VDH Updates & Discussion	1:40 – 2:10 PM
BREAK	2:10 - 2:20 PM
Subgroup Reports/Status Updates - PFAS Health & Toxicology (10 minutes) - PFAS Occurrence & Monitoring (10 minutes) - PFAS Policy & Regulation (10 minutes) - PFAS Treatment Technologies (10 minutes)	2:20 – 3:00 PM
PFAS in VA Drinking Water - Next Steps	3:00 – 3:15 PM
Open Discussion Forum	3:15 – 3:25 PM
Public Comment Period	3:25 – 3:30 PM
Conclude Meeting (Next Meeting proposed Time – September 2021)	3:30 PM

Virginia Department of Health

PFAS Workgroup

July 27, 2021, 1:00 p.m. to 3:30 pm

Driving Directions and Parking Information

Meeting Venue: James Madison Building, 109 Governor Street, Richmond 23219 VA

Driving Directions:

From the North: Follow 1-95 South to Exit 74B (Franklin Street). Turn right at the light, keep straight through the intersection and the Madison Building is on the right (top of the hill) Follow directions below to selected parking option.

From the South: Take I-95 North to Exit 74C. Follow Exit 74C, and then take the Broad Street East ramp to the right. Turn right onto Broad Street. Go to the first traffic light that is N 14th Street and turn left. Go to traffic light and make a right turn, the Madison Building is on the right (top of the hill). Follow the directions below to selected parking options.

From the West: Take I-64 East. As you get into the central Richmond area, I-64 merges with I-95. Follow signs for I-95 South to Exit 74B (Franklin Street) (do not get back onto I-64). Turn right at the light, keep straight through the intersection and the Madison Building is on the right (top of the hill). Follow directions below to selected parking options.

From the East: Take I-64 West to I-95 South. Follow I-95 South to Exit 74B (Franklin Street). Turn right at the light; keep straight through the intersection and the Madison Building is on the right (top of the hill). Follow directions below to elected parking options parking option.

Public Parking

Parking is not permitted in State parking areas. Cars illegally parked in these areas are subject to ticketing and towing, Public Parking areas are available on nearby streets. Each of these streets are South of the Madison Building, although other parking facilities exist, the following are a few of the closest (costs may have changed since this document was created):

1. Main and N. 14th Street (AOPCOA Parking Lot)
   Turn right onto Franklin Street off exit ramp. Go to N 14th Street – turn left. Go one block to Main Street. See parking lot on left (Small gravel lot.) $5.00 all day.

2. Cary off N 14th Street (Public Parking Deck- AOPCOA)
   Turn right onto Franklin Street off exit ramp. Go to N. 14th Street – turn left. Go two blocks to Cary Street. Turn left onto Cary. Parking deck will be on he left. Early bird rate – If in before 9:00 a.m. (unknown at this time) after 9:00 a.m. $16.00 all day

3. Cary and 15th Streets (VA Park – Value Parking Lot)
   Turn left onto Franklin Street off exit ramp. At first corner, turn right onto 15th Street. Go two locks to Cary Street – turn left onto Cary, see parking lot on right corner $5.00 all day.

4. Cary between 16 & 17th Streets (V Park – Value Parking Lot)
   Turn left onto Franklin Street off exit ramp. At first corner, turn right onto 15th Street. Go two

blocks to Cary Street – turn left onto Cary. See parking lot on right one block down. $5.00 all day.

To get to parking lot from Broad Street; Turn left onto N. 14th Street. Go two traffic lights to Main Street and see parking lot #1 on the left or go three traffic lights to Cary Street and turn left. Parking lots #2, #3 and #4 will be seen as indicated above

Virginia PFAS Workgroup Meeting Minutes (Fianl)

April 29, 2021 – 1:00 pm. to 3:30 p.m.
WebEx platform
Virginia Department of Health (VDH) Office of Drinking Water (ODW)
109 Governor Street 6th Floor, Richmond, VA 23219

Workgroup Members /Alternate Attendees:

Chris Harbin (City of Norfolk, Dept. of Public Utilities, waterworks > 50,000 consumers)
Jillian Terhune (City of Norfolk, Dept. of Public Utilities, waterworks > 50,000 consumers)
David Jurgens, (City of Chesapeake, Dept of Public Utilities, waterworks> 50,000 consumers)
Jamie Hedges (Fairfax Water, waterworks > 50,000 consumers)
Mike Hotaling (Newport News, waterworks > 50,000 consumers)
Jessica Edwards (Loudoun Water, waterworks > 50,000 consumers)
Russ Navratil (Virginia Chapter, American Water Works Association, advocacy group)
Geneva Hudgins (VA AWWA (alternate), advocacy group)
Mark Estes (Halifax County PSA, Community Waterworks serving <50,000 consumers)
Wendy Eikenberry (Augusta County Service Authority, waterworks < 1,000 consumers)
Steve Rissoto (American Chemistry Council, manufacturer with chemical experience)
Paul Nyffeler (Chem Law, represents Waterworks, alternate)
Henry Bryndza (DuPont (retired), manufacturer with chemical experience)
Phillip Musegaas (Potomac Riverkeeper, environmental organization)
Christopher Leyen (VALCV, environmental organization, alternate)
Erin Reilly (James River Association, environmental organization)
Jeff Steers (Virginia Department of Environmental Quality)
Dr. William Mann (Consumer of Public Drinking Water)
Dwight Flammia (VDH, State Toxicologist, Health & Toxicology Subgroup Lead)
Tony Singh (VDH, Office of Drinking Water, PFAS Workgroup Lead)

ODW Staff Supporting the Meeting:

Dwayne Roadcap (VDH Office of Drinking Water)
Robert Edelman (VDH, Office of Drinking Water, Monitoring & Occurrence Subgroup Lead)
Nelson Daniel (VDH Office of Drinking Water, Policy & Regulation Subgroup Lead)
Dan Horne (VDH, Office of Drinking Water, Treatment Technology Subgroup Lead)
Christine Latino (VDH Office of Drinking Water)

Guest Speaker

Mitchell McAdoo U.S. Geological Survey (USGS) Virginia and West Virginia Water Science Center

1. Call to Order

The Virginia Department of Health (VDH) Office of Drinking Water (ODW) Deputy Director, Tony Singh, Ph.D. called the meeting to order 1:02 p.m. ODW held the meeting via electronic communication means due to the public health emergency associated with the coronavirus pandemic. ODW recorded the meeting and will post minutes on the Town Hall website (https://townhall.virginia.gov). The recording will be available at the VDH-ODW PFAS webpage https://www.vdh.virginia.gov/drinking-water/pfas/

2. Meeting minutes from March 4, 2021

Workgroup members did not have any comments or corrections to the minutes from the March 4, 2021 meeting. ODW will post the March 04, 2021 meeting minutes as final on Town Hall.

3. U.S. Geological Survey PFAS Study in West Virginia

Mitch McAdoo is a hydrologist with the U.S. Geological Survey's Virginia and West Virginia Water Science Center. He currently oversees a cooperative program between the USGS, West Virginia Department of Environmental Protection (WVDEP), and West Virginia Department of Health and Human Resources (WVDHHR) to sample per and polyfluoroalkyl substances (PFAS) in West Virginia public source water supplies. His research interests include identifying the occurrence of PFAS in the environment, characterizing water quality in abandoned underground coalmine aquifers and using environmental tracers to understand aquifer vulnerability.

Mr. McAdoo spoke about the study of PFAS contamination in West Virginia drinking water sources. He said the study involved collecting raw water samples from each community water system and school that operates a water system in West Virginia (roughly 280 sample sites). USGS personnel collected all of the samples to ensure consistent methodology. Sample collection should be completed this month (April 2021). USGS expects to release results in a peer-reviewed data release later this year and complete its report by June 2022. The data set will include field parameters (pH, dissolved oxygen, turbidity, etc.) major inorganics, nutrients, trace metals, and PFAS to get better information about water quality statewide. However, funding was not sufficient to include radionuclides and VOCs.

To date, preliminary results indicate PFAS (perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS)) at levels above 70 parts per trillion (ppt), the U.S. Environmental Protection Agency's (EPA) lifetime health advisory level for PFOA + PFOS, at 5 sites. Due to the known contamination sources close by, the USGS was expecting PFAS results of greater than 70 ppt at 4 sites prior to sampling.

Following the presentation, PFAS Workgroup members had an opportunity to ask questions, including:

- Did you consider sampling for radionuclides / radium?
    - *The list of analytes was limited by funding and the study parameters WVDEP and WVDHHR established.*
- The FY2020 National Defense Authorization Act (NDAA) required USGS to survey for ecological exposure to PFAS, with priority in determining direct human exposure through drinking water. Was this project part of the NDAA mandate? What else is USGS doing under the NDAA mandate?

  - *The USGS involvement in those projects is more focused at a regional level instead of a state level so the project is not part of the NDAA mandate.*
- What analytical method is being used for PFAS?
  - *The contract lab is using modified version of EPA Method 537 and 537.1 since both are designed for finished water and the sampling program is collecting raw water samples. The average MDL is 5.3 ng/L (nanograms per liter).*
- Mr. McAdoo indicated that the USGS had to adapt sample collection procedures for differences at water systems (in part based on the sample point). There were 8 teams collecting samples so quality assurance methods were based on the number of teams, project budget, and site conditions. They collected duplicates, field blanks, equipment blanks, etc. at approximately 15% of the sample sites.
- The budget for the project is $1.69 million with funding from WVDEP, WVDHHR, and the USGS.

4. VA PFAS Workgroup Updates:

Dr. Singh provided updates on ODW and Workgroup actions since the last meeting on March 4, 2021. Dr. Singh's presentation follows the meeting minutes. In addition to the information in the presentation, Dr. Singh highlighted:

- Old Dominion University (ODU) is conducting a literature review and adding reports to the database of information about PFAS. Information about the literature review is on the PFAS SharePoint site. The ODU researchers are currently looking into any human/animal studies and have provided a complete excel reference list that is updated every Thursday.
- ODW scheduled and conducted a webinar to provide training on PFAS sample collection procedures. The video with sampling instructions is available under the tab "VA PFAS Sampling" at: https://www.vdh.virginia.gov/drinking-water/pfas/
- ODW communicated with waterworks about the PFAS sampling study and requested acknowledgements from them; ODW has received 27 acknowledgments, 1 waterworks declined to participate in the study and another is not using the proposed sample collection point so it also dropped out.
- ODW revised and submitted the Quality Assurance Project Plan (QAPP) for EPA approval, EPA wanted more information about the analytical method for raw water samples (Department of Defense method); while ODW works to resolve this, sampling will occur in 2 phases: Phase 1 will focus on finished water (groundwater sources and entry point samples at 17 large waterworks): Phase 2 will focus on surface water sources (raw water samples).
- ODW is currently compiling a list of Waterworks that will be included in Phase 1 and will send that to the lab so they can prepare and ship sampling kits. Waterworks should open the test kits only when they are ready to sample. Please do not collect and ship samples on Fridays because the lab does not accept delivery on the weekends. Once the sample is sent to lab, results will be sent to ODW and the waterworks at the same time.

- Once ODW receives results from the lab, they will go through a data validation process to ensure the lab followed proper analytical procedures, to look for signs of contamination or qualifiers, etc. (see presentation).
- ODW will maintain validated results in a searchable database, but not in the Safe Drinking Water Information System (SDWIS) database that ODW uses for monitoring results waterworks submit for compliance with requirements in the Waterworks Regulations.

ODW is developing a PFAS Communication Toolkit for waterworks that participate in the Sampling Study and health officials in the communities where those waterworks are located. The Toolkit contains guidance for waterworks on how to respond to results that indicate PFOA and/or PFOS are present, communication templates, fact sheets, and available resources. ODW shared a draft of the Communication Toolkit with VA PFAS Workgroup members so they can review and provide feedback. ODW requests comments by May 6, 2021.

5. Subgroup Reports:

Health & Toxicology

Subgroup leader Dwight Flammia said the toxicology subgroup is reviewing each of the six PFAS named in HB586 individually, starting with PFOS. Subgroup members looked at states that had established regulatory limits for PFOS and what technical supporting documentation they relied on to establish a maximum contaminant limit (MCL). For PFOS, the subgroup found a lot of literature but focused on three research papers. The next month, the subgroup focused on PFOA and noticed there was more literature, pertinent animal studies to get their MCLs range from 8 ppt to 20 ppt. The subgroup also reviewed the EPA relative source contribution decision tree and discussed exposure factors. Based on research and literature, it appears most exposure to PFAS comes from sources other than drinking water. All the Subgroup's research documents are saved on the PFAS Workgroup SharePoint site.

Future meetings will be on the second Wednesday of each month. The slide Dr. Flammia used for his portion of the meeting follows the minutes.

Occurrence and Monitoring

Robert Edelman provided an update on the Occurrence and Monitoring Subgroup activities. His presentation follows the meeting minutes.

During his comments about what to expect after sampling, VA PFAS Workgroup members asked what happens if a waterworks detects PFAS? Mr. Edelman referred to the recommendations in the Communication Toolkit. Jeff Steers (DEQ) said that DEQ can provide assistance if the PFOA/PFOS concentration in source water is above 70 ppt.

Policy and Regulation

Nelson Daniel provided an update on the Policy and Regulation Subgroup activities. His presentation follows the meeting minutes.

Paul Nyffeler expanded on the difference between the acid and anionic salt names of the PFAS listed in HB 586, saying that the different forms have different properties in the environment, and cautioned against generalizations.

Treatment Technologies

Dan Horne provided an update on the Treatment Technologies Subgroup activities. His presentation follows the meeting minutes.

After evaluating several different technologies, the Subgroup is focusing on the three that are generally considered the best available treatment technologies (BATT): Granulated Activated Carbon (GAC) Filtration, Ion Exchange Filtration, and Reverse Osmosis. The Treatment Technologies Subgroup's next step is to develop a template to use in preparing summaries/measurements of the treatment process, identify information gaps, and complete the summaries. Mr. Horne noted that treatment alternatives may be affected by what DEQ will or will not allow in discharges to wastewater treatment facilities or surface water.

The Subgroup meets on the fourth Thursday of the month at 10 am.

6. Moving Forward: April through June 2021

Dr. Singh provided a summary of upcoming activities for ODW and the Workgroup:

- PFAS sampling related activities are underway.
- PFAS Communications Toolkit is in development.
- PFAS Webpage: https://www.vdh.virginia.gov/drinking-water/pfas/
- VDH is required to submit reports to the Governor and General Assembly on PFAS in Drinking Water in Virginia (for HB586) by December 1, 2021 and the status of MCLs for PFOA, PFOS, 1,4-Dioxane, and Chromium (VI) by October 1, 2021 (HB1257). For both reports, ODW will need to have a draft ready for internal review and approval approximately 45 days before the deadline.
- ODW estimates to receive all the PFAS results by July 2021.

7. Public Comment

Dr. Singh invited members of the public at the meeting to provide comments. One person asked if the 2 waterworks that were not going to be part of the Sampling Study would be replaced. Dr. Singh said that ODW intends to replace them with new sampling sites.

The same person also asked about the making recordings of meetings available on the PFAS website. Dr. Singh said that ODW would update the website with the recordings.

8. Conclude Meeting

Following public comment, Dr. Singh concluded the meeting. The next VA PFAS Workgroup meeting will be in late June or July, 2021. Anyone who is interested in attending a subgroup meeting, please contact Christine.Latino@vdh.virginia.gov for login information. Meeting dates are posted on the Town Hall website.

Establishing Regulatory Limits for PFAS in Virginia Drinking Water

Tony Singh, Ph.D., MPH, PE, BCEE

Virginia Department of Health

July 27 2021

Office of Drinking Water
Safe Drinking Water for a Healthy Virginia

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment

Meeting Overview – July 27, 2021

- **Introductions**
  - VA Workgroup Members & VDH team
- **Agenda adoption - Overview**
  - Todays External Speaker
  - VDH Updates
  - Subgroup Reports
  - Next Steps & Open Discussion
- **Review/Approval** of Meeting Minutes April 29, 2021

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment

Housekeeping

- Please use chat feature generously for any discussions and questions
- Please contact Christina Latino (Christina.Latino @vdh.virginia.gov)for any technical issues with WebEx platform
- There will be a public comment period at the end of the meeting

Rebecca-Ann Warns

Rebecca Warns is a Natural Resources Planner with the Maryland Department of the Environment's Water Supply Program. Since joining the Department in 2019, she has been involved with a variety of program initiatives including identifying priority source protection areas under the 2019 Farm Bill, participating on MDE's Water and Science Administration Climate Change workgroup, and most recently, organizing and implementing the statewide public water system study for PFAS in state drinking water sources.

Maryland Department of the Environment

Maryland Department of the Environment

Understanding, Communicating, and Managing the Risks of PFAS in Maryland

VA PFAS Workgroup Meeting
July 27, 2021

Rebecca Warns, MDE Water Supply
Rebecca-ann.warns@Maryland.gov

Overview- Maryland PFAS Initiatives

- Previously Completed PFAS Work
- PFAS Initiatives Currently Underway
  - Understanding Drinking Water Exposure Risks
  - Other occurrence studies, risk communications, and work
- Future Initiatives to be Considered

What are “problem areas?”

- Generally, contamination is associated with a specific facility
  - Fire training facility, military installation, industrial sites
  - Cumulative, localized impact on nearby drinking water supplies
  - PFAS Forensics needed to confirm
- Contamination of drinking water and accumulation of aquatic species – national concern
- In Maryland – legacy compounds may be main concern
  - New generation PFAS has not been detected in first two phases of MDE’s PWS Study (e.g., GenX and ADONNA)
- More investigation required

Previously Completed PFAS-Work in MD (DW)

2012-2015

- Third Unregulated Contaminant Monitoring Rule (UCMR3)
- Communication with CWS, health departments, and other agencies

2016-2019

- Formation of Internal MDE Workgroup

Late 2019-8/2020

- Planning of multi-phased Public Water System Study

9/2020-5/2021

- Implementation and Completion of PWS Study – Phases 1 & 2

MDE'S MULTI-PHASED PWS STUDY FOR PFAS IN DRINKING WATER

PWS Study for PFAS in DW- Planning Stage (Completed)

- Data Collection- geospatial info for 2,000 potential sources of PFAS throughout the State
- GIS Analysis: assess proximity of sources to DW supplies
- Integration of Geological Setting, Source Water Type, and other system-specific information
- ID Lab for Analysis (MDH-Laboratories Administration- EPA Method 537.1)
- Establish sampling protocols – limiting the risks of cross-contamination

PWS Study - Response Plan Development (Completed)

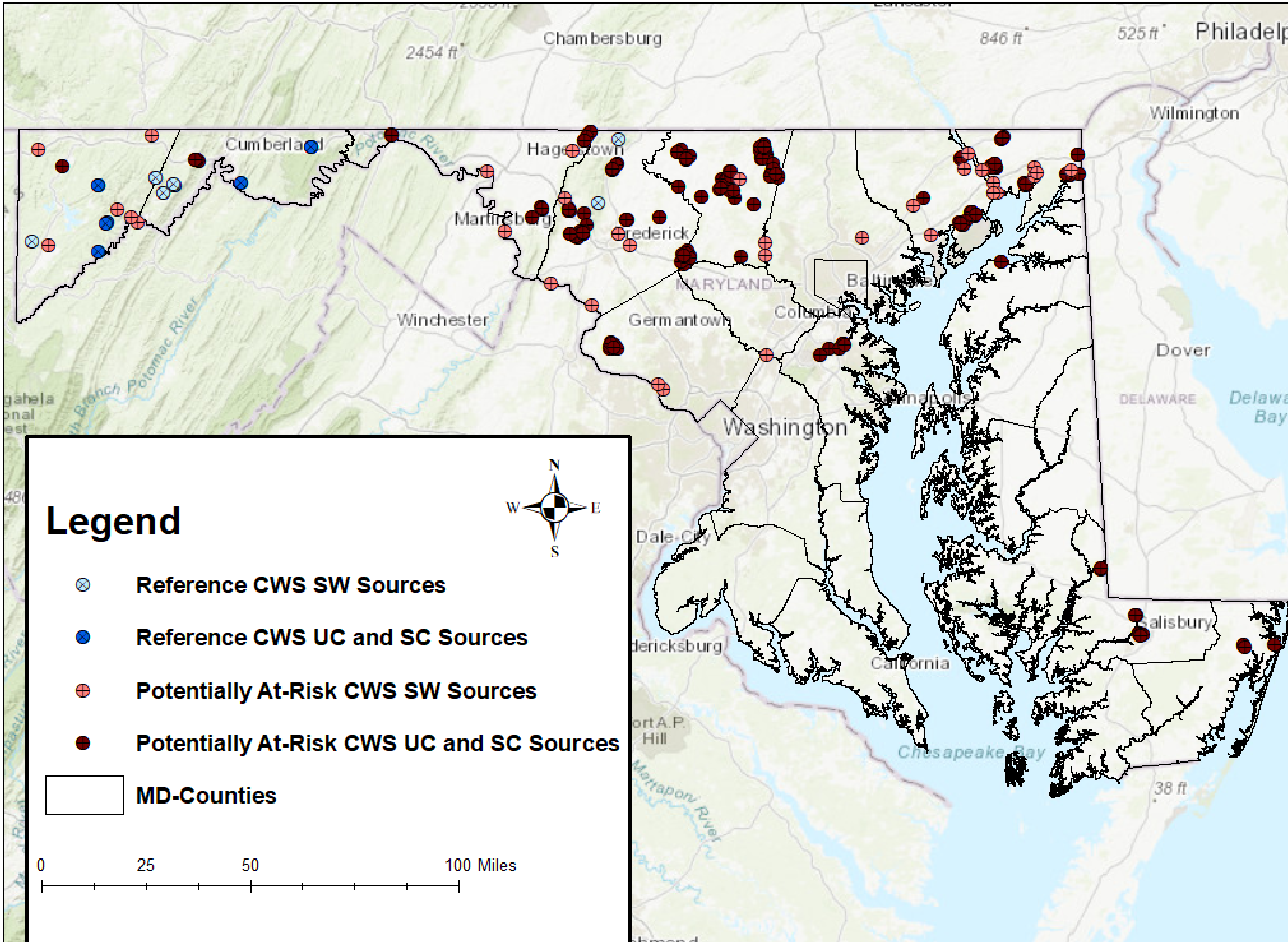
- Prior to Phase 1 Implementation
- Based on PFOA + PFOS concentrations
- Outlines additional actions to be carried out by MDE and/ or utilities
  - E.g., additional monitoring, treatment implementation, source abandonment, etc.
- Thresholds: 70, 35, 28 parts per trillion (ppt)
  - 70 ppt: USEPA HAL for PFOA + PFOS
  - 35 ppt: ½ HAL; similar to MCL responses
  - 28 ppt: accounts for SPE variability

Response Plan

Thresholds*	MDE Action(s) - after notification of initial results	Utility Action(s) – after results received
28 ppt	-Conduct confirmation sample	-Encouraged to conduct yearly monitoring -Encouraged to share results with MDE
35 ppt	-Conduct confirmation FW sample -Collect unfinished water sample	-Conduct semi-annual monitoring at impacted WTP -Conduct yearly sampling at other POEs -Encouraged to share results with MDE
70 ppt	-Request impacted WTP/ source taken offline -Conduct confirmation FW sample -Collect unfinished water sample -Encourage submission of additional monitoring efforts.	-Issue Tier II Public Notification -(If feasible) system to take impacted WTP offline - (If needed) explore treatment options or acquiring alternate water sources - (If treatment installed) conduct quarterly monitoring

*** Based on initial finished water concentrations**
Utilizing EPA Health Advisory Level (HAL) of 70 parts per trillion (ppt)

Phase I: Targeted Monitoring and Reference Sites Determine by MDE's Risk-Base Approach



PFAS PWS Study – Phase 1 (Completed: Sept. 2020 – Feb. 2021)

- Risk-based Prioritized Approach
  - Monitored 129 Community Water System Water Treatment Plants (CWS-WTPs)
  - Withdrawing and treating surface water or groundwater from **unconfined/semi-confined** aquifers
  - Within 1,000-ft radius of **potential** sources of PFAS
  - serving ~4.3 million Marylanders (~70%)
  - Monitored 11 “reference” CWS-WTPs
- Results
  - 2 CWS-WTPs > 70 ppt PFOA + PFOS
  - 2 CWS-WTPs 35 - 70 ppt PFOA + PFOS
  - 1 CWS-WTPs 28-35 ppt PFOA + PFOS
- Report made publicly available July 1, 2021

PFAS PWS Study – Phase 2 (Completed: Mar. 2021– May 2021)

- Similar methodology used as in Phase 1
  - Monitoring of CWS
  - Maintain focus on groundwater from UC/SC aquifers
  - Assess proximity to potential sources of PFAS
- Differences
  - – Shifted to sample collection of untreated water sources
  - – Expanded PFAS search radius from 1,000 ft – 1 mile
  - – Sampling of select confined groundwater sources
  - – Adjusted response plan
- PFAS Results found intermittently throughout the study
  - – No samples > 70 ppt [PFOA + PFOS]
  - – Majority of samples < 28 ppt [PFOA+PFOS]
- Report forthcoming

PFAS PWS Study – Phase 3

- Focus: sample remaining CWS systems
  - Remaining groundwater from Unconfined/ Semi-Confined aquifers
  - Groundwater from confined aquifers
  - Potentially revisit inactive sources during Phases 1 & 2
- Expected to start Late Aug./ Early Sept. 2021

Other Initiatives Currently Underway

- Risk-based prioritization approach to protect public health
  - Determining PFAS occurrence in WWTPs (Multi-Phased Study)
    - Influent, effluent, and biosolids
    - Developing action levels to incorporate into monitoring/ reporting requirements
  - Monitoring PFAS in Seafood
    - Piloted an approach to measure PFAS in oyster tissue and surface water (St. Mary's Pilot Study)
    - Integrate PFAS analysis into existing fish tissue monitoring framework
    - Conducted additional targeted fish tissue monitoring in Piscataway Creek
    - Working to shift fish tissue framework to focus more on PFAS locations (may add sites)
    - Following EPA progress on Aquatic Life and Human Health Water Quality Criteria
  - Developing outreach documents (PFAS-containing foam users, Local EHDs)
  - Incorporating PFAS language into Industrial Stormwater Permits
  - Implementing PFAS Spill Response SOP
  - Meeting with two Workgroups: MD Interagency and Multi-State
  - Continuing our understanding of PFAS in drinking water (public and private)
    - Outreach efforts + sampling

Future PFAS Work to be Considered

- PFAS Roundtable Recommendations
  - Developing the Maryland "PFAS Footprint"
  - Assessing impact of MD's Fresh-Estuarine-Saltwater gradient on PFAS Fate and Transport
  - Researching the accumulation of PFAS in shellfish (i.e. blue crabs)

Where can I find more information?

- MDE’s PFAS Landing Page
  - https://mde.maryland.gov/PublicHealth/Pages/PFAS-Landing-Page.aspx
- MDE’s Water Supply PFAS Webpage
  - https://mde.maryland.gov/programs/Water/water_supply/Pages/PFAS_Home.aspx

QUESTIONS?

Rebecca Warns

MDE: Water and Science Administration

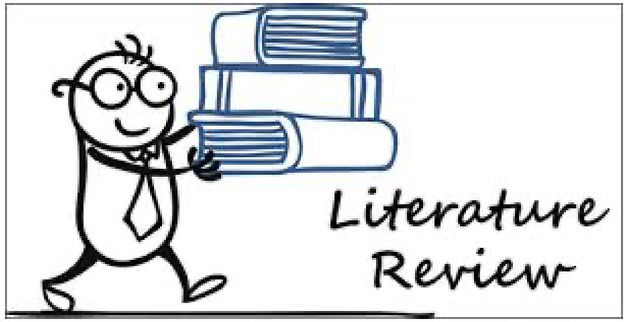
rebecca-ann.warns@maryland.gov

VDH Updates – July 27, 2021

PFAS Literature Review - Status

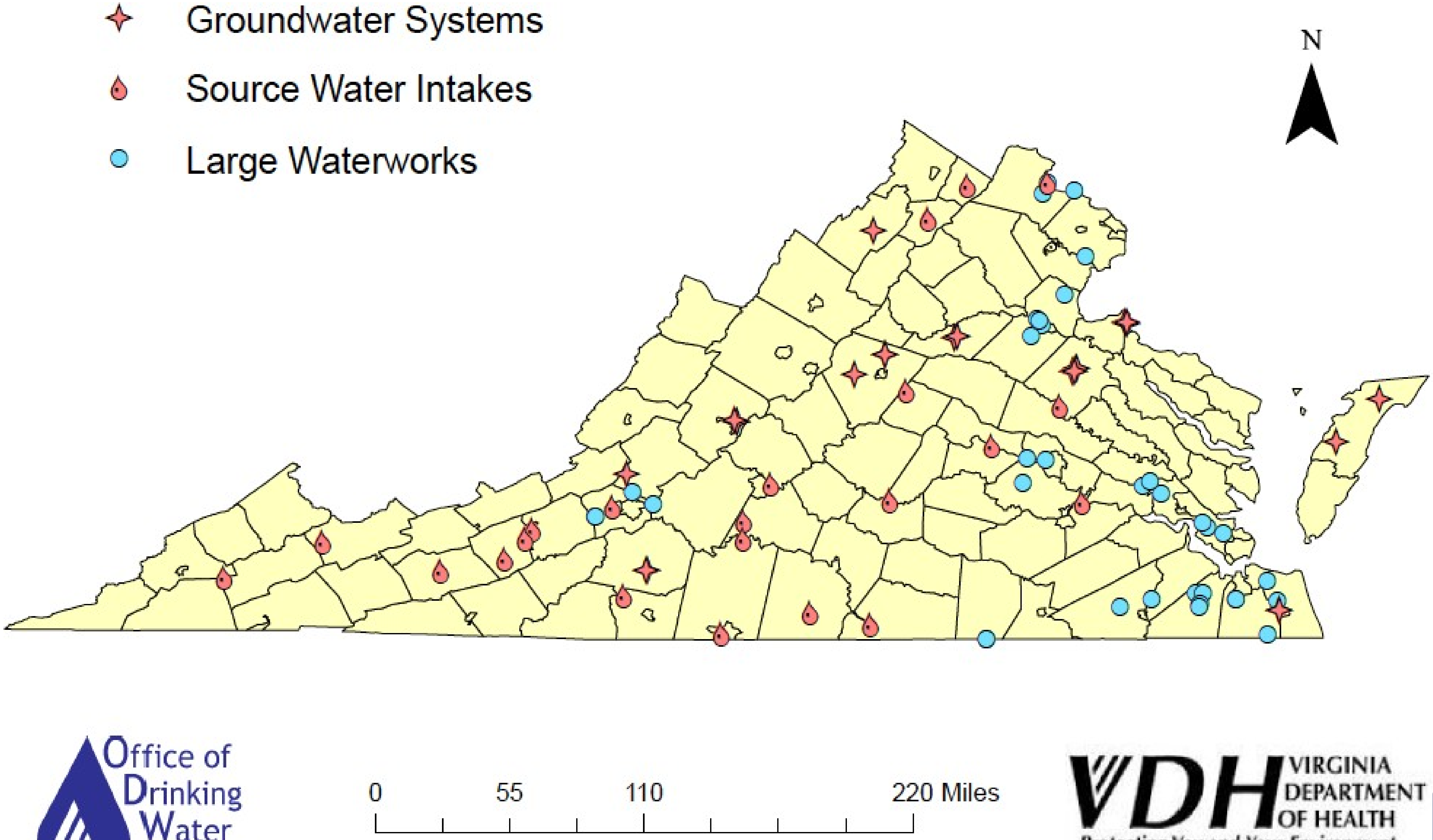
DRAFT PFAS Literature Report is, currently under VDH internal review

- Draft report will be shared with VA PFAS Workgroup in **August 2021**
- Members are encouraged to share their review, feedback, and any additional information they would like the workgroup to consider.
- Duration for this review will be **10 days**.
- This literature review information will be used for the legislative report that are due on October 01, 2021 (HB1257) and December 01, 2021 (HB586)



Where we were on April 29, 2021

VA PFAS Sampling Sites



Office of Drinking Water
Safe Drinking Water for a Healthy Virginia

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment

Hybrid Approach Summary

	# Samples	# Systems	Population
Large Waterworks	31	17	4,541,619
GW – Potential High Risk	6		13,329
GW – Potential Medium Risk	13	11	2,124
Major Water Sources	22	22	
Total	72	50	4,557,072

PFAS Sampling Results: Guidelines for Publication

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), 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 when a FOIA request is received so the waterworks can prepare.

VDH will provide a technical contact information to assist the participating waterworks with the media inquiries. Please refer to the "PFAS Communication Toolkit" for additional resources.

Data Handling & Management

Sampling Results

- Laboratory reports emailed to ODW and waterworks
- Electronic Data Deliverable (EDD) emailed to ODW

ODW will maintain results in a searchable database

- Not in SDWIS; Not available on Drinking Water Watch (DWW)

Quality Assurance Project Plan (QAPP)

- Specifies project quality assurance requirements
- Evaluate if data meets Quality Control (QC) criteria
- Evaluate usability and bias of data not meeting criteria
- Discard data if it fails QA/QC requirements

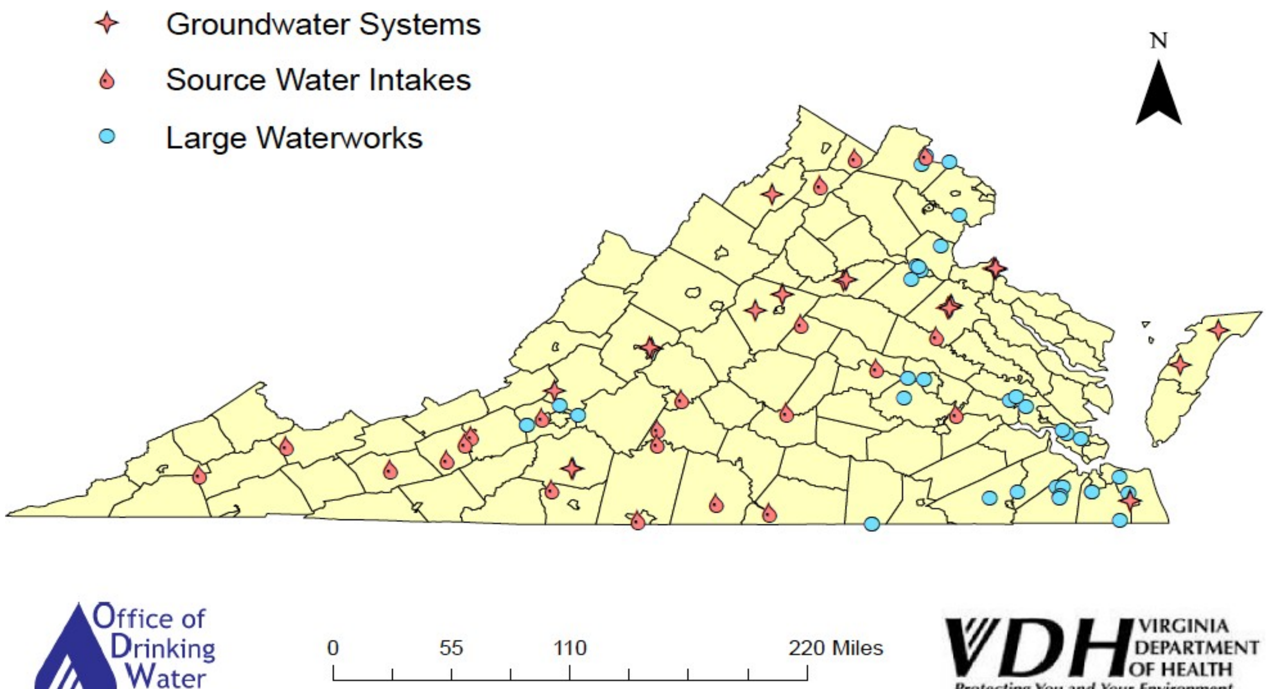
Changes to the Plan …

	Waterworks Sent Kits	Not Responded	Declined/ Withdrew
Large Surface	18	1	0
Ground Water	3	5	1
Raw Water intakes	17	1	4
Total	**38**	**7**	**5**

- VDH team came up with few additional systems for the PFAS sampling
- Five systems did not participate

VA PFAS Sampling Preliminary Results

Water systems participating:	45 vs 50 as planned
Total sampling points:	63 vs 72 as planned



Office of Drinking Water
Safe Drinking Water for a Healthy Virginia

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment

What happens after PFAS Sampling

VA PFAS Sampling Results: Guidelines for Publication

- Lab shared PFAS sampling results with waterworks and VDH-ODW at the same time; Results are labeled as **"Provisional"** prior to QA/QC evaluation
- All the results are currently undergoing through extensive QA/QC review process
- Detailed PFAS sample results from this statewide sampling will be available to the workgroup after the sampling is complete (August 2021)

QA/QC Checks

We review the following (COC items)

- Whether the samples were received and run within **holding time**?
- If the **temperature** upon arrival was within limit?
- If there was a **dilution factor**?

QA/QC Checks

We review analytical method performance using:

- The method blanks (MB)
- Laboratory control sample (LCS)
- Laboratory control sample duplicate (LCSD)
- Matrix spike (MS)
- Matrix spike duplicate (MSD).

QA/QC Checks

When reviewing the reports, we look at:

- if there are any **hits** in the method blank
- if there are any **qualifiers (U, I)**
- if the **surrogate recovery** is within the 50-150% range
- if the **spike recovery** is within the 70-130% range
- if the **RPD** is less than 20%.

VA PFAS Sampling Preliminary Results

Results Received (as of 07/23/2021):	42 water systems
	58 samples
Results pending/waiting:	3 water systems
Re-sampling:	4 locations

Why Resampling

- The sample and its blank have very similar hits
- These two are being re-sampled.
- Has a 10 fold dilution on the FRB
- Diluted at 10x for being "colored and exhibiting matrix issues" and taking a long time to concentrate.

This sample and FRB are being re-sampled.

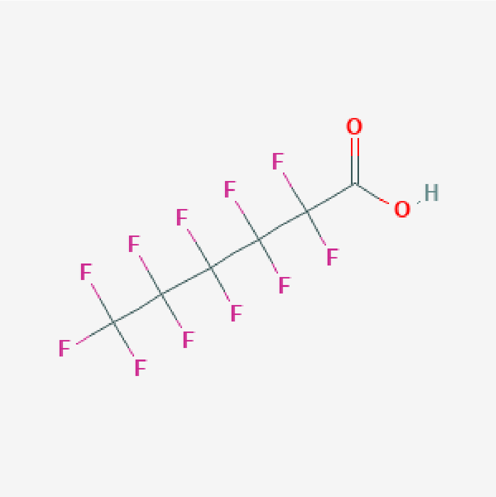
VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment

PFAS Detections (above 10 ng/L)

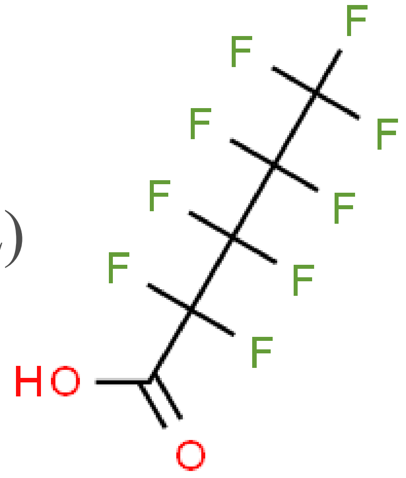
EP004:	PFPeA (10 ng/l)
EP022:	PFHxA (10 ng/L), PFPeA (11 ng/L)
EP001:	PFOA&PFOS (10 ng/L)
EP001-2:	PFBA (12 ng/L), PFHxA (11 ng/L), PFPeA (12ng/L)
EP002:	PFOS (17ng/L), PFOA&PFOS (20ng/L)
EP002:	HPFO-DA (51 ng/L*

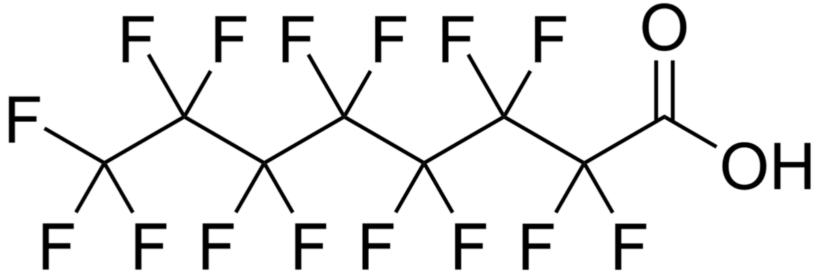
* With a 10x dilution; currently under review

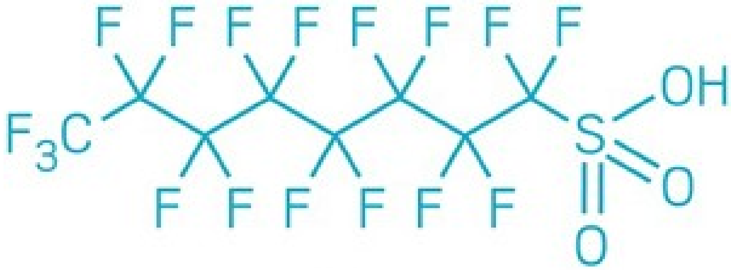
Preliminary - Most frequently Detected PFAS



PFPeA (10 ng/l)
PFHxA (10 ng/L), PFPeA (11 ng/L)
PFOA&PFOS (10 ng/L)
PFBA (12 ng/L), PFHxA (11 ng/L), PFPeA (12ng/L)
PFOS (17ng/L), PFOA & PFOS (20ng/L)







PFOS

Out of the HITS, How many of these are ground, or surface water systems

PFAS Sampling Study: Next Steps

Draft PFAS Literature review Report

HB1257 Report – Due Ocotber 01, 2021

HB586 Report – Due December 01, 2021 – October 15, 2021 (internal deadline)

- Review process – Workgroup/stakeholder feedback

BREAK

Subgroup Updates

PFAS Health and Toxicology

PFAS Treatment Technology Subgroup Update

Dan Horne

VDH – Office of Drinking Water

July 27, 2021

Office of Drinking Water
Safe Drinking Water for a Healthy Virginia

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment

Subgroup Members

Henry Bryndza (DuPont)
Jessica Edwards (Loudoun Water)
Wendy Eikenberry (Augusta County Service Authority)
Mark Estes (Halifax County Service Authority)
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 AWWA)
Kelly Ryan (Virginia American Water)

Dan Horne (VDH – ODW) Team lead

Subgroup Meetings

Subgroup meets on the fourth Thursday of the month – 10:00 a.m.

May 27, 2021

June 24, 2021

July 22 2021

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment

Subgroup discussions have focused on:

Reviews of GAC, IX, RO processes:

- General applicability
- Process limitations
- Case histories
- Applicability to small systems
- Wastes/disposal options

Presentation on Cost Issues and Factors

Presentation on July 22 by Dr. Erik Rosenfeldt (Hazen & Sawyer)

- **Covered PAC (as short-term step in phased approach), GAC, IX, and RO/NF**
- **Various cost factors – both capital and operating**
  - **How design choices affect both types of costs**
  - **How to get better cost comparisons between technology choices**
- **Role of disposal methods, potential cost changes**
- **Case histories – surface water and groundwater systems, large and small systems**

Next Steps

- **Template has been developed for use in preparing summaries/assessments of the various treatment processes**

- **Subgroup now ready to begin completing the summaries**

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment

PFAS Policy and Regulations Subgroup Update

Nelson Daniel

Virginia Department of Health

July 27, 2021

Office of Drinking Water

Safe Drinking Water for a Healthy Virginia

Subgroup Meetings

Subgroup has been meeting on the third Monday of the month, 11:00 a.m.

- May 17, 2021
- June 21, 2021

Changed meeting schedule with the end of the Declaration of Public Health Emergency

- July 27, 2021

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment

Subgroup discussions have focused on:

Completing Communication Toolkit

- Template letter for situation where PFOA/PFOS > 70 ppt

Sampling Study

Legislative/Regulatory Action in Other States and U.S. EPA

- California
- Pennsylvania
- Rhode Island
- U.S. EPA

Recent Legislative Highlights

Rhode Island:

S0107 (2021) – proposed to add Chapter 32, the "PFAS in Drinking Water, Groundwater and Surface Waters Act" to Title 46 of the General Laws… passed Senate 6/15 (w/substitute), referred to House, left in committee (legislature adjourned 6/30/21)

- Would have established 20 ppt interim drinking water standard and testing requirements
- Individual or sum of 6 PFAS (PFOA, PFOS, PFHxS, PFNA, PFHpA, and PFDA)
    - (Same PFAS as Massachusetts)

    - https://webserver.rilegislature.gov/BillText21/SenateText21/S0107A.pdf

Recent Legislative Highlights

Pennsylvania:

- 2017 petition from the Delaware Riverkeeper Network asking the PA Environmental Quality Board to set safe drinking water limits between 1 ppt to 6 ppt for PFOA, one of several PFAS chemicals.

- Rulemaking should be based on available data, studies, and science, and should consider all factors such as health effects, technical limitations, and costs. (factors in addition to health effects – as required by the Federal SDWA and Pennsylvania Regulatory Review Act)

Recent Legislative Highlights

Pennsylvania – PFAS Study

- PA had a $500,000 budget and planned to collect samples from 360 targeted public water system sources and 40 baseline sources for a total of 400 samples
- PA used EPA Method 537.1 (18 PFAS – the original 6 from UCMR 3 (PFOS, PFOA, PFNA, PFHxS, PFHpA, PFBS) + others)
- Sampling began in 2019, halted March 2020 until August 2020, completed in March 2021
- Results released May, 2021

Office of Drinking Water
Safe Drinking Water for a Healthy Virginia

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment

Recent Legislative Highlights

Pennsylvania:

- A Drexel University study on PFAS rules set by other states and statewide sampling published in January 2021:
  - Recommended a limit of 8 ppt for PFOA and 14 ppt for PFOS.

- Based on sampling, Delaware Riverkeeper requested PA set MCL for PFOA at 1 ppt or, in the alternative, 6 ppt (original request).

- PA Environmental Quality Board voted 18-1 (June 15, 2021) to pursue a MCL rule for the per- and polyfluoroalkyl substances found in public and private drinking water wells throughout the commonwealth.

Legislative Actions – U.S. EPA

- Proposed a new rule under the TSCA requiring PFAS manufacturers and importers to report detailed information about their PFAS use, disposal, and potential health and environmental impacts (going back to Jan 1, 2011). This will enable EPA to better characterize the sources and quantities of manufactured PFAS in the United States.
  - 86 FR 33926, June 28, 2021; 60-day public comment period closes 8/27/2021

- Withdrew a Trump-era compliance guide that had narrowed a prior EPA Significant New Use Rule (SNUR) restricting the use, manufacture, and import of certain long-chain PFAS

- Added three PFAS chemicals to the Toxics Release Inventory (TRI) program
  - perfluorooctyl iodide, potassium perfluorooctanoate, and silver(I) perfluorooctanoate

Next Steps

Develop state summaries – will discuss template at subgroup meeting today

Consider input and recommendations from Treatment Technologies and Toxicology Subgroups

When Sample Study results are available, begin discussion about whether to recommend MCLs for any, some, all PFAS specified in HB586, taking recommendations from other subgroups into consideration.

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment

What’s Next - ?

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment

Workgroup Next Steps

Proposal

September 2021 Workgroup Meeting

- VA PFAS Sampling Study results and Draft HB586 Report

October 2021 Workgroup meeting

- Final HB586 Report & Recommendations

Moving forward; August – December 2021

- PFAS report due to the VA General Assembly by October 01, 2021 (HB1257 - VDH internal deadline August 15, 2021) and December 01, 2021 (HB586 - VDH internal deadline September 15, 2021)

- VDH-ODW expects to have the PFAS sampling results by August 2021

- PFAS webpage - https://www.vdh.virginia.gov/drinking-water/pfas/

Open Discussions

Public Comment

Proposed Next meeting – September 2021

VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment

Have any Question, Comment or Suggestion, contact Us

Tony S. Singh

Tony.Singh@vdh.Virginia.gov

804-310 3927

Dwayne Roadcap

Dwayne.Roadcap@vdh.virginia.gov

804-864 7522

Office of Drinking Water
Safe Drinking Water for a Healthy Virginia

VDH VIRGINIA DEPARTMENT OF HEALTH
Protecting You and Your Environment

Hazen

Experiences in PFAS Cost of Treatment

Erik Rosenfeldt, PE, PhD

Director of Drinking Water Process Technologies

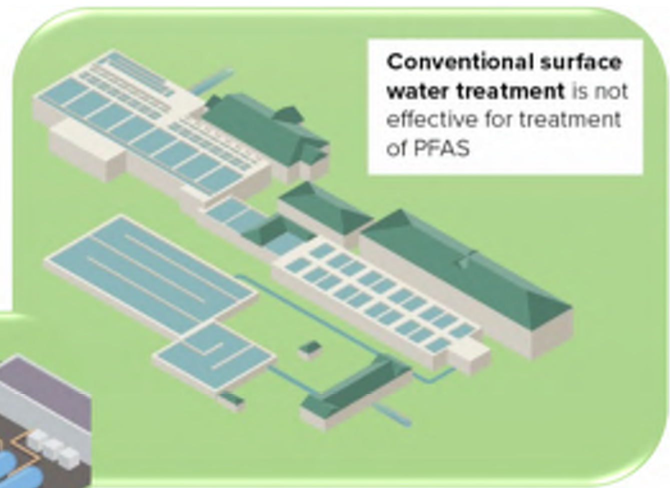
Agenda

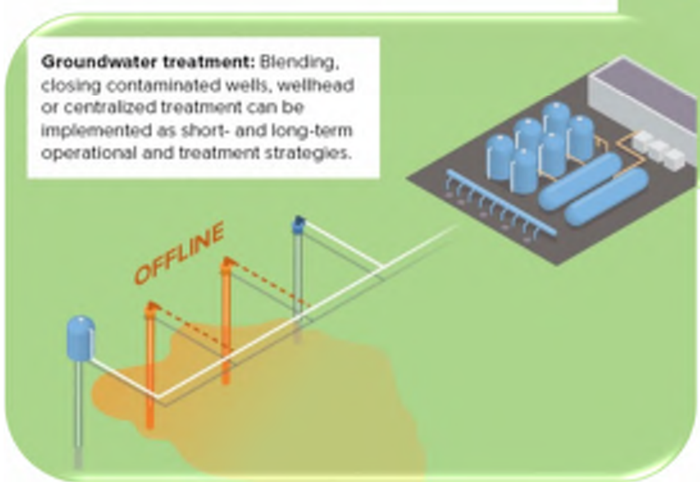
- Introduction
  - **Treatment Technologies for addressing PFAS – PAC, GAC, RO, IX, alternative media, alternative approaches**
    - *Benefits and challenges to implementation*
  - **Examples of "Phased Approaches"**
    - *Piloting to distribution*
    - *"Shutting Down" groundwater wells to achieve treatment*
    - *Phased Implementation of Carbon – PAC → GAC*
- Cost of PFAS treatment systems?
  - **What goes into costs of treatment**
    - *CapX – Design Elements*
    - *OpX – Pumping, media replacement, hidden costs?*
    - *Size, additional treatment needs*
- Case studies

Introduction

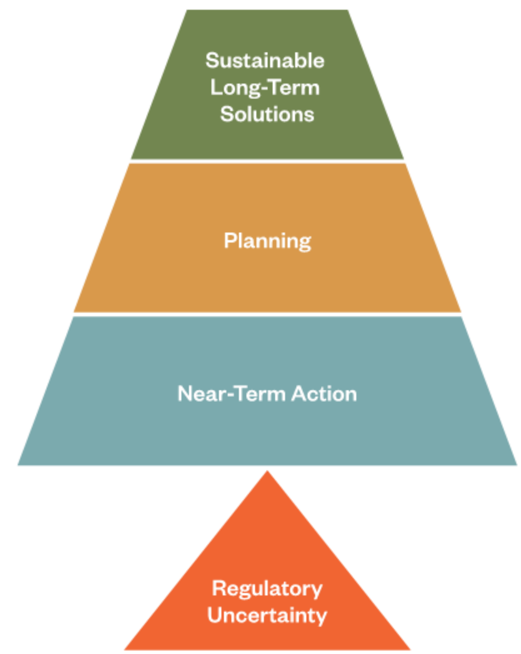
PFAS Treatment Options in Drinking Water

Limited effective technologies…





But opportunities for optimized implementation



Summary of PFAS removals for various treatment processes

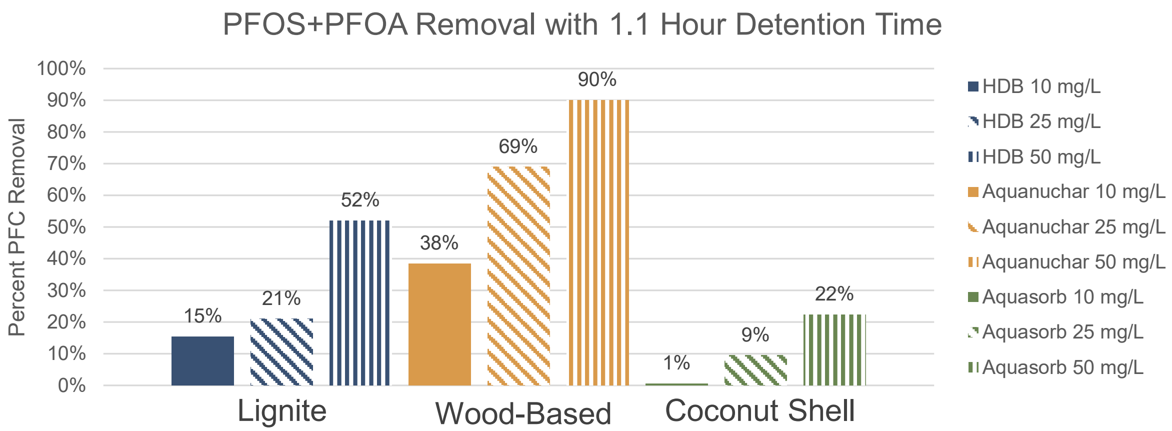
Removal <10%	Removal 10-90%	Removal > 90%

	M.W. (g/mol)	AER	COAG/ DAF	COAG/ FLOC/ SED/ G-or M-FIL	AIX	GAC	NF	RO	MnO4, O3, ClO2, Cl2, CLM, UV, UV-AOP
PFBA	214	Assumed	Assumed						
PFPeA	264								
PFHxA	314								
PFHpA	364								
PFOA	414								
PFNA	464		Unknown		Assumed	Assumed			
PFDA	514		Unknown		Assumed	Assumed			
PFBS	300								
PFHxS	400								
PFOS	500								
FOSA	499	Unknown	Unknown		Unknown	Assumed	Unknown	Assumed	Unknown
N-MeFOSAA	571	Assumed	Unknown		Assumed	Assumed	Assumed		Unknown
N-EtFOSAA	585		Unknown		Assumed	Assumed	Assumed		Unknown

Effective removal of PFAS from source waters depends on target, concentration, raw water quality and other variables (WaterRF 4322)

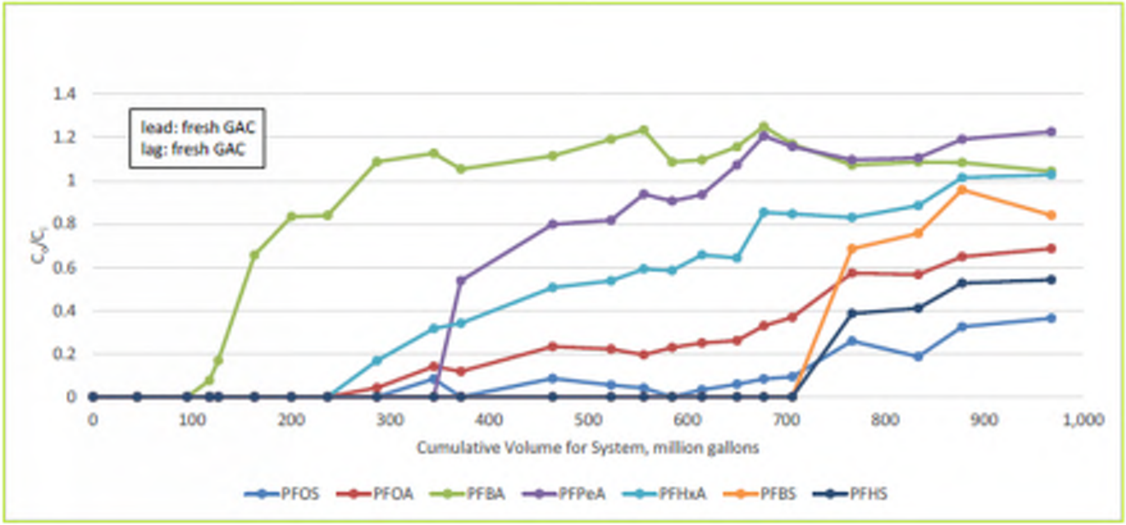
Powdered Activated Carbon Adsorption

- Effective for removal of long chain PFAS (PFOA, PFOS)
- Less effective for short chain PFAS
  - Less affinity
- Requires High PAC doses and extended contact times for efficient removal
- Performance impacted by water quality and type of carbon used
- Questions around fate of PFAS in plant residuals



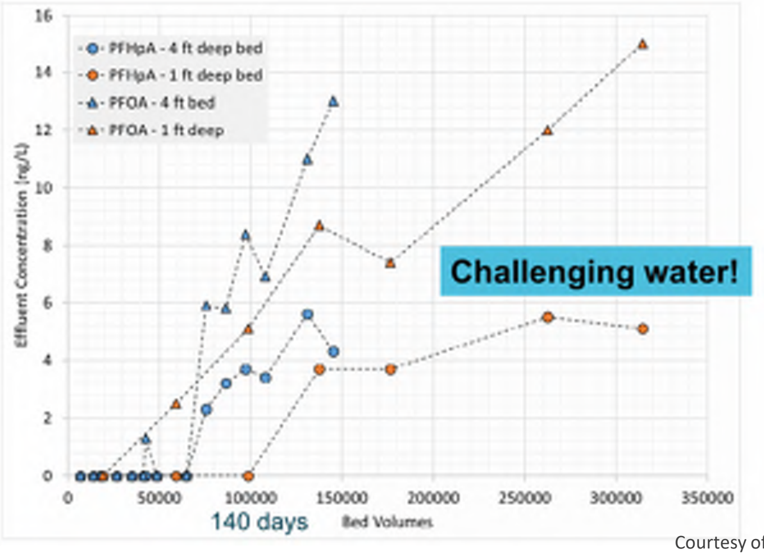
Granular Activated Carbon Adsorption

- Effective for removal of long chain PFAS (PFOA, PFOS)
- Less effective for short chain PFAS
  - Less affinity
  - Breakthrough earlier
  - Carbon usage can be significantly higher
  - Higher O&M costs for GAC regeneration
- Spent Carbon "Reactivation" Possible



Ion Exchange

- PFAS are anions so ion exchange can be effective for removal
- Resin is typically not regenerated at exhaustion due to limitations on discharge
- Typical approach is offsite disposal (incineration)
- Suppliers tout resins selective for PFAS species



Courtesy of Purolite

Reverse Osmosis / Nanofiltration

- High Pressure membranes provide compound exclusion from permeate
- As close to a "complete" PFAS barrier as exists today
- PFAS concentrated in the reject stream, leading to disposal challenges
- "Loose" NF membranes are being examined for short- and long- chain PFAS rejection at reduced O&M

Low Pressure Reverse Osmosis Pilot Data

Parameter	RO Influent (ng/L)	RO Effluent (ng/L)
PFOS +PFOA	18 - 26	ND
PFHxA	19 - 20	ND
PFPeA	16 - 17	ND
PFMOAA	320 - 750	ND – 11
PFO2HxA	12 - 26	ND
GenX	7 - 12	ND
Sum of 45 PFAS tested	423 - 892	ND - 11

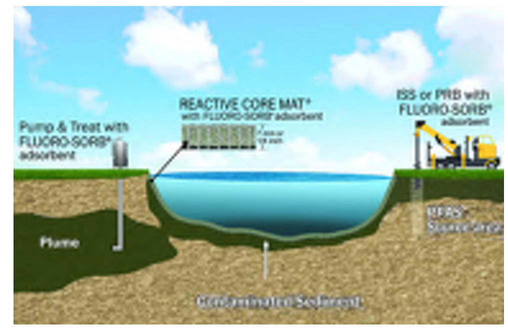
(Data provided in-kind to WRF 4913)

RO concentrate at levels 7 – 10x influent

Comparison of PFAS Removal Technologies

PAC	GAC	Ion Exchange	Reverse Osmosis / Nanofiltration
Effective for removal of long chain PFAS (PFOA, PFOS)	Effective for removal of long chain PFAS (PFOA, PFOS)	Effective for removal of long chain PFAS (PFOA, PFOS)	Effective barrier to PFAS and *almost all* additional CECs
Less effective for short chain PFAS	Less effective for short chain PFAS	More effective for short chain PFAS	High energy use
Many facilities may already have PAC	Effective Removal of many CECs	PFAS Specificity a blessing and a curse	Disposal challenges of highly concentrated PFAS reject stream
High doses of PAC required	Media can be reactivated and put back into service	No media regeneration process	
Long contact time ideal	EBCT required ~ 10 – 15 minutes	EBCT ~ 2 – 4 minutes	
Variable PAC performance (water quality and carbon)			
Impacts to solids handling?			

Novel / Alternative Media



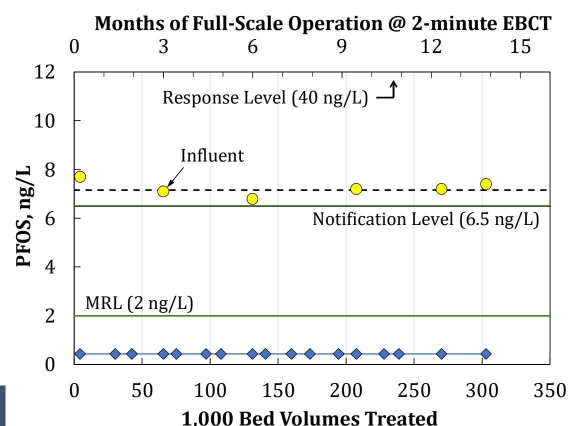
https://www.mineralstech.com/business-segments/performance-materials/cetco/environmental-products/products/fluoro-sorb

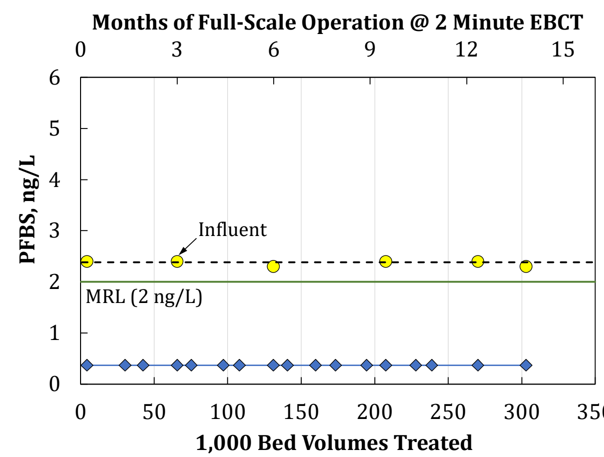
Benefits

- Similar EBCT as IX but potentially lower cost
- NSF Certified

Drawbacks

- Limited industry track record
- Testing necessary

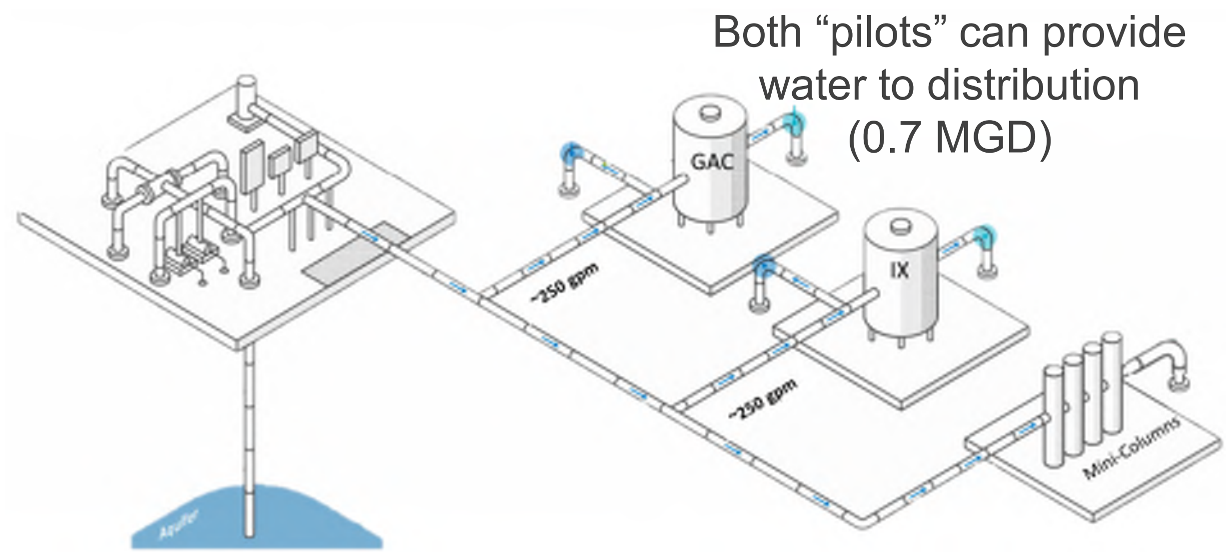


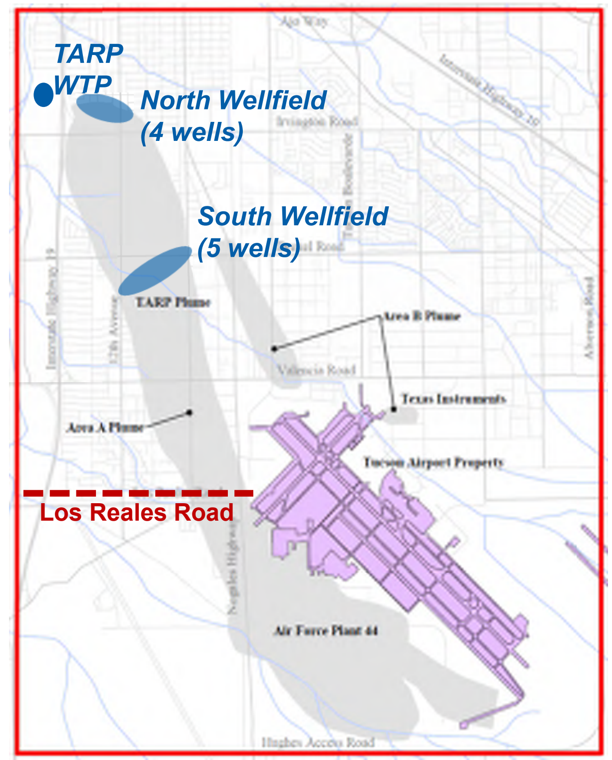


Examples of Phased Approach

“Piloting” Groundwater Technology while meeting demands

Both “pilots” can provide water to distribution (0.7 MGD)





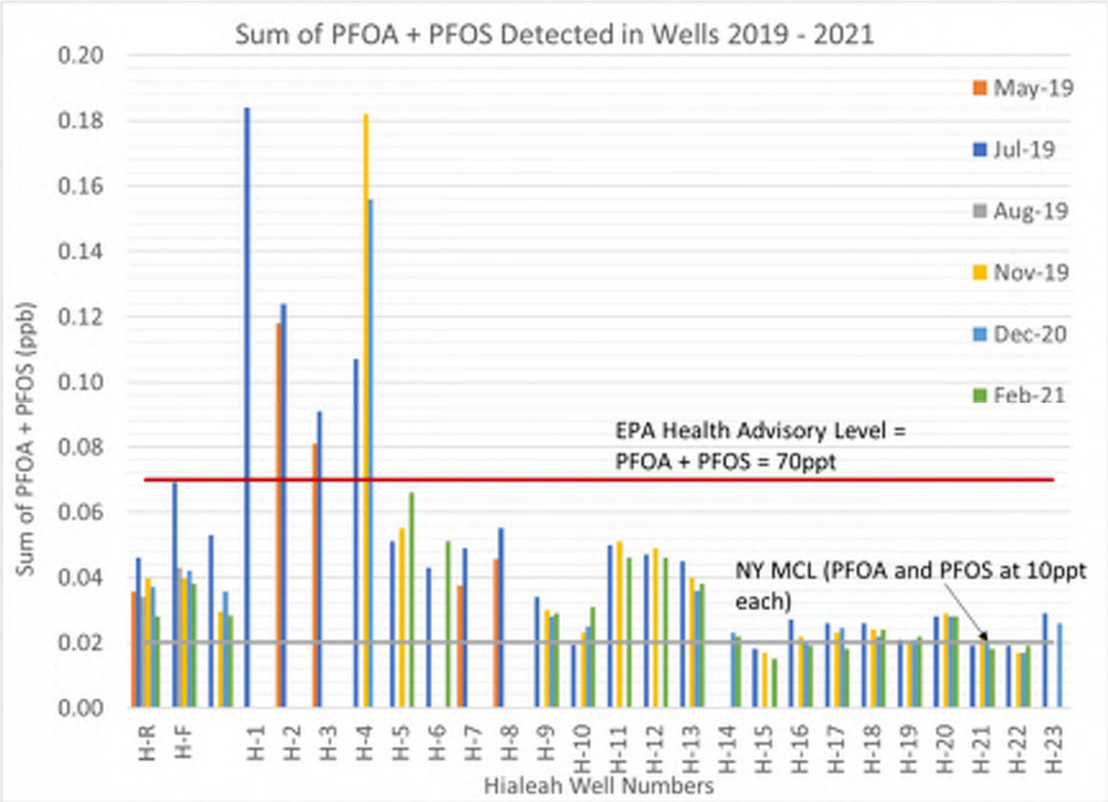
TARP =
Tucson International Airport
Area Groundwater Remediation

Examples of Phased Approach

Short-term blending or removing wells from service to achieve PFAS limits

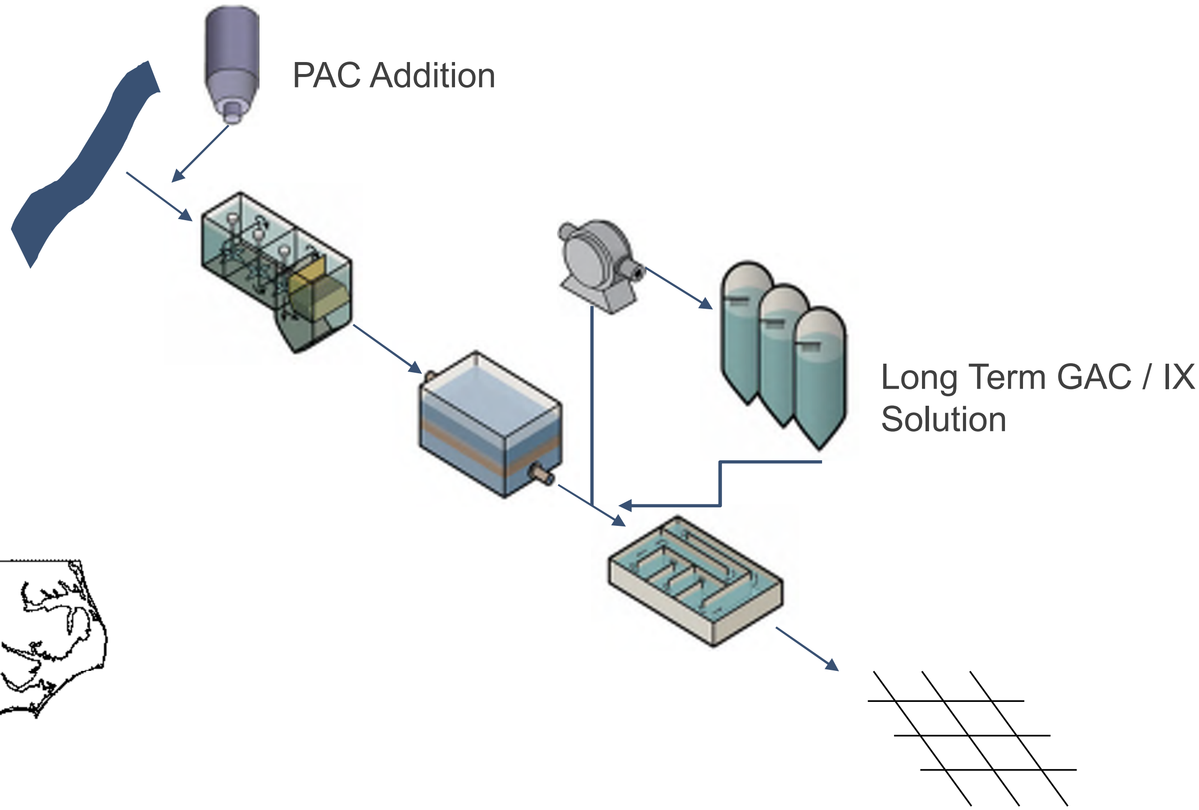
- 60 – mgd groundwater plant
- Served by 23 large wells (> 3 mgd each)
- H-1 – H-4 largely impacted by PFAS
- H-14 – H-23 are highest water quality

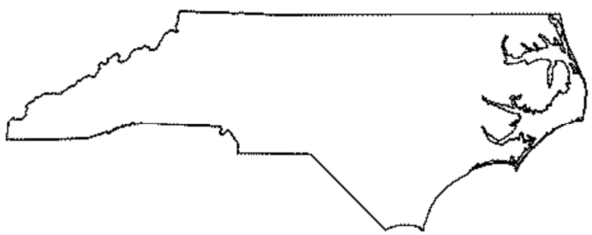
- *Upon observing this trend, utility removed wells H-1 – H-3 from service, dramatically reducing finished water PFOA + PFOS from 68ppt - ~40ppt*



Examples of Phased Approach

- Conventional Treatment Plant
- Detected Elevated PFAS
- Install more PAC capacity and more effective delivery
- Within 5 years, implement GAC or IX technology for PFAS removal





Cost Factors

What goes in to cost of treatment evaluations

Capital Cost

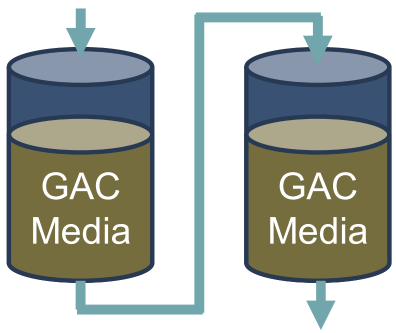
- Cost of Equipment
- Cost of Pumping Facilities!
- Cost of Facility – concrete pad, building?
- Cost of supporting facilities
  - **Chemical systems**
  - **Yard piping**
  - **Site Work**
  - **Electrical, I&C**
- Cost of residuals / concentrate handling
- How to handle potential cost of lost infrastructure?

Operating Cost

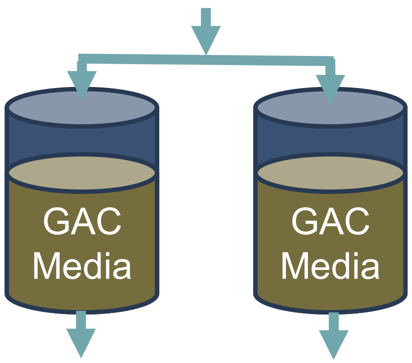
- Cost of media / element replacement
  - **Water quality**
- Cost of pumping
- Cost of sampling
  - **Ex 1: Small System with 1 impacted wells**
    - *3 PFAS samples every 2 weeks (raw, after lead, finished).*
    - *At $250/sample this is $19,500/year*
  - **Ex 2: Larger System with 8 trains**
    - *1 "raw", 1 "finished" and 8 "intermediate"" (after lead) samples. Sample every 2 weeks.*
    - *At $250/sample this is $65,000 / year*
- Cost of media disposal (if necessary)
- Cost of residuals or concentrate handling

Vessel Configuration – GAC or IX

Lead-Lag (Series) Vessels



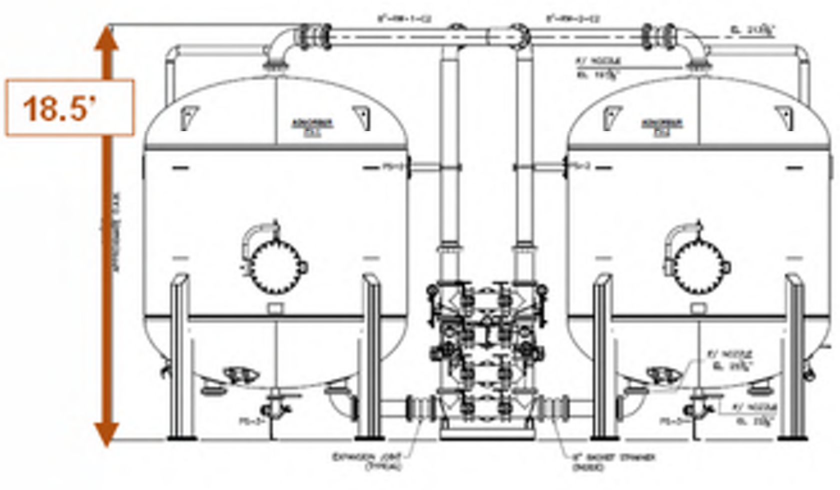
Parallel Vessels



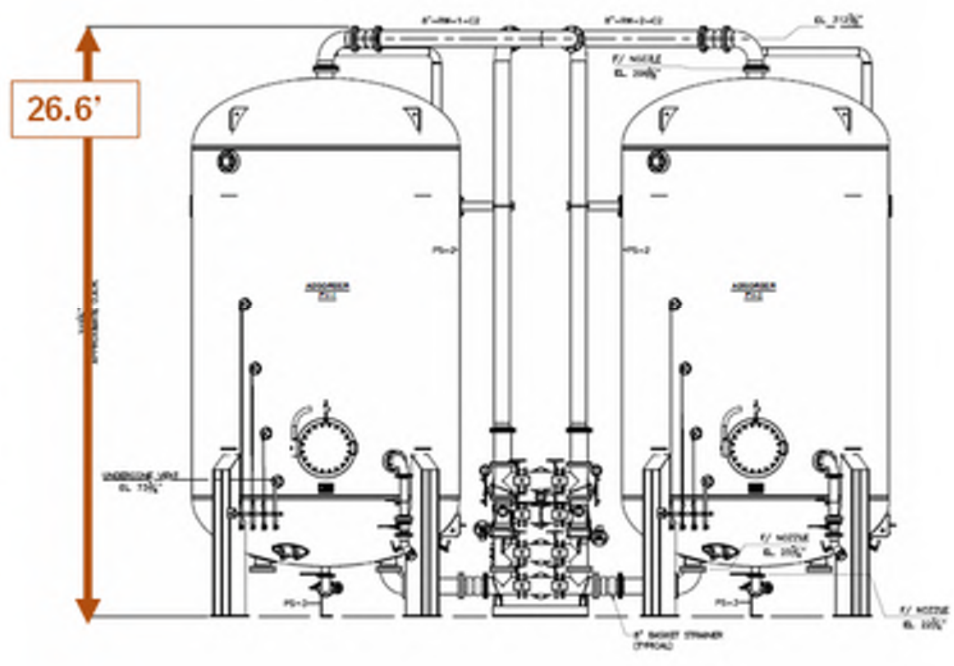
	Lead-Lag	Parallel
Pros	• Allows for longer EBCT • Full media utilization • No down time • Potential to reduce sampling frequency	• Less vessels needed • Lower capital cost • Lower footprint
Cons	• More vessels needed • Higher pressure loss • Higher capital cost • Higher footprint	• Special permitting • Risk of contaminant breakthrough • Down time (media replacement)

System Heights

Calgon (20k lb, 12 ft diam.)



Calgon (40k lb, 12 ft diam.)



What goes in to cost of treatment evaluations

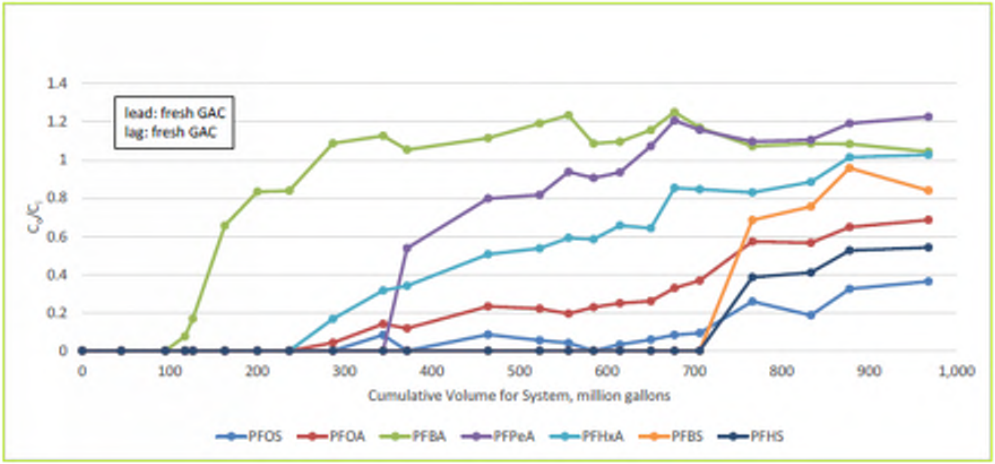
Capital Cost

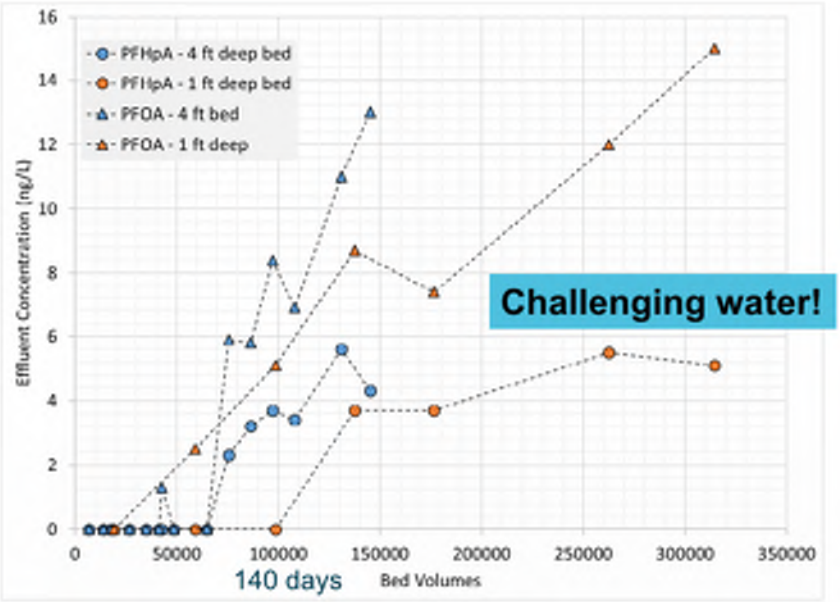
- Cost of Equipment
- Cost of Pumping Facilities!
- Cost of Facility – concrete pad, building?
- Cost of supporting facilities
  - **Chemical systems**
  - **Yard piping**
  - **Site Work**
  - **Electrical, I&C**
- Cost of residuals / concentrate handling
- How to handle potential cost of lost infrastructure?

Operating Cost

- Cost of media / element replacement
  - **Water quality**
- Cost of pumping
- Cost of sampling
  - **Ex 1: Small System with 1 impacted wells**
    - *3 PFAS samples every 2 weeks (raw, after lead, finished).*
    - *At $250/sample this is $19,500/year*
  - **Ex 2: Larger System with 8 trains**
    - *1 "raw", 1 "finished" and 8 "intermediate'" (after lead) samples. Sample every 2 weeks.*
    - *At $250/sample this is $65,000 / year*
- Cost of media disposal (if necessary)
- Cost of residuals or concentrate handling

GAC or IX? Media selection is a big challenge

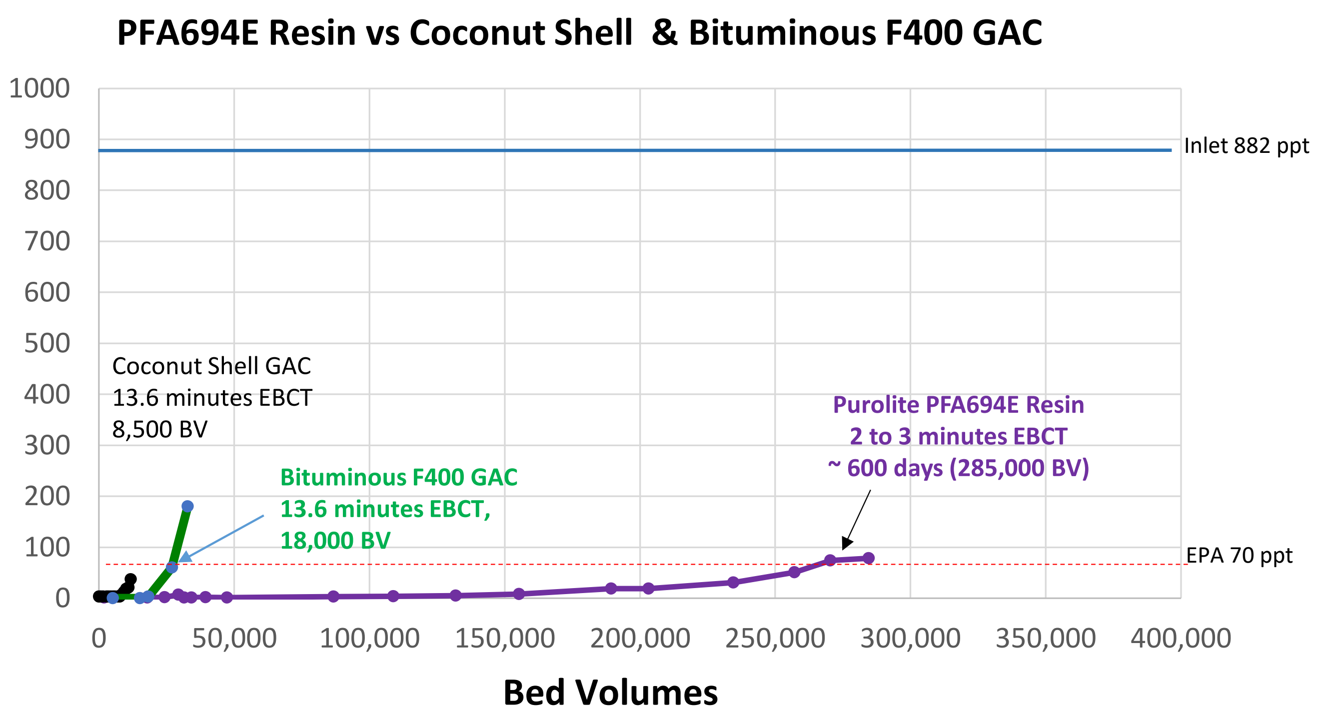




Hazen

Comparing IX and GAC not straight forward

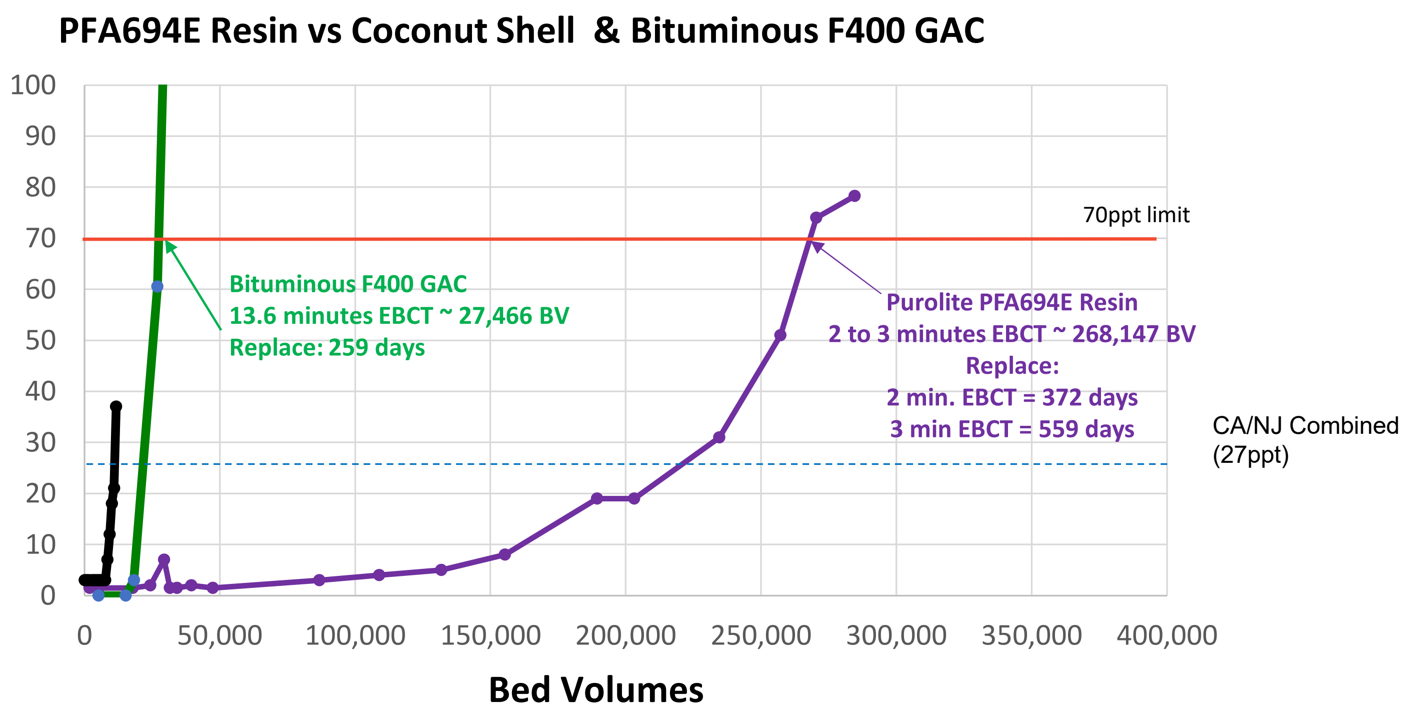
Here's what their data shows when they describe it…



Hazen

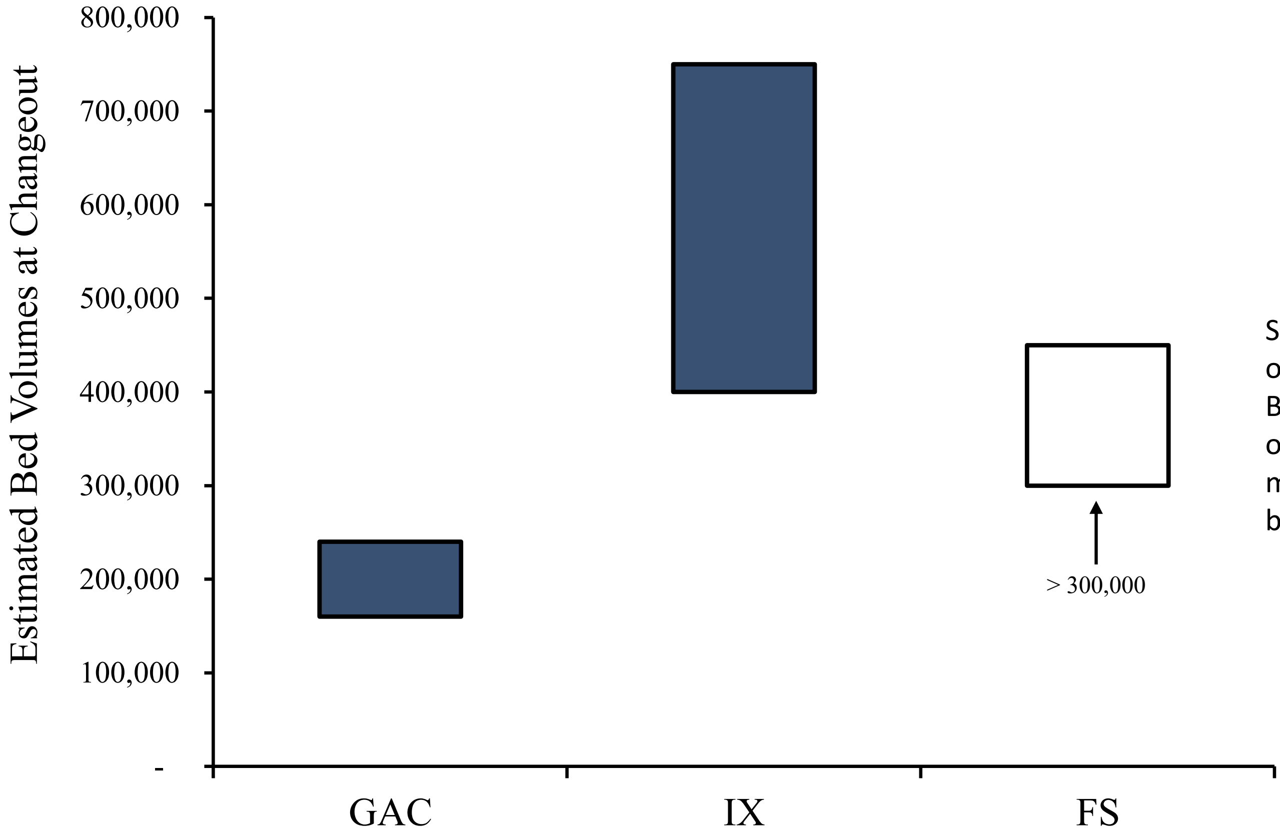
Comparing IX and GAC not straight forward

Here's the same data as I see it...



Water Quality can significantly impact performance of each

Example Comparison of Media Performance (based on PFOS)



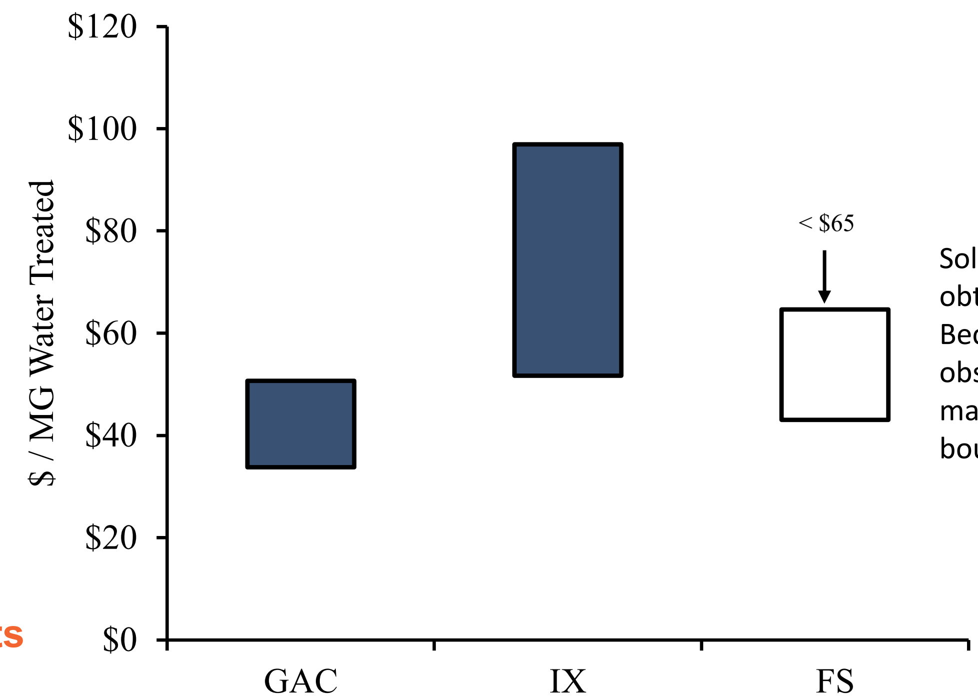
Solid bars represent error bars obtained from bench testing (GAC, IX). Because breakthrough was not observed for FS, lower bound is the maximum BV tested with an upper bound of +50% BV.

Translating Bed Volumes to O&M Costs

- Although GAC would have much shorter BV, the media has a lower cost than IX or FS

Media Replacement Cost

	$ per cubic foot
GAC	$61
IX	$290
FS	$145



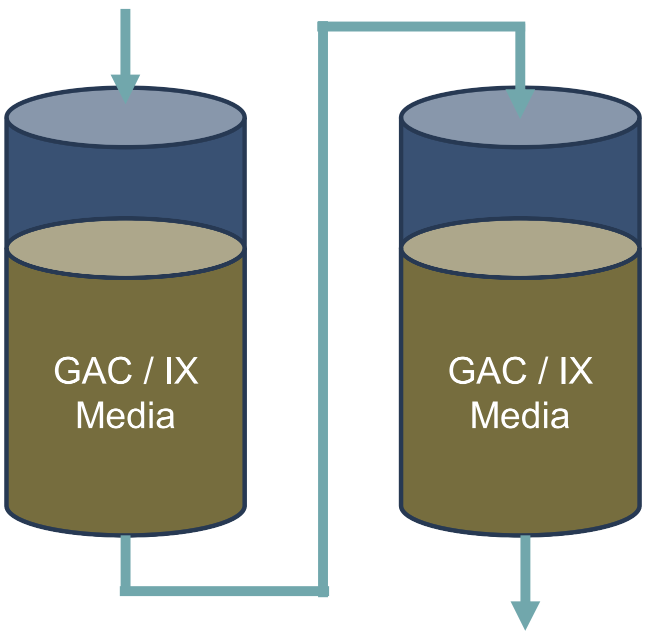
Solid bars represent error bars obtained from bench testing (GAC, IX). Because breakthrough was not observed for FS, upper bound is the maximum BV tested with a lower bound of +50% BV.

Disposal Costs are also important factors in O&M costs

Cost of sampling

- Why monitor breakthrough?
  - **Regulatory Requirement**
  - **Optimize media replacement / regeneration**
- In order to effectively monitor breakthrough, best to monitor at least 3 locations in each lead/lag train
  - **Inlet**
  - **After the lead vessel**
  - **After the lag vessel**
- PFAS monitoring takes time (often 2 – 3 week sample turnaround) and can be expensive
- Example Cost of sampling
  - **Ex 1: Small System with 1 impacted wells**
    - *3 PFAS samples every 2 weeks (raw, after lead, finished).*
    - ***At $250/sample this is $19,500/year***
  - **Ex 2: Larger System with 8 trains**
    - *1 "combined raw", 1 " combined finished" and 8 "intermediate"' (after lead) samples. Sample every 2 weeks.*
    - ***At $250/sample this is $65,000 / year***

Lead-Lag (Series) Vessels



Cost of Media Disposal

EPA moves to regulate PFAS as “hazardous waste” has created a challenge for media disposal for utilities

Alabama GAC Example

2018 Information

Original quotes from 2 incinerators

- **Vendor A: $200/ton**
- **Vendor B could match**

2021 Information

Updated quotes from 2 incinerators

- **Vendor A: $800/ton**
- **Vendor : No longer accepting GAC**

Client had to rethink entire GAC procurement strategy and entered into a Custom Reactivation agreement with Calgon Carbon including a “Swing Load” for improved speed of replacement

California Media Challenges

- **GAC reactivation not allowed**
- **Incinerators have modified their waste IX media acceptance practices**
  - *Calgon – prices have increased significantly*
  - *Covanta – stopped accepting IX due to concerns about transfer of PFAS to air*
  - *Clean Harbors – will accept IX media so far and appreciates the relatively high heaving value (IX > GAC > Alternate Media)*

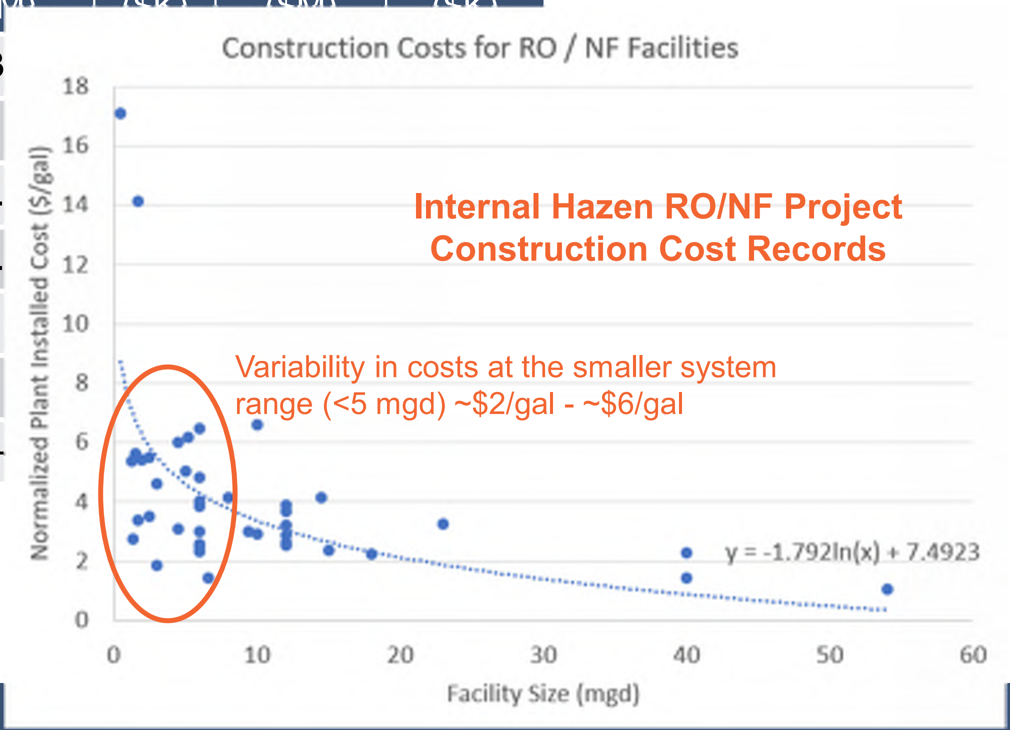
Costing Case Studies

Case Study Cost Summary

Project Location	GAC		IX		RO/NF	
	CapX ($M)	O&M ($K)	CapX ($M)	O&M ($K)	CapX ($M)	O&M ($K)
Alabama (10 mgd)	9.0	650	13.0	400	33	2,700
Alabama (6 mgd partial)	4.2					
New Mexico (2 mgd)	4.5	88	3.3	126		
New Mexico (200 gpm)	2.7	76	1.0	72		
New York (40 gpm)	1.0	25				
California (6.2 mgd)	15.0	100	11.1	200		
Massachusetts (2 mgd)	2.5 – 3.4	45	2.0 – 2.5	85		

Case Study Cost Summary

Project Location	GAC		IX		RO/NF	
	CapX ($M)	O&M ($K)	CapX ($M)	O&M ($K)	CapX ($M)	O&M ($K)
Alabama (10 mgd)	9.0	650	13			
Alabama (6 mgd partial)	4.2					
New Mexico (2 mgd)	4.5	88	3.			
New Mexico (200 gpm)	2.7	76	1.			
New York (40 gpm)	1.0	25				
California (6.2 mgd)	15.0	100	11			
Massachusetts (2 mgd)	2.5 – 3.4	45	2.0 –			

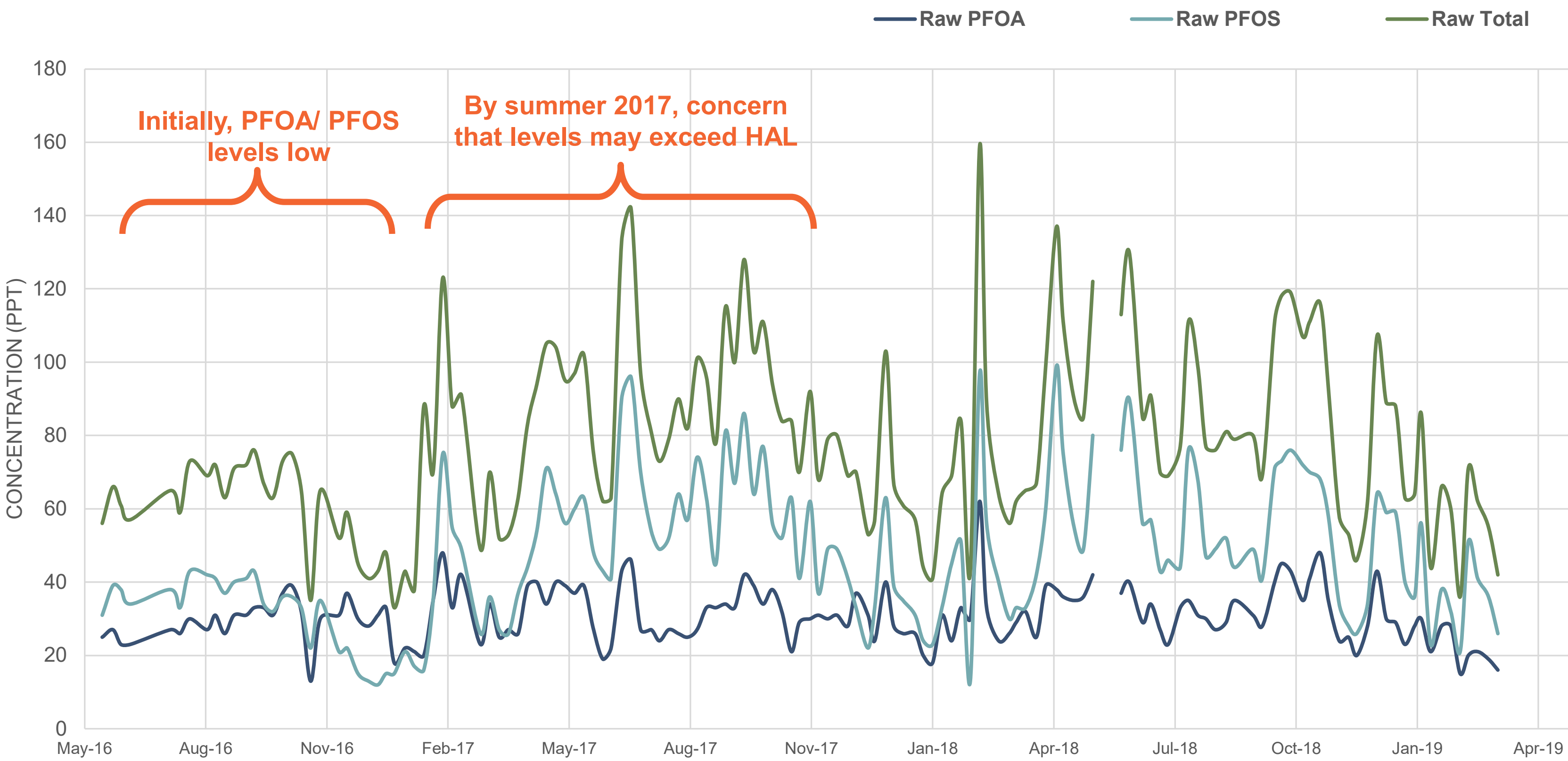


Alabama

Case Study 1

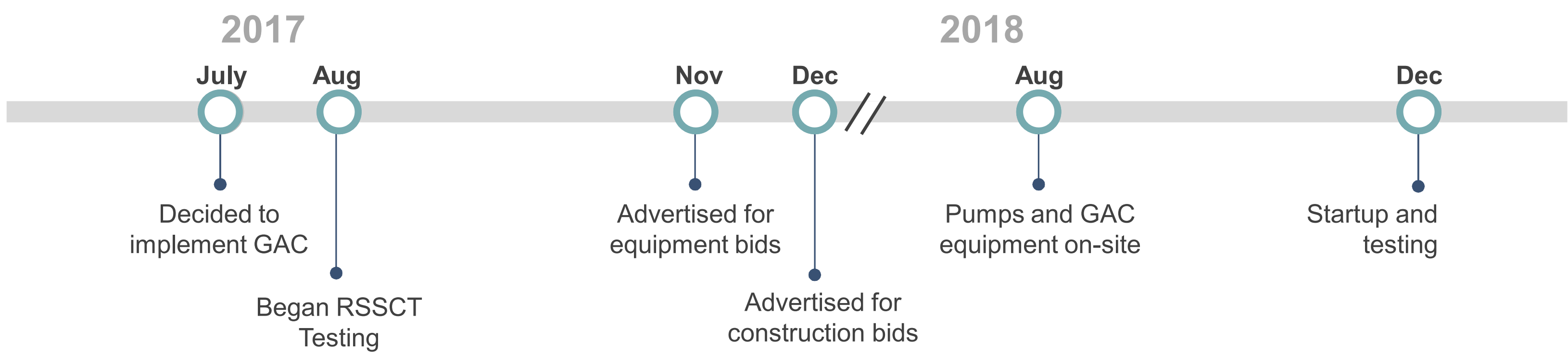
- 24 MGD Plant
- River water source
- River contamination from upstream carpet manufacturers
- Target Treatment:
  - **Achieve Running Average of Less than Federal HAL – 70 ppt**
  - **“Partial Treatment” and Blend to achieve PFAS targets**

Source Water PFOA and PFOS Levels



Project Schedule

✓Detailed Design completed in 4 months
✓On-line in 18-months



GAC Adsorption Basis of Design

Design Criteria	Value
GAC System Capacity	6 mgd
Total Number of Contactors	8
Number of Lead-Lag Pairs	4
Flow per Pair of Contactors	1.33 mgd
Empty Bed Contact Time (minutes)	20
Minimum GAC Capacity per Contactor	40,000 lbs

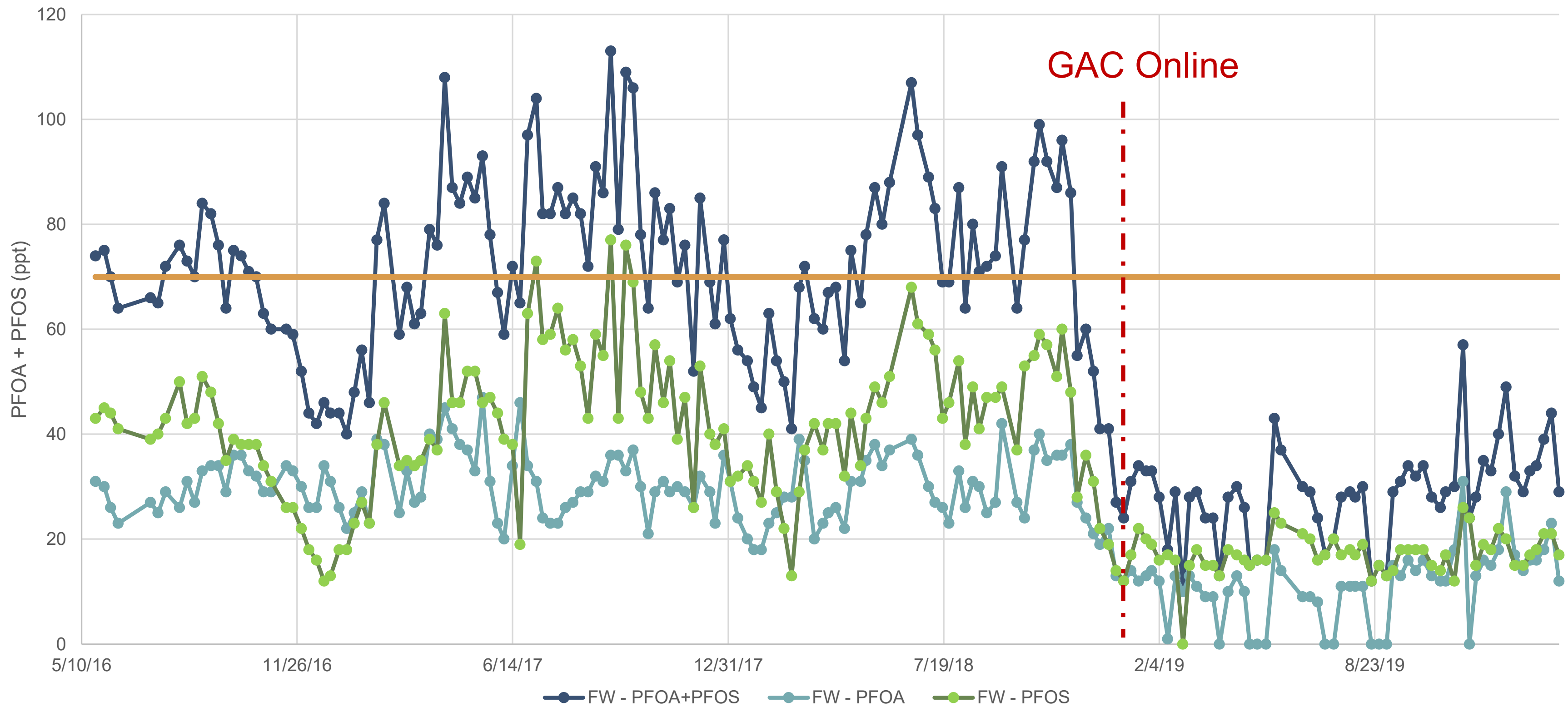
Phase 1 GAC Facility Project Costs

6 mgd capacity

GAC Facility Construction	$2,713,500
GAC Contactors and Media	$1,228,900
Intermediate Pumps and VFDs	$205,200
Total Construction Cost	**$4,147,600**
Engineering and Design	$705,600
Total Project Cost	**$4,853,200**
Unit Cost (per gpd)	**$0.81/ gpd**

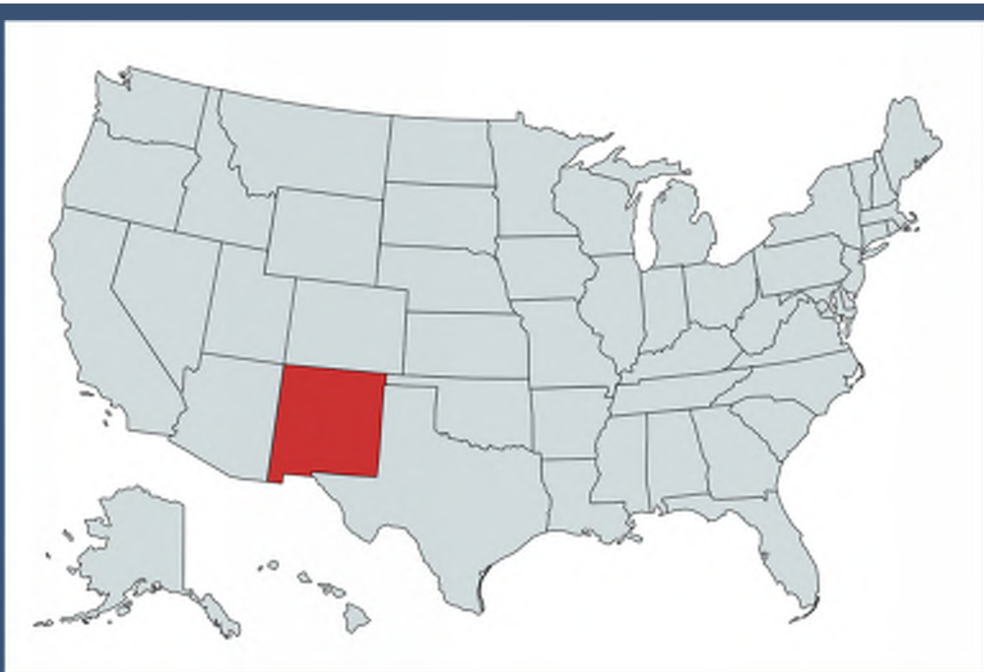
GAC Adsorption for PFOA and PFOS Control

Full-Scale Data from WTP in Alabama, Partial Treatment



“Long-term” Technology Comparison

	Benefits	Drawbacks	Cost
GAC	• Removal of most PFASs • Removal of other chemical constituents • DBP precursor reduction	• Carbon replacement costs can be costly • Need to consider breakthrough time and regeneration cycles	$9M for 10 MGD $0.7 M/year O&M
Ion Exchange	• Proven PFOA/PFAS removal • Potential for removal of short chain PFASs	• Single use of resin • More costly per unit than GAC • Competing ions may affect performance • Limited removal of other contaminants • Resin disposal	$13M for 10 MGD $0.4 M/year O&M
Reverse Osmosis	• Proven PFOA/PFAS removal • Removal of other chemical constituents • DBP precursor reduction	• Most costly option • RO recovery – lose portion of WTP capacity • Biofouling with surface water is key concern • RO concentrate disposal/permitting	$33M for 10 MGD $2.7 M/year O&M



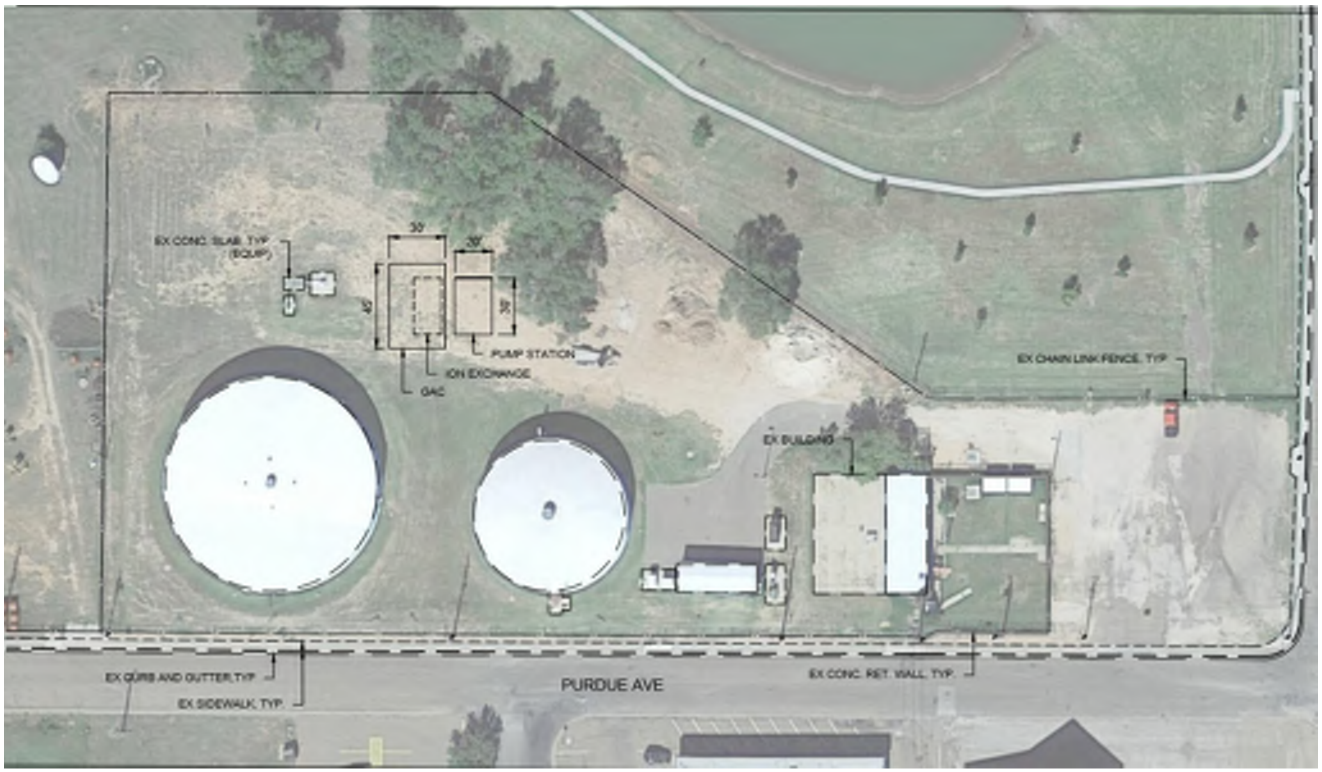
New Mexico

Case Study 2

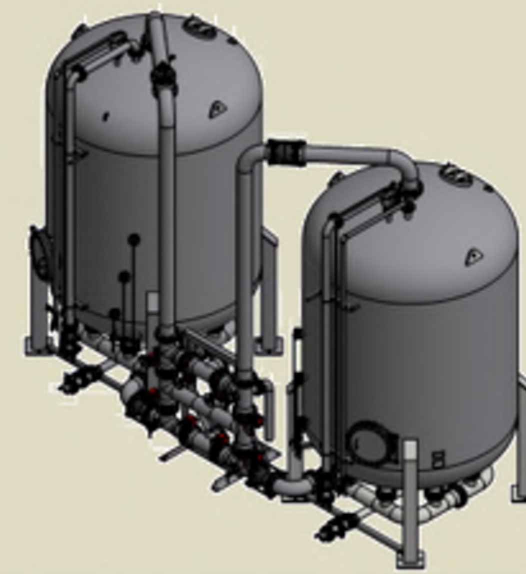
- 2 MGD Treatment Plant
- Groundwater source
  - **> 70 wells ranging in size from 40 gpm – 200 gpm**
- Contamination from upgradient airforce base
- Target Treatment:
  - **Achieve PFAS concentration less than 5 ppt**
- Questions to answer
  - **Technology Selection**
  - **Effective Treatment Approach (Centralized vs. Wellhead)**

Centralized versus Wellhead Treatment Approach

Single 2-MGD Centralized System

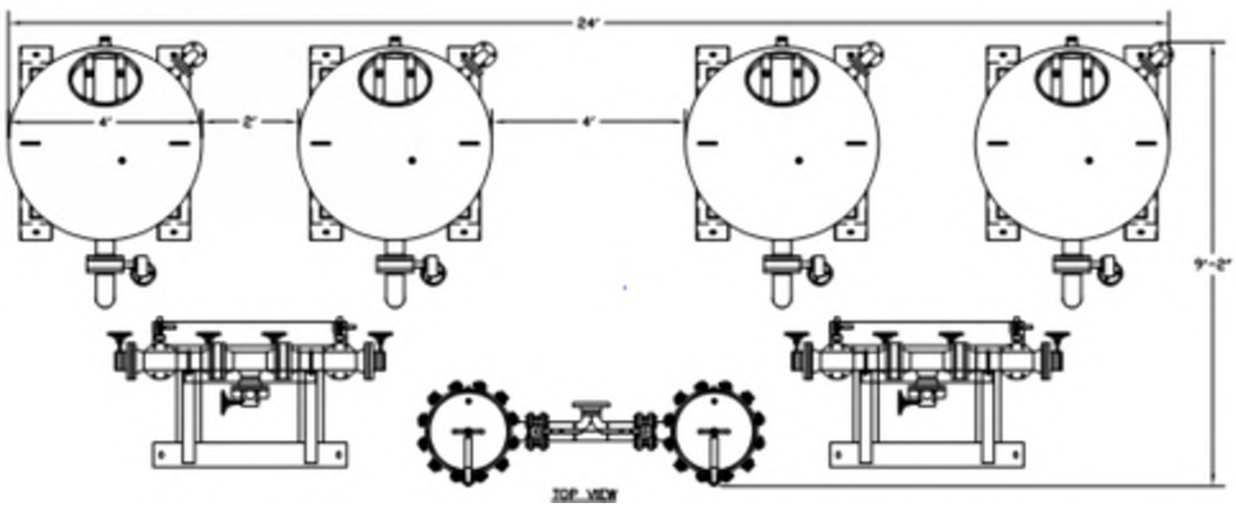


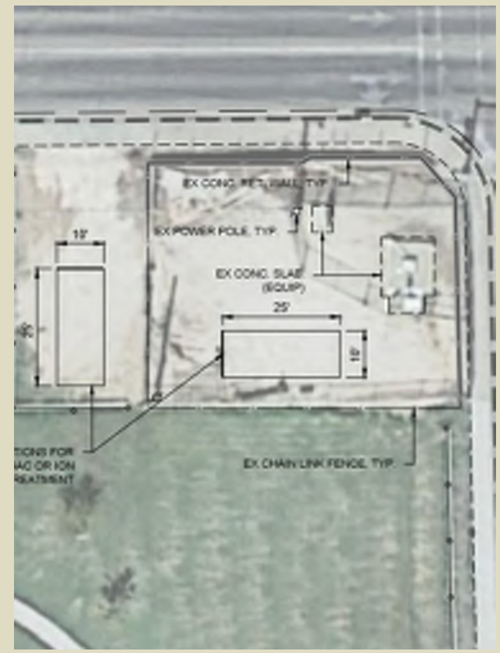
Led Lag GAC or IX
GAC 2 Trains (4 vessels) 12’ Diam.
IX – 3 Trains (6 vessels) 10’ Diam.



Centralized versus Wellhead Treatment Approach

Individual Wellhead Treatment





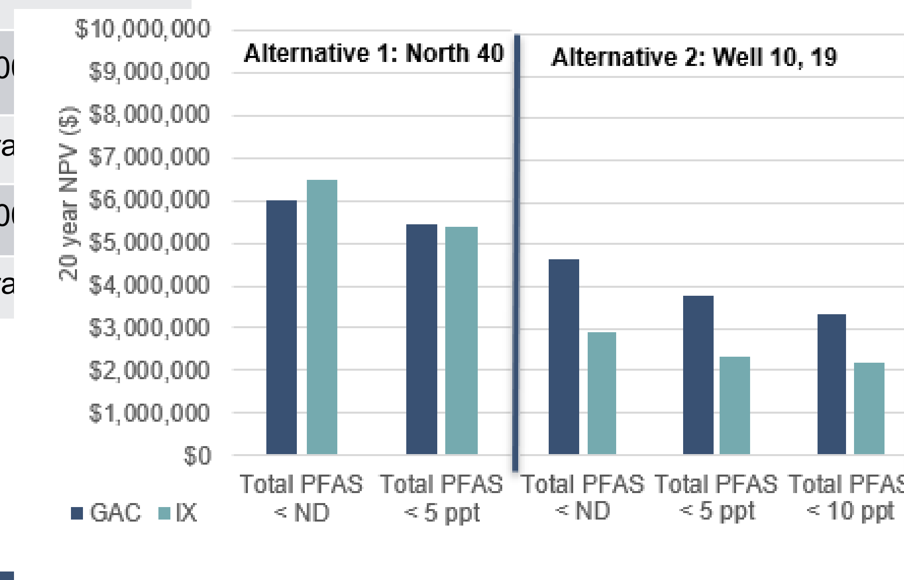
Cost Comparison for the approaches

Alternative	Treatment Strategy[1,2]		ΣPFAS < 5 ng/L
Alternative 1: 2 mgd	GAC	Construction Cost	$4,540,000
		Annual O&M	$88,000
	IX	Construction Cost	$3,286,000
		Annual O&M	$126,000
Alternative 2: 200 gpm	GAC	Construction Cost	$2,668,000
		Annual O&M	$76,000 + operating rules
	IX	Construction Cost	$1,017,000
		Annual O&M	$72,000 + operating rules

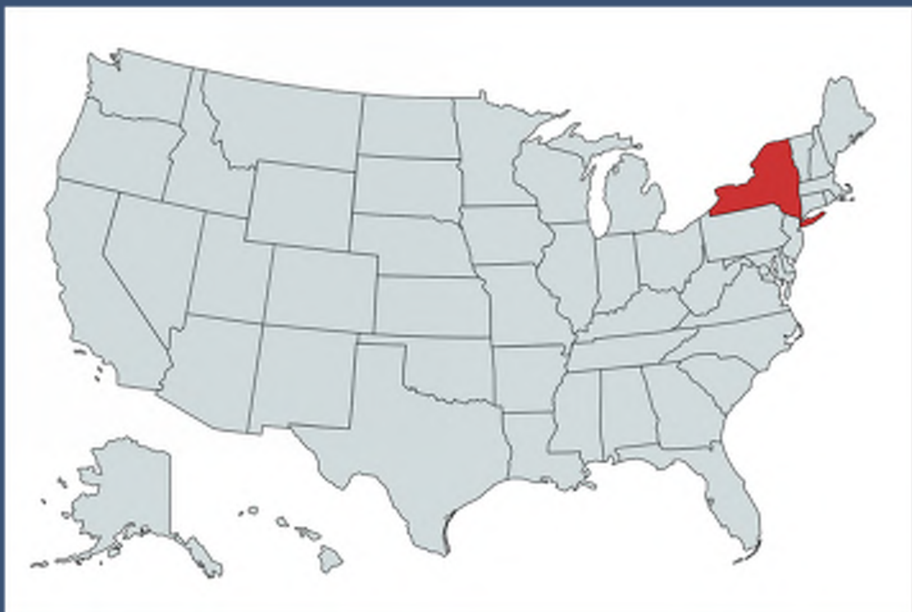
Big difference in appropriate technology selection at 200 gpm scale compared to 2 mgd scale

Cost Comparison for the approaches

Alternative	Treatment Strategy[1,2]		ΣPFAS < 5 ng/L
Alternative 1: 2 mgd	GAC	Construction Cost	$4,540,000
		Annual O&M	$88,000
	IX	Construction Cost	$3,286,000
		Annual O&M	$126,000
Alternative 2: 200 gpm	GAC	Construction Cost	$2,668,0
		Annual O&M	$76,000 + opera
	IX	Construction Cost	$1,017,0
		Annual O&M	$72,000 + opera



Big difference in appropriate technology selection at 200 gpm scale compared to 2 mgd scale



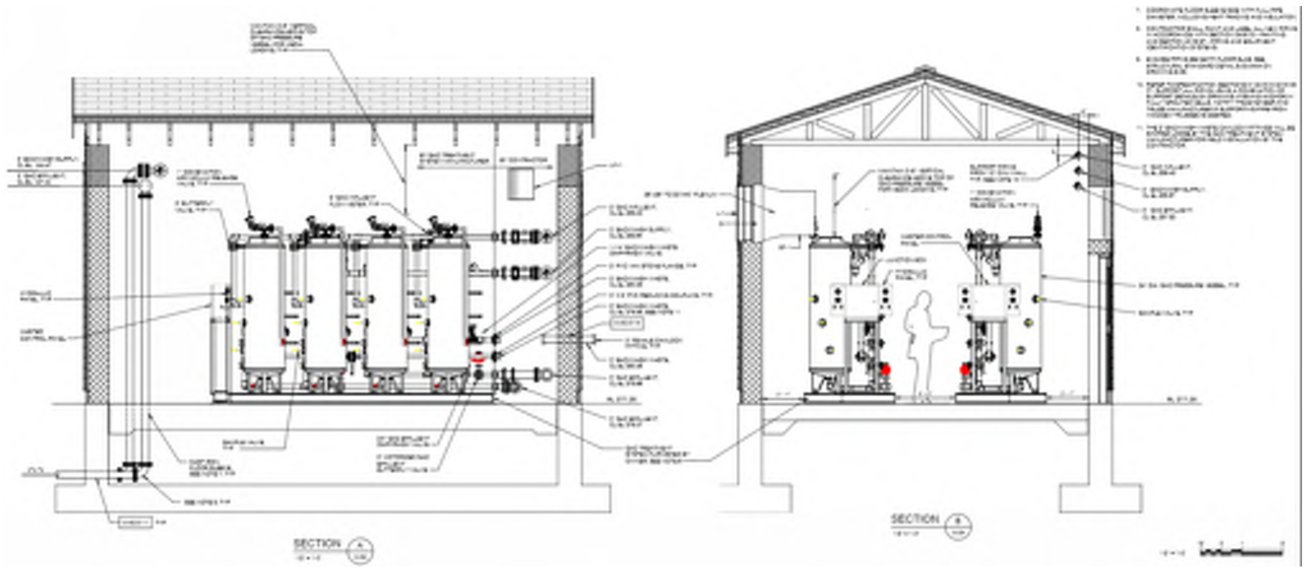
New York

Case Study 3

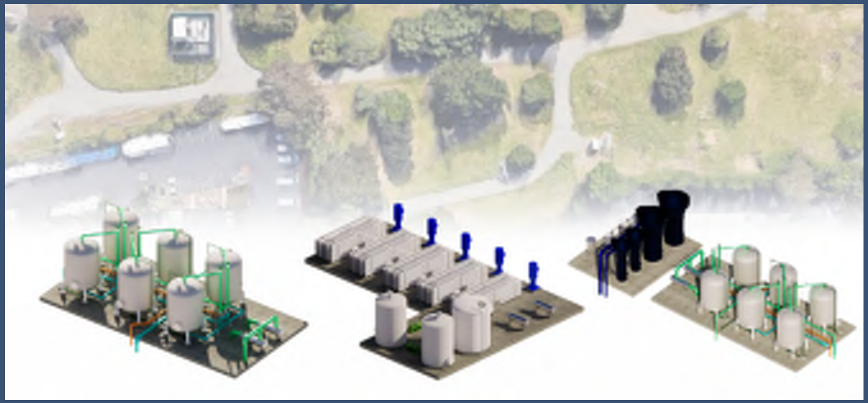
- 40 gpm Treatment Plant Upgrade
- Groundwater source
  - Combined wells sum to 40 gpm
  - Typically operated at 21 gpm
- Contamination from regional industrial contamination
- Target Treatment:
  - Achieve PFOA and PFOS concentration less than 10 ppt each

Case Studies

40 gpm GAC – NY GW



Unit	Quantity	Engineer's Base Estimate		Construction Company A			Construction Company B			Construction Company C			Construction Company D		
		Unit Price	Total Price	Unit Price Bid	Total Bid Price	Deviation from Engineer's Base Estimate	Unit Price Bid	Total Bid Price	Deviation from Engineer's Base Estimate	Unit Price Bid	Total Bid Price	Deviation from Engineer's Base Estimate	Unit Price Bid	Total Bid Price	Deviation from Engineer's Base Estimate
LS	1	$996,120.00	$996,120.00			9%			12%			20%			19%
ALLOW	1	$6,075.00	$6,075.00			0%			0%			0%			0%
ALLOW	1	$3,925.00	$3,925.00			0%			0%			0%			0%
			$1,006,100.00			9%			12%			20%			19%
LS	1	N/A	N/A			N/A			N/A			N/A			N/A
LS	1	N/A	N/A			N/A			N/A			N/A			N/A
			$1,006,100.00		$1,128,413.00	12%		$1,135,000.00	13%		$1,229,890.00	22%		$1,232,878.00	23%
			$1,006,100.00		$1,128,413.00	12%		$1,135,000.00	13%		$1,229,890.00	22%		$1,319,629.00	31%



California

Case Study 4

- 6 mgd Treatment System
- Groundwater source
  - **Needs to meet multiple treatment criteria (PFAS, Iron, etc.)**
- Contamination from airport / industry
- Target Treatment:
  - **Achieve PFOA, PFOS, PFBS concentration less than Notification Limits**
    - *PFOA = 5.1 ppt*
    - *PFOS = 6.5 ppt*
    - *PFBS = 500 ppt*

GAC vs IX/FS Footprint per 5,000 gpm (~ 7 mgd)

GAC TREAMENT
(10: 12ft vessels)

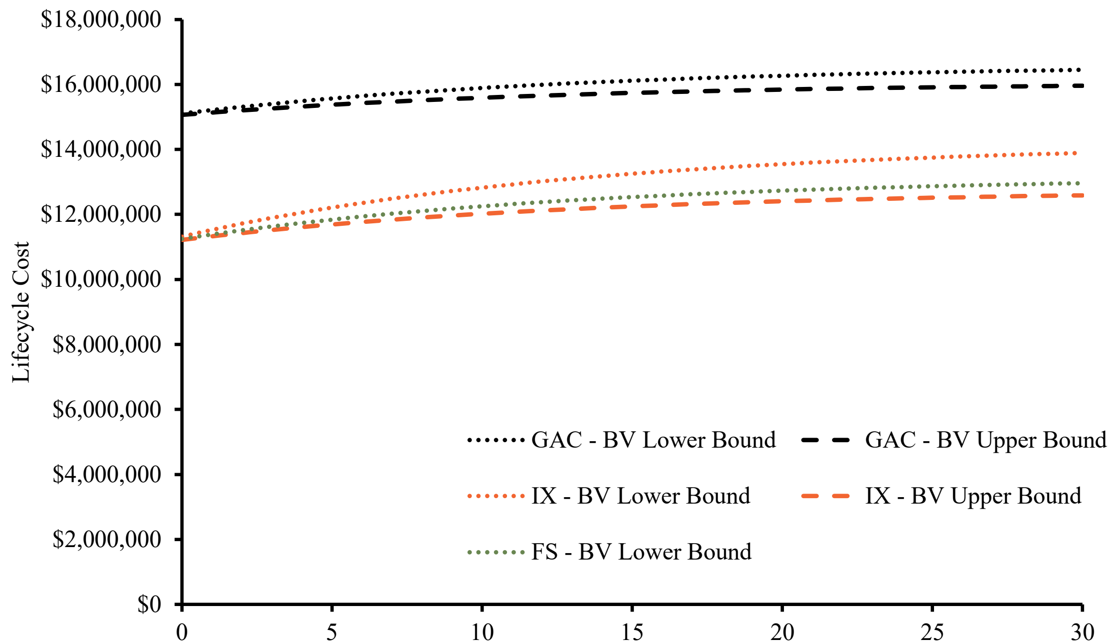
IX/FS TREAMENT
(6: 12ft vessels)

Lifecycle Cost Comparison (7.2 MGD)

- Capital:

	Equipment	Project
GAC	$5.55M	$15.0M
IX / FS	$4.11M	$11.1M

- Asset Life: 30 years
- Discount Rate: 7.64%

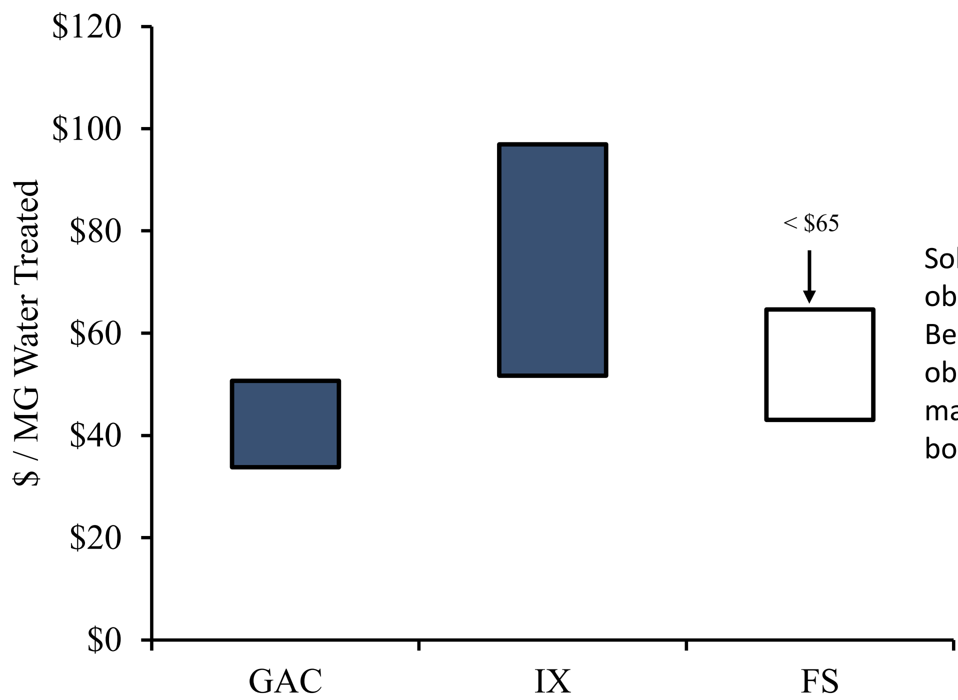


Lower capital and lifecycle cost for IX and FS compared to GAC

Translating Bed Volumes to O&M Costs

- Although GAC would have much shorter BV, the media has a lower cost than IX or FS

	$ per cubic foot
GAC	$61
IX	$290
FS	$145



Solid bars represent error bars obtained from bench testing (GAC, IX). Because breakthrough was not observed for FS, upper bound is the maximum BV tested with a lower bound of +50% BV.

Cost Estimate

PFAS treatment accounts for ~33% of the project's construction costs

Description	No Greensand	With Greensand
Demolition	$200,000	$200,000
Booster Pump	$1,300,000	$1,300,000
Break Tank	$1,800,000	$1,800,000
Greensand Filters	$0	$3,900,000
Cartridge Filters	$1,400,000	$900,000
Ion Exchange/FS	$11,100,000	$11,100,000
IX/FS Feed Pump Station	$300,000	$300,000
Weak Acid Cation IX	$13,000,000	$13,000,000
Decarbonator	$1,900,000	$1,900,000
Electrical Building	$500,000	$500,000
Site Work	$700,000	$700,000
Yard Piping	$3,300,000	$3,300,000
Electrical and Instrumentation	$3,000,000	$3,500,000
PROBABLE CONSTRUCTION COST	**$38,500,000**	**$42,400,000**
Project Costs (Design & ESDC, PM, CM, Legal)	$11,600,000	$12,800,000
PROBABLE PROJECT COST	**$50,100,000**	**$55,200,000**

Massachusetts

Case Study 5

- "Supplemental" Well supplies – 1 mgd each
- Treatment of 2 groundwater wells
  - **Additional Water Quality Challenges (Fe/Mn)**
  - **Combine treatment?**
  - **Well pumping restrictions**
- Target Treatment:
  - **Achieve Compliance with "Massachusetts 6" < 20 ppt**

Best Available Technology (BAT) defined by MassDEP

- GAC
- Ion Exchange (IX)
- ~~RO~~
- ~~NF~~
- ~~PAC~~

Most common PFAS treatment strategies in MA

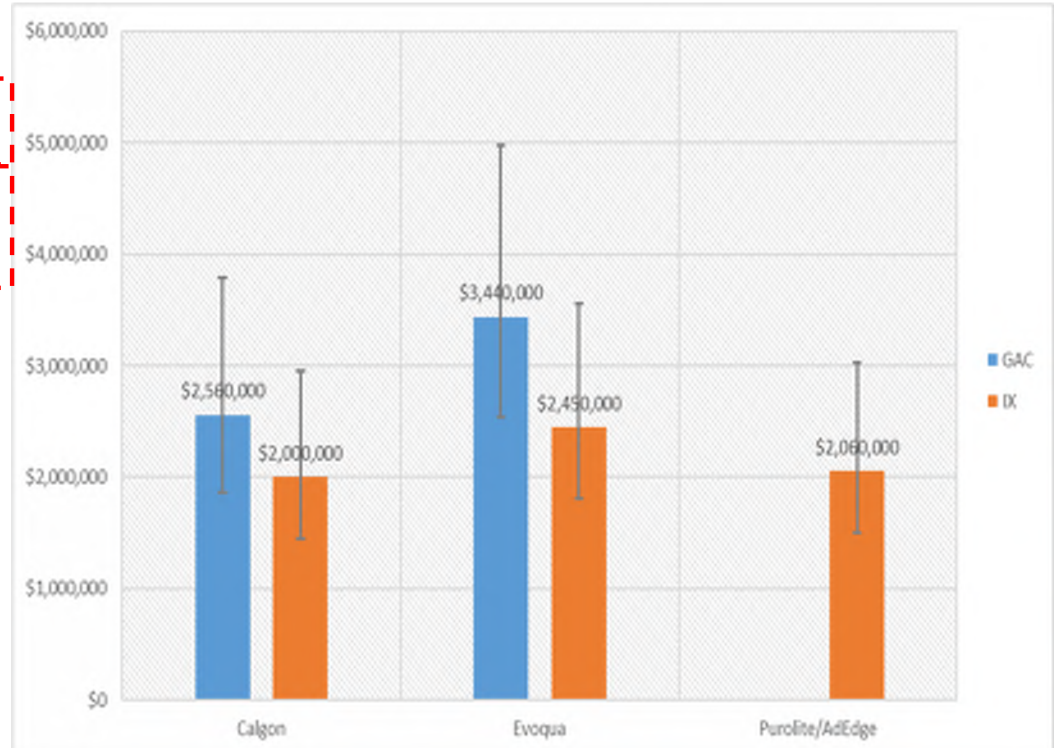
MADEP recognized Concentrate Disposal Challenges

Disposal, Efficiency Challenges – not approved by USEPA

Capital Cost Comparison of Technology

Treatment Technology	Vendor	Estimated Technology Cost[1,2]
GAC	Calgon	$1,860,000 - $3,790,000
	Evoqua	$2,540,000 - $4,980,000
IX	Calgon	$1,450,000 – $2,950,000
	Evoqua	$1,810,000 - $3,560,000
	Purolite/AdEdge	$1,500,000 - $3,030,000

1 Technology costs reflect installed equipment that are specific to the IX and GAC technologies and building, construction, engineering, and 25% design contingency.
2 **Cost does not represent total project cost. Only technology specific equipment and building costs are included.**



- IX less capital cost (1 train vs 2 vs GAC) = smaller building footprint
- Cost is for **Technology (PFAS Equipment + Building)** Only

Media Replacement

Treatment Technology	Vendor	Lead Vessel Media/Resin Replacement Frequency	Estimated Cost per Replacement
GAC	Calgon	6 - 12 months	$60,000
	Evoqua	6 - 10 months	$65,900
IX	Calgon	18 - 24 months	$226,000
	Evoqua	6 - 9 months	$192,000
	Purelite/AdEdge	6 - 10 months	$166,500

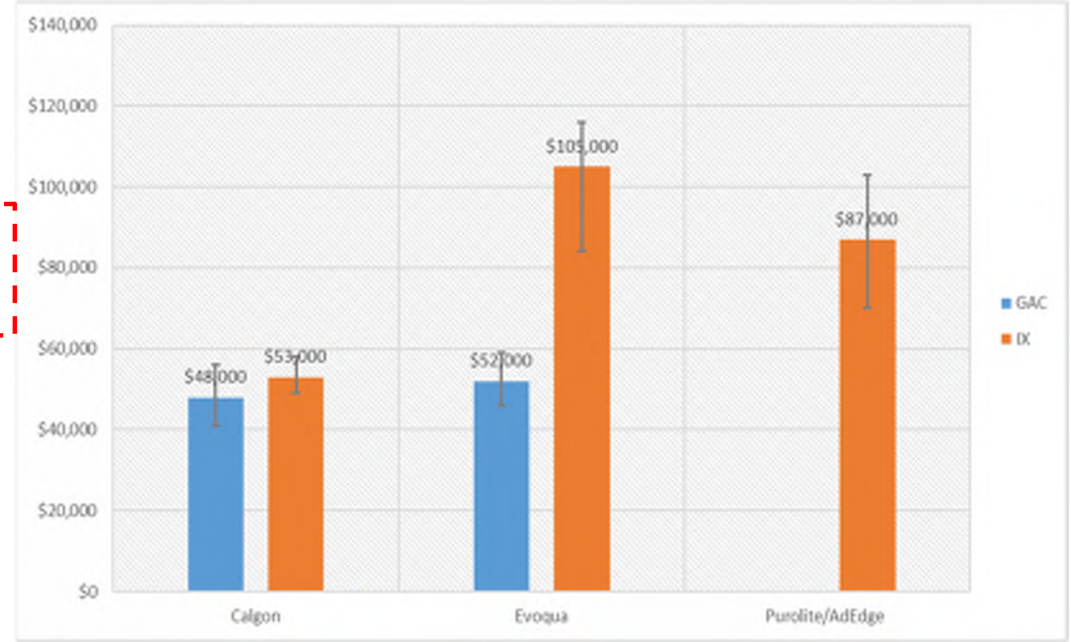
- Comparable media replacement frequency
- Frequencies based on 100% operation of wells – actual replacement will be less frequent
- IX media is more costly to replace (typical)

Annual Operating Cost

Treatment Technology	Vendor	Estimated Annual Operating Cost[1]
GAC	Calgon	$41,000 – $56,000
	Evoqua	$46,000 - $59,000
IX	Calgon	$49,000 - $58,000
	Evoqua	$84,000 - $116,000
	Purolite/AdEdge	$70,000 - $103,000

1 Annual operating cost assumes Well 1 and 2 operate 47% of the year and at a flow of 41% of the rated well capacity based on historical operation of the wells.

- Higher media replacement cost and quoted frequency leads to increase Operating cost for IX



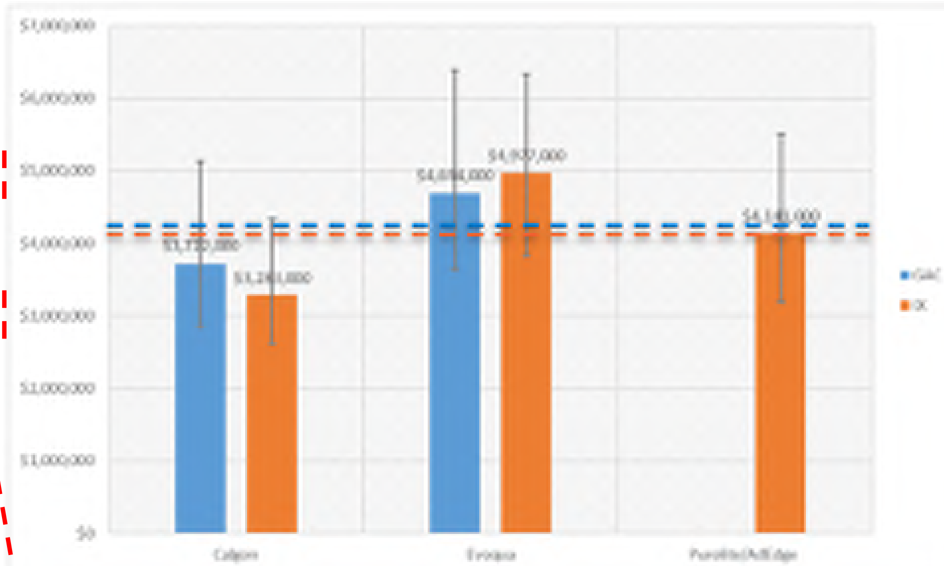
Lifecycle Comparison of Technology Costs

Treatment Technology	Vendor	20-Year NPV[1]
GAC	Calgon	$2,844,000 - $5,130,000
	Evoqua	$3,638,000 - $6,391,000
	Average	$4,208,000
IX	Calgon	$2,621,000 - $4,344,000
	Evoqua	$3,829,000 - $6,338,000
	Purolite/AdEdge	$3,186,000 - $5,506,000
	Average	$4,091,000

1 20-Year NPV assumes Wells 1 and 2 run 47% of the year at 41% of rated capacity.

Treatment Technology	Description	Estimated Technology Cost
GAC	Technology Cost	$3,000,000
	Annual O&M	$50,000
IX	Technology Cost	$2,170,000
	Annual O&M	$80,000

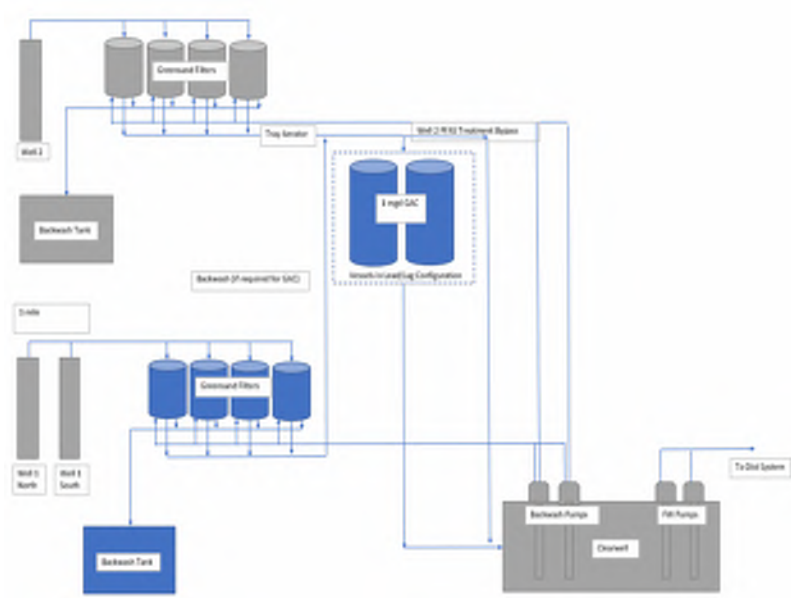
[1]Technology Costs reflect installed equipment and building, yard improvements, construction, engineering, DWD labor, Owner Contingency, and 25% design contingency,
[2] Annual operating cost assumes Wells 1 and 2 run 47% of the year at 41% of rated capacity.



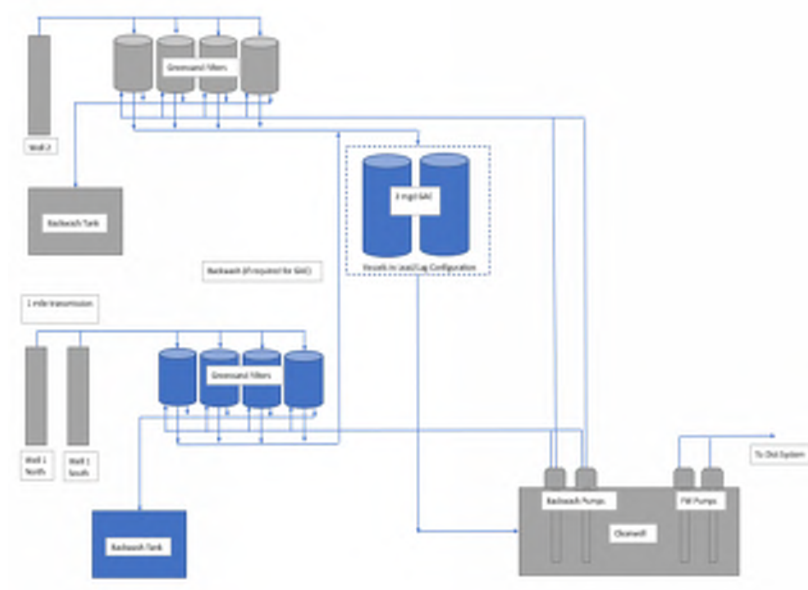
- Comparable lifecycle costs for IX & GAC

Second Question – Best Way to Implement Treatment?

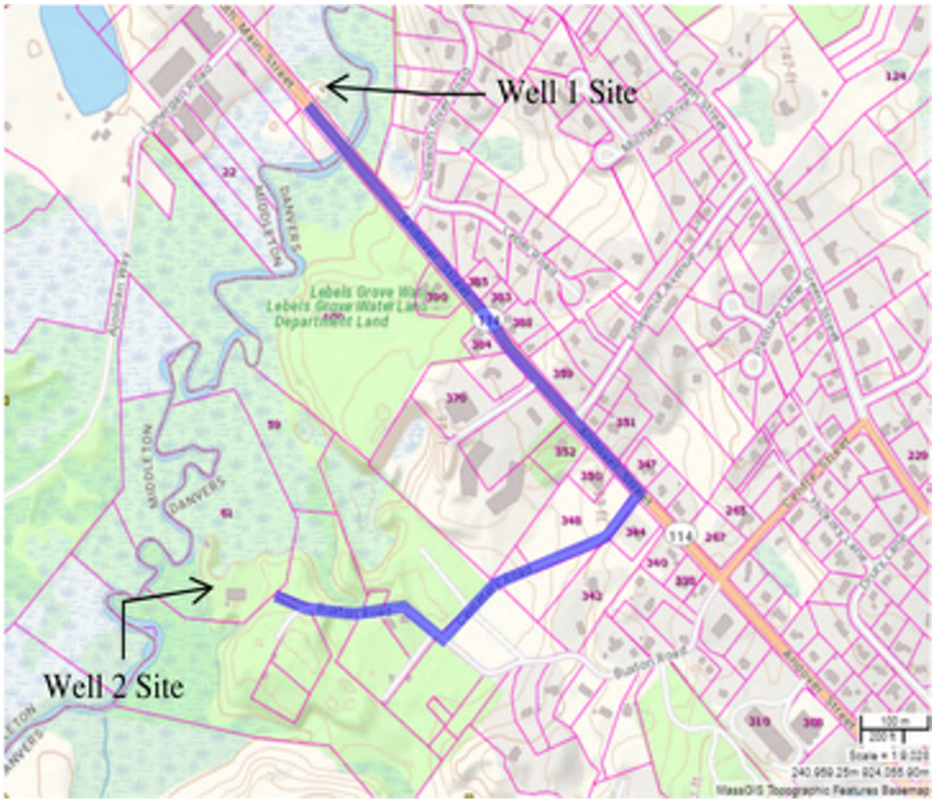
Option #1 – **1 MGD** PFAS facility w/ bypass



Option #2 – **2 MGD** PFAS facility (capability to treat both wells simultaneously for PFAS)



Transmission Main



Item	Low Range Estimate	High Range Estimate
Water Main	$1,600,000	$2,260,000
General Conditions	$240,000	$340,000
Below the Line Adjustments[1]	$520,000	$730,000
Contingency (25%)	$590,000	$830,000
Contract Allowances	$60,000	$80,000
Total	$3,010,000	$4,240,000

1. OH&P, Subcontractor OH&P/markup, Bonds/Insurance, Escalation to 2023.

Option #1 vs Option #2 Cost Comparison

Option #1 – 1 MGD PFAS facility w/ bypass

Item	Low Range Estimate	High Range Estimate
WTP Cost	$2,800,000	$3,960,000
General Conditions	$420,000	$590,000
Below the Line Adjustments[1]	$910,000	$1,280,000
Contingency (25%)	$1,030,000	$1,460,000
Contract Allowances	$100,000	$150,000
Total	$5,260,000	$7,440,000

1. OH&P, Subcontractor OH&P/markup, Bonds/Insurance, Escalation to 2023.

Option #2 – 2 MGD PFAS facility
(capability to treat both wells simultaneously for PFAS)

Item	Low Range Estimate	High Range Estimate
WTP Cost	$3,780,000	$5,330,000
General Conditions	$570,000	$800,000
Below the Line Adjustments[1]	$1,220,000	$1,720,000
Contingency (25%)	$1,390,000	$1,960,000
Contract Allowances	$140,000	$200,000
Total	$7,100,000	$10,010,000

1. OH&P, Subcontractor OH&P/markup, Bonds/Insurance, Escalation to 2023.

Questions?

Erik Rosenfeldt, PE, PhD

erosenfeldt@hazenandsawyer.com