CAROLLO ENGINEERS | VOL 3 2019

currents

WHAT ARE **PFAS?**

PLUS —

THIS ISSUE'S **EDITORIAL**

JESS BROWN, PhD, PE (jbrown@carollo.com)

I hope you enjoyed last quarter's Special Edition of ***Currents***, Innovation to Impact, highlighting the latest from the Carollo Research Group… my favorite ***Currents*** edition each year! That said, this edition is packed with interesting and timely articles as well. You'll meet this year's Bryant L. Bench Scholarship winner, dive into Fairfax County's master planning projects, and be amazed by Water ARC®'s latest testing capability — flavor profile analysis. We've also showcased three engineering excellence awards, recent Water Research Foundation wins, and our participation in AWWA's recently published manual of practice on inland desalination and concentrate management. And finally, our Feature Story covers several angles on PFAS (one of the hottest topics in the water industry today), including background, a full-scale case study, innovative tools and technologies, and a handful of links to additional resources.

Hope you enjoy this issue. Please let me or the primary authors know if you have any questions or comments!

IN THIS ISSUE

carollo
Engineers...Working Wonders With Water®

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WATER ARC'S® **NEW TOOL** TO HELP CLIENTS TEST FOR TASTE AND ODOR IN WATER SUPPLIES

CAROLINE RUSSELL, PhD, PE, BCEE (crussell@carollo.com)

WATER ARC® JUST ADDED FLAVOR PROFILE ANALYSIS (FPA) TO THE GROWING LIST OF TESTS THAT OUR LAB CAN CONDUCT FOR CLIENTS AND PROJECTS.

FPA is a published method in Standard Methods for the Examination of Water and Wastewater* and is used to identify the taste and odor (T&O) of water samples and their corresponding intensities. Unlike the threshold odor number (TON), which is the method historically used to assess T&O in water samples, FPA provides information on the specific T&O that customers may perceive in their water.

*(SM 2170; APHA/AWWA/WEF, 2005).

The FPA method relies on extensive training of panelists to calibrate odor characteristics with industry standards and to normalize intensity ratings. A well-trained FPA panel can provide meaningful information on the likelihood of water utility customers detecting a T&O characteristic in their water supply. FPA panels can be used to:

- Assess whether a change in treatment or source water supply will impact the T&O characteristics of delivered water, potentially leading to customer complaints.
- Evaluate the impact of strategies to reduce T&O.
- Identify specific T&O in water as a first step to address a T&O issue.
- Provide early warning of a T&O event.

Carollo has already used FPA to support clients on several projects. For example, Dr. Greg Pope (*Principal Technologist, Austin office*) used FPA to provide data (adjacent table) to support a decision of whether to invest in granular activated carbon (GAC) for T&O control for a new 10-mgd surface water treatment plant (SWTP). The Carollo team conducted five rounds of FPA analyses to capture seasonal variability during pilot testing of the proposed treatment train for the new SWTP. Additionally, the team facilitated two workshops with utility staff, allowing them to test the T&O characteristics of their new surface water supply in comparison with current supplies.

DR. LIN XU (*Lead Laboratory Technologist, Water ARC®, Boise office*) is one of six trained FPA panelists at our Water ARC® lab. Dr. Xu is testing samples from Salem, Oregon, to assess whether the dechlorination procedures are expected to impact the T&O characteristics of the delivered water.

Carollo can also conduct training for utilities that are interested in developing their own FPA panels, and/or facilitate consumer panels using taste testing as a customer engagement tool.

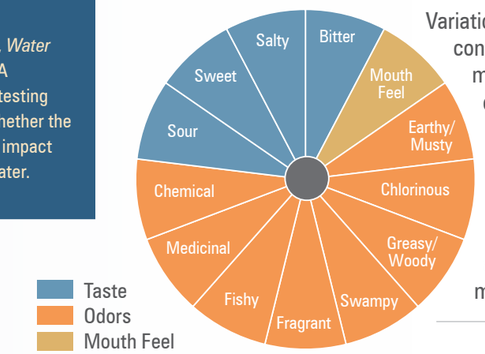
Contact Dr. Justin Sutherland (*Water ARC® Manager*; jsutherland@carollo.com, 512-427-8116) to inquire about our FPA capabilities and to request an analysis. Our trained panelists include: Nita Birdsong, Laura Corrington, Stacy Fuller, Tawnya Rea, Nicole Williams, and Lin Xu, in Boise, Idaho. We also have a satellite FPA panel in Texas, comprised of Vidula Bhadkamkar, Curtis Feronti, Greg Pope, Caroline Russell, and Carol Serna. All of the panelists were trained following SM 2170 and using the AWWA video and manual for Screening and Training of FPA Panelists.

The table below shows an example of FPA panel results. In this test, FPA was used to evaluate the T&O characteristics of current supplies in comparison to a new surface water supply with and without GAC treatment.

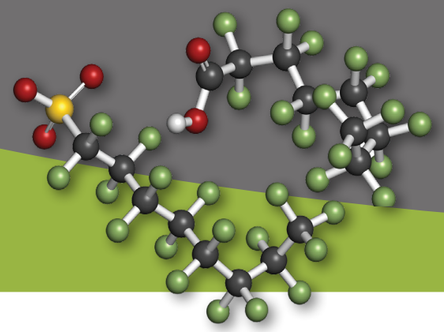
Example FPA Panel Results

Sample ID	Odor Characteristics and Intensities[1,2]	Taste Characteristics and Intensities[1,2]	MIB (ng/L)	Geosmin (ng/L)
New Surface Water Supply, No GAC	Earthy 2.0	Earthy 1.5 Notes: Chlorinous	18.3	7.9
New Surface Water Supply, with GAC	Notes: Grassy, Chlorinous	Notes: Chlorinous, Metallic	<2	<2
New Surface Water Supply, with GAC	Chlorinous 1.0 Notes: Musty	Notes: Chlorinous	<2	<2
Current Groundwater Supply	Rubber 1.0 Notes Chlorinous, Cardboard	Notes: Chemical, Swimming Pool	<2	<2
Current Purchased Surface Water Supply	Notes: Grassy, Chlorinous	Notes: Chlorinous, Bitter	<2	9.3

1 Intensities range from 0 to 12, with an intensity of 12 being the highest.
2 Notes are used to describe T&O characteristics that a minority of panelists detected.



Variations in the concentrations of constituents in drinking water may impact the taste and odor. For example, MIB and geosmin are metabolites of certain blue-green algae and actinomycetes that occur naturally in surface water supplies and can impart an earthy/ musty odor to the water.



DESIGNING AND **TESTING** TREATMENT SYSTEMS TO REMOVE **PER- AND POLYFLUOROALKYL SUBSTANCES** (PFAS) FROM DRINKING WATER

CAROLINE RUSSELL, PhD, PE, BCEE ■ KELLEY NEWMAN, PE ■ CORIN MARRON, PE ■ EVA STEINLE-DARLING, PhD, PE

What are PFAS and Why are They a Hot Button Issue?

Per- and polyfluoroalkyl substances (PFAS) are synthetic fluorinated organic compounds that are widely used in industrial, commercial, and consumer products due to their oil and water repellent characteristics. Over 600 manufactured compounds can be classified as PFAS, including perfluorooctanoic acid (PFOA) and perfluorooctanyl sulfonate (PFOS), the two perfluorinated compounds that have been produced in the largest amounts within the United States. Product applications include oil and water repellent surface coatings for packaging, textiles, and cookware (e.g., pizza boxes, fabric coating, non-stick frying pans, etc.), and firefighting foams.

The detection of PFAS in water supplies is of significant concern for impacted water systems due to potential adverse health effects at low nanogram-per-liter (ng/L) concentrations and the limited removal achieved through conventional treatment processes. The USEPA established a 70 ng/L drinking water health advisory (HA) for PFOA and PFOS in May 2016. While the 70 ng/L HA for PFOA and PFOS is non-enforceable, more than 10 states have enforceable standards and many utilities have their own goals to meet the HAs. There are additional concerns about the unknowns of PFAS, such as the identification of the PFAS compounds that are present, which compounds pose the most significant health effects, and thus, how to prioritize remediation and treatment efforts.

Granular activated carbon (GAC) adsorption, ion exchange (IX), and reverse osmosis (RO) have been demonstrated to effectively remove PFOA and PFOS from drinking water supplies. As illustrated in the table below, the treatment choice will depend on which PFAS are present, whether other contaminants must also be addressed, treatment goals, and residuals handling considerations.

Effectiveness of Treatment Technologies to Remove PFAS

Treatment Technology	PFOA and PFOS Removal	Effectiveness for Removal of Other PFAS	Residuals Generated
GAC	>98% Removal	Limited effectiveness for shorter chain PFAS	Spent Carbon
IX	>98% Removal	Resin-specific removal of some other PFAS compounds has been observed	Spent IX Resin
RO and NF	>99% Removal	Removes both long- and some short-chain PFAS	Concentrate

Presented next is a case study of full-scale treatment that is currently being implemented to reduce PFAS contamination from a drinking water supply, followed by a summary of Carollo's innovative work to help address PFAS.

Full-Scale Design of a 10.4-mgd GAC PFAS Treatment System for Tucson Water

Drawing from decades of experience testing and designing the technologies that have been demonstrated to remove PFAS from drinking water, Carollo is helping multiple water utilities quickly implement treatment to remove these contaminants from their source waters. Examples of proven technologies being deployed at full scale include GAC adsorption and IX.

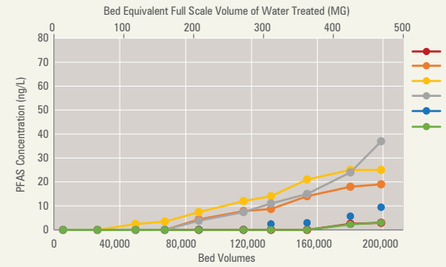
Carollo is currently designing a new 10.4-mgd (7,200-gpm) PFAS treatment system for the existing Tucson International Airport Area Groundwater Remediation Project (TARP) Water Treatment Plant (WTP). This facility was constructed in 1994 to remove trichloroethylene and other volatile organic compounds (VOCs) from a contaminated groundwater plume and to supply the treated water to the City of Tucson, Arizona, potable water distribution system. The original treatment process was air stripping by packed column aeration. In 2002, 1,4-dioxane was detected in the plume. To remove this new contaminant, in addition to VOCs, a UV-hydrogen peroxide advanced oxidation process (AOP) and GAC contactors for hydrogen peroxide quenching were added to the TARP WTP in 2014.

In 2013-2014, PFAS were detected in the TARP plume. Initial detections were well below the 400 ng/L PFOA and 200 ng/L PFOS provisional health advisories in effect at the time. However, after the EPA published its new drinking water HA for PFOA+PFOS of 70 ng/L (combined) in 2016, and based on subsequent TARP water quality trends, Tucson Water has taken actions to minimize PFOA+PFOS concentrations at the entry point to the distribution system.

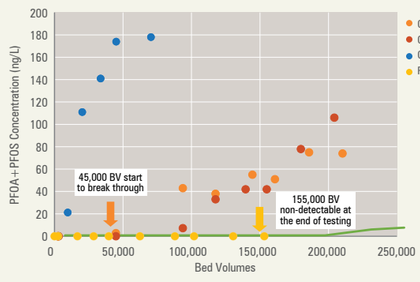
In 2018, Carollo assisted Tucson Water with bench-scale testing of four GAC media and one IX resin for PFAS removal using rapid small-scale column tests (RSSCTs). The results of the bench-scale testing were used in an economic analysis comparing GAC and anion exchange. Since eight GAC contactors were already being used as part of the UV AOP process and could provide both hydrogen peroxide quenching and PFAS adsorption in the same vessel, Tucson Water decided to retrofit these existing GAC contactors and add 12 new GAC contactors for PFAS treatment downstream of the UV AOP system at the TARP WTP. The retrofit also includes converting from parallel operation of all contactors to lead/lag contactor pair operation, improving utilization of GAC media and consistency of treatment performance.

Existing contactors at the TARP WTP.

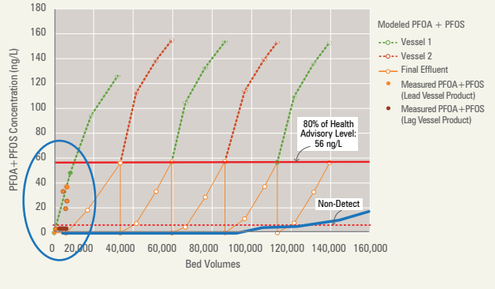
Tucson Water hopes to have the new PFAS treatment system online by the end of 2020. In the meantime, the utility installed new GAC media in the existing eight contactors (shown to the left) at the beginning of 2019 and has been tracking the movement of PFAS compounds through the GAC beds. The goal is to correlate the results from the bench-scale testing with full-scale performance to aid in predicting PFAS breakthrough and media replacement planning.



STEP 1: Column tests evaluated PFAS breakthrough for four carbons and two IX resins.



STEP 2: Test results used to compare performance of the different GAC media types and IX resins. Results illustrated that "similar" carbons perform very differently!



STEP 3: Blue Plan-it® modeling was conducted to predict change-out frequency. The modeling facilitated cost comparison for different media types and vessel configurations, design, and future operation.

STEP 4: Full-scale operating data on interim treatment units (to date) matches model predictions.

Advancing Tools and Solutions for PFAS Treatment

In the past 5 years, Carollo has been engaged in research and innovative projects to advance tools and solutions for PFAS treatment.

Tools to Optimize Design of GAC and IX for PFOA and PFOS Treatment

Carollo's experience designing full-scale treatment systems is bolstered by previous and ongoing research to advance tools and solutions for PFAS treatment. In partnership with Arizona State University (ASU), Chief Technologist Charlie He (Phoenix office) has conducted over 40 sets of RSSCTs evaluating PFAS removal through six different carbons and two IX resins. The results have been integrated into Blue Plan-it®, Carollo's comprehensive decision support platform, providing a tool to evaluate and optimize the number of contactors and configuration to meet a target treated water quality goal. Carollo worked with ASU to develop a modified RSSCT method to test IX at bench-scale and has been validating the results using pilot and full-scale test data.

Evaluating Innovative Technologies to Treat PFAS Residuals

While RO (or nanofiltration, NF) is the best demonstrated technology to remove PFOA and PFOS and some shorter-chain compounds, the dilemma of how to dispose of PFAS-laden concentrate can be a major hurdle to implementing this technology. Harold Wright (*Chief Technologist, Boise office*) is working with Dr. Timothy Strathmann and Dr. Chris Bellona (*Colorado School of Mines*) to pilot test an innovative UV-bisulfite treatment process to degrade PFAS from NF concentrate.

Look for more details on the innovative work Carollo is doing to address PFAS in our next issue of *Currents*.

WHERE CAN I LEARN MORE?

AWWA Fact Sheet

USEPA PFAS Action Plan

AWWA's PFAS State Regulatory Overview

CAROLLO PROVIDES MASTER PLANNING IN FAIRFAX COUNTY, VIRGINIA

BILL BARRACK, PE, BCEE (bbarrack@carollo.com)

Fairfax County (Virginia) forms part of the inner suburban ring of Washington, D.C. With 1.1 million people, it is the most populous jurisdiction in Virginia and in the Washington metropolitan area, accounting for 19.8% of the regional population. Wastewater is conveyed through over 3,250 miles of sewers and 63 pump stations to three wastewater treatment plants in the region.

For years, Fairfax County has been one of the fastest growing counties in the US, and it continues to experience significant growth. Recent projections show over 25% growth in population and over 35% growth in employment by 2045. Carollo was recently selected to provide master planning services in **two** major growth areas: the Embark Richmond Highway and Tysons Corner. These services are being provided out of **Carollo's Arlington, Virginia (DCO) office**.

EMBARK RICHMOND HIGHWAY

Embark Richmond Highway is a multi-faceted project facilitating revitalization along a 7.5-mile segment of the Route 1 / Richmond Highway Corridor by creating a series of mixed-use activity centers. It is supported by a Bus Rapid Transit (BRT) system; roadway, pedestrian and bicycle improvements; enhanced open space and park systems; and ultimately a 3-mile extension of the Metro Yellow Line. Phase I of the two-phase plan identified existing system capacity constraints and immediate sewer upgrades needed in conjunction with the Route 1 road widening and future population growth development. The scope of work for Phase II will evaluate the larger sewer infrastructure affected by the Embark development and determine potential upgrade needs on downstream trunk sewers and pump stations.

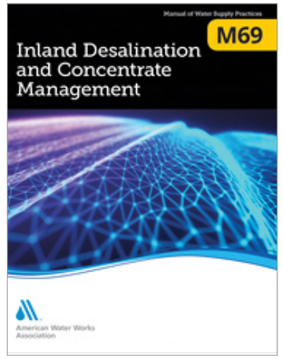
GIS graphics were used to present complex model results to County staff.

Tysons Corner is experiencing rapid densification due to the expansion of Metro (subway) lines.

TYSONS CORNER Since the 1960s, Tysons Corner has been the focus of continued growth and has evolved from a quiet, rural intersection to what is now home to over 20,000 people, two "super-regional" shopping malls, and numerous corporate headquarters (Booz Allen Hamilton, Capital One, and Freddie Mac, to name a few). In 2008, with plans for the new Metro Silver Line to add four stops in the very near future, the Fairfax County Board of Supervisors unanimously approved a 40-year plan to urbanize Tysons Corner. This urbanization has resulted in an increased demand on the existing infrastructure, especially on the wastewater collection system. To help plan for wastewater collection system needs resulting from this urbanization, County staff asked Carollo to complete an alternative evaluation to address the capacity concerns in the Tysons Corner wastewater collection system. The alternatives to be evaluated include: capacity upgrades, flow management alternatives (such as alternative flow routing or storage of wet weather flows), and management of flows to the DC Water Blue Plains Advanced Wastewater Treatment Plant through modifications to pump station operation.

AWWA M69 Inland Desalination and Concentrate Management Manual

As desalination technologies advance and the availability of conventional freshwater sources decreases, inland water users are increasingly turning to desalination. The American Water Works Association recently published a manual that deals with inland desalination issues: *Manual of Practice M69 - Inland Desalination and Concentrate Management*. This manual provides technical and planning guidance for inland water utilities (public and private) that currently operate, are developing, or are considering brackish water desalination. It presents practical information on current inland desalination concentrate management approaches, concentrate treatment technologies and management strategies, permitting procedures, environmental impacts, costs, safety, and more.



This manual resulted from coordination and teamwork led by Carollo's Chief Technologist, Charlie He, who served as the chair of this AWWA task force for the past 5 years. We are pleased to announce the collaboration of several of our engineers, including Graham Juby, Sandeep Sethi, Brandon Yallaly, and Tom Seacord, as authors, co-authors, and contributors to five of the nine chapters.

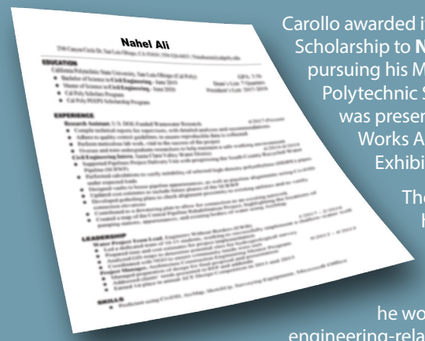
RECENT WRF WINS

Carollo is currently involved with several projects for The Water Research Foundation (WRF), which have just started. Our role is either Principal Investigator or Co-Principal Investigator.

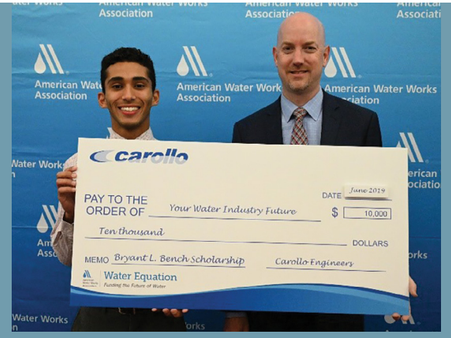
PROJECT TITLE	CAROLLO'S ROLE	COMPLETION YEAR
WRF 4833 Understanding the Impacts of Wastewater Treatment Performance on Advanced Water Treatment Processes and Finished Water Quality	Principal Investigator	2020*
WRF 4915 Characterization and Contamination Testing of Source Separated Organic Feedstocks and Slurries for Co-Digestion at Resource Recovery Facilities	Principal Investigator	2021
WRF 4916 The Impact of Pre-chlorination and GAC Treatment on DBP Formation and Overall Toxicity in Drinking Water	Co-Principal Investigator	2021
WRF 4957 Compiling Evidence of Pathogen Reduction through Managed Aquifer Recharge and Recovery	Principal Investigator	2020*
WRF 4958 New Techniques, Tools, and Validation Protocols for Achieving Log Removal Credit across NF and RO Membranes	Principal Investigator	2020*
WRF 4959 Evaluation of a Validation Protocol for Membrane Bioreactors Based on a Correlated Surrogate to Achieve Pathogen Credit for Potable Reuse	Principal Investigator	2020*
WRF 4960 Review of Industrial Contaminants Associated with Water Quality or Adverse Performance Impacts for Potable Reuse Treatment	Co-Principal Investigator	2020*
WRF 4971 Leveraging the Role of Pretreatment Programs in One Water Initiatives: Synthesis of Best Practices and Path Forward	Principal Investigator	2021*

**Extension into 2021 likely due to extended contracting period.*

Carollo Awards **BRYANT L. BENCH SCHOLARSHIP** to California Polytechnic State University Student



Carollo awarded its fourth Bryant L. Bench Scholarship to **Nahel Ali,** a student who is currently pursuing his Master's degree at California Polytechnic State University. The scholarship was presented to him at the American Water Works Association Annual Conference and Exhibition 2019 in Denver, Colorado.



Left: Nahel Ali (Bryant L. Bench Scholarship Recipient); and right: Chris Cleveland (Senior Vice President – Carollo Engineers, Inc.)

The scholarship was established in honor of Carollo Engineers' Water Practice Director Bryant Bench, who dedicated his career to water treatment and developed unique treatment methods to improve drinking water quality for millions across the country. Bryant was also a mentor and teacher, setting "Benchmarks" to care for, trust, and learn from those with whom and for whom he worked. Applicants for this scholarship must be pursuing a Master's degree in a water engineering-related field and have shown a passion and dedication to providing innovative solutions to the world's water challenges.

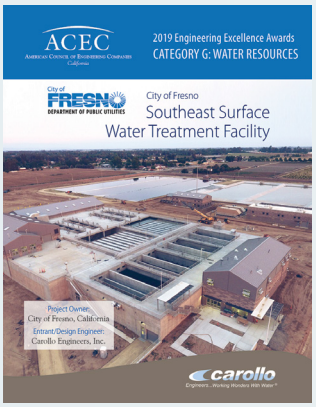
The scholarship consists of a one-time $10,000 award that students can use to complete or further their education in their chosen field. ***Congratulations to Nahel!***

2019 ACEC AWARDS

Two Carollo projects received awards from the American Council of Engineering Companies (ACEC) in 2019

SOUTHEAST SURFACE WATER TREATMENT FACILITY, CITY OF FRESNO, CA

Carollo was the design engineer and construction manager for the 80-mgd surface water treatment facility, where the design flowrate will be achieved through high-rate filtration. The facility, constructed on a greenfield site, uses conventional treatment with an intermediate ozone process. It was the largest component of the City's $429M Recharge Fresno Water Supply Program.



2019 State Honor Award
February 2019

AQUIFER STORAGE AND RECOVERY WELLS NO. 29 AND 30, CITY OF WOODLAND, CA

Carollo was involved in the planning, design, and construction support for two new ASR wells to provide a sustainable, high quality water supply for Woodland's customers. During the winter, excess treated surface water is stored in these aquifers and recovered during the peak-demand summer season.

2019 Golden State Award
February 2019

The Golden State Award is the highest honor ACEC California bestows as part of its Engineering Excellence Awards program.

2019 National Honor Award
May 2019

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