JOURNAL OF THE NEW ENGLAND WATER ENVIRONMENT ASSOCIATION

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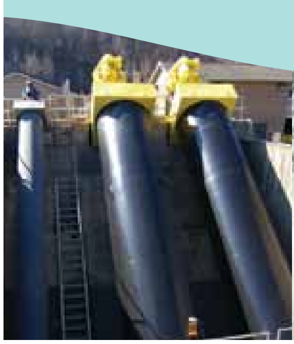
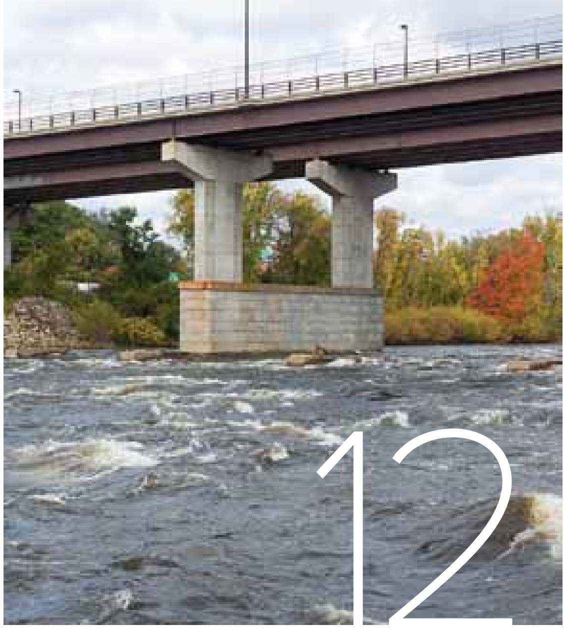
EMERGING CONTAMINANTS

NEWEA
WORKING FOR WATER QUALITY





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OUR ASSOCIATION WAS ORGANIZED NINETY-FIVE YEARS AGO in Hartford, Connecticut, on April 23, 1929, with the objectives of advancing the knowledge of design, construction, operation and management of waste treatment works and other water pollution control activities, and encouraging a friendly exchange of information and experience. From 40 charter members, the membership has steadily grown to more than 2,000 today. Membership is divided into the following classes:

Professional Member—shall be any individual involved or interested in water quality including any manager or other officer of a private waste treatment works; any person engaged in the design, construction, financing, operation or supervision of pollution control facilities, or in the sale or manufacture of waste treatment equipment.

Executive Member—shall be an upper level manager interested in water quality and who is interested in receiving an expanded suite of WEF products and services.

Corporate Member—shall be a sewerage board, department or commission; sanitary district; or other body, corporation or organization engaged in the design, consultation, operation or management of water quality systems.

Regulatory Member—this membership category is a NEWEA only membership reserved for New England Environmental Regulatory Agencies, including: USEPA Region 1, Connecticut Department of Energy and Environmental Protection, Maine Department of Environmental Protection, Massachusetts Department of Environmental Protection, New Hampshire Department of Environmental Services, Vermont Department of Environmental Conservation, and Rhode Island Department of Environmental Management.

Academic Member—shall be an instructor or professor interested in subjects related to water quality.

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President's Message

On working for water

As our world struggles with the increasingly urgent need for better environmental solutions, one industry stands out as particularly vital: WATER.

The importance of clean water—quality drinking water, cleaner wastewater, clean rivers, and pristine oceans—cannot be overstated. And in the quest for a more sustainable future, the individuals who choose to work in the water industry play a crucial role in preserving our most precious resource. We need to reach out to the current and future pool of available talent with convincing reasons to look to this industry for an inviting career. Here are some suggestions to increase the personal appeal of this field.

Why should someone consider working for water?

The benefits are numerous and far-reaching. For starters, the water industry offers great job security as well as long-term benefits. In times of increasing economic fears and career uncertainties, the clean-water industry is an attractive option that should not be overlooked. The vital necessity of water makes it a recession-proof field, and this stability translates into long-term employment opportunities that are particularly appealing in an age where job security, due to outsourcing and consistently changing technologies, is increasingly hard to come by.

Now is the time to start your forever job.

We all know the water industry is facing a unique challenge: an aging workforce on the brink of retirement. This presents an opportunity for new workers to enter the field and make a meaningful impact. Succession planning is crucial in ensuring that the industry continues to thrive, and those who choose to work for water are well positioned to play an important role. Whether you have a GED or a PhD, are a military veteran or a mom or dad looking to get back to work, many positions are available, ready, and waiting for the right individuals to fill them.

Feel good about what you do!

Working in the water industry is not just about the technical aspects of the job. It's also about sharing stories and experiences with like-minded individuals who are passionate about making a difference. If someone were to ask me for three words that best describe my job, I would say environment, sustainability, and collaboration. Environment, because clean water is essential to all natural life on our planet. Sustainability, because clean water is necessary for maintaining society and fostering global development. And collaboration, because it is more than working toward a common goal or teamwork, it also can encourage innovation and creativity. When individuals with diverse skills and backgrounds come together, it leads to the exchange of unique perspectives and ideas, and from there, the sky is the limit!

The satisfaction that comes from knowing that your work is directly contributing to a cleaner, healthier environment is so cool. And the personal rewards go way beyond monetary compensation; they extend to a sense of purpose and fulfillment that can only be found in a career dedicated to serving the greater good.

To summarize: Working for water is a rewarding and fulfilling career choice that offers a unique opportunity to make a tangible impact on the world around us. With great benefits, local job opportunities, and the chance to be a part of a stable and resilient industry, there has never been a better time to consider a career in water. So why work for water? The answer is simple: Because you will have an awesome career that is much more than just a job, and the future of our planet will benefit from your work.

Please share these thoughts and your own water story with others and ask them to consider a clean-water career and Work for Water to enhance our communities, environment, and our future.

Working for water is a rewarding and fulfilling career choice that offers a unique opportunity to make a tangible impact on the world around us

From the Editor

Contaminants of emerging concern—let's face it, these days we're talking about per- and polyfluoroalkyl substances (PFAS). I thought about avoiding them for this column, but these "forever chemicals" are near impossible to avoid. They are in everything from our food wrappers to our toilet paper, to our tap water and wastewater. They are also the subject of two feature articles in this edition of the *Journal*, so here we are.

While PFAS are currently unmatched in their ability to provide oil and water repellency to nearly everything, they impact human health at extremely low exposure levels, and when released to the environment, they resist breakdown and move quickly. The United States Geological Survey recently estimated that at least 45 percent of tap water across the country has at least one PFAS.[1] And studies performed at wastewater treatment plants consistently detect PFAS in in waste-activated sludge and biosolids.[2] When it comes to remediating PFAS, we in the water and wastewater industry have our work cut out for ourselves.

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This edition's first article, by Baxter Miatke et al., discusses an innovative foam fractionation technology as a viable option for concentrating PFAS within waste streams. The technology has shown to be especially promising for PFAS removal from landfill leachate. The next article, by Neal Megonnell, highlights the best ways to optimize pressure vessel design for PFAS removal, through corrosion management, hydraulic performance, media optimization, and maintenance and operations. In a nice synergy with Baxter's article, Neal reconfirms that media lifespan is fully dictated by PFAS concentrations.

The third article, by Diana Pizarro et al., takes us away from PFAS for a moment and summarizes the types and quantities of plastic litter in the coastal waterways of four New England states: Maine, Massachusetts, New Hampshire, and Rhode Island. I'll admit, before I read this article, I never pieced together that one of the biggest contributors to microplastics in the environment is standard plastic litter (such as plastic cups, plastics bags, etc.) that has broken down. And in an unfortunate spiral, plastic fragments on their way to becoming microplastics are less likely to be picked up in a cleanup event.

The final article, by Shane Mullen, tackles an unusual contaminant causing leachfield failures for a senior care facility in Vermont. I won't ruin the surprise though—flip ahead and read the article! I *will* reveal the article's ending: The newly designed treatment system addresses this contaminant spectacularly, and it is consistently meeting its design effluent goals.

I am also excited to introduce this edition's Young Professional Spotlight! Isabella Silverman just returned home from a year in Peru with Peace Corps Response. Peace Corps volunteers work across the globe alongside local communities to help solve some of today's most pressing challenges, including safe, affordable, and sustainable water and sanitation. In her interview, Isabella shares an honest accounting of her experience working with rural water systems in Peru, and lessons she plans to bring to her next job stateside. (I hear that she's still searching for her next position!) I may be biased, but Returned Peace Corps Volunteers (RPCVs) are some the best employees and NEWEA members. We have a handful in our ranks: Rita Fordiani designed and installed 10 drinking water systems in Ecuador; Fred McNeill managed a rural water supply program in Sierra Leone; I helped procure sanitation infrastructure in Morocco; and I am sure I am overlooking many more. I know that my experience in the Peace Corps continues to impact my work every day, and I'm know many other RPCVs would say the same.

1. https://www.usgs.gov/news/national-news-release/tap-water-study-detects-pfas-forever-chemicals-across-us.

2) Dickman, R.A. and Aga, D.S. (2022) Efficient workflow for suspect screening analysis to characterize novel and legacy per- and polyfluoroalkyl substances (PFAS) in biosolids. *Analytical and Bioanalytical Chemistry* 414(15): 4497-4507.

Source Water Brewers Competition

July 22, 2024
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The Merrimack River and Notre Dame Bridge as seen from Arms Park in Manchester, NH

EPA salutes citizen scientists' water quality monitoring of the Merrimack

In April, EPA joined safe water guardians along the banks of the Merrimack River to acknowledge their water quality protection efforts and share results of water sampling data collected by so many. Those who participated in the routine monthly water testing included scientists, stewards, and students from Lawrence High School.

"Without good science, how can we protect human health and the environment? It's an extraordinary effort to collect water samples, take field measurements, and get the samples to EPA's North Chelmsford laboratory within six hours for accurate analysis, all under strict quality assurance protocols every month," said EPA Regional Administrator David W. Cash. "The collaborative efforts of all the volunteers and the Merrimack River Watershed Council are invaluable."

Merrimack River Watershed Council Executive Director Curt Rogers underscored the importance of its partnership with EPA, "We simply could not do our intensive water monitoring program without EPA's robust collaboration—from assisting in drafting the sampling protocols to running the lab analyses throughout the year. This sampling program identifies areas of high concern for pathogens, such as *E. coli* and *Enterococcus*, which gives us a better understanding of the impacts on recreation and wildlife."

The Merrimack River and its watershed is one of New England's iconic waterways. The watershed is a recreational resource for nearly 200 communities and 2.6 million people and is the primary drinking water source for about 550,000 people in Massachusetts and New Hampshire. The vast two-state watershed covers 5,010 mi^2 (12,975 km^2) and is home to a variety of sensitive species and habitats.

EPA created an interactive StoryMap that highlights maps and important themes such as flooding and water quality risks from developed land, and it has a new section on water quality monitoring resources for the watershed.

EPA and partners have been working to improve the ease with which organizations large and small can store their water quality monitoring data in the Water Quality Portal by submitting data to EPA's Water Quality Exchange. Once there, data become accessible to scientists, government policy makers, and the public in a permanent archive. From the portal, data can be integrated into a variety of viewers, data analytical tools, portals, and data assessment products. For more information, visit epa.gov.

Over $400 million for New England water infrastructure upgrades announced

In late February, EPA announced funding for drinking water and clean water infrastructure upgrades in New England, including over $50 million for Maine, $61.4 million for Connecticut, $151 million for Massachusetts, $43 million for Vermont, $47.5 million for Rhode Island, and $55.7 million for New Hampshire.

The funding is part of the over $50 billion investment in water infrastructure upgrades from the Bipartisan Infrastructure Law. The funding will support essential water infrastructure that protects public health and water bodies throughout the region. Almost half of this funding will be available as grants or principal forgiveness loans, ensuring funds reach underserved communities most in need of investments in water infrastructure.

"With $50 billion in total, the largest investment in water infrastructure in our nation's history, EPA will enable communities across the nation to ensure safer drinking water for their residents and rebuild vital clean water infrastructure to protect public health for decades to come," said EPA Administrator Michael S. Regan.

The funding EPA announced is part of a $5.8 billion investment through the Clean Water and Drinking Water State Revolving Funds (SRF). This multi-billion-dollar investment will fund state-run, low-interest loan programs to address key challenges, with $2.6 billion going to the Clean Water SRF for wastewater and stormwater infrastructure and $3.2 billion going to the Drinking Water SRF for drinking water infrastructure nationwide. This announcement includes allotments for Bipartisan Infrastructure Law General Supplemental funds and Emerging Contaminant funds for SRF programs for fiscal year 2024. EPA also announced allocations of several billion dollars in additional resources nationwide for the Bipartisan Infrastructure Law Lead Service Line Replacement fund this spring resulting in some $190 million to be applied specifically to lead drinking water pipe replacement projects throughout New England.

Note: All EPA industry news provided by EPA Press Office

Specific Bipartisan Infrastructure Law—clean and drinking water funding in New England

Since 2022, the Bipartisan Infrastructure Law has injected over $1 billion into water infrastructure projects across New England, including the following:

- $11 million to Saco, Maine, for a wastewater treatment facility upgrade
- $17 million to Livermore Falls, Maine, for replacement of aging water main infrastructure
- $520,000 to Dexter, Maine Utility District, for water main replacement/upgrades on Gould Avenue
- $52 million to Bristol, Connecticut, for upgrades to Bristol Water and Sewer Department's SCADA system, which monitors and controls treatment facilities and distribution systems
- Over $26 million to Montville, Connecticut, for the construction of a new water storage tank to replace the Cook Hill Tank
- Over $10 million to Chicopee and Gardner, Massachusetts, for wastewater treatment plant upgrades
- $925 million to North Attleboro, Massachusetts, for new drinking water treatment capital improvements
- Nearly $293,000 to Hyannis, Massachusetts, for developing a lead service line inventory and a lead service line replacement plan within the water supply system
- $64 million to St Johnsbury, Vermont, for the construction of a new water treatment plant
- Over $1 million to Burlington, Vermont, for preliminary engineering of wastewater treatment plant upgrades
- $10 million to the University of Rhode Island, to investigate and address local PFAS contamination
- $1 million to Providence, Rhode Island, to evaluate drainage areas and develop recommendations for improved water quality treatment infrastructure and stormwater management practices
- $216 million to Plymouth Village Water & Sewer District in New Hampshire, for the Holderness Well Treatment Project
- Over $1 million to Lisbon, New Hampshire, for treatment and distribution improvements
- $765,000 to Troy, New Hampshire, for upgrades to wastewater treatment facilities.

Bill Golden honored at Charles River Watershed Association annual meeting

– Charles River Watershed Association press release

Bill Golden

Charles River Watershed Association (CRWA) honored former state senator Bill Golden at the group's 58th Annual Meeting on March 27. Mr. Golden was awarded the Anne M. Blackburn Award, the group's premier lifetime achievement award for individuals who have demonstrated dedication and leadership toward achieving a cleaner and healthier Charles River, its watershed, and our natural environment.

Bill Golden has served at every level of government, from the White House to the State House to City Hall. As White House staff, Mr. Golden assisted in the establishment of EPA and the National Oceanic and Atmospheric Administration. As a three-term Massachusetts state senator, Mr. Golden wrote legislation that reorganized Massachusetts county government, created the Special Senate Committee on Long Range Policy Planning, established two Areas of Critical Environmental Concern, created the UMass Boston Urban Harbors Institute, and co-wrote air, water, solid waste, indoor air pollution, and energy conservation legislation.

Most impactfully for the Charles River, as city solicitor for the City of Quincy, Mr. Golden filed the lawsuit that secured the first court-mandated cleanup schedule for Boston Harbor and the creation of the Massachusetts Water Resources Authority (MWRA). Mr. Golden was famously going for a morning run in 1982 along Wollaston Beach in Quincy when he stepped in what turned out to be human waste. In his own words, "It was everything that was being released from the sewer pipes in Boston. I just got ticked off. I went to the mayor immediately with this stuff on my shoes and said we had to do something about it."

Mr. Golden won that suit, which initiated a series of lawsuits that culminated in the creation of the MWRA, the construction of the Deer Island Treatment Plant, and an over 90 percent reduction in sewage discharges into the Charles River.

Emily Norton, executive director of CRWA, expressed her admiration for Mr. Golden's contributions, stating, "Bill Golden kicked off the whole cleanup of the Harbor—and therefore the Charles—with his fateful decision to go running that morning along Wollaston Beach, and his willingness to take on state and federal governments on behalf of the people, who he believed deserve clean water and clean beaches. Everyone who lives or works in greater Boston owes Bill a debt of gratitude for his brave actions over 40 years ago."

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WINTER—Biosolids Management
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The role of innovative PFAS treatment technologies for managing PFAS waste from water treatment systems

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ABSTRACT | Per- and polyfluoroalkyl substances (PFAS) have multiple pathways into waste streams and the water environment, presenting challenges for removal and ultimate disposal across multiple sectors. While PFAS destruction technologies continue to develop and become commercially available, their throughput capacities are limited; thus, concentrating and minimizing the overall volume of PFAS waste are equally important. Effective waste minimization can reduce overall costs of treatment, destruction, and disposal as well as further limit liability and promote pragmatic, sustainable solutions. This article evaluates current conventional and innovative treatment options that can ultimately reduce overall waste volumes of PFAS, with a focus on how the foam fractionation technology ties into the current treatment train approach of these technologies. Results from bench-scale and pilot-scale foam fractionation tests demonstrate PFAS treatment removal efficiencies and low waste-generation rates that can make the technology cost competitive with comparative treatment technologies.

KEYWORDS | PFAS destruction, foam fractionation, water treatment

The current state of remediation of PFAS from water is a treatment train concept, primarily focused on reducing the treatment volume by concentrating the PFAS to be destroyed or disposed.[1,2,3,4] This reduces the volume of waste requiring expensive treatment/destruction, which better matches the throughput capabilities and high costs of these technologies. For water treatment, PFAS may be concentrated through adsorption or separation-based technologies—those technologies that exploit electrostatic and/or hydrophobic adsorption or partitioning to the gas/liquid interface.[4,5] Figure 1 shows the spectrum of the developmental stage and relative effectiveness of relevant water treatment technologies for managing PFAS impacts, highlighting adsorption, separation, and destruction technologies and their relative development stages and effectiveness for PFAS treatment.

Foam fractionation, specifically, has seen significant development over the past few years. Foam fractionation is a separation technology that uses gas bubbles (air producing millimeter or ozone producing nanometer bubbles) to remove emerging contaminants, such as PFAS, from water. Contaminant characteristics, like whether a compound is a perfluorinated or polyfluorinated alkyl substance—number of carbon atoms fully substituted with fluorine atoms (i.e., fluorinated tail length), and type of functional or "head" group—can affect which treatment technology will provide most effective removal. Most PFAS molecules have both hydrophilic and hydrophobic properties, and act as surfactants, attracting them to the gas-liquid interfaces present in foam fractionation as the injected gas bubbles move through water. Foam fractionation exploits the physicochemical tendency of PFAS to partition to the gas-liquid interface, concentrating them in a resultant foam fractionate.[6,7] The concentrated foam fractionate is physically separated from the treated water, reducing the PFAS contaminated volume.

Foam fractionation has developed into a commercially viable component of effective treatment trains for PFAS removal from water by combining the foam fractionation step with an adsorbent or filtration polish alongside destruction of the concentrated PFAS waste. In this arrangement, foam fractionation reduces the resultant volume for destruction, while greatly increasing the concentration of PFAS in the waste foam fractionate. A polish stage would generate a spent media waste stream, which makes three possible waste streams—foam fractionate, low concentration solids from pretreatment, and spent media. In addition to destructive technologies, the use of adsorptive media to remove PFAS from foam fractionate may also provide the ability to treat this waste stream.

Foam fractionation can be performed using air or ozone, or a combination of the two. Foam fractionation with ozone gas is a patented process available commercially as ozofractionative catalyzed reagent addition (OCRA).[8,9] In ozone foam fractionation systems, common organic co-contaminants such as petroleum hydrocarbons can be oxidized by the ozone during the separation process, potentially reducing wider treatment requirements. In one comparative study, ozonated air fractionation showed better PFAS removal efficiency as a result of the enriched OH radicals in the gas bubbles.[10] Using both air and ozone, foam fractionation can be optimized for site-specific characteristics and reduce overall foam fractionate volumes.[25] Figure 2 shows a process flow diagram of a foam fractionation process with both gases.

Foam fractionation is a viable treatment option for high concentration waste streams with high organic co-contaminants that would otherwise affect

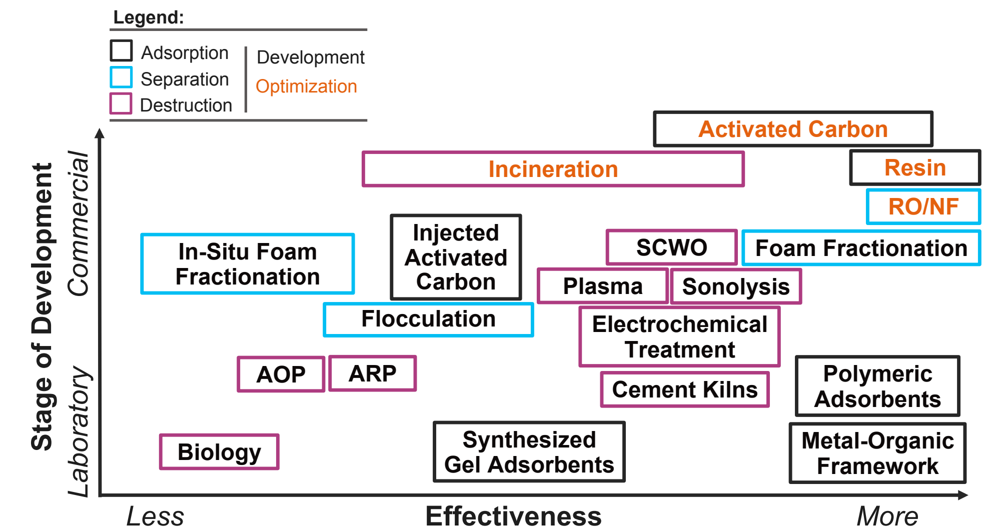

Figure 1. PFAS water treatment technology matrix[23]

Foam fractionation pilot system foam generation: in collection cup head (left), in column (right)

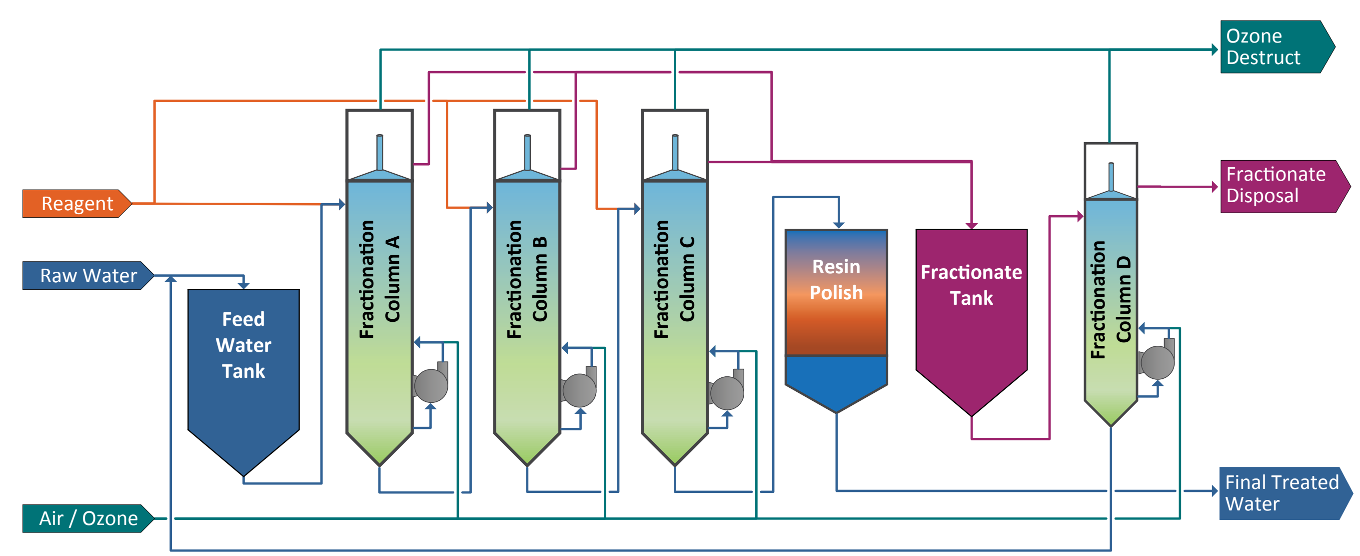

Figure 2. Fractionation process flow diagram
(Copyright Evocra Pty Ltd, Australian Patent No. 2012289835, Copyright Evocra Pty Ltd, United States Patent No. 2014/0190896)

Fractionate being produced in Australia

more traditional adsorptive technologies. Target sources for foam fractionation include industrial and municipal wastewater treatment plants, landfill leachate, groundwater in firefighting foam-impacted source zones or spill areas, reverse osmosis rejectate, and other similar waste streams. Bench-scale, pilot tests, and full-scale applications have demonstrated that under the right circumstances foam fractionation is effective as a stand-alone technology for low- to medium-flowrate applications and integral to a treatment train for minimizing waste disposal costs by further reducing the volumes of high-concentration waste streams from membrane exclusion and filtration technologies.[11,12,13,14] Additional field data using ozone foam fractionation and a polishing adsorptive media at a site in Australia achieved greater than 99.99 percent total PFAS removal from untreated sewage water, reducing waste management costs significantly.[15]

Landfill leachate is often contaminated with PFAS, and the presence of multiple co-contaminants presents a challenge for conventional treatment technologies.[16] Studies have investigated the applicability of foam fractionation for the removal of PFAS from landfill leachate specifically, with promising results.[17,18,19] Additional ongoing current foam fractionation pilot projects in New England include projects at Anson-Madison Sanitary District in Maine[20] and Casella's landfill in Coventry, Vermont.[21]

PROJECT BACKGROUND

This work began with a desktop feasibility study (FS) to evaluate treatment technologies to treat PFAS in leachate at the Detroit Steel Corp McLouth Steel Gibraltar Superfund Site in Gibraltar, Michigan. The purpose of the FS was to screen potential treatment technologies for treatment of PFAS within landfill leachate prior to discharge to surface water. The current leachate management strategy used off-site treatment and disposal at approximately 10,000 to 20,000 gpd (38,000 to 76,000 L/d).

Based on the findings of the desktop FS, bench-scale testing with the landfill leachate was performed using the following three approaches:

- Foam fractionation paired with anionic exchange (AIX) resin polish
- Membrane technology (ultrafiltration [UF], nanofiltration [NF], and reverse osmosis [RO]) paired with AIX resin polish
- Clarification (coagulation/flocculation) with granular activated carbon (GAC)

Based on the bench-scale testing, foam fractionation, paired with an adsorptive media polish, and a pretreatment using break-point chlorination were recommended for pilot testing at the site. Pilot testing followed at the site in December 2021, with successful results.

The objective of pilot-scale testing was to treat the leachate from the site to standards from the Michigan Rule 57 Surface Water Quality Values (February 2020) for potential contaminants, including PFAS, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and metals. In addition, ammonia nitrogen concentrations were significantly elevated relative to the Rule 57 criteria. Results were compared to the human non-cancer value (HNV) and the final chronic value (FCV). Metals were also compared to the chronic water quality-based effluent limit (WQBEL). Because the receiving water body for the treated leachate is a tributary to the Detroit River—a source of drinking water—the drinking water HNV values were used for comparison.

PROJECT METHODS

Sample Methods

Samples were collected and placed in laboratory-supplied containers, stored, shipped on ice, and handled with chain-of-custody documentation. All samples were sent to a laboratory accredited for PFAS analysis. Water samples were analyzed for the 28 PFAS compounds that are reportable using ASTM D7979. As part of the internal QA/QC, one matrix spike (MS) sample and one matrix spike duplicate (MSD) sample were collected during the initial bulk sampling in the influent. One MS and one MSD for VOCs and PFAS were also taken per final effluent sample. Trip blanks and equipment blanks were also collected at the testing laboratory for bench-scale testing and onsite for pilot-scale testing.

Bench-Testing Methods

A third party was used for treatability labs for coagulation, GAC filtration testing, and membrane filtration to compare results to foam fractionation for screening. Foam fractionation bench testing was performed in-house.

Electrocoagulation (EC) was tested using ferric chloride ($FeCl_3$) and aluminum chlorohydrate (ACH) with chitosan. Each type of coagulation was tested with a 500 mL jar test simulating fast and slow mixing. Hydrogen peroxide was tested for its potential to oxidize the sulfide to sulfate as a pretreatment process. Following pretreatment, samples were filtered through media filtration prior to GAC treatment. GAC selection testing was conducted by passing a limited volume of pretreated leachate through three GAC materials with qualitative and quantitative observations (such as pH, turbidity, color, and chemical oxygen demand [COD]) to help inform GAC selection for further rapid small screen column testing (RSSCT). Three GAC materials were tested initially. Effluent from the GAC with the lowest color and COD was the basis for selecting a product as the possible best material for filtration.

Membrane filtration (UF, NF, and RO) was tested using a batch process in reducing pore-size sequence to simulate a pilot or full-scale treatment system. Three membranes were tested initially. Treatment batches recirculated across the membranes and back into a stainless-steel tank for further treatment. As could be expected at full scale, permeate was recirculated for additional concentration steps to increase recovery with the number of steps reported. The batches of NF and RO treatment were both dosed with an anti-scalant to reduce fouling of the membranes.

Foam Fractionation Bench-Testing Methods

Foam fractionation bench-scale testing was completed using a laboratory-scale foam fractionation reactor. The reactor included the following equipment:

- Peristaltic pump (feed)
- Foam fractionation reactor with fractionate collector head
- Centrifugal pump (recirculation)
- Venturi and jet assembly
- Ozone generator
- Air separator
- Balance tube cuff

During testing, the reactor was operated continuously, using the following operation and sampling procedures. Steady-state operation of the fractionation reactor was achieved by managing foam production rate and foam quality. Generally, the objective for the bench-scale test was to obtain a dry structural foam that collapsed into a liquid phase, producing a liquid foam fractionate and a treated water stream. The bench-scale test targeted a fractionate volume representing 5 percent or less of the raw water volumetric feed rate, while typically less than 1 percent is achievable at full scale.

Laboratory personnel monitored the quantity and quality of foam produced in the fractionate collection head during testing and made system adjustments, as necessary. Process adjustments were made to optimize the volume of generated foam if the test produced excessive high-structure foam, which fails to collapse on itself, or excessive low-structure foam, which collapses easily and contains too much water to achieve fractionate volume reduction goals. Hydraulic head, recirculation loop flow, and gas feed flow rates were monitored to optimize the column to inform design and likely outcomes for full-scale operations.

Foam fractionation bench-scale column, Durham, North Carolina

Two trials were performed to vary and optimize contact time, gas reagent (i.e., air, ozone), gas flow rate, and gas addition rates. Trial 1 used a combination of air and ozone for the gas reagent, and Trial 2 used ozone only. Trial 1 simulated columns in series by processing the first pass with air and then re-processing the treated effluent through the column for a second pass with ozone. The second pass occurred immediately after the first pass was completed, in a batch sequence to simulate the continuous operation of two columns in series at full scale. Trial 2 also simulated two columns in series, but with both passes using ozone. Figure 3 displays the process flow diagram for both trials.

During fractionation testing, the system performance data listed below was collected and monitored at incremental time points (approximately every 15 to 30 minutes):

- Wastewater influent flow rate
- Recirculation loop flow rate
- Fractionate volume
- Effluent volume
- pH
- Oxidation reduction potential
- Gas flow rate and loading rate
- Optimization adjustments

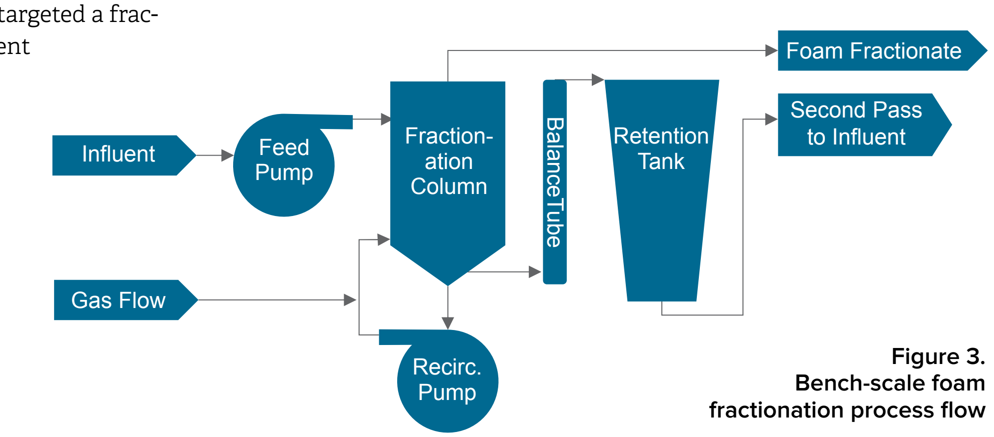

Figure 3. Bench-scale foam fractionation process flow

Foam fractionation pilot-scale system, Syracuse, New York

Table 1. Pilot-testing scenarios

Test	Chlorine Pretreatment	OCRA A	OCRA B
1	No	Air	Ozone
2	No	Ozone	Ozone
3	Yes	Air	Ozone
4	Yes	Ozone	Ozone

Analytical samples of the influent, effluent, and foam fractionate streams were collected during each trial. A media polish on the foam fractionation treated effluent was not evaluated on the bench-test scale due to volume limitations.

Foam Fractionation Pilot-Testing Methods

A foam fractionation pilot system in a shipping container was used for pilot testing. The process flow design of the pilot system seen in Figure 4 included pretreatment using break-point chlorination to address ammonia specifically. Both air and ozone were used in the foam fractionation columns with the primary goal of removing PFAS from the leachate. Resin media, which have been proven effective at removing PFAS from water, were used for downstream treatment of the treated water from the fractionation columns.[22] The leachate was treated through two fractionation columns in series using air or ozone as specified in the testing scenarios (see Table 1). There were two primary foam fractionation columns (OCRA) running throughout the pilot test, and one concentrating foam fractionation column (OSCAR). The foam fractionate waste from both primary foam fractionation columns was sent to the concentrating column where it was treated again to further reduce the overall waste volume. The water exiting the concentrating column was the system's final waste effluent while the water exiting the primary column was the system's final treated effluent. The foam fractionate waste was sampled and containerized for disposal. The treated water from the OSCAR column was recycled back to the beginning of the treatment system to the first OCRA column for re-processing. The pilot was operated at a continuous flowrate with no batch processing.

The pilot-scale fractionation system and pretreatment equipment were mobilized in November and operated from December 2–20, 2021. Operators monitored and managed foam generation in the columns to optimize foam generation rates.

Foam fractionation pilot system ozone generator

PROJECT RESULTS

An untreated leachate sample of 275 gal (1,041 L) was collected for bench testing, and a representative sample was submitted to an environmental analytical laboratory for analyses of PFAS, VOCs, SVOCs, metals, inorganics, and general water chemistry. Select PFAS and general water quality analytical results are presented in Tables 2 and 3, respectively.

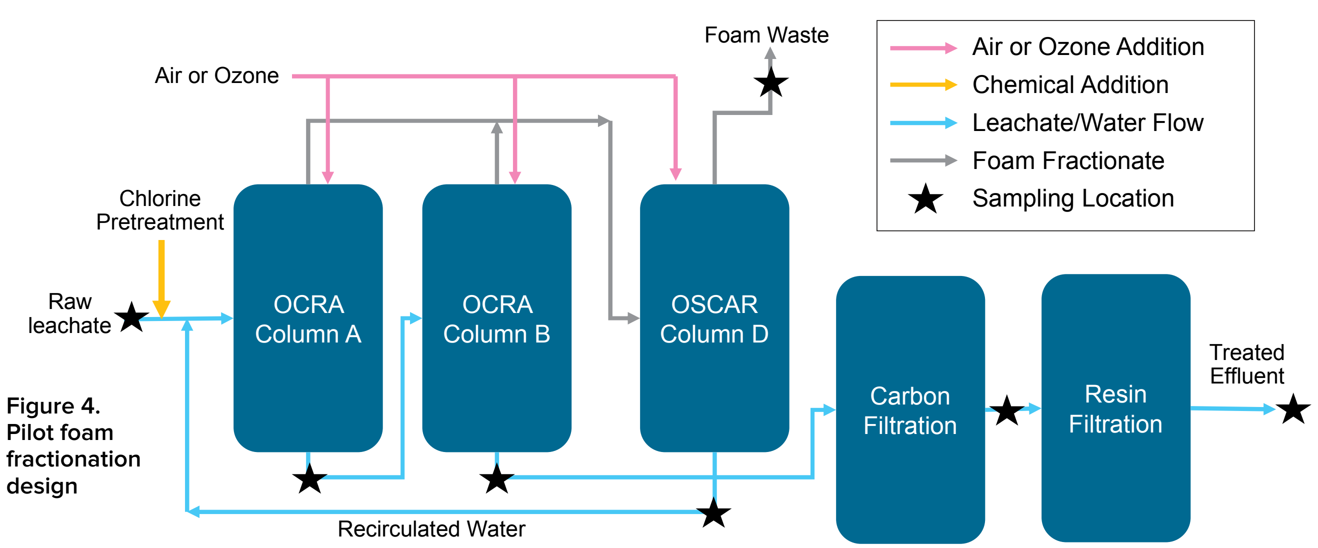

Figure 4. Pilot foam fractionation design

Table 2. Select influent PFAS concentrations

PFAS Compound	Influent Concentration
Perfluorooctanoic acid (PFOA)	430 ng/L
Perfluorooctanesulfonic acid (PFOS)	190 ng/L
Perfluorononanoic acid (PFNA)	80 ng/L
Perfluorohexane sulfonic acid (PFHxS)	380 ng/L
Perfluorohexanoic acid (PFHxA)	350 ng/L

Table 3. Select general water chemistry influent concentrations

Analyte	Influent Concentration
Alkalinity-Total	490 mg/L
Ammonia-N	18,000 ug/L
Chemical Oxygen Demand	290 mg/L
Chloride	410 mg/L
Fluoride	0.61 mg/L
Hexavalent Chromium (dissolved)	<50 ug/L
Nitrate/Nitrite-N	<0.2 mg/L
pH (field)	8.7 pH Units
Sulfate	210 mg/L
Total Cyanide	<0.5 ug/L
Total Dissolved Solids	1500 mg/L
Total Organic Carbon	74 mg/L
Total Suspended Solids	380 mg/L

Bench-Testing Results

During bench-scale testing for EC, ferric chloride was found to form a black solid, which was slow to settle in the jar test. Ferric chloride treatment caused iron and sulfide to oxidize, creating more solids in the leachate without increasing the settling rate. ACH dosing with EC created a visual color reduction, but color was not the goal of pretreatment. Therefore, EC methods were determined to be ineffective and suspended due to poor performance.

During coagulation testing, it was noted that the raw leachate had a strong sulfide odor. The pretreatment focus was shifted to sulfide oxidation to remove the strong sulfide odor and effect pretreatment of sulfur reducing bacteria. Hydrogen peroxide was added and mixed with the leachate in a beaker test to determine dosing before adding hydrogen peroxide to the bulk sample of leachate. Sodium metabisulfite (SMBS) was then added to the leachate after a 2-hour mixing time to quench residual hydrogen peroxide in the leachate prior to filtration.

Following the hydrogen peroxide pretreatment, the leachate was filtered through media filtration of crushed glass prior to GAC RSSCT testing. A brand name carbon product designed for PFAS removal from potable water was selected for RSSCT testing as a preferred carbon, based on it having the lowest color and COD. The GAC RSSCT results showed breakthrough and exhaustion nearly immediately at the first sample taken (fewer than 2,000 bed volumes) for perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) across all three types of carbon. The breakthrough occurred in the first sample and the media was fully exhausted. This is equivalent to approximately seven days of full-scale operation until the GAC would require a changeout when operating at a 10-minute empty bed contact time (EBCT).

While GAC as PFAS treatment has been proven to be effective in the industry, the high concentrations of co-contaminants in this leachate most likely created significant competitive loading and resulted in faster breakthrough of the PFAS. The hydrogen peroxide and glass filtration could have also possibly oxidized precursors and removed more PFAS. Based on this initial data, operating with a 30-minute EBCT would likely be required to reduce the changeout frequency to be more cost-effective, and that would require larger GAC vessels.

Table 4. Bench-scale membrane and foam fractionation PFOS and PFOA treated effluent results (ng/L)

	Rule 57 Standard	UF Permeate	NF Permeate	RO Permeate	Treated Effluent*
PFOS	11	600	12	<1.9	<10
PFOA	420	300	6	<1.9	<10

* Foam fractionation treated effluent (air + ozone)

During membrane testing, analytical samples were collected for PFAS, including PFOS and PFOA, as shown in Table 4. PFAS passed through the UF as expected and exhibited detections above the Rule 57 standards. After NF, PFOS and PFOA concentrations were reduced to 12 ng/L and 6 ng/L, respectively. Based on those results, membrane treatment was shown to be effective for PFOA and PFOS, but membrane treatment recoveries were lower than expected, requiring multiple steps to get higher recoveries. The percent recovery is defined as the ratio of permeate flow rate divided by feed flow rate multiplied by 100 percent. Recoveries for each step and total recovery for the membrane testing are summarized in Table 5 (next page). RO had the highest total recovery with 97 percent after two passes. Since the membranes were tested in series, the recovery may be lower if RO is used as

Table 5. Bench-scale membrane testing recovery results

Membrane	Step Recovery	Total Recovery
UF Step 1	83%	83%
UF Step 2	80%	96%
NF Step 1	59%	59%
NF Step 2	60%	82%
NF Step 3	56%	90%
RO Step 1	93%	93%
RO Step 2	71%	97%

Table 6. Bench-scale foam fractionation volume and run time results

Trial / Description	Treated Effluent	Foam Concentration	Foam (%)	Run Time (minutes)
	collection volume (L)			
1 / Single Pass with Air	61.3	12.7	21	135
2 / Second Pass with Ozone	39.5	1.0	2	60
1+2 / Grand Total Volume (Air + Ozone Passes)	**100.8**	**13.7**	**14**	**195**
3 / Single Pass with Ozone	83.4	5.1	6	120
4 / Second Pass with Ozone	35.0	0.1	0.3	90
3+4 / Grand Total Volume (Ozone + Ozone Passes)	**118.4**	**5.2**	**4**	**210**

Table 7. Bench-testing results summary

Bench-test	PFOA and PFOS Treated <10 ng/L	Concentrated Waste Volume Estimates
Foam Fractionation	Yes	4%
Membrane (UF, NF, RO)	Yes	16.2%
Coagulation – GAC	No	N/A

a standalone treatment process. A conservative estimate for every 10 MG (37.8 ML) of leachate treated, approximately 8.4 MG (31.8 ML) of treated water would be discharged to surface water and 1.6 MG (6.1 ML) of membrane reject would need to be disposed of.

Raw leachate was tested for foam fractionation. The results for all four trials are summarized in Table 6. This data shows that the ozone trials were more successful at reducing the volume of foam fractionate in both the first and second passes (4 percent compared to 14 percent). Analytical samples were collected during fractionation testing for PFAS. Both PFOS and PFOA were successfully treated to non-detect in the treated effluent for both air and ozone passes (see Table 4). The foam fractionate had high PFAS concentrations in the ozone passes (19,000 ng/L PFOA and 12,000 ng/L PFOS). The high-concentration, low-volume waste shows a successful proof of concept of the fractionation bench testing. PFAS removal from landfill leachate water was well within the operating envelope of the bench system and the presence of co-contaminants did not hinder the PFAS removal directly. This supported previous research and operational knowledge from which it was expected that effective PFAS removal from the landfill leachate water would be achieved. A conservative estimate for a retention time of 2 hours was used for the first pass and approximately 1 hour for the second pass. The bench test highlighted ozone fractionation positive proof of concept to non-detect PFOS and PFOA, validating pilot-scale trials compared to other technologies.

The suitability of resin for the leachate at the site was also evaluated. Two resins were modeled. The resin model assumed a total organic carbon (TOC) concentration in the water going into the resin to be between 38 to 74 ppm. Ideally, TOC would be less than 2 ppm for optimal performance. Without an additional reduction of TOC, exhaustion of the resin is anticipated to be about 25,000 bed volumes (BVs). This calculates to a changeout of resin roughly every 52 days, which should be enough to last the four-week pilot test. Use of GAC as part of a pretreatment train with resin is common and would help reduce the TOC load prior to the resin bed since GAC is effective for adsorbing all organics.

Bench-test summary results are shown in Table 7. The bench test provided results indicating membrane filtration would be effective at treating PFOS and PFOA to below the required Rule 57 Standards.[26] However, membrane filtration was expected to have a higher capital and operational cost with higher disposal costs when estimating the total concentrated waste volume of other technologies tested at the bench scale. Therefore, membrane filtration was not recommended for further consideration at the pilot scale. Foam fractionation also showed promising results at the bench scale for PFAS removal and a lower expected concentrated waste volume to manage, and therefore was recommended to proceed to pilot testing onsite.

Pilot-Testing Results

During pilot-testing commissioning, a white milky color was observed in the effluent that was not seen in the bench-scale test. Several jars of the effluent were collected to evaluate if the milky coloration was due to settleable solids or the entrainment of air or ozone, and settling did not result in removal or dissipation of the milky coloration. Several jar filtration tests were completed with different-sized micron filters, and the coloration was not removeable by physical filtration. A GAC media polish using regenerated GAC was added to assess the removal of the coloration. Adding GAC can also remove any residual VOCs from the wastewater at a lower cost than resin.

Final operational waste volumes for each test are shown in Table 8, and concentrations for each test and sample location are provided in Figures 5 and 6 (next page). During all four test scenarios, PFOA and PFOS concentrations decreased to less than 4 ng/L, and in some cases were non-detectable. Resin polish significantly treated to non-detect levels post-fractionation. Final foam fractionate waste ratios were less than 5 percent overall except for Test 1. Test 4, which used ozone and chlorination pretreatment had the lowest waste volumes, 0.7 to 3.3 percent, of all the tests. This would equate to an estimated reduction from 20,000 gpd (76,000 L/d) of influent to less than 1,000 gpd (3,800L/d) of concentrated waste during full-scale operation. Tests 1 and 2 did not include pretreatment to assess if air-ozone or ozone-ozone fractionation reduced the ammonia concentrations. In Tests 3 and 4, pretreatment with break-point chlorination was used with the ozone fractionation. The only scenario where ammonia concentrations dropped below the Rule 57 target concentrations was in the final effluent samples from Test 4 where the ammonia concentrations were 1.0 mg/L and 0.9 mg/L, respectively. Test 4 results confirmed that break-point chlorination is an effective pretreatment method for reducing the ammonia concentration, and that some optimization of the dosing may be required to consistently meet discharge limits.

Table 8. Pilot foam fractionation operational and waste volume results

Test	Avg. Influent Flowrate gpm (L/min)	Volume Treated gal (L)	Final Influent to Waste Ratio (%)
Test 1 / Air-Ozone No Pretreatment	5 to 8 (18.9 to 30.3)	3,700 (14,006)	3.1 to 7.8
Test 2 / Ozone-Ozone No Pretreatment	5 to 8 (18.9 to 30.3)	5,848 (22,137)	3.9 to 4.9
Test 3 / Air-Ozone With Pretreatment	5 to 8 (18.9 to 30.3)	9,282 (35,136)	2.1 to 4.4
Test 4 / Ozone-Ozone With Pretreatment	5 to 8 (18.9 to 30.3)	8,524 (32,267)	0.7 to 3.3

COST ESTIMATES

In conformance with guidance documents from the Association for the Advancement of Cost Engineering (AACE), rough order of magnitude (ROM) Class 5 cost estimates were prepared for the various treatment technologies based on their bench-scale performance.[24] The cost estimates included design, construction, major equipment, budgetary quotes from vendors, and estimated operation and maintenance (O&M) costs based on bench- and pilot-scale testing. Conceptual treatment trains were considered to provide a comprehensive overview of cost comparison among different options. The options prepared are for an estimated average total treatment volume of 10 MG (37.8 ML) per year shown in Table 9 as U.S. million dollars for comparison only.

Table 9. Rough order of magnitude cost estimates (for comparative purposes only)

Treatment Train	ROM Capital	Annual O&M
	cost estimate (US$M)	
GAC and Resin Treatment	1.4 to 3.0	0.42 to 0.89
NF+RO Membrane Treatment, Resin Polish, Reject GAC Treatment	2.0 to 4.2	0.44 to 0.94
Foam Fractionation and GAC and Resin Polish Treatment	2.1 to 4.5	0.25 to 0.53

ONGOING WORK

Additional pilot studies have been ongoing at various sites in 2023 and 2024, looking at more PFAS compounds, optimizing gas flow rates, air sampling, off-gas treatment options, and destruction testing of foam fractionate. As regulations develop, more PFAS compounds are added to results and studies. In late 2023, a pilot test on landfill leachate mixed with groundwater was conducted. Based on data from that recent pilot test, typical and conservative percent removal estimates for the Massachusetts PFAS compounds shown in Table 10 for landfill leachate mixed with groundwater were developed.

Percent removal can vary significantly based on the composition of the source matrix, PFAS concentrations, surfactant load, hydraulic residence time, and foaming characteristics. These calculations provide a typical and conservative estimate of performance to allow stakeholders to evaluate how the technology might perform at full-scale. Since performance can vary at sites, bench and pilot testing are recommended to determine site specific parameters prior to full-scale installation. Foam fractionation has shown to be less suitable for the removal of the more mobile short-chain PFAS[13,14] and ongoing work continues to evaluate methods to improve the

Table 10. Foam fractionation performance estimate*

PFAS	Typical Removal	Conservative Removal
PFOA	99%	96%
PFOS	99%	96%
PFNA	98%	95%
PFHxS	97%	93%
PFHpA	81%	70%
PFDA	98%	96%
Sum6	95%	91%

*Based on September 2023 pilot test on landfill leachate mixed with groundwater

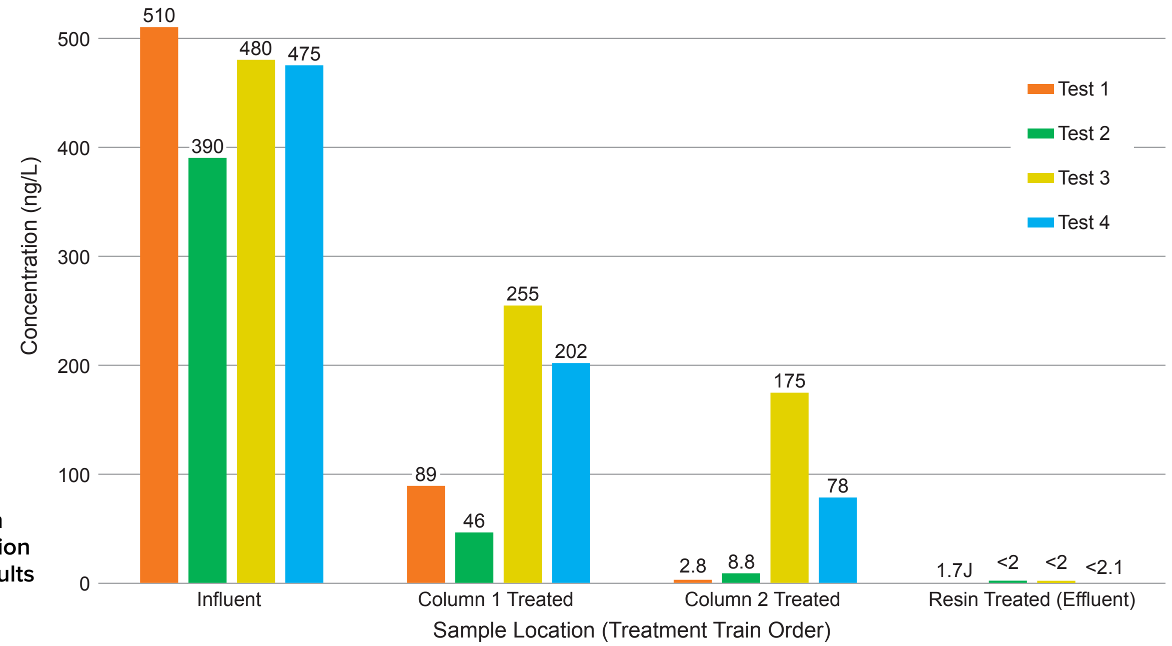

Figure 5. Pilot foam fractionation PFOA results

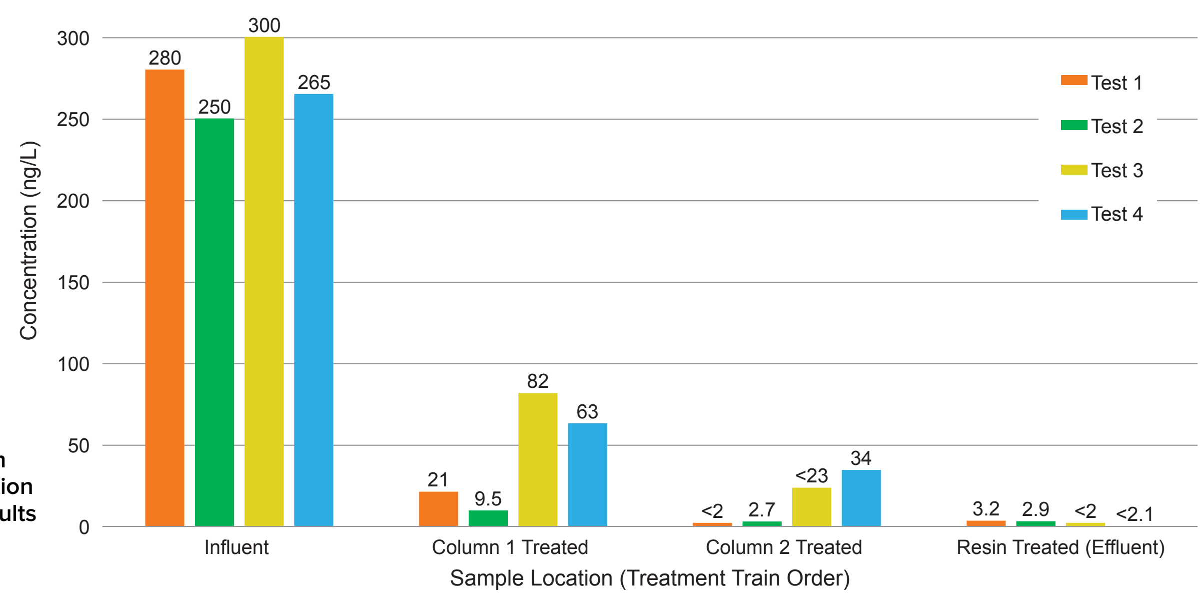

Figure 6. Pilot foam fractionation PFOS results

removal of short-chain PFAS with the addition of co-surfactants in the foam fractionation process.

There is a growing need for PFAS separation technologies, such as foam fractionation, globally to minimize the costs and environmental footprint of PFAS destruction. To meet increased demand and deployment of these approaches in Europe and Australia, bench-scale foam fractionation columns and a mobile pilot unit are in production to meet demand across multiple industrial sectors associated with the increasing restrictions on trade effluent discharge consents and environmental permits.

A full-scale foam fractionation system for leachate treatment is forecasted for construction in 2024. As part of that full-scale design, there has been significant development and validation of destructive treatment technologies for PFAS concentrated waste, such as super critical water oxidation (SCWO).[3] Research and development recently relating to the destructive treatment of concentrated PFAS waste streams such as the foam fractionate generated from foam fractionation is ongoing. SCWO may be a future complementary treatment unit operation for the complete mineralization of concentrated PFAS in various liquid and slurry waste streams, such as foam fractionate waste. It is through a holistic treatment train approach using recent innovative technologies that PFAS can be effectively managed through various waste streams.

CONCLUSIONS

Foam fractionation is an innovative PFAS treatment technology that has been commercialized in the industry and can be considered as part of a treatment train approach. Foam fractionation with ozone gas can improve the PFAS removal efficiency and have additional oxidative benefits in foam fractionation treatment. Results from this bench and pilot study showed PFAS removal from landfill leachate water was well within the expected operating parameters of the foam fractionation system, and the presence of co-contaminants did not hinder the PFAS removal directly. A cost analysis of rough order of magnitude estimates compared current treatment and disposal strategies with fractionation and media polish to show potential cost savings from reduced volumes of waste that requires further management, as well as from increased longevity of the filtration media. Ongoing pilot studies and design of full-scale systems continue to provide more information on PFAS removal, optimization of gas flow rates, air emissions sampling, off-gas treatment options, and final destruction testing of foam fractionate. Further PFAS destruction technology advancement can help provide the final step in the destruction of foam fractionate waste residuals to eliminate PFAS from the waste cycle.

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The four tenets of pressure vessel design

NEAL MEGONNELL, Aqueous Vets, Pittsburgh, Pennsylvania

ABSTRACT | This article discusses the four tenets of designing pressure vessels—corrosion management, hydraulic performance, media optimization, and maintenance and operations—and their relation to optimizing PFAS removal. Enlisting strong specifications, computational fluid dynamics software, and piloting, engineers can influence pressure vessel lifespan, cost of ownership, and ease of operations. Leveraging a career in activated carbon vessel design, the author explains pressure vessel design steps that ensure the least complex and most cost-effective outcome.

KEYWORDS | PFAS, pressurized vessels, contaminants of emerging concern, design, granular activated carbon (GAC), ion exchange

Engineers pride themselves on the performance of their design once the concrete has been poured and the cranes leave the site. So, when utility customers report premature failures and underperformance, engineers are left questioning the cause. The engineering team spent hours perfecting the sizing, media type, and redundancy to serve their client for years, only for it to fail before anyone anticipated.

As state and federal drinking water agencies pass regulations for contaminants of emerging concern like PFAS with increasing frequency, engineers across the United States will be relied upon to design the necessary solutions to remove them. Pressurized vessels have served New England communities for decades to combat a long list of water contaminants, and now PFAS is being added to their charge. But system failures and expensive operations costs can frustrate water providers aiming to distribute clean, affordable water to ratepayers.

It all starts with a quality design. Keeping the four tenets of pressure vessel design in mind, water infrastructure engineers can optimize pressure vessel treatment performance while maximizing life expectancy with the lowest cost of ownership for customers.

CORROSION MANAGEMENT

Water. Air. Sunlight. The environment that pressure vessels live in makes corrosion inevitable. However, the design phase can lay the foundation for anticipating and deterring premature vessel corrosion. Engineers can ensure their designs have a long life with minimal operational costs by considering vessel materials, writing strong coatings specifications, and making maintenance accessible for operators, among other considerations.

Materials

When selecting vessel materials, the galvanic series can serve as a simple guide to minimize a pressure vessel's corrosion potential. Anodic and cathodic metals used to build pressure vessels will naturally interact as raw water serves as a medium between the two, setting the stage for a chemical reaction. Accounting for this, important for corrosion control is choosing materials that are not widely separated within the galvanic series that may speed degradation of the vessel's anodic metal.

In addition to the material selection, coating these metals appropriately is also important in corrosion control. During the design phase, some vessel specifications exclusively call for the coating of the anodic member, as this is the electron donor that erodes. However, the National Association of Corrosion Engineers (NACE, now the Association for Materials Protection and Performance) recommends coating both cathodic and anodic metals to reduce the interaction between them.[1]

Simply coating a vessel is not enough to prepare for corrosion either. In fact, 70 percent of pressure vessel coating failures are due to inadequate surface preparation.[1] By borrowing specifications from the Society of Protective Coatings, SSPC SP-5 or NACE Standard RP0178-2007, and heeding coating manufacturer recommendations, engineers can keep vessel materials free of oils, dust, and rust before being coated, installed, and exposed to the elements. Welding specifications can also lay critical groundwork for long-term life and reduced corrosion rates, such as NACE RO0178, which requires welds and sharp edges to be ground down to avoid crevices.

Figure 1. Materials Selection—Galvanic Series (seawater at 25°C)

Design

A vessel's physical design can also affect rates of corrosion and lifespan. After deciding on materials, engineers must gather and analyze water quality data such as inlet water temperature, flow rates, hydraulic loading, required pressure, and general water chemistry.

Pressure vessel design is significantly affected by the geometry of the underdrain design. A proper underdrain design can prevent electrolyte buildup, which corrodes vessel outlets. In correlation with the welding specifications, avoiding creating unintentional crevices within the vessel will prevent eddies and stagnant water, and media that wear coatings and vessel materials. Finally, designs should facilitate accessibility for operators and technicians to access the inside of vessels and perform timely maintenance, such as periodic media exchanges and recoating.

HYDRAULIC PERFORMANCE

When designing pressure vessels, it's important to categorize them into their three regions:

- **Overdrain**—Where water enters the system and is distributed onto the media bed
- **Media bed**—A resin or carbon-based media that interacts with water on a molecular level to remove contaminants, ideally in plug flow and isotropic distribution
- **Underdrain**—Nozzles or slotted pipe that separates treated water from media

The coordinated sizing and geometry of these three regions can dictate the long-term performance of a pressure vessel and affect corrosion rates, lifespan, and operational cost. Each region must work in harmony to create a plug flow within the media, the ideal hydraulic condition for pressure vessel treatment.

The Three Regions

Overdrain design establishes the pressure differential within the system and offers different distribution patterns. Based on the pressure differential required, industry standard designs such as inlet diffusers, header-lateral distributors, and four-point nozzles distribute influent onto the media bed.

Four well-established underdrain designs play an equal and opposite role to the overdrain, maintaining appropriate outflow rates, plug flow, and the proper pressure differentials within the vessel (see Figure 2):

- **Header-lateral—**Typical for smaller vessels, this design employs a horizontal drainage pipe with laterals to drain treated water to the outlet.
- **External cone—**Also common in smaller vessels, this design uses a circular pattern of nozzles and screens.
- **Internal cone**—More typical in larger vessels, this underdrain is welded inside the unit. Its design is similar to a colander.
- **External ring header**—The latest evolution of underdrain design, the external ring header uses nozzles and screens, and fits flush with the vessel.

Optimizing the water flow between these three regions while also optimizing the media will reduce costs over the vessel's life. Accounting for the relationship between these three regions during the design saves energy, lowers

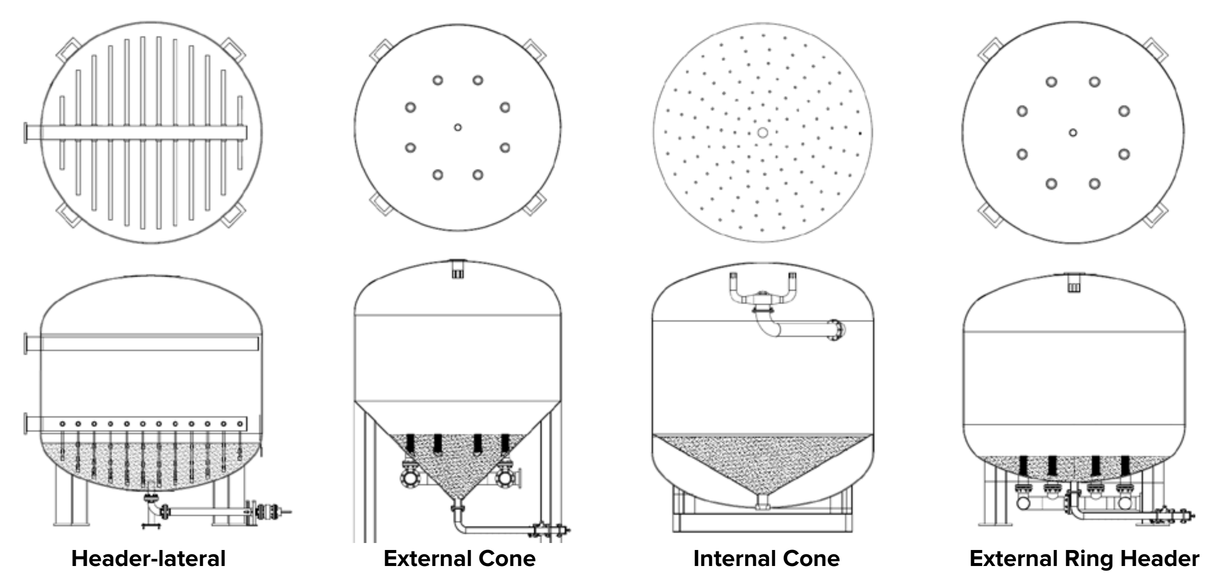

Figure 2. Four well-established underdrain designs

maintenance time and expenses, and optimizes media use. Minimizing head loss and achieving plug flow are the keys for vessel design, which can be aided by modern modeling tools.

Computational Fluid Dynamics

With the proper software, design engineers can take the parameters discussed here to experiment with and identify a design that will maintain plug flow within a vessel. Computational fluid dynamics (CFDs) software provides a model of internal velocity and pressure distributions of fully developed flows that is helpful for internal flows that cannot be viewed. CFD models can inform sizing and validate the designs of the three vessel regions.

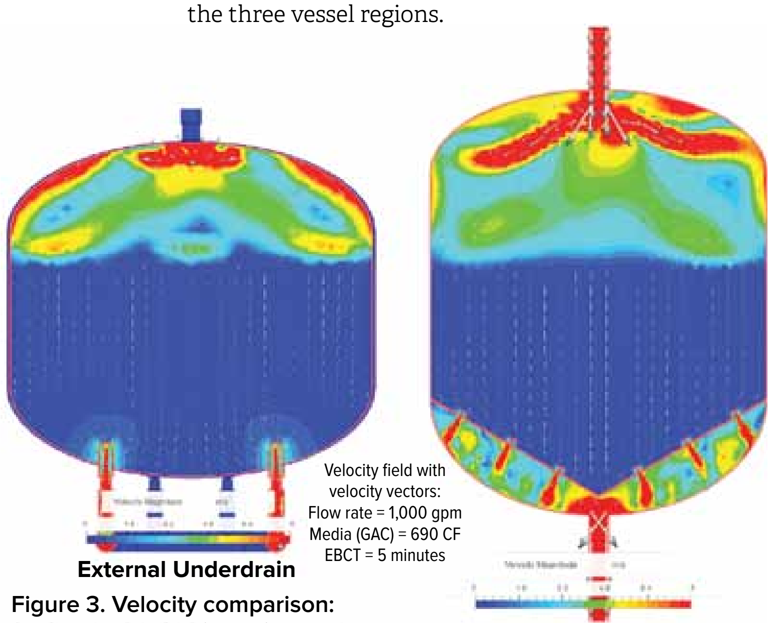

Figure 3. Velocity comparison: external underdrain vs. internal cone (12 ft [3.7 m] diameter vessels)

MEDIA OPTIMIZATION

CFDs continue to play an important role in design when optimizing media. The velocity maps that CFDs provide are valuable in selecting the best overdrain and underdrain, which can have lasting effects on mass transfer zone performance and plug flow. Pressure vessels often contain granular activated carbon (GAC) and for good reason; it's a universal water purifier that removes countless water contaminants. However, in the face of contaminants of emerging concern such as PFAS, other media may be better to secure long-term lifespan, manageable maintenance costs, and treatment performance results of a water utility's unique situation.

GAC

GAC is produced from various raw materials and manufacturing processes. Common carbon sources, such as coconut shell, bituminous, sub-bituminous, and lignite carbon, require different processing. Raw materials such as coconut shell, sub-bituminous, and lignite coals do not require an agglomeration process due to the inherent porosity of the starting material.

Carbon's ability to adsorb the most water contaminants has made it a long-established choice for water treatment. GAC vessels operate at hydraulic loading rates between 2 and 10 gpm/ft^2 (0.7 and 3.4 Lpm/m^2) and typically 10 minutes of empty bed contact time (EBCT). The density of the activated carbon must be considered carefully since in some cases bituminous coal-based products can be up to 20 percent more dense than sub-bituminous- and lignite coal-based products. It has been shown that sub-bituminous- and lignite coal-based products can treat equal volumes of water at identical EBCTs, meaning the carbon use rate in lbs of GAC/1,000 gal (kg of GAC/1,000 L) of water is less for the sub-bituminous- and lignite-based carbons.

A suggested equation for determining media volume based on desired empty bed contact time (EBCT):

EBCT (min) = Carbon Vol. (ft^3)/Flow Rate (ft^3/min)

EBCT (min) = Carbon Vol. (m^3)/Flow Rate (m^3/min)

Competitive adsorption from other organic compounds in the feed water can reduce the adsorption capacity for targeted compounds such as PFAS. Feed water containing high total organic carbon (TOC) or other competing contaminants may shorten the life of the GAC media bed.

Ion Exchange

Ion exchange (IX) tends to cost more per pound but can target specific contaminants like perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS). They treat PFAS at an EBCT of 2 to 3 minutes, withstanding higher hydraulic loading rates, between 6 to 18 gpm/ft^2 (2 to 6 Lpm/m^2). While IX can treat contaminants more selectively than GAC, competing anion contaminants such as SO_4, NO_3, and TOC must be accounted for in sizing and predicting media bed lifespan.

Proprietary Media

PFAS is a complex family of chemicals that has inspired alternative media development. Novel proprietary media such as CETCO's Fluoro-Sorb™ or Cyclopure's Dexsorb™ offer lower EBCT and higher hydraulic loading rates (a 2-minute EBCT and hydraulic loading rate of up to 14 gpm/ft^2 [5 Lpm/m^2] for Flurosorb). Performance testing shows that this medium matches the results of IX and is effective against both long- and short-chain PFAS. Media lifespan is fully dictated by PFAS concentrations.

No matter which media is right for the job, the ability to access, remove, and replace spent media for inspection, regeneration, or incineration is vital to facilitating long-term operations and maintenance by staff for decades.

LONG-TERM OPERATION & MAINTENANCE

Pressure vessel design does not end after selecting media. The final tenet of pressure vessel design considers where your final product will live and how it will be operated and maintained. The design choices made earlier in the process can dictate the standard operating procedures required of utilities once they take ownership.

The underdrains are of particular note:

- **Header-lateral**—The internal structure of this design includes multiple nozzle weld penetrations and maintenance challenges that can cause lining corrosion. Media must be removed from the vessel for any underdrain maintenance and requires confined space protocol when being maintained.
- **External cone**—This allows for simpler media exchange, with its conical shape pushing media toward the center. No vessel entry is required for working on its nozzles, and no confined space protocol is required for maintenance.
- **Internal cone**—Welded inside the vessel, this cone design increases the height of the vessel. Because of its shape and welding seams, this design comes with lining challenges and can be prone to corrosion.
- **External ring header**—This design allows for shorter heights, advantageous when installing in existing buildings. It features one homogenous lining throughout the vessel to avoid corrosive crevices. It does not require carbon removal for maintenance and repair or confined space entry.

Table 1. Pressure vessel design comparison

Description	External Ring Header	Internal Cone	Header Lateral
NACE Standard #RP0178-2007 compliant	✓	X	✓
Design mitigates risk of corrosion	✓	X	✓
One homogenous lining	✓	X	✓
Underdrain fully pressure rated to the vessel	✓	X	✓
Media optimized design*	✓	X	X
Optimizes pressure drop & pumping costs	✓	X	X
Prevents confined space entry	✓	X	X

*volume beneath top nozzle

Design Considerations

When vessel professionals discuss simpler designs, they are typically referring to ease of inspection during service events. Especially when using media that need reactivation like GAC, accessibility and lack of confined space protocol make upkeep simple for operators.

These systems often operate inside a building, so designing them with height in mind can affect a facility's operational costs. The annual electric costs related to HVAC, heating and cooling, and pumping water to the overdrain are all directly affected by vessel height.

The use of expansion joints when constructing pressure vessels can allow on-site assembly. However, expansion joint materials, such as ethylene propylene diene monomer (EPDM) rubber and neoprene, withstand much lower pressures than steel and are degraded by UV over time.

The final design parameter to consider is backwashing. Media like GAC and Fluoro-Sorb require backwashing to stratify the media and remove fine particles. Backwashing requires a larger volume vessel to make space for the process.

PFAS REMOVAL IN THE FIELD

When designing pressure vessels to remove PFAS, several factors affect the design. In choosing media, engineers must consider the types and concentrations of PFAS compounds, the presence of competing contaminants, and associated plant upgrades required prior to the pressure vessels and media. With the four tenets of pressure vessel design in mind, engineers can be assured their design will perform well for water providers and protect public health.

CONCLUSION

As new federal and state PFAS regulations change the landscape of water and wastewater treatment, consulting engineers will continue to see an uptick in treatment projects to remove and destroy these chemicals. Pressure vessels have shown great results in PFAS removal, due to their media variability, throughput, and cost of ownership.

Following the four tenets of pressure vessel design, engineers can know that they build the least complex system with the lowest cost of ownership to prevent late-night calls from clients about failing equipment. The order of operations presented here comes from many years of collective experience in designing, constructing, and operating these systems globally.

Consulting engineering comes with variety, so if pressure vessels are new to you, these tenets can guide you to the best solution for your project. It's also recommended to work with a technology provider early in the process, to leverage the provider's experience and augment design quality.

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Plastic debris in the environment: sources, transport, degradation, and insights from Debris Tracker data in New England

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ABSTRACT | This article provides an overview of the varieties of plastic pollutants frequently encountered in the environment, along with their sources, migration pathways, and degradation processes when exposed to natural weathering conditions. A case study examining the quantities, composition, and temporal variations of debris collected near the coastal waterways of four New England states—Maine, Massachusetts, New Hampshire, and Rhode Island—from 2019 to 2022 is discussed using data extracted from the Marine Debris Tracker database. Of all types of waste, plastic debris constituted more than 70 percent of the debris collected in each state. Within the broad category of plastic debris, foam and fragments, smoking-related items (mostly as cigarette butts), and plastic films including food wrappers were among the most collected items in these states. Much of the data reported in the database was contributed by local beach cleanup organizations. Their activities not only protect the coastal eco-system from debris pollution but also provide important information to guide the design of effective measures targeting the most littered items so as to minimize the formation of microplastics in the beach environment.

KEYWORDS | Marine debris, plastic debris, litter, microplastics, plastic fragments, Marine Debris Tracker, New England

Nearly 440 million tons (400 million tonnes) of plastics are produced globally each year.[1,2] Plastic debris has been found in various eco-compartments, including marine and freshwater bodies,[3,4] estuaries and sediments,[5-7] wastewater effluent,[8-10] and remote arctic ice.[11] The major sources of microplastic debris—extremely small pieces of plastic debris in the environment resulting from the disposal and breakdown of consumer products and industrial waste—include resin pellets, tire wear, urban litter, fishing and boating debris, and wastewater treatment plant effluent.[3,12,13] These materials are composed of relatively few distinct polymer classes (e.g., polyethylene [PE], polypropylene [PP], polyester, nylon, polystyrene, and polyvinyl chloride [PVC]), but there can be variability within the classes. For example, PE can have linear or branching chain structures, giving rise to high-density polyethylene (HDPE) and low-density polyethylene (LDPE), respectively. Table 1 summarizes common plastics used in consumer products and their pertinent properties.

Plastic makes up approximately 80 percent of all marine debris studied.[14] In other words, more than three-quarters of all marine debris is plastic, a persistent and potentially hazardous pollutant that can fragment into microplastics and be taken up by air, water, sediments, and organisms. Plastic debris may entangle or injure marine animals, and it can enter the food chain via direct ingestion or indirect consumption of prey species containing plastics. Plastic waste has also been known to damage the aesthetic value of tourist destinations, leading to decreased tourism-related incomes.

Large areas with a concentrated presence of marine plastics, known as garbage patches, have been found in the five global ocean gyres, with some gyres having more than one garbage patch. In the Great Pacific Garbage Patch, plastic outweighs plankton by a factor of six to one.[15] The name "garbage patch" may mislead many to believe that trash piles up on the ocean surface only. Instead, the debris can be spread throughout the water column and down to the ocean floor. An estimated 5.25 trillion macroplastics and microplastics float in the open ocean weighing up to 269,000 tons (244,000 tonnes).[16]

Table 1. Properties of common plastics found in environment

Plastic	Abbreviation	Production[1]	Specific Gravity[2]	Glass Transition Temp, T_g	Common Use[3]
Low-density polyethylene	LDPE	20%	0.91 – 0.93	- 100 °C	Films, carrier bags, bottles, straws
High-density polyethylene	HDPE	16%	0.94	- 100 °C	Milk and juice jugs
Polypropylene	PP	21%	0.83 – 0.89	- 50 °C	Bottle caps, fishing nets, ropes
Polyethylene terephthalate	PET	10%	1.39	70 °C	Beverage bottles
Polystyrene Expanded PS	PS EPS	8%	1.06 ~ 0.02	100 °C	Plastic utensils Food containers
Nylon / Polyamide	PA-6 or PA-66	<3%		40 -70 °C	Fishing nets and traps
Poly(vinyl chloride)	PVC	12%	1.39	varies	Cables, pipes, films clamshells

[1] From Geyer et al., *Science Advances*, 3 (2017), e1700782
[2] Density info from Teegarden, D.M. (2004), *Polymer Chemistry: Introduction to an Indispensable Science*
[3] Adapted from Andrady A.L., *Marine Pollution Bulletin*, 62 (2011), 1956

TRANSPORT AND DEGRADATION OF PLASTICS IN THE ENVIRONMENT

The pathways of plastic debris from land sources to aquatic environment are manifold. Eighty percent of the marine plastic debris is estimated to come from terrestrial sources via river or airborne transport.[12,17,18] Plastics may enter rivers from urban, industrial, and agricultural runoffs, as well as from wastewater treatment plant effluent. The transport of a plastic particle in terrestrial water is a function of size, shape, and density as well as water velocity and waterway morphology (e.g., the presence of vegetation filters).[19,20] The remaining 20 percent of marine plastics are from sources such as fishing and shipping industries.[21,22] The transport pathways for plastics are usually from inland to shoreline through river runoffs and wind transport, from shoreline to coastal water through tidal activity and currents, and from coastal to offshore water by gravity and deep thermohaline (bottom) currents.[5] The ocean is a major sink for plastics in their macro-, micro- and nano-forms.[5] Most floating plastics circulate between beach and coastal water by waves and shoreline currents for years to decades before eventually escaping into the offshore environment. A significant time delay exists between the release of plastics (source) and their deposition in offshore waters (sink), during which degradation and breakdown occurs.

Once released into the environment, plastics undergo continuous chemical reactions, erosion, and fragmentation through interactions with sunlight, microbes, and chemical excipients found concurrently.[23,24] Prior work has shown the effects of UV light, oxidation, thermal stress, and aqueous environments on different types of plastics.[23,24] Plastic degradation and weathering are influenced by polymer properties (such as density and crystallinity), type and quantity of chemical additives, and environmental exposure conditions. The beach surface provides a high exposure to solar UV, elevated temperatures, and high oxygen availability.[4] This environment favors plastic fragmentation due to concerted actions of photooxidation, surface ablation, and hydrolysis. In contrast, plastics in marine sediments with no exposure to solar UV, low levels of oxygen, and low temperatures are likely to undergo biofouling.[4]

The exposure of plastics to sunlight initiates photooxidation by the formation of free radicals propagating rapid reactions in the presence of oxygen. The predominant degradation mechanism of PE and PP is initiated with solar exposure, resulting in the formation of polymer free radicals.[3] As PP and PE are made of saturated carbon bonds that are resistant to photo degradation, the initial sites of UV attack are the structural defects or adventitious impurities in the polymers.[24] Once initiated, radicals react with oxygen to form a peroxyl radical, which propagates further radical reactions leading to chain scission, branching, or a combination of both depending on the ratio of secondary and tertiary carbons present.[24,26] The radical reactions may also create an increased amount of oxygen-containing functional groups (e.g., carbonyl and hydroxyl groups) on the surface.[27-29] The extent of surface oxidation of plastics can be quantified by the carbonyl index, which measures the relative change in the intensity of carbonyl infrared (IR) absorption band. [27,29]

In polyethylene terephthalate (PET), both photolytic and hydrolytic degradation is observed. Laboratory experiments conducted to reveal the degradation mechanisms of PET indicate that yellowing occurs due to photolytic oxidation, while a hazy appearance is a consequence of both photolytic and hydrolytic degradation.[30] Chain scission and crystallization are common mechanisms of degradation of PET under both photolytic and hydrolytic conditions.[30] Recent work on PET has shown that appreciable rates of enzymatic hydrolysis can occur in certain environments as well,[31] and this has been exploited for controlled depolymerization of PET.[32-35]

Like PET, polyamides undergo hydrolytic and photolytic breakdown. A recent study investigated the environmental degradation of nylon,[6] PET, and polyvinylidene fluoride (PVDF) in fishing line fibers by lab-simulated weathering conditions.[36] Structural changes were observed in all three polymers after UV exposure, indicating that UV exposure increased polymer susceptibility to mechanical deformation. Chain scission by photooxidation was observed in nylon 6 as well.[36]

Understanding biodegradation of plastics ecologically is important; they are responsible for converting bulk plastics or partially degraded polymers to smaller molecules and to eventual mineralization.[4] Biodegradation of PE and PP is considered very slow until other degradation processes convert polymer backbones to smaller pieces and increase surface oxygenation and hydrophilicity.[24,37] Biological actions, however, may lead to surface fouling within weeks to months of weathering.[38-40] In the marine environment, extensive bio-mats on plastic surface formed by a diverse population of bacteria, algae, diatoms, and barnacles have been observed.[3,38,41] Biofilm formation may affect the degradation of plastics in several ways. The unique ecosystem in the biofilm supports the growth of plastic-degrading bacteria that can enable slow degradation in the long run.[41] The fouling layer absorbs light and protects the underlying plastics from UV damage.[39] Fouling also increases the density of buoyant plastics such as PE and PP causing them to be denser than seawater and enabling vertical fallout of particles from surface into the deeper ocean zones.[4,42] The extent of density change depends on the particle size[38,43,44] and the type of organisms accumulated,[45,46] with smaller particles experiencing a greater density change.

CURRENT METHODS FOR ANALYSIS OF MICROPLASTICS IN ENVIRONMENTAL MEDIA

The National Oceanic and Atmospheric Administration (NOAA) defines microplastics as plastic particles smaller than 5 mm (0.2 in.).[47] Plastics smaller than a micron (1 μm [.00004 in.]) are known as nanoplastics.[4] Identification and quantification of microplastics in environmental matrices are challenging due to the high concentrations of inorganic solids, natural organic matter, and other debris in the background. Pretreatment methods facilitate the purification and extraction of microplastics from their original matrices.[48] This in turn is expected to improve the sensitivity and accuracy of microplastic identification. Wet peroxide oxidation, density separation, and enzymatic digestion are the pretreatment methods used extensively for separation of microplastics.[47]

Upon pretreatment, microplastics are amenable to detection using visual or microscopic inspection based on their physical appearance (e.g., shape, size, color, and surface morphology). As particle size decreases, properties used in visual or microscopic detection are less distinctive and may lead to significant errors. Identification of chemical structure is therefore indispensable.[49] Currently, identifying plastics in environmental samples is achieved with spectroscopic and thermo-analytical methods. Vibrational spectroscopic methods such as Fourier-transform infrared (FTIR) and Raman spectroscopy can inform the type of plastics.[50-52]

Thermo-analytical techniques provide an alternative to identify and quantify microplastics. Unlike spectroscopic techniques, thermo-analytical methods are not size-dependent. These techniques are considered more robust against impurities and potential interference from environmental matrices. The most applied thermo-analytical techniques are thermogravimetric analysis (TGA, often hyphenated with mass spectrometry or other analytical techniques), thermal desorption-gas chromatography-mass spectrometry (TED-GC-MS), and pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS).[48,49,53-55] These methods could complement microscopic and spectroscopic studies by providing quantitative information about plastic type, mass abundance, and the presence of additives.

A lack of standardization exists in approaches for plastic sample collection, sample pretreatment, extraction, and analysis. Each analysis method has advantages and disadvantages, and a combination of several analysis techniques is necessary to draw conclusions about the presence of microplastics and describe their size, density, morphology, and chemical properties.

CITIZEN SCIENCE-BASED TOOLS FOR COLLECTING MARINE DEBRIS DATA

Many organizations around the world organize beach cleanups to collect and report back debris data. Marine debris is defined as any human-made, solid material that enters coastal and ocean waters directly (e.g., by littering, dumping, or being swept overboard) or indirectly (e.g., poorly secured garbage cans caught in the wind or caught up in stormwater runoff). Numerous smartphone-based tools exist to enable environmental groups, civic organizations, and volunteers to report marine debris findings during beach surveys or cleanup events. The Marine Debris Tracker (MDT) mobile app powered by Morgan Stanley in partnership with the National Geographic Society and the University of Georgia is an open-source citizen science tool for reporting marine debris.[56] The app, developed in 2010, initially allowed participants to contribute data on trash along coastlines and later allowed for data reporting from inland waterways as well. Geospatial data is collected when participants record the characteristics of litter (e.g., litter type and quantity). These records are then uploaded to a public database. In addition to MDT, the Marine Debris Monitoring and Assessment Project (MDMAP) also exists through NOAA's Marine Debris Program. MDMAP surveys are conducted by trained volunteers using a standardized process to examine the coastal marine debris problem. Surveys are done repeatedly at regular intervals over an extended time so that temporal changes in debris can be observed consistently. Another app, Clean Swell, is much like MDT, but it was developed by the U.S.-based environmental group Ocean Conservancy in 2015.[57] Platforms such as Clean Swell, MDMAP, and MDT all advance the growing datasets on pollution that can contribute to marine debris.

One challenge of solid waste management is the lack of high-quality data on waste characteristics and distribution. The MDT database contains a large volume of geospatially tagged debris information accumulated over years. Nonetheless, this extensive dataset has seldom been analyzed to understand the nature of litter pollution, especially in areas of high population densities. The objective of the following case study was to use crowd-sourced data from the MDT data platform to analyze the quantities, composition, and seasonal trends of debris near coastal environments in Maine, Massachusetts, New Hampshire, and Rhode Island from 2019 to 2022. Although the app has been in use since 2010, the MDT registered fewer data logs prior to 2019. Compared to prior years, data collected in 2019 and 2020 does not indicate a decrease in debris collection activities due to the Covid-19 pandemic. Nonetheless, the public safety guidelines implemented during the pandemic likely affected cleanup practice and debris statistics, and for this reason, detailed item composition and seasonal trend analyses were performed on data reported in 2021 and 2022 only.

METHODS

Data from the MDT global database was extracted between January 1, 2019, and December 31, 2022, in the format of a .csv (comma-separated value) file. Data extracted on different occasions over the last few years suggests a few changes in debris categorization by the app. For this reason, data was re-extracted in April 2024 over all four years to ensure all data was labeled according to the latest categorization scheme. The data was then converted into a software spreadsheet table. All data entries recorded in the four states (i.e., Maine, Massachusetts, New Hampshire, and Rhode Island) were selected for this study based on the location information of the data logs using appropriate software filtering functions. Once the initial data preparation was complete, data analysis was performed with the assistance of software pivot table analysis. Each debris record has location, time, material, and item descriptors associated with it and the quantity of the item found. The descriptor "material" classifies debris into major material categories such as plastics, cloth, glass, metals, and others (see Figure 1). Debris of the same material type may be further divided based on "item name." As an example, cigarettes, plastic and foam fragments, and plastic food wrappers are a few common item names registered under plastic material (see Figure 2). It was recognized that certain non-plastic material categories also contain plastic items. For instance, the material "fishing gear" encompasses an item name "plastic rope or net." These out-of-category plastic items were manually included into some of the analyses to explain the results.

Inspection of the data suggests that some data logs have a large item count per record, likely reported by group cleanup events. Data with more than 500 items in one record commonly occurred in the months of July, August, and October. Some but not all of these large-quantity single entries have organization names indicated in the records. Examples of organization names associated with notable large-quantity records are Blue Ocean Society for Marine Conservation (New Hampshire and Massachusetts), Clean Ocean Access (Rhode Island), and Rozalia Project (Massachusetts). These group records are included in the analysis in this study. In an ongoing geospatial analysis (not covered in this study), they are excluded due to their likelihood to skew debris geospatial representation.

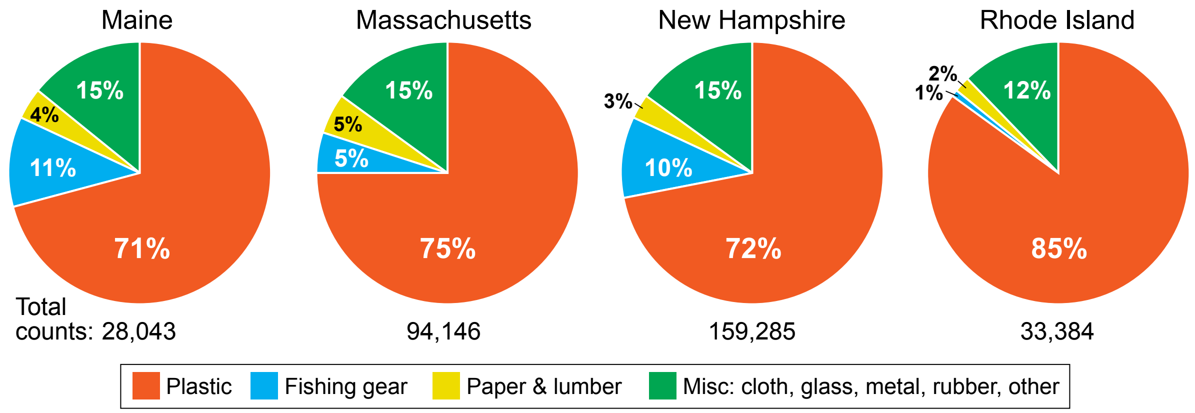

Figure 1. Distribution of marine debris composition by state between 2019–2022

RESULTS AND DISCUSSION

Figure 1 shows the distribution of all debris records in the MDT database from 2019 to 2022 by state and material type. The debris counts are shown to indicate the size of the data pool, and they should not be used to construe the extent of littering or the effectiveness of cleaning efforts in each state due to large differences in the geographical size, population, land use, industrial (including fishing) activities, and proximity to major urban centers. It is also recognized that, although the MDT app was originally designed to track debris along coastlines, volunteers also logged in data from inland locations. These do not affect the analysis as this case study aims to understand the makeup of common debris, particularly plastic waste. The pie charts in Figure 1 indicate that for all states a dominant fraction, corresponding to over 70 percent of debris recorded and submitted to the MDT app, was of polymer nature. It was followed by fishing gear, which accounts for 10 percent and 11 percent of debris in New Hampshire and Maine, respectively. The contribution of fishing gear is markedly smaller in Massachusetts and Rhode Island. Miscellaneous waste is the third largest category. Other categories, including cloth, glass, paper and lumber, and rubber, constitute minor shares of less than 5 percent of the annual total.

Debris recorded as plastic material (i.e., plastic debris) is further classified into subcategories based on its item name. In the original data, over 20 item names exist for plastic material, and they were grouped into seven subcategories, factoring in their properties or use. The grouping system is shown in Figure 2, in which the name of each subcategory is accompanied by a list of items included in the group. For instance, lighters and cigarettes are grouped as "smoking-related," "foam and fragments" includes fragments, fibers, and other plastic debris of relatively small dimensions, whereas "films and plastic sheeting" encompass food wrappers, plastic bags, and other items of film nature.

The Figure 2 pie charts show the composition of plastic debris over the four-year period. Overall, similar distribution patterns were observed in the time studied, but noticeable trends occurred. Smoking-related items accounted for 37 percent of plastic debris in 2019, the largest among all

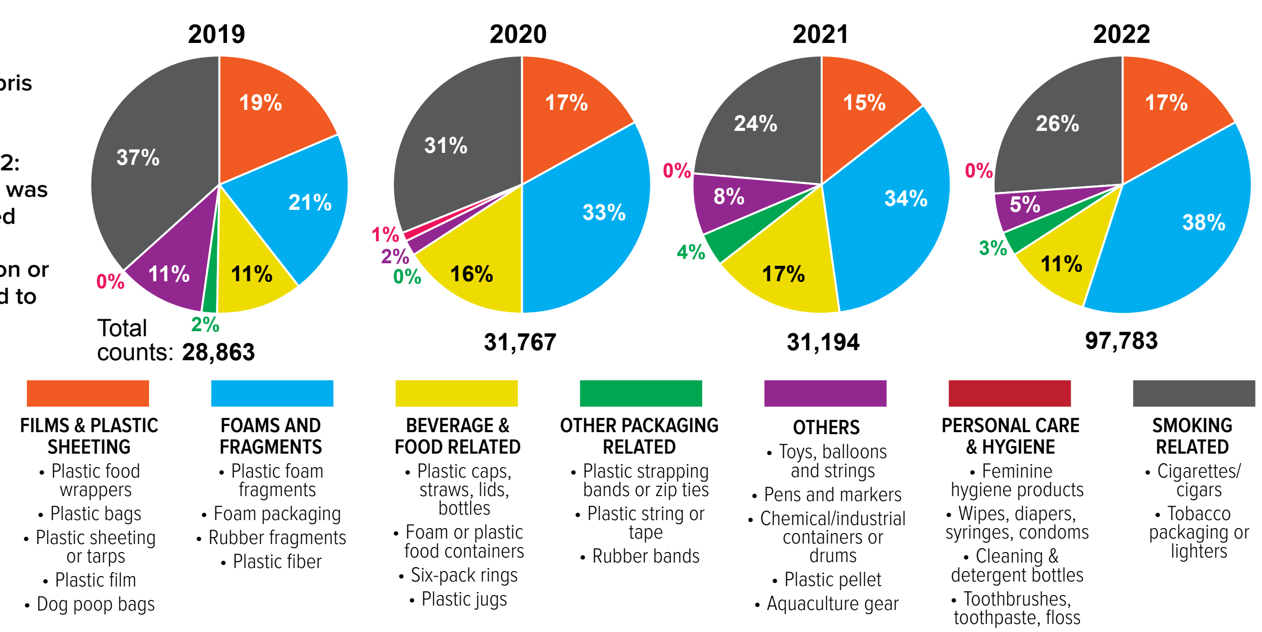

Figure 2. Plastic debris by type between 2019–2022: the plastic was categorized based on composition or use related to that item

subcategories. However, its share declined to 26 percent in 2022. Meanwhile, foam and fragments increased consistently from 21 percent to 38 percent in the same period. Other than the above, the other two most collected plastic debris were films/plastic sheeting and food and beverage-related items. Collectively, the top four subcategories accounted for over 85 percent of all the plastic debris recorded. An interesting, albeit inconclusive, observation is that the highest quantity of personal care and hygiene items was collected in 2020, during the early phase of the pandemic, but its contribution was generally small over all years.

Table 2 shows the top 10 most collected plastic items ranked by their item counts over the most recent two years (2021–2022) across all states. Plastic or foam fragments led with 47,730 items collected, followed by cigarettes/cigars with 32,519 and plastic food wrappers with 13,617 items collected. These top three items contribute to over two-thirds of plastic debris collected in the period.

Figure 3 presents monthly counts of plastic debris in 2021 and 2022 to give insights into the temporal variations in debris collection. The trends do not necessarily correlate with the quantities of debris generation, but reflect the level of debris cleaning activities in each state across the seasons. In 2021, all four states showed two peak periods of debris counts; however, the timing of the peaks varied from each other. Massachusetts and New Hampshire saw the highest records in mid-summer (July–August) and early fall (September–October), whereas Rhode Island collected the most debris in early summer (June) and late fall (November). In Maine, the two distinct peaks arose in spring (April) and late fall (November). Trends in 2022 differ notably from those in the prior year. Both New Hampshire and Massachusetts had a spring peak in the month of March or April that was less noticeable in the prior year. Plastic debris counts peaked again in the summer in both states, and the absolute counts in New Hampshire during the summer of 2022 were significantly larger than other states in the same period. The records show that cigarettes, foam fragments, and food wrappers were the most collected items in those months in New Hampshire, consistent with the findings in Table 2. Similar to the prior year, high debris counts in Maine occurred in early spring and in fall, with the exact peak timing varying from year to year, possibly influenced by weather and other factors. Rhode Island showed low activities in 2022 in general.

Table 2. Top 10 plastic debris collected in 2021–2022

Rank	Item Name	Total
1	Plastic and Foam Fragment	47,730
2	Cigarettes/Cigars	32,519
3	Plastic Food Wrappers	13,637
4	Other Plastic	6,781
5	Plastic Caps or Lids	5,906
6	Plastic Film	4,537
7	Plastic Bottle	4,455
8	Plastic Bags	3,384
9	Plastic Strapping Bands or Zip Ties	2,552
10	Straws	2,391

Every year, the Ocean Conservancy holds the International Coastal Cleanup (ICC), a day when communities across the globe collect and document the trash littering their coastlines. The organization asks volunteers to use the app Clean Swell to compile data from global efforts to publish its annual ICC report, which consists of the collective effort of more than one million volunteers worldwide. In its 2023 report, which is based on the ICC data collected in 2022, cigarette butts were the top litter on beaches globally, followed by plastic bottles and food wrappers.[57] In the same report, the most collected items in the United States were cigarette butts followed by bottle caps, food wrappers, beverage bottles, and straws. The ICC data focuses on primary litter objects. Secondary waste, which consists of breakdown products of primary litter, including plastic fragments, foam pieces, and synthetic fibers, is not included in the ICC data. This explains a major difference between the observations of the current study and those identified by the

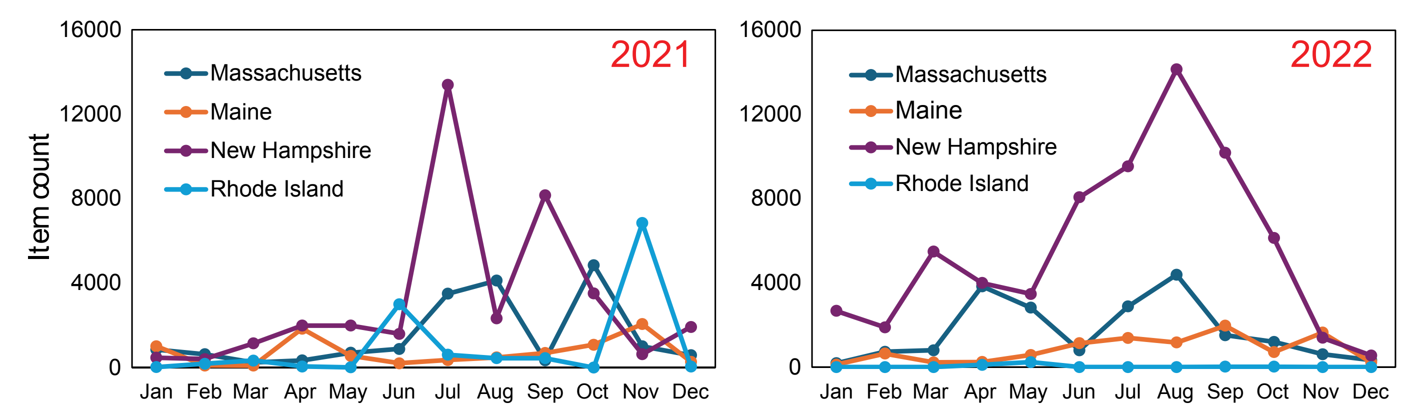

Figure 3. Monthly item counts of plastic debris in 2021 and 2022

PLASTIC DEBRIS

ICC. Fragmentation takes place when plastic litter deteriorates in the environment due to exposure to sunlight, mechanical abrasion, and biological weathering. Because of their diminutive sizes, fragments are less amenable to removal in cleanup events. They exhibit increased mobility in the environment, carry a higher load of hydrophobic contaminants due to their larger specific surface areas, and are more likely to be ingested by organisms.[12,13] The emergence of microplastics as a result of fragmentation of bulk plastic debris is the primary reason for concerns over plastic pollution. In the MDT app, plastic fragments outnumber all primary litter items, confirming the extensive occurrence of fragmentation of larger debris in the environment. This highlights the importance of minimizing littering in the first place and the swift removal of primary litter objects through regular cleanups by municipal and state programs and voluntary organizations.

Excluding plastic fragments, cigarette butts are the most frequently collected items according to both the MDT data (see Table 2) and the ICC report. Cigarette butts can persist in the environment for up to 10 years. A 2009 study conducted by Keep America Beautiful (KAB), a national nonprofit that provides resources and runs programs to reduce littering near roadways, found that smokers are more likely to litter if the environment contains any type of litter, not just cigarettes.[58] In other words, previously littered environments have been shown to encourage more littering. Food wrappers are the next most littered items after cigarette butts in the New England states. Compared to the national data in the 2023 ICC report, beverage bottles and bottle caps are less prominent litter items in the New England states, and further analysis is needed to discern whether state-run bottle deposit programs, currently active in Massachusetts and Maine, may reduce littering of this type of waste.

While the data available for this study cannot pinpoint the sources of debris, the seasonal trends provide insights into the influence of human activities on debris counts. Peak beach tourist seasons for most states in New England are in the summer. Additionally, the northern states attract visitors in later months when fall foliage is in full display. In the summer, frequent waste collections occur during peak tourism. Other times, cleanup tends to occur in the late fall when fewer tourists are around or in the spring before the arrival of large crowds. In all cases, organized efforts by local organizations contribute greatly to debris collection and data reporting. For instance, more than 90 percent of debris counts in New Hampshire in 2022 were contributed by Blue Ocean Society for Marine Conservation. Group-led cleaning is also is crucial in recovering large quantities of plastic fragments, as the latter often go unnoticed by individual, untrained volunteers.

A common limitation of crowd-sourced data is the likely presence of inconsistent data collection and reporting methods. This drawback is less significant with the heavy involvement of organized collection. Most notably, the large volume of data in the MDT dataset allows meaningful insights into the composition of debris that are otherwise difficult to obtain through more rigorous but small-scale beach surveys. Given that beaches are important venues of plastic fragmentation, the generation of microplastics can be mitigated by reducing the influx of primary plastic debris into beach sites. To this end, the observation that a small set of litter items form a predominant portion of plastic debris in the New England states provides ideas for designing focused litter prevention programs to minimize the release of microplastic precursors.

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You have to know the problem before you implement a solution: a science-based solution for a failed wastewater system

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ABSTRACT | The owners of a multi-unit senior care facility in Vermont were faced with replacing an on-site, soil-based wastewater disposal system. This was not the first time this issue had arisen; this system had failed and been replaced several times over the years. Previous replacement designs expanded the leachfield footprint and used chamber-style treatment and disposal. The replacement systems also failed, causing effluent backups and surfacing within just a few years.

A new approach for a replacement system for the latest failure took a more comprehensive approach. The focus was to understand the root cause of the leachfield failures, then design a treatment and disposal system that targeted reduction of that impact. First, a wastewater characterization study was conducted that showed the effluent was not responding to primary treatment as typically seen with domestic-strength wastewater. A chemical-use inventory and historical wastewater quality/flow data analysis established why the treatment systems had failed in the past. A pilot test of a different pretreatment technology was performed to ensure effluent quality would be suitable for on-site disposal.

In addition, the facility owners received a State Revolving Fund (SRF) grant to help finance these critical upgrades. They now have a properly functioning wastewater system that not only addresses their waste profile but also the facility's wastewater treatment and disposal needs now and into the future.

KEYWORDS | Wastewater, leachfield, sampling, pilot test, SRF funding

A retirement community in Vermont provides a full spectrum of living options to seniors in a campus-like setting, including independent living apartments, assisted living, and full nursing care. The facility's water and wastewater infrastructure was permitted and built piecemeal over several years as the campus evolved, with five on-site, soil-based wastewater disposal systems being built at the rear of the buildings. Total water and wastewater used at the campus amounts to about 20,000 gpd (75,700 L/d). These leachfields occupy essentially all of the campus area with suitable soils, leaving no space for new disposal fields.

Four of the five leachfields functioned without issues, but one wastewater system was problematic. This system accepted sewage from the assisted living facility that houses the campus's commercial kitchen furnishing all the meals served and where wastewater flows amount to 6,000 gpd (22,710 L/d). The original septic system consisted of a number of narrow leaching trenches which had failed in the past. This original field was replaced with new leaching trenches adjacent to the original location, but this new system failed again in a few years.

The facility's third leachfield was placed in the same footprint as the previous replacement leachfield since no other location was available. This third system used a state-approved pretreatment technology with fabric-wrapped chambers placed in mound sand. This system also failed after only a few years. The owner subsequently implemented the recommendations of the system vendor to attempt to rejuvenate the system, but it fouled yet again in a short time. All these failures were believed to be caused by the leachfield and pretreatment chambers clogging. After that most recent failure, the main field was taken offline, with effluent being collected in temporary holding tanks and pumped out weekly. This service cost thousands of dollars per month, an untenable situation for a nonprofit facility.

Faced with yet another failure and mounting disposal costs, the owners contracted a wastewater engineering firm to evaluate how to correct their wastewater issues and prevent them from recurring again.

WASTEWATER CHARACTERIZATION STUDY—FINDING THE CULPRIT

A review of the site history and uses showed that the facility's effluent was not of typical domestic strength. With this in mind, the recommended first step was to obtain the data necessary to understand the makeup of the facility's wastewater.

Composite samples were taken throughout the wastewater collection system for the assisted living facility discharging to the failed leachfield. Sampling locations included a manhole receiving domestic wastewater, grease tank influent and effluent from the commercial kitchen, and septic tank influent and effluent containing both kitchen and domestic wastewater. Each sample was collected with an autosampler over 24 hours and analyzed for biological oxygen demand (BOD), total suspended solids (TSS), nitrate, nitrite, ammonia, total Kjeldahl nitrogen (TKN), and oil and grease. Table 1 shows BOD, TSS, and oil and grease results.

To determine flow and the chemical makeup of the effluent, facility personnel monitored and recorded total water usage, softener backwash flow, and kitchen component usage (dishwasher, preparation sinks, pot sinks, etc.). The neighboring facility staff also summarized the types and volumes of chemicals used annually. Active ingredients in the bulk of the chemicals used were surfactants (soaps), caustics, alcohols, glycol, sodium hydroxide, and quaternary ammonia compounds (Quats).

Typical domestic strength effluent has a BOD of 250 to 300 mg/L. Domestic-strength effluent was assumed and used as the basis of design for the prior disposal systems. Measured BOD levels were found to be nearly 600 mg/L and oil and grease levels over 30 mg/L. The collected data also showed little reduction in BOD and oil and grease concentrations in the septic tank, something that is not typical.

An evaluation of the chemicals used at the facility was performed to determine if one or more could be hindering primary treatment. Most of the chemicals used are readily degraded by the bacteria present in wastewater systems. Surfactants can impede TSS partitioning; however, the sampling results indicated that TSS reduction was occurring in the septic tank.

Quaternary ammonium compounds (Quats) on the other hand are not readily biodegraded. They are stable and highly effective at disinfection in high concentrations. These products are used to comply with regulatory requirements for disinfection and are integral to facility kitchen cleaning processes. Research into Quats' toxicity and function indicated that anerobic degradation of nutrients is inhibited with 5 to 15 mg/L of Quats present. Significant inhibition of functions such as nitrification can occur with as little as 2 to 5 mg/L Quat concentration. The reported inhibition of biologic treatment is intensified by shock loads (i.e., occasional high-concentration doses) of Quats.

Table 1. Wastewater sampling results

Location	BOD 5-Day	TSS	Oil & Grease
	mg/L		
Typical wastewater effluent (domestic strength)	300	180	10.8
Grease trap – influent	>1,800	370	222
Grease trap – effluent	1,900	190	44.4
Septic tank 1 – influent	480	340	15.4
Septic tank – effluent	590	94	32.5

Review of chemical usage logs indicated that shock loads of Quats could be occurring. These records, combined with the flow logs, provided the information needed to estimate the septic tank's Quat concentrations. Estimated Quat concentrations ranged from 4 to 18.4 mg/L, which is above the level at which biologic activity is inhibited. The high end of this range is nearly 10 times the concentration at which biologic activity inhibition had been observed. The presence of Quats appeared to cause the reduced primary treatment efficiency. Quat presence also limited biologic treatment in the pretreatment chambers and soils of the leachfield, likely resulting in clogging and system failure.

Removal of Quats from the wastewater stream would greatly reduce effluent strength and increase biologic treatment of the effluent. The owners had researched alternative disinfectants, but only chlorine-based products were suitable by regulation. They had previously used chlorine-based products but had abandoned them because of the eye, skin, and nasal irritation impacts on workers. No other regulatorily acceptable disinfection alternative was available. In the interest of staff safety, the continued use of Quats was required.

Thus, the impact of Quats had to be overcome to reduce effluent strength to levels that would not result in leachfield failure. A pilot study using actual effluent was recommended to prove that potential pretreatment systems would be effective.

Installation of the pilot treatment system

TREATMENT SYSTEM PILOT TESTING

The goal for pretreatment was to overcome Quats' biologic activity inhibition by creating highly advantageous conditions for aerobic biologic growth. Aerobic treatment systems are highly effective at BOD concentration reductions of 98 percent or better. The results of the wastewater evaluation were shared with several vendors. A treatment goal of under 30 mg/L for BOD and TSS was established, which is the tertiary treatment standard of the Vermont Department of Environmental Conservation (VT DEC) wastewater rules. Ideally, BOD and TSS would be reduced to 10 mg/L each. If the pilot system could bring BOD and TSS levels to 10 mg/L, the replacement disposal field would be essentially dispersing clean water, allowing 3 times the amount of effluent per unit area to be applied to the ground surface. As open space was limited, achieving tertiary strength wastewater was a key objective for the full-scale system design.

A trickling filter-based technology vendor was selected and asked to perform a pilot test to treat up to 300 gpd (1,135 L/d) of side-streamed effluent. The pilot treatment system was set up in May 2020 (see adjacent photo).

Two plastic septic tanks were arranged aboveground, adjacent to the facility septic tanks. A flexible impeller pump was installed above grade, with a small-diameter polyvinyl chloride pipe and foot valve to keep the system primed. Effluent from the septic tank was drawn by the pump and fed into the two pilot tanks. These pilot system tanks contained plastic media suspended above the effluent. Recirculating pumps sprayed effluent over the plastic media to promote biologic growth, and treated effluent was then discharged to frac tanks.

The pilot test ran from May to July and produced favorable results (see Figure 1). Approximately 300 gal (1,135 L) of effluent were passed through the treatment system per day. It took approximately 21 days for the biologic growth on the media to become robust enough to meet the 30/30 treatment goal (30 mg/L BOD and 30 mg/L TSS). The flow rate and recirculation volumes were then adjusted to optimize pilot system operation, achieving the desired 10/10 (10 mg/L BOD and 10 mg/L TSS) for several weeks. (see Figure 1)

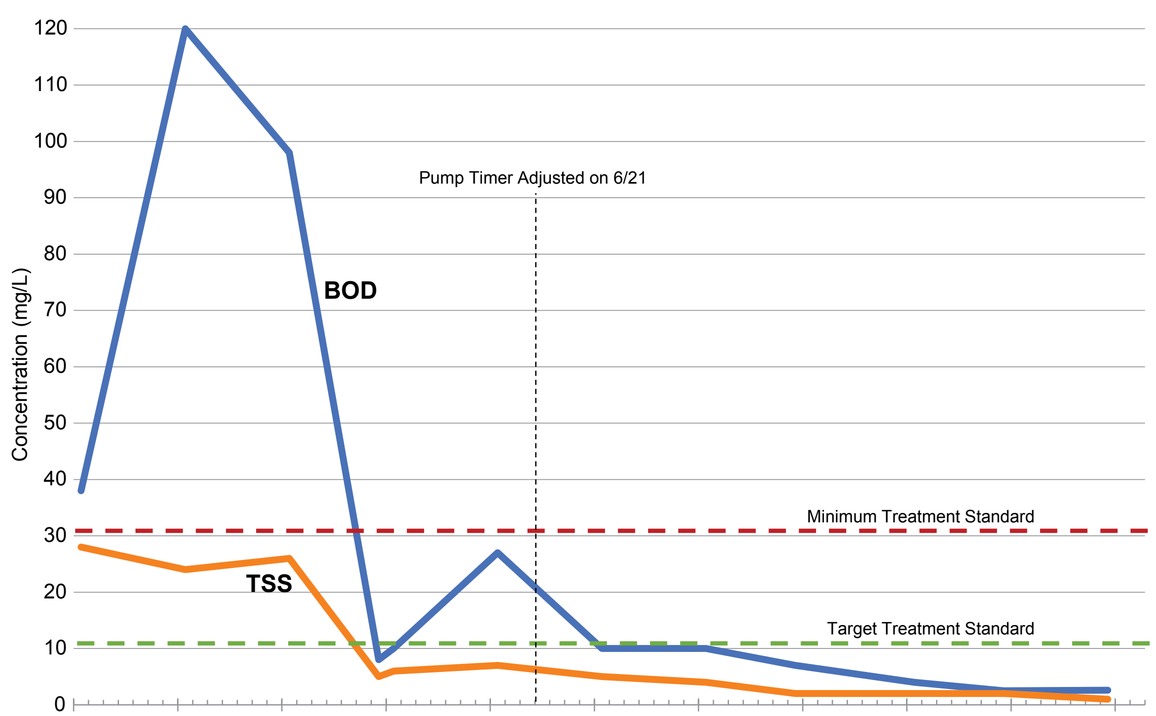


Figure 1. Pilot test results

The successful pilot test indicated that treated effluent quality was such that replacement of the soil-based disposal field in the same footprint as the previous fields would be possible. A drip disposal field was proposed which would maximize the amount of effluent able to be discharged in the limited footprint. The chamber-based disposal system and impacted soils surrounding it would be removed and replaced with mound sand prior to shallow placement of the drip disposal field.

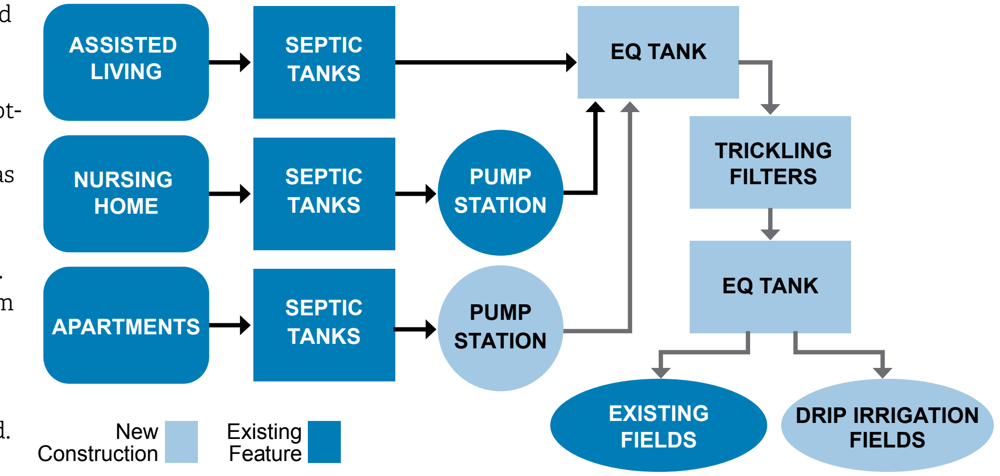


Figure 2. Process flow diagram for the consolidated wastewater system

THE SOLUTION

While considering next steps following the pilot study, the sewer infrastructure of the entire campus was discussed, since the wastewater systems were over 20 years old. The owners' vision for the campus included improving the standard of care for residents; thus, a logical next step was to consider the other four disposal systems and whether building a single system that could serve the entire campus for at least the next 20 years would be beneficial.

Evaluation of alternatives indicated that the proposed pretreatment and drip disposal system could be scaled up to accommodate all campus wastewater flows. A new wastewater system would not only solve the immediate issues with the facility's effluent but also ensure that the whole campus would have a well-functioning system. It would also consolidate the permit-required inspection and monitoring requirements. The increase in capital costs appeared reasonable considering the ongoing upkeep and operation needs of the aging systems.

The campus's permitted flows are 20,000 gpd (75,700 L/d). Using the data from the pilot study and collaborating with the treatment system vendor, the owners had a campus-wide pretreatment and disposal system designed. The pretreatment system uses the existing primary treatment (septic tanks, grease interceptor, and pump stations) at each building and discharges to two equalization (EQ) tanks. Two treatment trains, each with five trickling filter tanks running in parallel, provide treatment prior to discharge to a second EQ tank. Treated effluent is pumped from the second EQ tank into either the new drip disposal system designed on the footprint of the former disposal field or to two stone-and-trench leachfields.

The two existing leachfields were selected as they were functioning properly, located adjacent to the drip field and oriented to optimize the available space. The discharge pumps for each of the three disposal fields were configured on their own timer-based float assemblies, allowing the operator the flexibility to fine-tune flow rates to each field. The operating goal is to have a uniform effluent flow across the linear footage of the combined disposal systems, minimizing groundwater mounding beneath the fields.

A new process control building was designed to house the control panels for the treatment system, along with suction lift discharge pumps that circulate effluent to the drip irrigation field. Figure 2 illustrates a process flow diagram of the new system.

PUBLIC FINANCING FOR A NONPROFIT

The campus now had a solution for the repeated failures of its wastewater system, as well as a comprehensive wastewater treatment system for the campus's future. However, the necessary capital for the full-campus system was not available, even after the owner conducted an exhaustive search for funding. One option presented was the Vermont SRF program, run by the VT DEC Water Investment Division (WID). With tens of millions of dollars in federally assisted aid, it is an important financing program for municipalities to bring water and sewer projects to fruition by providing low-cost loans for engineering, construction, and administrative costs. Typically, the users of the SRF program are cities and towns, but certain nonprofit organizations (like the one described here) can be eligible.

In 2021, the wastewater engineering firm advocated for the owner's eligibility for the program, noting the health hazards of a non-functioning septic system for senior citizens. After a series of meetings, the VT DEC WID found that the owners were eligible to participate in the SRF program. However, this did not mean that groundbreaking could occur immediately.

To use SRF funds, the WID requires an additional level of environmental and technological review. This includes not only an alternatives analysis to ensure that the most cost-effective technology is chosen, but also a review of environmental land

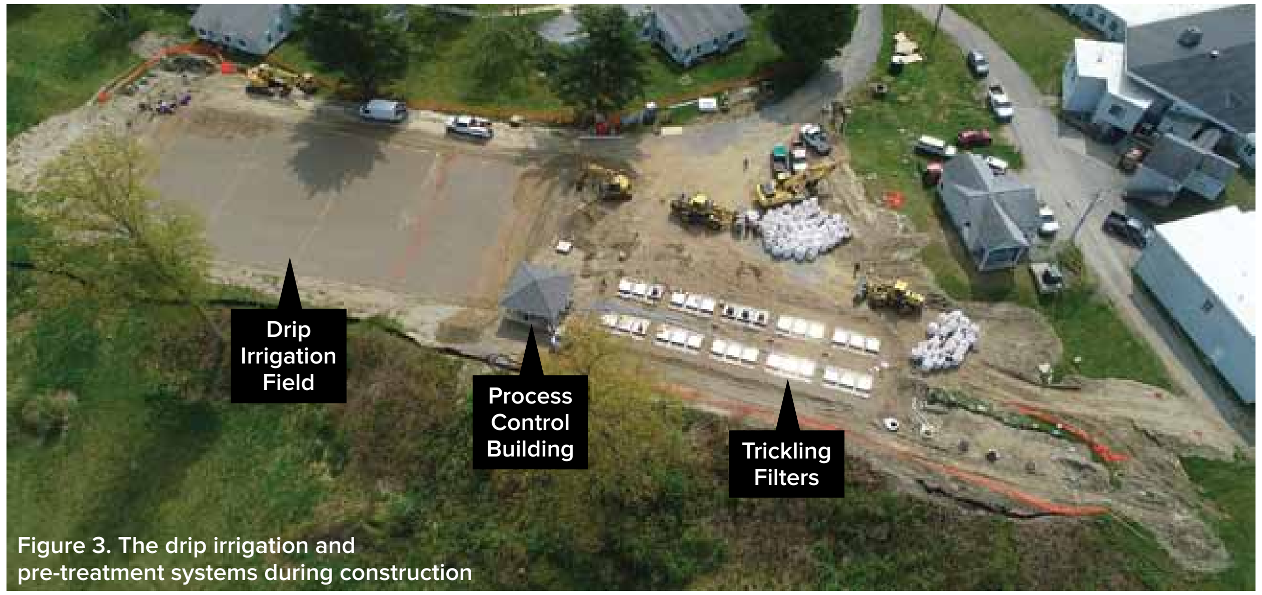


Figure 3. The drip irrigation and pre-treatment systems during construction

use including wetlands, archaeological research, and prime agricultural soils analysis. Construction documents must be prepared according to the standards of the Engineers Joint Contract Documents Committee (EJCDC), and a specific bidding/procurement process must be followed. This required additional time to address, meaning final VT DEC approval for the project to go out to bid was not received until the summer of 2022, nearly two years after pilot test completion.

CONSTRUCTION AND INITIAL RESULTS

Construction (see Figure 3) kicked off in the fall of 2022 but was subject to delays due to supply chain issues for electrical components and other building materials. The process control building was built by the end of the year, while construction of the treatment system and drip disposal field had to be postponed until the spring of 2023. Owing to a stretch of favorable weather, the contractor was able to complete construction of the system by the summer of 2023, when the commissioning process finally began.

COMMISSIONING

The initial step in the commissioning process was establishing the biologic population necessary in the treatment trains to fully treat the effluent prior to discharge into the disposal fields. Considering the history of multiple failed wastewater disposal systems, the engineer and owner were hesitant to discharge partially treated effluent to the new drip irrigation field during startup. Therefore, frac tank storage and offsite disposal were continued for a few more months. Samples were taken regularly over the summer from the two EQ tanks upstream and downstream of the trickling filters to determine when sufficient quality effluent could be sent to the disposal fields. Biologic treatment proceeded quickly, and results in late August showed that the system was achieving the design effluent goal of less than 10 mg/L each for BOD and TSS. Refer to Figure 4 for a summary of the results.

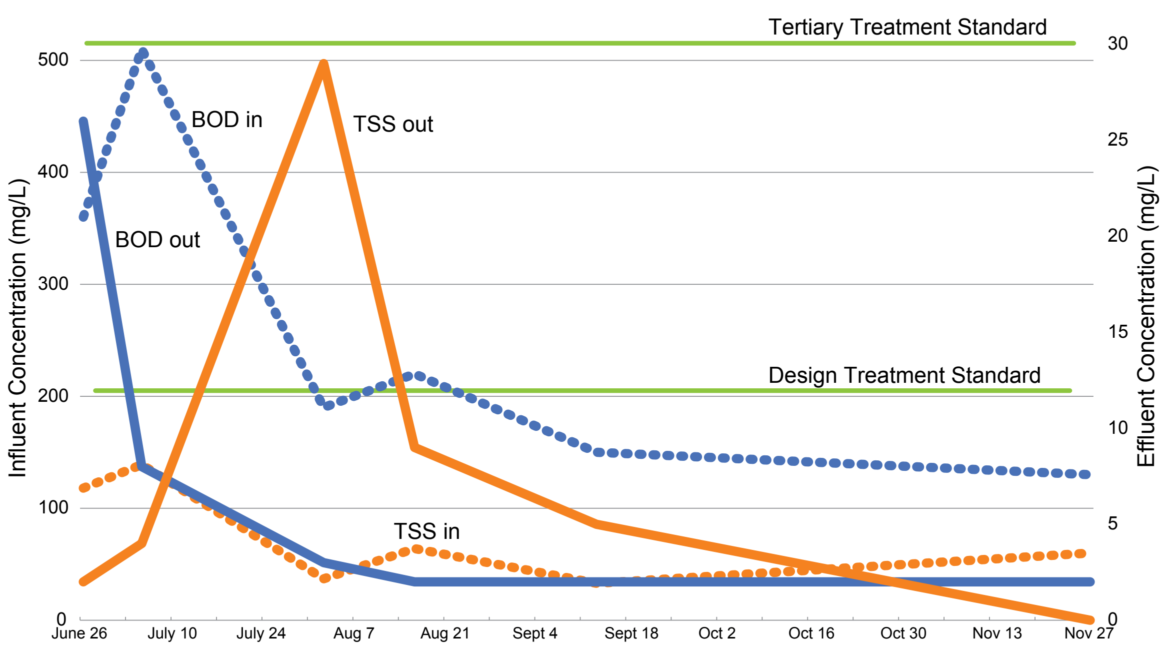


Figure 4. Consolidated wastewater system effluent quality results

SUMMARY

Through gathering and analyzing operational, water quality, and chemical use data at the facility, the presence of residual disinfectant in the campus effluent was found to be the cause of the multiple wastewater treatment system and leachfield failures. Pilot testing and optimization of proposed pretreatment methods provided the assurance that the system would meet performance goals of 10/10 mg/L of BOD/TSS. The pilot study also provided sufficient data to allow for design of pretreatment for the entire campus. High-quality effluent is now disposed of via a new drip irrigation field coupled with two existing leachfields to provide a single wastewater collection, treatment, and disposal system.

The pretreatment system is flexible and robust, and can compensate for varying flow rates and strengths of effluent. The control systems in the building allow for remote adjustment of recycle ratios in the trickling filters, balancing of wastewater flow to the drip irrigation field and former leachfields, and data collection for required monthly permit reporting.

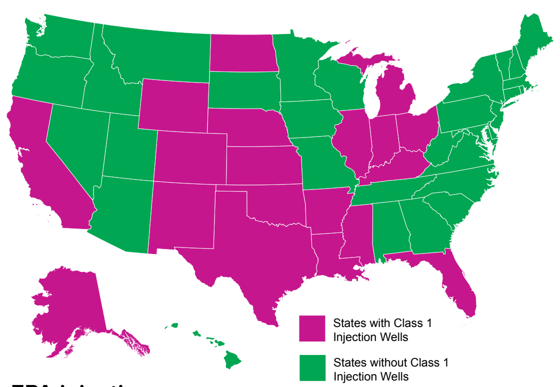
ABOUT THE AUTHOR

Shane Mullen, PE, CPESC, is a technical specialist at Weston & Sampson in Waterbury, Vermont. He earned his Bachelor of Science in Chemical Engineering from Clarkson University and has over 20 years of experience in wastewater disposal, potable water supply, stormwater, and site/civil engineering.

NEBRA Highlights

Updated PFAS disposal and destruction guidance

On April 16, EPA published a Federal Register notice of availability for its updated interim guidance for managing per- and polyfluoroalkyl substances (PFAS) containing wastes (Interim Guidance on Destroying and Disposing of Certain PFAS and PFAS-Containing Materials That Are Not Consumer Products | US EPA) Comments are due by October 15.



EPA injection well map

The first version was published three years ago as required by Congress under the National Defense Authorization Act (NDAA) in fiscal year 2020. The updated guidance is similar, with one major exception related to landfills. EPA continues to recommend underground injection, landfilling, and thermal processes as methods for containing, disposing, and/or destroying PFAS in certain waste materials as specified by Congress, including landfill leachate and biosolids and soils. EPA acknowledges there are some unknowns. According to the guidance, there are no permitted underground injection facilities in Regions 1, 2, or 3. The Northeast will have to ship its PFAS-contaminated wastes out of state for underground injection or continue to use landfills and incinerators until other emerging technologies are proven to destroy PFAS.

Section 2 contains updated information about biosolids generation and management. The recycling of biosolids to land is not discussed in the guidance. The guidance acknowledges other sources of soil contamination, including the use of firefighting foams and reuse water, spills and leaks, and even atmospheric deposition.

Landfills are classified as a containment method. In the updated guidance, EPA recommends the use of permitted hazardous waste landfills, or "Subtitle C Landfills," when the PFAS levels in the waste are "relatively high." EPA recognizes that hazardous wastes that go to landfill are not typically biodegradable so that Subtitle C landfills usually do not have landfill gas collection systems.

The review of thermal treatment processes included sewage sludge incinerators (SSIs); however, the data is insufficient for determining the effectiveness of SSIs to destroy PFAS.

Building on the original guidance, EPA has added several sections to the end of the report. Section 5 discusses research needs and data gaps for destruction and disposal technologies. EPA summarizes the research needs and identifies its priorities. Performance testing at full-scale thermal facilities is a priority as is testing of thermal oxidizer emissions. Analytical methods also need development. Section 6 is on emerging technologies for PFAS destruction and disposal. It also explains how EPA will evaluate those technologies, establishing a framework for evaluation.

Interim PFAS limits for residuals in Vermont

The Vermont Department of Environmental Conservation implemented a new interim policy on April 1 that includes very low limits on perfluoroalkyl substances in land-applied residuals/biosolids and requires analytical testing and reporting. According to the National Biosolids Data Project for Vermont (Vermont—National Biosolids Data Project), most biosolids come from the populated Burlington area and go to a Chateaugay, New York alkaline stabilization facility. The resulting bulk Class A EQ (Exceptional Quality) biosolids are land applied on farms in northern New York and southern Quebec. This new interim policy (not a regulation) is likely to have impacts on how biosolids are managed in Vermont with screening values for land-applied residuals that include 3.4 parts per billion (ppb) for perfluorooctane sulfonic acid (PFOS) and 1.6 ppb for perfluorooctanoic acid (PFOA) as well as limits on perfluoroheptanoic acid (PFHpA), perfluoronona-noic acid (PFNA), and perfluorohexane sulfonate (PFHxS). The first reports under the new policy are due July 1. For more information, go to Residuals & Emerging Contaminants Program | Department of Environmental Conservation (vermont.gov).

Massachusetts legislature revamps, PFAS bill, phasing out land application of biosolids

NEBRA's Reg-Leg Committee learned at its April meeting about a bill proposed in the Massachusetts legislature, H4486—An Act to Protect Public Health from PFAS (malegislature.gov/Bills/193/H4486). This bill directs the Massachusetts Department of Environmental Protection (MassDEP) to "promulgate regulations to implement a schedule for phasing out the use, sale, or distribution, or offer for use, sale, or distribution of sludge without the department's site-specific approval in the Commonwealth..." The Massachusetts Water Environment Association, NEBRA, and NEWEA submitted written testimony on the bill. NEBRA referred to the ongoing study by the MassDEP and asked that legislators await the results of that study due to concerns with the loss of any biosolids end use or disposal option.

EPA designates two PFAS as hazardous substances under CERCLA

EPA issued its final rule designating two PFAS chemicals—PFOA and PFOS—as hazardous waste for corrective action or cleanups of contaminated sites. EPA has also published its PFAS Enforcement Discretion and Settlement Policy Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) to formalize its stated intent to focus on manufacturers and not passive receivers of PFAS, like water and solid waste facilities.

There is concern that EPA's use of discretion will not prevent private parties from bringing passive receivers into a cleanup action through litigation. Passive receiver groups, which include NEBRA and the other regional biosolids associations, continue to advocate for limited liability relief. The U.S. Senate has held hearings examining PFAS as a hazardous substance. More recently, legislation filed in the House addresses the concerns of passive receivers like water resource recovery facilities and their biosolids managers. H.R. 7944—Water Systems PFAS Liability Protection Act—was introduced by Representatives John Curtis (R-Utah) and Marie Gluesenkamp (D-WA).

Naming PFOA and PFOS as hazardous under CERCLA enables EPA to remediate legacy pollution sites and require responsible parties to pay for the cleanup costs. It sets a reportable release level of 1 lb (0.45 kg) for PFOA and PFOS, individually.

The new CERCLA reportable quantities for PFOA and PFOS do not seem to be an issue for either wastewater effluent or biosolids: Based on current average concentrations in effluent and biosolids, PFAS in discharges are not near 1 lb (0.45 kg) a day. The National Association of Clean Water Agencies has a reportable quantity calculator for its members for both effluent and biosolids. Using that calculator, the York Sewer District in Maine, a NEBRA member, estimates it would have to generate 163,000 tons (148,000 tonnes) of biosolids per day (at 18 percent solids and a PFOS concentration in the sludge of 17 parts per billion) to reach EPA's reportable quantity. Nonetheless, York has signed onto a lawsuit against the manufacturers of PFAS impacting that sewer system.

The concern is that EPA will lower those reporting thresholds in the future and add more PFAS compounds to the list. Also, as CERCLA is a backward-looking law, some utilities could get pulled into litigation over biosolids that were land applied 20 or more years ago, before water resource recovery facilities (WRRFs) knew about PFAS.

Recent litigation on PFAS in biosolids

The Public Employees for Environmental Responsibility (PEER) intends to sue EPA on behalf of "injured individuals," accusing the agency of "neglecting its legal obligation to regulate PFAS in biosolids" if EPA does not act in 60 days.

PEER accuses EPA of shirking its duty under the Clean Water Act Section 405 requirements for biennial review of pollutants in biosolids. According to PEER, EPA has identified 250 pollutants in biosolids and is only regulating nine, referring to the standards in Part 503 limiting concentrations of chiefly heavy metals in materials being land applied. PEER says it knows of 18 PFAS compounds in biosolids that are not listed in the biennial report. In addition, PEER states that 12 of the PFAS that are listed[1] should be regulated.

A group of farmers in Johnston County, Texas, are suing Synagro Technologies under a product liability action alleging that the company "falsely markets its biosolids fertilizers as safe and organic" and failed to warn about its risks.[2] There is a related ongoing criminal investigation in Johnson County related to the land application of biosolids.

Elsewhere, the Coosa River Basin Initiative, with the assistance of the Southern Environmental Law Center, filed suit on March 7 against the City of Calhoun, Georgia, and Moss Land Company, LLC, in U.S. District Court in Rome, Georgia. In this case, the city operates a WRRF that has many carpet manufacturers and related businesses in its "sewershed" and had previously land applied its biosolids.[3]

Meanwhile, the number of lawsuits is growing against the producers of PFAS chemicals, such as 3M and Chemours. A few of these legal actions involve biosolids, for example:

- In central Maine, residents and landowners have filed a lawsuit against makers of PFAS claiming harm from measured elevated levels of PFAS in their soils, crops, and animals due to past uses of biosolids that had been industrially-impacted.
- In Wisconsin, in August 2023, the Milwaukee Metropolitan Sewerage District filed a lawsuit against 25 PFAS manufacturers and distributors.

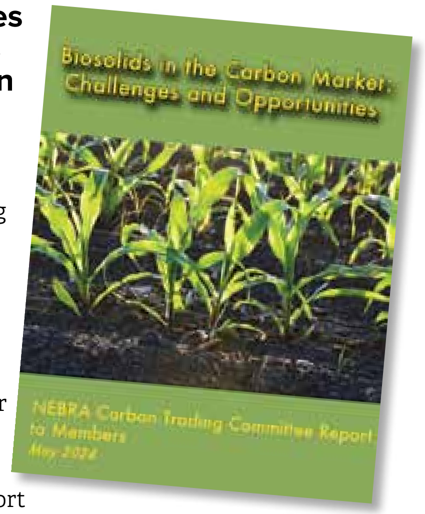
Portland, Maine, is charting its biosolids future

NEBRA member Portland Water District (PWD), in Portland, Maine, is seeking solutions for sustainable management of biosolids in Southern Maine.

Since issuing a Request for Information (RFI) on a biosolids processing facility in 2023, PWD has been exploring available technologies and services for receiving and processing undigested and dewatered sludge from PWD and (potentially) the surrounding communities. Although the focus is volume reduction, and to produce a more "landfill-able" product, PWD is still interested in alternative beneficial end uses for solids, if possible. PWD held a Technology Summit in August 2023 that included over 20 vendors with various technology solutions such as dewatering, thermal drying, anaerobic digestion, and pyrolysis/gasification for PFAS mitigation (11 vendors for this one). PWD's director of wastewater operations and new NEBRA Board Member Scott Firmin compares this phase of the project to a "speed-dating" event with quick introductions, short conversations, and a commitment to continue the conversation. He said he found it informative and important to the process.

The report is available on PWD's website (pwd.org). It scopes out different options based on combinations of technologies. PWD's plans are still conceptual, with the report laying out numerous concepts and portfolios of technologies as well as planning-level capital cost estimates. It will be expensive. PWD is meeting and speaking with stakeholders and potential partners to continue with the development of a biosolids solution for the area. The district will whittle down the list for technical solutions to continue during its phase two planning now underway.

Opportunities for biosolids in the carbon markets



In May, NEBRA's Carbon and Nutrient Trading Committee completed a report for members on the challenges and opportunities for biosolids in the carbon trading market. The report summarizes what the committee members have learned about the potential for biosolids projects in the carbon trading market. It delves into carbon trading programs to see if biosolids recycling would be beneficial. NEBRA hosted a Lunch & Learn webinar on May 24 to present the report to members interested in this topic.

Mark your calendars

The annual Northeast Residuals & Biosolids Conference joint NEWEA and NEBRA effort is scheduled for November 13–14 at the Graduate Hotel in Providence, Rhode Island.

NORTHEAST RESIDUALS & BIOSOLIDS CONFERENCE

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Committee Focus

Contaminants of Emerging Concern

The Contaminants of Emerging Concern (CEC) Committee organizes and promotes activities that increase awareness of CEC in the environment. The *Journal* reached out to its current chair, Amy Hunter, to learn more about CEC and what the committee has been up to.

Journal *Can you tell us about the CEC Committee and its charge/goals?*

The mission of the committee is to increase awareness of CECs in the environment by exchanging and conveying information on the contaminants themselves, and their occurrence, fate, transport, treatment, analytical requirements, and human health and aquatic impacts. Key goals of the committee are to keep members informed of evolving regulation and to assess the regulatory impacts on the water environment profession.

■ *What does the committee's membership look like? Are you looking for new members?*

The CEC Committee is always looking for new members! We have member representation from across the industry including engineers and scientists, educators and students, operators and utility managers, and vendors and technology manufacturers. We'd love to bring in more regulator and policy-maker perspectives.

■ *What activities have you recently completed? What do you have planned?*

In the fall of 2023, we hosted a well-received PFAS specialty conference in collaboration with the Plant Operations Committee. The specialty conference highlighted PFAS regulations, impacts, and treatment technologies. More recently we gave a virtual outreach presentation to students at a local university. This upcoming year, we are focusing on public awareness and outreach. We plan to give more presentations to universities and schools as well as pursue PFAS messaging outreach to utilities, municipalities, communities, etc.

■ *Given today's crazy world of contaminants, what does the committee see as the biggest challenges?*

The term "contaminants of emerging concern" speaks for itself: There will continue to be emerging contaminants that we will need to remediate, and the task is daunting. The rapidly evolving policies and regulations make it challenging for utility owners and operators to plan remediation strategies. All this uncertainty creates communication challenges that require special attention. For these reasons, the CEC Committee has made it a goal to pursue outreach opportunities and provide resources for public communication.

CEC Chair Amy Hunter and Plant Operations Committee Chair Nick Tooker open the 2023 PFAS specialty conference in Sturbridge, MA

■ *Are there any exciting new technologies out there you'd like to highlight, that are working on combatting contaminants of emerging concern?*

I'm personally excited about PFAS destruction technologies such as electrochemical oxidation that breaks the carbon–fluorine bonds as well as plasma and pyrolysis technologies that have the potential to completely mineralize PFAS. There is still more to be explored with these destruction technologies, but they show promise for PFAS destruction and could be a gateway to exploring the destruction of other CECs.

■ *What's your favorite part about being a member of the CEC Committee?*

As the chair of the CEC Committee, I appreciate the interdisciplinary collaboration and contributions from members with experience and backgrounds that span across the water environment industry. I have had the pleasure of getting to know some passionate people who share in a common goal and vision: leaving this place better than how we found it!

Student Design Competition

NEWEA held another successful virtual Student Design Competition (SDC) this year on May 17. Two teams participated, both representing Northeastern University. This competition, organized by the Student Activities Committee (SAC), promotes "real world" design experience for students interested in pursuing education or careers in water engineering and sciences. There are two categories, one for wastewater that includes treatment process design, and one for water environment that includes just about anything else related to water in the environment. The competition tasked teams of NEWEA student members to design a project that they worked on together. Most teams base their written reports and presentations on their senior capstone design projects. The teams presented their designs in front of judges, peers, and mentors during the SDC presentation. The team determined to have the best combined report and presentation in each category represents NEWEA at the national competition to be held during WEFTEC in New Orleans this October. Congratulations to all the teams for a robust competition—the future of the industry is in good hands with these bright students! The participating teams were as follows:

Wastewater Category: from Northeastern University, "Biosolids Processing Upgrades at East End Facility in Portland, Maine" by team members Stella Klingebiel, Nethra Iyer, Kyla Hampton, and Courtney Jackson.

Water Environment Category: from Northeastern University, "Green Infrastructure in the City of Boston" by team members Emily Heneghan, MJ Galvan, Reem Gawish, Nicholas Benavides, and Rotem Leshed.

The winning team project in the Water Environment category, the sole entry in the category, worked to improve permeability in flood-prone areas in the City of Boston by utilizing Green Infrastructure technologies that would filter harmful pollutants, manage large volumes of water, and improve ecological cycles in these urban areas. With careful analysis of flooding data, traffic data, and maps of historically marginalized communities, the team narrowed their focus to locations that needed the most immediate action and would bring the most impact to the surrounding community. At their selected site in East Boston, the Patrick James Kennedy Elementary School, the team recommended the redevelopment of the northside parking lot and the unoccupied sloped asphalt corridor at the south entrance. Final design recommendations included porous paving and bioretention practices to promote water treatment and storage of runoff, increase the tree canopy in a Heat Focus Neighborhood, and provide educational opportunities to students with informative signage. Quantitative projections demonstrate that the design exceeds all three requirements laid out by MassDEP and the City of Boston; the first inch flush stormwater infiltration minimum, the reduction of peak discharge rates for the 2, 10, and 100-year storm, and the removal of 80 percent Total Suspended Solids and an additional removal of 50 percent Total Phosphorus.

The winning team project in the Wastewater category, also the sole entry, simulated updates to Portland Water District's current biosolids disposal process at their East End Facility in order to evaluate different technologies in terms of their effectiveness, operating conditions, and ground footprint space requirements. The final recommendation involves an anaerobic digestion unit to decompose the organic solids thus reducing the amount of waste to dispose, while concurrently creating a useable biogas for energy and heat in a CHP system. And for dewatering, by replacing the rotary press with a thin film dryer, the final biosolids to dispose would be reduced to 7.99 wet tons per day, enough, enough to save 2.4 million in yearly disposal costs.

The winning teams will each receive a travel allowance to attend WEFTEC 2024 in New Orleans, where they will compete against other teams from around the world. Good luck to the teams; we know you will do a great job and make NEWEA proud! A huge thanks to our volunteer judges and organizers for the competition: Adam Higgins, Wright-Pierce; Emily Korot, CDM Smith; Janine Burke-Wells, NEBRA; Joanna Sullivan, VHB, and Kelsey George, Stantec.

We recognize and extend our appreciation to the companies that sponsored this event

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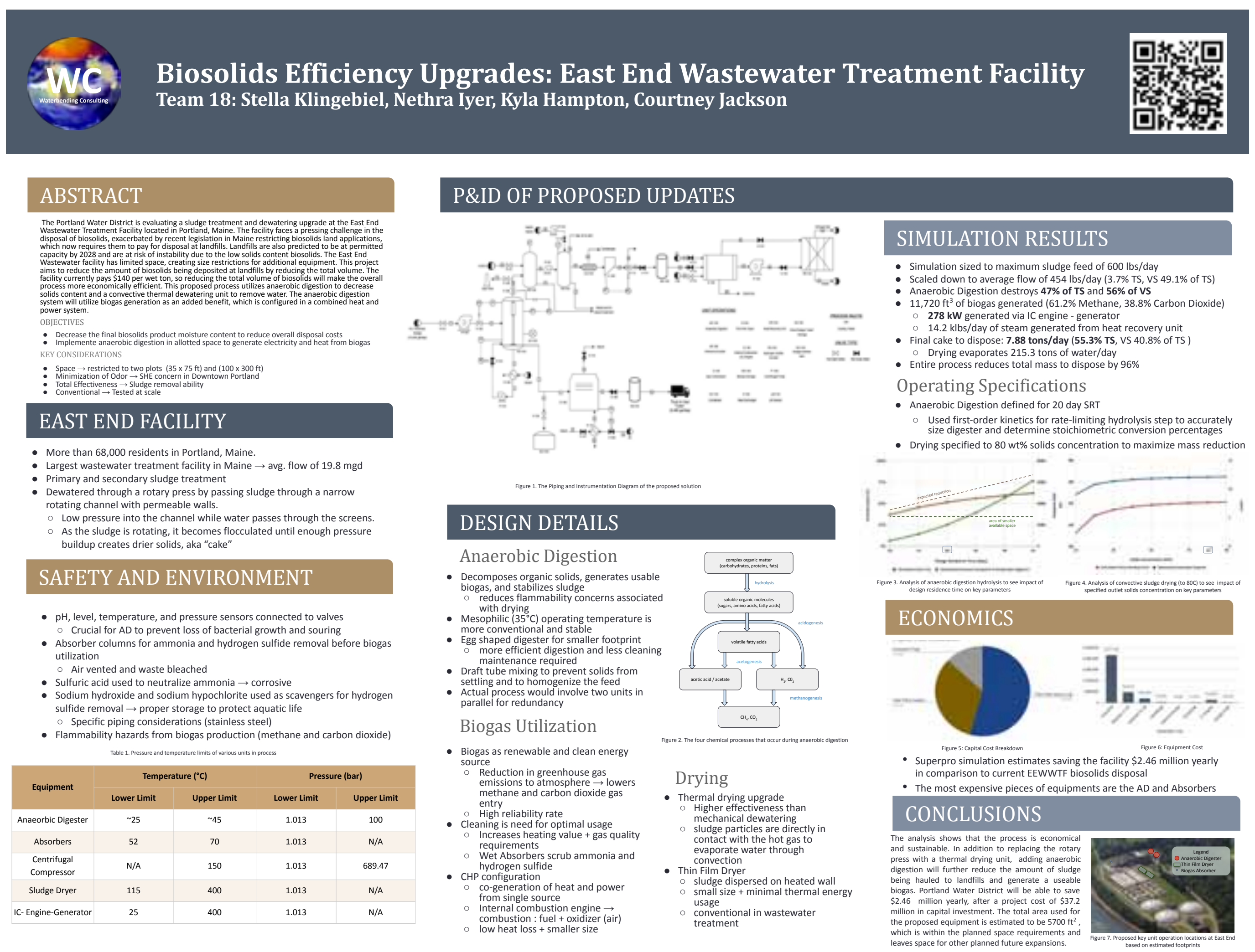

WEF Delegate Report

Peter Garvey, Delegate at large
The past several months have been action-packed on the NEWEA/WEF front as I settle into my delegate-at-large role. There have been too many activities to share in detail here, so I'll focus on two.

One was the National Water Policy Fly-in in early April. The event is a targeted couple of days each year when WEF, its members associations (MAs), and state organizations schedule visits with our legislators in Congress. I teamed with Massachusetts State Director John Digiacomo, Communications Director Jaimye Bartak of the Springfield Water and Sewer Commission, NEWWA Executive Director Kirsten King, and UMass Amherst graduate student Lucca Mancilio. Owing to excellent planning, we arranged meetings with the offices of nine Massachusetts legislators—in some cases meeting with the legislators themselves. They were welcoming and interested in hearing our views on PFAS, workforce development, wipes, and funding. Our goal was to educate them on these issues and to inform them as they decide how to vote. This is informational advocacy as opposed to lobbying. The "money shot" was with Representative Jim McGovern when he invited us onto his balcony for a photo.


NEWEA Massachusetts State Director John Digiacomo, U.S. Congressman Jim McGovern, NEWWA Executive Director Kirsten King, and Peter Garvey

The second activity was my participation in the WEF MA Exchange (WEFMAX) event in Alexandria, Virginia, hosted by the Virginia Water Environment Association. I had been asked to present a debrief session about the Fly-in. I shared a review of the Fly-in week and then arranged table-based brainstorming with attendees to determine their understanding of and interest in, or concerns about, participating in future Fly-ins. We obtained great input, which will help inform planning for future Fly-ins. As delegate-at-large, my constituents are WEF Water Advocates: we have had a surge in sign-ups for the program, and I'm happy to report that we registered our 1,000th Water Advocate during the WEFMAX event.

Jim Barsanti (for Ray Vermette)
Since last October's WEFTEC meeting in Chicago, I have been busy with several interesting and challenging WEF activities. My primary responsibility has been the House of Delegates (HOD) Nominations Committee. Our charge is to receive and review nominations for the HOD speaker-elect and for delegates volunteering for the various HOD committees. These committees include Budget, Communications, DEI (Diversity, Equity, and Inclusion), Nominations, WEFMAX, and Water Advocacy. Our charge fits well with WEF's Strategic Plan to "attract and develop a diverse and passionate workforce." The HOD committees provide opportunities for delegates to enhance their experience in both WEF and their MAs through collaboration with delegates from across the United States and Canada to enact the charges of each committee.

I have been serving on the MA New Delegate Selection Best Practices work group. Our charge is to develop guidance for MAs in selecting delegates to the WEF HOD, specifically emphasizing delegate participation and expectations. We have developed materials and guidance about the value of being a WEF delegate that MAs can use to solicit and promote the HOD and delegate role to potential candidates. We have also created an application template that MAs can use to review and select delegate candidates.

I have also participated in several WEF communities. I am currently the chair of the Collection Systems Community's Operation and Maintenance Technical Practice group. Earlier this year, we completed a Collection Systems Operation and Maintenance fact sheet that is available via the WEF Collection Systems web page. For the Public Communications and Outreach Community, I recently participated in the review of WEF award nominations for both individual and collective efforts by MAs and public utilities to promote public awareness of the work we do as water professionals. Finally, I am in my second year on the Community Leadership Council (CLC) as the operation and maintenance community of practice director. Similar to our NEWEA council director position, my focus is to be a leadership resource to the Lab Practices, Plant Operations and Maintenance, and Operations Challenge communities. My role is to assist the chairs and vice chairs of these communities with ideas and suggestions that will enhance their community activities, and to serve as their liaison to the CLC.

Janine Burke Wells
I am enjoying my duties with the WEF HOD. I have been attending the quarterly meetings, which are virtual. I serve on the Budget work group and recently reviewed the first round of grant applications for WEF's MA grant program. My favorite HOD committee is by far the Water Advocates Committee, co-chaired by fellow WEF Delegate (at large) Peter Garvey. We have been discussing production of a video interview with a U.S. senator or representative to talk about updating the Clean Water Act.

I went to Washington, D.C., on April 9 and 10 to participate in WEF's Water Week activities. I represented WEF, NEWEA, and of course my home state of Rhode Island, which has two senators and two representatives. I was accompanied by NEWEA's Rhode Island state director, Amy Anderson George. We had three in-person meetings while in D.C. and a virtual meeting when we returned home.

Most of my delegate time lately has been spent in planning a WEFMAX in New England in 2025. We have the date and venue selected: April 30 – May 2, 2025, at the Hawthorne Inn in Salem, Massachusetts. The volunteer committee will get together again in July to continue planning the program and marketing the New England WEFMAX as the place to be in 2025!

It's hard to believe that, following WEFTEC in New Orleans in October, I will be NEWEA's senior WEF delegate, entering my final year of representing NEWEA to WEF (and vice versa). I look forward to serving one more year, and welcoming our newest delegate, Emily Cole-Prescott from Maine, whose own three-year term will begin this October.


NEWEA Rhode Island State Director Amy Anderson George, Rhode Island U.S. Congressman Gabe Amo, and Janine Burke Wells

Virgil Lloyd
As mentioned in my last report, I am thrilled to have been selected for the HOD DEI Committee. This committee comprises 10 delegates, representing MAs from all over the United States. The committee's goals are to provide support, ideas, and collaboration for MAs on their DEI journey, as well as to provide tangible tools and best practices for MAs to use.

One of the most visible as well as rewarding activities is arranging and conducting quarterly calls of the MA leadership from all over the country. We typically have from 70 to 100 or more participants on the calls. In two calls so far in 2024, NEWEA leaders have made impressive presentations. In February, the chair of NEWEA's DEI Committee, Stephen King, presented on the focused training that NEWEA has conducted for our Executive Committee on unconscious bias over the past two years. In May, NEWEA Executive Director Mary Barry presented on NEWEA's Work for Water initiative and the significant intersection with DEI of that program. Both presentations stimulated much discussion and certainly reinforced NEWEA's stature as a national leader.

YP Spotlight

Over the past year, NEWEA's own Isabella Silverman worked in Peru as a Water Resource Management Specialist and Outreach volunteer with Peace Corps Response. Isabella recently returned home to Rhode Island, and for this edition of the *Journal*, we reached out to Isabella to learn more about her experiences in the program.

Journal *Can you tell us a bit about the program, and your role?*

The Peace Corps is an independent agency and program of the United States government that trains and deploys volunteers to provide international development support. From June 2023 – June 2024, I was a Peace Corps Response volunteer working in Peru as a Water Resource Management Specialist and Outreach volunteer with the National Superintendence of Sanitation Services, or SUNASS. As a volunteer in the Response program, my role in Peru was connected to a host-country governmental organization. I worked as a member of the team at SUNASS, supporting them in not only with technical expertise, but also in internal organizational management.

■ *Big question right upfront: How and why did you make the decision to leave your well-paying job in the city of Boston to live in South America to be a volunteer?*

I was recently giving a virtual presentation to a class of high school students in Connecticut, and they asked me this very question! My various professional and educational experiences have influenced the way I view the world, and the way I want to live in it. I hope to answer this big question by sharing a bit about my journey with international engineering work.

My initial introduction to concepts of international development was as an undergraduate where I worked on an international water, sanitation, and hygiene (WASH) project in the Dominican Republic (DR) for a span of over three years. I learned about the high rate of gastrointestinal maladies related to unsafe drinking water sources, not only among children in the DR, but also in other low-and middle-income countries. I collaborated with in-country partners, applied for and acquired grant funding, and managed project tasks through depending on an international team. Traveling each year to the DR taught me how to foster and maintain international relationships; I also began learning Spanish and realized the importance of speaking the same language as those in the area where one works. Learning about the challenges faced in underserved communities exposed me to new perspectives of problem-solving. From this, I developed a prototype for a portable water treatment system and even presented the model in NEWEA's 2020 Annual Conference at the Shark Tank competition!

I continued my interest in international development work by traveling to Indonesia to do research on ocean plastics on a small, water-rich island impacted by influxes of tourism. It became apparent that I needed to focus on bridging the gap between technical engineering and community health awareness. The need to broaden my knowledge in drinking water treatment for public health prompted the pursuit of my master's in environmental engineering, in a program where I could be co-advised by a professor in the College of Public Health. Graduate coursework focusing on the intersection of engineering, science, and public health inspired my master's thesis, "Community Perceptions of Point-of-Use Treatment Methods in Madagascar." My thesis involved remotely surveying community members in Madagascar during the height of Covid-19—a task I accomplished by working closely with field partners in Sub-Saharan Africa and required flexibility to redefine project success depending upon the situation.

Upon graduation, I worked as an environmental engineering consultant in Boston for over a year. My work focused on water resource projects such as nature-based solution design, emerging water contaminant treatment, and future cost analysis of climate change impacts on water treatment infrastructure. However, I felt the pull of international work. I decided to quit my job to join the Peace Corps to engage in a mutual exchange of knowledge, skills, and abilities with a community. I wanted to travel and get out of my comfort zone to work in a field I am passionate about. I wanted the opportunity to pass down education and technical skills I received to make a positive impact on a community. Immersing myself in the Peruvian culture and Spanish language has been the greatest lesson of all. I went to learn with them and from them, and to hopefully return to my country a more understanding person.

■ *Can you tell us a bit about your volunteer work in Peru?*

My role as a volunteer encompassed so much more than my given tasks. As a Peace Corps volunteer, I experienced numerous instances of "give and take," which shaped my evolving thought processes and approaches. Initially, I anticipated working tirelessly to effect profound change and assumed my ideas and words would be readily embraced and understood. Yet, in reality, many days revolved around simply showing up, sharing smiles, and engaging in casual conversations about the weekend with my colleagues.

Nevertheless, my main tasks included working with schools in urban and rural areas to spread awareness about water, sanitation, and hygiene best practices. I also accompanied my coworkers in the field, visiting small rural water systems and speaking with community members about the importance of drinking potable water through systems that offer chlorination and filtration. Additionally, I met with the board of directors of these rural water systems to discuss how to control the prices of the water services they offer the community. We offered reviews and recommendations for the community members who run the systems.

■ *During your time in Peru, did you encounter anything surprising, or anything you weren't ready for?*

As most Peace Corps volunteers, I come from a background of relative privilege; I have always had access to education, healthcare, economic resources, and even societal advantages based on my race and nationality. During my service in Peru, each day I was challenged to examine my own privilege, biases, and assumptions. The realities of the communities I served made me confront my own privilege and consider how my upbringing formed my own life's course. I recall standing in a classroom of 42 high school students in December. I was teaching about climate change and how it is affecting Peru, but no one was listening. At first, I was frustrated because it seemed like no one cared about climate change. But another teacher explained to me that the students had never heard of the term "cambio climatico" (climate change), so I probably needed to start teaching from a different level for the students to begin to gain interest. This small occurrence put my privilege of education into perspective.

Working internationally has also provided me with a different perspective on how to effectively interact with people from diverse backgrounds. The experience has exposed me to unique office dynamics and cultural nuances, enriching my professional expertise and perspective. I have gained firsthand knowledge of the regulatory framework in Peru, understanding how it facilitates project

Isabella Silverman was a Peace Corps Response volunteer working in Peru as a water resource management specialist and outreach volunteer with the National Superintendence of Sanitation Services

implementation and fosters community development. I have learned about different components of small water systems and how policy in Peru can impact not only urban but also rural communities and their water. Most of the time, life moved at a much slower pace in rural Peru, which was something that was challenging for me to adapt to, but I grew to love it. Although the pace of living was slower, there were often more streamlined processes that enabled quicker project execution once funding was available.

■ *Did you encounter anything surprising related to water practices?*

In the Andean region, there exists a prevalent belief that water, being a gift from nature or from a higher power, should be freely accessible to all. Consequently, during my visits to rural communities, I often observed a reluctance among residents to pay for water services, driven by this deeply ingrained cultural perspective. For me, this was hard to understand and respond to with realistic solutions or suggestions. I could not just say, "adding chlorine will kill potential bacteria in your water; therefore, you should!" because no one would listen. The ability to influence decisions and change behaviors is really difficult, not only for foreigners like myself, but also for my coworkers, whom I observed inform the population about the importance of drinking clean water numerous times through different methods. Chlorine is commonly donated to smaller communities by each city's government; although it is free, it is not usually added due to a combination of factors, such as taste preferences, cultural beliefs, health concerns, and trust issues.

Out of a community of 200 households in a small town near Chavin de Huantar that I visited, approximately 100 pay the monthly fee for water: 1 sol, equivalent to USD $0.26. However, many of the households have electricity and even cell phones which they pay much more for on a monthly basis. My colleagues consistently explained that paying for the water itself is different than paying for the service, which includes the tubes that bring the water from the source to the home as well as chlorine and maintenance of the system and reservoir. When speaking to these communities, my colleagues would state, "Go to the river with a bucket each morning and get water there if you do not want to pay for water. But if you turn on your tap in your kitchen and water comes out, that means you have a water service for which you should want to pay for." Or they would say, "we can all live without electricity and light as we did in the 90s, but we cannot live without water."

From visiting these rural communities, I saw the value in connecting with community members and building relationships. I was lucky enough to form bonds with them and found things to connect on that transcend our cultural differences. I recall spending time with my coworker Marta over cooking a typical Peruvian dish, "locro de zapallo," while we discussed how we both love to travel for vacation instead of resting at home. I recognize that despite the technical expertise I believe I can offer, I highly value the knowledge and wisdom of community leaders. There is a wealth of information to be gained from learning about traditional medicine, sustainable agriculture, and other social techniques and insights from the Peruvians around me. I relied on their expertise to shape my initiatives and interventions.

■ *Now that you've returned home to New England, do you have any reflections on the experience you'd like to share with NEWEA readership?*

As I find myself back home in Rhode Island, I find myself reflecting deeply on my journey in Peru and what I want to bring back with me. One thing that's really hit home for me, especially as an engineer, is the importance of making sure that whatever projects I dive into in the States are truly inclusive, welcoming everyone regardless of their background or financial situation.

As I begin my job search, I'm on the lookout for employers whose values align with mine, where I can see their values and commitments reflected in their work. I want to infuse a bit of that Peruvian warmth and openness into whatever workplace I end up in. That sense of community and kindness—it's contagious, and I want to spread it wherever I go.

But it's not just about work. Being here has taught me the value of spending quality time with family and taking time to appreciate little moments with friends. Finding joy and enjoying everyday tasks is something I think we should all try to do more of. You can often find just what you need around you, can find friendship in sharing a meal with a neighbor, happiness reading a book in the sun, or having a nice conversation with family on the phone.

I know I will remember to respect and value the resources around me, as I can think back to learning about ancient water practices used for farming and irrigation that the Incans applied in the Andes that have been used for generations. So, now that I am back, I am carrying with me a renewed sense of purpose and a commitment to bringing a bit of Peru with me, wherever I go.

If you have questions or comments for the author, please reach her at her personal email address: isabellasilverman2016@gmail.com

New Members March – May 2024

Zachary Adams
CDM Smith
Manchester, NH (PRO)

Lalitha Adusumilli
UMASS
Boston, MA (PWO)

Matthew Ahearn
Littleton Water Department
Littleton, MA (UPP)

Jordan Alexander
H2M
Meriden, CT (YP)

Nadine Ali
UMASS
Amherst, MA (STU)

Reed Allen
City of Portland Maine
Portland, ME (YP)

Gabe Archambault
Hazen and Sawyer
Wethersfield, CT (YP)

Katherine Arnold
NEIWPCC
Lowell, MA (YP)

Julius Atkins
The Pyure Company
Colden, NY (PRO)

Gabriel Bamforth
Brown and Caldwell
Andover, MA (PRO)

Nathaniel Banks
PolyGone Systems
Princeton, NJ (YP)

Nelya Bauer
City of Norwalk
Norwalk, CT (PRO)

Dipesh Bava
City Of Gloucester
Gloucester, MA (PRO)

Sarah Beckwith
Haley Ward
Maynard, MA (YP)

Scott Beeney
Veolia North America
North Haven, CT (PRO)

Derrick Bellavance
City of Bangor WWTP
Bangor, ME (UPP)

Nicholas Benavides
Northeastern University
Boston, MA (STU)

Sky Berube
Town of Milton
Milton, MA (YP)

Josh Biltcliffe
Synagro Technologies
Woonsocket, RI (PRO)

Derek Brillon
Bartlett & Brillon
Walpole, MA (PRO)

Peter Brodeur
Town of South Kingstown
South Kingstown, RI (PWO)

Matthew Buck
Town of Palmer WWTP
Palmer, MA (PRO)

Peralie Burbank
City of Lewiston
Lewiston, ME (PRO)

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Boston, MA (STU)

Owen Callaghan
University of Maine
Woburn, MA (STU)

Maeve Carlson
Wright-Pierce
Portland, ME (YP)

George Carson
Jacobs
Boston, MA (YP)

Glen Cassells
Metropolitan District
Andover, CT (UPP)

Karen Chan
Environmental Partners
Revere, MA (PRO)

Jeff Chapdelaine
Town of West Warwick
West Warwick, RI (PWO)

Abigail Charest
Sudbury, MA (PRO)

Samuel Charest
South Norwalk Electric
Wilton, CT (ACAD)

Nelson Chime
University of Maine
Orono, ME (STU)

Kuhu Choudary
Beta Group
Lincoln, RI (YP)

Ryan Christensen
Northeastern University
Barnstable, MA (STU)

Ryan Christensen
Volo, IL (STU)

John Clark
Hooksett Wastewater
Hooksett, NH (PWO)

Thomas Connelly
Woodard & Curran Hingham, MA (PWO)

Joshua Coroa
StormTrap
Bristol, RI (PRO)

Domitille Coulomb
Schneider Electric
Boston, MA (PRO)

John Currier
Woodard & Curran
Portland, ME (PRO)

Caroline Dalton
Haley Ward
Maynard, ME (YP)

Robert Delgado
Barnstable, MA
Hyannis, MA (PWO)

Eric Depradine
Upper Blackstone
Millbury, MA (PWO)

Luigi DiMonaco
GNHWPCA
New Haven, CT (PRO)

Sean Divoll
City of Worcester
Worcester, MA (PRO)

Kelley Dolan
Tighe & Bond
Worcester, MA (YP)

Kelley Dolan
Tighe & Bond
Worcester, MA (YP)

Kristin Dowdy
City of New Bedford
Bedford, MAv (PRO)

Sean Driscoll
Plymouth, MA (PWO)

McKenna Dunn
Kleinfelder
Somerville, MA (YP)

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Hatfield, ME (STU)

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Ernst Etheart
BWSC
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Lillian Farah
City of Melrose
Melrose, MA (YP)

Nichol Figueiredo
Capital Strategic
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Bartlett and Brillon
Walpole, MA (YP)

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Hoyle & Tanner
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Haverhill, MA (YP)

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John Kaminski
Canton, CT (PWO)

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Lindsey Kauffman
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Jennifer Nechamen
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Mark Nimiroski
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Varsha Niroula
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Newport, RI (PWO)

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Tata & Howard
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Abigail O'Keefe
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Frank Occhipinti
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Chelsea Phan
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Dewberry
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Kevin Raftery
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Green International
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Hosman Santos
BWSC (YP)

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Alexis Simpson
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Reading, MA (PRO)

Daniel Smith
Ti-SALES
Sudbury, MA (PRO)

Daniel St. Marie
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Belinda Stansbury
MADEP
Medford, MA (REG)

Graydon Stewart
Town of Farmington
Avon, CT (YP)

Eliza Styczynski
Brown and Caldwell
WOBURN, MA (PRO)

Timothy Sullivan
Veolia
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Ryan Tamayoshi
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Greater Augusta Utility
Augusta, ME (PRO)

Rachel Tenney
Tighe & Bond (YP)

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Brian Wrigley
BETA Group
Lincoln, RI (PRO)

Robert Zarnetske
Sewer Thermal Energy
Madison, CT (ASSOC)

James Zemartis
Ramboll
Somerville, MA (YP)

Academic (ACAD)
Affiliate (AFF)
Complimentary (COMP)
Corporate (COR)
Dual (DUAL)
Executive (EXEC)
Honorary (HON)
Life (LIFE)
Public Official (POFF)
Professional (PRO)
Wastewater Treatment Plant Operators (PWO)
Retired (RET)
Student (STU)
Utility Partnership Program (UPP)
Young Professional (YP)

2024 Spring Meeting & Exhibit Proceedings

Hotel Viking, Newport, Rhode Island • May 19–22, 2024

The New England Water Environment Association held its Annual Spring Meeting on May 19–22, 2024, at the Hotel Viking in Newport, Rhode Island. Meeting registrants totaled 304. The meeting also featured 17 exhibit booths.

A full NEWEA Executive Committee meeting with committee chairs was held on Sunday, May 19, 2024, with NEWEA President Scott Goodinson presiding. In addition to the Opening Session, there were ten technical sessions.

Breakfast and General Opening Session

Moderator:
- Maureen Neville, NEWEA Programs Chair, Woodard & Curran

Welcome
- Scott Goodinson, NEWEA President, Town of Narragansett, RI

Keynote Speaker
- Xay Khamsyvoravong, Newport, RI Mayor

Session 1: Asset Management: Cover Your Assets! Lessons Learned in Asset Management

Moderators:
- David Gaipo, Wright-Pierce
- Zach Henderson, Woodard & Curran

Buried Dollars: Past, Present and Future of Providence's Wastewater Infrastructure
- David Bowen, Narragansett Bay Commission

Newport's Proactive Asset Management Practices Lead to Performance Improvements and Cost Benefits
- Peter Von Zweck, Jacobs

How NYC DEP Ensures Proper and Efficient Construction of Thousands of Assets in the Nation's Largest Green Infrastructure Program
- Sean O'Donnell, NYC DEP

Managing Your Siphons: A Lesson in Maintaining and Rehabilitating Critical Infrastructure
- Daniel Kramer, Hazen and Sawyer

Session 2: Workforce Development: Working Toward the Future: Talent Pipelines and Workforce Development Programs

Moderators:
- Ian Catlow, Tighe & Bond
- Louis Ragozzino, Wright-Pierce

Our Holistic Approach for Addressing Root Cause Retention Issues
- Peter Yidiaris, Narragansett Bay Commission

Attracting Operators through Education & Internships
- Bradley Hayes, Woodard & Curran

Not Your Average Internship: An Innovative Approach to Water Workforce Development in Springfield, MA
- Katherine Shea, Springfield Water & Sewer Commission

Water Technology Training at Upper Cape Cod Regional Technical School
- Charles Lawrence, Upper Cape Cod Regional Technical School

Session 3: PFAS: Flowing Forward: Navigating PFAS Challenges in Treatment Facilities

Moderators:
- Wayne Bates, Tighe & Bond
- Helen Gordon, Environmental Partners

PFAS Wastewater Effluent Study of Maine Dischargers
- Judy Bruenjes, Maine DEP

EPA Method 1633 is Now Final, What That Means for Wastewater Professionals
- Jim Occhialini, Pace Analytical

Novel Wastewater Treatment Process for PFAS Removal
- Paul Rodriguez, ECT2

Understanding the Destruction Mechanisms of Sub and Supercritical Processes for PFAS Treatment
- Sudhakar Viswanathan, 374Water

Session 4: Enhanced Innovative/Alternative MA Septic Systems Update & Discussion

Moderators:
- Bruce Walton, NEWEA I/A OWTS Task Force
- Alissa Cox, University of Rhode Island

Enhanced Innovative/Alternative (EIA) Performance at Shubael Pond
- Laura Erban, US EPA ORD, Narragansett, RI

Photos by Charles Tyler

Opposite page: The five Operations Challenge teams before the Monday kickoff **1.** NEWEA President Scott Goodinson, RICWA President Peter Connell, Jaysen Wetherbee, and John Oatley at the President's Reception **2.** Hallway discussions were lively during session breaks **3.** Wayne Bates and Jillian Jagling converse during a session break **4.** Jay Sheehan, Mike Bonomo, Annette Bonomo, Peter Frick, Ben Rukavina, Mike Armes, and Kim Neesen at the President's Reception (photos 1 & 4 by Adam Yanulis)

Case Studies of Hybrid Solutions that Encompass Sewers, Clusters and EIAs in Wellfleet and Tisbury, MA
- Scott Horsley, Water Resources Consultant

A Look at EIAs as Infrastructure thorough a Responsible Management Entity (RME), Septic Utility Program (SUP) and Best Available Nitrogen Reducing Technologies (BANRT)
- Brian Baumgaertel, MASSTC
- David Iorio Izzo, MASSTC

Potential Financial Impact of EIAs Compared to Sewering using the Town of Barnstable's CWMP and Cape-wide Modeling
- Bruce Walton, NEWEA I/A OWTS Task Force

Session 5: Infrastructure Funding: Collaborative Approaches to Infrastructure Funding

Moderators:
- Dan Bisson, Tighe & Bond
- Chad Kershaw, CDM Smith

Tapping the SRF Program for Emergency Funding—A Success Story at the South Essex Sewerage District
- David Michelsen, South Essex Sewerage District

Using our Competitive Advantage to Fund Wastewater Infrastructure
- Erin Perry, Cape Cod Commission

Understanding and Accelerating Green Infrastructure Investment in Rhode Island
- William Guenther, Fuss & O'Neill

Estimating Rate and Customer Cost Impacts is the Key to Securing Funding Approval
- Michael Schrader, Tighe & Bond

Session 6: Sustainability: Sustainability in Way We Govern, Lead and Apply Technology

Moderators:
- Miles Moffatt, Tighe & Bond
- Matt Formica, AECOM

Leadership, Management and Succession Planning
- James Courchaine, Hazen and Sawyer

Environmental, Social and Governance Principles in the Public Water and Wastewater Industries
- Jillian Jagling, West Group Law

The Energy Program of the Narragansett Bay Commission—An Overview & Update
- Barry Wenskowicz, Narragansett Bay Commission

A Transformative Model-Based Disinfection Control Solution to Optimize Cost and Performance
- Michael Fagan, USP Technologies

Session 7: DE&I: An Interactive Session

Moderators:
- James Plummer, NEIWPCC
- Stephen King, Town of Danvers, MA

Navigating Parallel Career Paths towards Equitable Leadership in Water Industries and Associations
- Stephen King, Town of Danvers, MA

How to Drive Diversity, Equity, and Inclusion in the Water Sector
- Robert Zarnetske, Sewer Thermal Energy Network





1. Leroy Kendricks offers his perspective in a DEI panel discussion 2. 2024 Stormy Award winners: Robyn Saunders and Kelsey Johnson for the Saco, Maine Watershed Collaborative; Shawn Marston and Scott Holland for Auburn, Maine DPW; and Giovanni Zinn for the City of New Haven, Connecticut 3. Jason Kulpa discusses bacteriological benchmarking 4. Laura Erban of EPA presents on an innovative nitrogen removal project on Cape Cod 5. Ross Gambino makes a point during the DEI session

Session 8:
Operator's Perspective: Keeping the Water Out and Solids In: Infrastructure Hardening and WWTF Wet Weather Improvements

Moderators:
- Ken Carlson, Woodard & Curran
- Maureen Neville, Woodard & Curran

Balancing Wet Weather Capacity with Nitrogen Removal using the Modified Contact Stabilization Process
- Paul Dombrowski, Woodard & Curran

Refining Nitrogen Removal: Case Study of Greater New Haven WPCA's Hydrocyclone Study
- Karina Massey, Jacobs
- Jason Nenninger, GNHWPCA

Fecal vs. Entero Testing: A Benchmark Study
- Earl Salisbury, Veolia

3 Birds, 1 Stone: Three Perspectives on the Benefits and Considerations of Hardening and Upgrading Three Pump Stations as Part of One Project
- Ryan Palzere, Tighe & Bond

Session 9:
2023 Stormy Awards Best Ideas in New England Stormwater

Moderators:
- Zach Henderson, Woodard & Curran
- Kerry Reed, City of Hopkinton, MA

This session provided an overview of the STORMY Award program and presented the 2023 winning ideas:

Effective Street Leaf Litter Cleanup
- Scott Holland, Auburn, ME

Saco River Source Water Protection Pilot Project
- Robyn Saunders, Saco Watershed Collaborative

City of New Haven Downtown Resiliency Project
- Giovanni Zinn, New Haven, CT

Session 10:
Resiliency/Stormwater: Climate Change Impacts on Resiliency in Both Urban and Seaside Communities
- Moderator: Christina Stringer, NEIWPCC
- Matt Pitta, CDM Smith

Urban Resilience: Considering Climate Change Impacts in Long Term Control Plans
- Rupsa Roy, Weston & Sampson

Transcending Municipal Boundaries–Implementing Resiliency at Watershed Scale
- Indrani Ghosh, Weston & Sampson

Stormwater Management and Implementation in Seaside Communities
- Joseph Lanzafame, City of New London, CT

Enhancing Stormwater Management in New England: Integrating CRMI for Resiliency
- Robert Backman, Stormwater Investment Group

Mitigating CSOs Through Design of a New Storage Tank and Pump Station at the Gateway to the Town of Bar Harbor, ME
- McKenzie Schmitz, Jacobs






1. Indrani Ghosh speaks on watershed-level stormwater resilience 2. Barry Wenskowicz gives an update on the Narragansett Bay Commission energy program 3. Newport Mayor Xay Khamsyvoravong delivers the opening session keynote address 4. David Michelson shares an observation regarding bacteriological indicators 5. Sudhakar Viswanathan delivers a talk on developing PFAS destruction techniques 6. Maeve Carlson takes notes during a session about climatic impacts on stormwater

Operations Challenge
- Operations Challenge Committee:
- Jason Swain, Chair
- Nora Lough, Vice Chair

Operations Challenge was held on May 20 and 21. Five teams participated in the competition:

Force Main (Maine)
- Dan Munsey
- Jeff Warden
- Darren Lauletta
- Chris Cline
- Rob Pontau (Coach)

Mass Chaos (Massachusetts)
- Kelly Olanyk
- Scott Urban
- Justo Cabrera
- Ramon Garrick
- Nikita Johnson

RIsing Sludge (Rhode Island)
- Dave Bruno
- Shawn McCollum
- Riley Cobb
- Rob Norton
- Eddie Davies (Coach)

RICONN (Rhode Island/Connecticut)
- Kevin Mauricin
- Kevin Venancio
- Chris Cleaveland
- Graydon Stewart
- Jay Nenninger (Coach)

New Hampshire
- Dennis Celata
- Sam Wood
- Dan Demers
- Andrew Carr
- Joe Irving (Coach)

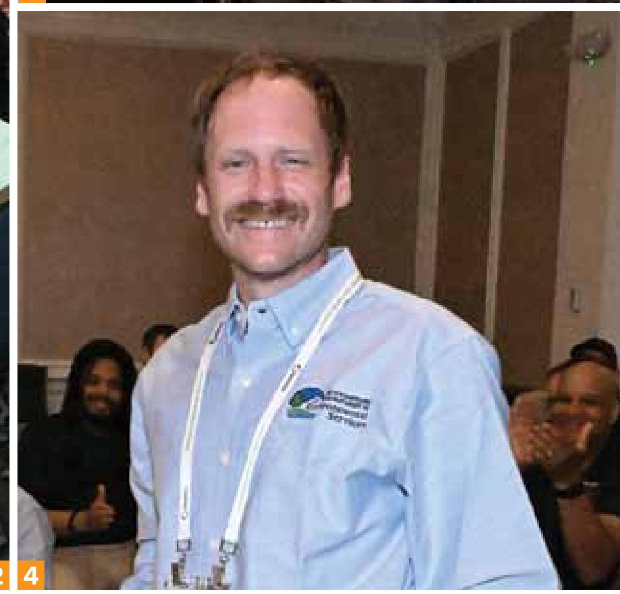
The Operations Challenge Awards Reception was on Tuesday, May 21. Committee Chair Jason Swain and each event coordinator presented trophies to the winning teams of each event and to the overall first-, second-, and third-place teams. Additionally, because RIsing Sludge placed third in Division 2 of last year's WEFTEC Operations Challenge, NEWEA is now eligible to send four teams to compete at WEFTEC. The results of the competition are as follows:

First Place Individual Events
- Collection Systems: Rising Sludge
- Laboratory: Rising Sludge
- Maintenance: Rising Sludge
- Process Control: Rising Sludge
- Safety: Rising Sludge

Overall Competition
- First: Rising Sludge
- Second: RICONN
- Third: Force Maine
- Fourth: Mass Chaos

Event Coordinators
- Collection Systems: Mike Armes
- Laboratory: Marylee Santoro
- Maintenance: Alex King
- Process Control: Alex Buechner
- Safety: Rick Hartenstein

Judges
- Collection Systems: Ben Rukavina, Matt Barnett
- Laboratory: Kim Sandbach, Dennis Palumbo, Nora Lough, Tracy Santoro, Ashley Harrington
- Maintenance: Dan LaFlamme, Paul Russell, Ryan Buckley



1. Jason Nenninger is cheered at the Ri-Conn Team table at the Ops Challenge Awards 2. Ramon Garrick leads the Mass Chaos table celebration after learning that they'll be competing nationally in New Orleans 3. Kelly Olanyk (center) of Mass Chaos congratulates Dan Munsey and Jeff Warden of Force Maine on their third-place win 4. Sam Wood of New Hampshire came in first in Sunday's morning's 5K charity event

- Process Control: Uday Karra, Paul Dombrowski
- Safety: Evan Karsberg, Scott Goodinson

Thank you to Gannett Fleming for its donation of pipe.

Select Society of Sanitary Sludge Shovelers

During the Monday evening reception, Influent Integrator Charles W. Tyler inducted 20 new members into the Select Society of SanitarySludge Shovelers:

- Wayne Bates
- Daniel Capano
- Ian Catlow
- Daryl Coppola
- Amy Corriveau
- Courtney Eaton
- Marina Fernandes
- Philip Forzley
- Peter Frick
- Jim Galasyn
- Don Gallucci
- Bob Goober
- John Jackman
- Sharon Nall
- Maureen Neville
- Dennis Palumbo
- James Plummer
- Dustin Price
- Maria Rose
- Jason Swain

Meeting Management

- Director – Scott Neesen
- Sponsors – Larry Scola

Meeting Planners

- Conference Arrangements – Ron Tiberi
- Program – Maureen Neville
- Registration – Meg Tabacsko and NEWEA Staff
- Operations Challenge – Jason Swain
- Golf Tournament – Fred McNeill

Exhibitors

ADS Environmental Services
DN Tanks
Duke's
F.R. Mahony & Associates
Flow Assessment Services
Green Mountain Pipeline Services, LLC
Hayes Group
Mechanical Solutions. Inc.
Savy & Sons
Schneider Electric
Special Breaks LLC
StormTank
Thompson Pipe Group
USA BlueBook
Veolia North America
Wilkem Scientific, Ltd.
Xylem Inc – Flygt Pumps

1. Mass Chaos rolls through the Safety event 2. Chris Cleaveland of the RI-Conn team runs tests at the Lab event under the eye of judge Marylee Santoro 3. Chris Cline of Force Maine eyes a meniscus during the Lab event 4. Champion RIsing Sludge team members Shaun Collum, Riley Greene, Dave Bruno, and Rob Norton, with inset of the new NEWEA Ops Challenge Winner's Cup

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Pare Corporation
Penn Valley Pump Co.
Stantec
Synagro Northeast, LLC
Tech Sales NE
The MAHER Corporation
Ti-SALES
Tighe & Bond, Inc.
Vaughan Company, Inc.
Veolia
Weston & Sampson
Woodard & Curran
Wright-Pierce

Early-rising participants in Tuesday's Morning Bike Ride

Upcoming Meetings & Events

HOMEBREW COMPETITION/ SWALES & ALES TOUR
Tilted Barn, Exeter, RI
July 22, 2024

JOINT NEWEA/CTWEA LABORATORY PRACTICES CONFERENCE
MDC, Hartford, CT
September 12, 2024

NEWEA GOLF CLASSIC
Derryfield Country Club
Manchester, NH
September 27, 2024

WEFTEC
Ernest N. Morial Convention Center
New Orleans, Louisiana
October 5–9, 2024

CSO/WWI CONFERENCE & EXHIBIT
Doubletree Hilton, Manchester, NH
October 22–23, 2024

JOINT NEWEA/NEWWA IT & ASSET MGMT FAIR
Holliston, MA
November 6, 2024

NORTHEAST RESIDUALS & BIOSOLIDS CONFERENCE, EXHIBIT & TOUR
Graduate Hotel, Providence, RI
November 13–14, 2024

NEWEA ONBOARDING
Boston Marriott Copley Place Hotel
Boston, MA
January 26, 2025

NEWEA ANNUAL CONFERENCE & EXHIBIT
Boston Marriott Copley Place Hotel,
Boston, MA
January 26–29, 2025

AFFILIATED STATE ASSOCIATIONS AND OTHER EVENTS

NHWPCA GOLF TOURNAMENT
Beaver Meadow Golf Course
Concord, NH
August 1, 2024

RICWA TRADE SHOW & LUNCHEON
Crowne Plaza, Warwick RI
September 6, 2024

NHWPCA FALL MEETING
Newington, NH
September 13, 2024

NEWWA FALL CONFERENCE
Sea Crest Hotel, Falmouth, MA
September 15–18, 2024

MAINEWEA GOLF TOURNAMENT
Sunday River, Newry, ME
September 18, 2024

MAINEWEA FALL CONVENTION
Sunday River, Newry, ME
September 19–20, 2024

MAWEA FALL QUARTERLY MEETING
Marconi Club, Springfield, MA
September 25, 2024

CTWEA FALL WORKSHOP
AquaTurf, Plantsville, CT
October 2, 2024

GMWEA FALL TRADE SHOW
Double Tree Hotel, Burlington, VT
November 7, 2024

NHWPCA WINTER MEETING
Merrimack, NH
December 6, 2024

Measurement unit conversions and (abbreviations) used in the *Journal*

U.S.	International System of Units (SI)	U.S.	International System of Units (SI)
Liquid volume		**Length**	
gallon (gal)	liter (L)	inches (in.)	centimeters (cm)
cubic feet (ft^3)	cubic meters (m^3)	feet (ft)	meters (m)
cubic yards (yd^3)	cubic meters (m^3)	miles (mi)	kilometers (km)
acre-feet (ac ft)	cubic meters (m^3)	**Area**	
Flow		square feet (ft^2) or yards (yd^2)	square meters (m^2)
million gallons per day (mgd)	million liters per day (ML/d)	acre (ac)	hectare (ha)
for larger flows (over 264 mgd)	cubic meters per day (m^3/d)	square miles (mi^2)	square kilometers (km^2)
gallons per minute (gpm)	liters per minute (L/min)	**Weight**	
Power		pounds (lb)	kilograms (kg)
horsepower (hp)	kilowatts (kW)	pounds per day (lb/d)	kilograms per day (kg/d)
British Thermal Units (BTUs)	kilojoules (kJ) / watt-hours (Wh)	ton – aka short ton (tn)	metric ton or tonne (MT)
Velocity		**Pressure**	
feet per second (fps)	meters per second (m/s)	pounds/square inch (psi)	kiloPascals (kPa)
miles per hour (mph)	kilometers per hour (km/h)	Inches water column (in wc)	kiloPascals (kPa)
Gas		**Head**	
cubic feet per minute (ft^3/min)	cubic meters per minute (m^3/min)	feet of head (ft of head)	meters of head (m of head)

THANK YOU

TO ALL OUR 2024 ANNUAL SPONSOR PROGRAM PARTICIPANTS

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Build relationships with water industry leaders *and* make a positive impact on the water environment

Join NEWEA's 2025 Annual Sponsor Program

NEWEA offers companies the opportunity to promote their products and services throughout the year by participating in multiple sponsorship activities. Annual Sponsorships include:

- NEWEA Annual Conference
- NEWEA Spring Meeting & Golf Tournament
- NEWEA Golf Classic
- A web presence on NEWEA.org's sponsorship program page
- The option to customize sponsorship levels by selecting to participate in up to eight additional unique NEWEA events plus additional activities

Sponsorship Benefits:

- Increased corporate visibility and marketing opportunities before a wide audience of water industry professionals
- Relationship-building access to key influencers involved in advancing water industry services, technology, and policy
- Recognition as an environmental leader among peers and customers

For more information contact Jordan Gosselin
Email: jgosselin@newea.org
Phone: 781-939-0908

NEWEA
WORKING FOR WATER QUALITY

Advertiser Index

Upcoming *Journal* Themes

Fall 2024—**Wet Weather**

Winter 2024—**Biosolids Management**

NEWEA/WEF* Membership Application

wef member association | NEWEA WORKING FOR WATER QUALITY

Personal Information (please print clearly)

First Name ____ M.I. ____ Last Name ____ (jr. sr. etc)

Business Name (if applicable) ____ Job Title

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City, State, Zip, Country

Home Phone ____ Cell Phone ____ Business Phone

Email Address ____ Date of Birth (mm/dd/yyyy)

☐ Check here if renewing, please provide current member I.D.

☐ Check here if you do NOT wish to receive information on special offers, discounts, training and educational events, and new product information to enhance your career.

***NEWEA is a member association of WEF (Water Environment Federation). By joining NEWEA, you also become a member of WEF.**

ACQ. Code (for WEF use only) | WEF24

Membership Categories (select one only)

		Dues
☐ **Professional**	Individuals involved in or interested in water quality	$215
☐ **Young Professional**	Water quality professionals, under the age of 35, are eligible to join. This program is available for new member applicants and Student Members and is available for 3 years..	$88
☐ **Professional Operator**	Individuals in the day-to-day operation of wastewater collection, treatment or laboratory facility, or for facilities with a daily flow of < 1 mgd or 40 L/sec. License # ____	$127
☐ **Academic**	Instructors/Professors interested in subjects related to water quality.	$215
☐ **Student**	Students enrolled for a minimum of six credit hours in an accredited college or university. Must provide written documentation on school letterhead verifying status, signed by an advisor or faculty member.	$27.50
☐ **Executive**	Upper level managers interested in an expanded suite of WEF products/services.	$385
☐ **Corporate** (member benefits for one person)	Companies engaged in the design, construction, operation or management of water quality systems. Designate one membership contact.	$446
☐ **Dual**	If you are already a member of WEF and wish to join NEWEA	$50
☐ **Associate Membership**	This membership category is a NEWEA only membership reserved for the general public who have an interest in water and the environment but are NOT currently employed in the industry (e.g., attorney or supplier). Examples of Associate Members include: teachers; journalists who cover water quality issues; citizen samplers/members of various watershed/sportsman/conservation organizations, etc.	$45
☐ **New England Regulator**	This membership category is a NEWEA only membership reserved for New England Environmental Regulatory Agencies, including: USEPA Region 1, CT Department of Energy and Environmental Protection, ME Department of Environmental Protection, MA Department of Environmental Protection, NH Department of Environmental Services, VT Department of Environmental Conservation, and RI Department of Environmental Management	$50

All memberships receive these:
- Water Environment & Technology
- Water Environment Research Online
- WEF Conference Proceedings Archive Online
- WEF SmartBrief
- Complimentary WEF Webcasts

WEF Utility Partnership Program (UPP): NEWEA participates in the WEF Utility Partnership Program (UPP) that supports utilities to join WEF and NEWEA while creating a comprehensive membership package for designated employees. As a UPP Utilities can consolidate all members within their organization onto one account and have the flexibility to tailor the appropriate value packages based on the designated employees' needs. Contact upp@wef.org to join.

Payment (Forms without payment will not be processed till payment is received.)

☐ **Check or money order enclosed**
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10 Tower Office Park, Suite 601
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Signature ____ Exp. Date

Name on Card (please print)

Depending upon your membership level, $10 of your dues is allocated towards a subscription to the NEWEA Journal. By joining NEWEA/WEF, you acknowledge the WEF Code of Conduct (www.wef.org/membership--community/membership-center/code-of-conduct/) is applicable for all members.

NEWEA/WEF Membership Application

MEMBERSHIP PROFILE

Please take a few moments to tell us about your background and professional interests.

What is the nature of your ORGANIZATION? (select only one–required) (ORG)

1 Consulting, Contracting, Planning Services
2 Educational Institution
3 Industrial Systems/ Plants
4 Manufacturer or Distributor of Equipment & Supplies (including representatives)
5 Non-profits/NGOs
6 Finance, Investment, and Banking
7 Laboratories
8 State or Federal Government
9 Utility: Wastewater
10 Utility: Drinking Water
11 Utility: Stormwater
12 Utility: Wastewater, Drinking Water, and Stormwater
13 Utility: Wastewater and Drinking Water
14 Utility: Wastewater and Stormwater
15 Other

____________________ (please define)

What is your Primary JOB FUNCTION? (select only one) (JOB)

1 Executive Level
2 Management Level
3 Elected or Appointed Official
4 Educator
5 Student
6 Consultant/Contractor
7 Engineering/Design
8 Operator
9 Scientist/Researcher
10 Legislator/Regulator
11 Analyst
12 Sales/Marketing
13 Manufacturer's Representative
14 Communications/ Public Relations
15 IT/OT
16 Other

____________________ (please define)

What are your KEY FOCUS AREAS? (circle all that apply) (FOC)

☐ **I would like to join the communities associated with my key focus area(s).**

1 Air Quality and Odor Control
2 Biosolids and Residuals
3 Climate
4 Collection Systems and Conveyance
5 Disinfection and Public Health
6 Drinking Water
7 Energy
8 Finance and Investment
9 Industrial Water Resources
10 Intelligent Water Technology
11 Laboratory Analysis and Practices
12 Nutrients
13 Operations
14 Public Communications and Outreach
15 Regulation, Policy, Legislation
16 Research and Innovation
17 Resource Recovery
18 Safety, Security, Resilience
19 Small Communities
20 Stormwater and Watershed
21 Utility Management and Leadership
22 Watershed Management
23 Wastewater Treatment, Design, and Modeling
24 Water and Wastewater Treatment
25 Workforce

Demographic Information (Check box) The following is requested for informational purposes only.

Gender: ☐ Female ☐ Male ☐ Non-binary

Education: ☐ Doctorate ☐ MA/MBA/MS ☐ BA/BS ☐ AA/AAS ☐ Technical School ☐ High School

Race/Ethnic Origin (Check box) The following is requested for informational purposes only.

☐ African-American (Not of Hispanic Origin) ☐ American Indian or Alaskan Native ☐ Asian ☐ Caucasian ☐ Hispanic/Latino
☐ Pacific Islander or Native Hawaiian ☐ Other

How Did You Learn About NEWEA/WEF?

Referring member's name: ____________________ Referring member's email: ____________________