

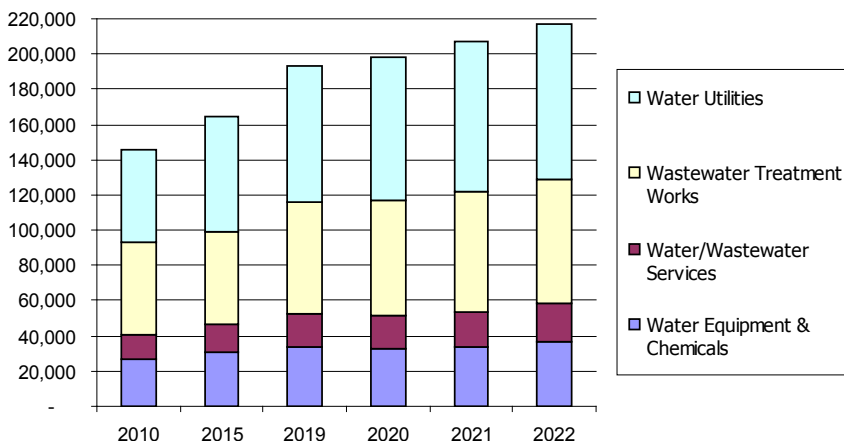
WATER THE MOST RESURGENT SEGMENT IN THE INDUSTRY—MORE OR LESS

The United States water industry accounted for \$220 billion in revenues and grew 4.7% in 2022, according to compiled segment analysis by *Environmental Business Journal*. Growth across the segments was particularly encouraging, according to data compiled by EBJ and summarized on the chart on this page, on the water industry table on page 3 and throughout this review. The covid onset year of 2020 led to a modest decrease in revenues in water equipment and water services, but overall industry growth as water usage went up along with pre-approved rate increases for water and wastewater.

Many utilities halted rate increases into 2021, a year in which growth returned to both water equipment and services categories. **U.S. Bureau of Census** data on state & local revenues and spending on water and wastewater through 2020 shows revenue increase of 7.0% in public water utilities and 5.5% in public sewerage, each higher than the annual growth of the last three years summarized on the table on page 4. Spending by these authorities, totaled over \$144 billion in 2020, according to Census data, and increased less than a percentage point lower than their revenues.

Investments in digital infrastructure likely paced the growth in instruments & information equipment and systems, contributing to equipment segments growing 7-8% in 2022, trailing only services. As more detailed analysis shows on page 8, revenues in water and wastewater for consultants and design engineering firms increased by double digits in 2022, and the industry leaders on the list of the top 20 almost uniformly benefited in increased billings. Environmental consulting & engineering (C&E) firms generated more

Revenue Growth in the U.S. Water Industry, 2010-2022 (\$bil)



Source: Environmental Business International, Inc. Segment models based on revenue generation and research by EBI derived from surveys, interviews and compilations of reliable secondary and published data.

Inside EBJ: The Water & Wastewater Industry

The U.S. Water Industry uses the springboard of federal infrastructure funding and multiple tailwinds to increase growth; Resilience, digitalization, personnel, PFAS and M&A are among factors separating the next generation of innovators and leaders. EBJ's data summary of the \$220-billion U.S. water industry focuses on key segments.

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AQUA MEMBRANES MAKES REVERSE OSMOSIS MORE EFFICIENT WITH PATENTED PRINTED SPACER TECHNOLOGY

Aqua Membranes, Inc. (Albuquerque, N.M.) is a water technology company that produces spiral wound membrane elements utilizing patented Printed Spacer Technology® to print directly on the membrane surface to make membrane treatment such as reverse osmosis more energy efficient and cost effective by increasing active area in the same size element, while reducing pressure drop. Aqua Membranes has 12 employees and is growing to scale production capacity. The company produces finished membrane elements in its Albuquerque headquarters and is largely focused on small industrial and wastewater reuse markets. In 2021 the company received funding from Micron and has been working to improve its RO systems and make them more sustainable. Aqua Membranes has 50 pending and granted patents worldwide.

EBJ: In response to climate impact, there must be a great deal going on in water reuse/recycling. What do you see as the most notable industry trends?

Aqua Membranes: Throughout the world, demand for water continues to grow while distribution is becoming less predictable. We are seeing greater interest in water reuse/recycling as a means to decrease the amount of external water needed to keep plants running. With droughts becoming longer and water supply growing scarcer, it has pushed many companies that might not have thought about investing in water reuse or recycling to do so. We are seeing manufacturers, energy companies and other industrial partners dedicate themselves to lowering water waste in the near future, searching for new solutions that will provide the ability to recycle in-house. This means expanding onsite water treatment systems that not only run reverse osmosis (RO) but also other filtration processes to help keep water out of the drain.

EBJ: What makes Aqua Membranes' products unique, and what problems are you trying to solve?

Aqua Membranes: Reverse osmosis has been around for decades and seen many innovations and changes in membrane chemistry. At this time, it's the construction of the spiral wound element that is limiting its efficiency. The innovation behind Aqua Membranes is a unique change to element construction leveraging developments in additive manufacture to create

custom designed channels for the incoming water to flow through, which replaces an extruded mesh netting which has been used for the past 60 years. Doing so leads to more efficient flow in, through, and out of the RO element allowing for a re-optimization of the overall element.

Replacing the spacer changes the way water is able to flow through the element by creating less resistance inside of the element. This creates the opportunity to fit more membrane inside of each element, lowering wasted energy, reducing fouling, and more. This innovation is unique because it is the first time anyone has been able to utilize new printing technologies in a way that meaningfully changes the spacer in reverse osmosis.

EBJ: When was Aqua Membranes' founded, and how did the company carve out its niche?

Aqua Membranes: The company was founded in 2011 out of learnings from a United States DARPA project with the intent to develop a portable water purification device capable of treating any water in the world to U.S. EPA drinking water standards that could be carried and used by an individual soldier. Through this project, it was discovered that the most wasteful component in a reverse osmosis element, both for space and performance, was the feed spacer. From this, Aqua Membranes began to look into novel ways to produce feed spacers before landing on Printed Spacer Technology.

Aqua Membranes is a team of innovators and problem solvers. From our founder all the way to the production staff on the floor, there is a constant drive to improve our process, the technology, and the world around us. By living this mentality, we have been able to push the technologies available in the industry to make printed spacers not only a viable solution but one that we know will become the standard for all spiral wound elements.

This innovation is unique because it is the first time anyone has been able to utilize new printing technologies in a way that meaningfully changes the spacer in reverse osmosis.

EBJ: How have you grown the company?

Aqua Membranes: We have been able to grow Aqua Membranes through our team's dedication to solving customers' water treatment challenges. This begins with our technology which gives increased flexibility in system design and operation and a more efficient starting point. Each set of water, site constraints, and customer needs is unique, and we work with end users to best solve their challenges — be it a need for more water, reducing energy consumption or improving performance of a system that might be running through elements way too fast. This is a bit different from the commoditized offering that is typical for our customers and allows us to best apply this new technology while having better feedback from our installed base of systems.

EBJ: How else is technology revolutionizing water recycling markets, and what should we expect to see in the next five to 10 years?

Aqua Membranes: In water recycling markets we are seeing a push toward onsite reuse, membrane technologies, and data monitoring. Also, there have been strides to make membranes easier to clean, more resistant to fouling contaminants, better able to handle solids and more robust overall

to allow for longer membrane lifetime. In addition to membrane improvements, we are seeing more interest in leveraging data monitoring for water systems and digital twins to develop algorithms for improved system performance. In the next five to 10 years, we expect to see more industrial users increasing the number of turns water takes inside their plant through reuse and water-centric process design, and municipalities to develop non-potable or indirect potable reuse of water, particularly in the Southwest United States to become more resilient to fluctuating water availability.

EBJ: How is the government distributing money to promote water recycling? Is funding coming from other sources?

Aqua Membranes: The government is distributing money in many water resource projects through the Inflation Reduction Act, which allots \$4 billion to drought mitigation. That money will be critical in building awareness of new water system treatment technologies and resources to promote wastewater reuse in both municipalities and industry. Grey water reuse, aquifer recharge, and updates to aging water infrastructure are all items with an active government focus.

Funding is also coming from the private sector as water is becoming more limited, demand is skyrocketing, and water quality requirements have become increasingly stringent. Both the semiconductor industry and oil and gas industry are looking to expand on water recycling. It has become increasingly advantageous for industry to find ways to use less water on site and invest in finding the best new technology to get it done. Funding from the VC community has also expanded as cleantech investors have realized the interconnectedness of water and energy and the need for better solutions to provide for continued economic growth.

EBJ: What is your perspective on regulations impacting the water recycling markets? Do regulations vary much from state to state?

Aqua Membranes: Regulations regarding water recycling markets vary from one region to the next. The regulations needed in areas like the Southwest vary from those

that are needed in the Midwest or on the East Coast. And many requirements are set at the state level. In the Southwest the rules governing the use and distribution of water coming from the Colorado River is in the limelight. The Colorado River serves 40 million Americans in the Southwest and Southern California and is experiencing a 22-year long drought. Since you can't allocate what isn't there, reductions in water distribution to the state are needed. Although we don't know how this distribution will be settled, cuts in water allocation are forcing many of these states to find new ways to lower their water use. Since water doesn't have a substitute, States will have to balance new sources such as seawater or brackish aquifer desalination with water reuse and reductions in consumption.

EBJ: What has been Aqua Membranes' most outstanding project?

Aqua Membranes: The most outstanding project Aqua Membranes has participated in is at the University of New Mexico. The University retrofitted its 70gpm boiler feed RO system with ConZerv membrane elements to provide more output to better deal with fluctuating demand on campus. The university has seen an output improvement of 20GPM. As a result of the increased active area and better ability to flush out impurities, this was accomplished with reduced need to clean. After nine months of run time, there hasn't yet been a need to clean despite producing more water at a higher recovery. □

Aqua Membranes Completes Financing in 2020 and 2021

In April 2021, Aqua Membranes secured a round of additional financing to apply its products to the semiconductor market. The deal was co-led by **Micron**, a world leader in innovative memory and storage solutions, and **Clean Energy Ventures**, a venture capital firm investing in early-stage climate tech. "Reducing the amount of energy we use to purify water and improving our ability to efficiently recycle that water after use is one of Micron's top environmental priorities," said Andrew Byrnes, director of Venture Capital at Micron. "Aqua Membranes' high-efficiency filtration solution will play a critical role in our future water sustainability efforts, and we are investing to help ensure their overall success to accelerate expansion into the semiconductor and ultrapure water market."

Aqua Membranes' patented 3D Printed Spacer Technology integrates into existing reverse osmosis (RO) systems to increase system capacity and reduce operating costs. By replacing existing feed mesh spacers with a customized 3D printed resin that adheres directly to the membrane surface, Printed Spacer Technology significantly reduces pressure drop and increases membrane surface area in spiral-wound elements. This improves filtration performance and dramatically reduces energy requirements in industrial processes like semiconductor manufacturing. In addition to providing financing, Micron is partnering with Aqua Membranes to advance its technology for the semiconductor industry, to improve wastewater recycling and ultimately reduce energy usage in Micron's UPW production processes. The initial partnership aims to improve the effectiveness of Micron's wastewater recycling while simultaneously lowering energy use per gallon of recycled water.

In September 2020, Aqua Membranes, secured \$2.1 million of financing led by **Clean Energy Ventures** and **Pentair**. "The nexus between water and energy is critical now more than ever," said Temple Fennell, Managing Director and Co-founder of Clean Energy Ventures. Pentair, a leading water treatment company, is also an investor in Aqua Membranes. "Our collaboration in Aqua Membranes aligns with our innovation roadmap and has the potential to provide our customers with more sustainable and lower cost water treatment." said Phil Rolchigo, Ph.D., Pentair Executive Vice President and Chief Technology Officer. At the time, Aqua Membranes said it will advance the development of its manufacturing technology and speed commercialization in the food and beverage and residential RO markets.