

High-Recovery Desalination to the Rescue: Making an Alternative Water Resource a Reality



Ronit Erlitzki, AdEdge Water Technologies

Ronit Erlitzki is Director of Business Development and Innovation with AdEdge Water Technologies, LLC. Ronit's career is based on strong scientific foundation and implementation of strategic and critical thinking. With more than 20 years of experience in biochemistry research and business development Ronit's main interest is water technology, and her goal is to accelerate the implementation of innovative and environmentally conscious technologies, focusing on improvement of high-recovery and low-waste sustainable solutions to environmental challenges. Ronit is a savvy water professional and has been successfully involved in the implementation of several technologies in the field of water quality analysis, biological water treatment for drinking water, and high recovery RO based on Flow-Reversal technology.

Ronit holds a BSc. in Biology from Tel Aviv University, and MSc and DSc degrees in Medical Sciences from Technion-Machon Technologi Le'Israel.

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We're going to talk about high-recovery desalination and how we help rescue communities by helping them identify an alternative water source. After listening to some of the presentations yesterday, I decided to start with a thank-you slide because, first of all, New Mexico is one of my favorite states; I spend quite a lot of time there. Second, when I listened to the discussions, I realized that all these terms—desalination, climate change, alternative water source, high recovery, low waste, concentrate management—are topics that so many communities in the Southwest are dealing with, including, of course, New Mexico. This will be more of a technical discussion and I'm open to any questions.

We need to look at high-recovery desalination in the broader context of how we help communities find alternative water sources, and hopefully in the most cost-effective way. We're always seeking new water sources, but we know that new water needs to be safe. The treatment must be cost-effective and environmentally responsible if we want it to reach users. The way we see it, it's a call for innovation.

Figure 1 is one of my favorite slides. I use it a lot because implementing innovation is really, really hard. When we think about innovation, it doesn't always have to mean something brand new, straight from the lab bench. Sometimes, it's about taking existing technologies and improving them. Even bringing innovation into something

Implementing Innovation is Hard



Typical time from conceiving an Idea to early commercial adoption* of water technology is 15 – 20 years

Figure 1. Implementing innovation is hard.

existing can be just as important. In the cartoon you see here, it's the same old umbrella, but it's been repurposed to collect water.

One important piece of information I also like to share is that a study published in 2018 on existing water technologies concluded that it takes between 15 and 20 years for an idea to reach early commercial adoption. So, we need to be patient, creative, and persistent. We'll get there, but it takes time.

Now, just a few words about the work that AdEdge is doing. Figure 2 shows a treatment matrix. On the left side is an alphabetical list of contaminants. Across the

Multiple Contaminants, Multiple Treatment Options - Focus on High Recovery & Low Waste

Process	Biological Filtration		Adsorption				O/F	C/F	HMO	Ion Exchange								RO/ NF	Physical	Oxidation
Technology or Media	biotta	NoMonia	AD74	E33	AD140	GAC	AD26	ADGS+	ADGS+	AD88	AD92	ADBor	ADCr6	ADNO3	ADPx	ADSOF	ADTOC	FR-RO	Air-Strp. & Filtration	Ozonation
Ammonia																				
Arsenic																				
Boron																				
Chromium VI																				
TDS																				
Fluoride																				
Gross Alpha																				
Hardness																				
Iron																				
Lead																				
Manganese																				
Nitrates																				
Perchlorate																				
PFAS																				
Radium																				
Selenium																				
Sulfides/Odor																				
TSS																				
TOC																				
Turbidity																				
Uranium																				
VOCs																				

O/F-Oxidation / Filtration

C/F-Coagulation /Filtration

HMO-Hydrous Manganese Oxide

RO-Reverse Osmosis

NF-Nanofiltration

Figure 2. Treatment matrix.

top, color-coded, are different treatment approaches. For example, green represents biological filtration from groundwater. I'm talking about treating groundwater, not wastewater. Orange shows adsorption technologies, yellow represents ion-exchange approaches, purple is reverse osmosis (RO), and so on. The idea, which many of us already know, is that there are multiple treatment options. Every water quality is different. We can craft the most cost-effective solution depending on specific water quality. Sometimes with one technology, we can treat multiple contaminants. Other times, we use a few methods in combination for a single contaminant. Multiple design considerations help us determine the best approach.

As a company, we know that innovation matters. AdEdge started by bringing to market Bayoxide E33 for arsenic removal. We completed multiple arsenic removal installations through a project with the Environmental Protection Agency involving 12 collaborative demonstration projects. Since then, a lot has happened. We developed H₂ Zero to recover backwash water, always important because there is never enough water. We created Biottta and NoMonia, biological treatments for groundwater, offering low-waste, high-recovery solutions

without generating hazardous waste. A few years ago, we began collaborating with an Israeli company, Rotec, on high-recovery RO based on flow-reversal technology.

In Figure 3, please focus on the white columns for now. These show a list of sites that were initially designed for conventional RO installations. We redesigned them for high-recovery RO with flow-reversal, shown in the lighter orange column. You can see the expected recovery rate in blue is much higher. Looking at these recovery rates, we see that RO with flow-reversal generates more permeate and significantly less concentrate. I'm sure you all know, especially when it comes to brackish water and commissioning wells, concentrate management is always a problem. What do we do with this wastewater? Whether it's brine from ion exchange or concentrate from RO, reducing its volume by 50 percent, 60 percent, even 70 percent makes a huge difference. And it's not just about waste reduction. The examples in Figure 3 show actual annual savings that these sites achieved. These savings are significant for any community.

Flow-reversal is essentially conventional RO with a patented twist. It's innovative, but it's not brand new; there are already 30 to 40 installations worldwide. Flow-reversal

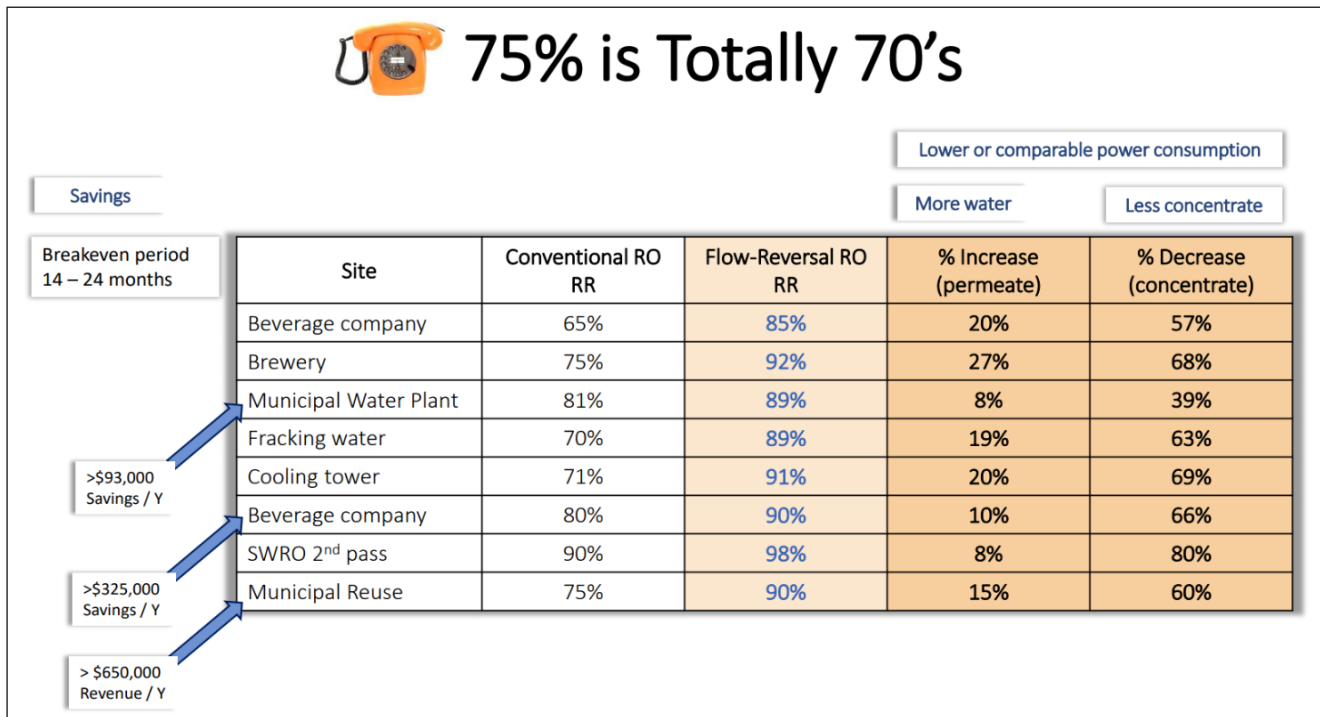


Figure 3. Recovery rates of conventional RO versus flow-reversal RO.

helps prevent scaling. Scaling might look gorgeous under an electron microscope, but in reality, it's ugly and inconvenient. Reversing the flow inside the RO system prevents scaling. This method can be used for any new RO system, we can retrofit existing RO systems, and we can even use it as a concentrator to treat concentrate from a primary RO.

Let's talk about some examples in the United States (Figure 4). There is a full-scale flow-reversal system in Arizona. We retrofitted a beverage plant in California; they went from basically zero recovery to reaching 55 percent recovery, with silica concentrations of 260 mg/L, which is very high. We're also starting up a pilot system in a California municipality and finishing fabrication of a high-recovery RO system for a beverage company in Texas. In the top right of Figure 4, you'll see an orange container. That's ROxy, our pilot system. We tested it at the Bureau of Reclamation's Brackish Groundwater National Desalination Research Facility (BGNDRF) in Alamogordo, New Mexico. We demonstrated a 92 percent recovery rate, compared to 82 percent in conventional systems. We were also awarded a Bureau of Reclamation grant to demonstrate high-recovery RO for reuse, another way we can support local water supply resilience, instead of moving water between communities.

Many people ask: What does it take to convert to flow-reversal RO? Figure 5 shows that with a conventional two-stage RO system, by adding just a few valves and pipes, we can operate it with flow-reversal.

Flow-reversal RO is based on three principles. First, we reverse the flow inside the pressure vessels. The second is a process called block rotation. Third, this is a continuous process. You don't have to stop the operation like in a batch process, and you generate permeate at the same quality continuously.

If you look at Figure 6, the top half shows a conventional RO pressure vessel, where water flows from right to left. Normally, scaling builds up at specific points. With flow-reversal, we reverse the water flow in that pressure vessel from left to right, as seen in the bottom of the figure. Areas that would otherwise scale now get a rinsing effect because they are exposed to undersaturated water instead of oversaturated water. That is how we achieve higher recoveries without the scaling problem.

Another key principle is block rotation, shown in Figure 7. In a standard two-stage RO system, the first stage membranes experience less stress while the second stage sees higher concentrations, leading to scaling. With block rotation, the pressure vessel blocks switch between functioning at stage one and stage two. This spreads the load of potential scaling more evenly across all membranes in the system, thereby extending membrane life and improving recovery. You'll notice that when we rotate the blocks, we also reverse the flow direction.

What makes flow-reversal so unique and important? First, it is flexible, meaning it can be used in new or existing RO systems. We can take systems operating at 75 percent, 78 percent, or 82 percent recovery, add

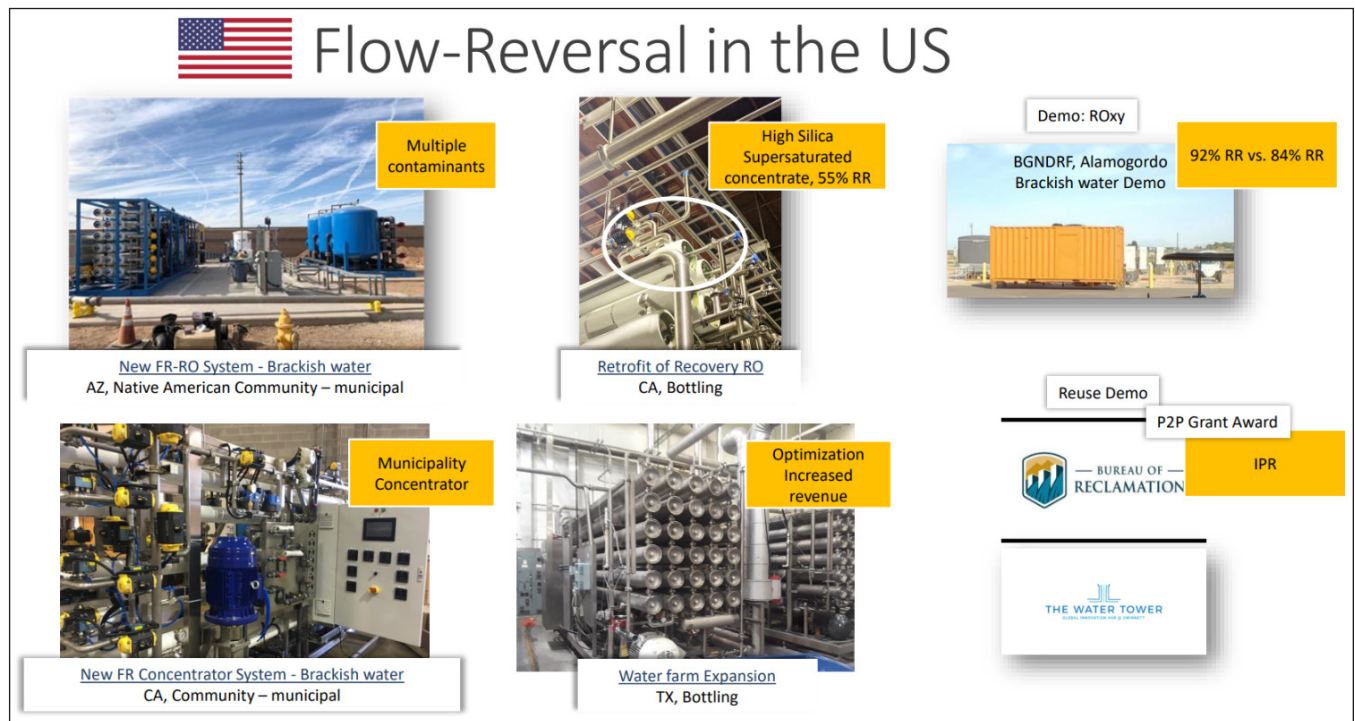


Figure 4. Flow-reversal RO projects in the United States.

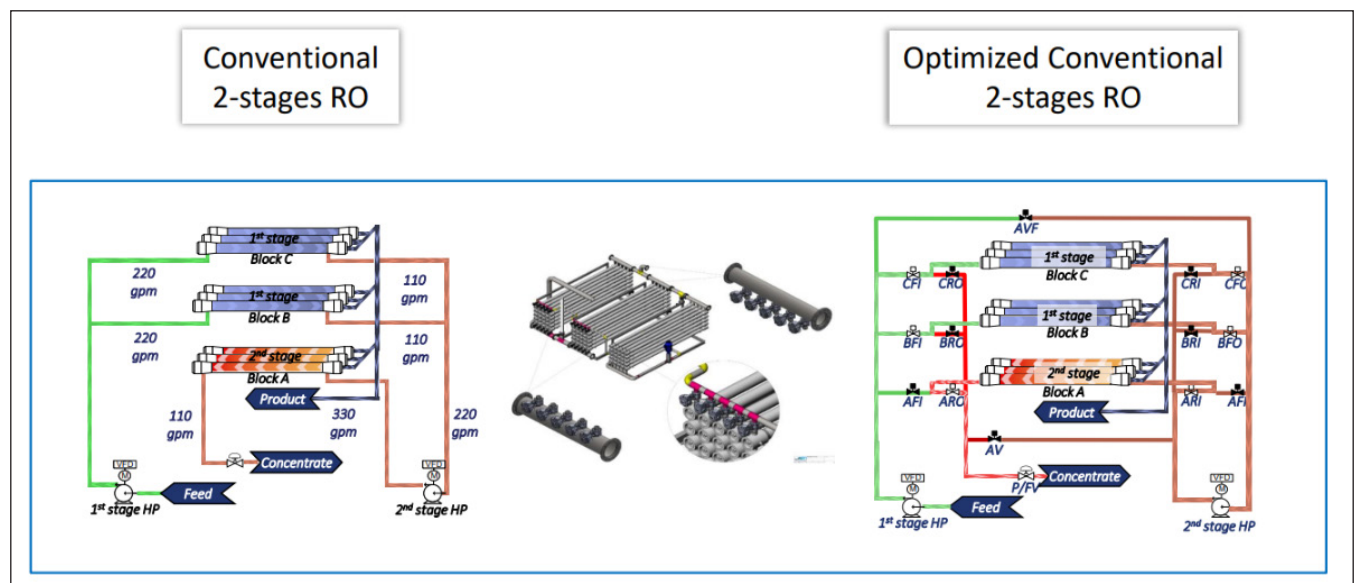


Figure 5. Flow-reversal RO technology.

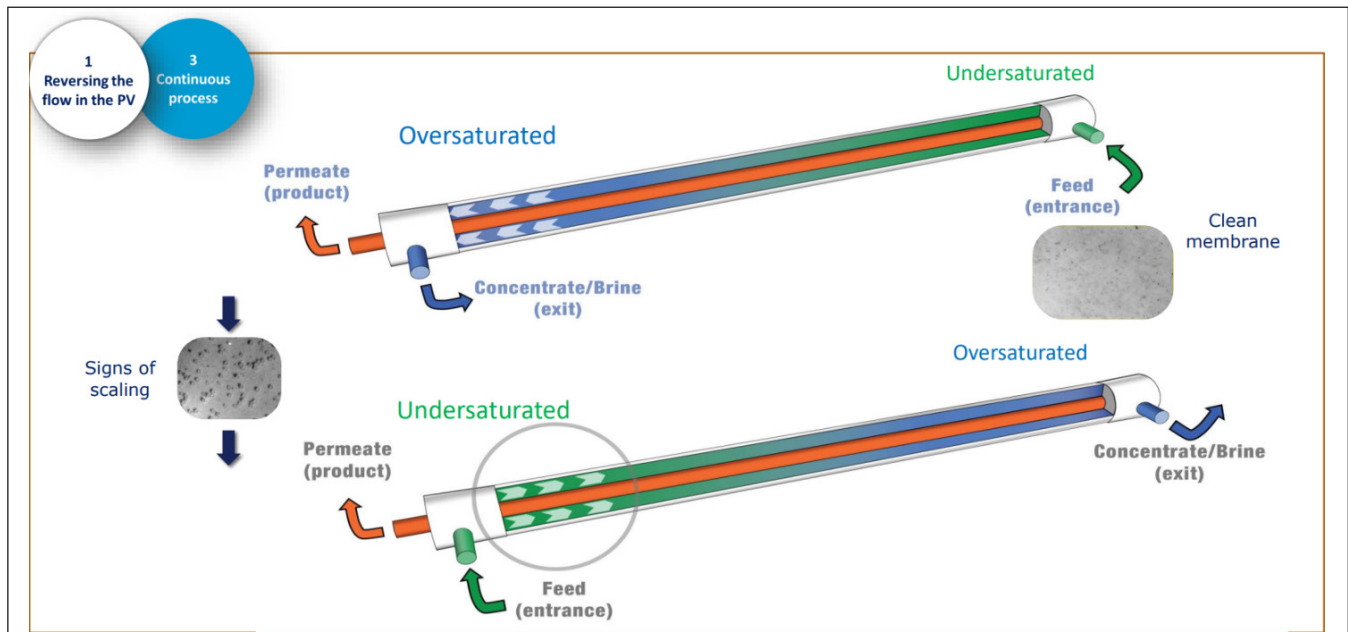


Figure 6. Flow reversal in the pressure vessel.

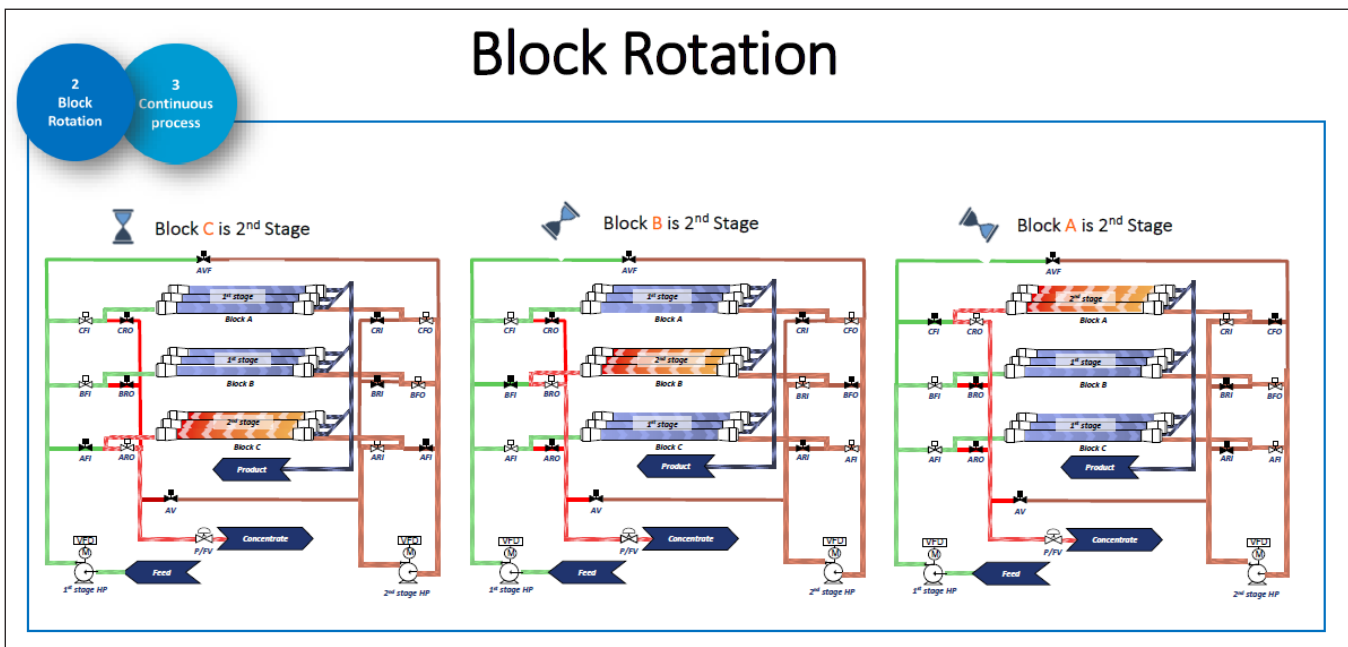


Figure 7. Block rotation.

flow-reversal, and then operate at 92 percent, 93 percent, 95 percent, even 98 percent recovery, depending on the water quality. Another advantage is that this process works with existing RO components available on the market. No proprietary equipment is used. Remember that cartoon with the umbrella? We’re improving RO as an existing, proven technology. Also, operators don’t need special training. It is easier to approach operators with a technology that is familiar to them. We believe that there is low operational risk because at any point the flow-reversal can be changed back to conventional operation, with the click of a button. We’ve also found that flow-reversal reduces biofouling. The shearing forces created by reversing the flow and changing osmotic pressures impact bacterial growth. By reducing scaling, we also save on chemicals and extend the life of membranes. But what matters most is how this helps real communities.

I’m going to present a case study from a community dealing with limited surface and groundwater resources, multiple water quality contaminants, cost effectiveness, innovation, and a very tight schedule. This community, the Ak-Chin community of the Maricopa Indian Reservation in Arizona, has a diverse economy, which includes agriculture, a casino, an airport, a golf course, and an entertainment complex. They’re continually investing in improvements, so they have a new fire station, a water

reclamation facility, and a surface water treatment plant built in 2012. Their primary water source is the Santa Rosa Canal, but in April 2019, they received notice that the canal would experience a temporary shutdown in November 2019, leaving them just six months to secure an alternative water source.

One possible solution was to recommission an existing idle well that could produce 800 gallons per minute. However, multiple contaminants were present in the groundwater, including nitrate, uranium, iron, and high total dissolved solids. All exceeded maximum contaminant levels (Figure 8).

Designing the treatment system meant balancing many factors: footprint, operational complexity, capital and operating expenses, and waste stream management. Working closely with the engineer and the community, we proposed a two-stage treatment: sorption-filtration for iron removal, followed by high-recovery RO using flow-reversal.

With high-recovery flow-reversal RO, they could achieve an 88 percent recovery rate, much better than the expected 75 percent for conventional RO. Plus, they reduced the concentrate volume by 50 percent. This meant they could manage the concentrate within their existing wastewater infrastructure until their planned evaporation pond expansion was complete. It also meant a smaller

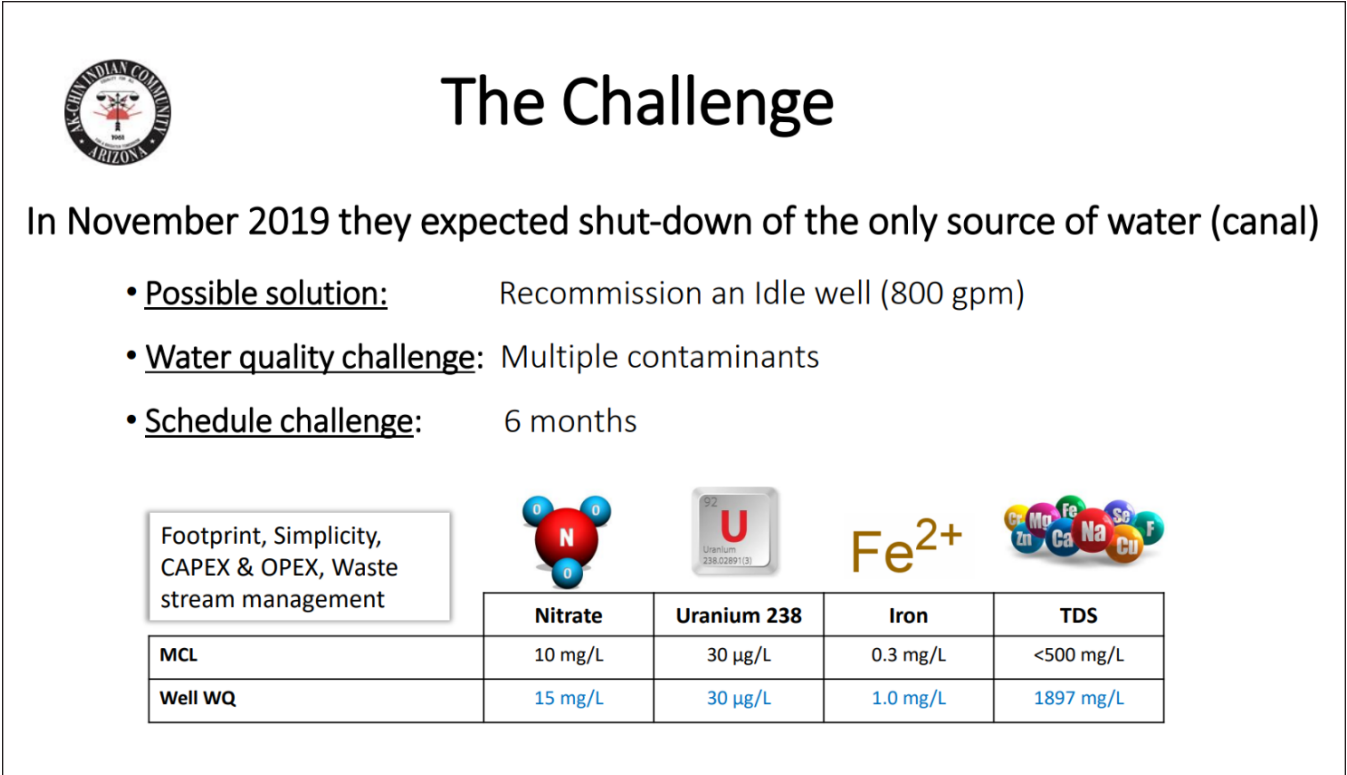


Figure 8. The challenge for the Ak-Chin community.

evaporation pond would be needed later. Additionally, of course, the system can handle three different contaminants plus the pre-treatment.

Fit-to-purpose design was key (Figure 9). Instead of treating all 800 gallons per minute through RO, we advised bypassing 250 gallons per minute and treating only 550 gallons per minute. With this plan, the plant reached a 91 percent recovery rate. At the bottom of Figure 9, you will see the progress we made from September through October 30, 2019, when the system was ready to provide water to the community. In mid-February, they also put a shed on the RO system, which is very critical because it did indeed cause problems later on, as I will explain.

Figure 10 shows a screenshot of the system in operation, with three blocks of stage one and a single block of stage three, rotating among themselves. Most exciting was the photo the operators and engineers sent us of them drinking the water produced by the system.

The flows and the recovery rate in the system are very stable. Still, remember that it's 2020. COVID-19 has caused us some delays and problems. One of the problems is that the community couldn't progress to the second

phase, which is a permanent building. That meant the RO system remained exposed to Arizona's sun, which eventually caused some biofouling issues in the flush tank. Also, there was a reduced water demand, and RO needs to work and work. They had reduced revenue, which further delayed the progression to phase two. But overall, we can tell you that they have a great team, and we collaborate very beautifully in order to continue this process.

Another shutdown of the canal is scheduled at the end of October 2020. The great news is that the system is working and ready to supply an alternative water source. Also, the permanent building is expected to be completed in the first quarter of 2021.

There are a few important take-home messages. It's time to reverse the flow—the mental flow. There is innovation out there; it's proven and it's working. If it's a good fit, we need to adopt it. We must also continue securing alternative water sources for every community. I am a very big admirer of the decentralized approach. Especially for communities that are spread out, there are solutions available. Finally, we need to continue looking for creative treatment solutions. Thank you very much.

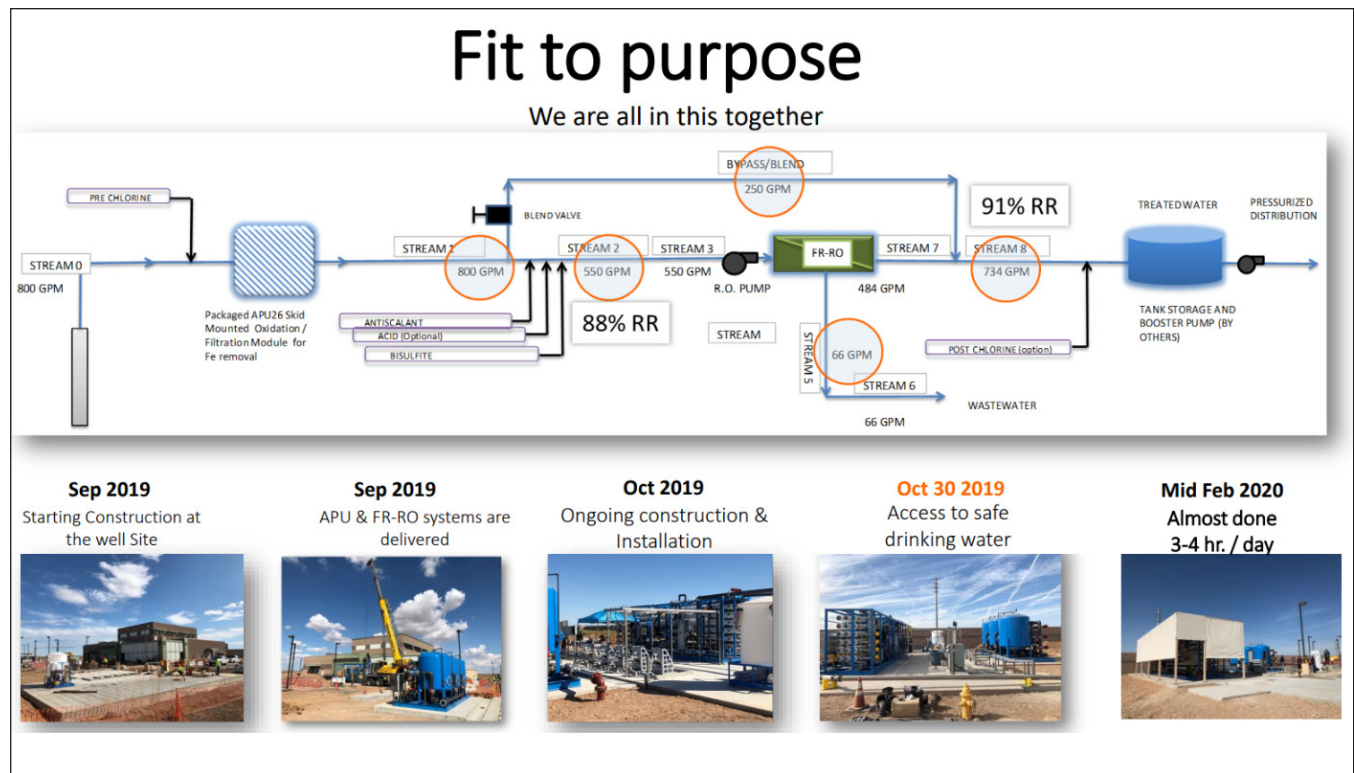


Figure 9. Fit to purpose and construction photos.

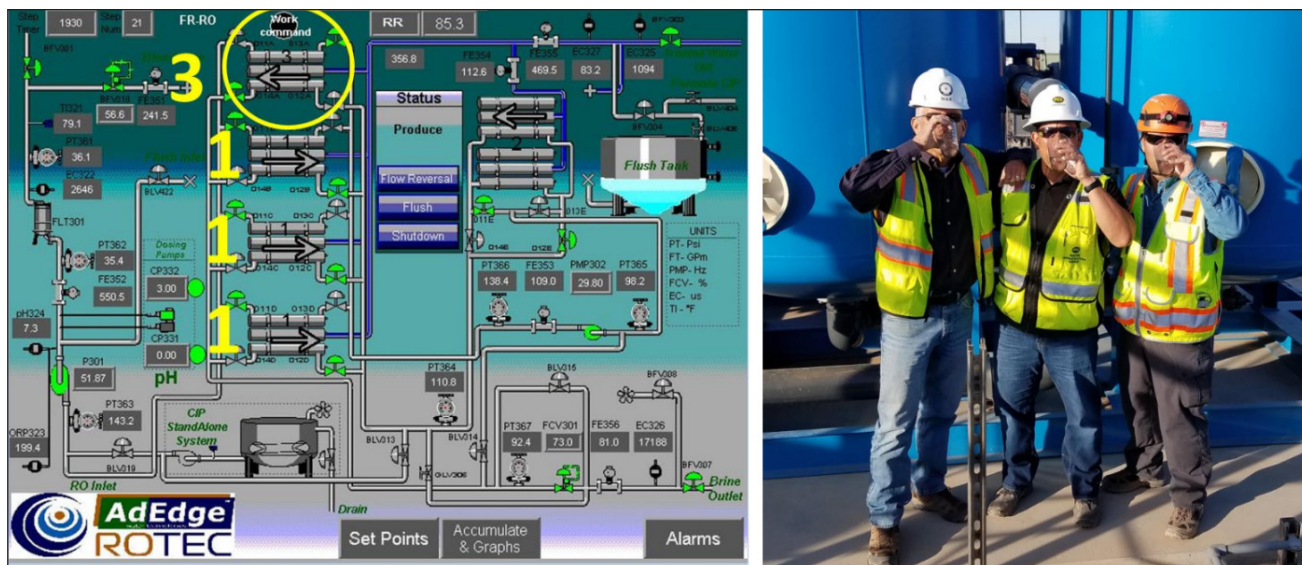


Figure 10. Fresh water supply starting on October 30, 2019.