http://dx.doi.org/10.5991/OPF.2017.43.0051

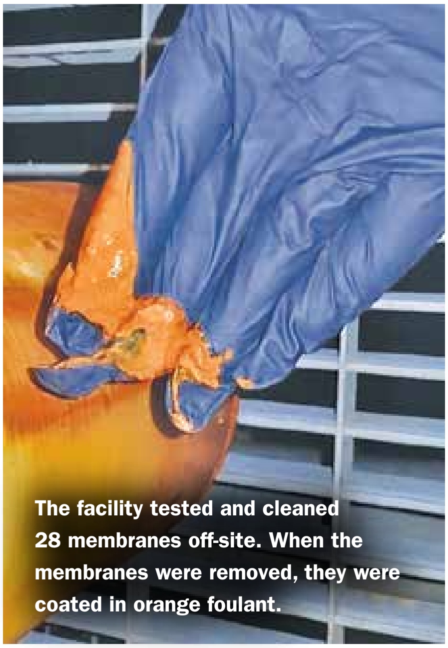
Ron Lutge is the chief plant operator with the Mission Basin Groundwater Purification Facility, Oceanside, Calif. (www.cityofoceanside.net).
Raul Gonzalez is a technical support engineer with Avista Technologies (www.avistatech.com), San Marcos, Calif.

Re-evaluate Plant Systems to Optimize Membrane Performance

Reduced groundwater levels from drought, seasonal changes, and excessive pumping poses significant challenges for membrane water treatment plants across California. Review system readiness to identify concerns before fouling events occur.

BY RON LUTGE AND RAUL GONZALEZ

GROUNDWATER provides drinking water for a large portion of the US population as well as for industrial and agricultural use. Reduced groundwater levels are making it necessary for water treatment plant operators to re-evaluate original plant equipment designs and feedwater changes to ensure they maintain system performance and avoid system shutdowns caused by worsening water quality.



The facility tested and cleaned 28 membranes off-site. When the membranes were removed, they were coated in orange foulant.

The Mission Basin Groundwater Purification Facility in Oceanside, Calif., is a desalting treatment facility that provides 15 percent of the city's water supply. The treatment plant has experienced the impact of reduced groundwater levels firsthand. The facility uses reverse osmosis (RO) to treat local brackish groundwater extracted from the Mission Basin.

The facility was put into service in 1994 with a capacity of 2 mgd. The treatment consisted of a single RO train with a 32:16 array. The plant capacity was expanded in 2001 to 6.3 mgd with an added second train as well as further well treatment. The heart of the facility is the RO system, consisting of two RO trains broken into three trees, with 16 pressure vessels each.

SYSTEM PERFORMANCE EVALUATION

In 2014, operations staff at the facility began proactively evaluating the plant's performance. This included reviewing equipment design, validating current chemicals used, system monitoring, and reviewing maintenance procedures.

Partnering with a local chemical supplier and RO process expert, two membrane autopsies were conducted using the first-stage lead and second-stage tail to identify fouling differences across the system. The analysis revealed that iron was the primary foulant, as seen in a physical inspection in which the membrane surface was visibly coated with an orange foulant.

Further autopsy analysis using a high-resolution image identified the exact location and concentration of the iron on the foulant sample. The image showed a relatively thick and even iron layer, confirming that iron was the main foulant on both the lead and tail positions and that a specialty iron cleaner was required for an optimal clean.

Off-site, 28 membranes were tested and cleaned, by position, to validate the recommended specialty cleaner and better predict the outcome of a full-scale cleaning. This strategy minimized the risk of membrane damage and rejection loss while testing the efficacy of the cleaning chemical on a full element. When the membranes were removed, they were coated in orange foulant (Figure 4), confirming the results of the lead and tail autopsies performed.

HOW THE IRON GOT IN

A comparison of the well levels between 2015 and 2016 revealed the static well level decreased, on average, by 14 ft. A loss in the static water level left the dynamic well head below a safe water level. Furthermore, when the wells were first drilled, they were placed in close proximity to each other. This wasn't a

PHOTOGRAPHS AND GRAPHICS: AVISTA TECHNOLOGIES

The primary foulant at the Mission Basin Groundwater Purification Facility is iron, as shown in this photo of a membrane cartridge filter taken out of service during a severe iron event. The foulant layer's thickness suggests the iron comes from the facility's well, already precipitated. Chromatic elemental imaging can be used to identify the exact location and concentration of iron on a membrane's surface (inset).

concern when the plant was designed, but as water levels decreased, the wells closest to each other competed for available groundwater. Operations staff noticed "rumbling" and "shaking" when the affected wells were placed online, especially when a higher demand was placed on the wells. In both instances, cascading of the wells entrapped air, causing iron oxidation and a resulting cartridge-filter and RO-fouling event.

Typical iron and manganese concentrations can be as high as 3 and 0.5 ppm, respectively. When air is introduced into the system, it causes metals to come out of solution. For example, air can change iron from its soluble (ferrous) to insoluble (ferric) form in seconds. During severe iron events, the differential pressure across the cartridge filters can rapidly increase upward of 10 psi. Similarly, the differential pressures across the RO membrane can increase beyond the plant's 55-psi shutdown alarm. Severe fouling events can bring the whole plant to a halt. Therefore, it's imperative to understand the system's behavior. As a preventive measure, operations staff has determined

BEST PRACTICES

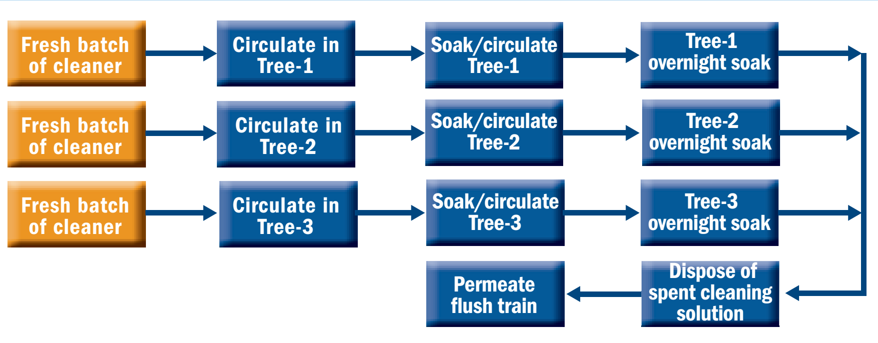
MINIMIZE EFFECTS OF SEASONAL CHANGES OR PROLONGED DROUGHT

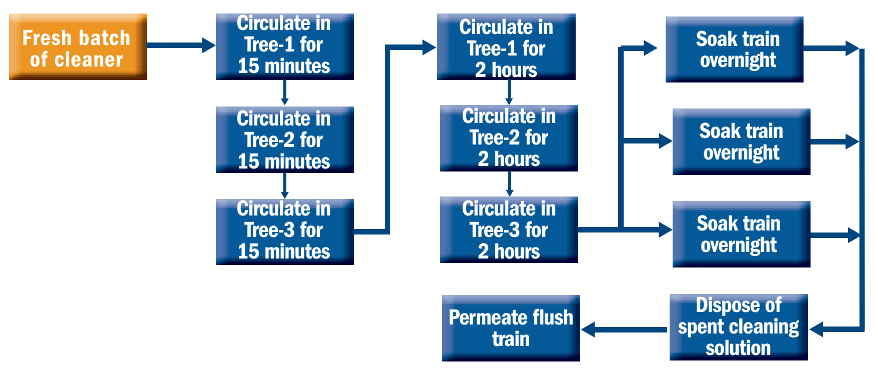
It's critical to monitor and take proactive steps to maintain membrane system performance and recoverability. These steps may include the following:

- Maintain balanced well production to avoid air intrusion in the feedwater.
- Perform routine water analysis to better predict and prevent fouling events.
- Perform regular equipment and design assessments to help prevent major system failures.
- Define an optimal cleaning procedure to potentially reduce chemical dose and save energy and water consumption.
- Autopsy membranes if needed to determine foulant deposition and the differences between the first and last elements.

Figures 1 and 2. Evolving Cleaning Procedures

The top figure shows a new cleaning procedure based on the results of single-element testing. The bottom figure shows an optimized cleaning approach based on a post-clean review.





safe flow rates and well combinations to prevent air from entering the system.

MAINTENANCE REVIEW

To further optimize system performance, the operations staff and the plant's chemical supply partner reviewed historical cleaning procedures. Historically, RO maintenance consisted of cleaning each train individually with high- and low-pH cleaners using a combination of generic chemicals, citric acid, and caustic as well as some formulated cleaners. System cleanings were based on a schedule rather than performance loss—about every six months—and took approximately one week to clean each train. In addition, the cleaning skid had the shortcoming of an inability to isolate individual trees when performing a clean. To overcome this, all three trains had to be full of water and maintain 2 percent weight cleaning solution for an optimal clean, therefore requiring higher chemical usage.

Based on the historical protocol review, as well as the results of the single-element testing and recommendation of a new specialty iron cleaner, a different cleaning procedure was drafted (Figure 1). The procedure consisted of using a single low-pH cleaner at a 2 percent concentration by weight. The cleaner was batched between trees, recirculated, and soaked overnight to give the system the contact time recommended in the single-element cleaning study.

The first clean with the recommended cleaner took approximately three days to clean a single train. Initial results showed restored membrane permeability and a decrease in differential pressures by approximately 50 percent.

A post-clean review determined that cleaning the whole train once could cut downtime and cleaning-chemical costs further, but the process is labor intensive. Given the fact a tree couldn't be fully isolated, it was determined the entire train could be cleaned with a single batch of cleaner. Figure 2 shows the improved cleaning procedure, resulting in similar performance enhancements as cleaning the single train and batching chemical in between trees. The cleaning consisted of a single batch at a 2 percent strength by weight of the low pH cleaner. The cleaning solution was recirculated through each tree for varying amounts of time. As a tree was recirculated, the other two were soaking. This further optimized cleaning, reducing cleaning time and downtime to approximately a day.

MONITORING SYSTEM HEALTH

Proper monitoring is one of the most important optimization steps. Data normalization examines flows, water quality, pressure, and temperature to determine whether performance changes are attributable to normal varying operating conditions or to actual system issues.

Mission Basin conducted a daily analysis of permeate flow performance. After the evaluation, plant operators implemented a data normalization program and made several instrumentation upgrades, including the addition of second-stage permeate, conductivity sensors, and flowmeters to better track individual stage performance.

After fully evaluating their system, operators at the Mission Basin Groundwater Purification Facility have put appropriate procedures in place to monitor their system's health and ensure they run the right chemistry and cleaning processes at the right frequency (see Minimize Effects of Seasonal Changes or Prolonged Drought, page 25). Such measures help the utility prevent major fouling events from occurring.

Acknowledgments: *The authors would like to thank John Perlman, with Separations Processes, Inc., for his support in writing this article.*