Over the last two decades, reverse osmosis (RO) has become the process of choice for removing dissolved salts and other contaminants from a variety of water sources, including seawater, groundwater and wastewater effluents. RO is a pressure-driven process, where the applied pressure required to drive water through the membrane is a function of the total dissolved solids (TDS) in the feed source. As foulants build up on the membrane surface, the foulant acts as an impediment to flow and the pressure required to drive water through the system increases. Left alone, the fouling can build up until the required pressure exceeds the feed pump capabilities, and a loss of permeate production eventually will occur. Membrane cleaning is used to remove the foulant from the membrane surface and return the system to baseline conditions.

A linear fouling model was selected as the foundation for the economic analysis. The OCWD GWR consists of 15 RO trains, each with a 5-mgd capacity, for a total plant production of 70 mgd of RO permeate capacity (N+1 design). The RO trains operate at 85% recovery and a maximum permeate flux of 12 gal per square foot per day. Each train houses 1,050 8-8 by 40-ft Hydranautics’ ESPA2 RO elements in a 78:48:24 array (seven elements per vessel). The membranes within the 15 GWR RO trains have a range of permeability due to intrinsic differences in membrane construction, cleaning effectiveness or exposure to different events and conditions during startup and operation. The inherent permeability of the membrane is the first contributor to the energy costs for an RO system. The second component contributing to the energy costs is the fouling rate. The fouling rate was considered representative of the anticipated fouling rate and used to extrapolate the long-term train performance.

Case Study: OCWD GWR System
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considered an acceptable assumption for this RO system. Other RO facilities with different fouling characteristics and cleaning effectiveness may not be able to make this assumption if consistent and repeatable cleanings cannot be achieved.

The cost associated with membrane cleanings included the labor cost, the chemical costs of the district’s cleaning procedure and the cost of lost production due to offline time. While the GWR system design accounts for one of the 15 trains being offline (N+1), it was assumed the fifteenth train could be offline for any number of other reasons; lost production due to cleaning was factored into this analysis. For this investigation, the total cleaning cost amounted to $15,929 multiplied by the number of cleanings per year. Even though the energy costs decrease further to deter mining the minimum operating cost, the chemical costs due to frequent cleanings. The total O&M costs to the right hand side of the parabolic curve are more heavily weighted toward energy costs as a result of accepting more fouling within the RO train. The minimum O&M costs can be determined by identifying the minimum point on the curve. This analysis was applied to each RO train and its unique condition and performance. The analysis described herein was based on a combination of real-world data and observations but should the fouling rate or cleaning effectiveness deviate from the model, the evaluation would need to be redone.

This is generally the case at OCWD, but should the fouling rate or cleaning effectiveness derive from the model, the evaluation would need to be redone. If this analysis indicates the benefit of a longer cleaning frequency, it would be wise for operators to confirm their assumptions through gradual implementation of longer cleaning frequencies. This would allow verification of the modeled fouling rate and confirm consistent cleanability is achieved.

All RO system operators should analyze energy and cleaning costs to find a balance between cost-effectiveness and performance.

A significant savings of approximately $250,000 per year was identified at OCWD through performing an economic analysis to identify the optimum cleaning interval for the district’s system. Not all RO systems are guaranteed the same degree of savings determined for OCWD, but most would likely benefit from applying a similar approach to their cleaning philosophy.

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