KEY POINT: Effective pretreatment can reduce membrane fouling and prevent other process complications, thereby reducing annual operating costs at desal facilities.

SUMMARY OF ISSUES

- **Capital vs. operating costs.** Inadequate pretreatment can be extremely detrimental to the overall efficiency of a desal plant, possibly resulting in costly repairs and significant facility down time. It is important to understand in advance that more expensive, better performing pretreatment processes may result in substantial avoided costs over the life of a desal facility.

- **Total costs.** Pretreatment construction costs include expenditures for removal of all contaminants in the source water that may impact normal operation of the membrane separation process.

  Vouckhov (2007) reports that the capital (construction) costs associated with pretreatment facilities typically account for about 6 – 9.5% of total project capital costs, and are generally within a range of $0.38 - $1.14/gpd ($100 to $300 per m$^3$/d) (Voutchkov 2007). However, CDWR notes that in many instances, pretreatment is the biggest performance and operating cost variable for desal and that the capital and operating costs of pretreatment can be greater than 50% of the overall cost of the RO system (CDWR 2003).

- **Factors affecting pretreatment costs.** Costs associated with pretreatment vary greatly based on source water quality and the type of technology used. Chemical costs and disposal of wastes generated by the pretreatment process also be important factors.

  - **Source water quality.** The annual costs of membrane desal plants are very sensitive to the salinity content of the source water. The sensitivity of operating costs to the salinity content of the source water supports the general proposition that, when concentrate management costs are ignored and all else is equal, it will virtually always be cheaper to desalinate brackish water than seawater when using membrane technologies (NRC 2008).

  Further, site-specific water quality factors such as turbidity, temperature, boat traffic, oil contamination, nearby outfalls, wind conditions, tides, and the influence of runoff will also affect the extent of pretreatment (and associated costs) necessary. Due to permitting regulations, available land and other...
environmental/economic considerations, however, desal plants cannot always be sited where they will have the lowest pretreatment costs.

- **Pretreatment technologies.** The capital costs of desal vary with the different pretreatment operations included in the total treatment system. A wide range of pretreatment options are available, however, conventional pretreatment is the most commonly used method for the treatment of open intake water prior to RO units.

In recent years, the use of membrane pretreatment processes including microfiltration (MF) and ultrafiltration (UF) has emerged as an alternative to conventional pretreatment. With UF and MF pretreatment systems, there is typically a marginal increase in capital costs compared to a conventional pretreatment process. However, a significant benefit of a UF/MF-based pretreatment is realized through reduced operating costs. The annual operating costs for a seawater RO system with UF/MF pretreatment are projected to be approximately 5 percent lower than one with a conventional pretreatment system (NRC 2008). Care should be taken to account for these sorts of trade-offs between capital and operating costs.

- **Chemical costs.** Chemical costs are also highly variable from one location to another and are primarily dependent on source water quality, the selected pretreatment processes and the target product water quality. Chemical costs are a variable expenditure and typically fall within the range of $0.06 - 0.17/kgal ($0.015 to 0.045/m³) of desalinated product water. However, actual chemical cost values for a given project should be established based on quotes from local suppliers of the site-specific chemicals (Voutchkov 2007).

For low-complexity projects, chemical costs usually account for 3 to 6.5 % of total project O&M costs. For higher complexity projects, chemical costs can make up 5.5 to 9.0% of total O&M expenditures (Voutchkov 2007). These estimates include expenditures for chemicals used in pretreatment and post-treatment processes.

- **Waste Disposal.** The wastes generated from pretreatment require proper disposal to avoid potential environmental pollution (typically as part of the desal concentrate). Depending on available disposal options, this can add significantly to overall desal costs. This can be a significant challenge at inland facilities.
Further, for conventional pretreatment systems, the sludge (usually containing coagulant FeCl₃) removed through media filter beds needs to be collected and processed for landfill disposal. If cartridge filters are used in pretreatment, the spent cartridge filters need to be disposed of at a sanitary landfill.

**STRATEGIES**

- Subsurface seawater intakes, aquatic filter barriers, and deep ocean water intakes can greatly reduce the need (and associated costs) for pretreatment. However, these technologies are often infeasible for larger plants and are dependent on appropriate geological conditions. Intake system and pretreatment costs should be evaluated together when comparing different options.

- Although in some cases it may seem prudent to utilize the most economical means of pretreatment at the sacrifice of some measure of performance, it is critical to understand that inadequate pretreatment can be extremely detrimental to the overall efficiency of a desal plant, possibly resulting in costly repairs and significant facility down time. More expensive, better performing pretreatment processes may result in substantial avoided costs over the life of the desal facility.

- Currently, MF or UF processes are being tested as alternatives to conventional pretreatment for RO at several treatment plants. VanderVenter et al. (2005) compared four pretreatment options in a feasibility study for the Corpus Christi, Texas Seawater RO (SWRO) Desalination Demonstration Project. The conventional treatment process of ocean water from open intakes using rapid mixing, 2-stage flocculation, and dissolved air floatation filtration, was ranked the highest of the four alternatives. This process provided an ease of implementation with high reliability and moderate costs. Although UF was determined to be highly reliable in terms of water quantity and quality, the high costs made this option less attractive (VanderVenter et al. 2005).

  In contrast, a one-year pilot study conducted by Marin Municipal Water District (MMWD) demonstrated that a MF/UF pretreatment system was better suited for treating the San Francisco Bay water compared to a conventional pretreatment system. The MMWD study found the MF/UF pretreatment provided more consistent and better water quality, and reduced fouling on the SWRO membranes. Moreover, the project capital costs and O&M costs of MF/UF pretreatment are lower than conventional pretreatment (MMWD 2007).
BENEFITS & COSTS

Benefits

❖ Effective pre-treatment can substantially reduce membrane fouling and prevent other process complications, thereby reducing annual operating costs.

❖ If proper pretreatment prolongs membrane life, then there can be appreciable savings by postponing or avoiding) the recapitalization cost of membrane replacement.

Costs

❖ Pretreatment costs can be substantial and depend greatly on site-specific factors such as water quality and available treatment technologies.

❖ Subsurface intakes can greatly reduce the need for pretreatment and associated costs. However, subsurface intakes are often infeasible at larger plants.

KEY UNCERTAINTIES

Pretreatment process design often relies on average source water quality taking into account the variation over several years. Unexpected events, such as the abnormal red tide event in California during the summer of 2005, can challenge and cause a complete failure of the desal process.

This was experienced at the Affordable Desalination Collaboration’s (ADC) demonstration-scale SWRO plant (up to 0.075 MGD or 2,830 m³/d permeate), which was designed to include in-line coagulation and media filtration to produce water with turbidity and SDI values acceptable for a SWRO system (Seacord et al. 2006). The design relied on more than ten years of experience treating Pacific Ocean water from the Naval Facilities Engineering Command desal test facility in Port Hueneme, California. Shortly after the ADC’s plant was commissioned in May 2005, a red tide event occurred that was substantially worse (i.e., regarding both water quality and duration of the event) than any previously occurred event. As a result, the ADC’s media filtration pretreatment was challenged to produce qualified water for its SWRO system, and the media filter differential pressure increased rapidly over the course of only two days. This made operating the SWRO equipment impractical and the ADC’s equipment remained shut down until October 2005, when the red tide event ended (Seacord et al. 2006).
ADDITIONAL RESOURCES


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