

EXHIBIT 14

Capital and O&M Costs for Membrane Treatment Facilities

Julie Nemeth-Harn, PE
Harn R/O Systems, Inc.
Venice, FL

Topics of Discussion

- **Feasibility and planning costs**
- **Capital cost guidelines**
 - Variability by capacity and water quality
- **O&M cost guidelines**
 - Predictable vs. unpredictable
- **Cost savings considerations**
- **Contracts and Procurement**



Feasibility and Planning Costs

- **Master Plan - \$50,000 to \$250,000**
 - Source water assessment
 - Permitting feasibility
- **Full-Scale Pilot Study – 3 months**
 - Equipment rental ~\$5,000/month
 - Equipment purchase ~\$100,000
 - Membranes, on-site service, etc. ~\$35,000-\$50,000
 - Engineering support and analysis ~\$75,000



Capital Cost Guidelines

- **Capacity**

- <100,000 gpd
 - 4-inch system, very expensive \$/gal
- 100,000 gpd to 1 mgd
- 1 mgd to 5 mgd
-
- >5 mgd, curve is flat

- **Water Quality**

- Under 1000 mg/l TDS, membrane softening
 - However, can have more colloid and biofouling problems!
- 1000 mg/l-3000 mg/l, low pressure RO
-
- 3000 mg/l to 15,000 mg/l, high brackish R/O
- >15,000 mg/l, might as well be seawater



Capital Cost Guidelines – Scope

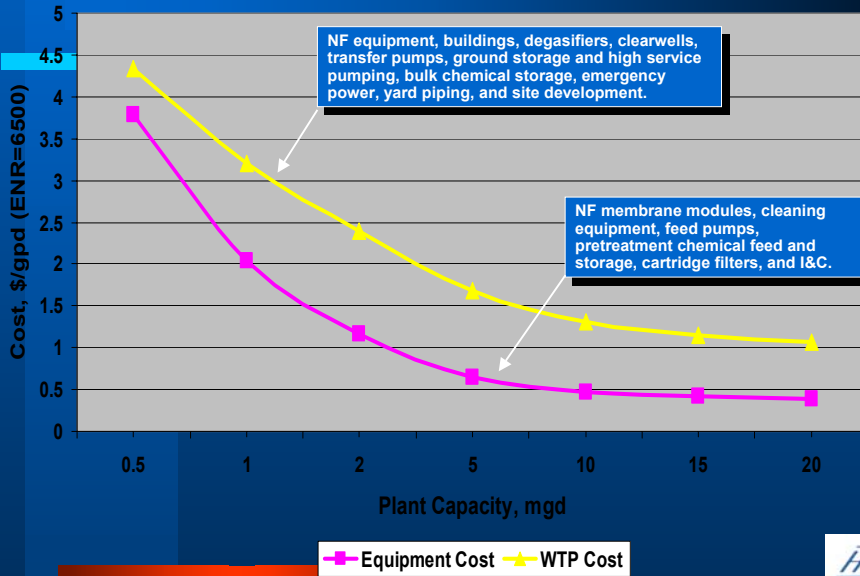
- **R/O Process Scope**

- Cartridge Filters
- Pre-treatment Chemical Systems
- R/O Feed and Interstage Pumps
- Skids: frame, piping, valves, vessels and elements
- Controls
- Optional: degasifiers/post-treatment



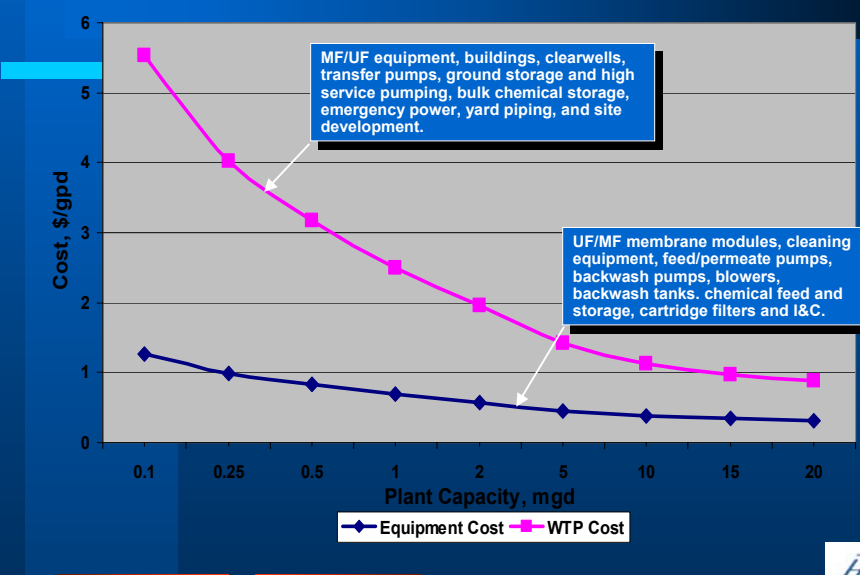
Membrane Softening Cost

curve courtesy of James Christopher – HAI Tetrattech



Membrane Filtration Cost

curve courtesy of James Christopher – HAI Tetrattech



Capital Cost Tidbits

- Membrane elements \$0.10 to \$0.25/gal
- R/O Process \$0.25 to \$1.50/gal (NF to brackish RO)
- Total WTP project cost \$1.25 to \$7.50/gal
- RO cost, percent of total project - 8% to 15%



Seawater – Sell Water Costs

- Hamma, Algeria 53 MGD - \$3.10/1000 gal
- Point Lisas, Trinidad 26 MGD - \$2.77/1000 gal
- Orange County, CA 30 MGD - \$3.32/1000 gal projected
- Carson, CA 20 MGD - \$2.75/1000 gal projected



24 MGD Tampa Bay Water Desalination Plant

- Original Construction Cost \$110,000,000
- Sell Water Price \$1.71
- Annual operating cost estimated \$10,000,000
- Currently two proposals to remedy plant
 - Veolia Water
 - \$50,198,000 additional capital
 - \$16,353,000 estimated annual operating cost
 - Delivered water cost \$2.63/1000 gal
 - American Water Services
 - \$28,670,000 additional capital
 - \$16,712,000 estimated annual operating cost
 - Delivered water cost \$2.54/1000 gal



Capital Cost Influences

- Economy of Scale
- Scope of supply
- Redundancy
- Level of automation
- New construction, expansion, or rehab
- Local site considerations
- Experience of team members
 - Owner
 - Engineer
 - Contractor
 - ROEM



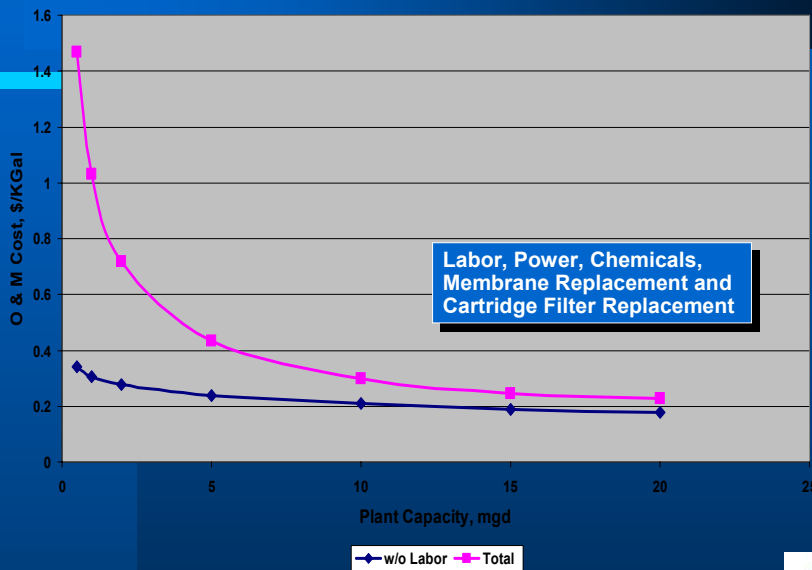
O&M Cost Guidelines

- Possible to predict
 - Operating pressure
 - R/O pump energy consumption
 - Chemical consumption
 - Cartridge filter life
- Difficult to predict
 - Cleaning frequency
 - Membrane life
 - Operator labor
 - Other plant energy consumption



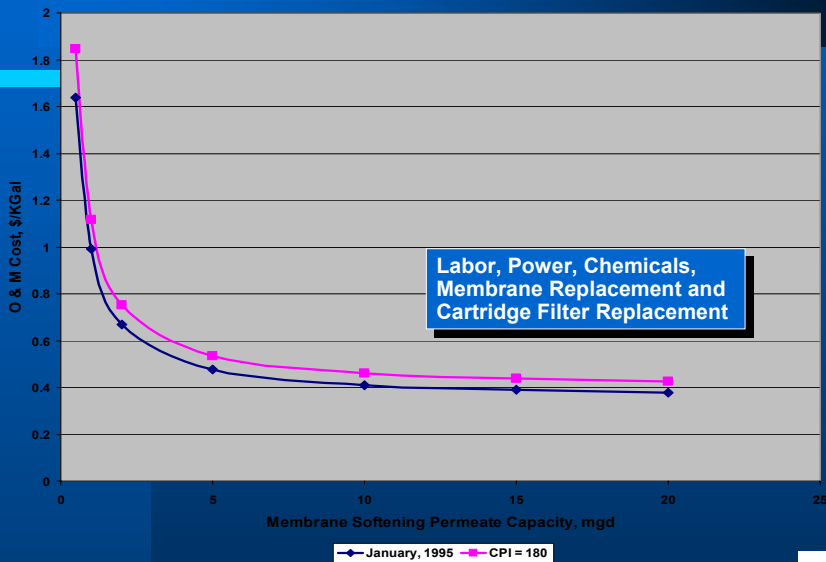
Membrane Filtration O & M Cost

curve courtesy of James Christopher, HAI Tetrattech



Membrane Softening O & M Cost

curve courtesy of James Christopher, HAI Tetrattech



O&M Cost Considerations

- Energy Savings
- Optimization of chemicals
 - Scale inhibitor/acid
 - Acid pre-treatment/degasification efficiency
- Operator safety and user-friendliness
- Low maintenance materials of construction



Operator Safety



Operator User-Friendliness



Low Maintenance Materials of Construction



Cost Savings Considerations

- Know your raw water characteristics
- Pilot Study
- Design for Low O & M
- Involve operators and service technicians
- Become an educated Owner – minimize discretionary changes
(the single most cited cause for cost overruns and delays)



Cost Example – St. Lucie West Utility

- 3.4 MGD brackish RO new construction
- Injection well \$3,770,925
- Building contract \$2,374,700
- RO bid range \$674,900 - \$1,045,000
- Avg. of RO bids \$850,000
- RO 12% of total project



**RO process is a
fraction of capital cost
– but the majority of
the O&M cost**

O&M Example – 10 MGD System

- **Assume**
 - 50 mg/l acid
 - 5 mg/l scale inhibitor
 - Change CF's 4 weeks
 - Feed Pressure 110 psi
 - Membrane life 5 years
- **O&M = \$0.3559/1000 gallon permeate**
- **All that has to change:**
 - CF's need changing every 3 weeks
 - Feed pressure climbs to 125 psi
 - Membranes need to be replaced after 3 years
- **O&M = \$0.4461**
an increase of 20%



O&M Example – 10 MGD continued

- **Assume water production cost of \$1.25/1000 gal**
 - 3650 MG/YR = \$4.5 million/year
- **20% increase, \$1.50/1000 gal**
 - 3650 MG/YR = \$5.5 million/year
- **\$1,000,000 per year increase!**



Contracts and Procurement

- **Contract Organization**
 - Parallel Prime Contractor
 - Single Prime Contractor
 - Single Prime w/ assigned OEM
 - Strategic Partnerships



Strategic Partnerships - Design/Build

- **Advantages**
 - involve contractor/OEM in early stages of project
 - long-term involvement encourages team spirit
 - selection process narrowed down to pre-qualified teams
- **Disadvantages**
 - not common in municipal market



Pre-qualification of OEM

- Description of company, background, years of experience
- list of installations including references
- project descriptions similar to project being considered
- resumes for key project personnel
- description of fabrication facility, quality control and testing procedures, in-house capabilities
- information on major sub-contractors
- visit installations and fabrication facility



Owner-Furnished Materials

- **Advantages: tax or mark-up savings**
- **Disadvantages:**
 - lack of experienced agent overseeing procurement
 - less resources for follow-through if a problem arises
 - storage and installation could affect warrantee
 - lose unit responsibility



Cost Notes

- **EQ Costs Include:** UF/MF membrane modules, cleaning equipment, feed/permeate pumps, backwash pumps, blowers, I&C, backwash tanks. NF membranes, vessels and supports, pretreatment chemical feed and storage, cartridge filters, feed pumps, I&C.
- **WTP Costs Include:** NF equipment, buildings, degasifiers, clearwells, transfer pumps, ground storage and high service pumping, bulk chemical storage, emergency power, yard piping, and site development.
- **O&M Costs Include:** Labor, Power, Chemicals, Membrane Replacement and Cartridge Filter Replacement



References

- **Numerous Water Desalination Report statistics**
- **AWWA Journal May 1996 – Characteristics and Costs of MF and UF Plants, Samar Adham et al.**
- **AWWA Journal May 1996 – Cost of Membrane Softening in Florida, Robert Bergman (*subtitled “...an easy way to estimate order of magnitude costs...”*)**



Conclusion

**Don't be
Penny-Wise
and Pound-
Foolish!**

