
**U.S. COSTS & SELLING PRICES FOR
POTABLE WATER PRODUCED
BY DESALINATION & MEMBRANE SOFTENING**

A Survey and Analysis for

**National Water Research Institute
10500 Ellis Avenue
Fountain Valley, California 92728-0865**

and

**U.S. Dept. of the Interior
Bureau of Reclamation
Denver, Colorado 80225-0007**

November, 1996

Prepared by

**Leitner and Associates, Inc.
Boca Raton, Florida & Mystic, Connecticut**

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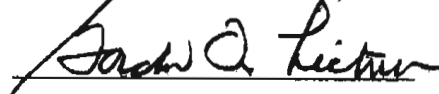
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Gordon F. Leitner, President

The contents of this report represent our interpretation and analysis of information provided by individuals in the subject municipalities or agencies. It is not guaranteed as to accuracy or completeness.

Acknowledgements

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1.0 INTRODUCTION

A recent definition of desalting (desalination) suggested by Klaus Wangnick is "All treatment of water (fresh water, river water, brackish water, seawater, waste water) by means of thermal (evaporation) or membrane (reverse osmosis, nanofiltration, electrodialysis) processes." If we can agree that membrane softening is a nanofiltration process, this definition provides an appropriate base for this survey report which covers a range of four processes, Reverse Osmosis for brackish and groundwater enhancement, electrodialysis, membrane softening, and seawater desalination, all of which are currently used in the US to produce potable water for municipal use.

While the production of potable water by these four process is minuscule (less than one half of one percent of the total potable water delivered in the US) desalting is now recognized having, perhaps, the greatest potential for growth, of the known alternative water supplies. The primary constraint for more rapid development is a continuing public understanding that "desalting is too expensive". In reality, costs for desalting have moved from the realm of "expensive" to "competitive" with both conventional and alternative sources.

The public misunderstanding is retarding plans for implementing desalting projects, and delaying the full realization of this alternative water supply. One typical example is the current situation in the greater Tampa-St. Petersburg, Florida area, where news media have compared the cost of desalted seawater, (\$4.00/1000 gallons) with current residential rates for delivered water from well fields (\$1.43/1000 gallons). Until a symposium was held, which was open to the public, the media had neglected to report the desalted water would be blended with water from conventional sources. The projected increase in cost to the average residential user when desalted water is blended with water from conventional sources? From \$11.44/month to \$14.44/month a 26% increase! The benefit? An

additional water source to meet increased demand resulting from population increase, without depletion of existing groundwater supplies. When the raw water source is ground water, the cost spread between conventional sources and desalted water, blended, is even lower.

The need for publicity concerning accurate cost information for the desalting alternative is evident. The National Water Research Institute and the US Bureau of Reclamation have elected to address this need in providing for this Survey and Analysis.

1.1. PROJECT DESCRIPTION

The objective is to provide, by means of a survey, an update from available sources on costs and selling prices for desalted water in the United States (including the US Virgin Islands and the US Navy base at Guantanamo Bay). For perspective, the survey has included data for one groundwater plant in Canada.

1.1.1 Sources Used for Database

The first task was to compile a list of desalting plants in the US. The EPA provided a list of contacts for the individual state agencies regulating water. See Appendix 1. The state agency responsible for water quality is most often a department of environmental protection, department of health, or a department of water resources. These agencies in states with substantial desalting activity were contacted to ask for lists of plants within their area of domain.

Desalting plant manufacturers and membrane manufacturers were also contacted. A list of US firms is shown in Appendix 2.

Publications were reviewed, including the Water Desalination Report, the American Desalting Association Biennial Conference Proceedings, and the IDA Worldwide Desalting Plants Inventory, #14, published by Wangnick Consulting in 1996.

From these sources a list of existing potable water desalting plants in the US was prepared, as shown in Appendix 3. To complete the database, including plant names, addresses, telephone numbers, plant capacities, names of principals, etc., many telephone calls and contacts by FAX were made. Table 1 is a summary list prepared from Appendix 3, of potable water desalting plants in the US and Canada. 180 plants were identified, including the large RO plant at Yuma, Arizona. For perspective, a few low capacity plants (30,000-50,000 GPD) were included in the list. Most of these small plants serve private condominiums, trailer parks, etc. 10 to 15 such small plants are not shown on the list.

1.1.2 Survey Questionnaires

Two survey questionnaires as shown herein were used, one for treatment plants operating on brackish water, the other for plants operating on seawater. To encourage the recipients to respond and to minimize the time required to respond, the survey was limited to one page. 195 survey questionnaires with transmittal letters were sent out. The transmittal letters stated a copy of the completed Survey Report would be sent to each respondent.

1.1.3 Response Rate

Of the 180 identified desalting plants in the US (including one in Canada), data for 98 plants is reported herein, a combined response and reporting rate of 54%. (70 completed survey questionnaires were received in response to the survey mailings and follow-up telephone calls.) Considering that completing a survey questionnaire would require several hours of time, the response rate would be considered quite acceptable. Those that responded can be assured they have made a substantial contribution to the development of the industry.

1.1.4 Data Analysis & Recording

Data from the returned questionnaires was supplemented, when available, with information from equipment suppliers, membrane manufacturers, and from literature and journals. In a few cases the plant owner or municipality responded to the 1992 survey by

A Survey of Capital Costs, Operating Costs & Selling Prices for Potable Water Desalination Plants in the U.S.

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Plant Data

Plant Name: _____ Address: _____ _____ Telephone: _____ Fax: _____ Respondent: _____ Title: _____	Plant Type Brackish RO _____ EDR _____ Softening _____ Groundwater _____ Enhancement _____	Year of Startup _____	Name of Equip. Mfr. & Contractor _____
------------------------------------------------------------------------------------------------------------------------------------------------------------	------------------------------------------------------------------------------------------------------------------	---------------------------------	------------------------------------------------------

The most recent process and cost data will be most relevant. If your plant consists of several units installed at different times it may be most convenient to provide the data based on the entire plant. If the most recent unit installed is most representative of your operations, please provide data for this unit, and so indicate.

Process Data

Rated Capacity GPD	Annual Production Mil Gal.	Quantity of Blend Water Added from Another Source, GPD	Salinity Feed/Product Mg/l	Recovery %	Cost of Electric Power \$/kwh

Membrane Data

Make	Model	Number

Capital Costs

Please show breakdown of costs if available, excluding all distribution costs. If breakdown is not available, please provide a number in the column for total capital costs.

Building	Plant Equipment	Wells or Feed Intake	Product Tanks	Brine Disposal	Other Costs	Total Capital Costs

Annual Operating Costs

Hourly Consumption of Power, KWH	Annual Electric Power Cost (\$)	Number of Personnel	Annual O&M Personnel Cost	Chemical-Cart. Parts, Other	Membrane Replacement	Total Annual Costs

Does power consumption include well pump power (y/n) _____ Is the well pump on the same meter (y/n) _____

Does power consumption include distribution power (y/n) _____

Selling Prices

Annual Sales Mil. Gal.	Monthly Use Gallons	Selling Price per 1000 Gal	Additional Charge for Connection/ Hookup Fee?	Additional Fixed Charge Added to Sewer Charge?	Other Rate Charge Formula (Please describe on Separate Page)
		(Example) 0-20,000 Gal 20,000-60,000 60,000 or more			

A Survey of Capital Costs, Operating Costs & Selling Prices for Potable Water Desalination Plants in the U.S.

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Plant Data

Plant Name: _____ Address: _____ _____ Telephone: _____ Fax: _____ Respondent: _____ Title: _____	Plant Type MED Distillation _____ Seawater RO _____	Year of Startup	Name of Equip. Mfr. & Contractor
------------------------------------------------------------------------------------------------------------------------------------------------------------	------------------------------------------------------------------	------------------------	---------------------------------------------

The most recent process and cost data will be most relevant. If your plant consists of several units installed at different times it may be most convenient to provide the data based on the entire plant. If the most recent unit installed is most representative of your operations, please provide data for this unit, and so indicate.

Process Data

Rated Capacity GPD	Annual Production Mil Gal.	Quantity of Blend Water Added from Another Source, GPD	Salinity Feed/Product Mg/l	Recovery %	Energy Power \$/kwh	Steam \$/1000#

Membrane Data

Make	Model	Number

Capital Costs

Please show breakdown of costs if available, excluding all distribution costs. If breakdown is not available, please provide a number in the column for total capital costs.

Building	Plant Equipment	Wells or Feed Intake	Product Tanks	Brine Disposal	Other Costs	Total Capital Costs

Annual Operating Costs

Hourly Power KWH	Ann. Electric Power Cost (\$)	Hourly Steam #/Hr	Ann. Steam Cost, \$	No. of Personnel	Ann. O&M Personnel Cost	Chem./Cart. Parts, Other	Memb Replace.	Total Ann. Costs

Does power consumption include well pump power (y/n) _____ Is the well pump on the same meter (y/n) _____

Does power consumption include distribution power (y/n) _____

Selling Prices

Annual Sales Mil. Gal.	Monthly Use Gallons	Selling Price per 1000 Gal	Additional Charge for Connection/ Hookup Fee?	Additional Fixed Charge Added to Sewer Charge?	Other Rate Charge Formula (Please describe on Separate Page)
(Example) 0-20,000 Gal 20,000-60,000 60,000 or more					

the National Water Supply Improvement Association, but not to this second survey. In those cases, the 1992 response was included in this report.

The plants are grouped, for each process, in ascending order according to rated capacity, and listings are shown for each of the following reporting categories:

- Process Data
- Capital Costs
- Operating and Maintenance Costs
- Water Rates

Process groups and the number of plants included in this report are as follows: *(As shown in Table 1, the total number of desalting plants in the US for the production of potable water is 180)*

Brackish RO/Groundwater Enhancement	56
Electrodialysis	17
Membrane Softening	15
Seawater Desalting	<u>10</u>
Total	98

From this list of plants for which data is reported, from four to seven plants were selected from each process category for case study comparisons for unit capital costs, unit O&M costs, and for water rates. The comparisons are shown in table and chart form. Finally, a process comparison is made for large capacity plants, showing unit capital costs, O&M costs, and water rates, in table and chart form.

1.1.5 Follow-up Mailing

After the survey data was grouped and recorded, a second mailing was sent to all owners or municipal agencies, with a copy of the survey group data in which their plant was, or

should be, included. Corrections were invited, and for those that had not responded previously, a second invitation.

TABLE 1

**POTABLE WATER DESALTING
PLANTS ---U.S. & CANADA**

(See Detail, Appendix 3)

State	Number of Plants	Capacity MGD
Arizona	7	7.82
California	17	33.09
Colorado	1	1.00
Florida	90	191.10
Hawaii	2	1.60
Illinois	7	3.66
Iowa	7	3.93
Mississippi	1	0.19
Missouri	1	1.00
New York	2	0.83
North Carolina	4	2.21
North Dakota	2	2.06
Oklahoma	2	3.55
Pennsylvania	1	0.11
South Carolina	4	8.60
Texas	11	23.09
Utah	1	0.35
Virginia	2	3.95
Washington	1	0.53
Puerto Rico	1	0.15
Virgin Islands	14	9.89
Canada	1	0.50
	179	299.21
Arizona (Yuma)	1	72.00

1.2 TERMS AND ABBREVIATIONS

EDR	Electrodialysis Reversal
GPD	Gallons Per Day
MED	Multi-Effect Distillation
MGD	Millions Gallons per Day
MSF	Multi Stage Flash
MS	Membrane Softening
NF	Nanofiltration
O&M	Operation and Maintenance
RO	Reverse Osmosis, (Brackish Water)
SWRO	Seawater Reverse Osmosis
WTP	Water Treatment Plant

1.3 SUMMARY

In this report it is intended to take a hard close look at the capital and O&M Costs for desalting plants in the US used for providing potable water, and to compare the several processes in commercial use for this service. It is also intended to look at what is being charged for this alternative water source, in water rates and supplementary impact and connection charges. It is also to define and examine emerging trends in desalting applications and construction, for the benefit of those owners, municipalities, and equipment and component suppliers, and consulting engineers already involved in this field, or with projects under consideration. Finally, the water rates being charged by desalting plant owners and operators are compared with current average rates for conventional sources.

The US, as a whole, is well-fixed for water. However, as shown in Table 1, there are limited regional water shortages, with 19 states, Puerto Rico and the Virgin Islands, where

desalination for potable water is now in use. The requirement for additional alternative water supplies will increase. For example, the population is projected to grow by 11% during the next ten years. The new federal Clean Water Act mandates higher water quality standards for potable water. Some heretofore sub-standard supplies will be brought into service using advanced water treatment technologies, thus creating additional alternative water sources.

1.3.1 Cost & Water Rate Comparisons

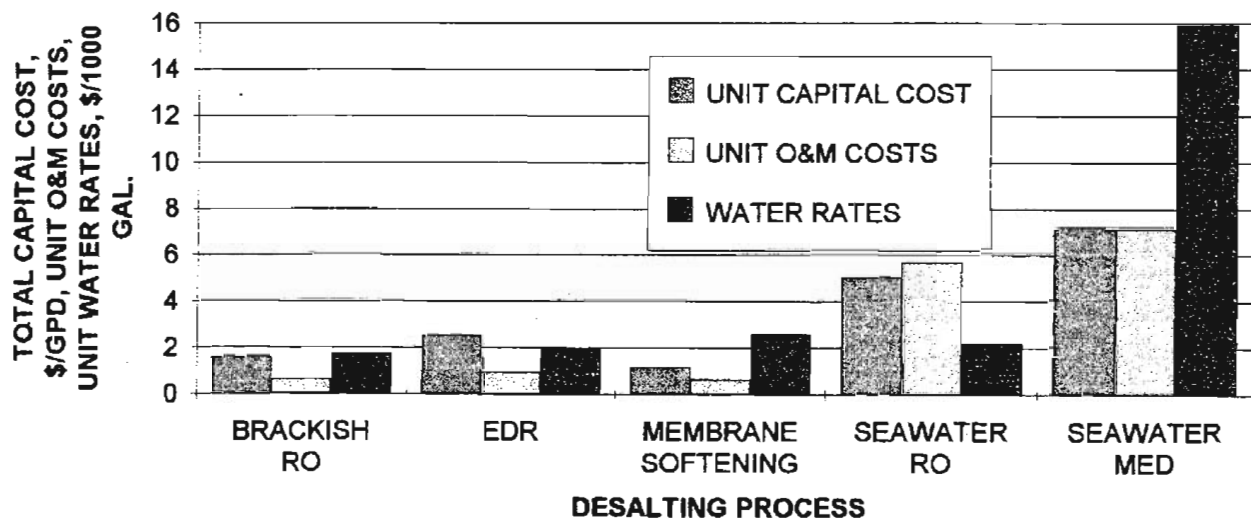
The data from the completed surveys was sorted according to process, and listed for each process in ascending order for plant capacity. Second listings were then prepared for each plant, showing capital costs. Third listings were prepared for each plant showing operation and maintenance costs. Fourth listings were prepared for each plant showing water rates.

From these four listings, representative plants, one for each of several plant capacities were then selected, and separate tabulations prepared for these plants for capital costs, O&M costs, and for water rates. From these tabulations charts were then prepared, to illustrate cost and water rate changes according to plant capacity.

For an overall comparison, one of the large plant capacities for each process was then selected for process comparison. This is illustrated in Figure 1. Membrane softening has the lowest capital and O&M costs, as would be expected. EDR has higher capital costs, with O&M costs about equal. Water rates for RO, EDR, and membrane softening are all comfortably above the O&M costs. Figure 1 also has seawater RO capital costs and O&M costs lower than for MED distillation for the production of potable water from seawater. It is important to note that these costs are site specific, given conditions at another site, where cost of steam might be lower, than for the case illustrated in Figure 1, the O&M costs could be quite different.

The water rate for seawater RO shown in Figure 1 seems out of proportion. The selected plant is the Santa Barbara, California facility. The plant is on standby, and the O&M costs

FIGURE 1: COST COMPARISONS, CAPITAL, O&M, AND WATER RATES, SELECTED POTABLE WATER DESALTING PLANTS IN U.S.

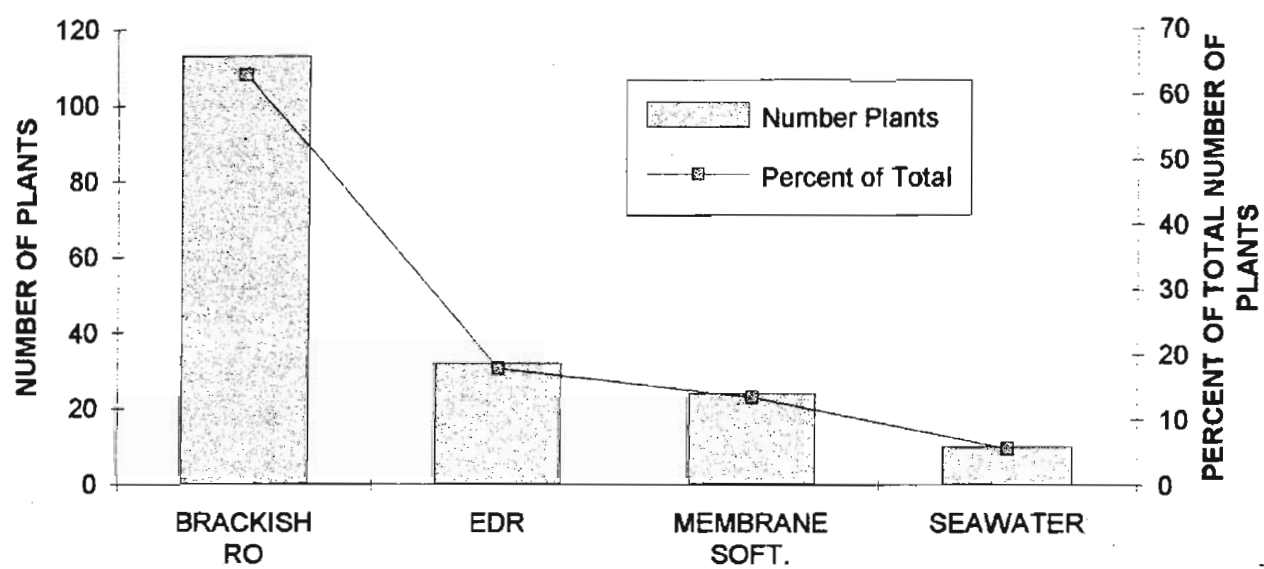


shown representative for when the plant is in operation. The water rates reflect the supply of water from the conventional source, and not for desalted seawater.

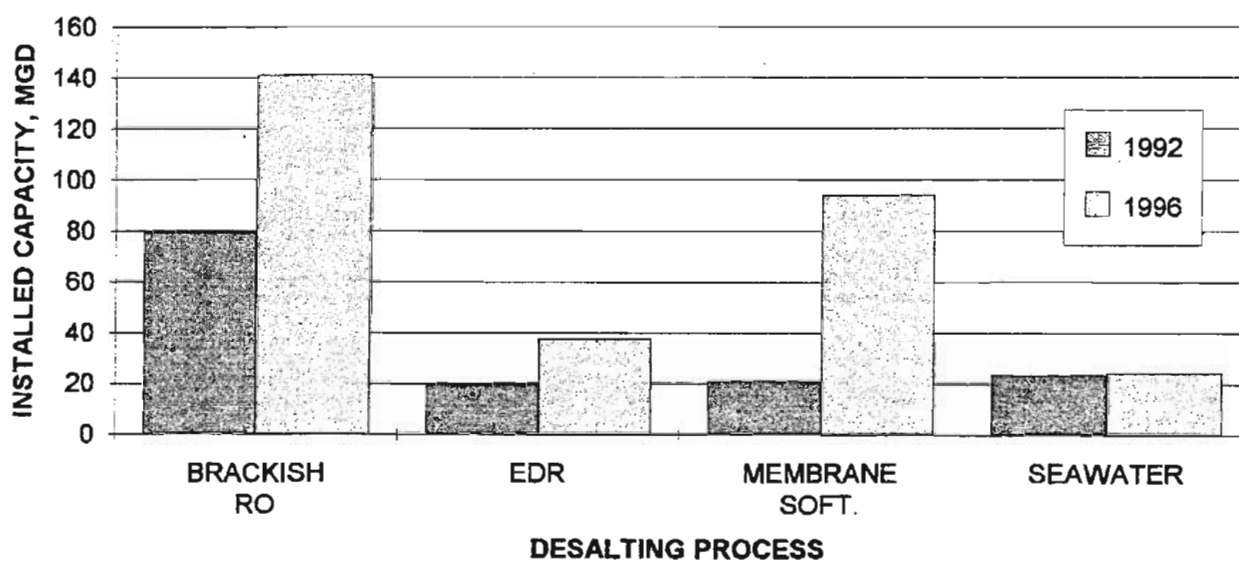
1.3.2 Significant Trends

- Figure 2 shows the number of identified desalting plants in the US, as of August, 1996, (180 total) grouped according to process. A comparable figure from the 1992 Survey prepared for the National Water Supply Improvement Association is 144, a growth rate of 25% in four years, or an average growth of 6.25% per year.
- Figure 3 compares the installed capacity in 1992 Vs 1996. (The Yuma Desalting Plant is not included, since there has not yet been a requirement for this plant to be placed in operation. The total installed capacity in the US for all desalting processes was 147 MGD. In 1996 the total is 267 MGD, in increase of 81% in four years, or 20% per year.
- Referring to Figure 3, brackish water RO shows a 75% increase over 4 years, or 18.75% per year. EDR had a 100 % growth over the same period, however the total is still only 29% of the installed capacity for brackish water RO. Once again seawater desalting in the US has not grown, to date, and has not been a significant factor in potable water supply.
- Membrane softening had the largest growth, nearly 500% in four years, or 120% per year. This may be the most important finding from this survey. It highlights an opportunity that most likely will far surpass the requirement for membrane softening. Membrane softening was originally intended to primarily reduce total hardness in groundwater or surface water, however a side benefit was soon revealed, these membranes can also remove trihalomethane formation potential (THMFP) and color and reject bacteria and viruses and dissolved organic carbons.

**FIGURE 2: POTABLE WATER DESALTING PLANTS IN U.S.
(As of August, 1996)**



**FIGURE 3: INSTALLED CAPACITY FOR POTABLE WATER
DESALTING PLANTS IN U.S. COMPARISON, 1992 vs 1996**



1.3.3 Water Rate Comparisons, Desalting Vs Conventional Sources

A survey of water rates for conventional sources by Ernst and Young shows a continuing trend toward rate structures that encourage conservation, such as seasonal rates and inverted volume charges in which costs rise with consumption. The findings from our survey for water rates for desalted water show that for the respondent reporting water rates, only 33% have inverted volume charges.

Figure 3A was prepared from the findings from the Ernst and Young report, through year 1994. For comparison purposes, the average rate for 1996 was projected as shown in Figure 3A. The Ernst and Young report is based on responses from 159 utilities serving the 100 largest metropolitan areas in the US, and show the average monthly charges for a typical residential customer had increased 5.2% in the period 1992 through 1994. The report states "Rising costs are a factor of almost all aspects of utility operation, including capital investments, regulatory compliance, and customer service. To meet the rising costs, utilities review their financial condition more frequently and increase rates every two to three years."

Figure 3B compares the water rates for the first 1000 gallons of potable water from each of three desalting processes, brackish RO, EDR, and Membrane Softening, with the projected average rate for water from conventional sources. (See Figure 3A). The very small difference in rates should help to dispel the myth that "desalting is too expensive".

1.3.4 Connection Charges and Impact Fees

With a few exceptions, (significantly the seawater desalting plants in the Virgin Islands), no attempt is made by the desalted water utilities to recover capital costs as a part of the water rates. Instead, capital costs for government-owned utilities are paid for by grants or loans from federal or state agencies, or by general obligation bonds. Later, to offset these

costs, one time impact fees, or monthly basic facility charges, or connection fees are assessed. The results of the data from the survey respondents are set forth in a separate listing for each facility.

FIGURE 3A: U.S. WATER RATES, CONVENTIONAL SOURCES, THROUGH 1994, BY ERNST & YOUNG. 1996 AVERAGE RATE IS PROJECTED

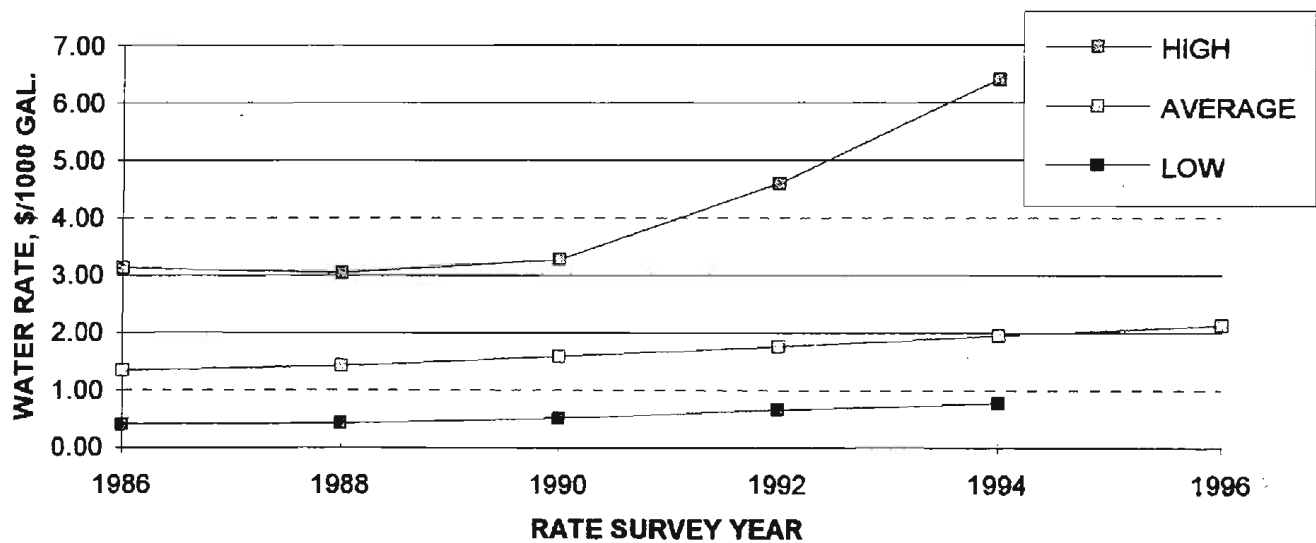
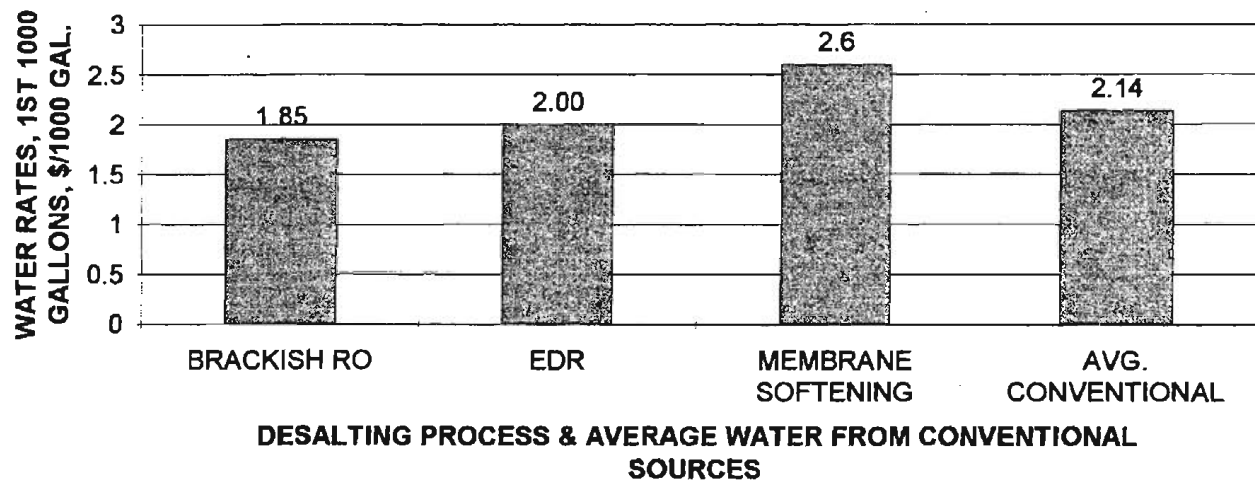


FIGURE 3B: WATER RATES, 1996, EXCLUSIVE OF DEBT SERVICE & IMPACT FEES, SELECTED POTABLE WATER DESALTING PLANTS IN U.S. vs AVERAGE RATE, WATER FROM CONVENTIONAL SOURCES



2.0 SURVEY DATA, BRACKISH WATER REVERSE OSMOSIS/GROUNDWATER ENHANCEMENT

Reports for 56 plants are included in this portion of the Survey. A separate tabulation is shown for each of the following:

- Process Data
- Capital Costs
- Operation and Maintenance Costs
- Water Rates
- Connection Charges and Impact Fees

Brackish RO/Groundwater Enhancement Process Data

Plant Name/Owner	Rated Capacity GPD	Annual Production Gallons	Qty. Blend Wtr. Added GPD	Feed Salinity mg/l	Product Salinity mg/l	Recovery %	Cost Elec. Power \$/kwh
Grove City (Seaside Service Sys.)	18,000	3,900,000	none	22,000	500	50	\$0.09
Santa Ana (Irvine Ranch Water Dist)	28,800	Pilot unit	Color Rem.	290	230	90	\$0.08
Englewood (Bocillia Utilities, Inc.)	30,000	7,000,000	0	2,700	80	60	\$0.066
Olds Water Supply (Iowa)	34,560		17,280			50	
Sarasota (Lake Tappanoe)	40,000	14,500,000	5,660,000	680	180	74	\$0.085
Nokomis (Bay Lakes Estates)	50,000	10,950,000		50			1 meter
El Paso (Haciendas Del Norte)	50,000	10,000,000	20,000,000	1,600	450	80	\$0.0.18
Sarasota (Myakka River St. Park)	50,000						
Nokomis (Kings Gate Club)	60,000	14,000,000	5,000	900	119	73	
Ormond Beach (Kingston Shores)	60,000	9,125,000	none	7,000		95	\$750/mo
Sarasota (Windward Isle MHP)	60,000	12,700,000	8,500	350	17	64	
Melbourne (Service Mgt.. Systems)	80,000	5,400,000	4,000				\$0.049
Iowas, City of Sully	90,000						
St. Augustine (Marineland, Inc.)	100,000	16,400,000	0	6,500	400	50	\$0.067
Osprey, Hastings, Florida W.T.P.	221,000		10%			70	
Osprey (Southbay Utilities)	225,000	48,900,000	na	1,100	47	50	\$0.065
Lutz (Holiday Pines Service Corp)	238,000	52,000,000	30,000			83	\$0.065
Punta Gorda (Burnt Store SSU)	240,000	68,300,000	40,300			76	\$2208/mo
Castle Point (VA Medical Center)	250,000	25,000,000					
Texas, City of Kennedy WTP	259,200	94,608,000	864,000	1,200	870	72	\$0.07
Iowa, Manson Water Plant	266,400	97,236,000	43,200			74	\$0.622
Toluca, Illinois RO Plant	375,000	86,000,000	94,000	1,540	480	70	\$0.075
Indian River County, Stuart	400,000	43,000,000		2,000			
N.Carolina (Ocracoke Sanitary Dis)	430,000	50,204,000		3,600	400	50	\$0.82
Harbor Hts. (Charlotte Harbor)	450,000	120,000,000	10%	700	160	75	
Fairfield, Hyde County WTP	500,000			500	160	80	\$5000/mo
City of Tustin, California	500,000	179,400,000	650,000			93	\$0.08
Ewa Beach , Hawaii	500,000	18,250,000	125,000	600	40	40	\$0.135
Rotunda West, Florida	500,000	146,000,000		3,500			
Venice (Sarasota Co. Plantation)	500,000	62,000,000		2,500	80	54	
Nokomis (Sorento)	680,000	107,000,000	EDR 300,000	3,000		60	\$0.08
Gasparilla Island Water, Florida	750,000	192,000,000	210,000	3,700	180	75	\$0.073
Dare County, Rodanthe WTP	1,000,000	77,500,000	47,520	1,230	29	75	\$0.11-.065
City of Nevada, Mo	1,000,000	350,455,000	blend	332	143	75	
North Beach (Wabasso, FL)	1,000,000	109,500,000	na	1,800		75	\$0.066
City of Wauchula, FL	1,310,000	313,991,000	na			84	\$0.078
Jasper, Florida WTP	1,400,000	18,000,000					
Pine Island Water	1,500,000	373,962,000	166,000	1,220	222	83	\$0.059
Englewood Water District, FL	2,500,000	400,000,000	0	5,500	150	70	\$0.075
City of Vero Beach, FL	2,000,000	655,000,000				85	\$0.078-.063
Chandler, AZ RO Facility	2,840,000			3,200	<600	88	\$0.074
Dare County RO Water Plant	3,000,000	503,748,000	56,044,000	3,450	395	75	\$0.03775
Darien, IL (S.E. Reg. Water Fac.)	3,200,000	435,000,000	40%	800	300	75	\$0.075
Riverside CA (SAWPA Arl.)	4,000,000	1,200,000,000	2,000,000	1,050	400blend	76	\$0.09
Santa Ana (Irvine Ranch Water)	4,500,000	1,478,250,000	none	310		90	\$0.075
Venice, FL	4,000,000	768,474,000	91,178	600	30	50	\$0.055
Marco Island, FL (S.State Util.)	4,000,000	780,000,000	2,000,000	4,400	90	90	\$21,375/mo
Sarasota, City of (Florida)	4,500,000	950,000,000	7,500,000	2,000	160	60	\$0.0525
Sanibel Island Water Assn. (FL)	4,700,000	1,021,000,000	74,355,000	3,000	75-100	80	\$0.068
Melbourne, City of (FL)	5,000,000	1,800,000,000	1,500,000(peak)			80	
Fountain Val. CA (Wat.Fact.21)	6,000,000	1,800,000,000		1,000	25	85	\$0.072
Jupiter, FL WTP	6,000,000	821,000,000	9,629,000	2,000	205	75	\$0.059
Mount Pleasant, S.C. WTP	6,850,000	1,709,013,000	1,370,000	190	50	84	\$0.05
Chesapeake, VA WTP	10,000,000	Startup in 1998					
Cape Coral, City of (FL)	15,000,000	2,620,000,000	10%	1,500	75	80	\$0.05
Yuma Desalting Plant	72,000,000	22,338,000,000	none	3,000	300	72	\$0.03

Brackish RO/Groundwater Enhancement Capital Costs, Dollars

Plant Name/Owner	Building	Plant Equipment	Wells or Feed Intake	Product Tanks	Brine Disposal	Other Costs	Total Capital Costs
Grove City, FL (Seaside Service Sys.)							\$525,000
Santa Ana (Irvine Ranch Water Dist.)	245,000	80,000	600,000				925,000
Englewood, FL (Bocillia Utilities)	40,000	120,000	49,000	120,000	\$ 10,000	\$ 42,000	381,000
Olds Water Supply (Iowa)							
Sarasota, FL (Lake Tippicanoe)	25,000	55,000	10,300	Existing	5,000	5,500	93,800
Nokomis, FL (Bay Lakes Estates)	Old	New	New	Rebuilt	New		350,000
El Paso, TX (Haciendas Del Norte)	25,000	150,000	150,000	250,000	100,000	25,000	700,000
Sarasota, FL (Myakka River St. Park)							139,493
Nokomis, FL (Kings Gate Club)	250,000	125,000	10,000	60,000			445,000
Ormond Beach, FL (Kingston Shores)	40,000	70,000	4,000	50,000	2,000	5,000	171,000
Sarasota, FL (Windward Isle MHP)	16,000	41,000	6,000	1,000		3,000	67,000
Melbourne, FL (Service Mgt. Sys.)	48,519	1,579,047	230,861			143,905	2,002,332
Sully, City of (Iowa)							
St. Augustine (Marineland, Inc.)							
Osprey (Hastings, Florida W.T.P.)							1,000,000
Osprey, FL (Southbay Utilities)							2,187,100 (1)
Lutz, FL (Holiday Pines Svc. Corp)	42,890	251,761	92,849	219,839	65,513	327,102	999,954
Punta Gorda (Burnt Store SSU)							
Castle Point, NY VA Medical Center							
Texas, City of Kennedy WTP	414,918(3)	349,000	285,000	18,291	6,000	10,000	1,083,209
Manson Water Plant (Iowa)	20,000	174,000	53,796	2,663	none	476,842	727,301
Toluca, Illinois RO Plant	40,000	300,000	175,000	45,000	25,000		715,000
Indian River Co. Stuart, FL	<100,000	1,400,000	59,000	94,000	negligible	375,000	1,653,000
N. Carolina (Ocracoke Sanitary Dis)	200,000	1,006,876	203,425	351,977			1,762,278
Harbor Hts., FL (Charlotte Harbor)							94,000 (2)
Fairfield, NC (Hyde County WTP)							4,000,000
City of Tustin, CA							898,339
Ewa Beach, Hawaii	2,968,000	2,039,000	616,000	422,000	77,000	264,000	6,386,000
Rotunda West, FL							
Venice, FL (Sarasota Co. Plant.)	300,000	500,000	200,000	225,000	300,000		1,525,000
Nokomis, FL (Sorento)							
Gasparilla Island Water, (FL)	196,447	884,471	289,440		243,274	634,698	2,248,330
Dare County, Rodanthe, NC	1,944,815	483,452	319,240	668,243	9,040	1,433,367	4,858,157
City of Nevada, MO	1,200,000	1,780,000	400,000		444,000	3,350,000	7,174,000
North Beach (Wabasso, FL)	1,125,000	933,417	389,024		53,262	59,065	2,559,768
City of Wauchula, FL							2,898,500
Jasper, Florida WTP							800,000
Pine Island, FL WTP	2,505,000 (4)	182,000	339,000	300,000	275,000	3,601,000	
Englewood Water District (FL)	514,980	8,149,244					8,664,224
City of Vero Beach, FL	3,400,000	2,500,000	810,000		400,000		7,100,000
Chandler, AZ RO Facility	4,828,000	2,305,000	523,147			2,256,238	9,912,385 (5)
Dare County RO WTP (NC)	3,329,505	1,899,738	1,291,560	1,640,000	121,400	1,603,639	10,444,956
Darien, IL (S.E. Reg. Water Fac.)							5,000,000
Riverside, CA (SAWPA Arl.)	3,700,000	3,650,000	500,000		6,000,000		13,850,000
Santa Ana (Irvine Ranch Water)	308,000	2,827,000	850,000		25,000	1,521,000	6,609,000
Venice, FL	5,710,000		3,480,000		Existing		9,190,000
Marco Island, FL (S.State Util)							16,000,000(appr)
Sarasota, City of (FL)	6,500,000	1,795,000	875,000				9,170,000
Sanibel Island Water Assn (FL)							
Melbourne, City of (FL)	8,600,000	2,840,000	510,000	1,000,000	830,000		13,780,000 (6)
Fountain Val. CA (Wat.Fact.21)	3,000,000					3,000,000 (7)	
Jupiter, FL WTP	2,400,000	4,800,000	2,760,000		1,124,000	1,000,000	12,084,000
Mount Pleasant, S.C. WTP							9,200,000
Vero Beach, FL (Ind. River Co)	1,230,000	5,560,000	500,000		81,500		7,290,000
Chesapeake, VA WTP	Startup in 1998						
Cape Coral, City of (FL)					(Replacement)		24,000,000
Yuma Desalting Plant	4,000,000	250,000,000	2,000,000		6,000,000	8,000,000	270,000,000

Notes: (1) Current replacement cost (2) Annual depreciation (3) Includes erection, piping, for wells.
 (4) Building cost included in Plant Equipment cost (5) Plus product lines & disposal, \$5,746,035
 (6) Engineering not included (7) Not including engineering, waste water reclamation, injection barrier facilities, product rec. wells.

Brackish RO/Groundwater Enhancement Operating & Maintenance Costs, Dollars

Plant Name/Owner	Power Req'd KWH	Annual Power Cost	Personnel (Number)	Annual Personnel Cost	Annual Parts/Chem Cost	Replacement Membrane Cost	Total Annual Costs	(*)
Grove FL (Seaside Service Sys.)							\$ 60,000	n
Santa Ana (Irvine Ranch Water Dis)	28.0	20,000	2	80,000	39,500	3,000	142,000	y y n
Englewood, FL (Bocillia Utilities)	240/day	6,500	2	32,000	4,200		92,000	y y y
Olds Water Supply (Iowa)			1	4,200				y y n
Sarasota, FL (Lake Tippicanoe)		5,985	<1	6,000	5,791		17,776	y y n
Nokomis, FL (Bay Lakes Estates)			1	8,700	8,100			
El Paso, TX (Haciendas Del Norte)		22,000	0.75	15,000	2,000	5,000	70,000	y y y
Sarasota, FL (Myakka River St. Pk)		5,868	1		7,070	10,500		
Nokomis, FL (Kings Gate Club)								
Ormond Bch, FL (Kingston Shores)		9,000	2	10,000	6,000	3,000	28,000	y y
Sarasota, FL (Windward Isle MHP)		6,000	1	5,700	4,300		16,000	
Melbourne, FL (Service Mgt. Sys)		27,000	2	24,500	contracted	2,500	54,000	y n y
Iowa, City of Sully		13,276	1	4,804	16,883		34,963	y y y
St. Augustine (Marineland, Inc.)		19,700	3	25,000	34,640	14,600	93,940	y n a y
Osprey, FL (Hastings, W.T.P.)		14,061	3		7,432		21,493	
Osprey, FL (Southbay Utilities)		45,969 (1)	<1		20,995	30,000	226,850	y y y
Lutz, FL (Holiday Pines Svc. Corp)	35	21,000	1	24,000	21,000		66,000	y y y
Punta Gorda, FL (Burnt St. SSU)		26,505	2		28,431			
Castle Pt. NY (VA Medical Ctr.)			2	80,000	20,000			y y y
Kennedy, City of, (TX) WTP		70,760 (2)	2	35,000	22,055	1,924	129,740 (2)	y y y
Iowa, Manson Water Plant		39,139	1	18,000	25,245		73,385	y y n
Toluca, Illinois RO Plant	50							y y y
Indian River Cty. Stuart, FL		55,000			22,000			
N. Carolina (Ocracoke Sanitary D.)	230	52,624	5	97,117	178,030	0	327,771	y y y
Harbor Hts. FL (Charlotte Harbor)							429,300	y y y
Fairfield, N.C. (Hyde County WTP)		60,000	7		30,000	30,000		
City of Tustin, CA	92	63,639	1.2	19,302	19,458	10,000	334,000	n y n
Ewa Beach, Hawaii								
Rotunda West, FL								
Venice, FL (Sarasota Co. Plantation)								y y y
Nokomis, FL (Sorento)		100,000	2	60,000	31,000	200,000	391,000	n n y
Gasparilla Island Water, FL	103	65,868	4	107,850	34,000		207,718	y n n
Dare County, Rodanthe, NC								
City of Nevada, MO		150,295	6	134,378	119,081		439,595	y n y
North Beach (Wabasso, FL)	177	72,270	4	80,000	60,000		212,270	
City of Wauchula, FL	179 (3)		1	25,000				y n y
Jasper, FL WTP								
Pine Island, FL WTP		117,000	5	35,000	70,000	275,000	497,000	y y y
Englewood Water District (FL)		145,000	4	104,600	125,000		374,600	
City of Vero Beach, FL	288 (4)	149,854	3	136,000				y n n
Chandler, AZ RO Facility			8				1,600,000 (5)	
Dare County, NC. WTP	480	131,182	12	258,226	113,996	100,000	798,680	y n y
Darien, IL (S.E. Reg. Water Fac)		232,901	13 (6)	416,000	222,000	35,000	905,901	y y y
Riverside, CA (SAWPA Arling)	220	500,000	2	70,000	125,000	210,000	1,205,000	y n n
Santa Ana (Irvine Ranch Water)		370,000	2	100,000	171,000	95,000	736,000	y n y
Venice, FL, City of	1,500	445,898	15	307,995	97,030	110,000	863,990	
Marco Island, FL (S.State Util)		513,000	6	700,000	67,000		1,300,000	y n y
Sarasota, FL, City of	1,150	530,000	15	701,636	634,727		1,866,363	n n y
Sanibel, FL (Island Water A.)		238,895					634,486	y n n
Melbourne, FL, City of	1,104		8		142,836			y y y
Fountain V., CA (Water Fac. 21)	1,375	867,240	1	38,000	276,820	200,000	1,724,112 (7)	
Jupiter, FL WTP	516	245,624	24	461,658	262,853	225,216	1,195,351	n n n
Mount Pleasant, S.C. WTP		530,000	8	351,644	396,400	0	1,795,468	y y y
Vero Beach, FL (Ind. River Co)		240,000	12	201,000	150,000	99,000	690,000	y y y
Chesapeake, VA WTP	Startup in 1998							
Cape Coral, City of (FL)		877,124	23	478,411	528,000		1,883,586	y y y
Yuma Desalting Plant	19,000	5,700,000	90	4,200,000	8,600,000	4,500,000	23,000,000	y

Notes: (1) Includes distribution (2) O&M costs for nine months (3) Power consumption estimated by Editor
 (4) Includes well pump motors (5) Estimated, not yet on line (6) Includes support personnel (7) Not include pretreatment
 (*) Questions: Does power consumption include well pump power? (y/n) Is the well pump on the same meter? (y/n) Does power consumption include distribution power? (y/n)

Brackish RO/Groundwater Enhancement Water Rates, Volume Charges, \$/1000 Gallons

Plant Name	Residential Water Usage, thousands of gallons per month						
	1	2	3	5	10	30	40 50 60
Grove, FL (Seaside Service Sys.)	2.75						
Santa Ana (Irvine Ranch W.D.)	na (pilot plant)						
Englewood, FL (Bocillia Utilities)	3.32 up to 6,000 G/Mo			5.60 for 6-12,000 G/Mo		8.95 for use above 12,000 G/Mo	
Olds Water Supply (Iowa)	3.50						
Sarasota, FL (Lake Tippicanoe)	na (Included in monthly condo fee)						
Nakomis, FL (Bay Lakes Estates)	na						
El Paso, TX (Haciendas D.Norte)	1.00 aveage						
Sarasota, FL (Myakka River S.P.)	na						
Nokomis, FL (Kings Gate Club)	na						
Ormond Bch, FL (Kingston Shrs)	na (Part of maintenance fee)						
Sarasota, FL (Windward I. MHP)	4.59 for 5 customers. For residents, charge included in other fees.						
Melbourne, FL (Service Mgt. Sys)	2.91						
Iowa, City of Sully						3.20 - 2.25 - 2.00	
St. Augustine (Marineland, Inc.)	na						
Osprey, FL (Hastings, W.T.P.)	4.95						
Osprey, FL (Southbay Utilities)	5.30						
Lutz, FL (Holiday Pines Svc.C.)	3.05						
Punta Gorda, FL (Burnt St. SSU)	1.23						
Castle Pt. NY (VA Medical Ctr)	na						
Kennedy, City of (TX) WTP	7.50 (for use above 2000 G/Mo, charge is \$1.50/1000 gal)						
Iowa, Manson Water Plant	7.00 (for use above 1000 G/Mo, charge is \$2.30/1000 gal)						
Toluca, Illinois RO Plant	3.20 (up to 20,000 G/Mo)				2.15 (up to 60,000 G/Mo)		1.90 (above 60,000 G/Mo)
Indian River City, Stuart, FL	6.94						
N. Carolina Ocracoke San. Dis.	5.50		7.50	8.50	9.50		10.50
Harbor Hts. FL (Charlotte Har.)	14.10	7.75	5.60	3.75			
Fairfield, N.C. (Hyde Co. WTP)	4.00						
City of Tustin, CA		0.44 (for use above 2,246 G/Mo, charge is \$0.95/1000 gal)					
Ewa Beach (Also have EDR)	1.34						
Rotunda West, FL							
Venice, FL (Sarasota Co. Plant)			2.51	2.95	4.43	5.90	
Nokomis, FL (Sorento)(Also EDR)			2.51	2.95	4.43	5.90	
Gasparilla Island Water, FL	18.75			3.75		4.00	5.00
Dare Country, Rodanthe, NC	5.67				4.50		
City of Nevada, MO	10.00						
North Beach (Wabasso, FL)	1.75		2.15				
City of Wauchula, FL	5.50	1.25					
Jasper, Florida, WTP	1.70						
Greater Pine Island Water, FL	2.75		3.30				
Englewood Water District, FL	1.80				2.40	4.80	
City of Vero Beach, FL	3.85		2.21			4.42	5.53
Chandler, AZ RO Facility							
Dare County RO Water Plant	5.67				4.50		
Darien, IL (S.E. Reg. Water Fac)	2.68						
Riverside, CA (SAWPA Arl.)	1.30						
Santa Ana (Irvine Ranch Water)							
City of Venice, FL	2.84						
Marco Island, FL (S. States U.)	3.21						
City of Sarasota, FL	2.14					2.93	3.72
Sanibel I., FL (Island Water)	2.80						5.55
City of Melbourne, FL							
Fountain V. CA (Water Fact 21)							
Jupiter, FL (WTP)	1.27 plus base charge of \$9.334/month						
Mount Pleasant, SC (WTP)	2.46				4.92	7.38	
Chesapeake, VA WTP	Startup in 1998						
City of Cape Coral, FL	1.75			1.85	2.35	2.85	3.35 3.85
Yuma Desalting Plant							

Brackish RO/Groundwater Enhancement Connection Charges and Impact Fees, Dollars

Plant Name/Owner	Annual Sales Mil. Gal.	Basic Facility Charge	Sewer Basic Fac.Chg.	Sewer Vol. Charge \$/1000 Gal	Gen.&Admin. New Account	Connect	Impact Fees
Grove City(Seaside Svc.Sys)	3.9	\$ 22.00/Mo				\$3,750	
Santa Ana (Irvine Ranch Water Dist)		na (pilot plant)					
Englewood, FL (Bocillia Utilities, Inc)	7.0	31.33				4,300	
Olds Water Supply (Iowa)							
Sarasota, FL (Lake Tippicanoe)		na (Included in monthly condo fee)					
Nokomis (Bay Lakes Estates)		na					
El Paso (Haciendas Del Norte)	10.0					100	
Sarasota, FL (Myakka River St. Pk)							
Nokomis, FL (Kings Gate Club)							
Ormond Beach, FL (Kingston Shores)		na (Part of maintenance fee)					
Sarasota, FL (Windward Isle MHP)		For residents, charge included in other fees.					
Melbourne (Service Mgt. Systems)	0.25	8.81/Mo				805	
Iowa, City of Sully	32.21	17.50/Quarter					

St. Augustine, FL (Marineland, Inc.)							
Osprey FL (Hastings W.T.P.)	0.22						
Osprey, FL Southbay Utilities	41.8		\$ 545			925	
Lutz (Holiday Pines Service Corp)	46.0	26.29/Mo					
Punta Gorda, FL (Burnt Store SSU)		5.13/Mo					
Castle Point VA Medical Center							
City of Kennedy, Texas WTP	94.6			\$ 7.50/Mo + 20% of water charge			
Manson, Iowa Water Plant	97.2			\$ 0.75, first 1000 gal, \$0.40/1000 gal thereafter			
Toluca, Illinois RO Plant	86.0	3.33/Mo					
Indian River Co. Stuart, FL						1,000	
N.Carolina, (Ocracoke San. Dist.)	50.2					200 (1)	\$3,612 (1)
Harbor Heights, (Charlotte Harbor)	0.58						
Fairfield, (Hyde County WTP)	150.0 (2)						\$ 400
City of Tustin, CA	225.0	5.01/Mo (3)					
Ewa Beach, Hawaii (Also have EDR)							
Rotunda West, FL							
Venice (Sarasota County Plant.)							
Nokomis, FL (Sorento) (Also have EDR)							
Gasparilla Island WTP, FL	225.0			\$21.50/Mo	\$60	\$3,919 (water)	\$1,796 (sewer)

Dare County, Rodanthe, NC	77.5 est.						\$2,942 (4)
City of Nevada, Mo	316.6					\$50	
North Beach (Wabasso, FL)	109.5						1,571
City of Wauchula, FL	250.0						
Jasper, Florida	168.0		\$400	\$1.95/1000 gal			300
Greater Pine Island, FL WTP	315.1					1294	
Englewood, FL Water District	400.0						1,860
City of Vero Beach, FL	655.0		1,330				1,016
Chandler, AZ RO Facility							
Dare County RO Water Plant	482.1						2,942 (4)
Darien, IL (Southeast Reg. W.Fac.)	435.0					830	
Riverside, CA (SAWPA Arl.)	1,800.0					430	
Santa Ana (Irvine Ranch Water)							
City of Venice, FL		\$8.35		3.37/1000gal		150	
Marco Island, FL (S.State Utilities)	720.0	yes	yes				
City of Sarasota, FL	950.0	6.84 (5)					
Sanibel Island, FL (Water Assn.)	910.0	11.00					2,175
City of Melbourne, FL							
Fountain Val., CA (Water Fac.21)							
Town of Jupiter, FL (WTP)	821.0						1,634
Mount Pleasant, S.C. Water Works	1,429.6	3.28 (6)	1,452				1,283
Chesapeake, VA WTP	Startup in 1998						
City of Cape Coral, FL	2,620.0	7.65	5.75	3.05	15		

Yuma Desalting Plant

Notes: (1) 3/4 in. meter, 3 bedrooms, 2.5 baths. (2) Production estimated by Editor (3) 3/4 in. meter, includes debt service.
(4) 3/4 in. meter (5) 5/8 in meter (6) 5/8 in. meter

3.0 Electrodialysis

All of the electrodialysis plants listed in the Survey are of the electrodialysis reversal (EDR) process, and built by Ionics, Inc. Several EDR plants of significant size (above 1 MGD) have been brought on line since the 1992 NWSIA Survey, bringing the total number of EDR respondents to 17.

A separate tabulation is shown for each of the following:

- Process Data
- Capital Costs
- Operation and Maintenance Costs
- Water Rates
- Connection Charges and Impact Fees

Electrodialysis Process Data

Plant Name/Owner	Rated Capacity GPD	Annual Production Gallons	Qty. Blend Wtr. Added GPD	Feed Salinity mg/l	Product Salinity mg/l	Recovery %	Cost Electric Power \$/kwh
Kona Village Resort, Hawaii	30,000	11,900,000	none	1600/4000	250	60	\$0.11
Dell City, Texas	100,000	12,000,000	120,000	3,900	500	45	\$0.09
Georgetown, S. Carolina	190,000 *	34,800,000	50,000	956	347	65	\$40/day
Granbury, Texas WTP	300,000 **	47,500,000		600	47		\$0.104-.073
Nokomis, FL (Sorento)	300,000	60,000,000	340,000 (RO)	3,000	350	80	\$0.098
Alta, Iowa WTP	432,000	75,500,000		1,200	340	85	\$700/mo
Melville, Saskatchewan, Canada	500,000	184,000,000	325,000	1,900	600	80	\$0.078
Ewa Beach, Hawaii	500,000	66,430,000	125,000	600	40	70	\$0.135
Coupsville, Town of (WA)	528,000	44,000,000	150,000	900	450	75	
Yuma Proving Ground (AZ)	600,000	51,000,000		1,800	200	85	\$0.035
Buckeye, Town of (AZ)	1,000,000	346,000,000		1,600	600	75	
Washington, City of (Iowa)	1,900,000	300,000,000	96,000	1,200	628	13(?)	\$3000/mo
Foss Reservoir, Oklahoma	2,800,000	449,000,000	0	1,050	240	70	\$0.028
Lake Granbury, Texas WTP	3,500,000	500,000,000	35%	321	97	75	\$0.050
Suffolk, City of (VA) WTP	3,750,000	730,000,000	1,000,000	193	50	94	\$0.06
Sherman, City of (Texas)	4,500,000	821,000,000	2,500,000	1,350	650	85	\$0.049
Venice, FL (City of Carlton)	12,000,000		0	1,030	298	87	

* Annual production based on rated capacity (190,000 GPD) with unit operating at an average of 12 hours/day

** Three year average

Electrodialysis Capital Costs, Dollars

Plant Name/Owner	Building	Plant Equipment	Wells or Feed Intake	Product Tanks	Brine Disposal	Other Costs	Total Capital Costs
Kona Village Resort, Hawaii							
Dell City, TX	\$ 14,260	\$ 373,682	\$ 27,941	\$149,493			\$ 665,376
Georgetown, S.C. WTP							
Granbury, Texas WTP	700,000	500,000				\$ 67,645	1,267,645
Nokomis, FL (Sorento)							550,000
Alta, Iowa WTP	50,000	850,000					900,000
Melville, Saskatchewan, Canada	383,000	752,700	134,000		\$ 437,500	160,800	1,868,000
Ewa Beach, Hawaii	2,968,000	2,039,000	616,000	422,000	77,000	264,000	6,386,000
Coupsville, Town of (WA) WTP						Approx.	750,000
Yuma Proving Ground (AZ)			not included				2,200,000
Buckeye, Town of, (AZ) WTP							1,050,000
Washington, City of, (Iowa) WTP	280,000	1,212,600				315,000	1,807,000
Foss Reservoir, Oklahoma			not included	not included			
Lake Granbury, Texas WTP	3,900,000	2,200,000	320,000	600,000	230,000		6,100,000
Sherman, City of (TX)	2,000,000	3,000,000	8,000,000				13,000,000
Venice, FL (City of Carlton)							97,000,000

Electrodialysis Operating & Maintenance Costs, Dollars

Plant Name/Owner	Power Req'd KWH	Annual Power Cost	Personnel (Number)	Annual Personnel Cost	Annual Parts/Chem. Cost	Replacement Membrane Cost	Total Annual Costs	(*)
Kona Village Resort, Hawaii		\$ 6,531	3	\$20,610	\$ 15,751		\$ 40,953	
Dell City, Texas		8,352	1	36,000	1,500	\$ 5,000	50,852	n n y
Georgetown, S.C. WTP		15,000	1	35,000	1,000		50,000	y y y
Granbury, Texas WTP		5,220	4	78,021	50,265		133,506	y n n
Nokomis, FL (Sorento)		100,000	2	60,000			160,000	y y y
Alta, Iowa WTP	112	84,000	1	25,000	15,000		48,400(Est.)	
Melville, Saskatchewan, Canada	60	46,041	4	145,000	10,842	17,780	219,663	y n n
Ewa Beach, Hawaii								
Coupsville, Town of (WA) WTP	65							n n y
Yuma Proving Ground, AZ	553,400/Yr (1)	19,369	3	252,000	23,000	5,000	299,369	n n y
Buckeye, Town of (AZ) WTP	164	109,573		34,000	14,000		157,573	y y y
Washington, City of, (Iowa) WTP	152	36,000	2	21,000	18,000	18,750	93,750	n n n
Foss Reservoir, Oklahoma	438	124,989	6	160,769	239,809	35,260	560,829	n n n
Lake Granbury, Texas WTP	263	82,000	5	200,000			400,000	n n n
Suffolk, City of (VA) WTP	315	175,569	18	355,137	36,180	139,335	706,221	y n y
Sherman, City of (TX)		120,000	15	560,000	60,000	85,000	825,000	
Venice, FL, Carlton WTP			8				1,236,766	

Notes: (*) Does power consumption include well pump power? (y/n)
 Is the well pump on the same meter? (y/n)
 Does the power consumption include distribution power? (y/n)

Note 1. Yuma Proving Ground, KWH/yr includes not-potable system distribution for irrigation use. This system is separate from the potable system & pumps, approximately 250 million gallons per year.

Electrodialysis Water Rates, Volume Charges, \$/1000 Gallons

Plant Name	Residential Water Usage, thousands of gallons per month								
	1	2	3	5	10	30	40	50	60
Kona Village Resort									
City of Dell City	\$7.00								
Georgetown County WTP									
Granbury, Texas WTP	4.50 inside city limits, 6.75 outside city limits								
Sorento (also have RO)				\$2.51	\$2.95	\$4.43	\$5.90		
Alta, Iowa WTP	2.30			1.90	1.80	1.70			
Melville, Saskatchewan, Canada	4.50								
Ewa Beach, Hawaii	1.34								
Town of Couville, Wash. WTP	5.51 in town, in season, 8.26 out of town, in season 3.68 in town, off season, 5.51 out of town, off season								
Yuma Proving Ground	Water is supplied to residents of Army installation at no charge								
Town of Buckeye WTP	4.07								
City of Washington, Iowa WTP	1.80				1.60	1.33	1.00		
Foss Reservoir, Oklahoma	1.70								
Lake Granbury, Texas WTP	1.64								
City of Suffolk, VA WTP	2.81								
City of Sherman, Texas	2.07								
Venice, FL (City of Carlton)									

Electrodialysis Connection Charges and Impact Fees, Dollars

Plant Name/Owner	Annual Sales Mil. Gal.	Basic Facility Charge	Sewer Basic Fac. Chg.	Sewer Vol. Charge \$/1000 Gal	Gen. & Admin. New Account	Connect	Impact Fees
Kona Village Resort, Hawaii	12						
City of Dell City	12						
Georgetown County WTP	35						
Granbury, Texas WTP	246			\$2.60 (Based on water gallonage)			
Sorento (also have RO)							
Alta, Iowa WTP			\$6.00 (inside city limits, \$7.50 outside city limits)				
Melville, Saskatchewan, Canada	184				\$ 80.00		\$ 10.50/mo
Ewa Beach, Hawaii							
Town of Coupsville, Wash. WTP	77		\$13.00/mo (inside city limits, \$20.00/mo outside city limits)				
Yuma Proving Ground	51						
Town of Buckeye WTP	346						
City of Washington, Iowa WTP	300			50% of water bill	\$ 425.00		
Foss Reservoir, Oklahoma	449						
Lake Granbury, Texas WTP	500						
City of Suffolk, VA WTP	621			\$1.89			\$2,500
City of Sherman, Texas	821						
Venice, FL (City of Carlton)	4,289						

4.0 MEMBRANE SOFTENING

Whereas in 1992 there were on 7 respondents for membrane softening, in 1996 there were 15, significantly improving the database.

A separate tabulation is shown for each of the following:

- Process Data
- Capital Costs
- Operation and Maintenance Costs
- Water Rates
- Connection Charges and Impact Fees

Membrane Softening Process Data

Plant Name/Owner	Rated Capacity GPD	Annual Production Mil. Gal.	Qty. Blend Wtr. Added GPD	Feed Salinity mg/l	Product Salinity mg/l	Recovery %	Cost Electric Power \$/kwh
Palm Beach, FL Bank of Commerce	170,000	1.5	0	925	150	65	\$0.03
Alta, Iowa WTP	288,000	78	25%	1,200	120	68	\$0.02
Laurens, Iowa, WTP	350,000	80	7,200		85	74	\$0.04
St. Lucie West Services Dist. (FL)	1,000,000	70	0	500	170	85	\$3,400/mo
Village of Royal Palm Beach, FL	1,500,000	40	1,900,000	800	250	85	\$0.06
Wellington (Acme Imp. District)	1,800,000	Blend, Lime Soft.	2,500,000	3,600	78	75	\$0.065
Indian River County South	3,000,000	1,095	450,000	910	230	85	\$0.055
Boynton Beach, FL	4,000,000			360	90	85	
Miramar, FL	4,500,000			400		80	
Vero Beach, FL (Ind. River Co.)	8,570,000	1,642	900,000,000	900	110	80	\$0.049
Dunedin, City of (FL)	9,500,000	1,520	16%	442/990	268	83	\$0.06
Fort Myers, FL	12,000,000	2,555	0	480	285	90	\$0.08
Naples, FL (N. Collier County)	12,000,000	2,313	0	420	120	90	\$0.0366
Plantation, FL	12,000,000			480	35	85	
Hollywood, City of (FL)	14,000,000	3,650	8-15 MGD	585	210	90	

Membrane Softening Capital Costs, Dollars

Plant Name/Owner	Building	Plant Equipment	Wells or Feed Intake	Product Tanks	Brine Disposal	Other Costs	Total Capital Costs
Palm Beach, FL Bank of Commerce							
Alta, Iowa WTP	\$ 25,000(Remod)	\$ 210,000	Existing				\$ 235,000
Laurens, Iowa, WTP							1,300,000
St. Lucie West Services District, FL		2,340,000 Note 1				\$4,660,000	7,000,000
Village of Royal Palm Beach, FL	268,500	3,571,500	\$ 750,000		\$ 68,000	50,000	4,708,000
Wellington, FL (Acme Imp. Dist.)	2,776,795	1,298,350	696,000		535,099		5,306,244
Indian River County South							11,400,000
Boynton Beach, FL		7,520,000 Note 1				4,680,000	12,200,000
Miramar, FL		7,650,000 Note 1				4,650,000	12,300,000
Vero Beach, FL (Ind. River Co.)	1,230,000	5,560,000	500,000	Inc. Pht. Equip	81,500	Inc. Pht. Eq.	7,290,000
Dunedin, City of (FL)	9,500,000		Note 2				11,132,000
Fort Myers, City of (FL)							14,200,000
Naples, FL (N. Collier County)							26,000,000
Plantation, FL							
Hollywood, City of (FL)							18,000,000

Note 1: Bergman, R.A. "Florida, A Cost Comparison Update, Membrane Softening vs Lime Softening", The International Desalination & Water Reuse Quarterly, November/December 1995

Note 2: Bolin, L. "City of Dunedin, Florida, RO Water Treatment Facility", The International Desalination & Water Reuse Quarterly, February/March 1996

Membrane Softening Operating & Maintenance Costs, Dollars

Plant Name/Owner	Power Req'd KWH	Annual Power Cost	Annual Personnel (Number)	Annual Personnel Cost	Annual Chem/Parts Cost	Replacement Membrane Cost	Total Annual Costs	(*)
Palm Beach, FL Bank of Commerce								
Alta, Iowa WTP		\$ 17,395	1	\$ 45,141	\$ 26,283		\$ 88,819	yn y
Laurens, Iowa, WTP	77	15,744	1.5	65,110	30,229		111,083	yyy
St. Lucie West Services District		40,800	4					yyy
Village of Royal Palm Beach, FL	89	23,000	1	79,500	12,400		114,900	yn y
Wellington, FL (Acme Imp. District)			8					nnn
Indian River County South	405	195,129	7	182,000	160,000		540,000	yyy
Boynton Beach, FL								
Miramar, FL								
Vero Beach, FL (Ind. River Co.)		240,000	12	201,000	150,000	99,000	690,000	yyy
Dunedin, City of (FL)	797	419,750	Note 2	392,375	414,275	\$ 175,200	1,983,775	(3)
Fort Myers, City of (FL)	596	523,880	16	534,630	594,460		1,652,970	nnn
Naples, FL (N. Collier County)	667	306,804	14	575,000	600,000	5,000	1,486,804	nnn
Plantation, FL								
Hollywood, City of (FL)								

Notes: (*) Does power consumption include well pump power? (y/n)
Is the well pump on the same meter? (y/n)
Does the power consumption include distribution power? (y/n)

Note 1: Bergman, R.A. "Florida, A Cost Comparison Update, Membrane Softening vs Lime Softening", The International Desalination & Water Reuse Quarterly, November/December 1995

Note 2: Bolin, I., "City of Dunedin, Florida, RO Water Treatment Facility", The International Desalination & Water Reuse Quarterly, February/March 1996

Note 3: Annual cost for debt service of \$582,175 included in Total Annual Costs

Membrane Softening Water Rates, Volume Charges, \$/1000 Gallons

Plant Name/Owner	Residential Water Usage, thousands of gallons per month							
	1	2	3	5	10	30	40	50
Palm Beach, FL Bank of Commerce						\$2.00		\$1.50
Alta, Iowa WTP				\$2.30	1.90	1.80	1.70	
Laurens, Iowa WTP	\$3.53							
St. Lucie West Services District								
Village of Royal Palm Beach	1.60	(Plus 150% of gallonage rate per 1000 gallons used in excess of authorized. Single family, 18,000 g./mo)						
Acme Improvement District								0.94
Indian River County South			\$1.75	\$2.15				
Boynton Beach								
Miramar								
Vero Beach, FL (Ind. River Co.)	\$1.75		\$2.15		\$2.55			
City of Dunedin, FL	\$2.35			\$3.50		\$5.30	Note 2	
City of Fort Myers, FL	2.60							
Naples, FL (N. Collier Co. WTP)	1.75					\$2.20	\$2.75	
Plantation, FL								
City of Hollywood, FL	1.80							

Note 1: Bergman, R.A. "Florida, A Cost Comparison Update, Membrane Softening vs Lime Softening", The International Desalination & Water Reuse Quarterly, November/December 1995

Note 2: Bolin, L. "City of Dunedin, Florida, RO Water Treatment Facility", The International Desalination & Water Reuse Quarterly, February/March 1996

Membrane Softening Connection Charges and Impact Fees, Dollars

Plant Name/Owner	Annual Sales Mil. Gal.	Basic Facility Charge	Sewer Basic Fac.Chg.	Sewer Vol. Charge \$/1000 Gal	Gen.&Admin. New Account	Connect	Impact Fees
Palm Beach, FL Bank of Commerce							
Alta, Iowa WTP	80	\$6.90/mo					
Laurens, Iowa, WTP	45	5.25/mo					
St. Lucie West Services District							\$3,660
Village of Royal Palm Beach							1,590
Acme Improvement District							
Indian River County South	1,095					\$130	1,441
Boynton Beach							
Miramar							
City of Dunedin	1,520	Note 1			Revenue bonds plus some impact fees		
City of Fort Myers	2,086						
North Collier County WTP	2,313				(Volume charge 1-10,000 g/mo, \$1.75, 10,000-20,000, \$2.20, above 20,000, \$2.75)	900	
Plantation, FL							
City of Hollywood, FL							

Note 1: Bolin, L. "City of Dunedin, Florida RO Water Treatment Facility", The International Desalination & Water Reuse Quarterly, February/March, 1996.

5.0 SEAWATER RO AND DISTILLATION

Ten plants are included in the list with some significant cost reporting for the 6.7 MGD SWRO plant for the Santa Barbara, California facility. The 3 MGD SWRO plant at Key West, built in 1981, has been upgraded and maintained for use in event of any emergency at this remote location. A response was again received for the 8.1 MGD MED (total) distillation plants at St. Thomas, and St. Croix, Virgin Islands.

A separate tabulation is shown for each of the following:

- Process Data
- Capital Costs
- Operation and Maintenance Costs
- Water Rates
- Connection Charges and Impact Fees

Seawater RO and Distillation Process Data

Plant Name/Owner	Rated Capacity GPD	Annual Production Mil. Gal.	Qty. Blend Wtr. Added GPD	Feed Salinity mg/l	Product Salinity mg/l	Recovery %	Energy Power\$/kwh Steam \$/1000#
Stouffers Hotel, V.I.	30,000						
Monterey Bay Aquarium, (CA)	32,000						
Sapphire Beach Hotel, V.I.	40,000						
San Simeon Hearst Castle (CA)	40,000			36,000	500	35	\$0.08
Marina Coast Water District, (CA)	260,000	98.0		25,000	300	40	\$0.10
Santa Catalina Island, (CA)	332,000	(Note 1)				30/33	\$0.10
Morro Bay, CA	864,000	315.0		31,000	270	40	\$0.08
Key West, Florida RO Plant	3,000,000	(Note 2)		38,000	300	30	\$0.10
Santa Barbara, City of (CA)	6,700,000	(Note 3)		34,000	300	45	\$0.05
Virgin Islands Water. & Power Auth.		(Note 4)					
St. Thomas	4,450,000						
St. Croix	3,650,000						
Total	8,100,000	2,621.0		37,000	50	na	Elec. \$0.077 Steam \$2.56

Note 1. Santa Catalina Island. Data for this plant was completed by the authors from data and information in "Connections" Spring 1991, a newsletter to Community Colleges and Universities issued by Southern California Edison Company; from Water Desalination Report, and from San Gabriel Valley Tribune, January 17, 1990

The Santa Catalina Island seawater desalination plant provides supplementary water to the island. The primary source is from Middle Ranch Reservoir. The supply from the Reservoir has been curtailed because of the low rainfall. (Normal 12 inches/year))

The original desalination plant was purchased by the developer of Hamilton Cove, and was then deeded to Southern California Edison (SCE) at no cost to own and operate. SCE supplies all electricity, gas and water for the island. Since the developer paid for the original plant, and deeded it to SCE at no charge, there is no capital to be recovered (for the original plant) and no debt service. Also, SCE report the same 27 employees who operate the diesel generating plant and the gas system also operated the desalination plant. With no debt service and no charge for O&M labor (as of 1990), the only O&M costs are for electric power and consumables, estimated to be about \$4.94/1000 gallons, based on operating at 85% load factor.

The product water from the desalination plant is piped directly to the city water mains, and mixed with water from the reservoir. Residential users are charged \$8.00/1000 gallons. (As of 1990)

Note 2. The Key West SWRO plant is maintained on standby basis to meet emergencies. The normal supply of water to the Florida Keys is by pipeline from Homestead, on the mainland.

Note 3. The Santa Barbara, California plant was provided as a "drought-proofing" measure, and is maintained to provide water when water from the normal sources is inadequate.

Note 4. The seawater desalination units at St. Thomas and St. Croix, Virgin Islands, are of the multi-effect distillation type (MED), and were supplied by I.D.E. Technologies, Ltd.

Seawater RO and Distillation Capital Costs, Dollars

Plant Name/Owner	Building	Plant Equipment	Wells or Feed Intake	Product Tanks	Brine Disposal	Other Costs	Total Capital Costs
Stouffers Hotel, V.I.							
Monterey Bay Aquarium (CA)		\$ 336,000	Existing	\$ 25,000	Existing	\$ 20,000	\$ 400,000
Sapphire Beach Hotel, V.I.							
San Simeon Hearst Castle (CA)						Approx.	230,000
Marina Coast Water Dist. (CA)	\$ 250,000	\$ 960,000	\$ 150,000	\$ 20,000	\$ 150,000	\$ 970,000	\$ 2,500,000
Santa Catalina Island (CA)						Note 1	2,400,000
Morro Bay, City of (CA)	100,000	2,100,000	800,000		230,000	1,300,000	4,530,000
Key West, Florida RO Plant							11,250,000
Santa Barbara, City of, (CA)							34,000,000
Virgin Islands Water. & Power Auth.		(Note 4)					
St. Thomas							
St. Croix							
Total							57,751,695

Note 1. Santa Catalina Island. Data for this plant was completed by the authors from data and information in "Connections" Spring 1991, a newsletter to Community Colleges and Universities issued by Southern California Edison Company; from Water Desalination Report, and from San Gabriel Valley Tribune, January 17, 1990

The Santa Catalina Island seawater desalination plant provides supplementary water to the island. The primary source is from Middle Ranch Reservoir. The supply from the Reservoir has been curtailed because of the low rainfall. (Normal 12 inches/year)

The original desalination plant was purchased by the developer of Hamilton Cove, and was then deeded to Southern California Edison (SCE) at no cost to own and operate. SCE supplies all electricity, gas and water for the island. Since the developer paid for the original plant, and deeded it to SCE at no charge, there is no capital to be recovered (for the original plant) and no debt service. Also, SCE report the same 27 employees who operate the diesel generating plant and the gas system also operated the desalination plant. With no debt service and no charge for O&M labor (as of 1990), the only O&M costs are for electric power and consumables, estimated to be about \$4.94/1000 gallons, based on operating at 85% load factor. The capital cost estimate shown above is for the original plant with capacity of 132,000 GPD

The product water from the desalination plant is piped directly to the city water mains, and mixed with water from the reservoir. Residential users are charged \$8.00/1000 gallons. (As of 1990)

Note 2. The Key West SWRO plant is maintained on standby basis to meet emergencies. The normal supply of water to the Florida Keys is by pipeline from Homestead, on the mainland.

Note 3. The Santa Barbara, California plant was provided as a "drought-proofing" measure, and is maintained to provide water when water from the normal sources is inadequate.

Note 4. The seawater desalination units at St. Thomas and St. Croix, Virgin Islands, are of the multi-effect distillation type (MED), and were supplied by I.D.E. Technologies, Ltd.

Seawater RO and Distillation Operating & Maintenance Costs, Dollars

Plant Name/Owner	Power Req'd KWH	Annual Power Cost	Annual Personnel (Number)	Annual Personnel Cost	Annual Chem/Parts Cost	Replacement Membrane Cost	Total Annual Costs	(*)
Stouffers Hotel, V.I. Monterey Bay, CA Aquarium Sapphire Beach Hotel, V.I. San Simeon Hearst Castle	50			\$ 40,000	\$ 20,000		n n n	
Marina Coast Water District, CA Santa Catalina Island, CA Moro Bay, City of	720	\$144,000 Note 1 Note 5	2	\$ 80,000	\$ 12,000	\$ 4,000	\$ 240,000 y n n 188,000 Est. 1,052,000 y n n	
Key West, Florida RO Plant Santa Barbara, City of	3,171	1,889,422 Note 2		362,992	102,452	418,837	2,763,633 Est. 7,650,000 Est.	
Virgin Islands Water. & Power Auth. St. Thomas St. Croix Total		(Note 4)					25,443,796	

Note 1. Santa Catalina Island. Data for this plant was completed by the authors from data and information in "Connections" Spring 1991, a newsletter to Community Colleges and Universities issued by Southern California Edison Company; from Water Desalination Report, and from San Gabriel Valley Tribune, January 17, 1990

The Santa Catalina Island seawater desalination plant provides supplementary water to the island. The primary source is from Middle Ranch Reservoir. The supply from the Reservoir has been curtailed because of the low rainfall. (Normal 12 inches/year)

The original desalination plant was purchased by the developer of Hamilton Cove, and was then deeded to Southern California Edison (SCE) at no cost to own and operate. SCE supplies all electricity, gas and water for the island. Since the developer paid for the original plant, and deeded it to SCE at no charge, there is no capital to be recovered (for the original plant) and no debt service. Also, SCE report the same 27 employees who operate the diesel generating plant and the gas system also operated the desalination plant. With no debt service and no charge for O&M labor (as of 1990), the only O&M costs are for electric power and consumables, estimated to be about \$4.94/1000 gallons, based on operating at 85% load factor. The capital cost estimate shown above is for the original plant with capacity of 132,000 GPD

The product water from the desalination plant is piped directly to the city water mains, and mixed with water from the reservoir. Residential users are charged \$8.00/1000 gallons. (As of 1990)

Note 2. The Key West SWRO plant is maintained on standby basis to meet emergencies. The normal supply of water to the Florida Keys is by pipeline from Homestead, on the mainland. Estimated operating costs by manufacturer.

Note 3. The Santa Barbara, California plant was provided as a "drought-proofing" measure, and is maintained to provide water when water from the normal sources is inadequate. Operating costs shown assume operating at 2,445 million gallons per year.

Note 4. The seawater desalination units at St. Thomas and St. Croix, Virgin Islands, are of the multi-effect distillation type (MED), and were supplied by I.D.E. Technologies, Ltd.

Note 5. City of Moro Bay Total Annual Costs based on full capacity with 30 day down time.

(*) Questions: Does power consumption include well pump power? (y/n) Is the well pump on the same meter? (y/n) Does power consumption include distribution power? (y/n)

Seawater RO and Distillation Water Rates, Volume Charges, \$/1000 Gallons

Plant Name/Owner	Residential Water Usage, thousands of gallons per month								
	1	2	3	5	10	30	40	50	60
Stouffers Hotel, V.I. Monterey Bay Aquarium (CA) Sapphire Beach Hotel, V.I. San Simeon Hearst Castle (CA)									
Marina Coast Water Dis.(CA)	\$ 2.60								
Santa Catalina Island (CA)	\$ 8.00								
City of Morro Bay (CA)			\$7.33	\$7.42		\$7.67	\$8.37		
Key West, Florida RO Plant	\$10.49								
City of Santa Barbara	\$ 2.20 to \$4.45								
Virgin Islands Water. & Power Auth. (Note 4)									
St. Thomas									
St. Croix									
Total	\$15.90	\$17.90							

Note 1. Santa Catalina Island. Data for this plant was completed by the authors from data and information in "Connections" Spring 1991, a newsletter to Community Colleges and Universities issued by Southern California Edison Company; from Water Desalination Report, and from San Gabriel Valley Tribune, January 17, 1990

The Santa Catalina Island seawater desalination plant provides supplementary water to the island. The primary source is from Middle Ranch Reservoir. The supply from the Reservoir has been curtailed because of the low rainfall. (Normal 12 inches/year)

The original desalination plant was purchased by the developer of Hamilton Cove, and was then deeded to Southern California Edison (SCE) at no cost to own and operate. SCE supplies all electricity, gas and water for the island. Since the developer paid for the original plant, and deeded it to SCE at no charge, there is no capital to be recovered (for the original plant) and no debt service. Also, SCE report the same 27 employees who operate the diesel generating plant and the gas system also operated the desalination plant. With no debt service and no charge for O&M labor (as of 1990), the only O&M costs are for electric power and consumables, estimated to be about \$4.94/1000 gallons, based on operating at 85% load factor. The capital cost estimate shown above is for the original plant with capacity of 132,000 GPD

The product water from the desalination plant is piped directly to the city water mains, and mixed with water from the reservoir. Residential users are charged \$8.00/1000 gallons. (As of 1990)

Note 2. The Key West SWRO plant is maintained on standby basis to meet emergencies. The normal supply of water to the Florida Keys is by pipeline from Homestead, on the mainland. Estimated operating costs by manufacturer.

Note 3. The Santa Barbara, California plant was provided as a "drought-proofing" measure, and is maintained to provide water when water from the normal sources is inadequate. Operating costs shown assume operating at 2,445 million gallons per year.

Note 4. The seawater desalination units at St. Thomas and St. Croix, Virgin Islands, are of the multi-effect distillation type (MED), and were supplied by I.D.E. Technologies, Ltd.

Note 5. City of Morro Bay Total Annual Costs based on full capacity with 30 day down time.

Seawater RO and Distillation Connection Charges and Impact Fees, Dollars

Plant Name/Owner	Annual Sales Mfl. Gal.	Basic Facility Charge	Sewer Basic Fac.Chg.	Sewer Vol. Charge \$/1000 Gal	Gen.&Admin. New Account	Connect	Impact Fees
Stouffers Hotel, V.I. Monterey Bay Aquarium, CA Sapphire Beach Hotel, V.I. San Simeon Hearst Castle, CA	8						
Marina Coast Water District, CA Santa Catalina Island, CA City of Morro Bay, CA	60 315		yes			yes	\$3,000
Key West, Florida RO Plant City of Santa Barbara, CA	3,500						2,342
Virgin Islands Water. & Power Auth. St. Thomas St. Croix Total	2,620						

6.0 SELECTED CASE STUDY COMPARISONS, BRACKISH RO/GROUNDWATER ENHANCEMENT PLANTS

Ten brackish RO/groundwater enhancement plants were selected for comparison covering a range of plant rated capacity from 30,000 GPD to 15 MGD. Tables and charts were prepared based on submitted survey information as set forth below:

- Key elements for Process Data
- Table, Capital Cost components, and total
- Chart, Total Capital Costs Vs Plant Rated Capacity
- Table, Operation & Maintenance cost components, and total
- Chart, Total Operation & Maintenance Costs Vs Plant Rated Capacity

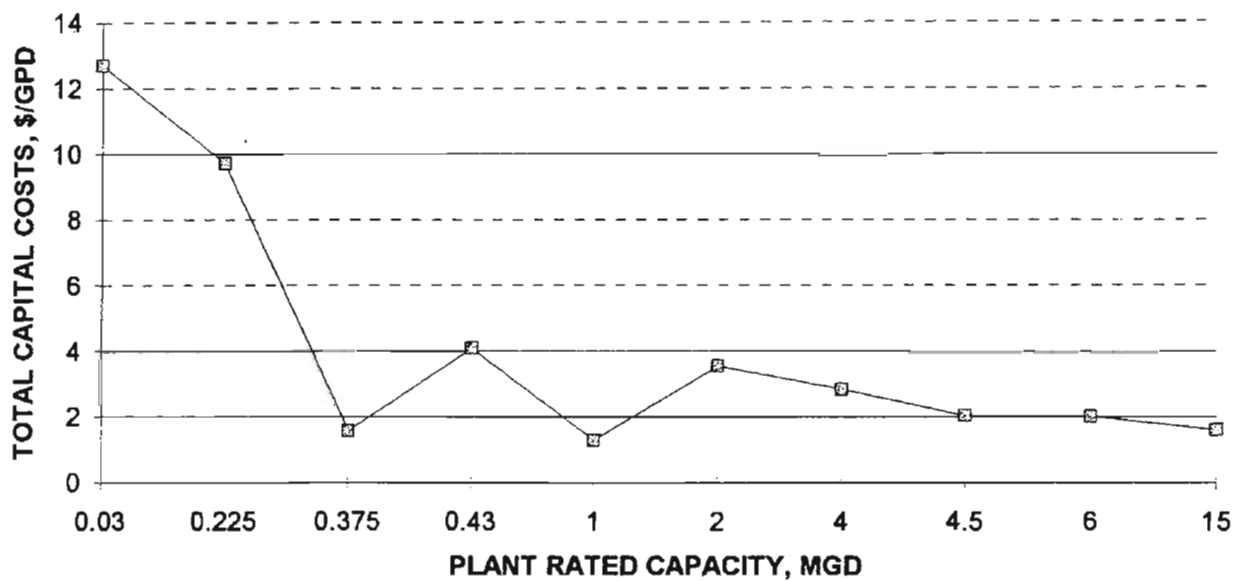
SELECTED BRACKISH RO/GROUNDWATER ENHANCEMENT PLANTS

PROCESS DATA

Plant Name, Location	Bocilla Utilities, Inc. Englewood, FL	Southbay Utilities Osprey, FL	City of Toluca IL	Ocracoke Sanitary Dist. Ocracoke, NC	North Beach Wabasso FL	City of Vero Beach FL	SAWPA Arlington Riverside, CA	City of Sarasota FL	Town of Jupiter FL	City of Cape Coral FL
Rated Capacity	0.03	0.225	0.375	0.43	1	2	4	4.5	6	15
Annual Production	7.00	48.90	86.00	50.20	109.50	655.00	1800.00	950.00	821.00	2620.00
Total Production + Blend	7.00	48.90	108.00	50.20	109.50	655.00	2700.00	2533.00	2135.00	2882.00
Feed Salinity	2700	1100	1540	3600	1800	1200	1100	2000	2000	1500
Recovery	60	47	70	50	75	85	76	60	75	80
Year of Startup	1985	1976	1992	1977	1985-1992	1992	1990	1982	1990	1976-84
CAPITAL COSTS										
Building	40	40	40	200		3,400	3,650	6,500	2,400	
Plant Equipment	120	300	300	1,007		2,500	3,700	1,795	4,800	
Wells or Feed Intake	49	175	175	203		810	450	875	2,760	
Product Tanks	120	45	45	352						
Brine Disposal	10	25	25			400	3,600		1,124	
Other Costs	42	Note 1					Note 2		1,000	Note 1
Total Capital Costs (See Notes)	\$381	\$2,187	\$585	\$1,762	\$1,311	\$7,110	\$11,400	\$9,170	\$12,084	\$24,000
Total Capital Costs/GPD	\$12.70	\$9.72	\$1.56	\$4.10	\$1.31	\$3.56	\$2.85	\$2.04	\$2.01	\$1.60

Notes:
 (1)Southbay Utilities & City of Cape Coral capital costs are current replacement costs
 (2)SAWPA annual capital debt service, \$985,000, not included above

FIGURE 4: TOTAL CAPITAL COSTS, SELECTED BRACKISH RO/GROUNDWATER ENHANCEMENT PLANTS



SELECTED BRACKISH RO/GROUNDWATER ENHANCEMENT PLANTS

COST PROFILE

Plant Name, Location	Bocilla Utilities, Inc. Englewood, FL	Southbay Utilities Osprey, FL	City of Toluca IL	Ocracoke Sanitary Dist. Ocracoke, NC	North Beach Wabasso FL	City of Vero Beach FL	SAWPA Arlington CA	City of Sarasota FL	Town of Jupiter FL	City of Cape Coral FL
RO Plant Rated Capacity	0.03	0.225	0.375	0.43	1	2	4	4.5	6	15
Annual RO Production	7.00	48.90	86.00	50.20	109.50	655.00	1800.00	950.00	821.00	2620.00
Total, RO+Blend	7.00	48.90	108.00	50.20	109.50	655.00	2700.00	2533.00	2135.00	2882.00
Electric Power Cost	0.066	0.065	0.075	0.82	0.066	0.63-.078	0.098	0.0525	0.059	0.05
Hourly Power Required	24			230		288.3	220	1150	516	
Well Pump Power Incl.?	yes	yes		Yes		Yes	Yes	No	No	Yes
Distribution Power Incl.?	yes	yes		Yes		No	No	Yes	No	Yes
Operation, Maint. Personnel	2	1		5	4	5	2	15	24	23

ANNUAL OPERATING & MAINTENANCE COSTS

	53	72	150	500	530	246	877
Electric Power							
O&M Personnel(See note 1)							
Parts, Chemicals(See note 2)							
Replacement Membranes							
Not Specified							
Total Annual Costs	\$92	\$227	\$417	\$1,205	\$1,866	\$1,195	\$1,883
Unit Costs, RO Production	\$13.14	\$4.64	\$4.85	\$0.67	\$1.96	\$1.46	\$0.72
Unit Costs, RO+Blend	\$13.14	\$4.64	\$3.86	\$0.45	\$0.74	\$0.56	\$0.65

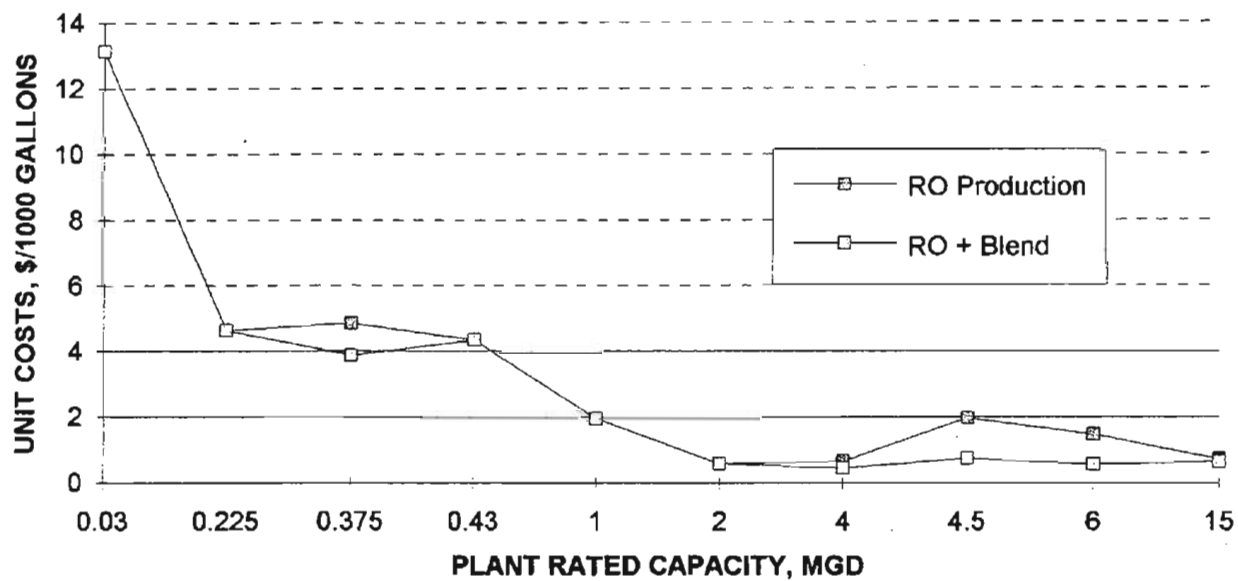
Notes: (1) O&M personnel costs estimated for City of Toluca

(2) Parts, chemical costs estimated for City of Toluca

(3) Costs for principal & interest payments & plant expansion purchases not included, Ocracoke Sanitary District.

(4) Town of Jupiter, additional cost for brine disposal, \$300,000/year

FIGURE 5: OPERATING & MAINTENANCE COSTS, SELECTED BRACKISH RO/GROUNDWATER ENHANCEMENT PLANTS



7.0 SELECTED CASE STUDY COMPARISONS, ELECTRODIALYSIS REVERSAL PLANTS

Ten electrodialysis plants were selected for comparison covering a range of plant rated capacity from 30,000 GPD to 12 MGD. Tables and charts were prepared based on submitted survey information as set forth below:

- Key elements for Process Data
- Table, Capital Cost components, and total
- Chart, Total Capital Costs Vs Plant Rated Capacity
- Table, Operation & Maintenance cost components, and total
- Chart, Total Operation & Maintenance Costs Vs Plant Rated Capacity

SELECTED ELECTRODIALYSIS REVERSAL PLANTS

PROCESS DATA

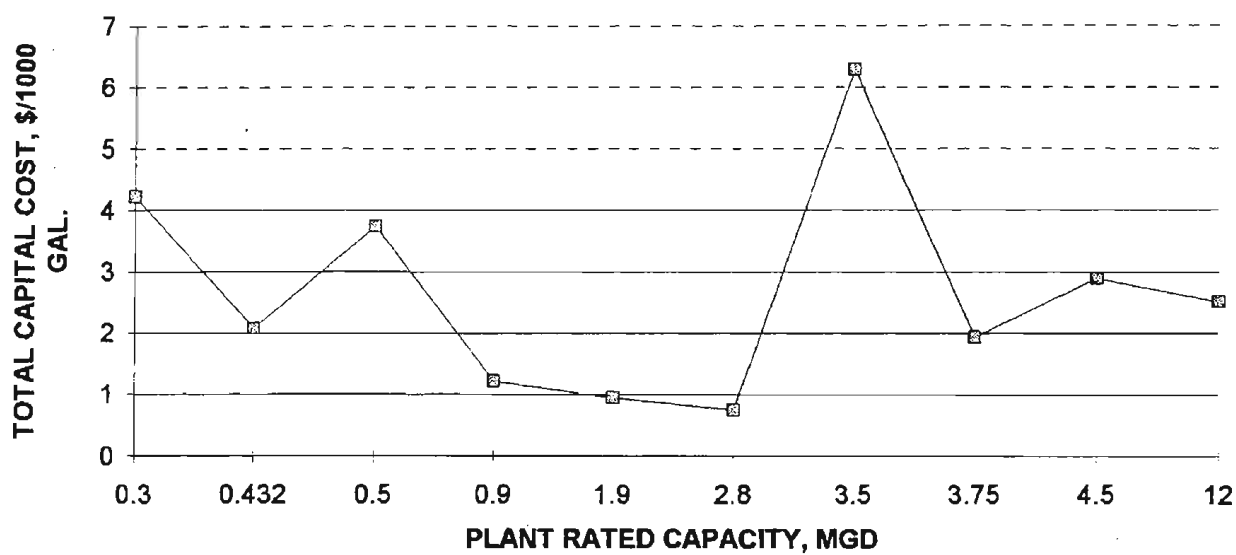
Plant Name, Location	Granbury WTP	Alta Munic. Utilities	Melville WW Saskatchewan Canada	Buckeye WTP	Washington Water Dept.	Foss Reservoir	Lake Granbury	City of Suffolk	City of Sherman	Carlton WTP
	Granbury, TX	Alta, IA		AZ	IA	Foss, OK	TX	VA	TX	Sarasota Co. Sarasota, FL
Rated Capacity	0.3	0.432	0.5	0.9	1.9	2.8	3.5	3.75	4.5	12
Annual Production	15	76	64	234	300	449	500	489	821	4289
Total Production + Blend	15	76	184	234	315	449	675	621	1281	4289
Feed Salinity	600	1200	1900	1600	1200	1050	321	563	1350	1030
Recovery		85	80	75		70	75	94	85	87
Year of Startup	1985	1995	1990	1989	1993	1974	1989	1990	1993	1995

CAPITAL COSTS

Building (See Note 1)	700	50	383	291	280			3,900	2,000	
Plant Equipment	500	850	753	709	1,212			2,200	3,000	8,800
Wells or Feed Intake			134					320	8,000	
Product Tanks								600		
Brine Disposal			437					230		
Other Costs	68		161	100	315					
Total Capital Costs (See Note 2)	\$1,268	\$900	\$1,868	\$1,100	\$1,807	\$2,100	\$22,000	\$7,250	\$13,000	\$30,100
Total Capital Costs/GPD	4.23	2.08	3.74	1.22	0.95	0.75	6.29	1.93	2.89	2.51

- Notes
- (1) Cost shown for Alta, Iowa building for remodeling only.
- (2) Total reported capital cost for Carlton WTP is \$97 million. This includes costs such as distribution system, etc.

**FIGURE 6: TOTAL CAPITAL COSTS, SELECTED
ELECTRODIALYSIS REVERSAL PLANTS**



SELECTED ELECTRODIALYSIS REVERSAL PLANTS

PROCESS DATA

Plant Name, Location	Granbury WTP	Alta Munic. Utilities	Alta, IA	0.432	76	76	0.02	112	yes	no	4	1	Granbury WTP	Buckeye WTP	0.9	129	129	0.066	150	yes	no	2	18	5	8	City of Sherman TX	City of Suffolk VA	Carlton WTP Sarasota Co. Sarasota, FL
Rated Capacity	0.3	0.432	0.432	0.432	76	76	0.02	112	yes	no	4	1	Granbury WTP	Buckeye WTP	0.9	129	129	0.066	150	yes	no	2	18	5	8	City of Sherman TX	City of Suffolk VA	Carlton WTP Sarasota Co. Sarasota, FL
Annual Production	48	76	76	76	76	76	0.02	112	yes	no	4	1	Granbury WTP	Buckeye WTP	0.9	129	129	0.066	150	yes	no	2	18	5	8	City of Sherman TX	City of Suffolk VA	Carlton WTP Sarasota Co. Sarasota, FL
Total Production + Blend	48	76	76	76	76	76	0.02	112	yes	no	4	1	Granbury WTP	Buckeye WTP	0.9	129	129	0.066	150	yes	no	2	18	5	8	City of Sherman TX	City of Suffolk VA	Carlton WTP Sarasota Co. Sarasota, FL
Electric Power Cost	.07-.10	0.02	0.02	0.02	0.02	0.02	0.02	0.02	yes	no	4	1	Granbury WTP	Buckeye WTP	0.9	129	129	0.066	150	yes	no	2	18	5	8	City of Sherman TX	City of Suffolk VA	Carlton WTP Sarasota Co. Sarasota, FL
Hourly Power Req'd																												
Well Pump Power Incl.?	yes								yes	no	4	1	Granbury WTP	Buckeye WTP	0.9	129	129	0.066	150	yes	no	2	18	5	8	City of Sherman TX	City of Suffolk VA	Carlton WTP Sarasota Co. Sarasota, FL
Distribution Power Incl.?	no								no	no	4	1	Granbury WTP	Buckeye WTP	0.9	129	129	0.066	150	yes	no	2	18	5	8	City of Sherman TX	City of Suffolk VA	Carlton WTP Sarasota Co. Sarasota, FL
Operation, Maint. Personnel	4																											

ANNUAL OPERATING & MAINTENANCE COSTS

Electric Power	5.2	8.4	46	85	36	125	82	175.6	120
O&M Personnel	70	25	9.1	34	21	161	200	355.1	560
Parts, Chemicals	50.2	15	10.8	14	18	240	36	60	60
Replacement Membranes			17.8	18.7	35	139.3	85		
Not Specified	8.1	Note 1							
Total Annual Costs	133.5	48.4	83.7	133	148.7	561	400	706	825
Unit Costs, EDR Production	\$2.81	\$0.64	\$1.31	\$1.03	\$0.50	\$1.25	\$0.80	\$1.44	\$1.00
Unit Costs, EDR+Blend	\$2.81	\$0.64	\$0.45	\$1.03	\$0.47	\$1.25	\$0.59	\$1.14	\$0.64

Note 2

Note 3

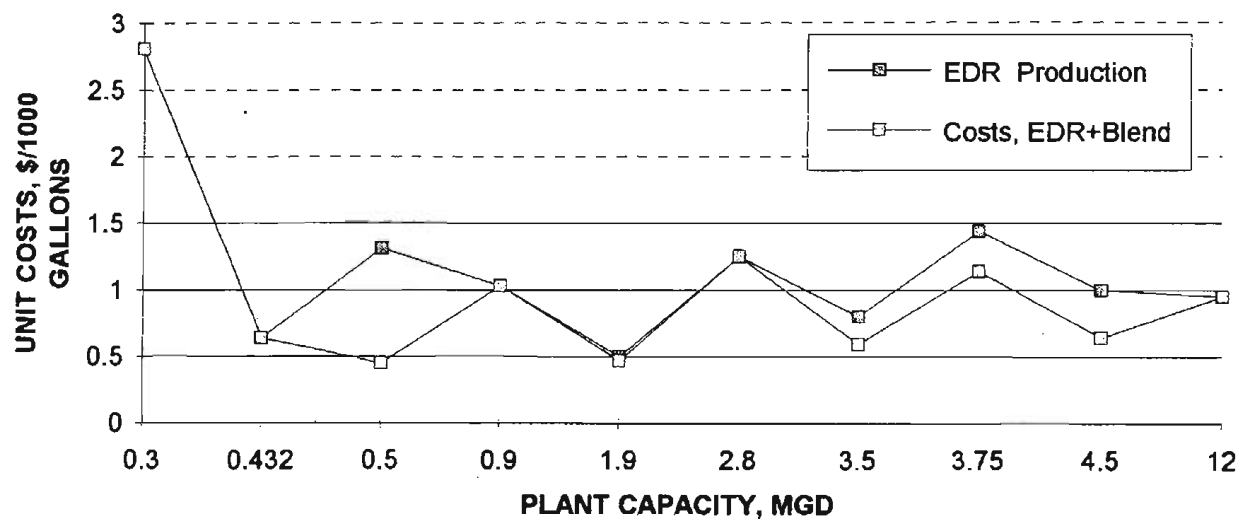
(1) For Buckeye, cost for bond amortization not included

(2) For Washington Water Dept. "Not Specified" costs added to correspond with published technical paper.

(3) For Carlton WTP, Sarasota County, annual production & cost/1000 gal from published technical paper.

Notes

FIGURE 7: OPERATING & MAINTENANCE COSTS, SELECTED ELECTRODIALYSIS REVERSAL PLANTS



8.0 SELECTED CASE STUDY COMPARISONS, MEMBRANE SOFTENING PLANTS

Five membrane softening plants were selected for comparison covering a range of plant rated capacity from 35,000 GPD to 12 MGD. Tables and charts were prepared based on submitted survey information as set forth below:

- Key elements for Process Data
- Table, Capital Cost components, and total
- Chart, Total Capital Costs Vs Plant Rated Capacity
- Table, Operation & Maintenance cost components, and total
- Chart, Total Operation & Maintenance Costs Vs Plant Rated Capacity

SELECTED MEMBRANE SOFTENING PLANTS

PROCESS DATA

Plant Name, Location	Laurens WS Laurens	Village, Royal Palm Beach	Indian River County	N. Collier County	City of Ft. Myers
	IA	FL	Vero Beach, FL	Naples, FL	FL
Rated Capacity	0.35	1.5	8.57	12	12
Annual Production	45	330	1479	2313	2555
Total Production + Blend (See Note)	46	750	1642	2313	0
Feed Salinity			900	420	150
Recovery	74	80	80	90	90
Year of Startup	1990	1994	1994	1993	1992

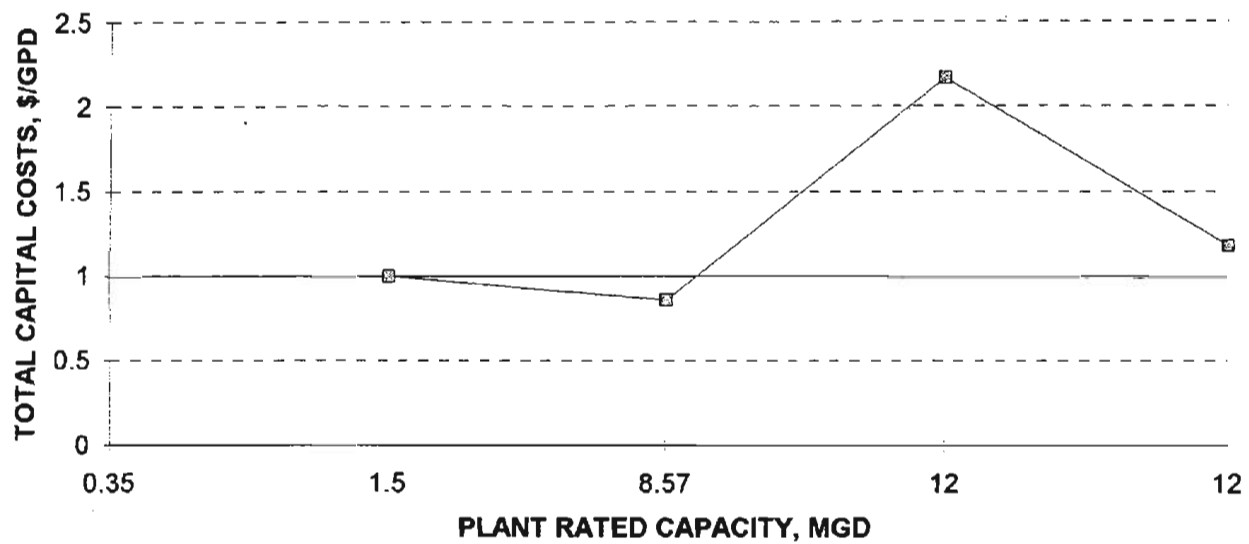
CAPITAL COSTS

Building	269	1,230
Plant Equipment	358	5,560
Wells or Feed Intake	750	500
Product Tanks		
Brine Disposal	68	82
Other Costs	50	
Total Capital Costs	1,494	7,372
Total Capital Costs/GPD	\$1.00	\$0.86
		26,000
		\$2.17
		\$1.18

(1) For Village of Royal Palm, blend addition is from a lime softening plant

Notes

FIGURE 8: TOTAL CAPITAL COSTS, SELECTED MEMBRANE SOFTENING PLANTS



SELECTED MEMBRANE SOFTENING PLANTS

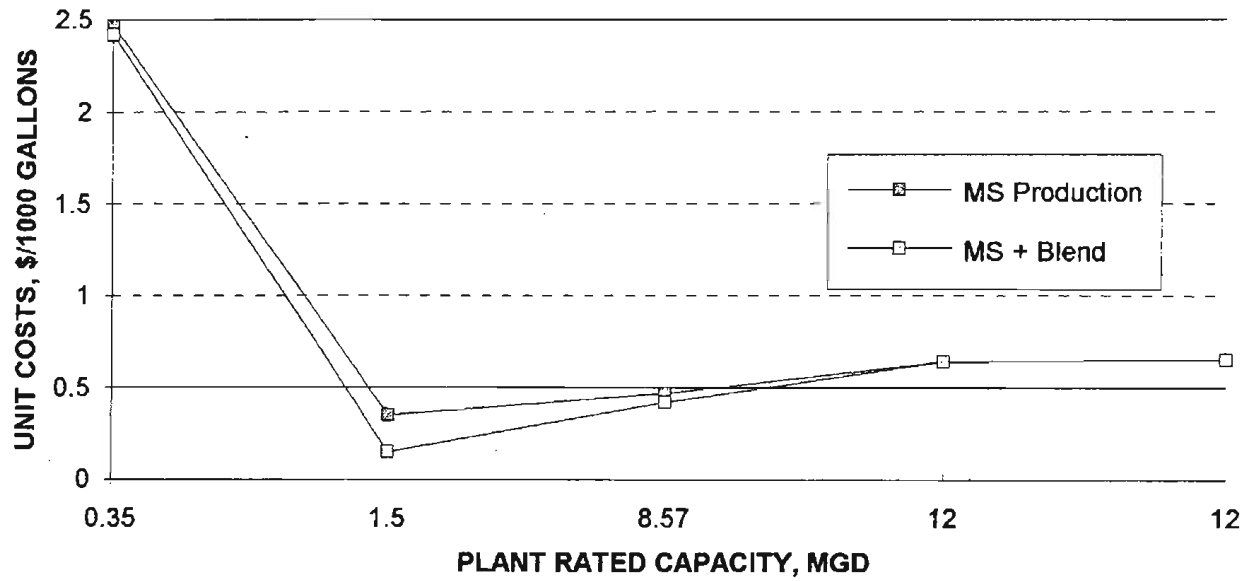
COST PROFILE

Plant Name, Location	Laurens WS Laurens	Village, Royal Palm Beach	Indian River County	N. Collier County	City of Ft. Myers
	IA	FL	Vero Beach, FL	Naples, FL	FL
Rated Capacity	0.35	1.5	8.57	12	12
Annual Production	45	330	1479	2313	2555
Total Production + Blend (See Note)	46	750	1642	2313	2555
Electric Power Cost	0.038	0.06	0.049	0.037	0.08
Hourly Power Req'd	77	89		667	596
Well Pump Power Incl.?	yes	yes	yes	no	no
Distribution Power Incl.?	yes	yes	yes	yes	no
Operation, Maintenance Personnel	1.5	1	12	14	16

ANNUAL OPERATING & MAINTENANCE COSTS

Electric Power	16	23	240	307	524
O&M Personnel	65	80	201	575	535
Parts, Chemicals	30	12	150	600	594
Replacement Membranes			99	5	
Not Specified					
Total Annual Costs	\$111	\$115	\$890	\$1,487	\$1,653
Unit Costs, Production	\$2.47	\$0.35	\$0.47	\$0.64	\$0.65
Unit Costs, Production + Blend	\$2.42	\$0.15	\$0.42	\$0.64	\$0.65

FIGURE 9: OPERATION & MAINTENANCE COSTS, SELECTED MEMBRANE SOFTENING PLANTS



9.0 SELECTED CASE STUDY COMPARISONS, SEAWATER DESALINATION PLANTS

Seven seawater RO plants and one MED distillation facility were selected for comparison covering a range of plant rated capacity from 33,000 GPD to 8.1 MGD. Tables and charts were prepared based on submitted survey information as set forth below:

- Key elements for Process Data
- Table, Capital Cost components, and total
- Chart, Total Capital Costs Vs Plant Rated Capacity
- Table, Operation & Maintenance cost components, and total
- Chart, Total Operation & Maintenance Costs Vs Plant Rated Capacity

SELECTED SEAWATER DESALINATION PLANTS

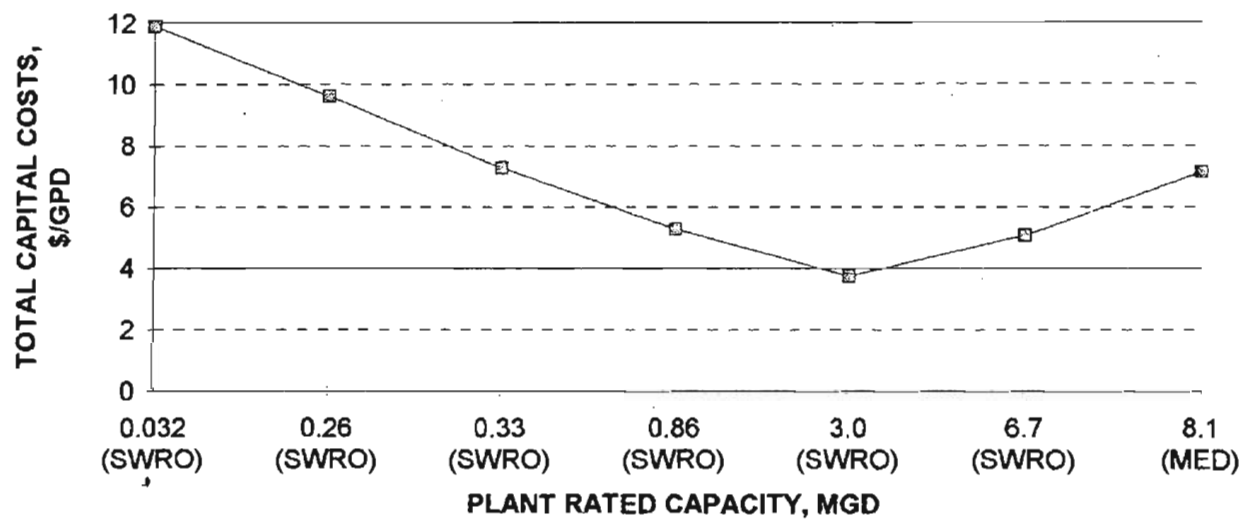
PROCESS DATA

Plant Name, Location	Aquarium Monterey CA	Marina Water Dist. Marina, CA	Catalina Island CA	City of Morro Bay CA	Key West FL	US Navy Guantanamo Cuba	City of S. Barbara CA	Water/Power Authority Virgin Islands
Process Type	SWRO	SWRO	SWRO	SWRO	SWRO	MSF/MED	SWRO	MED
Rated Capacity MGD	0.032	0.26	0.33	0.86	3.00	3.25	6.7	8.10
Annual Production Mil. Gal.	8	98	38	315	931	913		2621
Total Production + Blend Mil. Gal.	8	98	38	315	931	913		2621
Feed Salinity mg/l		25000		31000	0		34000	37000
Recovery %		40	30/33	40	30		45	
Year of Startup	1996	1996		1993	1981		1992	1981-1993

CAPITAL COSTS

Building		250		100				
Plant Equipment	336	960		2,100				
Wells or Feed Intake		150		800				
Product Tanks	25	20						
Brine Disposal		150		230				
Other Costs	20	970		1,300				
Total Capital Costs \$(000's)	\$381	\$2,500	\$2,400	\$4,530	\$11,250		\$34,000	\$57,752
Total Capital Costs \$/GPD	\$11.91	\$9.62	\$7.27	\$5.27	\$3.75		\$5.07	\$7.13

**FIGURE 10: TOTAL CAPITAL COSTS, SELECTED SEAWATER
DESALTING PLANTS**



PROCESS DATA

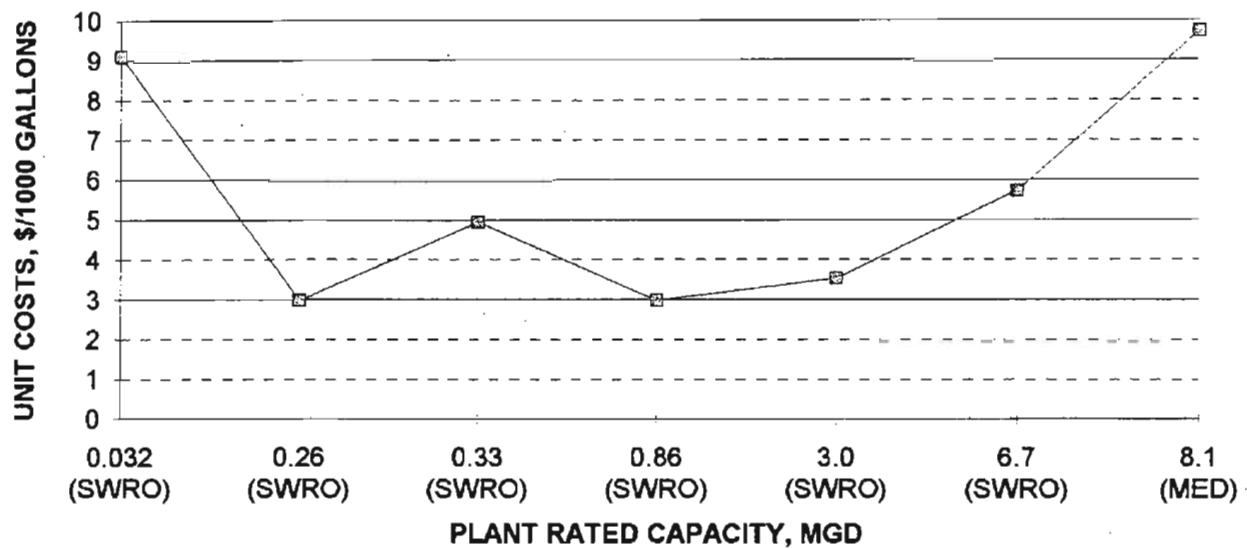
(1) Data for this plant was assembled by the authors from data and information in "Connections" (Spring '91, A Newsletter to Community Colleges & Universities issued by Southern California Edison Company, from Water Desalination Report, and from San Gabriel Valley Tribune, January 17, 1990. A completed questionnaire was sent to Southern California Edison Company for review & comment.

(2) Annual O&M costs equal \$110,000 + \$975/af

(3) Cost data from operation during period, 1981-1983

(4) The Santa Barbara plant is currently on "Standby Mode". In "Delivered Water Mode, the unit cost is as shown.

**FIGURE 11, OPERATING & MAINTENANCE COSTS, SELECTED
SEAWATER DESALTING PLANTS**

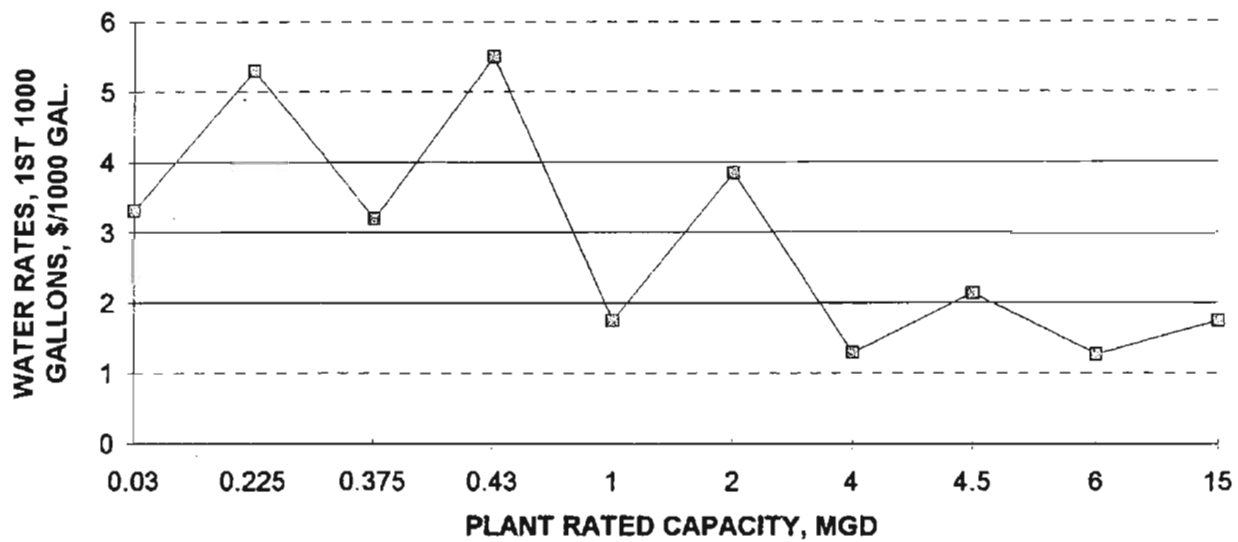


10.0 SELECTED CASE STUDY COMPARISONS, WATER RATES AND RATE STRUCTURES

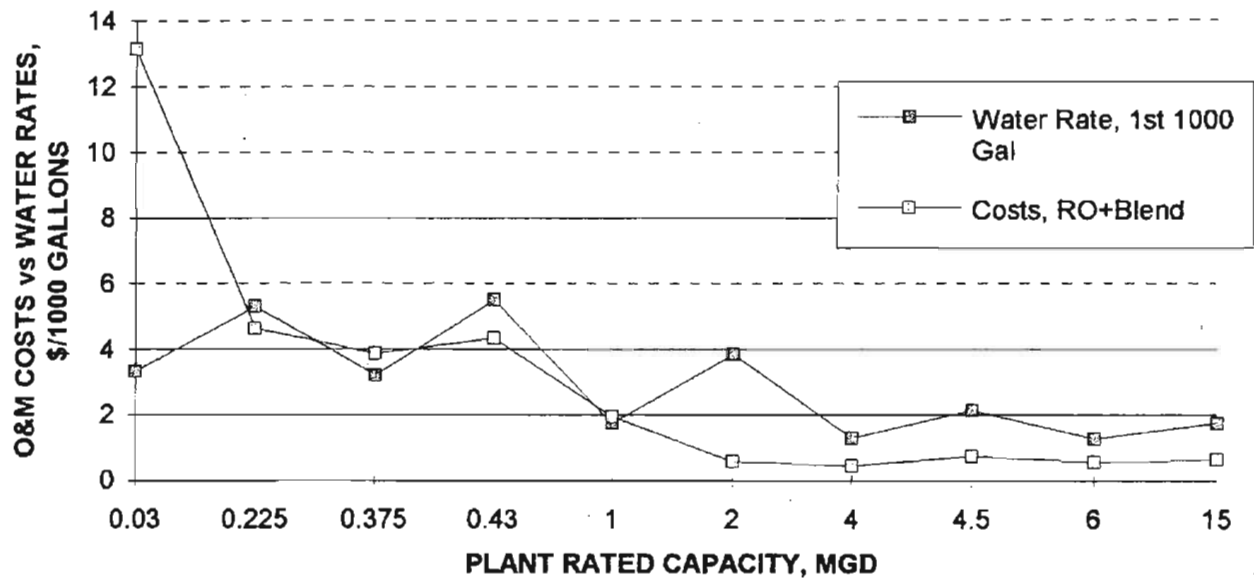
For the same selected plants described in Sections 6, 7, 8, and 9, tables and charts were prepared for each of the four processes based on submitted survey information as set forth below:

- Table, key elements for Process Data, plant rated capacity, & annual production & blend amount, impact fees, water rates for the 1st 1000 gallons.
- Chart, Water Rates, Exclusive of Debt Service & Impact Fees

**FIGURE 12: WATER RATES, EXCLUSIVE OF DEBT SERVICE,
SELECTED BRACKISH RO/GROUNDWATER ENHANCEMENT
PLANTS**



**FIGURE 13: WATER RATES vs O&M COSTS, SELECTED
BRACKISH RO/GROGROUNDWATER ENHANCEMENT PLANTS**



SELECTED ELECTRODIALYSIS REVERSAL PLANTS

WATER RATES

Plant Name, Location	Granbury WTP	Alta Munic. Utilities	Melville WW Saskatchewan	Buckeye WTP	Washington Water Dept.	Foss Reservoir	Lake Granbury	City of Suffolk	City of Sherman	Carlton WTP
	Granbury, TX	Alta, IA	Canada	AZ	IA	Foss, OK	TX	VA	TX	Sarasota, FL
Rated Capacity	0.3	0.432	0.5	0.9	1.9	2.8	3.5	3.75	4.5	12
Annual Production	48	76	64	129	300	449	500	489	821	1825
Total Production + Blend	48	76	184	129	315	449	675	621	1281	1825
Rate Change With Use	Even	Decrease	Even	Even	Decrease	Even	Even	Even	Even	Increase
Impact Fee, Monthly		6								12.70
Impact Fee, One Time			80		425			2500		
Water Rate, 1st 1000 Gal	4.50	2.30	10.50	4.07	1.80	1.70	1.64	2.81	2.07	2.00

(1) Some facilities use separate rate structures, within & without Corporate Limits.

Notes

FIGURE 14: WATER RATES, EXCLUSIVE OF DEBT SERVICE & IMPACT FEES, SELECTED ELECTRODIALYSIS REVERSAL PLANTS

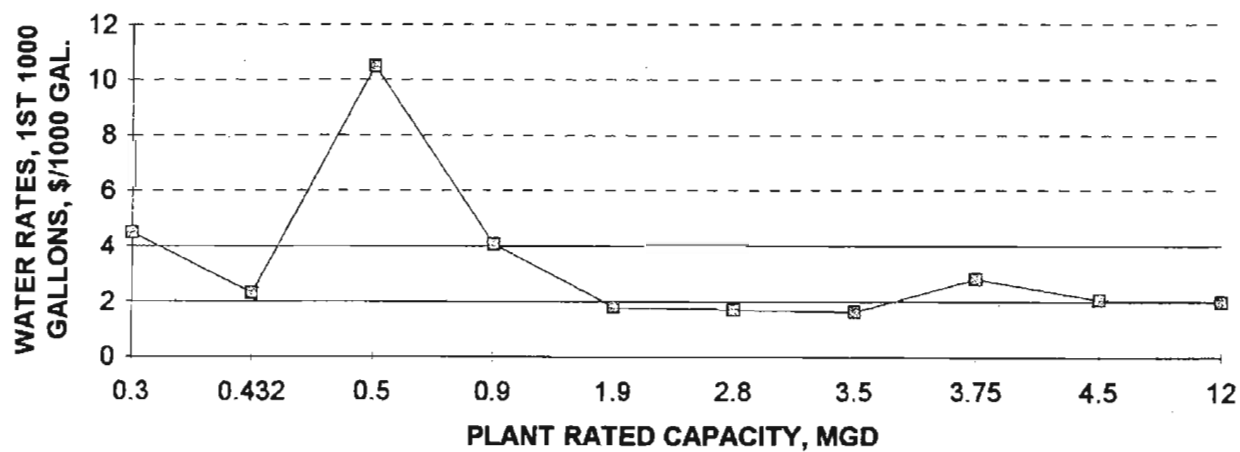
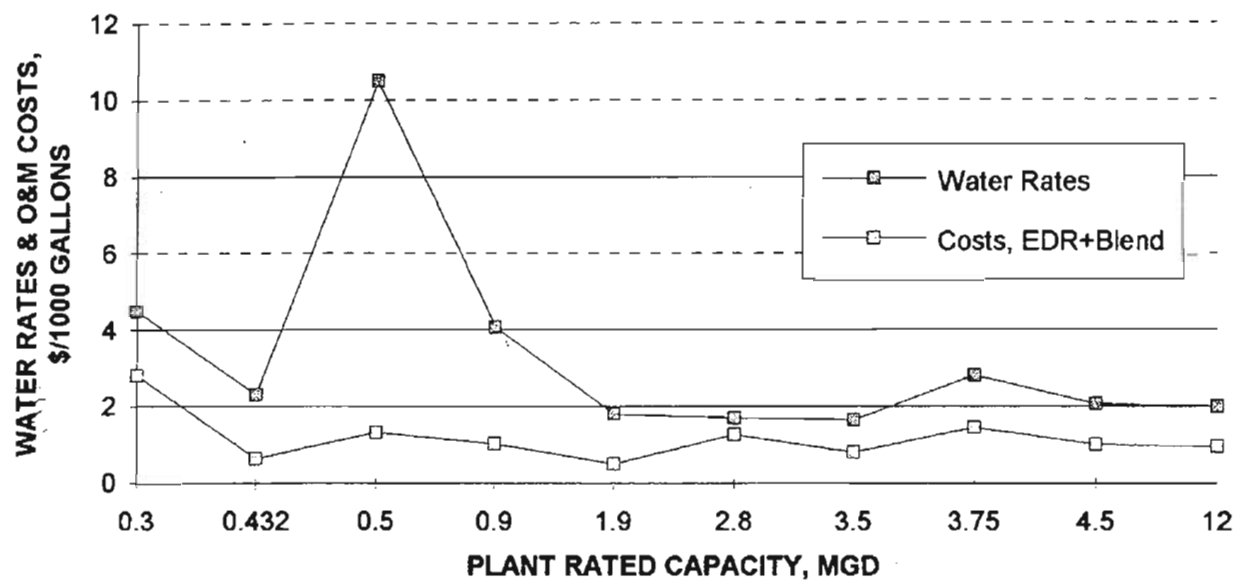


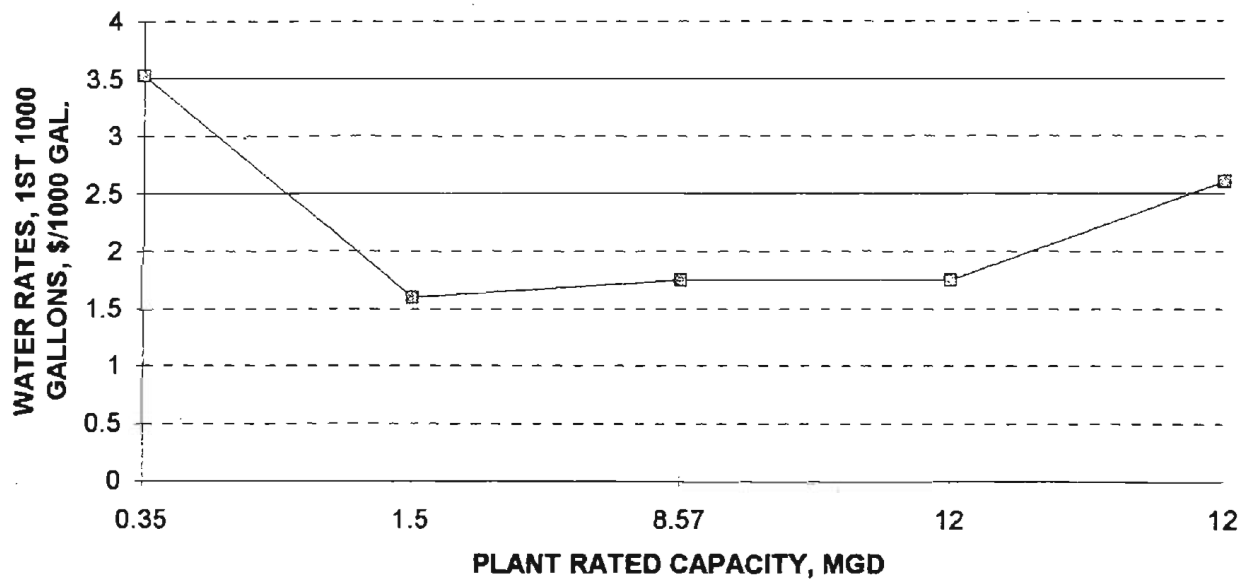
FIGURE 15: WATER RATES vs O&M COSTS, SELECTED ELECTRODIALYSIS REVERSAL PLANTS



WATER RATES

89

FIGURE 16: WATER RATES, EXCLUSIVE OF DEBT SERVICE & IMPACT FEES, SELECTED MEMBRANE SOFTENING PLANTS

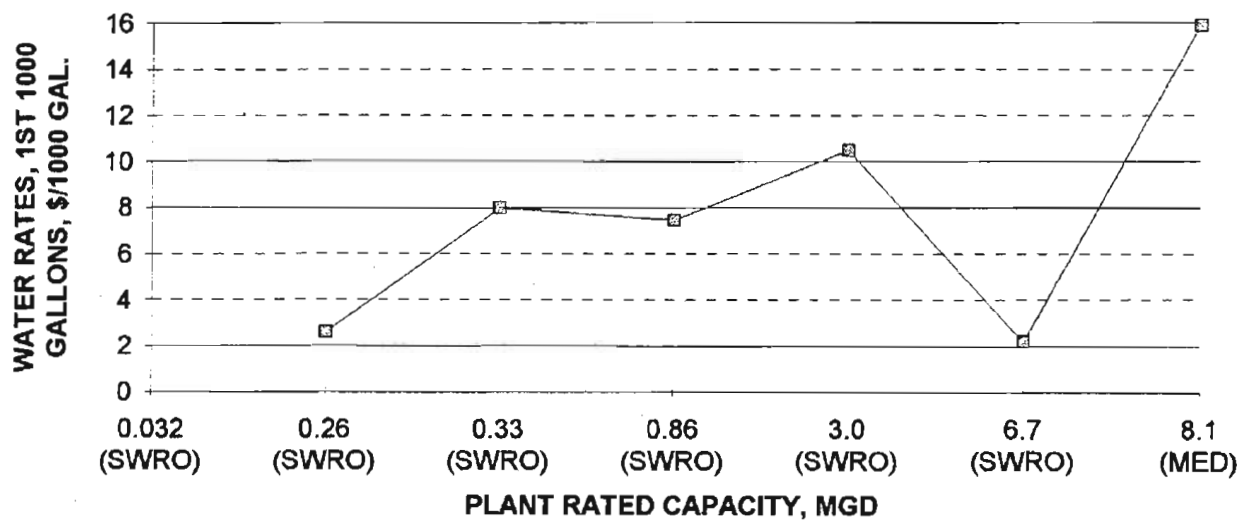


SELECTED SEAWATER DESALINATION PLANTS

WATER RATES

Plant Name, Location	Process Type	Aquarium		Marina		Catalina		City of		Key		US Navy		City of		Water/Power	
		Monterey	CA	Water Dist.	Marina, CA	Island	CA	Morro Bay	CA	West	FL	Guantanamo	Cuba	S. Barbara	CA	Authority	Virgin Islands
		SWRO	SWRO	SWRO	SWRO	SWRO	SWRO	SWRO	SWRO	SWRO	SWRO	MSF/MED	SWRO	SWRO	SWRO	MED	
Rated Capacity	MGD	0.032	0.26	0.33	0.86	3.00	3.25	6.7	8.10								
Annual Production	Mil. Gal.	8	98	38	315	931	913	2621	2621								
Total Production + Blend	Mil. Gal.	8	98	38	315	931	913	2621	2621								
Rate Change with Use		na	Even		Increase								Increase			Increase	
Impact Fee, Monthly	\$/Month																
Impact Fee, One Time	\$		3000											2342			
Water Rate, 1st 1000 Gal.	\$/1000 Gal.		2.60	8.00	7.47	10.49								2.20		15.90	

FIGURE 17, WATER RATES, EXCLUSIVE OF DEBT SERVICE & IMPACT FEES, SELECTED SEAWATER DESALTING PLANTS



11.0 COMMENTS AND CONCLUSIONS

Several significant conclusions can be drawn from these analyses of the Survey data.

1. The desalting industry, engineers, designer-builders, equipment component suppliers, and owner operators can now have factual data to show they are involved in a growth industry. The annual growth rates are 20% per year in installed capacity, and 6.25% per year in the number of new plants. Noteworthy, the comparison of number of new plants and the increase in installed capacity, signifies the growth has been in larger capacity plants.
2. The growth rate for membrane softening, 120% per year, strongly suggests that the time for nanofiltration applications in potable water treatment has arrived. The successful experiences to date may be opening a vast new opportunity for nanofiltration applications other than membrane softening, namely removal of trihalomethane formation potential (THMFP), and removal of color, and for rejection of bacteria and viruses and dissolved organic carbons.
3. There does not appear to be a significant increase in water rates when low salinity alternative water sources are treated using one of the desalting processes. This should help to dispel a misunderstanding by much of the media about desalting costs. How to convey this message is one that the desalting industry should address, perhaps a major public relations campaign through, for example, the American Desalting Association. One organization that has been successful in this area, and one that might be solicited for advice is the International Bottled Water Association.
4. The very slow growth in seawater desalting is difficult to understand, particularly in view of the high expectations for seawater desalting processes by the US government, with a research and development investment of just over \$1.4 billion (1994 dollars) in the years 1952 through 1985. Part of the answer may be the development of greatly improved membrane processes with lower costs for lower salinity and water treatment applications, as compared with seawater desalting. This has permitted the use of alternative sources of water, postponing the time when seawater desalting in the US must be brought into service.

12.0 APPENDICES

Public Water Supervision (PWSS) State Contacts

List of Manufacturers

Desalting Plants in the US, by State & Process

APPENDIX 1

**Association of State Drinking Water Administrators
Safe Drinking Water Hotline, Washington, D.C. (800) 426-4791**

NAME	ADDRESS	TELEPHONE
Alabama Dept. of Envir. Mgmt.	1751 Congressman W.L. Dickenson Dr. Montgomery	334-271-7773
Alaska Dept. of Envir. Conserv.	555 Cordova St. Anchorage, AK 99501	907-269-7500
Arkansas Dept. of Health	4815 W. Markham St. Little Rock, AR 72205	501-661-2623
Arizona Dept. of Envir. Quality	3033 N. Central, Rm 200, Phoenix, AZ 85001	602-207-4617
Calif. Div. Drink. Wtr/Env. Mgt.	P.O. 942732, Sacramento, CA 94234	916-323-6111
Colorado Dept. of Health	4300 Cherry Creek Dr. S. Denver, CO 80222	303-692-3546
Connecticut Dept. of Health Svcs.	150 Washington St. Hartford, CT 06106	203-240-9262
Delaware Div. of Public Health	Coopur Bldg. P.O. Box 637, Dover, DE 19903	302-739-5410
Florida Dept. of Envir. Reg.	2600 Blair Stone Road, Tallahassee, FL 32399	904-487-1762
Georgia Envir. Protection Div.	205 Butler St. S.E. Floyd Tower, Atlanta, GA 30334	404-651-5157
Hawaii Dept. of Health	P.O. 3378, Honolulu, HI 96801	808-586-4304
Idaho Dept. of Health/Welfare	1410 N. Hilton, Boise, ID 83706	208-334-5860
Illinois Envir. Prot. Agency	2200 Churchill Rd. Springfield, IL 62794	217-785-8653
Indiana Dept. of Envir. Mgmt.	100 N. Senate Ave. Indianapolis, IN 46206	317-233-4166
Iowa Dept. of Natural Resources	900 E. Grand Street, Des Moines, IA 50319	515-281-8869
Kansas Dept. of Health/Envir.	Forbes Field Bldg. 740, Topeka, KS 66620	913-296-5503
Kentucky Div. of Water	14 Reilly Rd. Frankfort, KY 40601	502-564-3410
Louisiana Dept. Health/Hospitals	P.O. Box 60630, New Orleans, LA 70160	504-568-5105
Massachusetts Dept. Envir. Prot.	One Winter St. 9th Fl. Boston, MA 02108	617-292-5529
Maine Div. of Health Engr.	State House, Sta 10, Augusta, ME 04333	207-287-2070
Maryland Dept. of Environment	2500 Broening Highway, Dundalk, MD 2122	410-631-3702
Minnesota Dept. of Health	12 E. Seventh Place, St. Paul, MN 55164	612-215-0746
Mississippi State Dept. of Health	P.O. Box 1700, Jackson, MS 39215	501-960-7518
Missouri Dept. Natural Resources	205 Jefferson St. Jefferson City, MO 65102	314-751-5331
Montana Water Qual. Bureau	Cogswell Bldg. Rm A206, Helena, MT 59520	406-444-5315
N.C. Dept. Envir./Health/Nat. Res.	P.O. Box 27687, Raleigh, NC 27611	919-715-3232
Nebraska Div. Drink. Wtr. & Envir.	505 E. King St. Carson City, NV 89710	702-687-6353
N.Hampshire Dept. Envir. Svcs.	P.O. Box 95, Hazen Dr. Concord, NH 03302	603-271-3503
New Jersey Div. Water Resources	P.O. Box CN-426, Trenton, NJ 08625	609-292-5550
New Mexico Envir. Dept.	2052 Galisteo, Santa Fe, NM 87505	505-827-7536
North Dakota St. Dept. of Health	1200 Missouri Ave. Bismark, ND 58502	701-328-5225
New York Dept. of Health	2 University Place, Rm 410, Albany, NY 12203	518-458-6731
Ohio Envir. Protection Agency	1800 Watermark Dr. Columbus, OH 43216	614-644-2752
Oklahoma Dept. Envir. Quality	1000 N.E. 10th St. Oklahoma City, OK 73117	405-271-5205
Oregon Health Div./Human Res.	800 N.E. Oregon St. Portland, OR 97201	503-229-6310
Penn. Dept. of Envir. Resources	P.O. Box 8467, Harrisburg, PA 17105	717-787-9037
Rhode Island Div. Water Supply	75 Davis St. Cannon Bldg. Providence, RI 02908	401-277-6867
SC Dept. Health/Envir. Control	2600 Bull St. Columbia, SC 29201	803-734-5310
S. Dakota Dept. Envir./Nat. Res.	523 E. Capitol Ave. Pierre, SD 57501	605-773-3754
Texas Nat. Res. Conserv. Comm.	P.O. Box 13807, Austin, TX 78711	512-239-6930
Tennessee Dept. Envir. & Conser.	401 Church St. Nashville, TN 37243	615-532-0191
Utah Dept. Environmental Qual.	P.O. Box 144830, Salt Lake City, UT 84114	801-536-4188
VI Div. of Envir. Protection	Nisky Center, Nisky 45A, St. Thomas, VI 00802	809-774-3320
Virginia Dept. of Health	1500 East Main St. Richmond, VA 23219	804-786-1765

APPENDIX 1 (Continued)
Association of State Drinking Water Administrators
Safe Drinking Water Hotline, Washington, D.C. (800) 426-4791

NAME	ADDRESS	TELEPHONE
Vermont Dept. of Envir. Conserv.	103 S. Main St. Waterbury, VT 05671	802-241-3400
Washington D. Cons./Reg. Affairs	2100 Martin Luther King Ave. Washington, DC 20020	202-404-1120
Washington Dept. of Health	A. Center, Bldg. 3, Olympia, WA 98504	360-753-1280
West Virginia Env./Health Svcs.	815 Quarrier St. Sta. 418, Charleston, WV 25301	301-558-2981
Wisconsin Dept. of Nat. Res.	P.O. Box 7921, Madison, WI 53707	608-267-7651
Wyoming Dept. Envir. Quality	Herschler Bldg. 4th Fl W. Cheyenne WY 82002	307-777-7781

APPENDIX 2

**Some Active North American Manufacturers of
Distillation, Reverse Osmosis/Ground Water Enhancement, & EDR Systems**

Manufacturer's Name	Address	Telephone
American Engineering Services, Inc.	5912 F. Breckenridge Pkwy, Tampa FL 33610	819-357-0910
Aqua Chem, Inc	P.O. Box 421, Milwaukee, WI 53201	414-961-2751
Aqua Design (Subsidiary Ionics)	470 Division Street, Campbell, CA 95008	408-374-8680
ASI	238-A Simpson Way, Escondido, CA 92025	
Culligan, International	One Culligan Pkwy, Northbrook, IL 60062	708-205-6000
Harn RO Systems, Inc.	185 S. Jackson, Venice, FL 34292	941-488-9671
Hydropro, Inc.	1346 S. Killian Dr. Lake Park, FL 33403	407-848-6788
Ionics, Inc.	65 Grove St. Watertown, MA 02172	617-926-2500
Israel Desalination Engineers	2999 NE 191st St, N. Miami Bch., FL 33180	305-937-0610
Mechanical Equipment Co.	861 Carondelet St. New Orleans, LA 70130	504-523-7271
Memtec America	24912 Via Lopez Ct. Ramona, CA 92065	410-252-0800
Osmonics, Inc.	5951 Clearwater Dr, Minnetonka, MN 55343	612-933-2277
Polymetrics Seawater Systems	550 S. Winchester Blvd. San Jose, CA 95128	408-983-2684
Source, Inc.	PO Box 1321, Cape Coral, FL 33910	813-549-2345
Trisep Corp.	93 La Patera Lane, Goleta, CA 93117	805-964-8003
US Filter (IWT Division)	4669 Shepherd Trail, Rockford, IL 61103	815-877-3041
Water Equipment Technology	832 Pike Road, W. Palm Beach, FL 33411	407-684-6300

APPENDIX 3 PLANT LIST BY STATE & BY PROCESS

State	Plant Location (Name)	Process	Capacity MGD	Start-up Year	Equipment Supplier	Membrane Manufacturer
Arizona	Buckeye, Town of	EDR	1.00	1989	Ionics	Ionics
Arizona	Chandler	RO	2.84	1996	Ionics	
Arizona	Not stated	EDR	0.30	1988	Ionics	Ionics
Arizona	Not stated	EDR	0.90	1988	Ionics	Ionics
Arizona	Not stated	EDR	0.96	1993	Ionics	Ionics
Arizona	Not stated	EDR	1.20	1995	Ionics	Ionics
Arizona	Yuma Proving Ground WTP	RO	0.60	1986	Ionics	Ionics
Arizona	Number of Plants 7	Total	7.82			
Arizona	Yuma Desalting Plant (Bureau of Rec.)	RO	72.00	1992		Fluid Systems Hydranautics
California	Not stated	EDR	0.38	1995	Ionics	Ionics
California	El Segundo	RO	5.00	1995	US Filter	
California	Fountain Valley (Water Factory 21)	RO	6.00	1977		
California	Garden Grove, City of	RO	0.31	1988		
California	Marina	SWRO	0.26	1996	Ionics	
California	Monterey, Aquarium	SWRO	0.03	1996		Filmtec
California	Morro Bay	SWRO	0.86	1993	Aqua Design	Filmtec
California	Oceanside (Capistrano Desalter)	RO	2.00	1994	Hydranautics	Hydranautics
California	Oceanside, San Luis Rey	RO	2	1993	Hydranautics	Hydranautics
California	Pendleton	MS	0.15	1994	Membrane Sys.	Fluid Systems
California	Riverside (Arlington Desalter)	RO	4.00	1990	Hydranautics	Hydranautics
California	Santa Barbara	SWRO	6.70	1992	Ionics	
California	Santa Ana (Irvine Ranch)	RO	0.03	1993	Aqua Design	
California	Santa Ana (Irvine Ranch)	RO	4.50	TBD		
California	Santa Catalina Island	SWRO	0.33	1991	Village Marine	
California	San Simeon (Hearst Castle)	RO	0.04			
California	Tustin	RO	0.50	1990	Gaco Systems	Fluid Systems
California	Number of Plants 17	Total	33.09			
Colorado	Las Animas	RO	1.00	1995	Membrane Sys.	
Colorado	Number of Plants 1	Total	1.00			
Florida	Not stated	EDR	2.10	1989	Ionics	Ionics
Florida	Not stated	RO	0.25	1988	Hydropro	Fluid Systems
Florida	Not stated	EDR	0.29	1990	Ionics	Ionics
Florida	Bonita Springs(Imperial Harbor Utilities)	MS	0.05			
Florida	Bookeelia (Usepa Island Club)	RO	0.06			
Florida	Boynton Beach	MS	4.00	1992	PWT America	Filmtec
Florida	Cape Coral	RO	15.00	1976/84	Permutit, WSA	Hydranautics
Florida	Deland (Indian Harbor Estates)	RO	0.13			
Florida	Dunedin	MS	9.50	1992		
Florida	Englewood (Bocilla Utilities, Inc>)	RO	0.30	1985	Harn RO	
Florida	Englewood	RO	2.50	1981	Hydranautics	Hydranautics
Florida	Estero (Mariner's Cove)	RO	0.05			

APPENDIX 3 PLANT LIST BY STATE & BY PROCESS

State	Plant Location (Name)	Process	Capacity MGD	Start-up Year	Equipment Supplier	Membrane Manufacturer
Florida	Estero Woods(Harbor Point Condos)	MS	0.05			
Florida	Fort Myers	MS	12.00	1992	Hydranautics	Hydranautics
Florida	Fort Pierce(Countryside N. MHP)	RO	0.13			
Florida	Fort Pierce (Fort Pierce Utilities)	MS	0.80			
Florida	Gasparilla Island Water Assn.	RO	0.75	1900	Harn RO	Fluid Systems
Florida	Grove City (Seaside Service Systems)	RO	0.02	1986		
Florida	Harbor Hgts (Charlotte Harbor WTP)	RO	0.45	1978		Dow/Filmtec
Florida	Hastings WTP	RO	0.22	1992	Harn RO	
Florida	Hollywood	MS	14.00	1996		Hydranautics
Florida	Indian River County (Stuart)	RO	0.40			
Florida	Indian River County (Wabasso)	RO	1.00	1985		Dow
Florida	Jasper WTP	RO	1.40	1991		
Florida	Jensen Beach	RO	1.50	1994	Hydropro	Hydranautics
Florida	Jensen Beach(Ocean Towers Utility)	RO	0.12			
Florida	Jensen Beach(River Club, Martin Bch)	RO	0.06			
Florida	Jensen Beach(Sailfish Point Utility)	RO	0.25			
Florida	Jensen Beach (Princess Condos)	RO	0.20			
Florida	Jensen Beach (Martin County Utilities)	RO	0.12			
Florida	Jensen Beach (Joe's Point Homeowner)	RO	0.12			
Florida	Jupiter	RO	6.00	1990	Hydranautics	Hydranautics
Florida	Key West	SWRO	3.00	1981	Water Services	DuPont
Florida	Lutz (Holiday Pines Service Corp.)	RO	0.24	1989		Fluid Systems
Florida	Maitland (Dixon Ticonderoga)	RO	0.15	1972		Fluid Systems
Florida	Marco Island (South.States Utilities)	RO	4.00	1992	Amer.Engr. Svcs.	
Florida	Martin County	MS	1.50	1996	Hazen	TriSep
Florida	Melbourne	RO	5.00	1995	LA Water	
Florida	Melbourne (Service Management Sys.)	RO	0.08	1984		Dow
Florida	Melbourne Bch.(S.Brevard Water Coop)	RO	0.10	1988		Dow
Florida	Melbourne Bch.(S.Shores Condos)	RO	0.10			
Florida	Melbourne Bch.(Chuck's , Invitron Util.)	RO	0.14			
Florida	Miramar	MS	4.50	1995	Membrane Sys.	
Florida	Naples (North Collier County WTP)	MS	12.00	1993	Great Mon.Const.	Hydranautics
Florida	Nokomis (Bay Lakes Estates)	RO	0.05	1990	Toyobo	
Florida	Nokomis (Kings Gate Club)	RO	0.06	1978		Dow
Florida	Nokomis (Kings Gate RV Park)	RO	0.06			
Florida	Nokomis (Sorento)	RO	0.68	1991		Hydranautics
Florida	Nokomis (Sorento)	EDR	0.30	1991	Ionics	Ionics
Florida	Nokomis(Lake Village MHP)	RO	0.10			
Florida	Nokomis (Spanish Lakes MHP)	RO	0.10			
Florida	Ormond Beach (Kingston Shores)	RO	0.60	1972	Permutit	
Florida	Osprey (Sorento Utilities)	RO	0.23	1975	Harn RO	
Florida	Osprey (Southbay Utilities)	RO	0.23	1976	Harn RO	
Florida	Palm Beach (Bank of Commerce)	MS	0.17	1988		Filmtec
Florida	Palm Coast (Palm Coast Utilities)	MS	6.00	1992	PWT America	Filmtec
Florida	Pine Island WTP	RO	1.50	1978/93	Envir./Mem.Sys.	

APPENDIX 3 PLANT LIST BY STATE & BY PROCESS

State	Plant Location (Name)	Process	Capacity MGD	Start-up Year	Equipment Supplier	Membrane Manufacturer
Florida	Plantation WTP	MS	12.00	1991	PWT America	Fluid Systems
Florida	Port St. Lucie (Spanish Lakes Fairways)	RO	0.50	1989		
Florida	Punta Gorda (Burnt Store)	RO	0.24	1975/94	Ham RO	
Florida	Punta Gorda (Alligator Park)	RO	0.04			
Florida	Punta Gorda (Charlotte Harbor Water)	RO	0.45			
Florida	Punta Gorda Hunter Creek Village)	RO	0.17			
Florida	Rotunda West	RO	0.50	1974		DuPont
Florida	Royal Palm Beach, Village of	MS	1.50	1994	Amer.Engr.Svcs.	Filmtec
Florida	San Carlos Park(Gulf Utilities)	MS	0.50	1991		Dow/Filmtec
Florida	Sanibel Island Water Assn.	RO	4.70	1980		Filmtec
Florida	Sarasota, City	RO	4.50	1982	Polymetrics	Du Pont
Florida	Sarasota (Lake Tippecanoe)	RO	0.04	1984		Toyobo
Florida	Sarasota (Myaka River State Park)	RO	0.05	1977		
Florida	Sarasota (Windward Isles)	RO	0.06	1983	BasicTech/Ham	
Florida	Sarasota(Camelot Lakes MHP)	MS	0.10			
Florida	Sarasota(Southbay Utilities)	RO	0.22	1976		Toyobo
Florida	Sarasota (Sun N Fun Resort)	RO	0.13			
Florida	St. Lucie West Services Dist.	MS	1.00	1988	Hydranautics	Hydranautics
Florida	St. Augustine (North Beach)	RO	0.17	1994	Hydranautics	Hydranautics
Florida	St. Augustine (Marineland)	RO	0.10	1972		
Florida	St. Augustine (Camanchee Cove Yt.)	RO	0.07			
Florida	Sebastian (Pelican Point Condos)	RO	0.08			
Florida	Venice (Plantation, Sarasota County)	RO	0.50	1984/90		Dow/Fluid Systems
Florida	Venice, City of	RO	4.00	1989	Ham/Emco	Fluid Systems
Florida	Venice (Carlton WTP)	EDR	12.00	1995	Ionics	Ionics
Florida	Venice (Venice Garden Utility Corp.)	RO	2.30	1984		Dow
Florida	Vero Beach (Indian River County)	MS	8.57	1994		Fluid Systems
Florida	Vero Beach (Indian River County)	RO	1.00	1985/92	Basic Tech.	Fluid Systems
Florida	Volusia County (Deland)	RO	0.50	1995	WET	
Florida	Wauchula	RO	1.30	1990		Filmtec
Florida	Wellington (Acme District)	MS	3.60	1990/96	PWT/Hydropro	Fluid Systems
Florida	West Basin	RO	1.50	1993	Ham RO	
Florida	West Palm Beach (P.Beach Co. Util.)	RO	14.00			
Florida	Number of Plants 90	Total	191.10			
Hawaii	Ewa Beach	EDR	1.00	1989	Ionics	Ionics
Hawaii	Kona (Kona Village Resort)	EDR	0.60	1975/79	Ionics	Ionics
Hawaii	Number of Plants 2	Total	1.60			
Illinois	Chenoa	RO	0.35	1992		Fluid Systems
Illinois	Darien (S.E.Regional Water Facility)	RO	0.86	1989	Osmonics	
Illinois	Kewanee	RO	1.50			
Illinois	Minonk	RO	0.23			
Illinois	Toluca, City of	RO	0.37	1992	Osmonics	
Illinois	Wenona, City of	RO	0.17			
Illinois	Wyoming, City of	RO	0.18			
Illinois	Number of Plants 7	Total	3.66			

APPENDIX 3 PLANT LIST BY STATE & BY PROCESS

State	Plant Location (Name)	Process	Capacity MGD	Start-up Year	Equipment Supplier	Membrane Manufacturer
Iowa	Alta Municipal Utilities	EDR	0.43	1995	Ionics	Ionics
Iowa	Laurens WTP	MS	0.35	1990	Coster Engr.	
Iowa	Manson Municipal WTP	RO	0.27	1992	Coster Engr.	
Iowa	Olds Water Supply	RO	0.03	1988	DESAL	
Iowa	Sibley WTP	RO	0.86			
Iowa	Sully, City of	RO	0.09	1988		Filmtec
Iowa	Washington, City of, Water Dept.	EDR	1.9	1993	Ionics	Ionics
Iowa	Number of Plants 7	Total	3.93			
Mississippi	Not stated	EDR	0.19	1993	Ionics	Ionics
Mississippi	Number of Plants 1	Total	0.19			
Missouri	Nevada, City of	RO	1.00	1984	Water Services	Dow/Filmtec
Missouri	Number of Plants 1	Total	1.00			
New York	Castle Point (VA Medical Center)	RO	0.25	1984		
New York	Not stated	EDR	0.58	1988	Ionics	Ionics
New York	Number of Plants 2	Total	0.83			
N.Carolina	Not stated	EDR	0.48	1993	Ionics	Ionics
N.Carolina	Rodanthe (Dare County WTP)	RO	1.00	1996	Amer.Engr.Svcs.	
N.Carolina	Fairfield (Hyde County)	RO	0.30	1994	Harn RO	
N.Carolina	Ocracoke, City of (Sanitary District)	RO	0.43	1977	Culligan/Harn RO	
N.Carolina	Number of Plants 4	Total	2.21			
N.Dakota	Grand Forks	MS	1.70	1996	Harn RO	
N.Dakota	Gwinner, City of	RO	0.36	1990	Osmonics	
N.Dakota	Number of Plants 2	Total	2.06			
Oklahoma	Oklahoma, City of	RO	0.75	1983	Graver	
Oklahoma	Foss, City of (Foss Reservoir MCD)	EDR	2.80	1974	Ionics	Ionics
Oklahoma	Number of Plants 2	Total	3.55			
Pennsylvania	Hastings, (Hastings Mun. Authority)	EDR	0.11	1988	Ionics	Ionics
Pennsylvania	Number of Plants 1	Total	0.11			
S.Carolina	Georgetown (Georgetown Co."Pauley's)	EDR	0.19	1991	Ionics	Ionics
S.Carolina	Not stated	EDR	0.36	1992	Ionics	Ionics
S.Carolina	Mt. Pleasant, City of (Waterworks)	RO	6.85	1991	Hydranautics	Hydranautics
S.Carolina	Palms Island, City of	RO	1.20	1993/94	Hydropro	Hydra./Fluid Sys.
S.Carolina	Number of Plants 4	Total	8.60			

APPENDIX 3 PLANT LIST BY STATE & BY PROCESS

State	Plant Location (Name)	Process	Capacity MGD	Start-up Year	Equipment Supplier	Membrane Manufacturer
Texas	Not stated	EDR	1.50	1996	Ionics	Ionics
Texas	Brazos River Authority	EDR	3.50	1988	Ionics	Ionics
Texas	Dell City	EDR	0.10	1975	Ionics	Ionics
Texas	Denison (Texoma Utility)	EDR	4.50	1992	Ionics	Ionics
Texas	El Paso (Haciendas Del Norte)	RO	0.05	1981		DuPont
Texas	Fort Stockton	RO	3.00			
Texas	Kennedy, City of	RO	0.30	1996	MEDRO	Hydranautics
Texas	Granbury (Lake Granbury WTP)	EDR	3.50	1989	Ionics	Ionics
Texas	Granbury (Oak Trail Shores)	EDR	0.14	1984	Ionics	Ionics
Texas	Robinson, City of	RO	2.00	1995	MEDRO	
Texas	Sherman, City of	EDR	4.50	1993	Ionics	Ionics
Texas	Number of Plants 11	Total	23.09			
Utah	Huntington	RO	0.35	1977	Aqua Media	
Utah	Number of Plants 1	Total	0.35			
Virginia	Culpepper	RO	0.20	1994	Harn RO	
Virginia	Suffolk (G.R.House Water Treat.Fac.)	EDR	3.75	11990	Ionics	Ionics
Virginia	Number of Plants 2	Total	3.95			
Washington	Coupeville, Town of	EDR	0.53	1978	Ionics	Ionics
Washington	Number of Plants 1	Total	0.53			
Puerto Rico	San Juan	SWRO	0.15	1982	Water Services	DuPont
Puerto Rico	Number of Plants 1	Total	0.15			
Virgin Islands	St. John (Caneel Bay)	SWRO	0.26			
Virgin Islands	St. John (Grand Hyatt Regency)	SWRO	0.34			
Virgin Islands	St. Thomas (Cowpet Bay East Assoc.)	SWRO	0.03			
Virgin Islands	St. Thomas (Cowpet Beach Resort)	RO	0.15			
Virgin Islands	St. Thomas (Limetree Resorts)	RO	0.11			
Virgin Islands	St. Thomas (Sapphire West Condos)	RO	0.43			
Virgin Islands	St. Thomas (Sapphire Hotel)	RO	0.04			
Virgin Islands	St. Thomas (Secret Harbor Beach Own)	RO	0.06			
Virgin Islands	St. Thomas (Stouffer's)	RO	0.03			
Virgin Islands	St. Thomas (Virgin Waters)	RO	0.03			
Virgin Islands	St. Thomas (Water Bay Mgt.)	RO	0.06			
Virgin Islands	St. Croix (VIWAPA)	HTME	3.60	1983/1993	IDE	
Virgin Islands	St. Croix (VIWAPA)	RO	0.25	1993	Amer. Engr. Svcs.	
Virgin Islands	St. Thomas (VIWAPA)	HTME	4.50	1981/83/92	IDE	
Virgin Islands	Number of Plants 14	Total	9.89			
Canada	Melville (Saskatchewan)	EDR	0.50	1990	Ionics	Ionics
Canada	Number of Plants 1	Total	0.50			