

SURVEY OF U.S. COSTS AND WATER RATES FOR DESALINATION AND MEMBRANE SOFTENING PLANTS

Water Treatment Technology Program Report No. 24



July 1997

**U.S. DEPARTMENT OF THE INTERIOR
Bureau of Reclamation
Technical Service Center
Water Treatment Engineering and Research Group**

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1216 Jefferson Davis Highway, Suit 1204, Arlington VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington DC 20603.				
1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE July 1997	3. REPORT TYPE AND DATES COVERED Final		
4. TITLE AND SUBTITLE Survey of U.S. Costs and Water Rates for Desalination and Membrane Softening Plants			6. FUNDING NUMBERS	
5. AUTHOR(S) Bureau of Reclamation			8. PERFORMING ORGANIZATION REPORT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Bureau of Reclamation Denver Federal Center P.O. Box 25007 Denver CO 80225-0007			10. SPONSORING/MONITORING AGENCY REPORT NUMBER Water Treatment Technology Program Report No. 24	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Bureau of Reclamation and National Water Research Institute				
II. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Available from the National Technical Information Service, Operations Division, 5285 Port Royal Road, Springfield VA 22161			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) This report is based on a survey by Leitner and Associates, Inc., of U.S. costs and water rates for utilities that use desalination and membrane softening. The report provides information on the following four processes: reverse osmosis for brackish/groundwater enhancement; brackish electro dialysis reversal; membrane softening; and seawater reverse osmosis/distillation.				
14. SUBJECT TERMS-- desalination/desalting/reverse osmosis/electrodialysis reversal/membrane softening/seawater reverse osmosis/distillation/brackish water/costs/water rates			16. NUMBER OF PAGES 45	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UL	18. SECURITY CLASSIFICATION OF THIS PAGE UL	19. SECURITY CLASSIFICATION OF ABSTRACT UL	20. LIMITATION OF ABSTRACT UL	

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Water Treatment Technology Program Report No. 24

Based on a survey by

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

For

**U.S. Bureau of Reclamation
and
National Water Research institute**

Water Treatment Engineering and Research Group
Technical Service Center
Denver, Colorado

July 1997

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Mission Statement***

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Researcher Acknowledgments

Leitner and Associates, Inc., express their thanks to the **Board** of Directors of the National Water Research Institute and the U.S. Department of the Interior, Bureau of Reclamation, for their support **of this** project; to the American Desalting Association for their endorsement and cooperation; to the state agencies and manufacturers for their assistance in locating existing potable water plants in order that they might be contacted; and to the respondents who devoted valuable time and effort in providing meaningful operating and cost data for their desalting and membrane softening plants.

Researcher Disclaimer

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.

ABBREVIATIONS

EDR	electrodialysis reversal
FAX	facsimile
GPD	gallons per day
IDA	International Desalination Association
MED	multi-effect distillation
MGD	million gallons per day
MS	membrane softening
MSF	multi-stage flash
NWSIA	National Water Supply Improvement Association
O & M	operation and maintenance
RO	reverse osmosis (brackish water)
SWRO	seawater reverse osmosis
THMFP	Trihalomethane formation potential
U.S.	United States
WTP	water treatment plant

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1 .0 INTRODUCTION

This report is based on a survey by Leitner and Associates, Inc., of U.S. costs and water rates for utilities that use desalination and membrane softening plants.

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, electro dialysis) 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, brackish **electrodialysis/electrodialysis** reversal, membrane softening, and seawater reverse osmosis/distillation-all of which are currently used in the U.S. to produce potable water for municipal use.

While the production of potable water by these four processes is minuscule (less than one half of one percent of the total potable water delivered in the U.S.), desalting is now recognized as having perhaps the greatest potential for growth of the known alternative water supplies. Costs for desalting in many applications have now moved from the realm of "expensive" to "competitive" with alternative sources of supply, depending upon site-specific conditions. Further, the difference between the cost of desalted water, or a blend with desalted water, and the cost of conventional supplies has narrowed substantially in the past 10 years. This is particularly true when a cost is assigned to withdrawing the diminishing resources from the ground (conventional groundwater supply).

Although desalting is competitive in many applications, the public generally has the misunderstanding that costs for desalting are never competitive, and this has delayed the full realization of this alternative water supply. One typical example of public misunderstanding is a recent situation in the greater Tampa-St. Petersburg, Florida, area where news media compared the cost of desalted seawater (\$4.00/1,000 gallons) with current residential rates for delivered water from well fields (\$1.43/1,000 gallons). Until a symposium was held, which was open to the public, the media neglected to report that the desalted water would be blended with water from the conventional sources. In this case, when desalted water is blended with water from conventional sources, the projected increase in cost to the average residential user went from \$11.44/month to \$14.44/month (only a 26-percent increase). However, greater benefit is realized from the additional water available to meet increased demand without depleting existing conventional groundwater supplies. Further, when the raw water source is brackish groundwater, the cost spread between conventional sources and desalted or blended water is even lower.

The need for publicity concerning accurate cost information for the desalting alternative is evident. The National Water Research Institute and the U.S. Bureau of Reclamation (Reclamation) elected to address this need by providing this survey and report.

1 .1 Project Objective

The project objective is to provide, by means of a survey of available sources, an update of U.S. costs and water rates for desalted water in the United States (including the U.S. Virgin Islands and the U.S. Navy base at Guantanamo Bay). For perspective, the survey includes data from 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 U.S. The U.S. Environmental Protection Agency provided a list of contacts of 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 department of water resources. 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, as identified by survey respondents, were also contacted (see appendix 2).

Publications were reviewed, including the *Water Desalination Report; the American Desalting Association Biennial Conference Proceeding*; and the *IDA Worldwide Desalting Plants Inventory, #I 4*, published by Wangnick Consulting in 1996.

Finally, a list of existing potable water desalting plants in the U.S. was prepared (see appendix 3). To complete the potable water desalting database (including plant names, addresses, telephone numbers, plant capacities, and names of principals), many telephone calls and contacts by FAX were made. Table 1 is a sample list, prepared from appendix 3, of potable water desalting plants in the U.S. and the one in Canada. A total of 180 plants were identified, including the large Reclamation reverse osmosis (RO) plant in **Yuma**, Arizona. For perspective, a few low-capacity plants (30,000-50,000 gallons per day [GPD]) were included in the list. Most of these small plants serve private condominiums, trailer parks, etc. Approximately 10 such small plants are not shown in the list.

1.1.2 Survey Questionnaires

Two survey questionnaires were used, as shown on pages 6 and 7—one for treatment plants operating on brackish water and the other for treatment plants operating on seawater, respectively. To encourage the recipients to respond and to minimize the time required to respond, the survey was limited to one page. A total of 195 survey questionnaires with transmittal letters were sent out. The transmittal letters stated that a copy of this completed final survey report would be sent to each respondent.

Table 1 .-Summary list of potable water desalting plants in
the U.S. and Canada
(See appendix 3 for detailed information)

State	Number of plants	Capacity (MGD) ¹
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
Total	179	299.21
Yuma	1	72.00

¹ Million gallons per day.

1.1.3 Response Rate

Seventy completed survey questionnaires were received in response to the survey mailings and **followup** telephone calls. When considering that completing a survey questionnaire would require several hours of time, this response rate is considered quite acceptable. The respondents can be assured they have made a substantial contribution to the development of the desalting plant industry.

1.1.4 Data Analysis and Recording

Of the 179 identified desalting plants in the U.S. and the one in Canada, data for 98 plants are reported herein—a combined response and reporting rate of 54 percent. Data from the 70 returned questionnaires were supplemented, when available, with information from equipment suppliers, membrane manufacturers, and literature and journals. In a few cases, plant owners or municipalities responded to a 1992 survey by the National Water Supply Improvement Association (NWSIA), but not to this survey. In those cases, the 1992 NWSIA responses were included in this report, listing the capital cost dollars for the year of construction and operation and maintenance (O&M) costs in 1992 dollars.

In sections 2.0 - 5.0 of this report, the plants are grouped by process in ascending order according to rated capacity, and listings are shown for each of the following reporting categories:

- . Process data
- . Capital costs
- . Operation and maintenance costs
- . Water rates

The process groups and the number of plants included in this report are as follows (*however, as shown in table I and appendix 3, the total number of desalting plants in the U.S. for the production of potable water is 179, and the number in Canada is 1*):

Brackish RO/groundwater enhancement	56
Brackish electrodialysis/electrodialysis reversal	17
Membrane softening	15
Seawater RO/distillation	10
Total	<hr/> 98

From this list of 98 plants for which data are reported, 4 to 7 plants were selected from each process category for case study comparisons of unit capital costs and unit O&M costs. The comparisons are shown in various tables in sections 6.0 - 9.0.

1.1.5 Followup Mailing

After the survey data were grouped and recorded, a second mailing was distributed with a copy of the appropriate process survey group data. Corrections were invited for entries that were added based on previous surveys, manufacturer or supplier information, or other sources. In a few cases, some minor changes were made. For those that had not responded previously, a second invitation for response was offered.

1.2 Summary

This survey examined the capital and O&M costs for potable water desalting plants in the U.S., and this report compares the several processes in commercial use for this service. This report looks at what is being charged for total water rates and supplementary impact and connection charges by those utilities using desalting plants. It also defines and examines emerging trends in desalting applications and construction for the benefit of those owners, municipalities, equipment and component suppliers, and consulting engineers already involved in this field or with projects under consideration.

Current raw water supplies for most areas in the U.S. are reasonably abundant. However, as shown in table 1, 19 States, Puerto Rico, and the Virgin Islands experience some limited regional water shortages and, as a result, desalination for potable water is now in use. The requirement for additional alternative water supplies will increase. For example, the U.S. population is projected to grow by 11 percent during the next 10 years, and the new Federal Clean Water Act mandates higher water quality standards for potable water. As a result of the growth and mandates, some heretofore substandard supplies will be brought into service using advanced water treatment technologies, including desalting, thus creating additional alternative water sources.

1.2.1 Significant Trends

Figure 1 shows the number of identified desalting plants in the U.S. and Canada as of August 1996 (180 total), grouped according to process. A comparable figure from the 1992 NWSIA survey is 144, a growth rate of 25 percent in 4 years, or an average growth of 6.25 percent per year.

Figure 2 compares the installed capacity in 1992 versus 1996. (The Yuma Desalting Plant is not included since there has not yet been a requirement for this plant to be placed in extended operation.) The 1992 total installed capacity in the U.S. for all desalting processes was 147 million gallons per day (MGD). In 1996, the total was 267 MGD, an increase of 81 percent in 4 years, or 20 percent per year.

Figure 2 also indicates brackish water RO showed a 75-percent increase over 4 years, or 18.75 percent per year. Brackish electro dialysis reversal (EDR) showed a 100-percent

A survey of capital costs, operating costs, and selling prices for potable water desalination plants in the United States

Plant data

Plant name: _____		Year of startup	Name of equipment mfg. and contractor
Address: _____	Plant type		
_____	Brackish RO _____		
_____	EDR _____		
Telephone: _____ Fax: _____	Softening _____		
Respondent: _____	Groundwater _____		
Title: _____	enhancement _____		

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 well pump on the same meter (Y/N)? _____
 Does power consumption include distribution power (Y/N)? _____

Selling prices

Annual sales (mil gal)	Monthly use (gal)	Selling price per 1,000 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, and selling prices for potable water desalination plants in the United States

Plant data

Plant name: _____		Year of startup _____	Name of equipment mfg. and contractor _____
Address: _____	Plant type _____		
_____	MED distillation _____		
_____	SWRO _____		
Telephone: _____ Fax: _____			
Respondent: _____			
Title: _____			

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

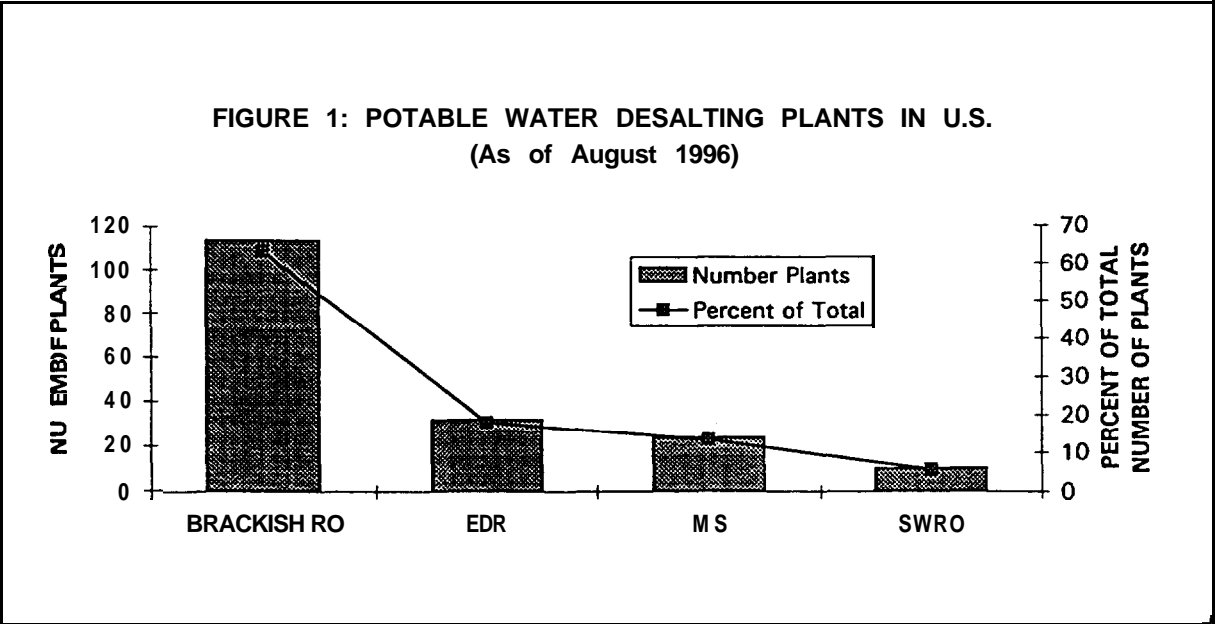
Does power consumption include well pump power (Y/N)? _____

Is well pump on the same meter (Y/N)? _____

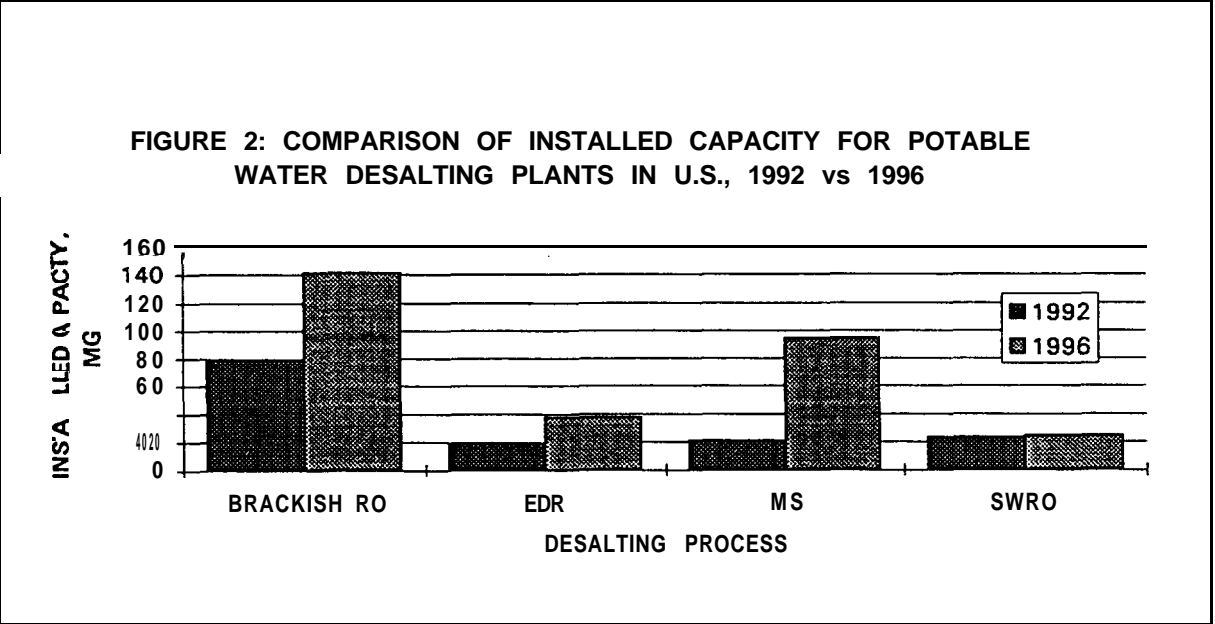
Does power consumption include distribution power (Y/N)? _____

Selling prices

Annual sales (mil gal)	Monthly use (gal)	Selling price per 1,000 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			



Figures 1 and 2



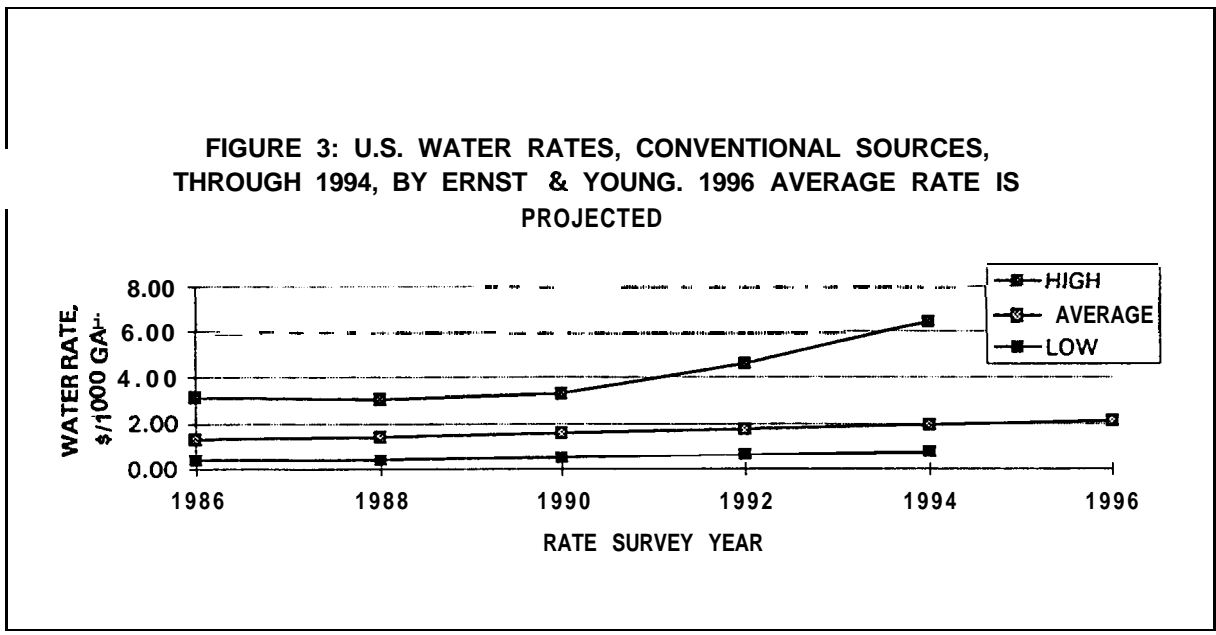
growth rate over the same period; however, its total is still only 29 percent of the installed capacity for brackish water RO. Seawater reverse osmosis (SWRO) in the U.S. has not grown in the last 4 years and has not been a significant factor in potable water supply.

Membrane softening had the largest growth rate, nearly 500 percent in 4 years, or 120 percent per year. This may be the most important finding from this survey. Membrane softening was originally targeted to reduce total hardness in groundwater or surface water; however, actual installations revealed several side benefits-these membranes can also remove trihalo-methane formation potential (THMFP) and color and reject bacteria, viruses, and dissolved organic carbons. The combined installation growth rate and additional benefits provides an opportunity for membrane softening to far surpass its original intended application.

1.2.2 Water Rate Comparisons

A survey of water rates for conventional sources by Ernst and Young showed a continuing trend toward rate structures that encourage conservation, such as seasonal rates and inverted volume charges in which costs rise with consumption. Our survey findings of water rates for those utilities using desalting plants indicate only 33 percent have inverted volume charges.

Figure 3 was prepared from the findings in the Ernst and Young report through 1994. For comparison purposes, the average rate for 1996 was projected and included. The Ernst and Young report is based on responses from 159 utilities serving the 100 largest metropolitan areas in the U.S. and shows the average monthly charges for a typical residential customer increased 5.2 percent 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 2 to 3 years."



1.2.3 Connection Charges and Impact Fees

With a few exceptions, significantly the SWRO plants in the Virgin Islands, no attempt is made by the desalting water utilities to recover capital costs as a part of the water rates. Instead, capital costs for government-owned utilities are paid 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.

2.0 SURVEY DATA, BRACKISH WATER RO/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 (table 2)
- Capital costs (table 3)
- Operation and maintenance costs (table 4)
- Water rates (table 5)
- Connection charges and impact fees (table 6)

Table 2.—Brackish RO/groundwater enhancement process data

Plant name/owner	Rated capacity (GPD)	Annual production (gal)	Quantity of water added (GPD)	Feed salinity (mg/L)	Product salinity (mg/L)	Product recovery (%)	Cost of electrical power (\$/kWh)
Grove City, FL (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, FL (Bocilla Utilities)	30,000	7,000,000	0	2,700	80	60	0.068
Olds Water Supply (Iowa)	34,560		17280			50	
Sarasota, FL (Lake Tippicanoe)	40,000	14,500,000	5,660,000	680	180	74	0.085
Nokomis, FL (Bay Lakes Estates)	50,000	10,950,000		50			1 meter
El Paso, TX (Haciendas Del None)	50,000	10,000,000	20,000,000	1,600	450	80	0.018
Sarasota, FL (Myakka River St Park)	50,000						
Nokomis, FL (Kings Gate Club)	60,000	14,000,900	5,000	900	119	73	
Ormond Beach, FL (Kingston Shores)	60,000	9,125,000	None	7,000		95	750/mo
Sarasota, FL (Windward Isle MHP)	60,000	12,700,000	8,500	350	17	64	
Melbourne, FL (Service Mgt Systems)	80,000	5,400,000	4,000				0.049
Sully, IA	90,000						
St. Augustine (Marineland, Inc.)	100,000	16,400,000	0	6,500	400	50	0.067
Osprey, Hastings, Florida WTP	221,000		10%			70	
Osprey, FL (Southbay Utilities)	225,000	48,900,000	NA	1,100	47	50	0.065
Lutz, FL (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	2,208/mo
Castle Point (VA Medical Center)	250,000	25,000,000					
Texas, Cii 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	8,600,000	94,000	1,540	480	70	0.075
Indian River City, Stuart, FL	400,000	43,000,000		2,000			
N. Carolina (Ocracoke Sanitary Dist)	430,000	50,204,000		3,600	400	50	0.82
Harbor Hts, FL (Charlotte Harbor)	450,000	120,000,600	10%	700	160	75	
Fairfield, NC, Hyde County WTP	500,000			500	160	80	5,000/mo
City of Tustin, CA	500,000	179,400,000	650,000			93	0.08
Ewa Beach, Hawaii	500,000	1,825,000	125,000	600	40	40	0.135
Rotunda West, FL	500,000	146,000,000		3,500			
Venice, FL (Sarasota Co Plant)	500,000	62,000,000		2,500	80	54	
Nokomis, FL (Sorento)	680,000	107,000,000 EDR	300,000	3,000		60	0.08
Gasparilla Island Water, FL	750,000	192,000,000	210,000	3,700	80	75	0.073
Dare County, NC, 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
Cii of Wauchula, FL	1,310,000	313,991,000	NA			a 4	0.078
Jasper, Florida WTP	1,400,000	18,000,000					
Pine Island, FL WTP	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	.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, NC, RO Water Plant	3,000,000	503,748,000	56,044,000	3,450	395	75	0.03775
Darien, IL (SE Reg Water Fac)	3,200,000	435,000,000	40%	800	300	75	0.075
Riverside, CA (SAWPA Ad)	4,000,000	1,200,000,000	2,000,000	1,050	400 blend	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. Slate Util)	4,000,000	780,000,000	2,000,000	4,400	90	90	21,375/mo
Sarasota, FL	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, FL	5,000,000	1,800,000,000	1,500,000 (peak)			80	
Fountain Valley, CA (Wat Fact 21)	6,000,000	1,800,000,000		1,000	25	a 5	0.072
Jupiter, FL WTP	6,000,000	821,000,000	9,629,000	2,000	205	75	0.059
Mount Pleasant, SC WTP	6,850,000	1,709,013,000	1,370,000	190	50	84	0.05
Chesapeake, VA WTP	10,900,000	Startup in 1998					
Cape Coral, 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

Table J.-Brackish RO/groundwater enhancement capital costs
(\$)

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 Dii)	245,000	80,000	600,000				925,000
Englewood, FL (Bocilia 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 . m	171,000
Sarasota, FL (Windward Isle MHP)	16,000	41,000	6,000	1,000		3,000	67,000
Melbourne, FL (Service Mgt Systems)	48,519	1,579,047	230,861			143,905	2,002,332
Sully, IA							
St. Augustine (Marineland, Inc.)							
Osprey, Hastings, Florida WTP							1,000,000
Osprey, FL (Southbay Utilities)							2,187,100 ¹
Lutz, FL (Holiday Pines Service Corp)	42,890	251,761	92,849	219,839	65,513	327,102	999,954
Pumta Gorra (Burnt Store SSU)							
Castle Point (VA Medical Center)							
Texas, City of Kennedy WTP	414,9182	349,000	285,000	18291	6,000	10,000	1,083,209
Iowa, Manson Water Plant	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 City, Stuart, FL	<100,000	1,400,000	59,000	94,000	Negligible	375,000	1,653,000
N. Carolina (Ocracoke Sanitary Dist)	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		2,432,74	634,698	2,248,330
Dare County, NC, Rodanthe WTP	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 Vem Beach, FL	34,000,000	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, NC, RO Water Plant	3,329,505	1,899,738	1,291,560	1,640,000	121,400	1,603,639	10,444,956
Darien, IL (SE Reg Water Fac)							5,000,000
Riverside, CA (SAWPA Art)	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, FL	6,500,000	1,795,000	875,000				9,170,000
Sanibel Island Water Assn. (FL)							
Melbourne, FL	8,600,000	2,840,000	510,000	1,000,000	830,000		13,780,000 ⁶
Fountain Valley, 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, SC WTP							9,200,000
Vem Beach, FL (Indian River Co)	1,230,000	5,560,000	500,000		81,500		7,290,000
Chesapeake, VA WTP	Startup in 1998						
Cape Coral, 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

Current replacement cost.

² Includes erection, piping for wells.

³ Annual depreciation.

⁴ Building cost included in plant equipment cost.

⁵ Plus product lines and disposal, \$5,746,035.

⁶ Engineering not included.

⁷ Not including engineering, waste water reclamation, injection barrier facilities, product rec. wells

Table 4.—Brackish RO/groundwater enhancement operation and maintenance costs (\$)

Plant name/owner	Power required (kWh)	Annual power cost	Personnel (number)	Annual personnel cost	Annual parts/chem cost	Replacement membrane cost	Total annual costs	(*)
Grove City, FL (Seaside Service Sys)							60,000	N
Santa Ana (Irvine Ranch Water Dist)	28.0	20,000	2	80,000	39,500	3,000	142,000	Y Y N
Englewood, FL (Bocillia Utilities)	2rwday	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 Park)		5,668	1		7,070	10,500		
Nokomis, FL (Kings Gate Club)								
Ormond Beach, 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 Systems)		27,000	2	24,500	Contracted	2,500	54,000	Y N Y
Sully, IA		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	93,840	Y N A Y
Osprey, Hastings, Florida WTP		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 Service Corp)	35	21,000	1	24,000	21,000		66,000	Y Y Y
Punta Gorda (Burnt Store SSU)		26,505	2		28,431			
Castle Point (VA Medical Center)			2	80,000	20,000			Y Y Y
Texas, City of Kennedy WTP		70,760 ²	2	35,000	22,055	1,924	129,740 ³	Y Y Y
Iowa, Manson Water Plant		39,139	1	1,800	25,245		73,385	Y Y N
Toluca, Illinois RO Plant	50							Y Y Y
Indian River City, Stuart, FL		55,000			22,000			
N. Carolina (Ocracoke Sanitary Dist)	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, NC, Hyde County VVTP		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 Plant)								Y Y Y
Nokomis, FL (Sorento)		100,000	2	60,000	31,000	200,000	391,000	N N Y
Gaspanilla Island Water, FL	103	65,868	4	107,850	34,000		207,718	Y N N
Dare County, NC, Rodanthe WTP								
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		1	25,000				Y N Y
Jasper, Florida 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 (SE Reg Water Fac)		232,901	13 ⁶	416,000	222,000	35,000	905,901	Y Y Y
Riverside, CA (SAWPA Art)	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	1,500	445,898	15	307,900	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	1,150	530,000	15	701,636	634,727		1,866,363	N N Y
Sanibel Island Water Assn. (FL)		238,895					634,486	Y N N
Melbourne, FL	1,104		8		142,836			Y Y Y
Fountain Valley, CA (Wat Fact 21)	1,375	867,240	1	38,004	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, SC WTP		530,000	8	351,644	396,400	0	1,795,468	Y Y Y
Vero Beach, FL (Indian River Co)		240,000	12	201,000	150,000	99,000	690,000	Y Y Y
Chesapeake, VA WTP	Startup in 1998							
Cape Coral, 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

Note: (*) = 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)?

¹ Includes distribution.

² O&M casts for 9 months.

³ Power consumption estimated researcher.

⁴ Includes well pump motors.

⁵ Estimated, not yet on line.

⁶ Includes support personnel.

⁷ Does not include pretreatment.

Table 5.—Total water rates for utilities using some brackish RO/groundwater enhancement volume charges
(\$/1,000 gallons^{1,2})

Plant name	Residential water usage, thousands of gallons per month									
	1	2	3	5	10	30	40	50	60	
Grove City, FL (Seaside Service Sys)	2.75									
Santa Ana (Irvine Ranch Water Dist)	NA (pilot plant)									
Englewood, FL (Bocilla Utilities)	3.32 up to 6,000 G/Mo		5.60 for 6-12,000 G/Mo			0.95 for use above 12,000 G/Mo				
Olds Water Supply (Iowa)	3.50									
Sarasota, FL (Lake Tippicanoe)	NA (indudad in monthly condo fee)									
Nokomis, FL (Say Lakes Estates)	NA									
El Paso, TX (Haciendas Del Norte)	1.00 average									
Sarasota, FL (Myakka River St Park)	NA									
Nokomis, FL (Kings Gale Club)	NA									
Ormond Beach, FL (Kingston Shores)	NA (part of maintenance fee)									
Sarasota, FL (Windward Isle MHP)	4.59 for 5 customers. For residents, charge indudad in other fees.									
Melbourne, FL (Service Mgt Systems)	2.91									
Sully, IA						3.20 + 2.25 + 2.00				
St. Augustine (Marineland, Inc.)	NA									
Osprey, Hastings, Florida WTP	4.95									
Osprey, FL (Southbay Utilities)	5.30									
Lutz, FL (Holiday Pines Service Corp)	3.05									
Pumta Gorrrda (Burnt Store SSU)	1.23									
Castle Point (VA Medical Center)	NA									
Texas, City of Kennedy WTP	7.50 (for use above 2,000 G/Mo, charge is \$1 .50/1 ,000 gal)									
Iowa, Manson Water Plant	7.00 (for use above 1,000 G/Mo, charge is \$2.30/1 ,000 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 Sanitary Dist)	5.50		7.50	8.50	9.50		10.50			
Harbor Hts. FL (Charlotte Harbor)	14.10	7.75	5.60	3.75						
Fairfield, NC, Hyde County WTP	4.00									
City of Tustin, CA		0.44								
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	16.75		3.75		4.00	5.00				
Dare County, NC, Rodanthe WTP	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									
Pine Island, FL WTP	2.75		3.30							
Englewood Water District, FL	1.60			2.40	4.60					
City of Vero Beach, FL	3.65		2.21			4.42		5.53		
Chandler, AZ RO Facility										
Dare County, NC, RO Water Plant	5.67				4.50					
Darien, IL (SE Reg Water Fac)	2.66									
Riverside, CA (SAWPA Art)	1.30									
Santa Ana (Irvine Ranch Water)										
Venice, FL	2.64									
Marco Island, FL (S. State Util)	3.21									
Sarasota, FL	2.14				2.93	3.72				
Sanibel Island Water Assn. (FL)	2.60					5.55				
City of Melbourne, FL										
Fountain Valley, CA (Wat 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 1996									
City of Cape Coral, FL	1.75			1.05	2.35	2.85		3.35	3.65	
Yuma Desalting Plant										

¹ Refer to table 2 for quantity of Mended water added.

² No attempt has been made to put these data on a common basis.

Table 6.—Connection charges and impact fees for utilities using some brackish RO/groundwater enhancement (\$^{1,2})

Plant name/owner	Annual sales (mil/gal)	Basic facility charge	Sewer basic facility charge	Sewer volume charge (\$/1,000 gal)	Gen and admin new account	Connect	Impact fees
Grove City, FL (Seaside Service Sys)	3.9	22.0/mo				3.750	
Santa Ana (Irvine Ranch Water Dist)		NA (pilot plant)					
Englewood, FL (Bocilia Utilities, Inc.)	7.0	31.33				4.300	
Olds Water Supply (Iowa)							
Sarasota, FL (Lake Tippicanoe)		NA (included in monthly condo fee)					
Nokomis, FL (Bay Lake-s Estates)		NA					
El Paso, TX (Haciendas Del Norte)	100					100	
Sarasota, FL (Myakka River St Park)							
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, FL (Service Mgt Systems)	0.25	8.81/mo				805	
Iowa. Cii of Sully	32.21	17.50/quarter					
St. Augustine (Marineland, Inc.)							
Osprey, FL (Hastings WTP)	0.22						
Osprey, FL Southbay Utilities	41.6		545			925	
Lutz, FL (Holiday Pines Service Corp)	46.0	26.29/mo					
Punta Gorda (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 1,000 gal. 0.40/1,000 gal thereafter			
Toluca, Illinois RO Plant	66.0	3.33/mo					
Indian River City, Stuart, FL						1,000	
N. Carolina (Ocracoke Sanitary Dist)	502					2003	3,612 ³
Harbor Ms. FL (Charlotte Harbor)	0.56						
Fairfield, NC, Hyde County WTP	150.0 ⁴					400	
City of Tustin, CA	225.0	5.01/mo ⁵					
Ewa Beach, Hawaii (also have EDR)							
Rotunda West, FL							
Venice, FL (Sarasota Co Plant)							
Nokomis, FL (Sorento) (also have EDR)							
Gasparilla Island Water, FL	225.0			21.50/mo	60	3,919 (water) 1,796 (sewer)	2,942 ⁶
Dare County, NC, Rodanthe WTP	77.5 est.						
City of Nevada, MO	316.6					50	
North Beach (Wabasso, FL)	109.5						1.571
Cii of Wauchula, FL	250.0						
Jasper, Florida WTP	168.0		400	1.95/1,000 gal			300
Pine Island, FL WTP	315.1					1,294	
Englewood Water District, FL	400.0						1.660
City of Vero Beach, FL	655.0		1,330				1.016
Chandler, AZ RO Facility							
Dare County, NC, RO Water Plant	462.1						2.9426
Darien, IL (SE Reg Water Fac)	435.0					630	
Riverside, CA (SAWPA Ad)	1,800.0					430	
Santa Ana (Irvine Ranch Water)							
Venice, FL		6.35		3.37/1,000 gal			
Marco Island, FL (S. state Util)	720.0	Yes	Yes				
City of Sarasota, FL	950.0	6.64 ⁷					
Sanibel Island Water Assn. (FL)	910.0	11.00					2.175
City of Melbourne, FL							
Fountain Valley, CA (Wat Fact 21)							
Town of Jupiter, FL (WTP)	621.0						1.634
Mount Pleasant, SC WTP	1,429.6	3.26 ⁸	1.452				1.263
Chesapeake, VA WTP	Startup in 1998						
City of Cape Coral, FL	2,620.0	7.65	5.75	3.05	15		
Yuma Desalting Plant							

¹ Refer to table 2 for quantity of blended water added.

² No attempt has been made to put these data on a common basis

³ 3/4 in. meter. 3 bedrooms. 2.5 baths.

⁴ Production estimated by editor.

⁵ 3/4 in. meter, includes debt service.

⁶ 3/4 in. meter.

⁷ 5/8 in. meter.

⁸ 5/8 in. meter.

3.0 SURVEY DATA, BRACKISH EDR

All the brackish electro dialysis plants listed in the survey are EDR processes which were 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 (table 7)
- Capital costs (table 8)
- Operation and maintenance costs (table 9)
- Water rates (table 10)
- Connection charges and impact fees (table 11)

Table 7.—Brackish EDR process data

Plant name/owner	Rated capacity (GPD)	Annual production (gal)	Quantity of water added (GPD)	Feed salinity (mg/L)	Product salinity (mg/L)	Product recovery (%)	cost of electrical power (\$/kWh)
Kona Village Resort, Hawaii	30,000	11,900,000	None	1,600/4,000	250	60	0.11
Dell City, Texas	100,000	12,900,000	120,000	3,900	500	45	40/day
Georgetown, S. Carolina	190,000 ¹	34,800,000	50,000	956	347	65	0.104-.073
Granbury, Texas WTP	300,000 ²	47,500,000		600	47		0.098
Nokomis, FL (Sorento)	300,000	60,000,000	340,000(RO)	3,000	350	80	700/mo
Alta, Iowa WTP	432,000	75,500,000		1,200	340	85	0.078
Melville, Saskatchewan, Canada	500,000	184,000,000	325,000	1,900	600	80	0.135
Ewa Beach, Hawaii	500,000	66,430,000	125,000	600	40	70	
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(?)	3,000/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	

¹ Annual production, based on rated capacity (190,000 GPD) with unit operating at an average 0112 hours/day.

² Three-year average.

Table 8.—Brackish EDR capital costs
(\$)

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, SC 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	160.80	1,868,000
Ewa Beach, Hawaii	2,968,000	2,039,000	616,000	422,000	77,000	0	6,386,000
Coupsville, Town of (WA) WTP						264.00	Approx. 750,000
Yuma Proving Ground (AZ)			Not included			0	2,200,000
Buckeye, Town of (AZ) WTP							1,050,000
Washington, City of (Iowa) WTP	280,000	1,212,600					1,807,000
Foss Reservoir, Oklahoma			Not included	Not included			
Lake Granbury, Texas WTP	3,900,000	2,200,000	32,000	600,000	230,000	315.00	6,100,000
Sherman, City of (TX)	2,000,000	3,000,000	8,000,000			0	13,000,000
Venice, FL (City of Carlton)							97,000,000

Table B.—Brackish EDR operation and maintenance costs
(\$)

Plant name/owner	Power required (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, TX		8,352	1	36,000	1,500	5,000	50,852	N N Y
Georgetown, SC 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	

Note: (*) = 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)?

¹ Yuma Proving Ground, kWh/yr includes nonpotable system distribution for irrigation use. This system is separate from the potable system and pumps approximately 250 million gallons per year.

Table 10.—Total water rates for utilities using some brackish EDR volume charges
(\$/1,000 gallons³)

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 Coupsville, WA WTP	5.51 in town, in season. 6.26 out of town, in season 3.66 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)										

¹ Refer to table 7 for quantity of blended water added

² No attempt has been made to put these data on a common basis.

Table 11.—Connection charges and impact fees for utilities using some brackish EDR
(\$^{1,2})

Plant name/owner	Annual sales (mil/gal)	Basic facility charge	Sewer basic facility charge	Sewer volume charge (\$/1,000 gal)	Gen and admin new account	Connect	Impact fees
Kona Valley 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	164					80.00	10.50/mo
Ewa Beach, Hawaii							
Town of Coupsville, WA WTP	77	13.00/mo (inside city limits, \$20.00/mo outside city limits)					
Yuma Proving round	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						

¹ Refer to table 7 for quantity of blended water added.

² No attempt has been made to put these data on a common basis.

4.0 SURVEY DATA, MEMBRANE SOFTENING

In the 1992 NWSIA survey, there were 7 respondents for membrane softening and, in our survey, there are 1.5 respondents. The larger number of respondents significantly improves the database. A separate tabulation is shown for each of the following:

- . Process data (table 12)
- . Capital costs (table 13)
- . Operation and maintenance costs (table 14)
- . Water rates (table 15)
- . Connection charges and impact fees (table 16)

Table 12.—Membrane softening process data

Plant name/owner	Rated capacity (GPD)	Annual production (gal)	Quantity of water added (GPD)	Feed salinity (mg/L)	Product salinity (mg/L)	Product recovery (%)	Cost Of electrical 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		a5	74	0.04
St. Lucie West Services Dist (FL)	1,000,000	70	0	500	170	a5	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)	8,500,000	1,520	16%	442/990	268	83	0.06
Fort Meyers, 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	

Table 13.—Membrane softening capital costs
(\$)

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					235,000
Laurens, Iowa, WTP							1300,000
St. Lucie West Services Distl (FL)		2,340,000 ¹				4,660,000	7,000,000
Village of Royal Palm Beach, FL	266,500	3,571,500	750,000		68,000	50,000	4,708,000
Wellington, FL (Acme Imp. District)	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 ¹				4,680,000	12,200,000
Miramar, FL		7,650,000 ¹				4,650,000	12,300,000
Vero Beach, FL (Ind. River Co.)	1,230,000	5,560,000 ²	500,000	Inc. pit. equip.	81,500	Inc. pit. equip.	7,290,000
Dunedin, Cii of (FL)	950,000						11,132,000
Fort Meyers, City of (FL)							14,200,000
Naples, FL (N Collier County)							26,000,000
Plantation, FL							
Hollywood, Cii of (FL)							18,000,000

¹ Bergman, R.A. 'Florida. A Cost Comparison Update. Membrane Softening vs. lime Softening,' *The International Desalination & Water Reuse Quarterly*, November/December 1995.

² Bolin, L. 'City of Dunedin, Florida, RO Water Treatment Facility,' *The International Destination & Water Reuse Quarterly*, February/March 1996.

Table 14.—Membrane softening operation and maintenance costs
(\$)

Plant name/owner	Power required (kWh)	Annual power cost	Personnel (number)	Annual personnel cost	Annual parts/chem cost	Replacement membrane cost	Total annual costs	(*)
Palm Beach, FL Bank of Commerce								
Alta, Iowa WTP		17.3%	1	45,141	26,283		88,819	Y N Y
Laurens, Iowa, WTP	77	15,744	1.5	65,110	30,229		111,083	Y Y Y
St. Lucie West Services District ¹		40,800	4					Y Y Y
Village of Royal Palm Beach, FL	89	23,000	1	79,500	12,400		114,900	Y N Y
Wellington, FL (Acme Imp. District)			8					NNN
Indian River County South	405	195,129	7	182,000	160,000		540,000	Y Y Y
Boynton Beach, FL ¹								
Miramar, FL ¹								
Vero Beach, FL (Ind. River Co.)		240,000	12	201,000	150,000	99,000	690,000	Y Y Y
Dunedin, City of (FL)	797	419,750 ¹	12	392,375	414,275	175,200	1,983,775 ¹	
Fort Meyers, Cii of (FL)	5%	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, Cii of (FL)								

Note: (*) = 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)?

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

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

³ Annual cost for debt service of 5582,175 included in total annual costs.

Table 15.—Total water rates for utilities using some membrane softening volume charges
(Yl .000 gallons^{1,2})

Plant name	Residential water usage, thousands of gallons per month									
	1	2	3	5	10	30	40	50	60	
Palm Beach, FL Bank of Commerce						2.00				1.50
Alta, Iowa WTP				2.30	1.90	1.80	1.70			
Laurens, Iowa STP	3.53									
St. Lucie West services District ²										
Village of Royal Palm Beach	1.60 (plus 150% of gallonage rate per 1,000 gallons used in excess of authorized. Single family. 18,000 gal/mo.									
Acme Improvement District										0.94
Indian River County South			1.75	2.15						
Boynton Beach ³										
Miramar ³										
Vero Beach, FL (Ind. River Co.)	1.75		2.15		2.55					
City of Dunedin, FL	2.35			3.50		5.30	(4)			
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									

¹ Refer to table 12 for quantity of blended water added.

² No attempt has been made to put these data on a common basis.

³ Bergman, R.A. 'Florida. A Cost Comparison Update. Membrane Softening vs. Lime Softening.' *The International Desalination & Water Reuse Quarterly*, November/December 1995.

⁴ Bolin, L. 'City of Dunedin, Florida. RO Water Treatment Facility.' *The International Desalination & Water Reuse Quarterly*, February/March 1996.

Table 16.—Connection charges and impact fees for utilities using some membrane softening
(^{\$}^{1,2})

Plant name/owner	Annual sales (mil/gal)	Basic facility charge	Sewer basic facility charge	Sewer volume charge (\$/1,000 gal)	Gen and admin new account	Connect	Impact fees
Palm Beach, FL Bank of Commerce							
Alta, Iowa WTP	80	6.90/mo					
Laurens, Iowa STP	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	(3)			Revenue bon& plus some impact fees		
City of Fort Myers	2,086						
North Collier County WTP	2.313		(Vol. charge 1-10,000 gal/mo. 51.75; 10,000-20,000, \$220; above 20,000. \$2.75)				900
Plantation, FL							
City of Hollywood, FL							

¹ Refer to table 12 for quantity of blended water added.

² No attempt has been made to put these data on a common basis.

³ Bolin, L. 'City of Dunedin, Florida. RO Water Treatment Facility.' *The International Desalination & Water Reuse Quarterly*, February/March 1996.

5.0 SURVEY DATA, SWRO AND DISTILLATION

This list is composed of 10 plants and includes significant cost reporting for the 6.7-MGD SWRO plant in Santa Barbara, California. The 3-MGD SWRO plant in Key West, Florida, built in 1981, has been upgraded and maintained for use in event of an emergency at this remote location. A response was **also** received for the 8.1 -MGD (total) multieffect distillation (MED) plant in St. Thomas and St. Croix, Virgin Islands. A separate tabulation is shown for each of the following:

- . Process data (table 17)
- . Capital costs (table 18)
- . Operation and maintenance costs (table 19)
- . Water rates (table 20)
- . Connection charges and impact fees (table 21)

Table 17.—SWRO and distillation process data

Plant name/owner	Rated capacity (GPD)	Annual production (gal)	Quantity of water added (GPD)	Feed salinity (mg/L)	Product salinity (mg/L)	Product recovery (%)	Cost of electrical power (\$/kWh)
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	0.06
Marina Coast Water District (CA)	260,000	98.0 ⁽¹⁾		25,000	300	40	0.10
Santa Catalina Island (CA)	332,000					30/33	0.10
Morro Bay, CA	864,000	315.0 ⁽²⁾		31,000	270	40	0.08
Key West, Florida RO Plant	3,000,000			38,000	300	34	0.10
Santa Barbara, City of (CA)	6,700,000			34,000	300	45	0.05
Virgin Islands Water & Power Auth.		(4)					
St. Thomas	4,450,000						
St. Croix	3,650,000						
Total	8,100,000	2,621.0		37,000	50	NA	Electric 0.077 Steam 2.56

¹ Santa Catalina Island: Additional data for this plant were provided by '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 Middle Ranch Reservoir. The supply from the reservoir has been curtailed because of 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 reports 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 65 percent 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).

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.

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.

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.

Table 18.—SWRO and distillation capital costs (\$)

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. 970,000	230,000
Marina Coast Water Dist. (CA)	250,000	960,000	150,000	20,000	15,000		2,500,000
Santa Catalina Island (CA)						(1)	2,400,000
Mono Say, City of CA	100,000 (2)	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. St. Thomas			(4)				
St. Croix							
Total							57,751,695

¹ Santa Catalina Island: Additional data for this plant were provided by '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 Middle Ranch Reservoir. The supply from the reservoir has been curtailed because of 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 reports 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 65 percent 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).

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.

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.

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.

Table 19.—SWRO and distillation operation and maintenance costs
(\$)

Plant name/owner	Power required (kWh)	Annual power cost	Personnel (number)	Annual personnel cost	Annual parts/chem cost	Replacement membrane cost	Total annual costs	(*)
Stouffers Hotel, V.I.								
Monterey Bay, CA Aquarium	50			40,000	20,000			N N N
Sapphire Beach Hotel, V.I.								
San Simeon Hearst Castle								
Marina Coast Water District, CA	720	144,000 ⁽¹⁾	2	80,000	12,000	4,000	240,000	Y N N
Santa Catalina Island, CA		(2)					188,000 est.	
Mono Bay, City of							1,052,000	Y N N
Key West, Florida RO Plant	3,171	1,889,422 ²		362,992	102,452	418,837	2,763,633 est.	
Santa Barbara, City of							7,650,000 est.	
Virgin Islands Water & Power Auth.		(5)						
St. Thomas								
St. Croix								
Total								

Note: Questions: 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)?

¹ Santa Catalina Island: Additional data for this plant were provided by "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).

² City of Morro Bay total annual costs were based on full capacity with 30-day down time.

³ 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.

⁴ 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.

⁵ The seawater desalination units at St. Thomas and St. Croix, Virgin Islands, are of the multi-effect distillation type (MED). Answers were supplied by I.D.E. Technologies, Ltd.

Table 20.—Total water rates for utilities using some SWRO and distillation volume charges
(\$/1,000 gallons²)

Plant name	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 Dist. (CA)	2.60								
Santa Catalina Island (CA) ³	8.00								
City of Morro Bay (CA) ⁴			7.33		7.42		7.67	6.37	
Key West, Florida RO Plant ⁵	10.49								
City of Santa Barbara ⁶	2.20 to 4.45								
Virgin Islands Water & Power Auth. St. Thomas		m							
St. Croix									
Total	15.96	17.90							

¹ No blending.

² No attempt has been made to put these data on a common basis.

³ Santa Catalina Island: Additional data for this plant were provided by "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 65% 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).

⁴ City of Morro Bay total annual costs were based on full capacity with 30-day down time.

⁵ 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.

⁶ 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. This is a SOOT plant.

⁷ 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.

Table 21.—Connection charges and impact fees for utilities using some SWRO and distillation
(\$^{1,2})

Plant name/owner	Annual sales (mil/gal)	Basic facility charge	Sewer basic facility charge	Sewer volume charge (\$/1,000 gal)	Gen and admin new account	Connect	Impact fees
Stouffers Hotel, V.I.							
Monterey Bay Aquarium (CA)	8						
Sapphire Beach Hotel, V.I.							
San Simeon Hearst Castle, CA							
Marina Coast Water District, CA	60						3,000
Santa Catalina Island, CA							
City of Morro Bay, CA	315		Yes			Yes	
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						

¹ No blending

² No attempt has been made to put these data on a common basis.

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

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

- Key elements for process data (table 22)
- Table, capital cost components, and total (table 22)
- Table, operation and maintenance cost components, and total (table 23)

Table 22.—Selected brackish RO/groundwater enhancement plants¹

Plant name, location	Process data									
	Bocilla Utilities, Inc. Englewood, FL	Southbay Utilities, Osprey, FL	City of Toluca, IL	Ocracoke Sanitary District 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, MGD	0.03	0.225	0.375	0.43	1	2	4	4.5	6	15
Annual product, mil gal	7.00	48.90	86.00	50.20	109.50	655.0	1 800.00	950.00	821.00	2,620.00
Total prod.+blend, MGD	7.00	48.90	1 08.00	50.20	109.50	655.0	2,700.00	2,533.00	2,135.00	2,882.00
Feed salinity, mg/L	2,700	1,100	1,540	3,600	1,800	1,200	1,100	2,000	2,000	1,500
Recovery, %	60	47	70	50	75	85	76	60	75	80
Year of startup	1985	1976	1992	1977	1965-92	1992	1990	1982	1990	1976-84
	Capital costs									
Building, \$ (1,000s)	40		40	200		3,400	3,650	6,500	2,400	
Plant equipment	120		300	1,700		2,500	3,700	1,795	4,800	
Wells or feed intake	49		175	203		810	450	075	2,760	
Product tanks	120		45	352						
Brine disposal	10		25			400	3,600 ⁽³⁾	1,124		
Other costs	42	(2)						1,000	(2)	
Total capital costs \$ (1,000s)	381	2,187	585	1,762	1,311	7,110	11,400	9,170	12,084	24,000
(See footnotes.)										

¹ No attempt has been made to put these data on a common basis.

² Southbay Utilities and city of Cape Coral capital costs are current replacement costs.

³ SAWPA annual capital debt service, \$985,000, not included above.

Table 23.—Selected brackish RO/groundwater enhancement plants¹

Plant name, location	Cost profile									
	Bocilla Utilities, Inc. Englewood, FL	Soulhbay Utilities, Osprey, FL	City of Toluca, IL	Ocracoke Sanitary District Ocracoke, NC	North Beach Wabasso, FL	City of Vero Beach, FL	SAWPA Arlington Riverside, CA	City of Sarasota, FL	Town of Jupiter, FL ²	City of Cape Coral, FL
Rated capacity, MGD	0.03	0.225	0.376	0.43	1	2	4	4.5	6	15
Annual product, mil gal	7.00	46.90	66.00	60.20	109.50	656.00	1,800.00	950.00	821.00	2,620.00
Total prod.+blend, MGD	7.00	48.90	108.00	50.20	109.50	655.00	2,700.00	2,533.00	2,135.00	2,882.00
Elec. power cost, \$/kWh	0.066	0.065	0.075	0.82	0.066	0.063.0.078	0.098	0.0525	0.059	0.05
Hourly power reqd, kW	24			230		286.3	220	1150	616	
Well pump power incl?	Yes	Yes		Yes		Yes	Yes	No	No	Yes
Distribution power incl?	Yes	Yes		Yes		No	No	Yes	No	Yes
O&M personnel, #	2	1		6	4	5	2	15	24	23
	Annual O&M costs									
Electric power, \$ (1,000s)	7	46	275	53	72	150	500	530	246	a77
O&M personnel ³	32	20	40	97	a0	100	70	702	462	476
Parts, chemicals ⁴	4	21	42	66	60	136	125	635	263	526
Replace membranes	49	140		(5)			210		225	
Not specified							300			
Total annual costs \$ (1,000s)	92	227	417	218	212	366	1,205	1,666	1,195	1,833

¹ No attempt has been made to put these data on a common basis.

² Town of Jupiter, additional cost for brine disposal, \$300,000 per year.

³ O&M personnel costs estimated for city of Toluca.

⁴ Parts, chemicals costs estimated for city of Toluca.

⁵ Costs for principal and interest payments and plant expansion purchases not included, Ocracoke Sanitary District.

7.0 SELECTED CASE STUDY COMPARISONS, BRACKISH EDR PLANTS

Ten electro dialysis plants were selected for comparisons 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 24)
- Table, capital cost components, and total (table 24)
- Table, operation and maintenance cost components, and total (table 25)

Table 24.—Selected brackish EDR plants¹

Plant name, location	Process data										
	Granbury WTP, Granbury, TX	Alla Municipal Utilities, Alta, IA ²	Melville WW, Saskatchewan Canada	Buckeye WTP, AZ	Washington Waler Dept., IA	Foss Reservoir, Foss, OK	Lake Granbury, TX	City of Suffolk, VA	City of Sherman, TX	Carlton WTP, Sarasota, CO Sarasota, FL ³	
Rated capacity, MGD	0.3	0.432	0.5	0.9	1.9	2.8	3.5	3.75	4.5	12	
Annual product, mil gal	15	76	64	234	300	449	500	489	821	4,289	
Total prod.+blend, MGD	15	76	184	234	315	449	675	621	1,281	4,209	
Feed salinity, mg/L	60	1,200	1,900	1,600	1,200	1,050	321	563	1,350	1,030	
Recovery, %		05	80	75	75	70	75	94	05	87	
Year of startup	1985	1995	1990	1989	1993	1974	1989	1990	1993	1995	
	Capital costs										
Building, \$(1,000s)	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 \$(1,000s) (See footnotes.)	1,268	900	1,868	1,100	1,807	2,100	22,000	7,250	13,000	20,100	

¹ No attempt has been made to put these data on a common basis.

² Cost shown for Alla, Iowa, building is for remodeling only.

³ Total reported capital cost for Carlton WTP is \$97 million. This includes costs such as distribution system, etc.

Table 25.—Selected brackish EDR plants¹

Plant name, location	Process data										
	Granbury WTP, TX	Alla Municipal Utilities, Ala, IA	Melville WW, Saskatchewan Canada	Buckeye WTP, AZ	Washington Water Dept., IA ²	Foss Reservoir, Foss, OK	Lake Granbury, TX	City of Suffolk, VA	City of Sherman, TX	Carlton WTP, Sarasota, CO	Sarasota, FL ³
Rated capacity, MGD	0.3	0.432	0.5	0.9	1.9	2.6	3.5	3.75	4.5	12	
Annual product, mil gal	15	76	64	129	300	449	500	409	821	1,025	
Total prod.+blend, MGD	15	76	184	129	315	449	675	621	1261	1,625	
Elec. power cost, \$/kWh	0.07-0.10	0.2	0.076	0.066		0.026	0.05	0.06	0.049		
Hourly power reqd, kW		112	60	150	152	4,366	263	315			
Well pump power incl?	Yes		Yes	Yes	No	No	No	Yes			
Distribution power incl?	No		No	No	No	No	No	Yes			
O&M personnel, #	4	1	4		2	6	5	16	15	8	
	Annual O&M costs										
Electric power, \$ (1,000s)	5.2	a.4	46	95	36	125	82	175.6	120		
O&M personnel	7.0	25	9.1	34	21	161	200	355.1	560		
Parts, chemicals	50.2	15	10.8	14	16	240		36	60		
Replace. membranes			17.0		16.7	3.5		139.3	85		
Not specified		6.1			55		116				
Total annual costs \$ (1,000s)	133.5	40.4	03.7	133	146.7	561	400	706	625		
(See footnotes.)											

¹ No attempt has been made to put these data on a common basis.

² For Washington Water Department, "not specified" costs added to correspond with published technical paper.

³ For Carlton WTP, Sarasota County annual production and cost/1,000 gal from published technical paper

⁴ For Buckeye, cost for bond amortization not included.

8.0 SELECTED CASE STUDY COMPARISONS, MEMBRANE SOFTENING PLANTS

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

- Key elements for process data (table 26)
- Table, capital cost components, and total (table 26)
- Table, operation and maintenance cost components (table 27)

Table 26.—Selected MS plants¹

Plant name, location	Process data				
	Laurens WS, Laurens, IA	Village, Royal Palm Beach, FL ²	Indian River County, Vero Beach, FL	N. Collier County, Naples, FL	City of Ft. Myers, FL
Rated capacity, MGD	0.35	1.5	a. 57	12	12
Annual product, mil gal	45	330	1,479	2,313	2,555
Total prod.+blend, MGD	46	750	1,642	2,313	
Feed salinity, mg/L			900	420	150
Recovery, %	74	80	80	90	90
Year or startup	1990	1994	1994	1993	1992
	Capital costs				
Building, \$ (1,000s)		269	1,230		
Plant equipment		358	5,560		
Wells or feed intake		750	500		
Product tanks					
Brine disposal		6,882			
Other costs		50			
Total capital costs (1,000s)		1,494	7,372	26,000	14,200

¹ No attempt has been made to put these data on a common basis.

² For Village of Royal Palm Beach, blend addition is from a lime softening plant

Table 27.—Selected MS plants¹

Process data					
Plant name, location	Laurens WS. Laurens, IA	Village, Royal Palm Beach, FL	Indian River County, Vero Beach, FL	N. Collier County, Naples, FL	City of Ft. Mvers. FL
Rated capacity, MGD	0.35	1.5	8.57	12	12
Annual product, mil gal	45	330	1,479	2,313	2,555
Total prod.+blend , MGD	46	750	1,642	2,313	2,555
Elec. Power cost, \$/kWh	0.038	0.06	0.049	0.037	0.08
Hourly power reqd, kW	77	a 9		667	596
Well pump power incl?	Yes	Yes	Yes	No	No
Distribution power incl?	Yes	Yes	Yes	Yes	No
O&M personnel, #	1.5	1	12	14	16
Annual O&M costs					
Electric power, \$ (1,000s)	16	23	240	307	524
O&M personnel	65	80	201	575	535
Parts, chemicals	30	12	150	600	594
Replace. membranes			99	5	
Not specified					
Total annual costs (1,000s)	111	115	690	1,487	1,653

¹ No attempt has been made to put these data on a common basis.

9.0 SELECTED CASE STUDY COMPARISONS, SWRO AND DISTILLATION PLANTS

Seven SWRO plants and 1 MED distillation facility were selected for comparison covering a range of plant-rated capacity from 33,000 GPD to 8.1 MGD. Tables were prepared based on submitted survey information as set forth below:

- Key elements for process data (table 28)
- Table, capital cost components, and total (table 28)
- Table, operation and maintenance cost components (table 29)

Table 28.—Selected brackish EDR plants¹

Plant name, location	Process data							
	Aquarium, Monterey, CA	Marina Waler District, Marina, CA	Catalina Island, CA	City of Morrow Bay, CA	Key West, FL	U.S. Navy, Guantanamo. Cuba	City of Santa Barbara, CA	Water/Power Authority, Virgin Islands
Process type	SWRO	SWRO	SWRO	SWRO	SWRO	SWRO-MSF/MED	SWRO	MED
Rated capacity, MGD	0.032	0.26	0.33	0.86	3	3.25	6.7	8.10
Annual product, mil gal	a	98	38	315	931	913		2,621
Total product + bland, MGD	a	98	38	315	931	913		2,621
Feed salinity, mg/L		25,000		31,000			34,000	37,000
Recovery, %		40	30/33	40	30		45	
Year of startup	1996	1996		1993	1981		1992	1981-93
	Capital costs							
Building, \$ (1,000s)		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 \$ (1,000s)	381	2,500	2,400	4,530	11,250		34,000	57.752

¹ No attempt has been made to put these data on a common basis.

Table 29.-Selected SWRO and distillation plants'

Plant name, location	Process data							
	Aquarium, Monterey, CA	Marina Water District, Marina, CA	Catalina Island, CA	City of Morrow Bay, CA	Key West, FL	U.S. Navy, Guantanamo, Cuba	City of Santa Barbara, CA	Water/Power Authority, Virgin Islands
Process type	SWRO	SWRO	SWRO ²	SWRO ³	SWRO ⁴	SWRO-MSFIMED	SWRO ⁵	MED
Rated capacity, MGD	0.032	0.26	0.33	0.86	3	3.25	6.7	8.10
Annual product, mil gal	a	98	38	315	931	913		2,621
Total product + blend, MGD	a	98	38	315	931	913		2,621
Electric power cost, \$/kWh	0.0a	0.10		0.08	0.08		0.05	0.077
Hourly power required, kW	50							
Well pump power included?	No	Yes		Yes			Yes	
Distribution power included?	No	No		No			Yes	
Stream cost, \$/1,000#								2.56
Perforation, #water/#steam								9-10.5
O&M personnel, #		2					13	
Annual O&M costs								
Electric power, (1,000s)	13	144	140		1,889			
Steam								
O&M personnel	40	80			363			
Parts, chemicals	20	12	1a		75			
Replacement membranes		4	30		28			
Not specified								
Total annual costs \$ (1,000s)	73	240	188	942	2,355			25,444

¹ No attempt has been made to put these data on a common basis,

² Data for this plant were assembled by Leitner and Associates, Inc., from data and information in "Connections," Spring 1991. A newsletter to Community Colleges and Universities issued by Southern California Edison Co.; 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 and comment.

³ Annual O&M costs equal \$110,000 + \$975/af.

⁴ Cost data from operation during period 1981-83.

⁵ The Santa Barbara plant is currently in "standby" mode. In "delivered water" mode the unit cost is as shown. This is a BOOT plant,

10.0 COMMENTS AND CONCLUSIONS

Several significant conclusions can be drawn from analysis of this 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 percent per year in installed capacity and 6.25 percent per year in the number of new plants. Noteworthy, the comparison of the number of new plants and the increase in installed capacity signifies that growth has been in larger capacity plants.
2. The growth rate for membrane softening, 120 percent 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 the removal of THMFP and color and the rejection of bacteria, viruses, and dissolved organic carbons.
3. The very slow growth rate in SWRO is due to several factors, including:
 - Seawater is more costly to desalt than brackish water or high hardness water due to the much higher salinity of seawater.
 - Cost reductions that have taken place for treating brackish water and high hardness water have been significant, have been tested over time, and have received publicity through the 1992 NWSIA report and through journals. Accordingly, they would be the first choice when acceptable feedwater and brine disposal options are available.
 - The geographic areas where alternative water sources are sought may not correspond to those areas where seawater desalting may be cost effectively applied.
 - Some significant cost reductions in seawater desalting have been realized over the past 5 years, primarily in improved distillation processes, SWRO membranes, energy recovery devices for SWRO, and operating procedures. Unfortunately, some of these cost reductions have not yet been tested over time. Results are beginning to appear, however. A private supplier of fresh water from seawater for the Bahamas will sell water, unblended, at the plant boundary for \$4.50/1000 gallons, which includes all costs-capital and O&M. Prices in the U.S. can be expected to be even lower. (See *International Desalination & Water Reuse Quarterly*, May 1996.)

11.0 APPENDICES

- Association of State Drinking Water Administrators
- Manufacturers of RO/Groundwater Enhancement, EDR, MS, SWRO/Distillation Systems as Listed by Survey Respondents
- Desalting Plants in the U.S., by State and Process

Appendix 1

Association of State Drinking Water Administrators

Appendix 1

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

<i>Name</i>	<i>Address</i>	<i>Telephone</i>
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	Cooper 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 Galistec, Santa Fe, NM 87505	505-827-7536
North Dakota St. Dept. of Health	1200 Missouri Ave. Bismarck, 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
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

**Manufacturers of RO/Groundwater Enhancement, EDR, MS,
SWRO/Distillation Systems as Listed by Survey Respondents**

Appendix 2

Manufacturers of RO/Groundwater Enhancement, EDR, MS, SWRO/Distillation Systems as Listed by Survey Respondents¹

<i>Name</i>	<i>Address</i>	<i>Telephone</i>
American Engineering Services, Inc.	5912 F. Breckemidge Pkwy, Tampa FL 33610	819-357-0910
Aqua Chem, Inc.	PO Box 42 1, Milwaukee WI 53201	4 14-96 1-275 1
Aqua Design (Subsidiary of Ionics)	470 Division St, Campbell CA 95008	408-374-8680
ASI	238-A Simpson Wy, Escondido CA 92025	
Culligan, International	1 Culligan Wy, Northbrook IL 60062	708-205-6000
Fluid Systems	10124 Old Grove Rd, San Diego CA 92131-1691	6 19-695-3840
Filmtec/Dow Chemical Co.	7200 Ohms Ln, Edina MN 55439	6 12-835-5475
Ham RO Systems, Inc.	185 S. Jackson, Venice FL 34292	94 1-488-967 1
Hydranautics, Inc.	40 1 Jones Rd, Oceanside CA 92054	760-90 1-2500
Hydropure, Inc.	1346 S. Killian Dr, Lake Park FL 33403	407-848-6788
Ionics, Inc.	65 Grove St, Watertown MA 02 172	6 17-926-2500
Israel Desalination Engineers	2999 NE 19 1 st St, N. Miami Beach FL 33 180	305-937-06 10
Mechanical Equipment Co.	861 Carondelet St, New Orleans LA 70130	504-523-727 1
Memtec America	249 12 Via Lopez Ct, Ramona CA 92065	4 1 O-252-0800
Osmonics, Inc.	595 1 Clear-water Dr, Minnetonka MN 55343	612-933-2277
Polymetrics Seawater Systems	550 S. Winchester Blvd, San Jose CA 95 128	408-983-2684
Source, Inc.	PO Box 132 1, Cape Coral FL 339 10	8 13-549-2345
Trisep Corp.	93 La Patera Ln, Goleta CA 93 117	805-964-8003
US Filter (IWT Division)	4669 Shepard Trail, Rockford IL 6 1103	8 15-877-304 1
Water Equipment Technology	832 Pike Rd, W. Palm Beach FL 334 11	407-684-6300

¹There are other U.S. manufacturers; the reader should contact ADA and AWWA for a more complete listing.

Appendix 3

Desalting Plants in the U.S., by State and Process

Appendix 3

Desalting Plants in the U.S., by State and 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	19%	Ionics	
Arizona	Not stated	EDR	0.30	1988	Ionics	Ionics
Arizona	Not stated	EDR	0.90	1988	Ionics	tonics
Arizona	Not stated	EDR	0.96	1993	Ionics	tonics
Arizona	Not stated	EDR	1.20	1995	Ionics	Ionics
Arizona	Yuma Proving Ground WTP	RO	7.82	1986	tonics	Ionics
Arizona	Number of Plants 7	Total	7.82			
Arizona	Yuma Desalt Plant (BOR)	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	19%	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 Simcon (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	tonics
Florida	Not stated	RO	0.25	1988	Hydropro	Fluid Systems
Florida	Not stated	EDR	0.29	1990	tonics	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 , W S A	Hydranautics
Florida	Deland (Indian Harbor Estates)	RO	0.13			
Florida	Dunedin	MS	9.50	1992		
Florida	En&wood (Bocilla Utilities Inc)	RO	0.30	1985	Ham RO	
Florida	Englewood	RO	2.50	1981	Hydranautics	Hydranautics
Florida	Esterio (Mariner's Cove)	RO	005			
Florida	Esterio 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	1990	Ham RO	Fluid Sysrems
Florida	Grove City (Seaside Service Sys.)	RO	0.02	1986		
Florida	Harbor Hgts (Charlotte Harbor WTP)	RO	0.45	1978		
Florida	Hastings WTP	RO	0.22	1992	Ham 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		

state	Plant location (Name)	Process	Capacity (MGD)	start-up year	Equipment supplier	Membrane manufacturer ¹
Florida	Jensen Beach	RO	1.50	1994	Hydropro	Hydranautics
Florida	Jensen Beach (Ocean Towers Utility)	RO	0.12			
Florida	Jensen Beach (River Club, Martin Beach)	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 Serv Corp)	RO	0.24	1989		Fluid Systems
Florida	Maitland (Dixon Ticonderoga)	RO	0.15	1972		Fluid systems
Florida	Marco Island (Sooth 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 Bch. (Service Mgmt Sys.)	RO	0.08	1984		Dow
Florida	Melbourne Bch. (S. Brevard Wtr 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 (N. Collier Co 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 Bch (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 Utilitia)	MS	6.00	1992	PWT America	Filmtec
Florida	Pine Island WTP	RO	1.50	1978/1993	Envir. /Mem Sys.	
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	Harn RO	
Florida	Punta Gorda (Alligator Park)	RO	0.04			
Florida	Punta Gorda (Charlotte Harbor Water)	RO	0.45			
Florida	Punta Gorda Hunter Crk Village	RO	0.17			
Florida	Rotunda West	RO	0.50	1974		DuPont
Florida	Royal Palm Bch, Village of	MS	1.50	1994	Amer. Engr.Svcs.	Filmtec
Florida	San Carlo 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	Polymctics	DuPont
Florida	Sarasota (Lake Tippewnoe)	RO	0.04	1984		Toyobo
Florida	Sarasota (Myaka River St Park)	RO	0.05	1977		
Florida	Sarasota (Windward Isles)	RO	0.06	1983	Basic Tech/Harn	
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 (Comanche Cove)	RO	0.07			
Florida	Sebastian (Pelican Point condos)	RO	0.08			
Florida	Venice (Plantation, Sarasota Co)	RO	0.50	1984/90		Dow/Fluid Systems
Florida	Venice, City of	RO	4.00	1989	Harn/Emco	Fluid Systems

state	Plant location (Name)	Process	Capacity (MGD)	start-up year	Equipment supplier	Membrane manufacturer
Florida	Venice (Carlton WTP)	EDR	12.00	1995	Ionics	Ionics
Florida	Venice (Venice Garden Ut. Cotp)	RO	2.30	1984		Dow
Florida	Vero Beach (Indian River Co)	MS	8.57	1994		Fluid Systems
Florida	Vero Beach (Indian River Co)	RO	1.00	1985/92	Basic Tech.	Fluid Systems
Florida	Volusia County (Deland)	RO	0.50	1995	W E T	
Florida	Wauchula	RO	1.30	1990		Filmtec
Florida	Wellington (Acem 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 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	.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			
Iowa	Alta Municipal Utilities	EDR	0.43	1995	Ionics	Ionics
Iowa	Laurens W T P	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	Sibbrey 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 Ctr.)	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	Fair field (Hyde County) RO	RO	0.30	1994	Ham RO	
N. Carolina	Ocracoke, City of (Sanitary Dist)	RO	0.43	1977	Culligan&lam	RO
N. Carolina	Number of Plants 4	Total	2.21			
N. Dakota	Grand Forks	MS	1.70	1996	Ham 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	1994	Ionics	Ionics
Oklahoma	Number of Plants 2	Total	3.55			
Pennsylvania	Hastings (Hastings Mun Auth)	EDR	0.11	1988	Ionics	Ionics
Pennsylvania	Number of Plants 1	Total	0.11			

State	Plant location (Name)	Process	Capacity (MGD)	Start-up year	Equipment supplier ¹	Membrane manufacturer ¹
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	RO	6.85	1991	Hydranautics	Hydranautics
S. Carolina	Palms Island, City of	RO	<u>1.20</u>	1993/94	Hydropro	Hydran/Fluid Sys.
S. Carolina	Number of Plants 4	Total	8.60			
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	<u>4.50</u>	1993	Ionics	Ionics
Texas	Number of Plants II	Total	23.09			
Utah	Huntington	RO	0.35	1977	Aqua Media	
Utah	Number of Plants I	Total	0.35			
Virginia	Culpepper	RO	0.20	1994	Ham RO	
Virginia	Suffolk (G.R. House Water	EDR	3.75	1990	Ionics	Ionics
Virginia	Number of Plants 2	Total	3.95			
Washington	Coupville, Town of	EDR	<u>0.53</u>	1978	Ionics	Ionics
Washington	Number of Plants 1	Total	0.53			
Puerto Rico	San Juan	SWRO	<u>0.15</u>	1982	Water Services	DuPont
Puerto Rico	Number of Plants 1	Total	0.15			
Virgin Islands	St John (Cancel Bay)	SWRO	0.26			
Virgin Islands	St. John (Grand Hyatt Regency)	SWRO	0.34			
Virgin Islands	St. Thomas (Cowpet Bay E. Assoc)	SWRO	0.03			
Virgin Islands	St. Thomas (Cowpet Beach Resort)	RO	0.15			
Virgin Islands	St. Thomas (Limetree Resorts)	RO	0.1 I			
Virgin Islands	St. Thomas(Sapphire W. Condos)	RO	0.43			
Virgin Islands	St. Thomas (Sapphire Hotel)	RO	0.04			
Virgin Islands	St. Thomas(Secret Harbor Beach	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	198 1/83/92	IDE	
Virgin Islands	Number of Plants 14	Total	9.89			
Canada	Melville (Saskatchewan)	EDR	<u>0.50</u>	1990	Ionics	Ionics
Canada	Number of Plants 1	Total	0.50			

¹ There are other U.S. suppliers and manufacturers; the reader should contact ADA and AWWA for a more complete listing.