Energy Optimized Desalination
Technology Development Workshop

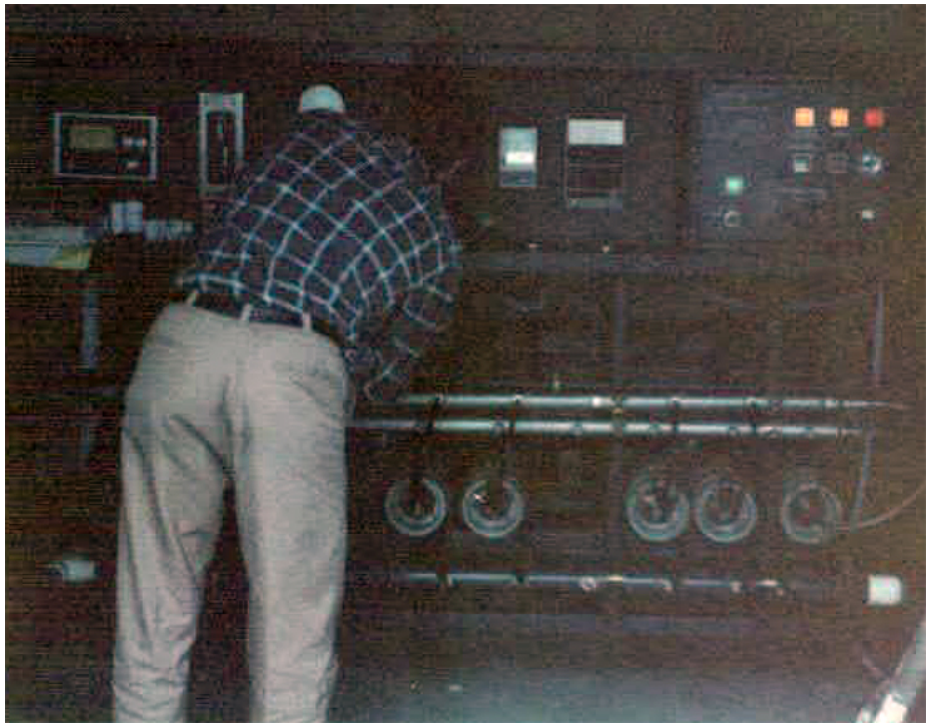
Reverse Osmosis Desalination

Tom Pankratz, Water Desalination Report

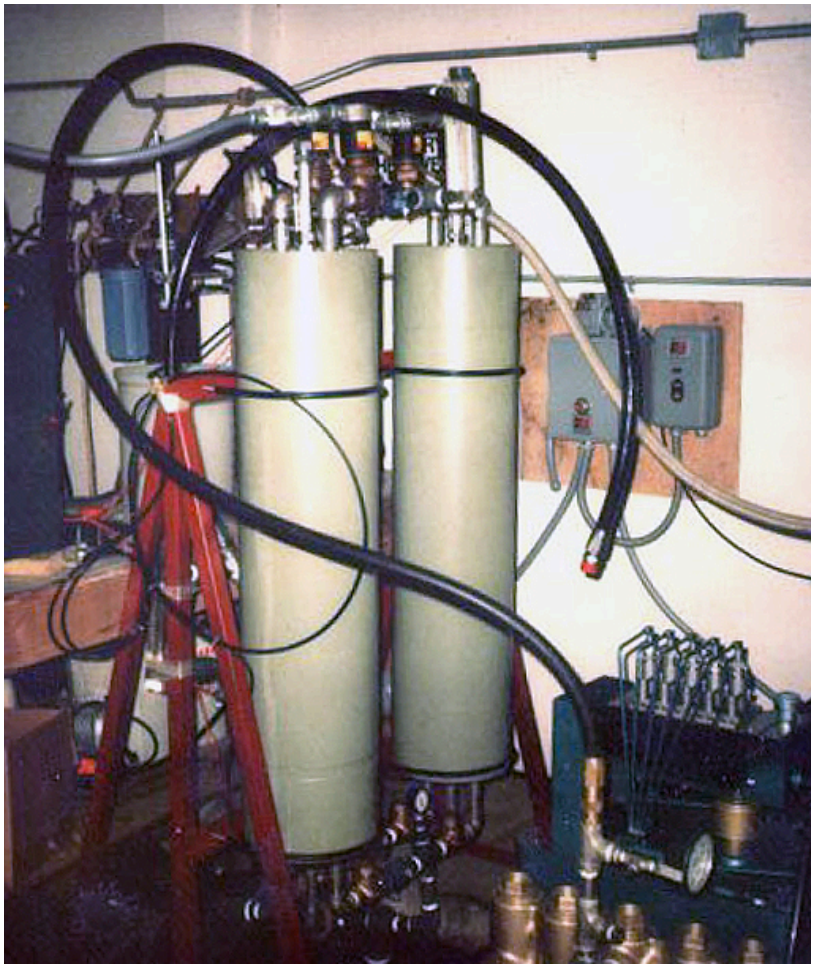
Coalinga, California – 1965

source: UCLA

Bermuda Aviation – 1974



source: Dave Laker

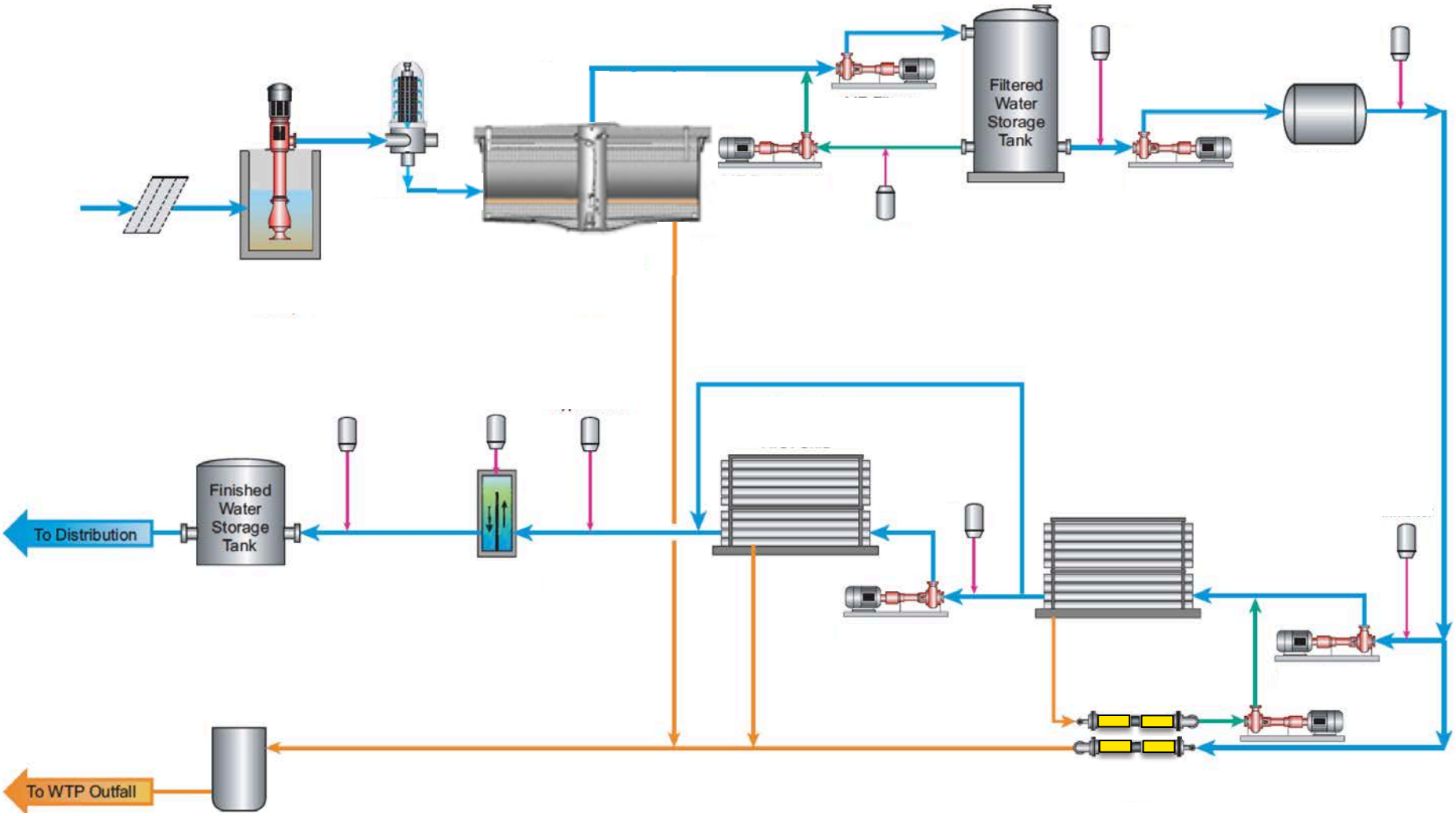


Carlsbad, California – 2015

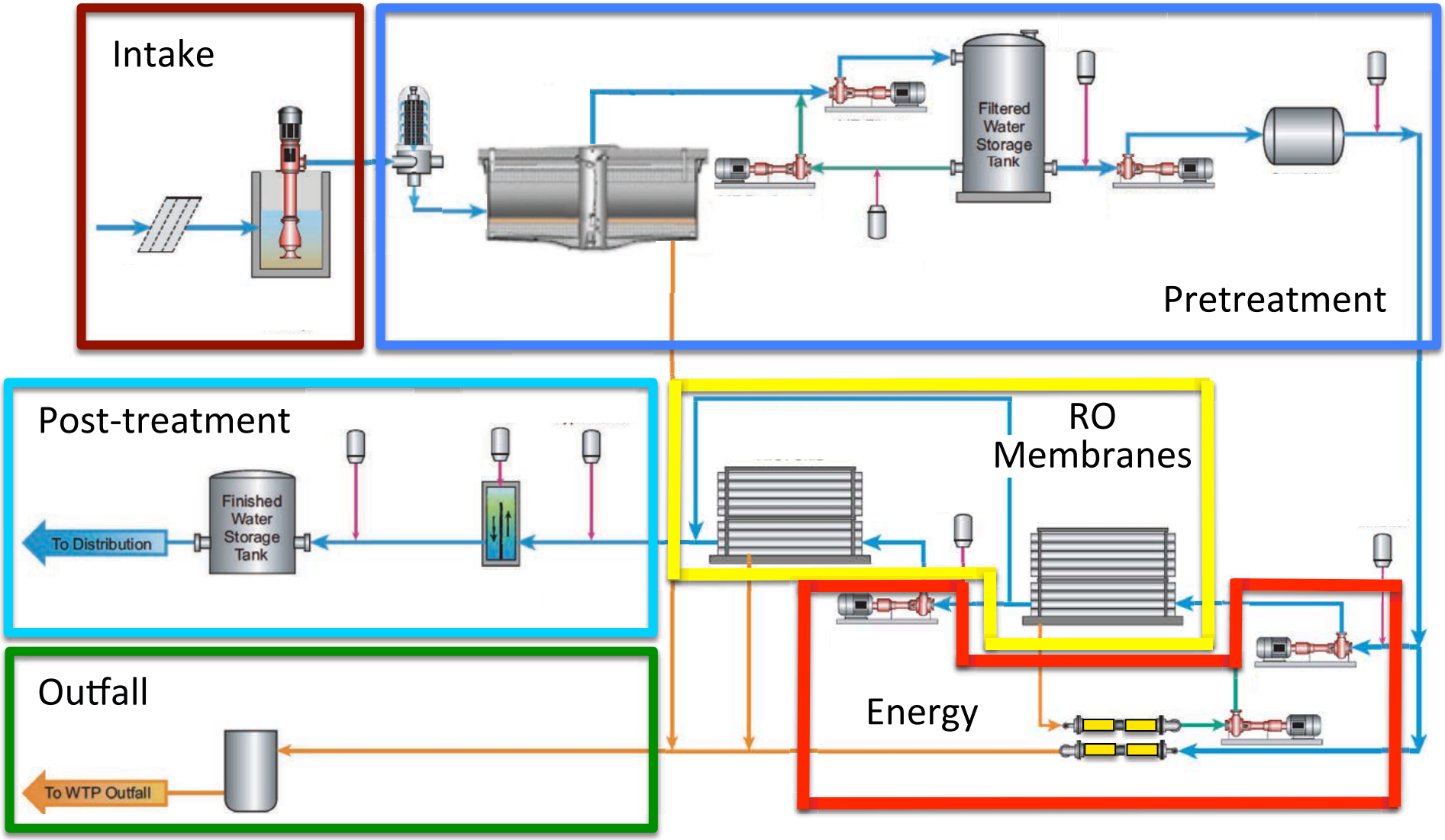
US vs Rest-of-World RO Capacity

- 14,440 RO plants produce 16,075 MGD
  - 10,340 BWROs produce 8,400 MGD
  - 4,100 SWROs produce 7,675 MGD
  - US: 2,114 BWROs produce 2,445 MGD
  - ROW: 8,227 BWROs produce 5,955 MGD
  - US: 15 SWROs produce plants 105 MGD
  - ROW: 4,085 SWROs produce 7,570 MGD

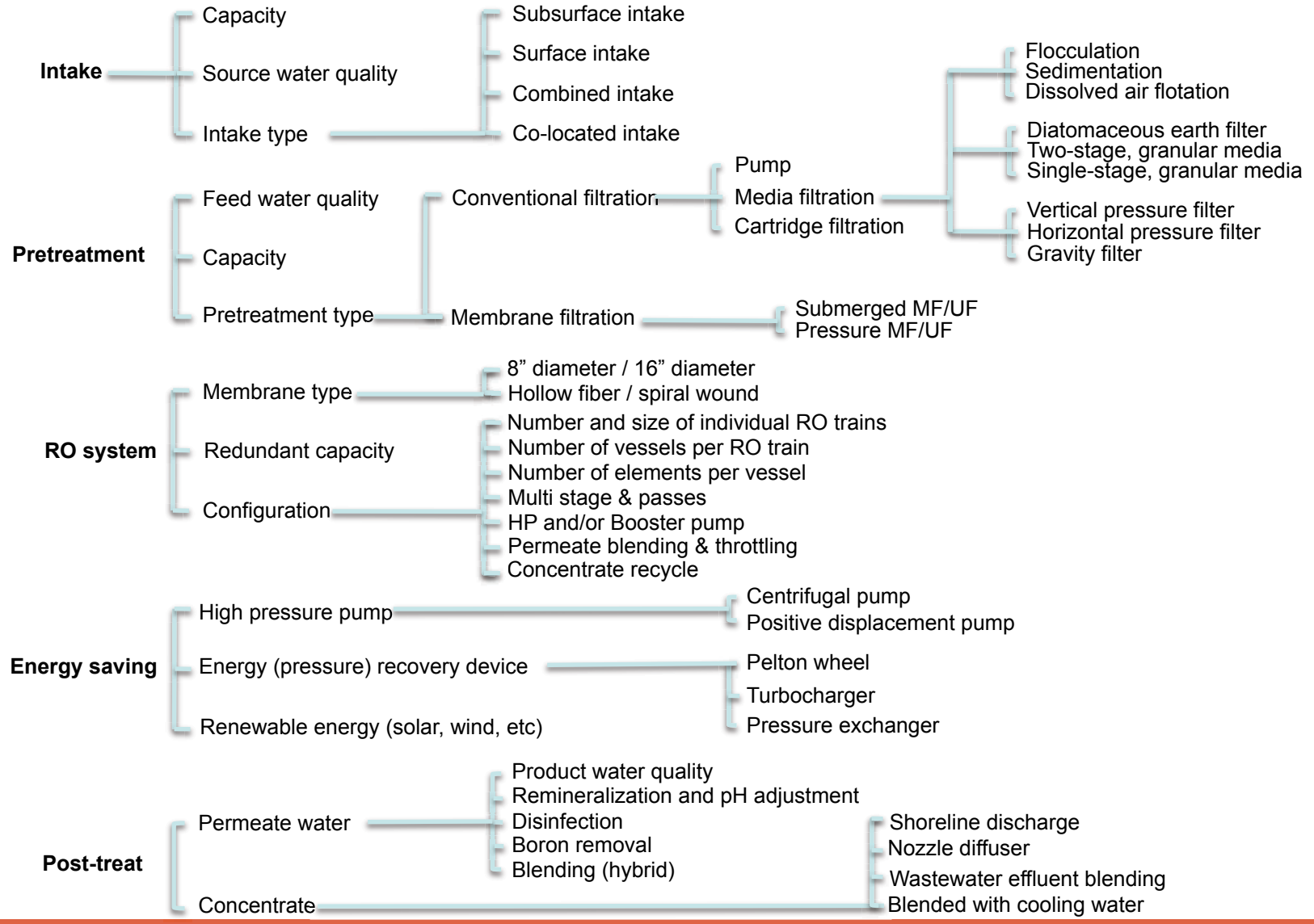
Reverse Osmosis (RO) Desalination



Reverse Osmosis (RO) Desalination

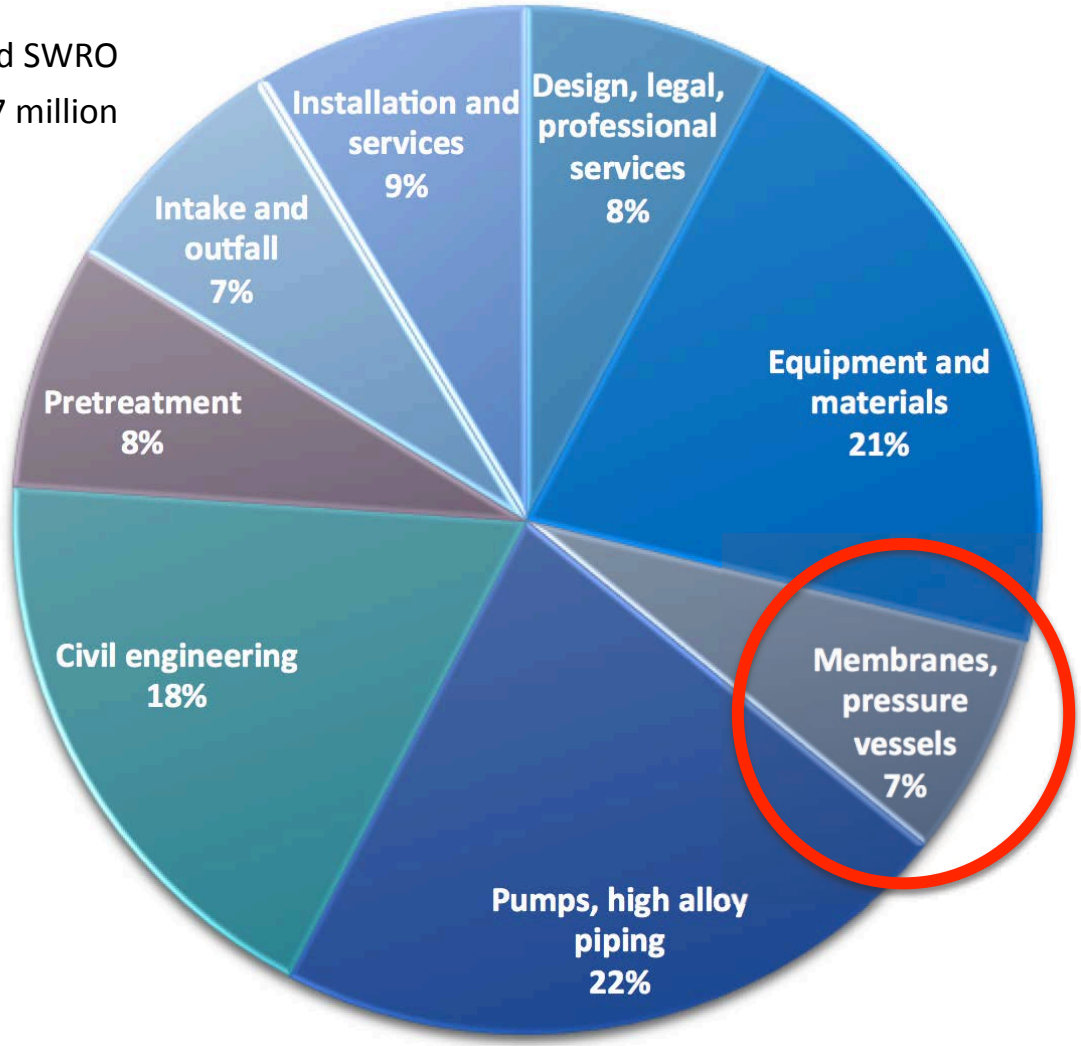


SWRO Total Water Cost



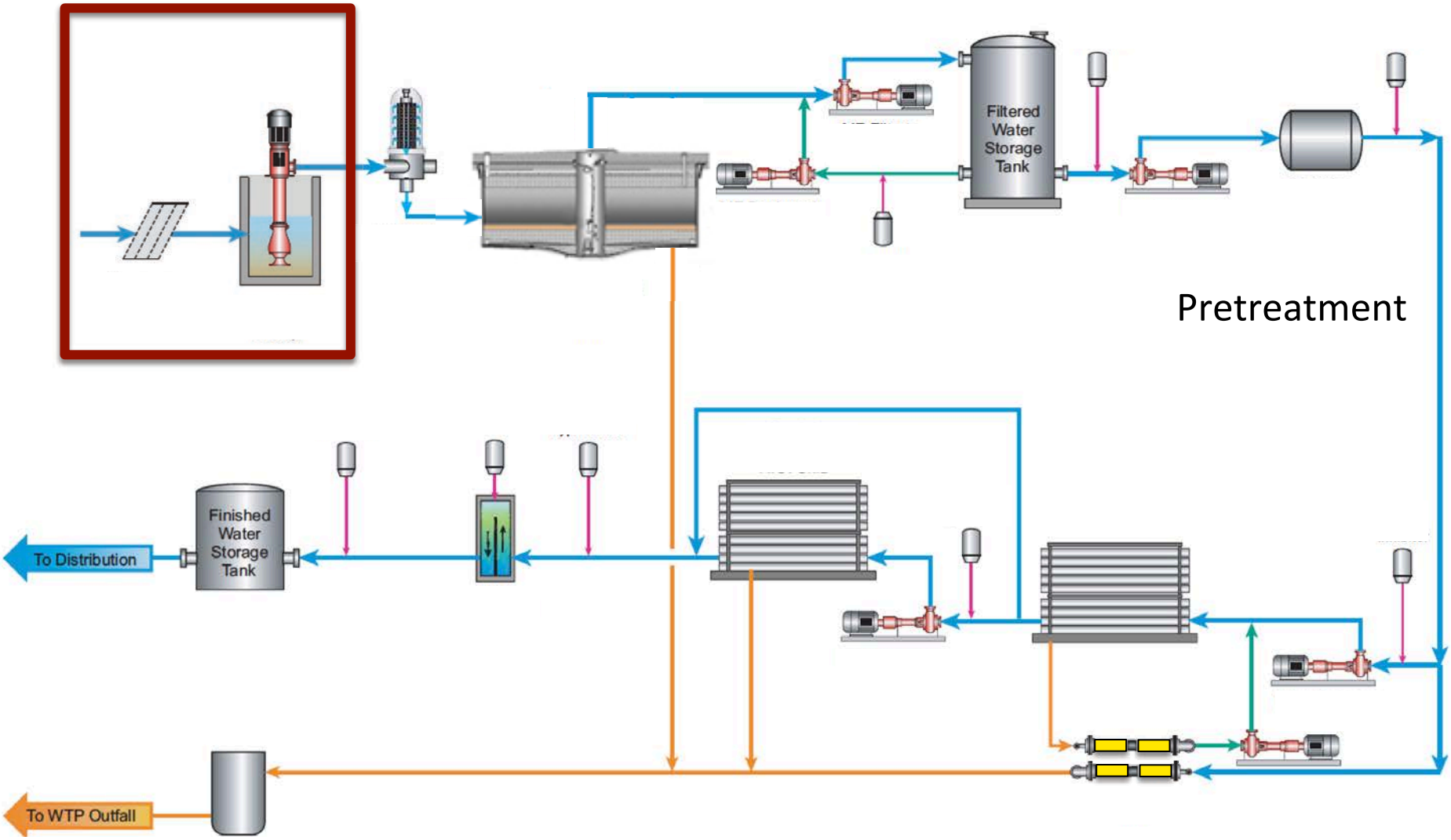
Membranes, Vessels = 7.1% of CapEx

Based on 100,000m^3/d SWRO
at a CapEx of $133.7 million

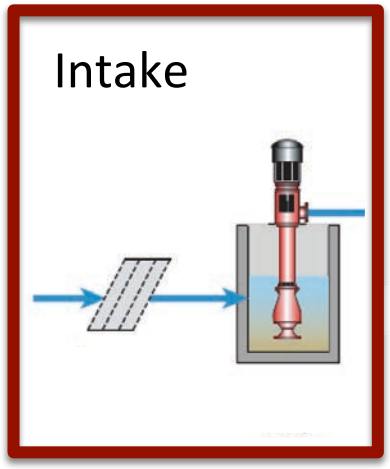


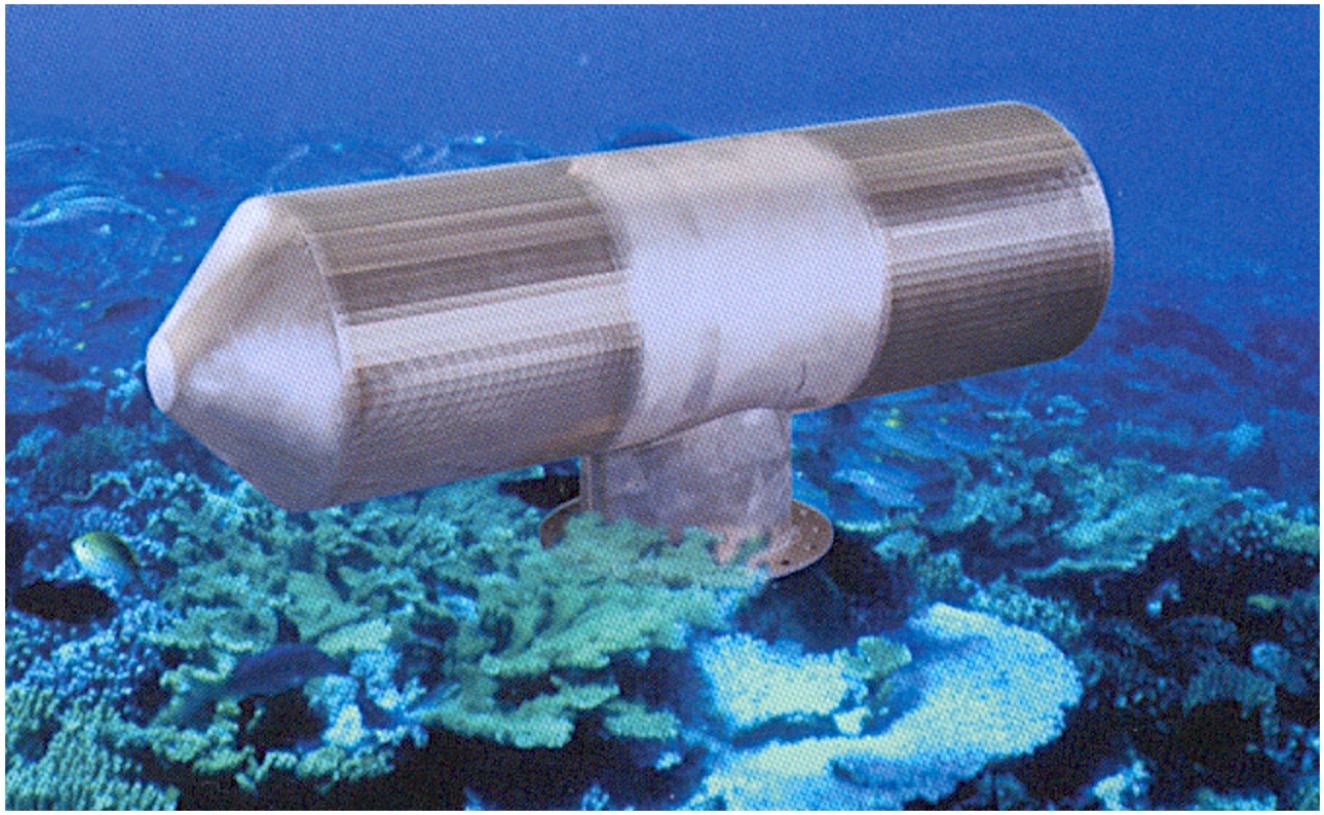
source: GWI DesalData

RO Pretreatment

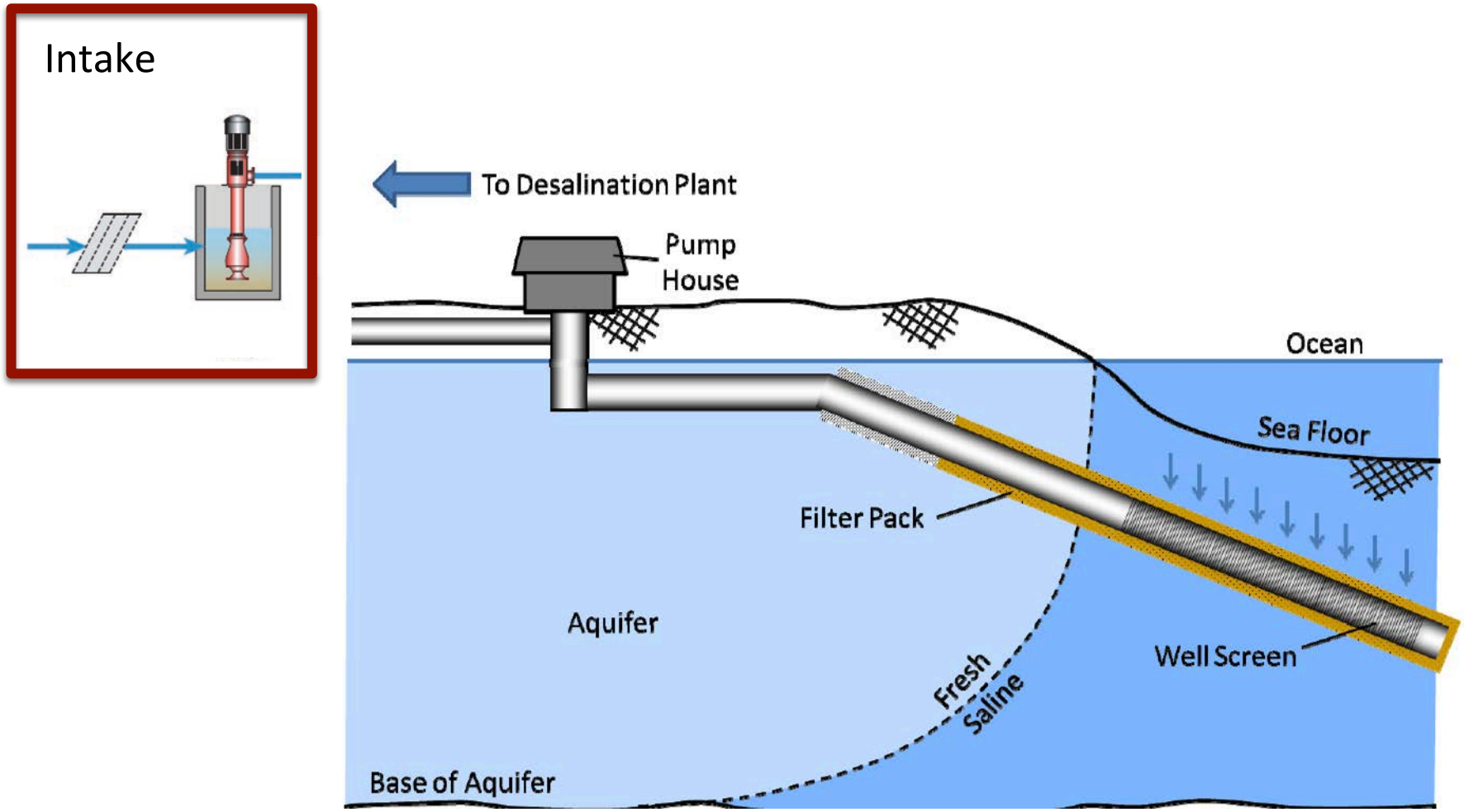


Passive Screens mitigate I&E

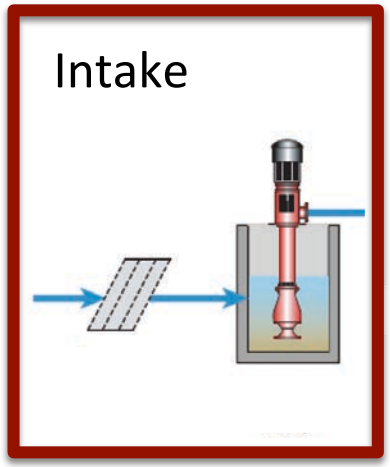


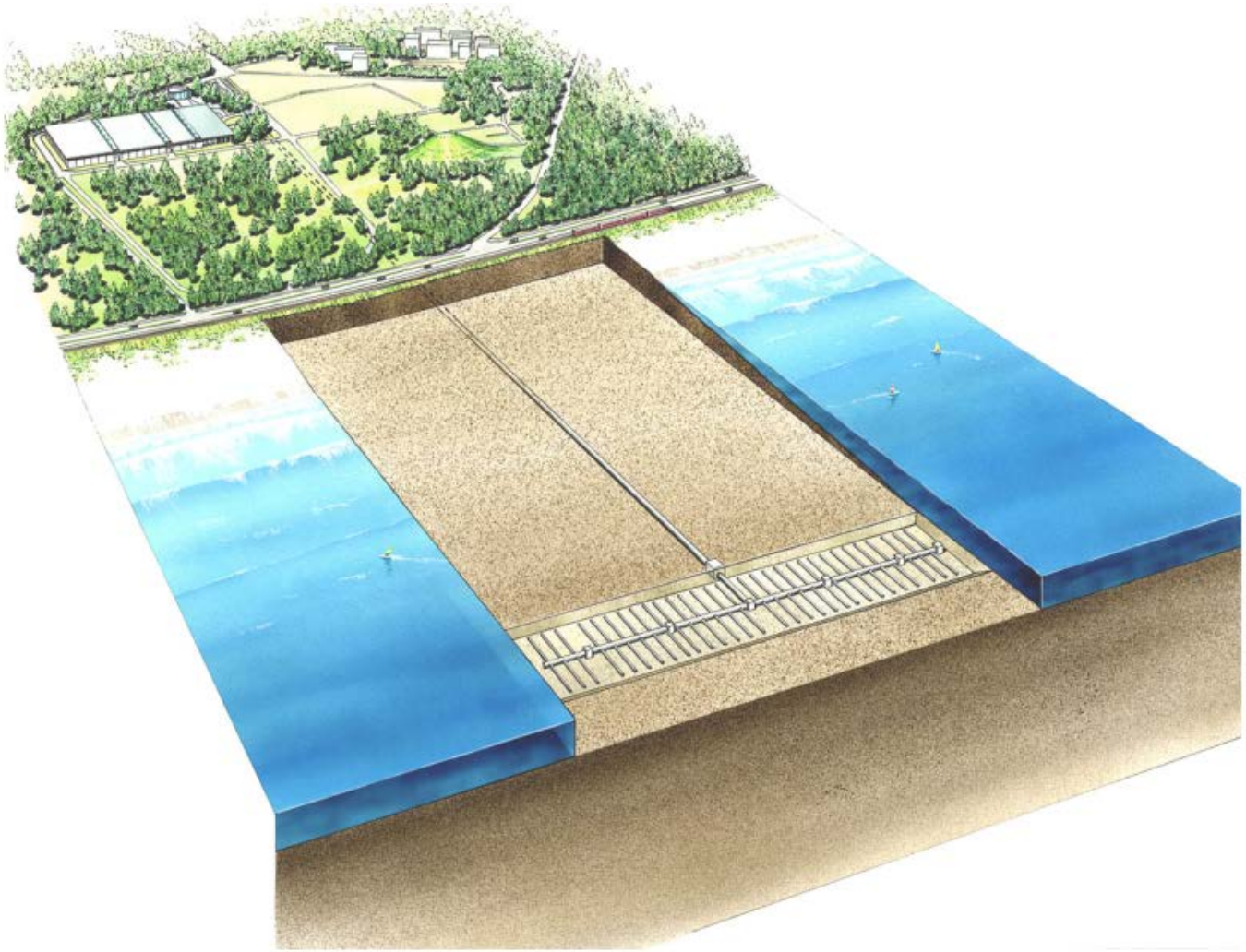


Slant Well Intake



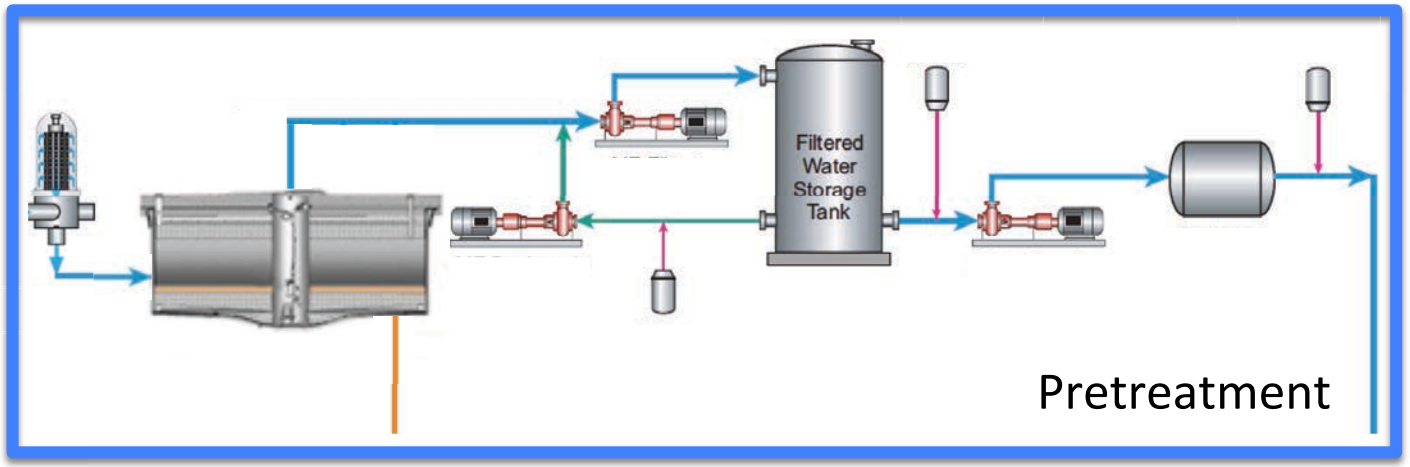
Infiltration Gallery Intake

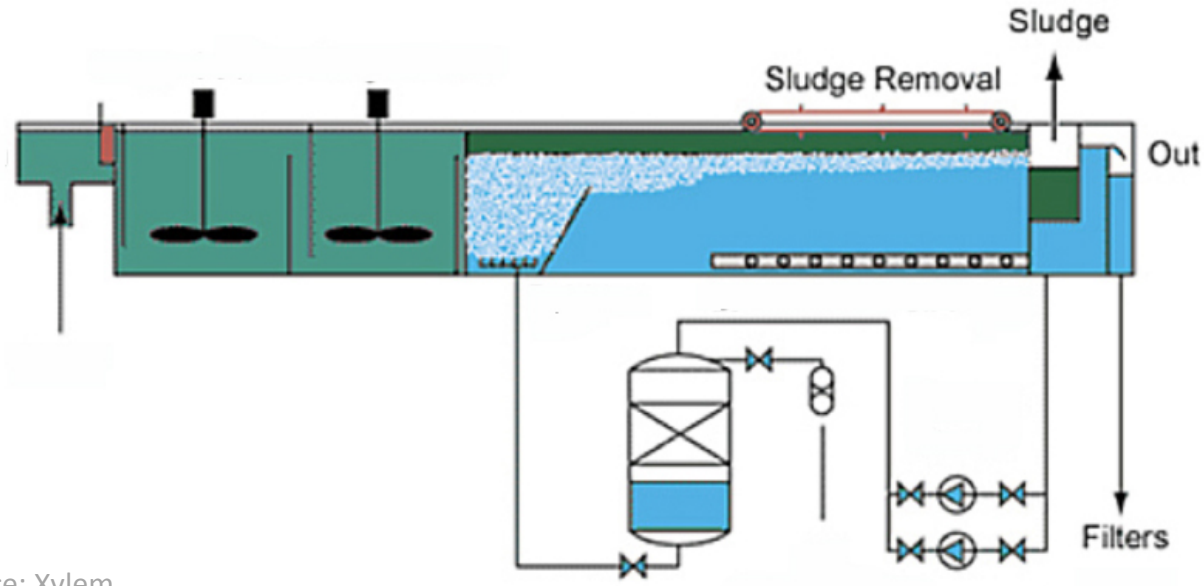




source: Fukuoka Waterworks

Dissolved Air Flotation (DAF) + UF

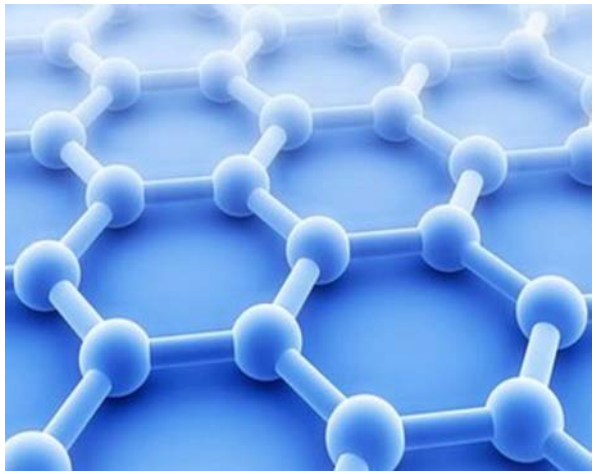


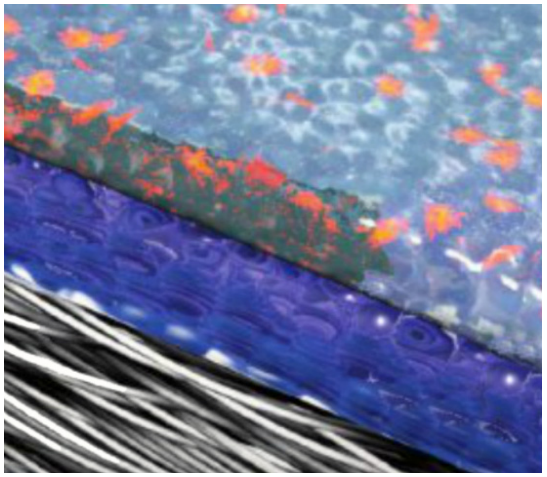


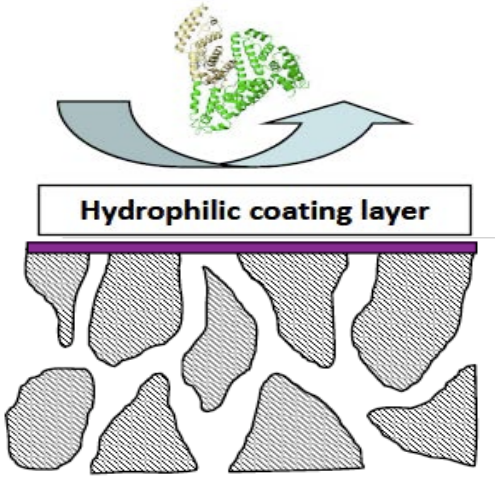
source: Xylem

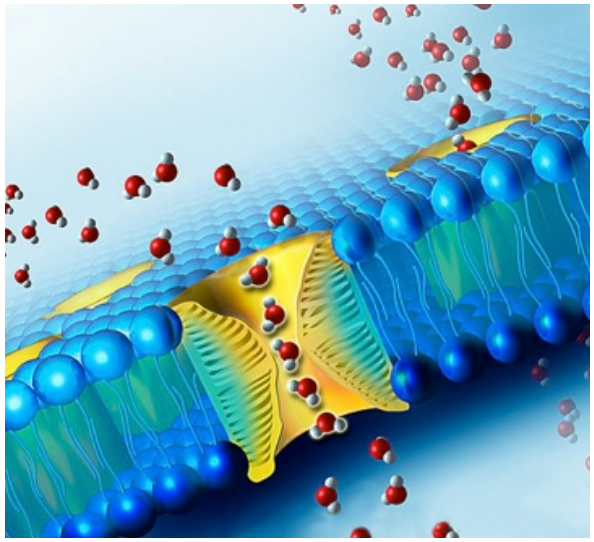
source: inge

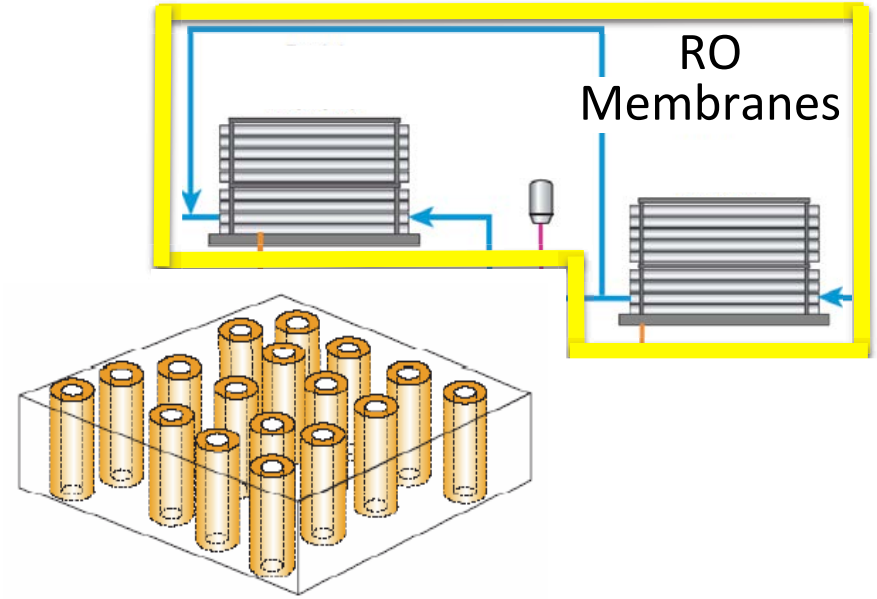
RO Membranes & Coatings



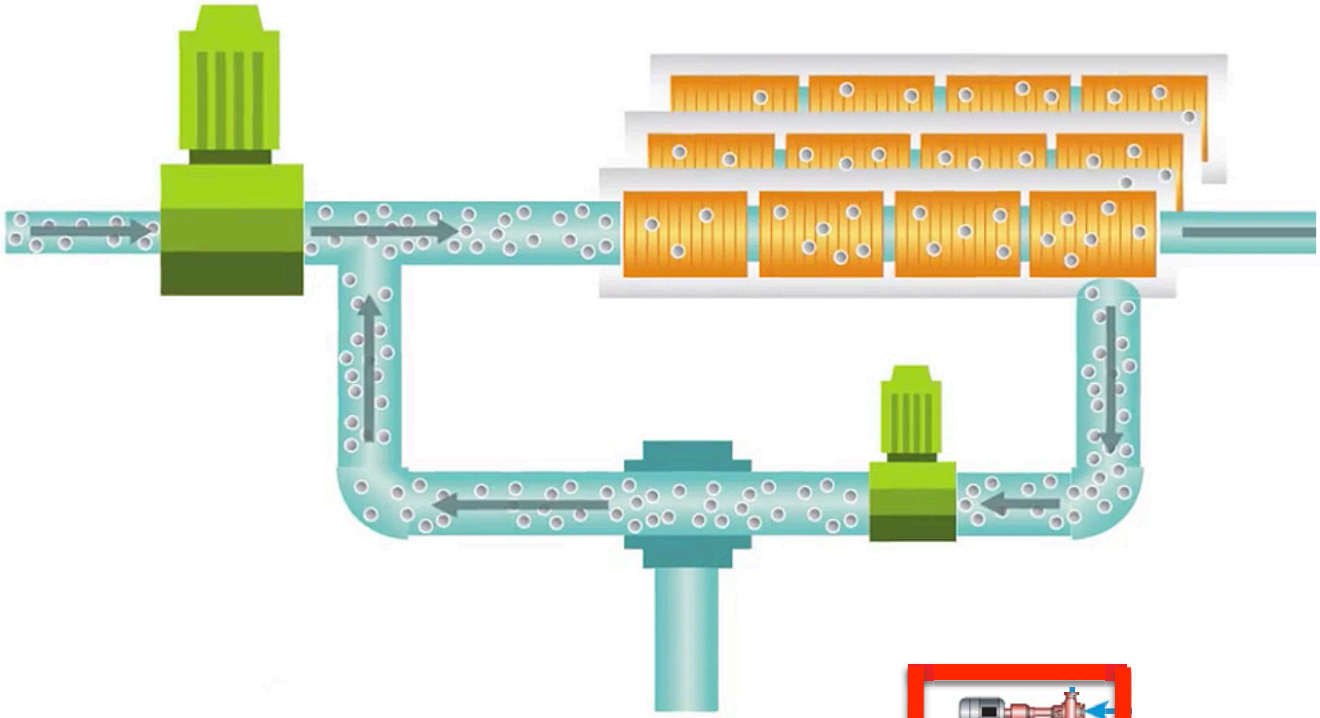


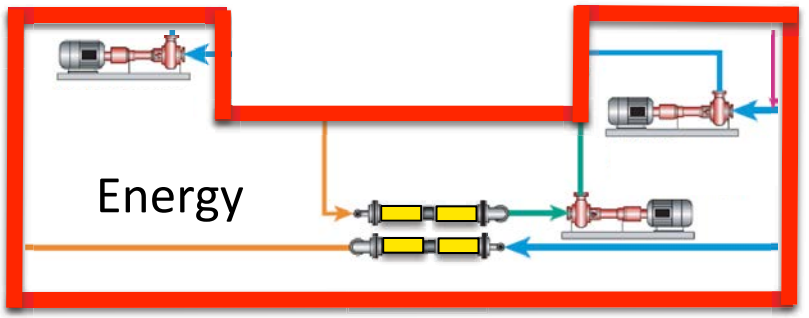






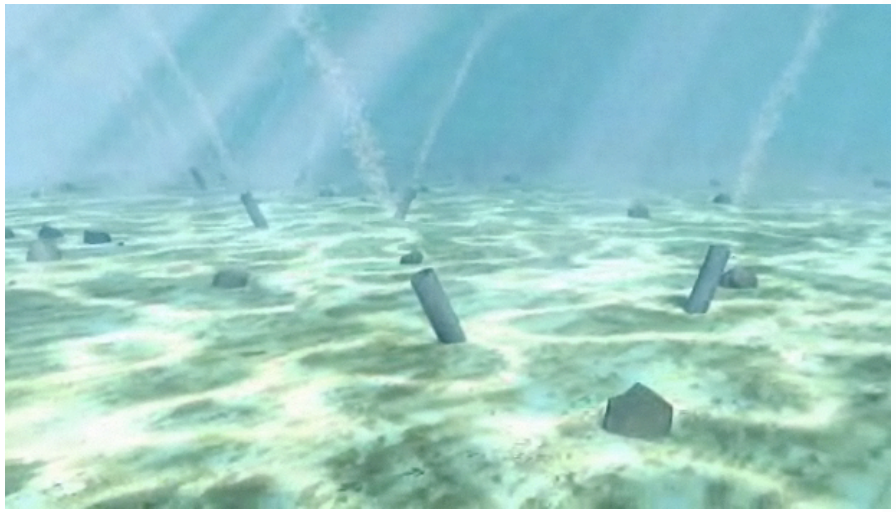
Closed Circuit Desalination

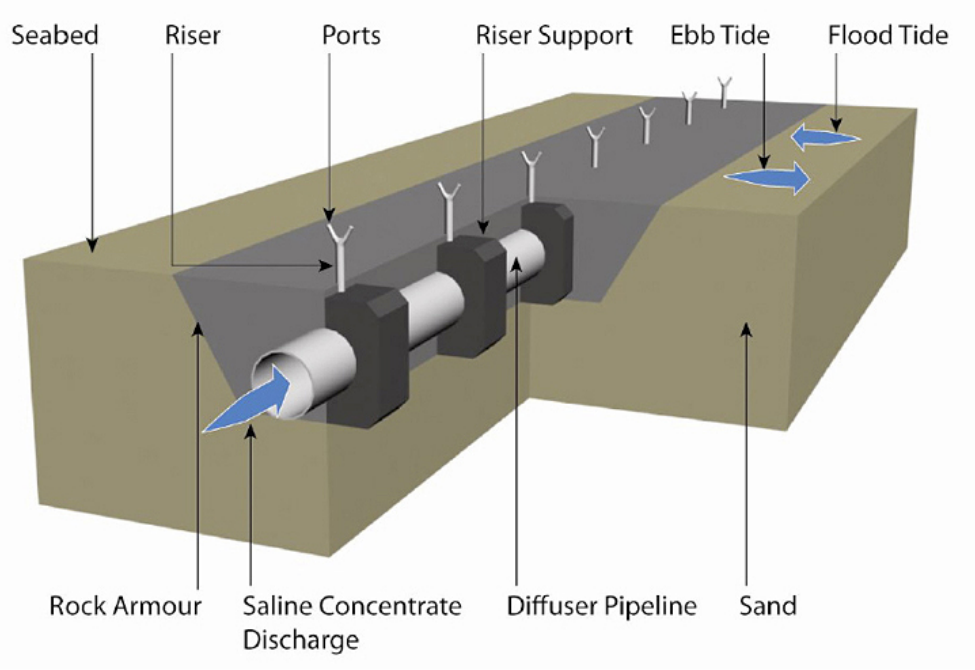


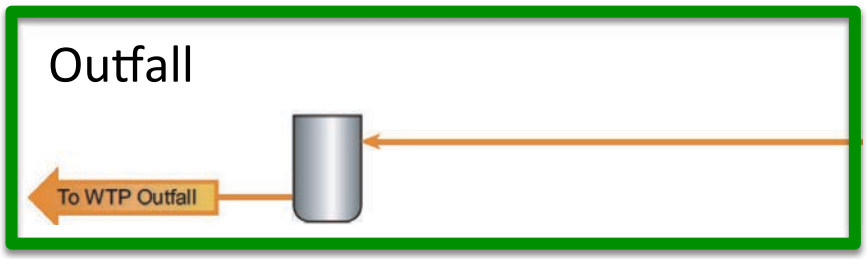


source: Desalitech

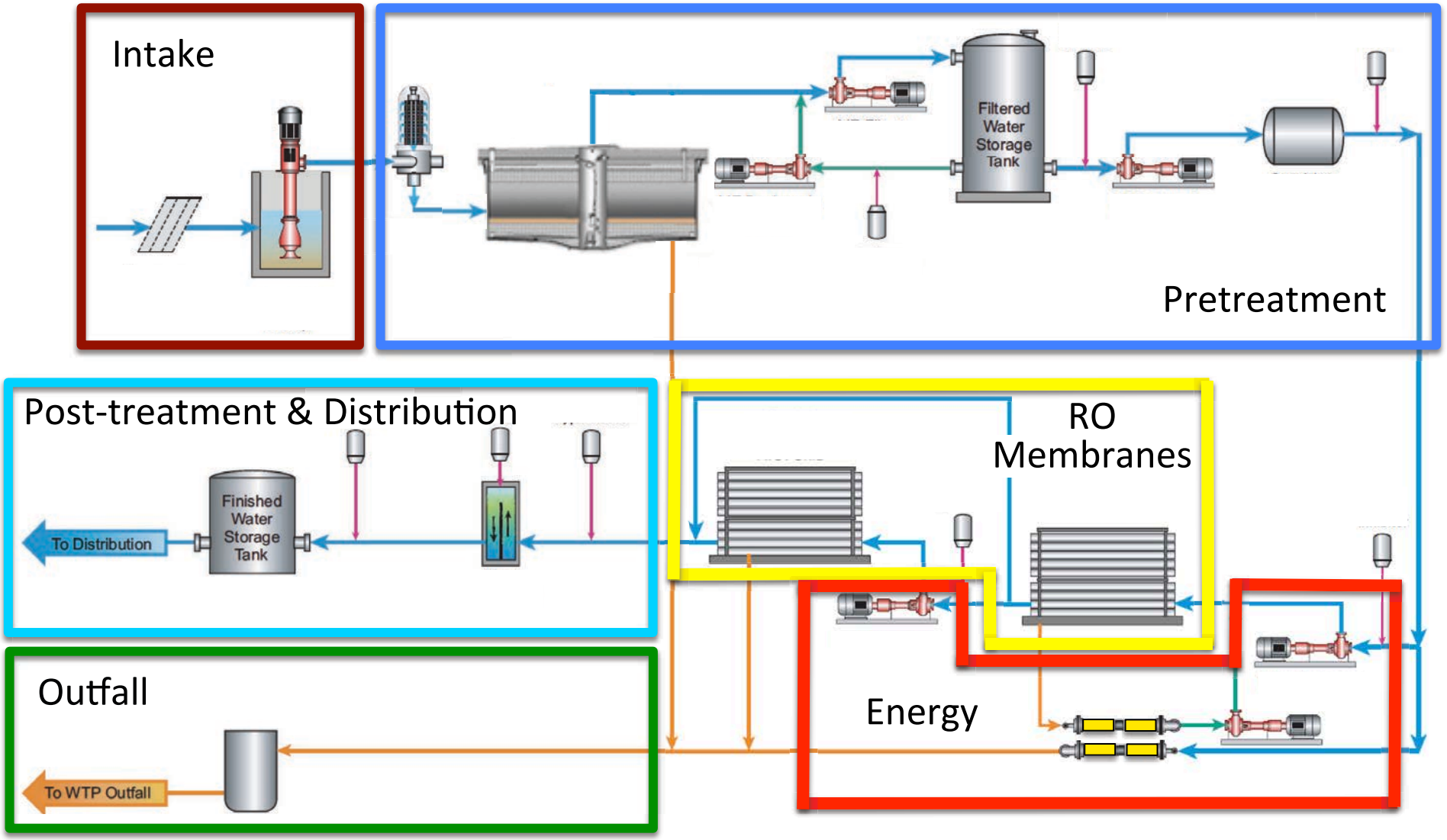
Diffused Concentrate Discharge



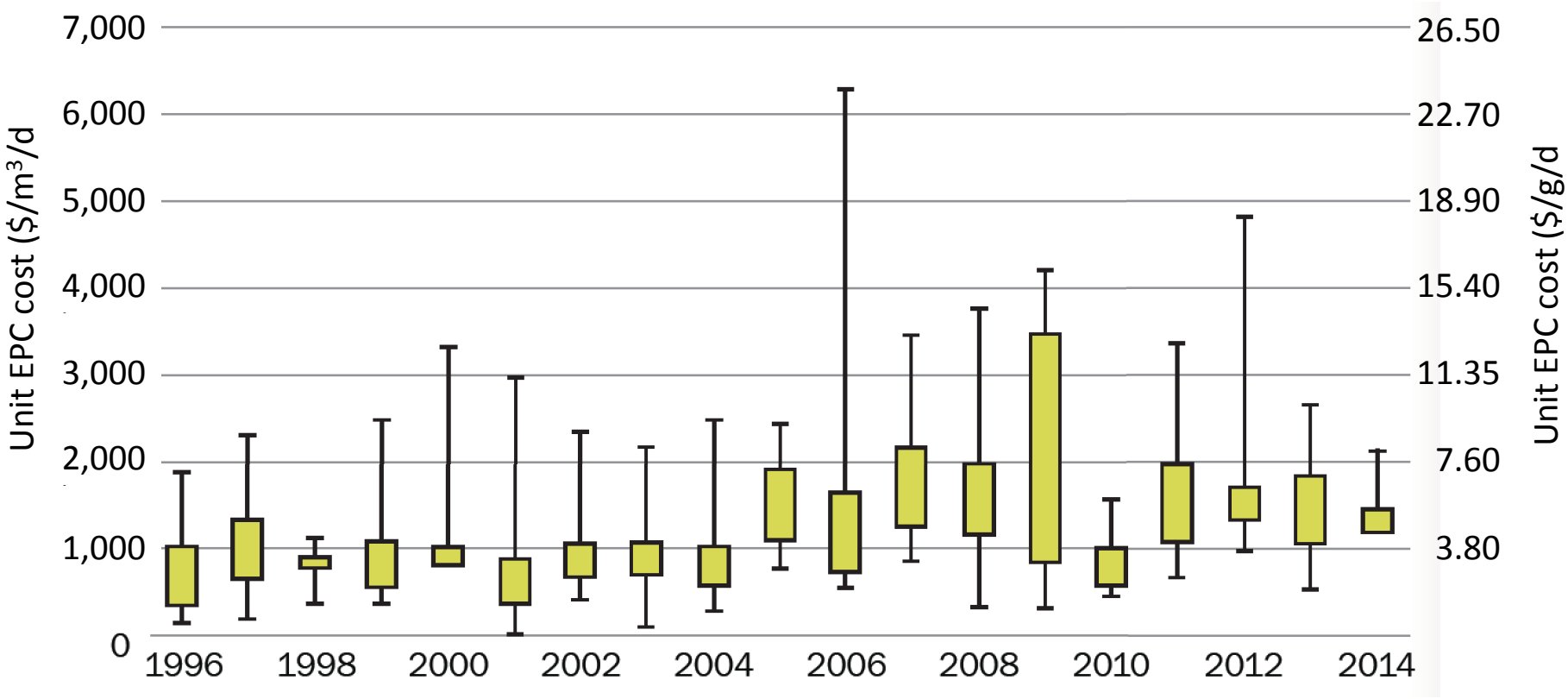




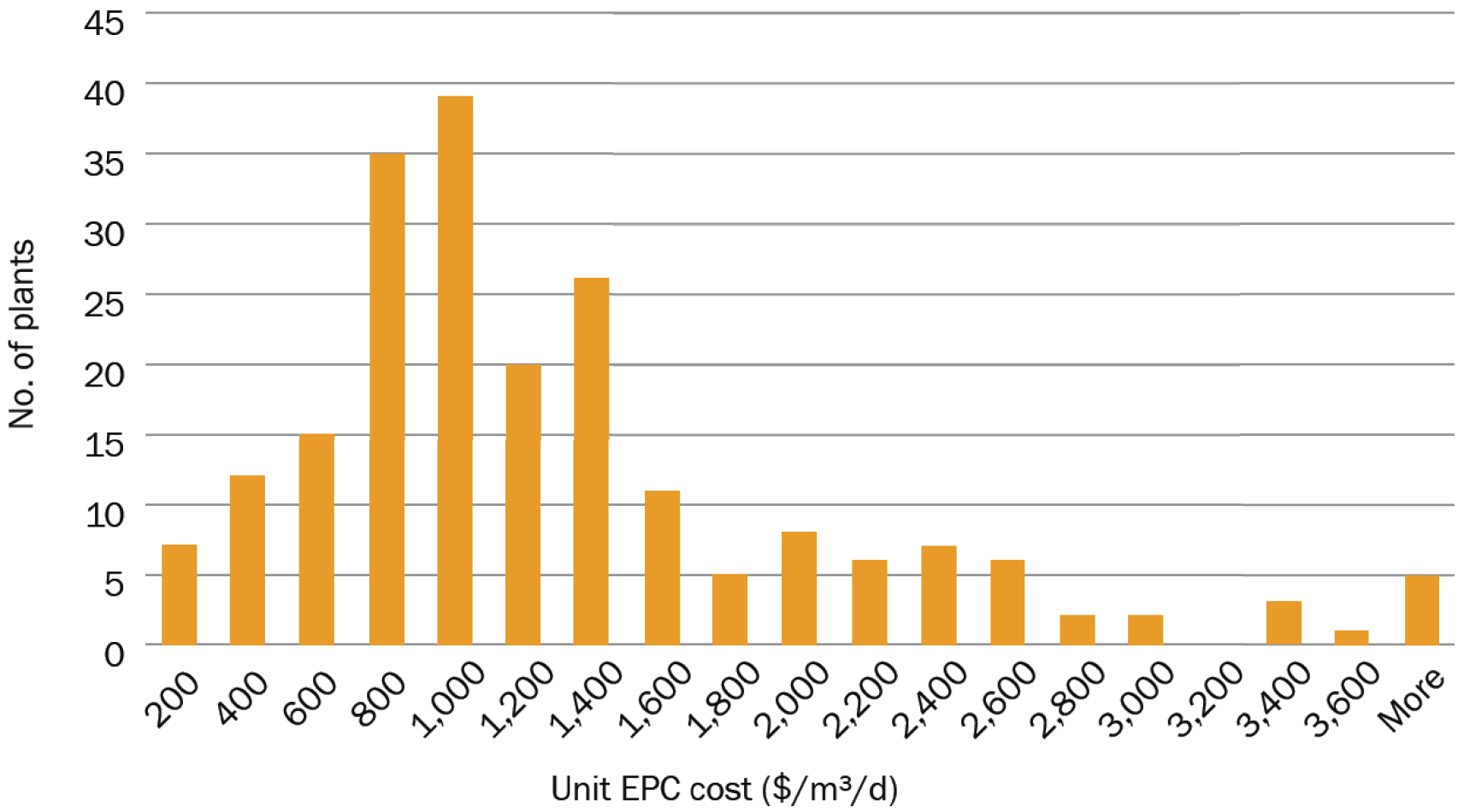
On-going R&D in all areas



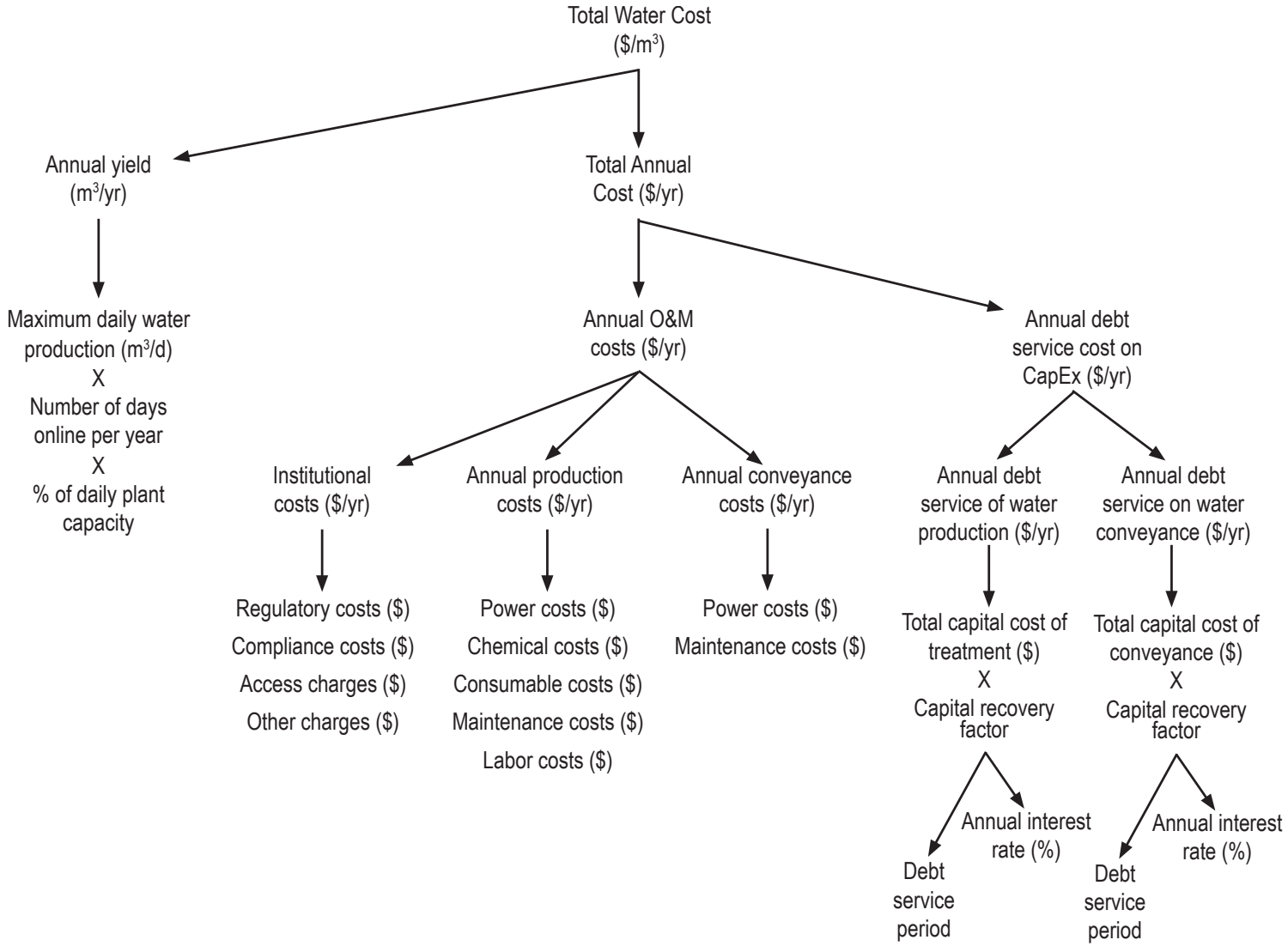
SWRO CapEx Cost Trend



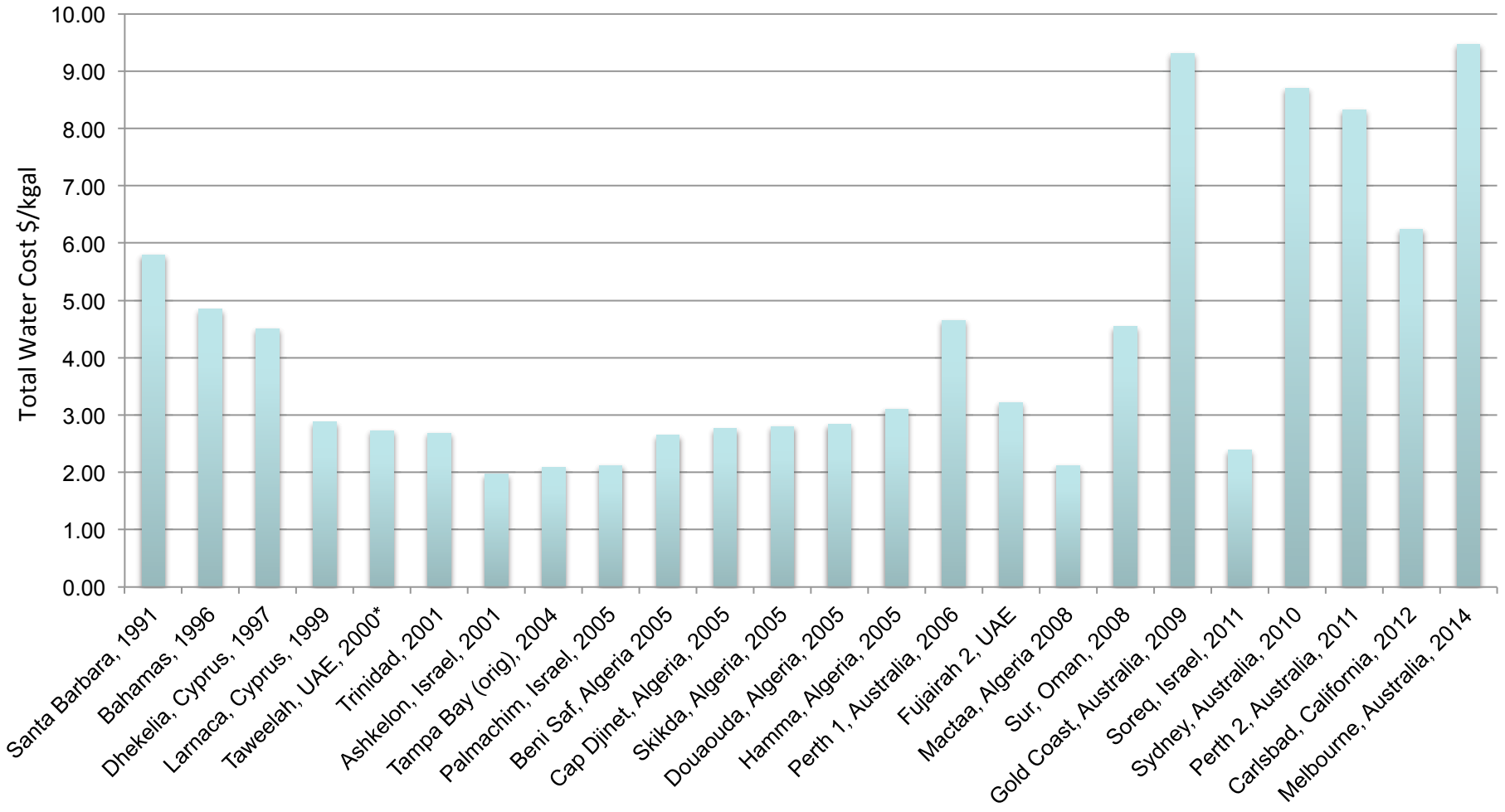
Distribution of unit SWRO EPC costs



SWRO Total Water Cost



SWRO Total Water Costs



Total Carlsbad Project Costs

Total Capital Cost

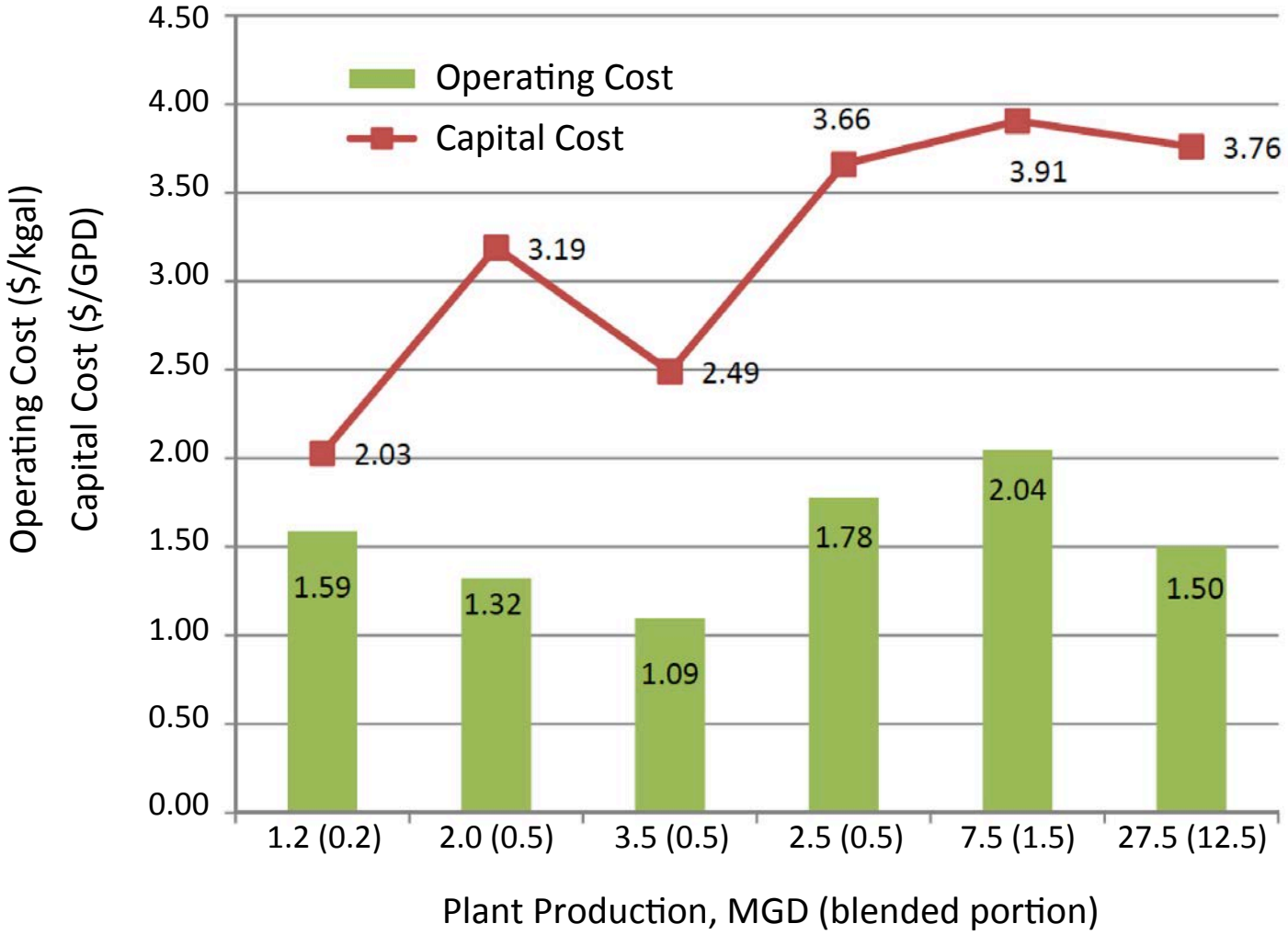
Total desalination plant	$537 million
Total conveyance pipeline	$159 million
Financing costs	$227 million
Water Authority improvements and oversight	$80 million
Total Capital Costs	**$1.003 billion**

2016 water purchase price* (includes pipeline)

*Current estimate based on highest electricity rate applicable

56,000 acre feet per year	48,000 acre feet per year
$2,131/AF ($5.80/kgal)	$2,367/AF ($6.45/kgal)

BWRO CapEx & OpEx



adapted from: TWDB, 2012

International Projects vs US

- Scope
- Offtake agreement
- Plant Availability
- Technical issues
- Development
- Level of government participation
- Environmental, permitting
- Local conditions

Desalination's Future

- RO-compatible technologies will continue to dominate
- MF/UF will be the predominant pretreatment technology
- Intake/outfall will be 'fatal flaw' issue in US
- Process optimization will improve
- More small/mid-size systems
- SWRO will be base-load supply in arid coastal regions, insurance policy in US
- Costs unlikely to come down
- Brackish water RO will be the new inland standard
- Industrial use of BWRO, SWRO will grow significantly
- More POE, POU systems