Membrane Applications in Water Treatment

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U.S. Bureau of Reclamation

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Sampling of Applications

- Desalting seawater
- Holding back seawater intrusion
- Treating brackish groundwater
- Water softening
- Waste water recovery
- Removing color, odor, and other organic contaminants

Basics of Membrane Technology

- What's a membrane?
- How does it work?
- What can it do?
- How much does it cost?

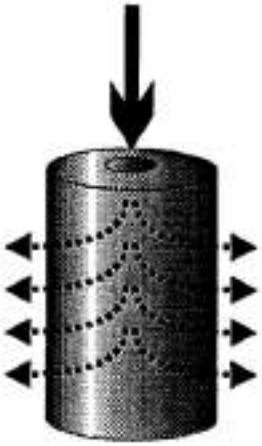
A membrane is a film.

- A semi-permeable membrane is a VERY THIN film that allows some types of matter to pass through while leaving others behind.

Membrane Types

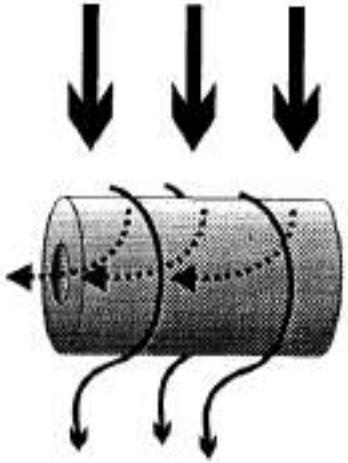
	ED	MF	UF	NF	RO
Retained	Water, TSS, microbes uncharged molecules	Larger particles	Larger molecules	Higher charged ions	Most everything
Transported	Dissolved salts	Dissolved salts, small particles	Small molecules and ions	Mono-valent ions, small molecules	Very small uncharged molecules
Productivity (gfd)	Practically None	20-100k	10-20	25	20

Filtration Mode terms -



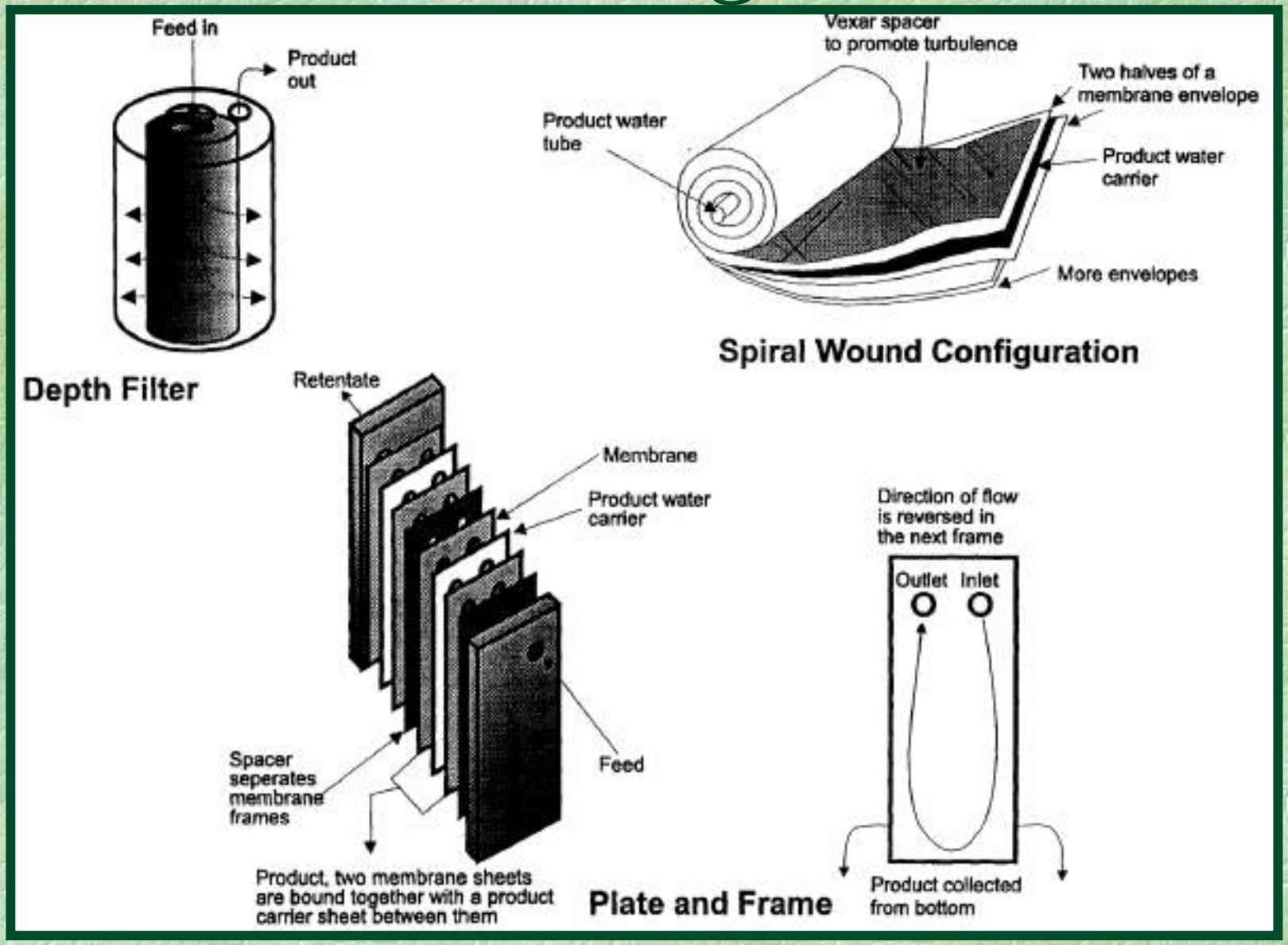
Dead end flow: All water passes through the membrane, particles are trapped within the membrane structure.

Cross flow: Feed water passes parallel to the membrane surface, product water permeates through the membrane, the concentrated stream helps carry particles out of the system.

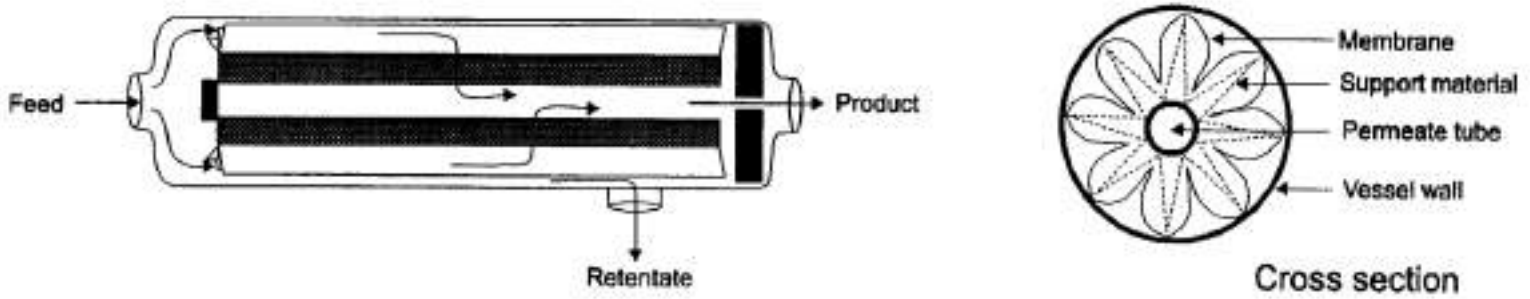


Transverse flow: Feed water meets the membrane surface at right angles, product water permeates through to the inside of the tube, concentrate washes over the outside of the tube removing particle build-up.

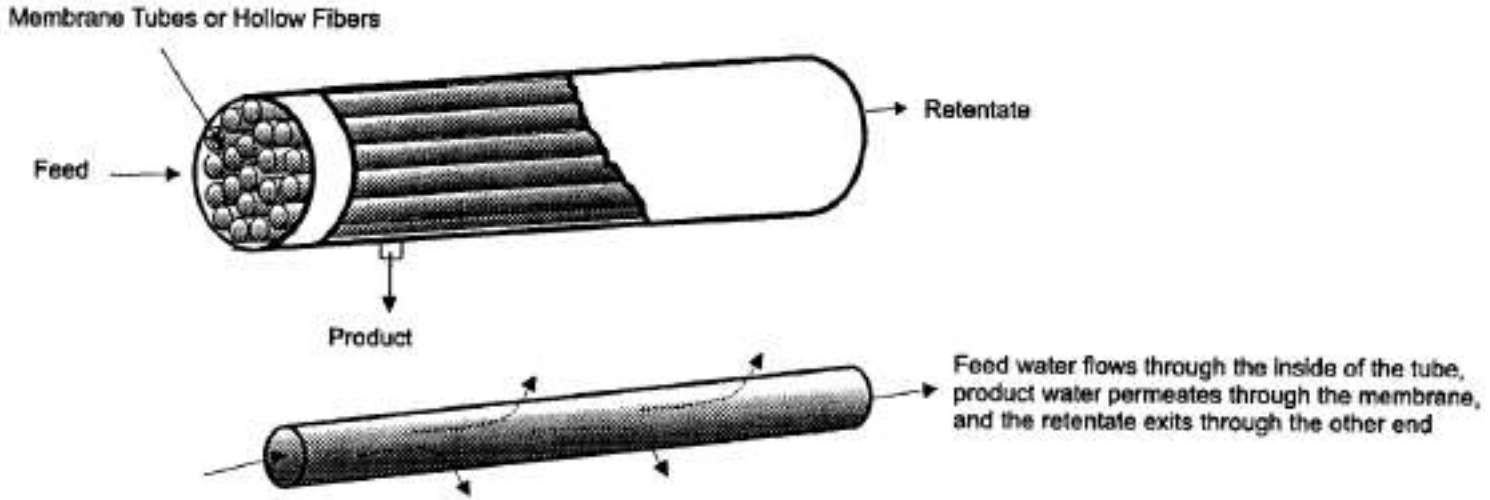
Membrane Configurations



More Membrane Configurations

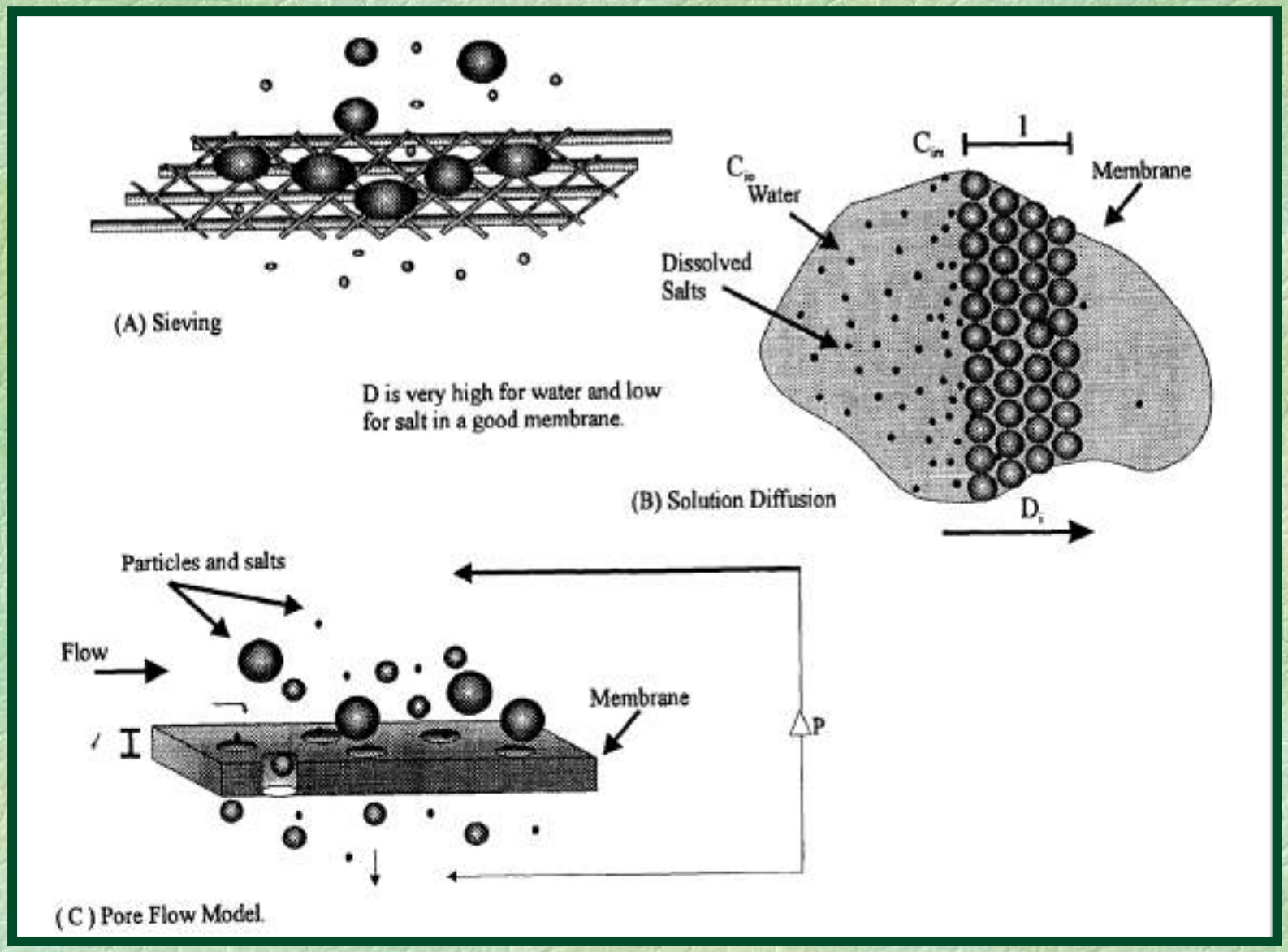


Pleated Membrane Cartridge



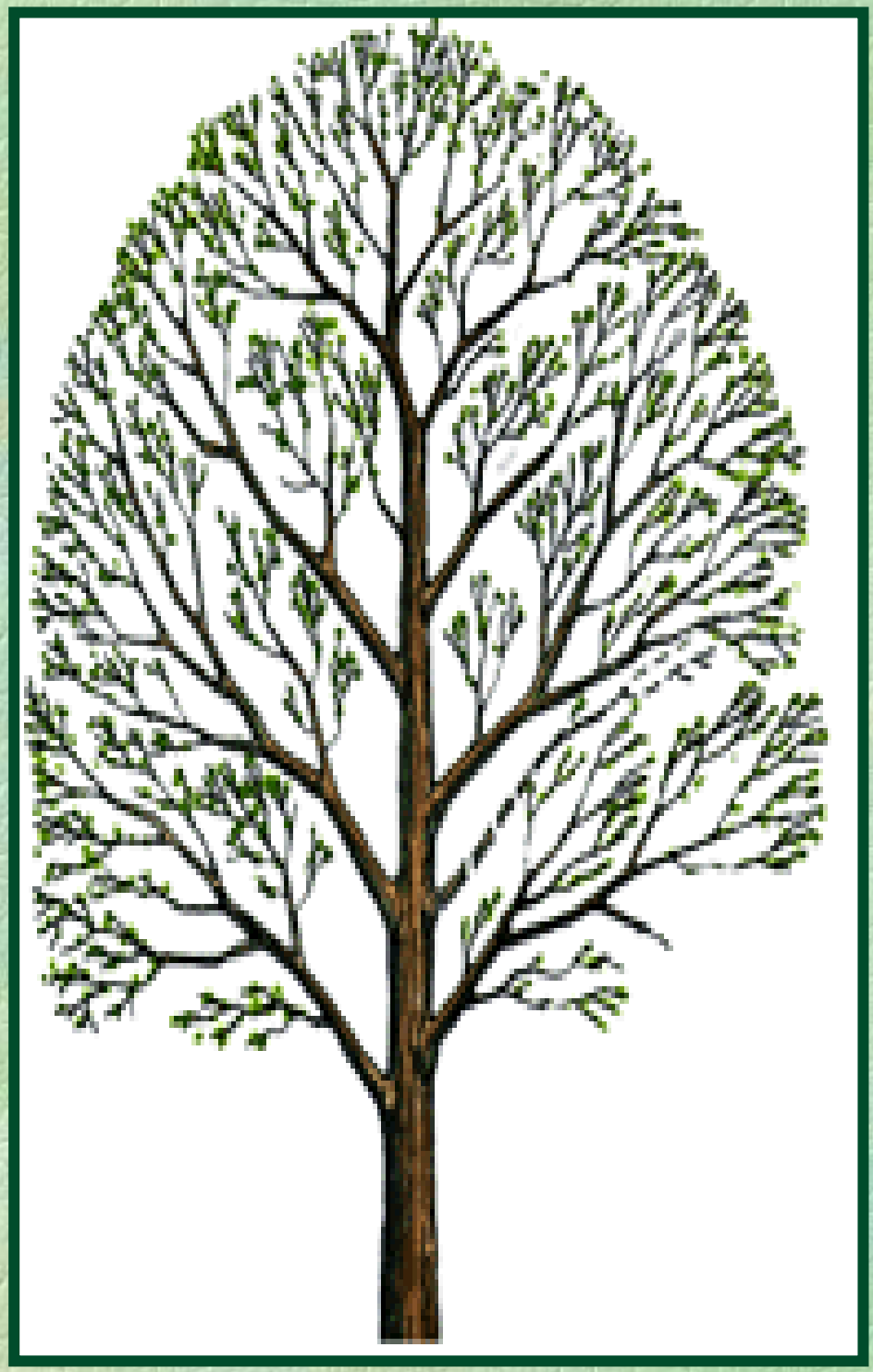
Tubular or Hollow Fiber Module

Sieving, Diffusion & Pore Flow

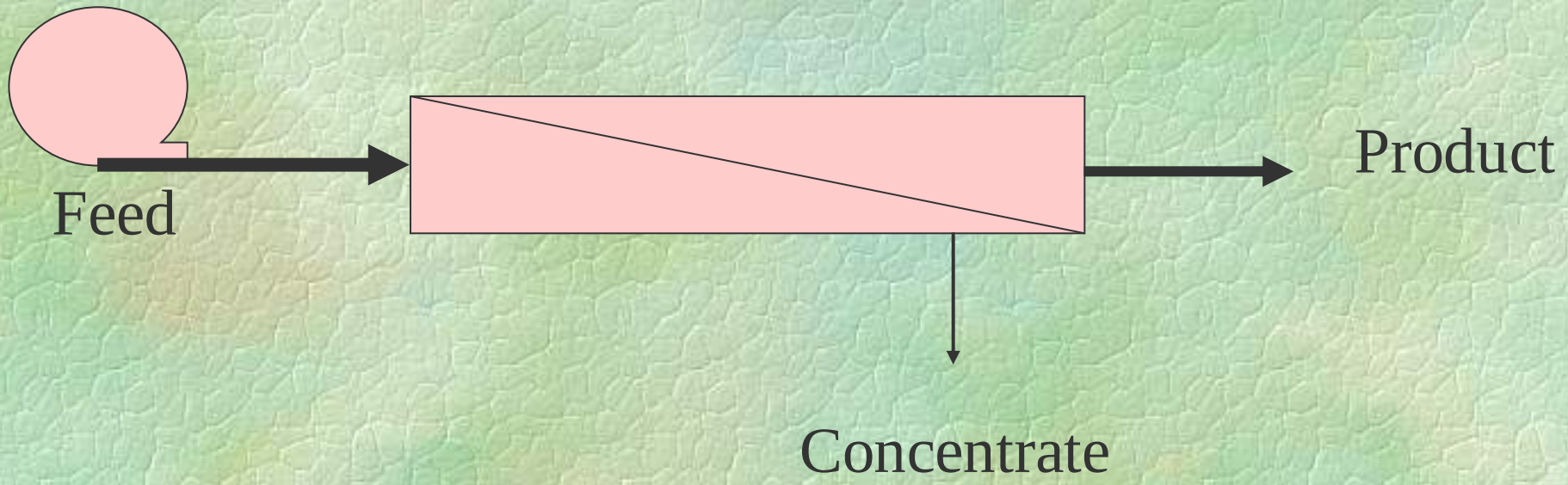


Reverse Osmosis - a Natural Process

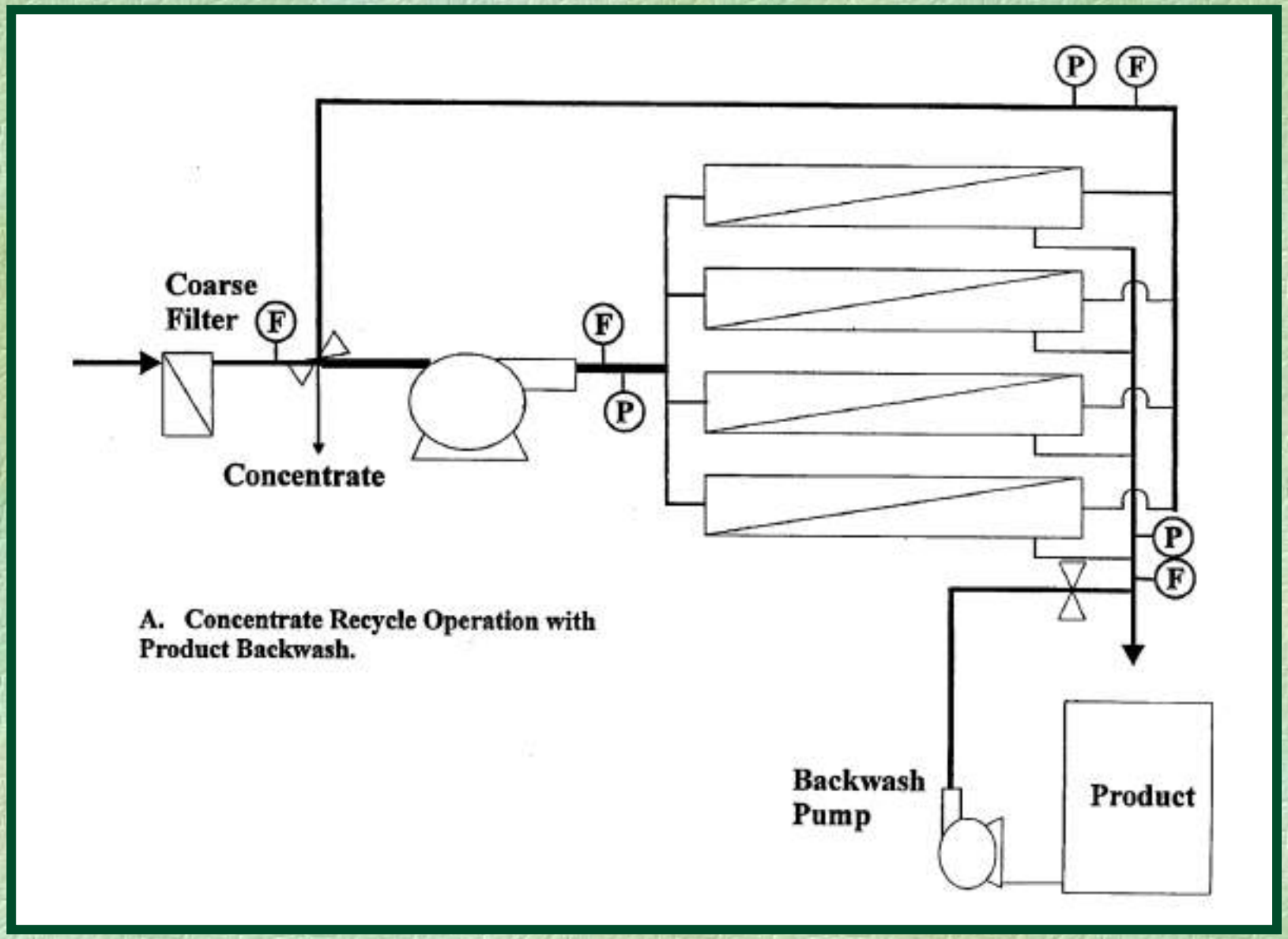
- Water is drawn from a low to a high concentration. Evapo-transpiration creates a suction which draws water up through the root hairs to the leaves.
- In RO systems pressure is applied to the high concentration side of the membrane to induce osmotic flow of clean water to the low concentration side.



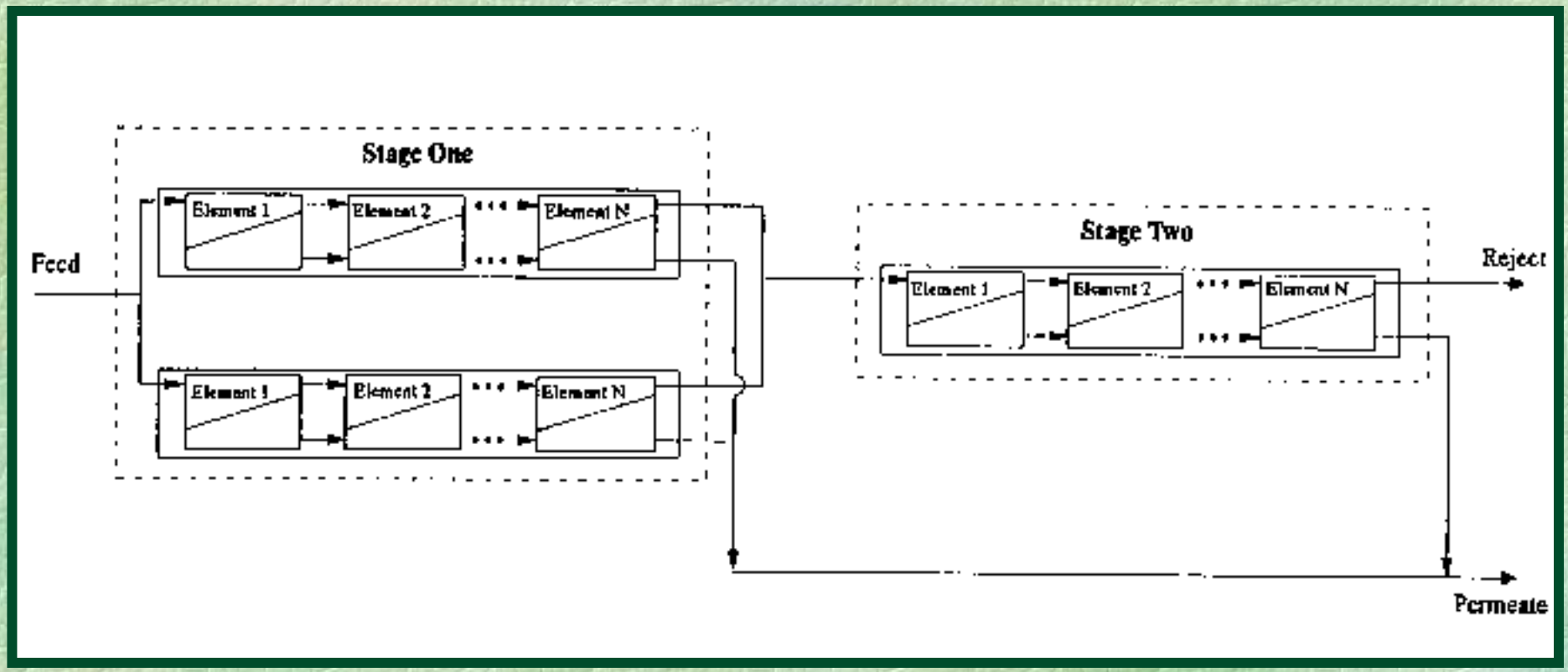
Process Configuration - General



One Stage - Elements in Parallel



Two Staged System - 2:1 array



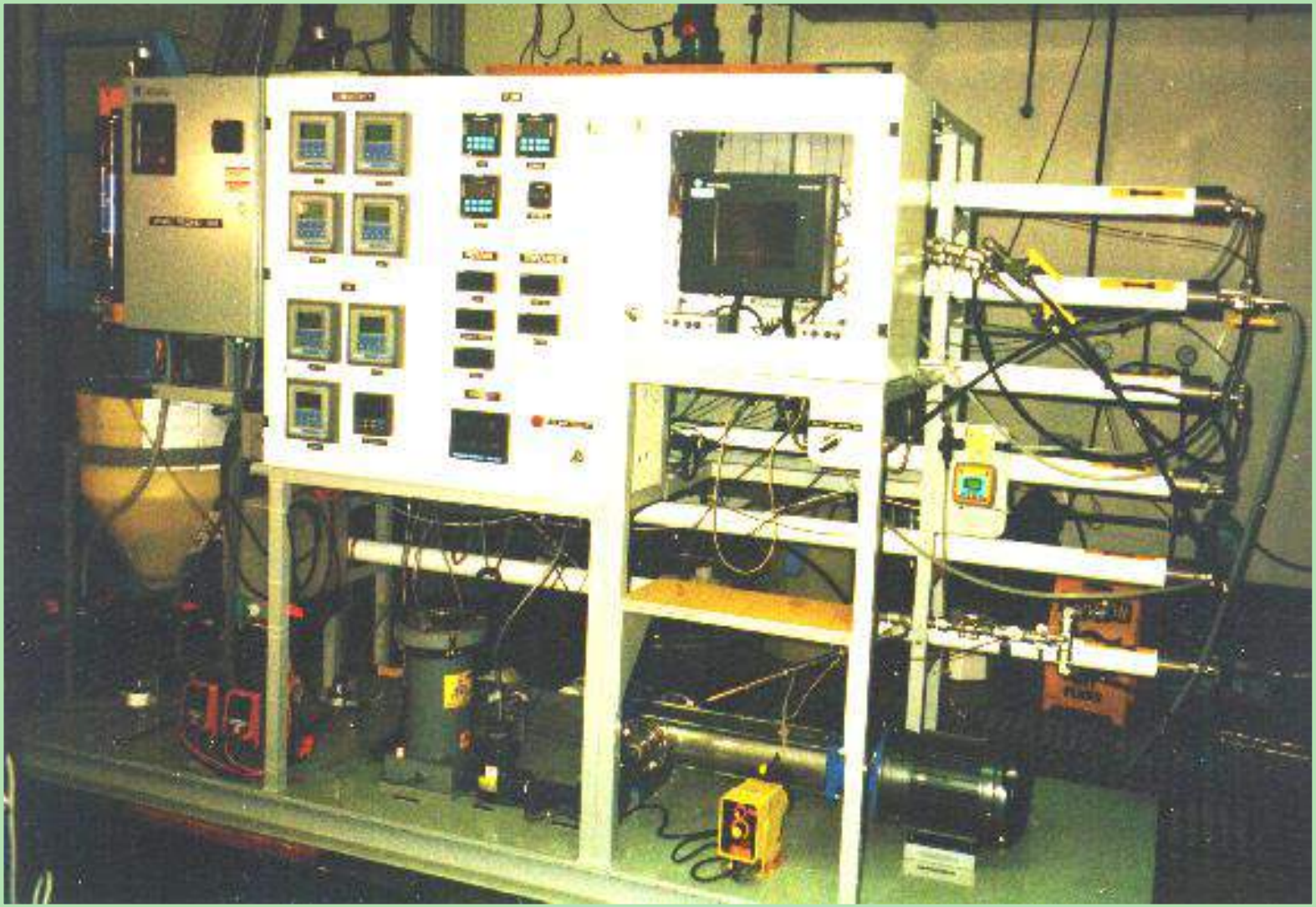
Reverse Osmosis

- Spiral wound or hollow fine fiber
- Pretreatment is critical to success
- NTU <1, SDI<3
- Operating pressures from 150 - 1000 psi
- Removes >95-99% TDS
- Concentrate Stream is 15-25% of flow with 4 to 6 times the TDS.

Nanofiltration

- Cross flow or transverse flow
- Any membrane configuration
- Need turbidity <1 NTU, SDI <5
- Operating pressure 50 - 200 psi
- Used for softening or special applications

McAllen, TX
Waste Water Recovery (6 g/min)

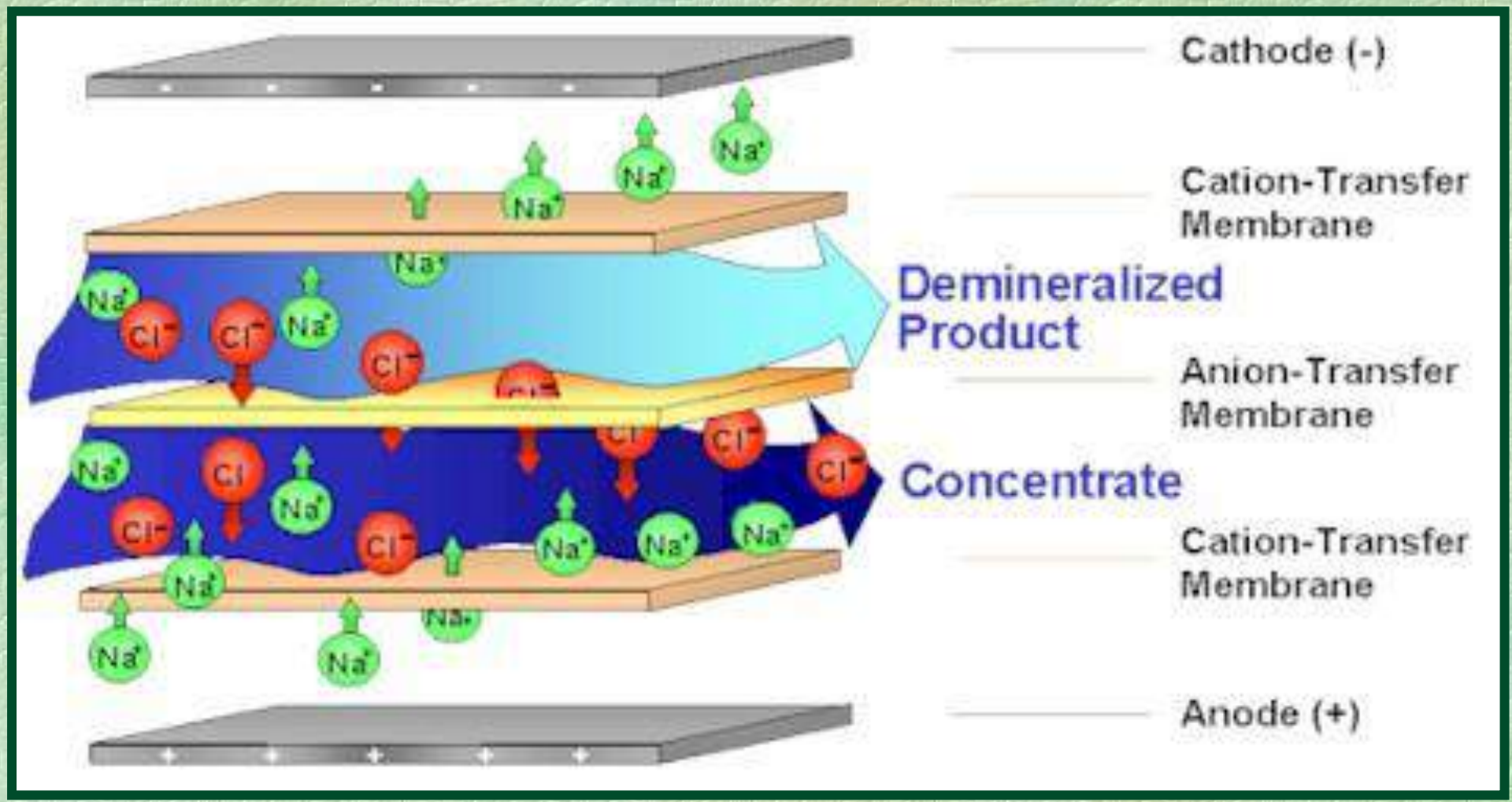


0.1 MGD RO Package System

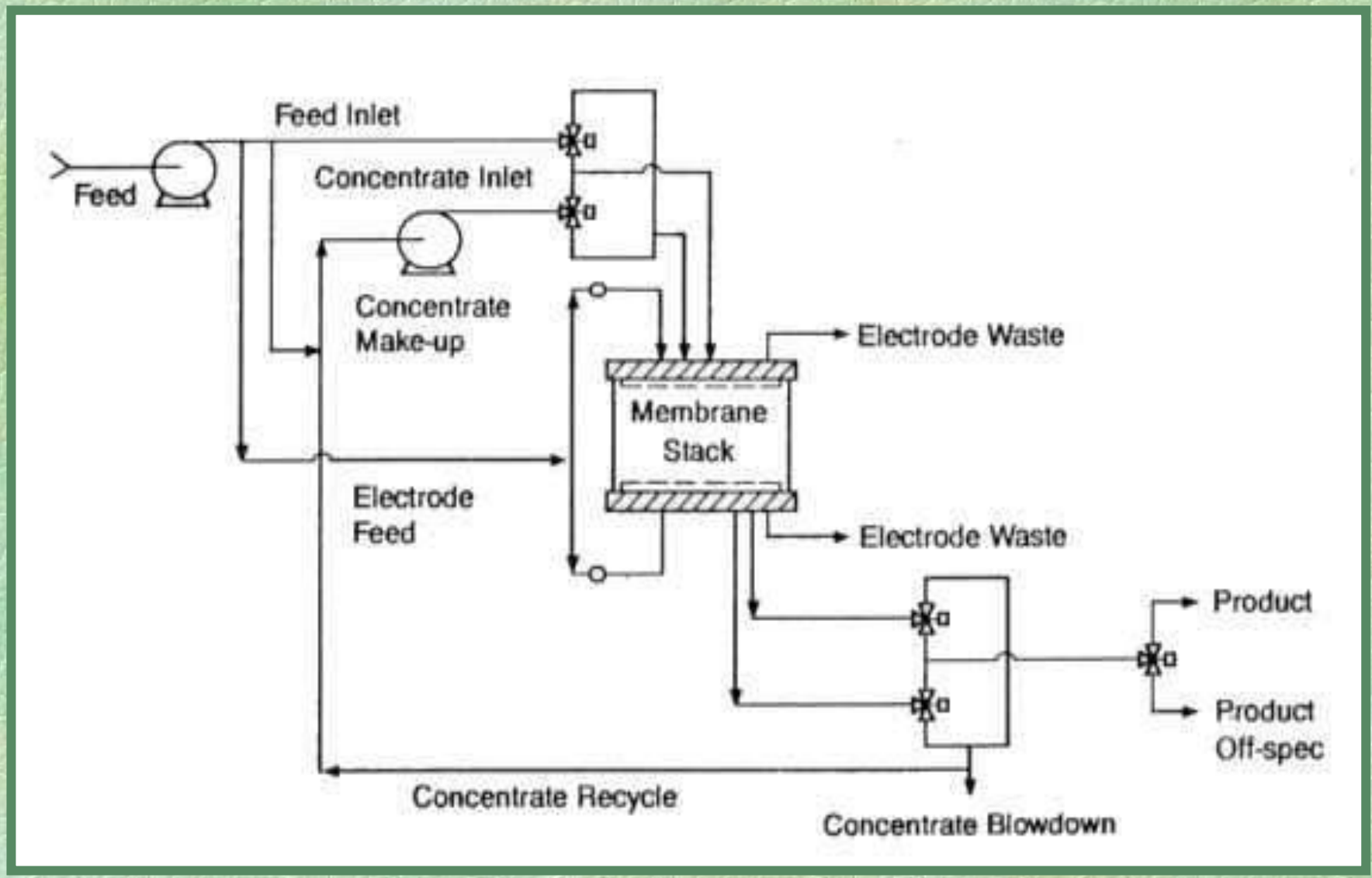
Yuma Desalting Plant (100 MGD)

Electrodialysis

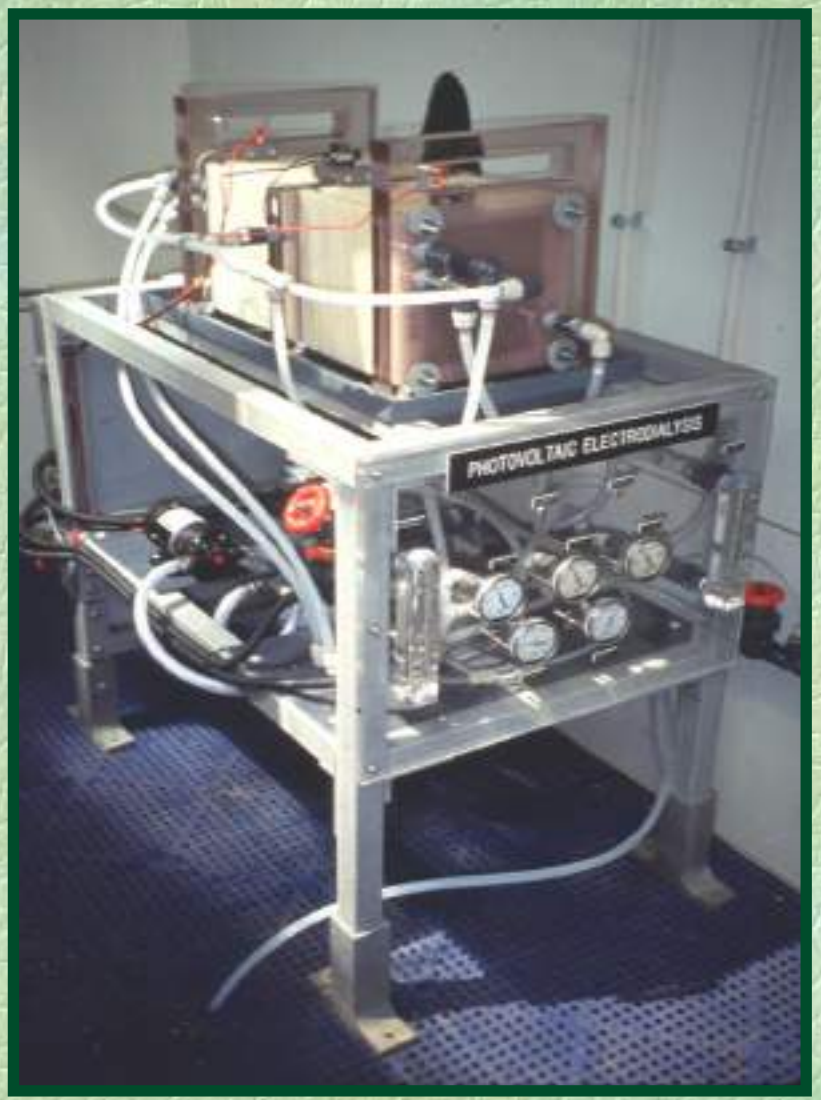
- Uses electrical power to draw ions from product water to the concentrate stream.



Plumbing for EDR



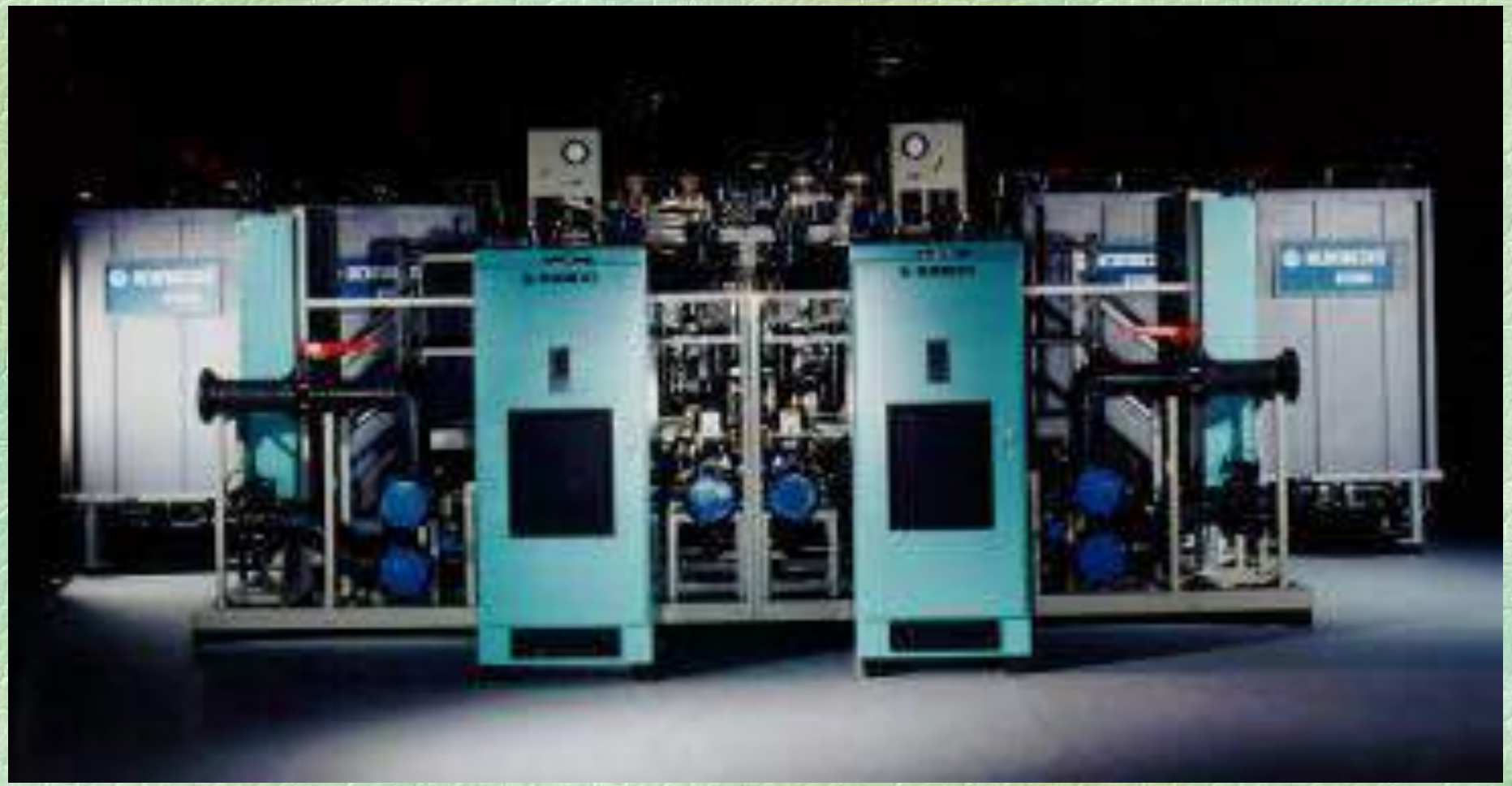
PV EDR, 1 g/min



Photovoltaic Electrodialysis

Ionics Aquamite V: 35,000 gpd

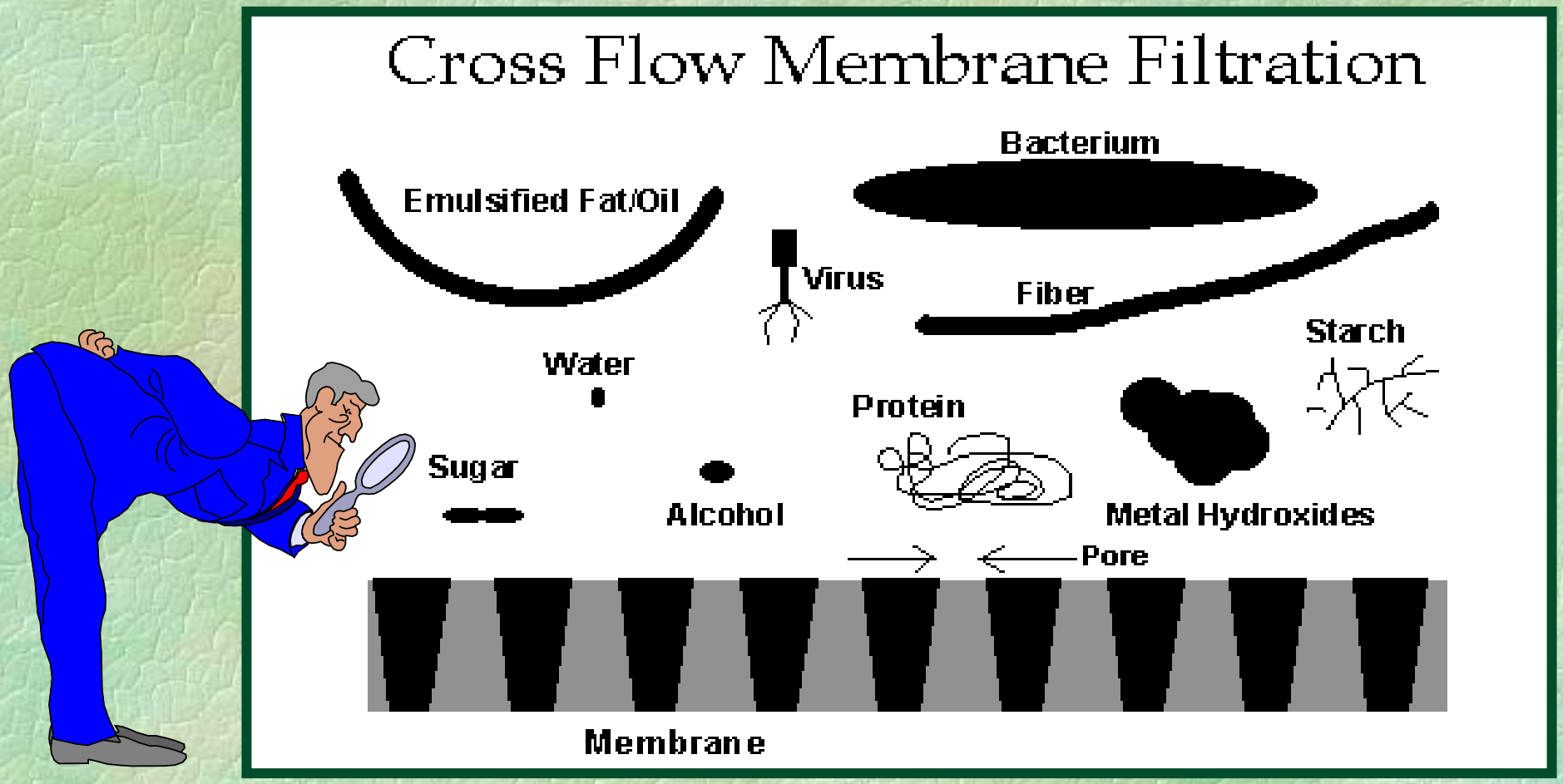
Aquamite 100: 1 MGD



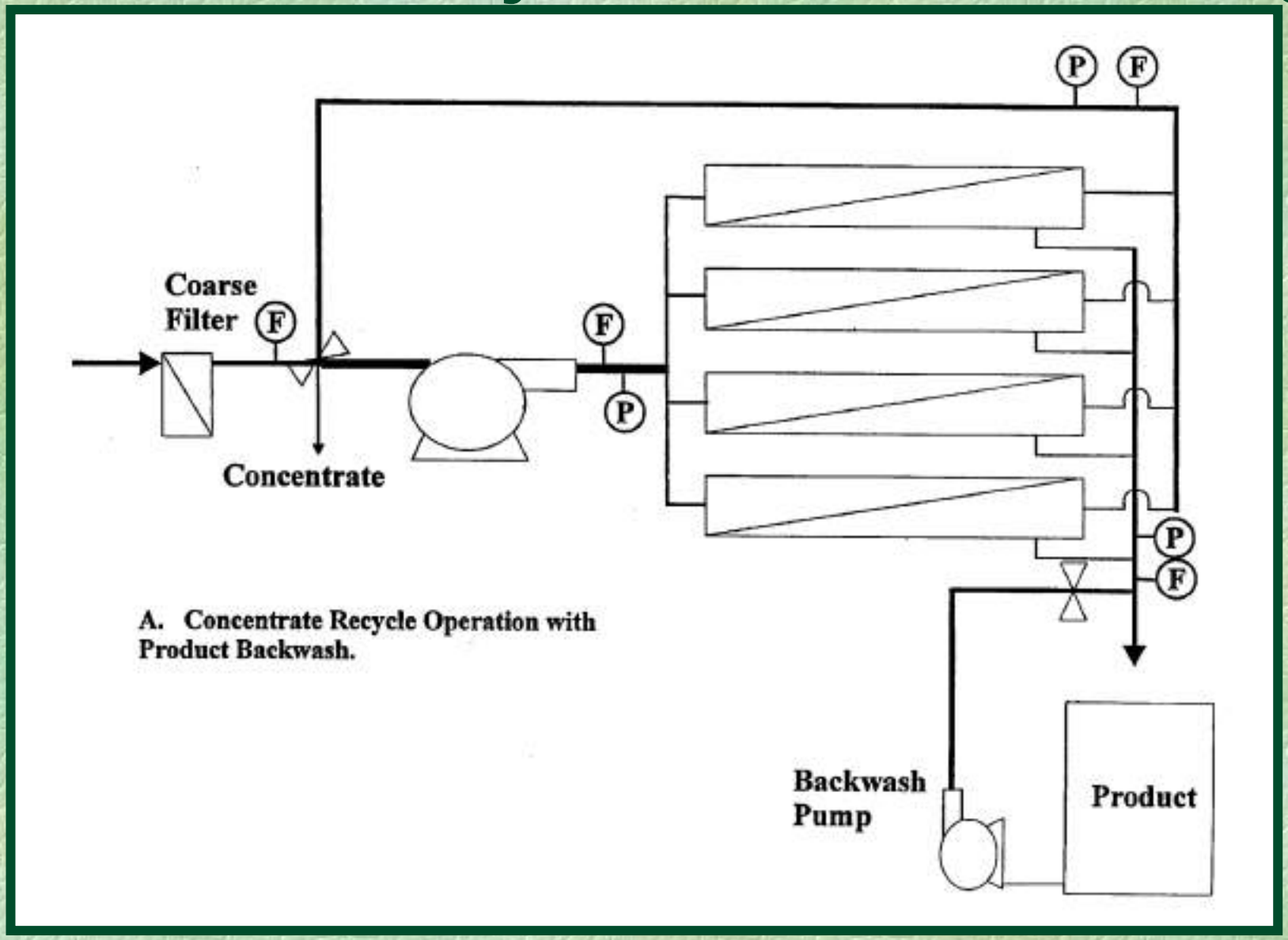
Ultrafiltration

- Cross flow or transverse flow
- Any membrane configuration
- Use re-circulation for high TSS
- Operating pressures ~ 50 psi
- Uses back flush to loosen fouling
- Excellent pretreatment for RO or Post treatment for ED.

Size Exclusion



Re-circulation to Increase Cross-Flow Velocity, Decrease Fouling

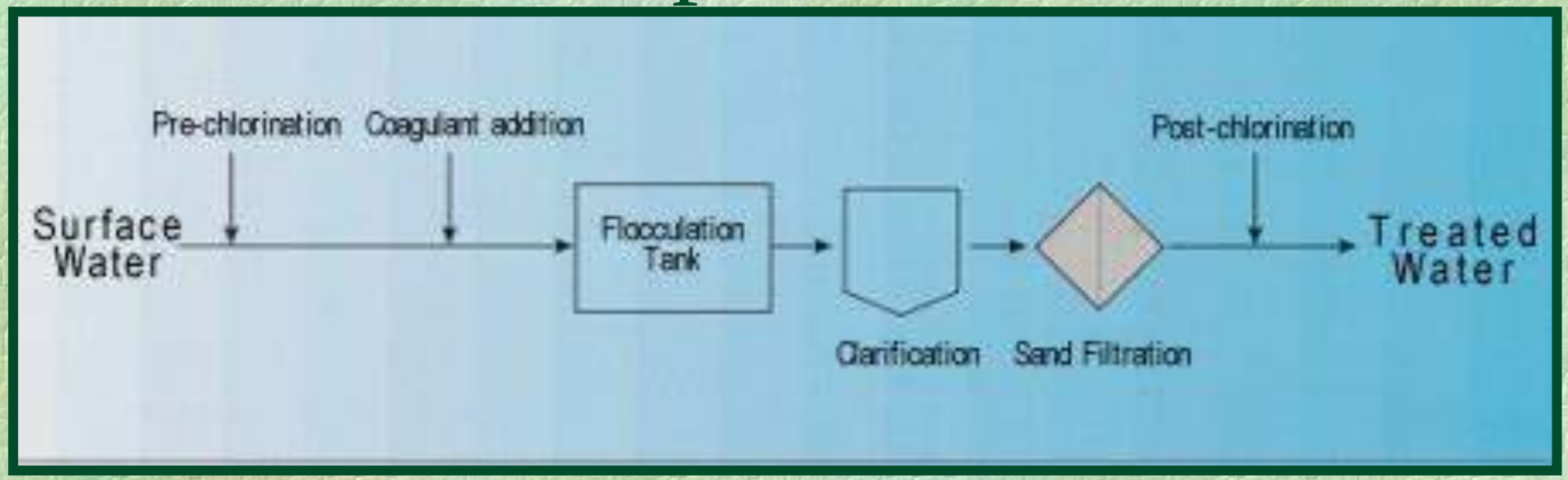


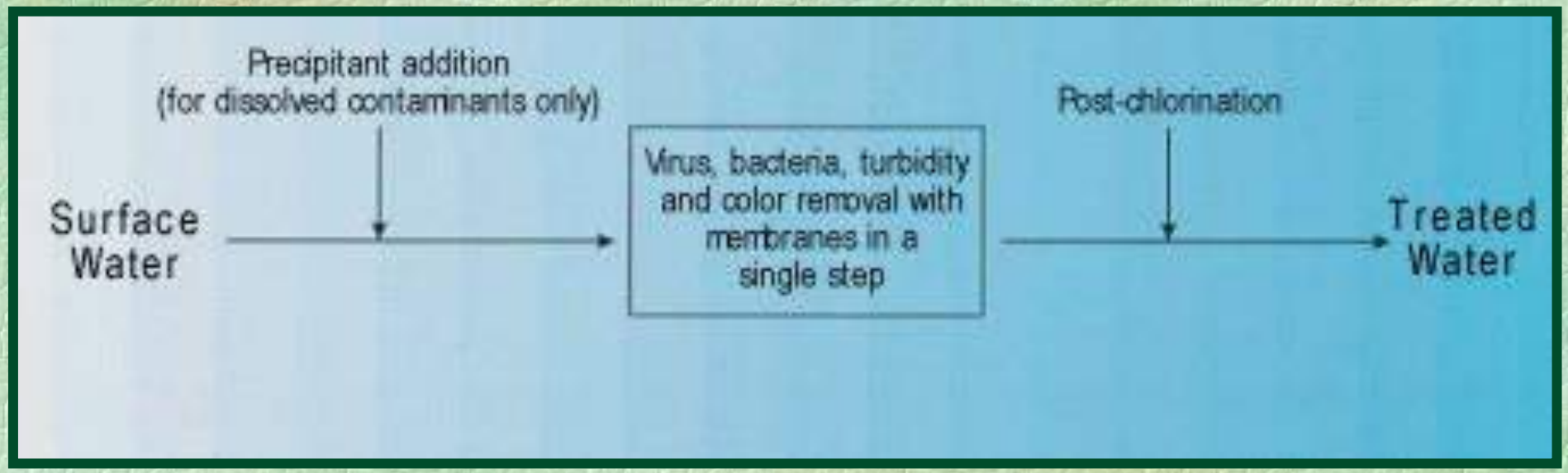
Vacuum driven separation MF or UF-

The ZeeWeed® membranes are immersed in the process tanks

The ZeeWeed® Hollow Fiber Membrane

UF can replace several conventional processes



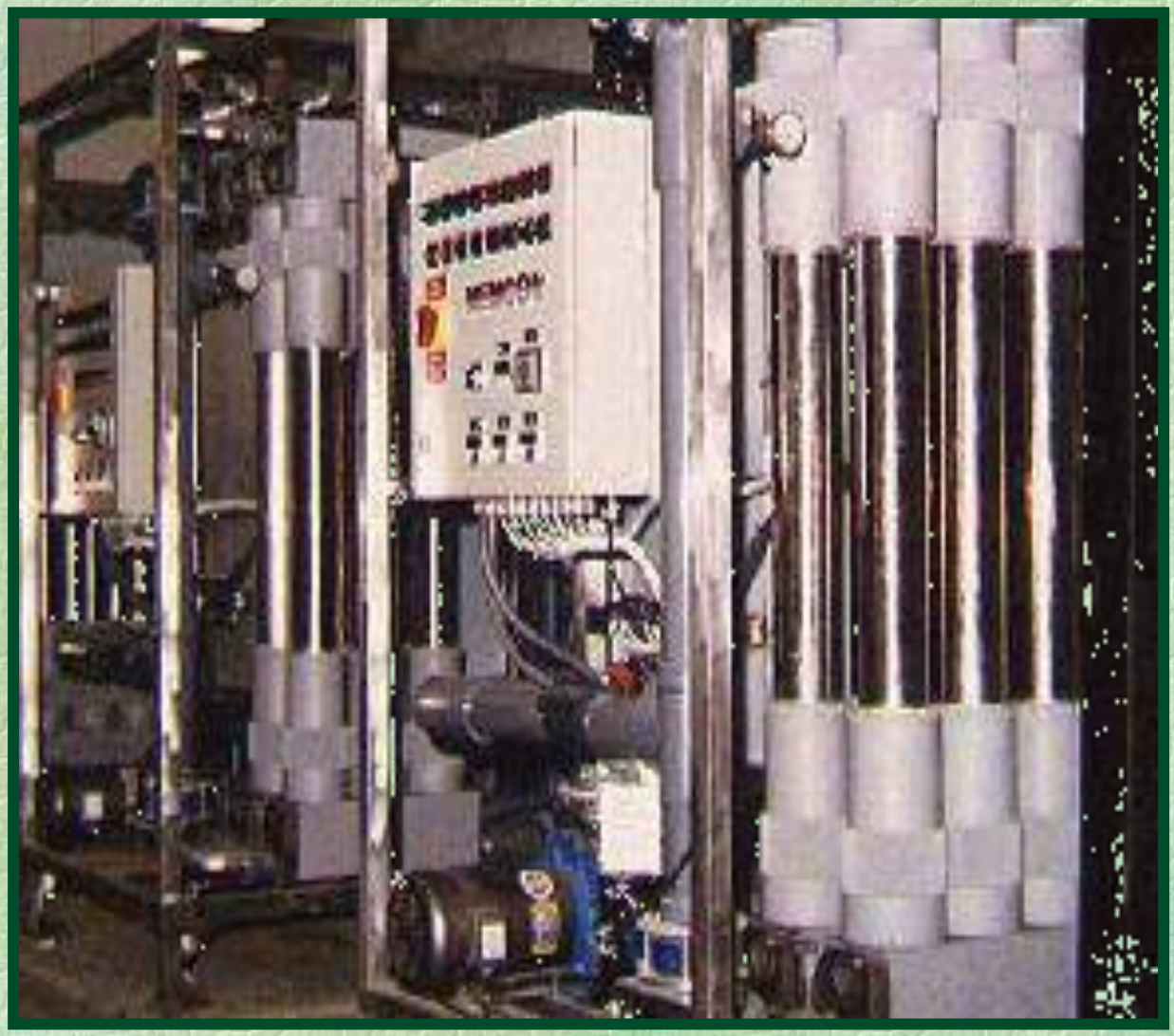


Microfiltration

- Any filtration mode
- Any membrane configuration
- Needs back flushing and air scour
- Operating pressure ~ 20-30 psi
- Highly automated!
- Can add coagulants to enhance filtration
- Can be a good pretreatment for RO or NF

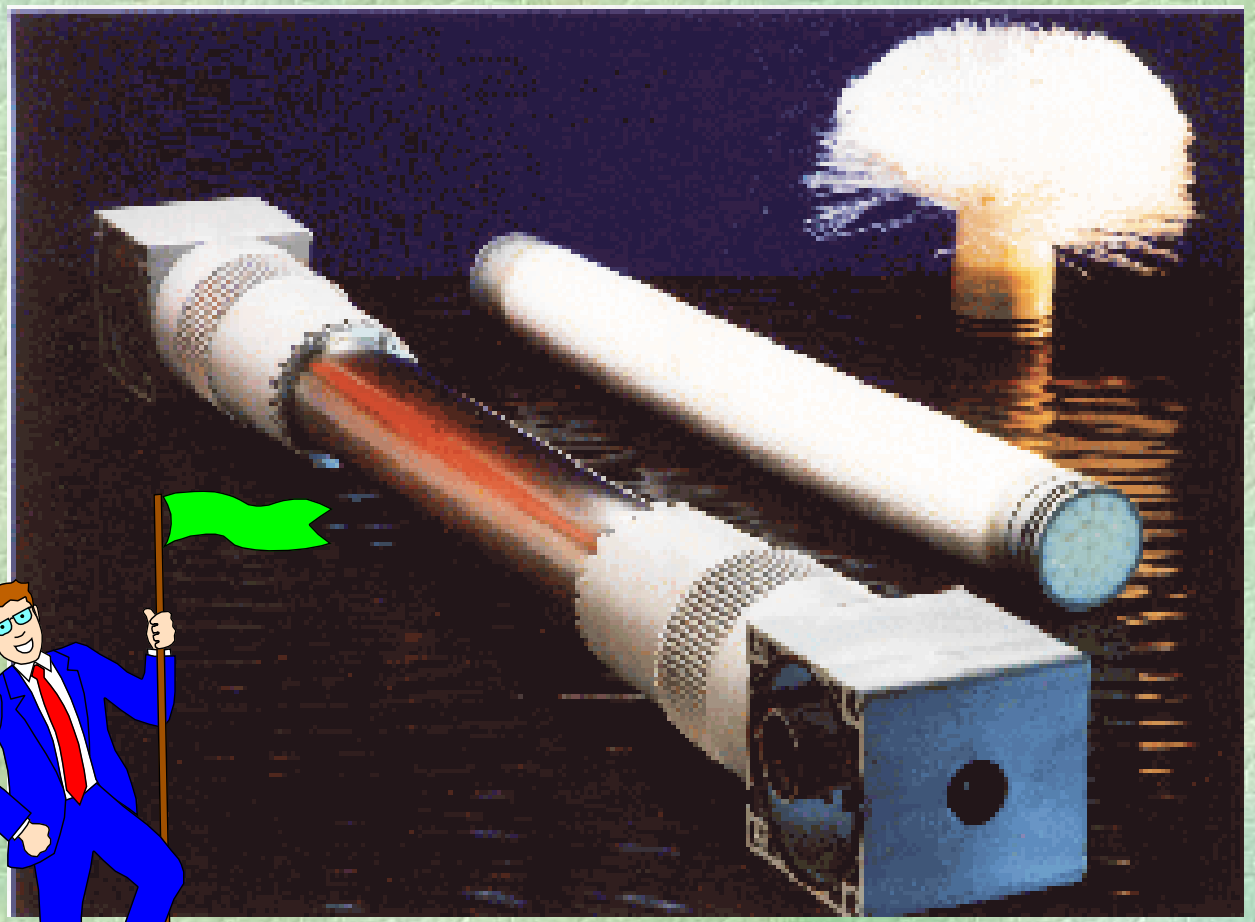
Bolinas Woodrat WTP
0.2 MGD MF

- High Turbidity
- 80% Recovery
- Product - .04 NTU
- Concentrate is discharged to surface water



MF Hollow Fiber Modules

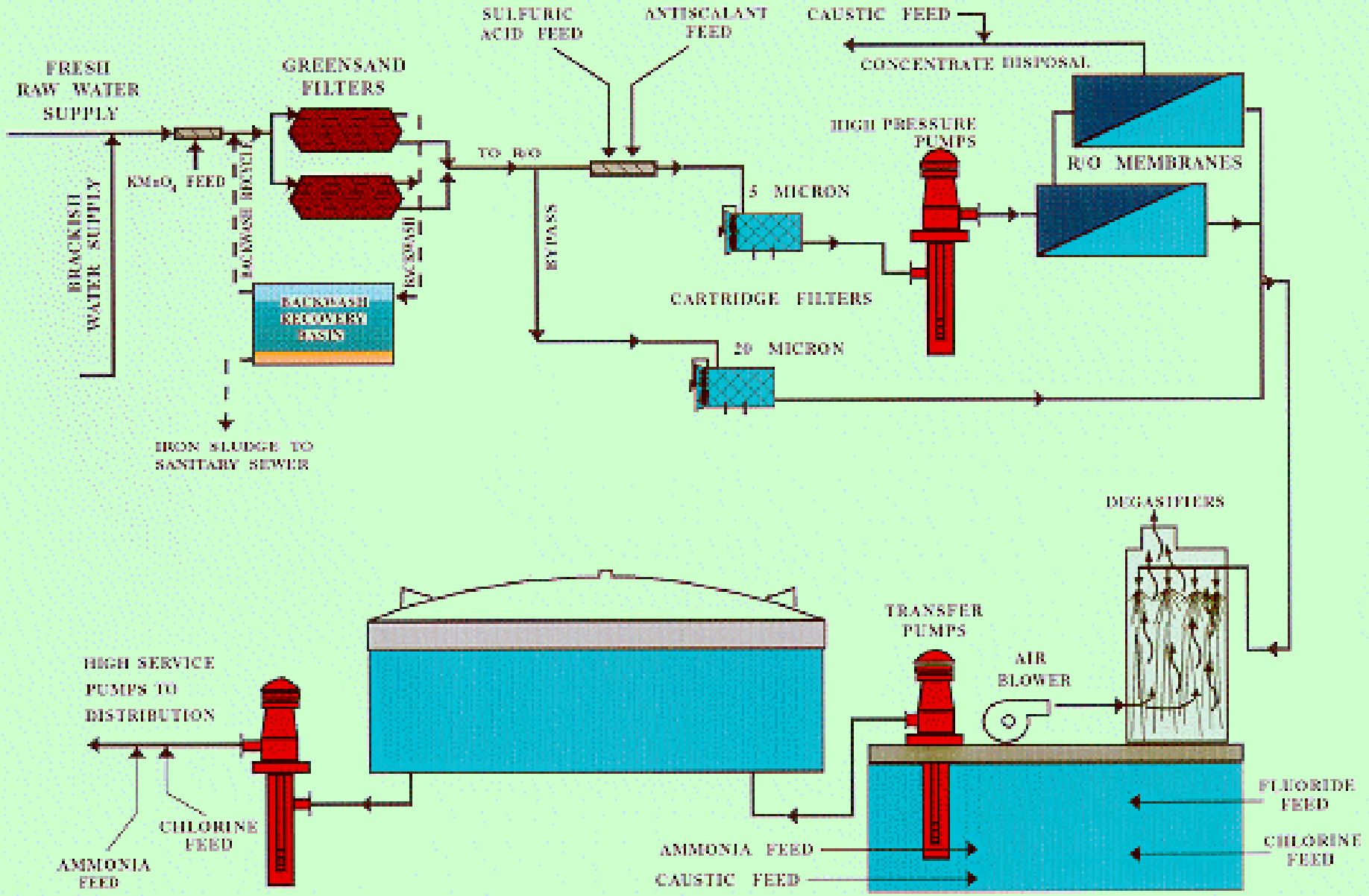
- Removes Giardia, Cryptosporidium, virus, turbidity:
- Great for waste water recovery.



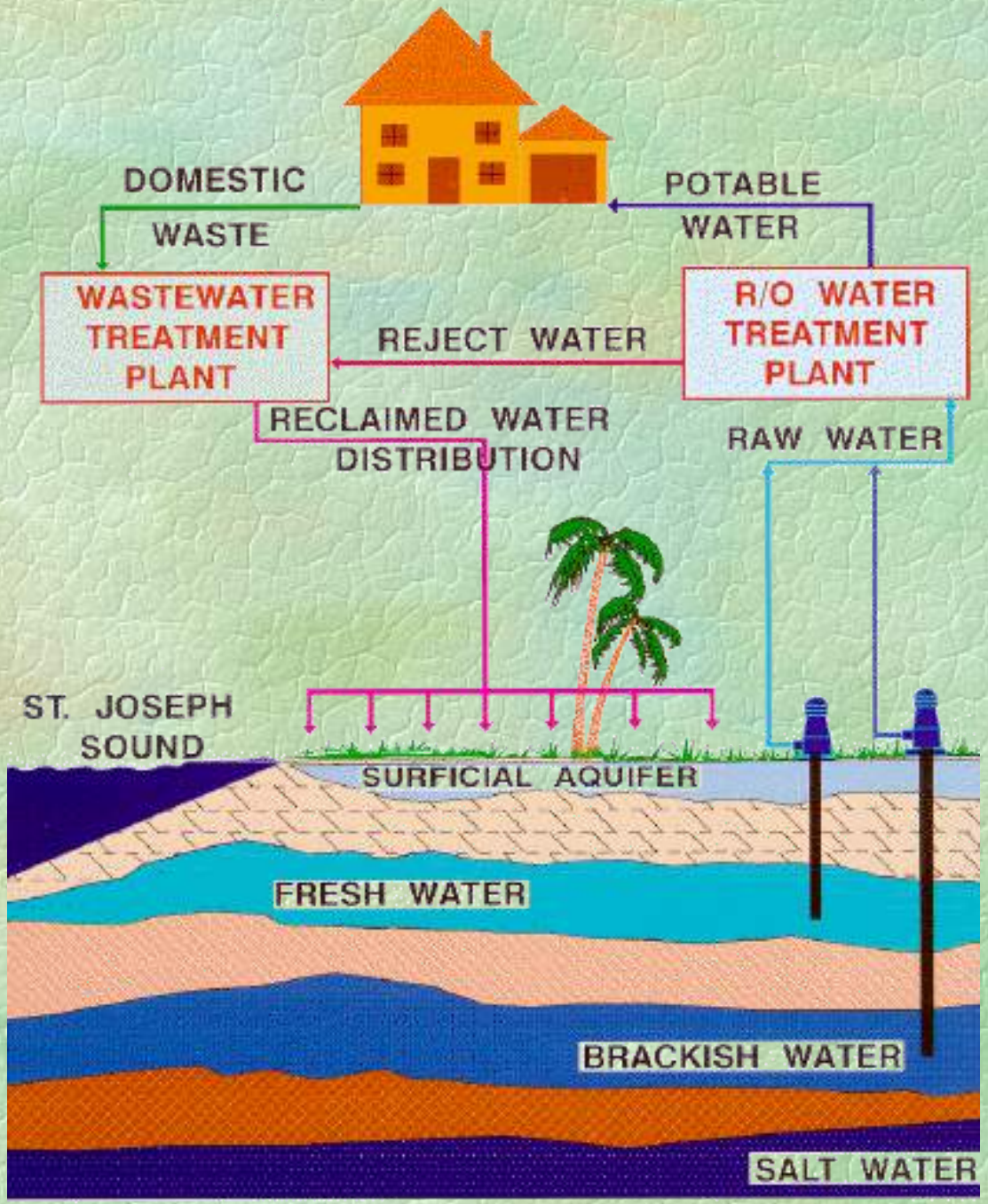
Concentrate Disposal

- Combine with reclaimed water and release to surface water.
- Deep Well injection - Limited by Geology
- Evaporation/Crystallization - Capacity limited
- Irrigating golf courses and roadway vegetation - Environmental limitations
- Saline wetlands - Capacity Limited

CITY OF DUNEDIN R/O PROCESS SCHEMATIC

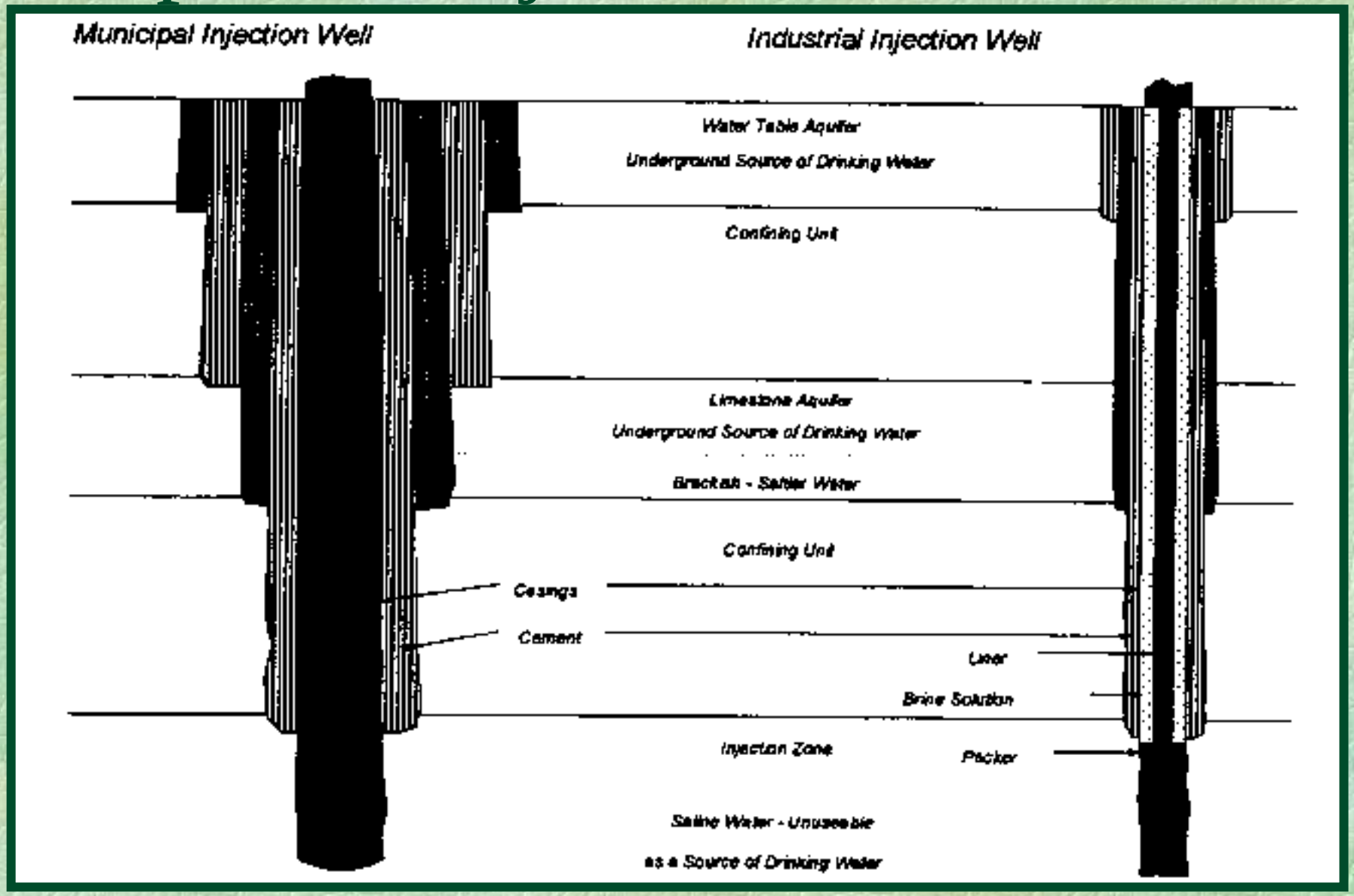


THE DUNEDIN WATER CYCLE

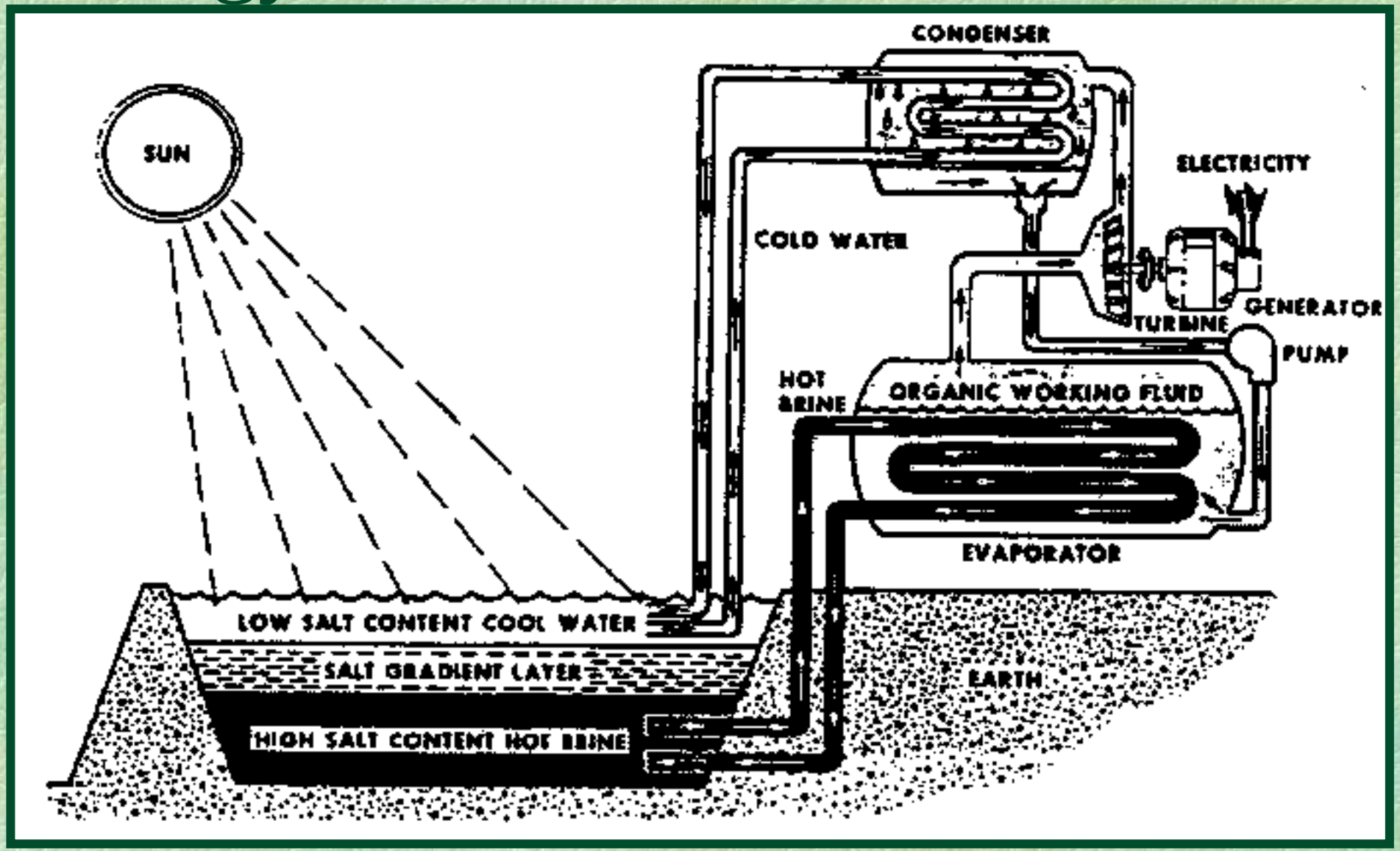


Saline Wetlands

Deep Well Injection Rules



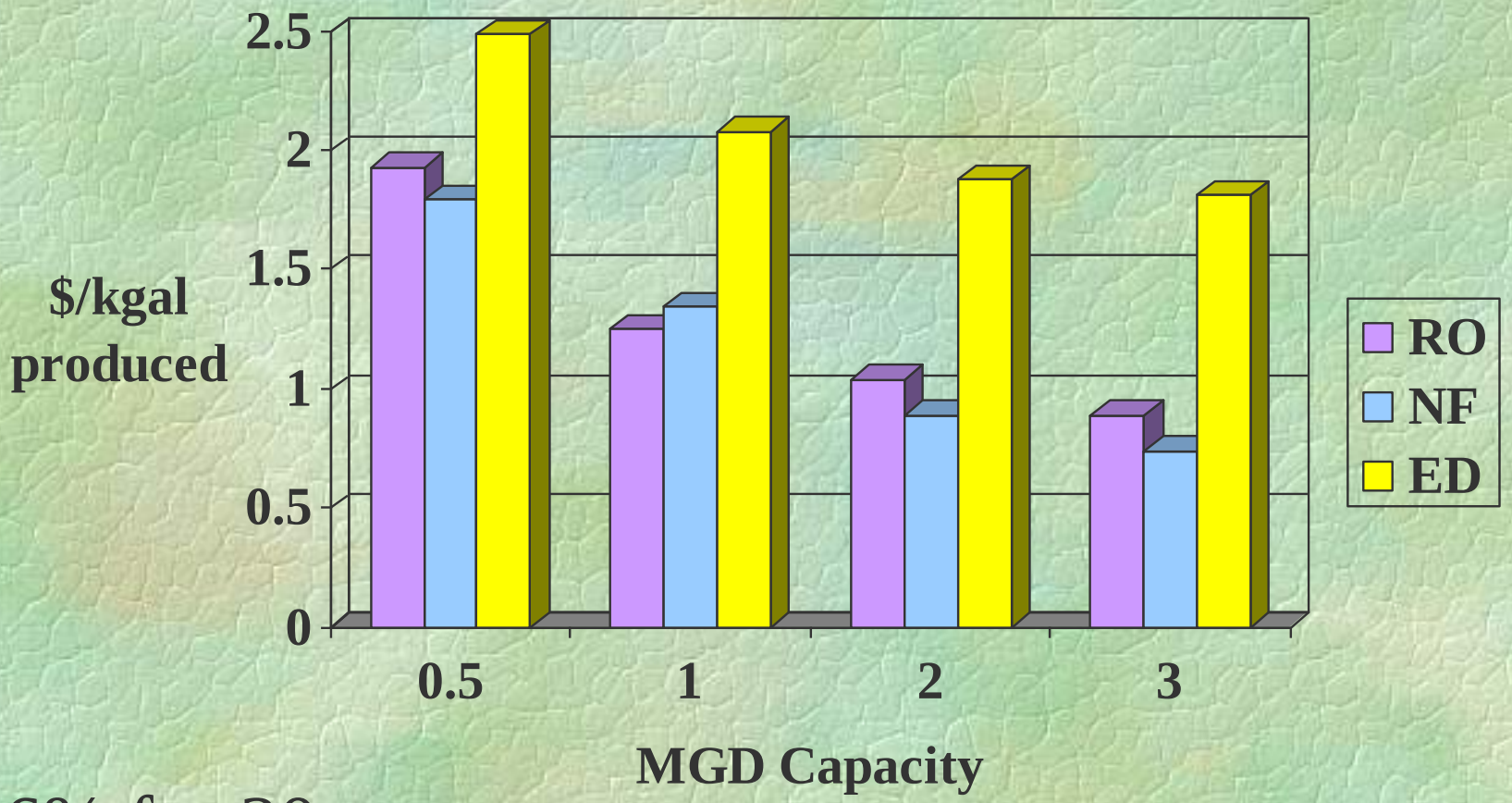
Energy from a Solar Pond



Irrigation -

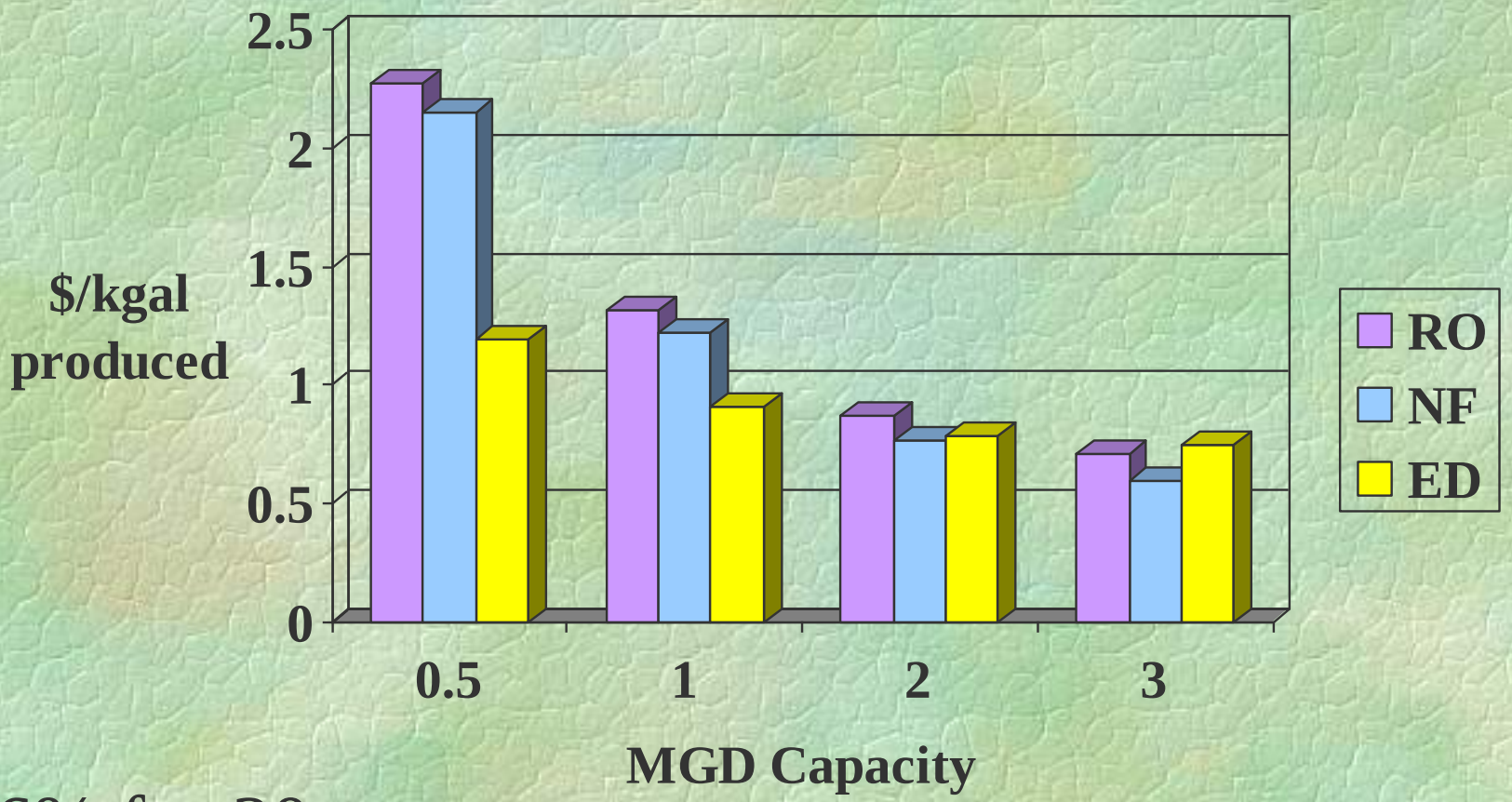
- Not a long term solution
- TDS should be <1000 mg/L
- Need careful irrigation management
- Need soil moisture monitoring equipment
- Good for golf courses with no surface discharge

Cost of Desalination



- 6% for 30 years
- **2000** mg/L TDS feed,
- product at 500 mg/L with blending.

Cost of Desalination



- 6% for 30 years
- **1000** mg/L TDS feed,
- product at 500 mg/L with blending.

Samples UF and MF Costs

Membrane	**Gal/day**	**$**
UF	50	4000
	50k	100,000
	360k	650,000
MF	500k	525,000
	1,000k	1,200,000

In Summary

- There is a membrane system to treat most any water problem.

- RO and NF systems should be used to remove only **dissolved** solids - they need VERY clear feed water.

Electrodialysis

- Electrodialysis can be less expensive for low TDS waters or when a 50% cut is adequate.
- ED removes IONS from water - it does NOT remove crypto, giardia, uncharged molecules, suspended solids etc.

UF and MF

- UF can remove color and odor causing organics, virus, and other microbiological pests. Not dissolved salts.

- MF can remove suspended solids, turbidity, crypto and giardia. Not color, virus, or dissolved solids.

The Bureau of Reclamation Water Treatment Engineering Group would be glad to help you with any of these processes!