Four Bureau Projects

SURVEY OF MUNICIPAL DESALINATION FACILITIES – 2018

EMERGING PROCESSES FOR HIGH RECOVERY PROCESSING – 2021

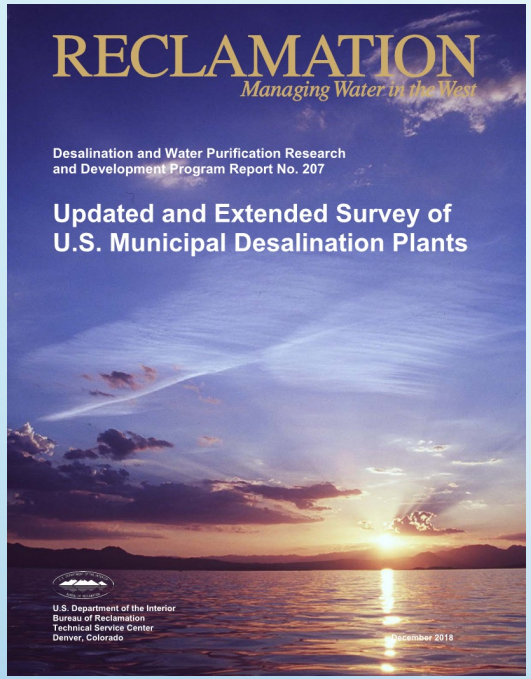
INFORMATION BASE OF CONCENTRATE MANAGEMENT – COMING IN 2022

INNOVATIVE ELECTRO-COAGULATION MEMBRANE PRE-TREATMENT WITH VACUUM-ASSISTED ELECTRO-DISTILLATION CONCENTRATE MANAGEMENT FOR COOLING TOWER BLOWDOWN MANAGEMENT – COMING IN 2022

Mike Mickley, PE, PhD
Mickley & Associates LLC

2022 MSSC Annual Salinity Summit

February 24 – 25, 2022
Las Vegas



PROJECT #1

Updated and Extended Survey of U.S. Municipal Desalination Plants

Mike Mickley, P.E., Ph.D.
Mickley & Associates LLC

Published in 2018
Report 207

To get reports→ https://www.usbr.gov/research/dwpr/DWPR_Reports.html

Context & Information Obtained

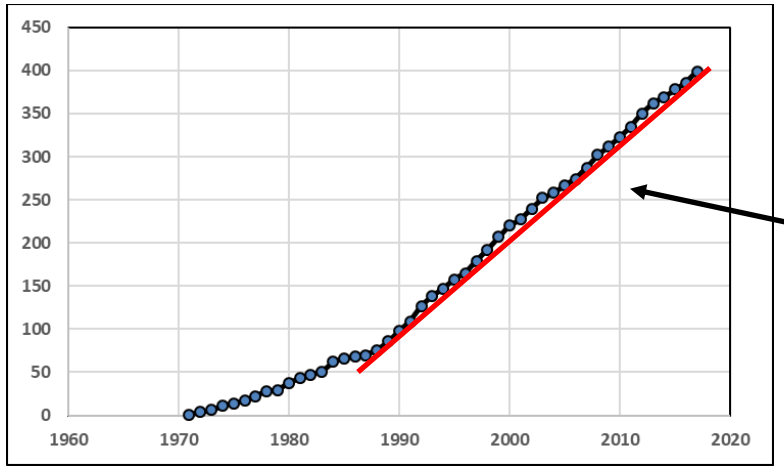
- U.S. municipal desalination facilities
- 50 U.S. States
- Facilities of size greater than 0.025 mgd (20 gpm)
- A survey – but an effort to contact every facility that could be identified
- Estimated coverage >90% of all facilities (missing facilities are likely small)
- Current project: 4th Survey since 1990; covers facilities built in period 2010-2017
- Overall database is of plants built – not plants currently operating

- **Basic information :**
  - Facility name
  - Facility owner
  - Contact information
  - Plant type
  - Desalination technology
  - Reason for desalination vs. conventional
  - Year of start-up
  - Desal Design capacity
  - Source water
  - Means of concentrate management
  - Treatment of concentrate

- **Additional information :**
  - Raw water TDS
  - Pretreatment steps
  - Feed pressure
  - Blending details
  - Plant Design capacity
  - Average capacity
  - Target TDS of permeate
  - Target TDS of blend
  - Membrane recovery
  - Post-treatment of permeate
  - Age of membrane at last replacement

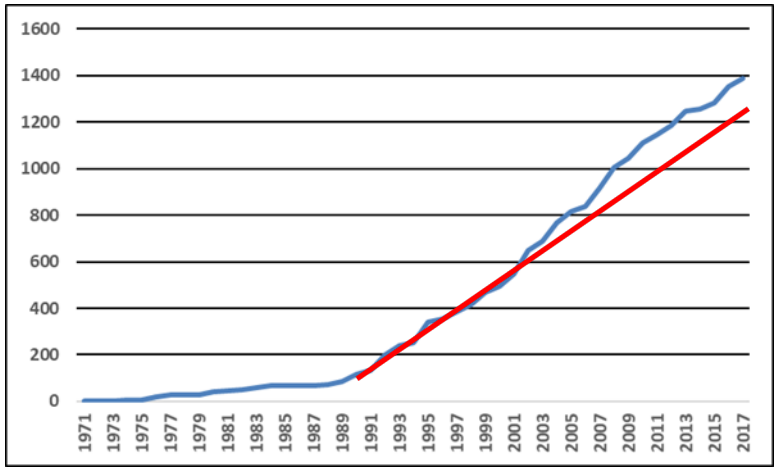
Numbers & Location of U.S. Municipal Desalination Plants Built

Number > 400



10 to 12 plants/yr

Capacity

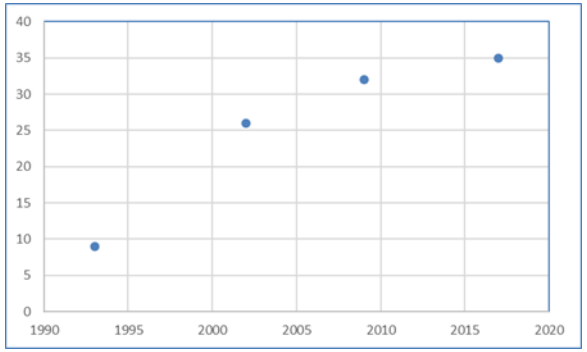


Location

State	1971-2017	2010-2017
Florida	167	19
California	58	13
Texas	53	23
North Carolina	17	5
Iowa	16	6

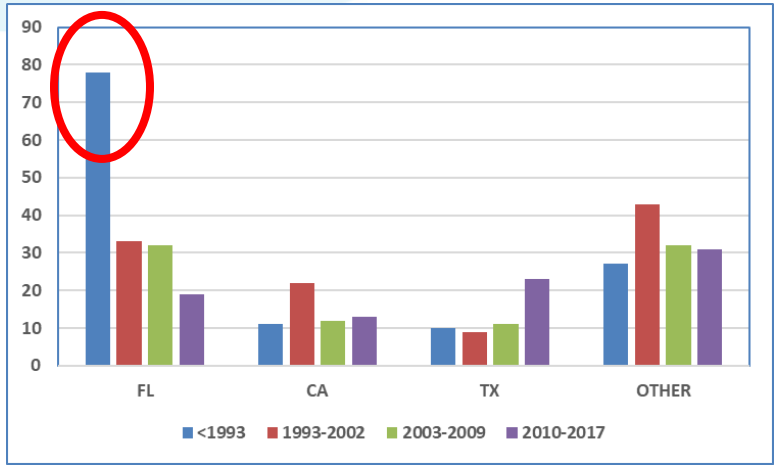
68% of facilities are in CA, FL, & TX

Number of states = 35



4 points = 4 surveys

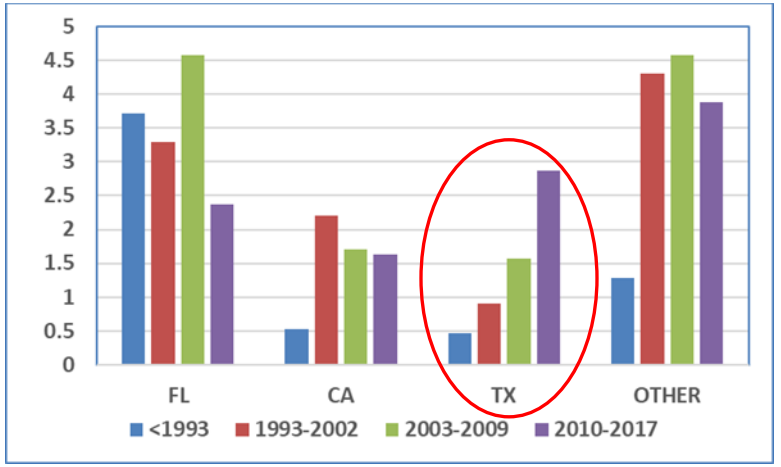
plants by state and survey



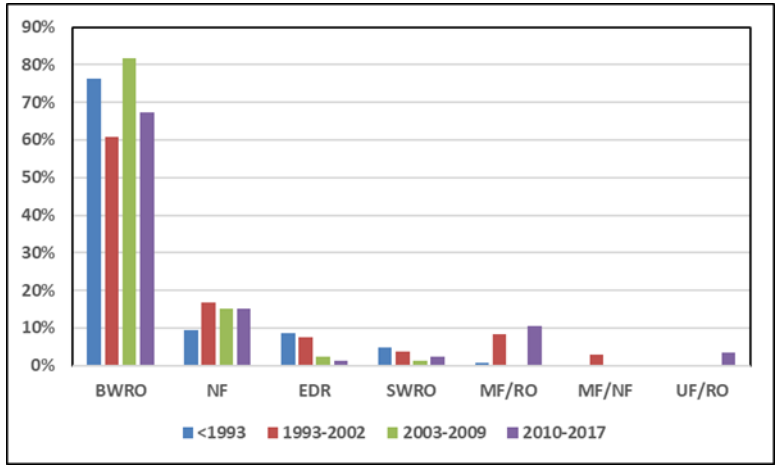
4 columns = 4 surveys

< 1993 FL had over 70% of all facilities

Avg. number of plants/yr by state and survey



% of plants by technology and survey

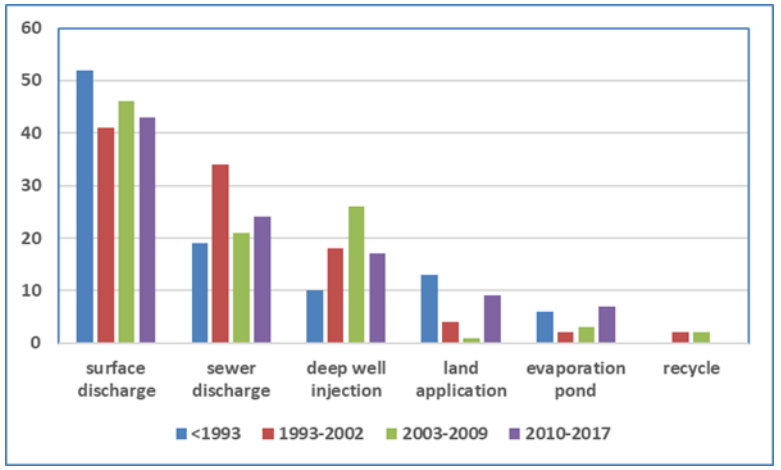


	number	%
BWRO	296	71.8%
NF	56	13.6%
EDR	22	5.3%
SWRO	13	3.2%
MF/RO	19	4.6%
MF/NF	3	0.7%
UF/RO	3	0.7%

Disposal method % use

1971-2017

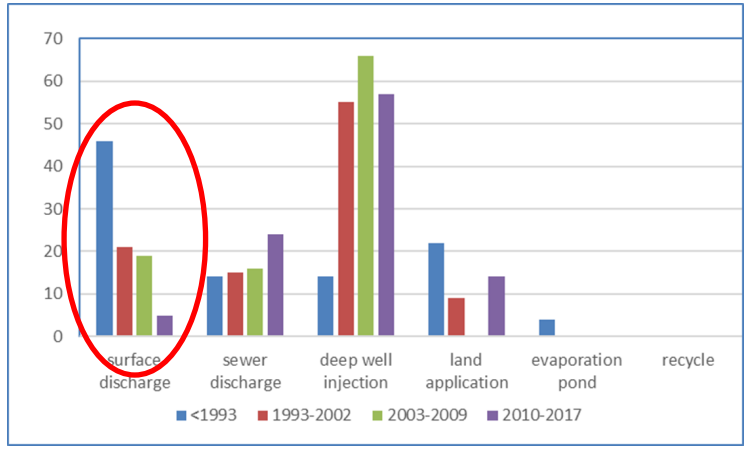
DISPOSAL OPTION	%
surface discharge	45
sewer discharge	25
deep well injection	17
land application	7
evaportion pond	4
recycle	1



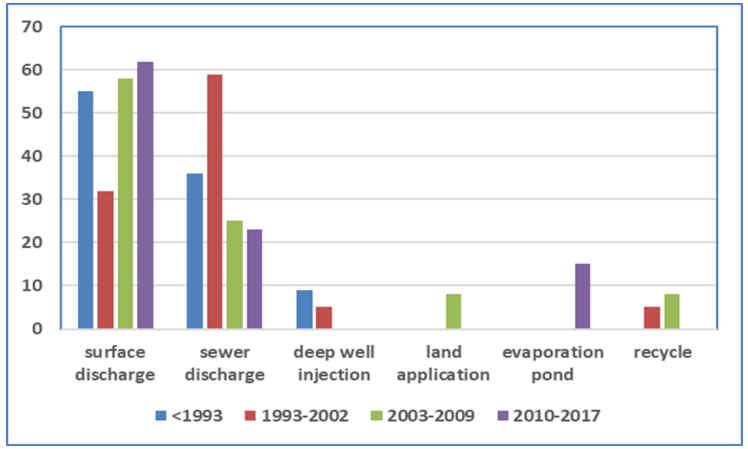
Disposal accounts for > 95% of facilities

Disposal Method % Use by Location

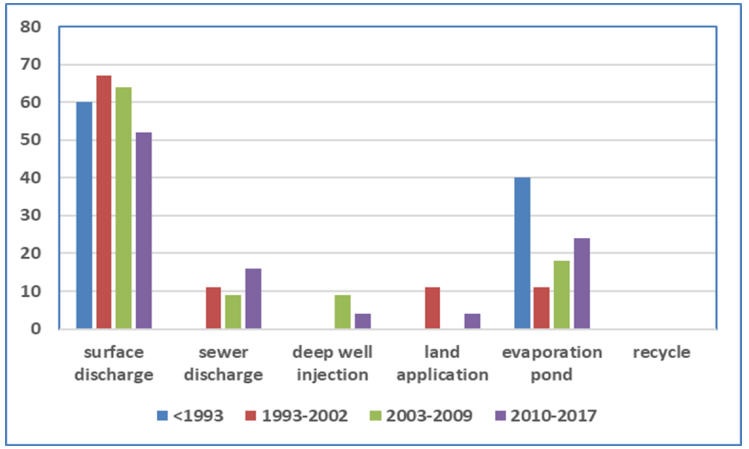
FLORIDA



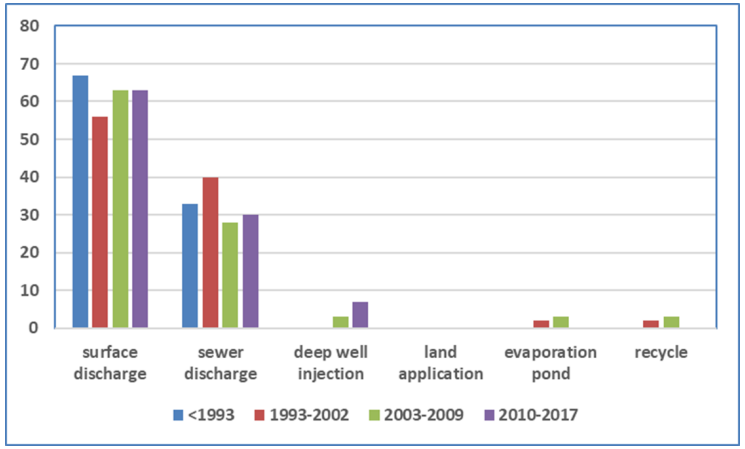
CALIFORNIA



TEXAS



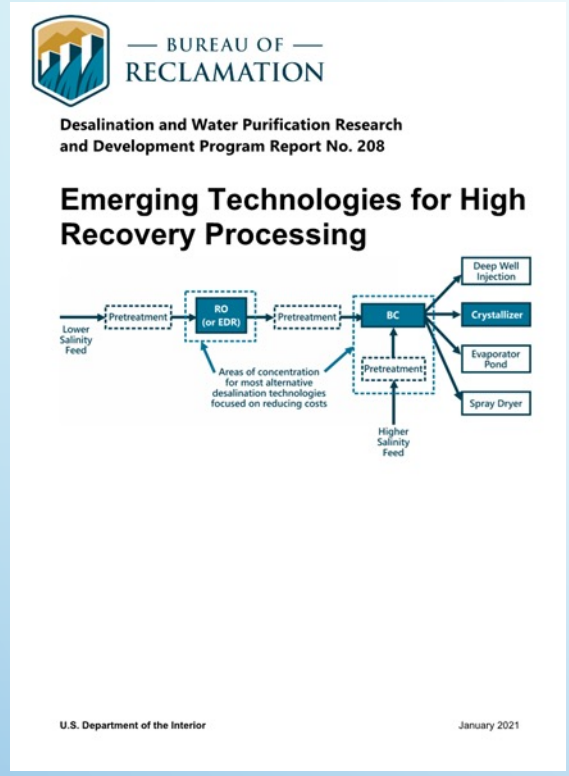
OTHER STATES



Number of states having:

- Deep well injection = 5
- Land application = 4
- Evaporation ponds = 4

	TOTAL	FL	CA	TX	KS	AZ	PA	CO
deep well injection	69	62	2	2	1	0	0	2
land application	27	23	1	2	0	1	0	0
evaporation ponds	21	3	2	13	0	3	0	0
recycle	4	0	2	0	0	1	1	0



PROJECT #2

High Recovery Desalination Technologies and Concentrate Management

Mike Mickley, P.E., Ph.D.

Mickley & Associates LLC

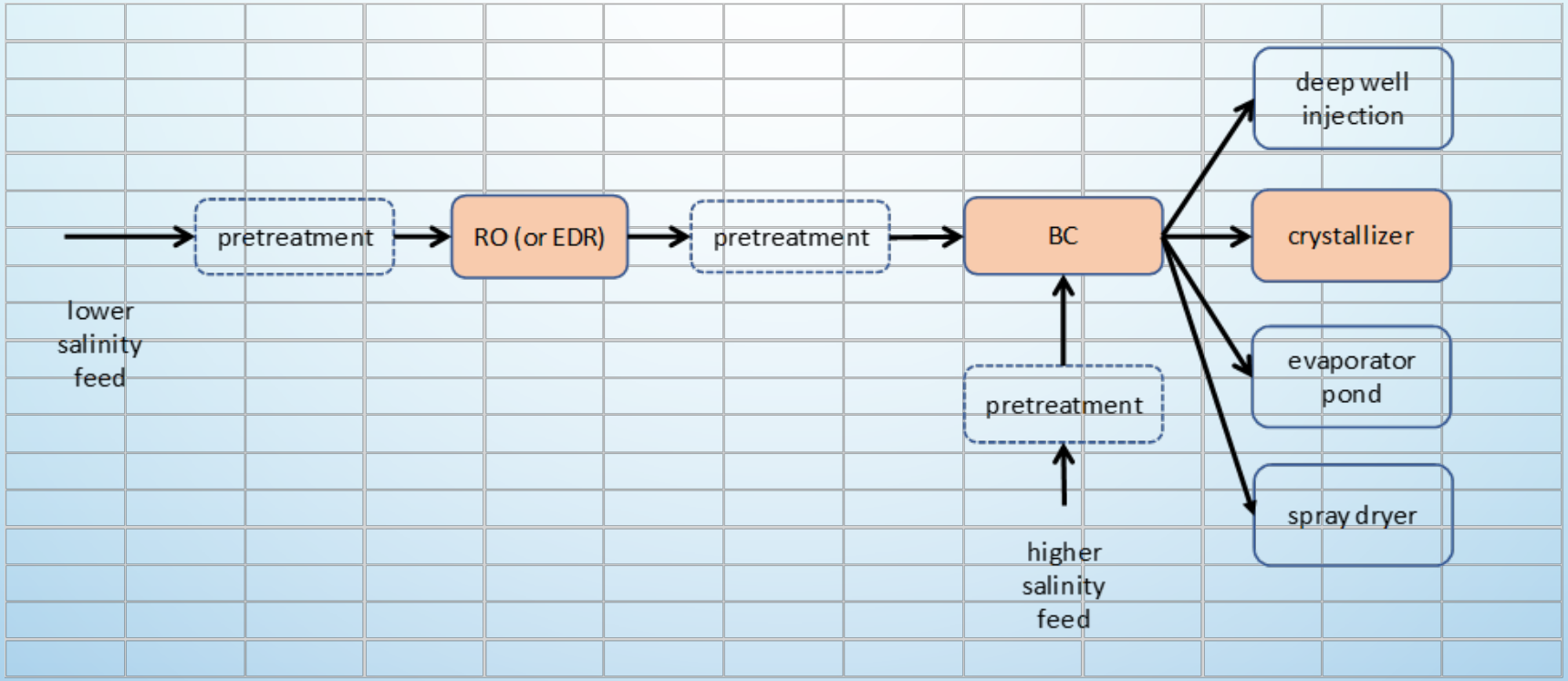
Published in 2021
Report 208

To get reports→ https://www.usbr.gov/research/dwpr/DWPR_Reports.html

THE STORY

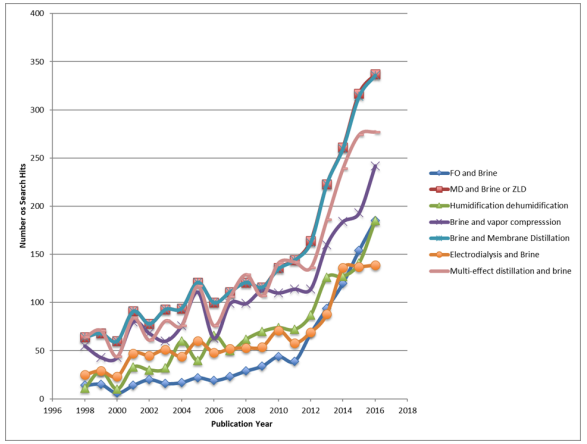
- **High recovery desalination technologies**: those used in MLD, ZLD, and volume reduction processing
- **Considerable effort** to **decrease the costs** of high recovery desalination
- **Many companies** investigating paths to reduce costs
- **Hypothesis:** Due to perception (perhaps 10 years ago) of significant market increases:
  - Unconventional O&G applications
  - Water reuse applications
  - More stringent disposal regulations
- **Purpose of 2021 report** = review status and impact of this effort

Conventional ZLD Processing Scheme



- **Expensive CAPEX & OPEX with costs increasing with feed salinity**
- **Slow growth market**

LITERATURE SEARCH RESULTS (2017)



Shape of curve supports the hypothesis of the perception of significant market increases due to unconventional O&G, water reuse, and tightening disposal regulations.

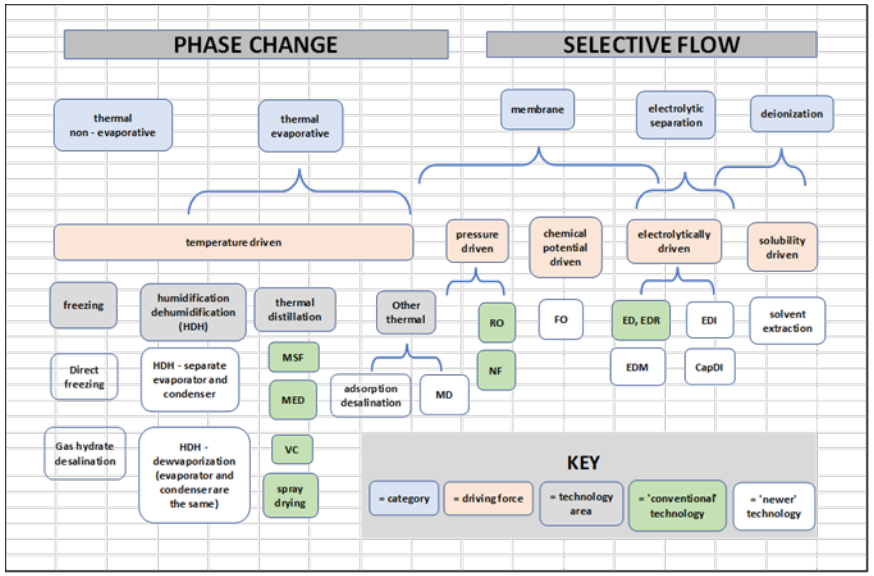
Many companies &
Many technologies
Looking to reduce costs

Purpose: document the status and impact of new HR technologies

Technology chapters and number of companies

- Reverse osmosis processes (23)
- Electrolytic processes (16)
- Forward Osmosis (7)
- Membrane Distillation (18)
- Humidification – Dehumidification (13)
- Other evaporative processes (8)
- Other technologies (9)

Desalination Technologies Addressed



Characterized over 100 companies and their technologies TWICE over a 2-year period

Content of technology chapters

- Operating principles & illustrations
- Attributes
- Energy considerations
- Limitations
- Applications
- Operating cost considerations
- Capital cost considerations
- Company information
  - 2018 status
  - 2020 status

Approaches to reduce costs

3 Approaches to Reduce Costs
(relative to the 3-step conventional ZLD process)

- Decrease unit costs of any of the 3 steps
- Increasing the recovery of the initial RO step
- Increase robustness (which decreases pretreatment cost and decreases process down-time)

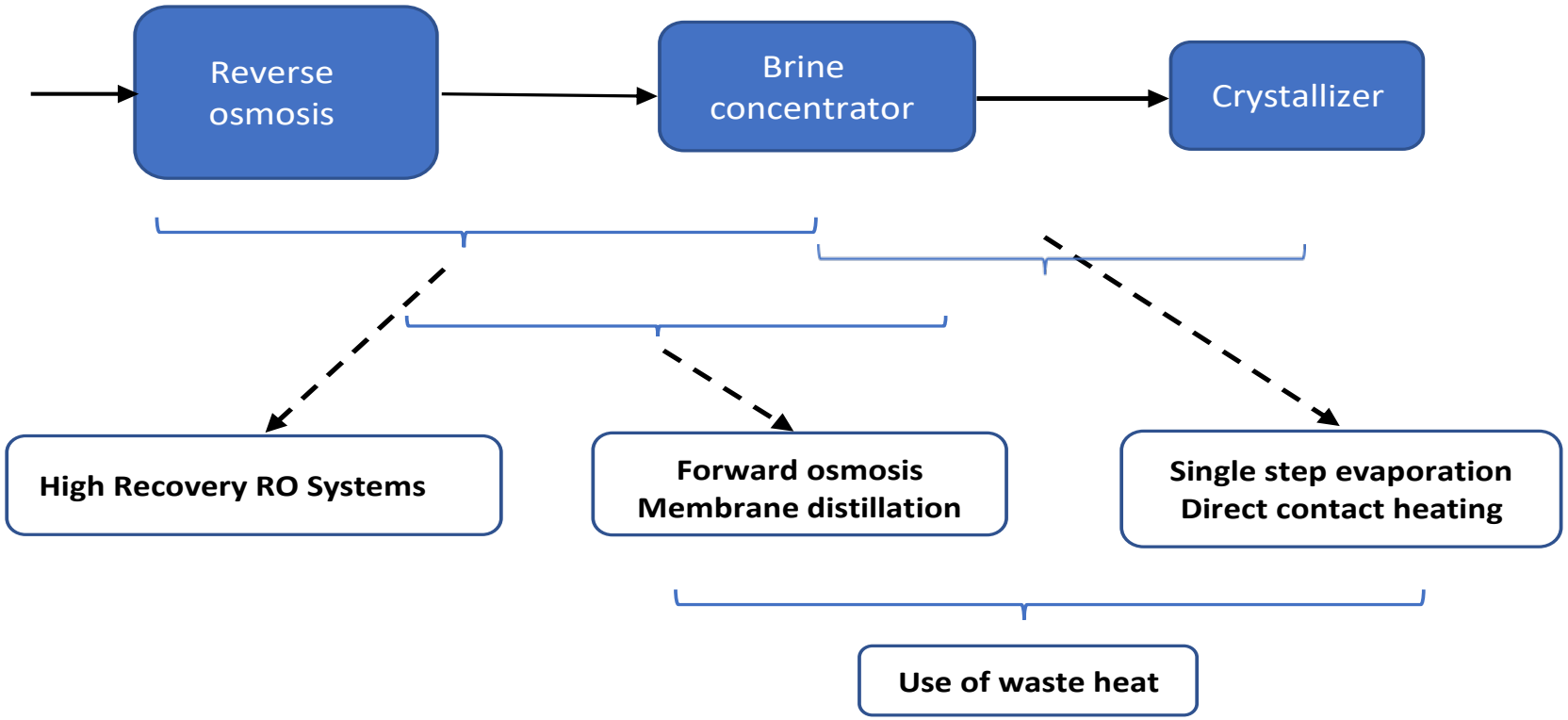
Market Study Identified ZLD markets served over last 20 years by big 3

- Power
- Chemical
- Oil & Gas

81%

- Paper and pulp
- Mining & minerals
- Coal to chemical
- Biofuels
- Electronics
- Municipal
- Manufacturing
- pharmaceutical

GENERAL AREAS OF LIKELY IMPACT



- **Present cost reductions** on the order of 20 to 50% have been indicated on small systems and the life of some systems is greater than 5 years.

PROJECT #3

Information Base of Concentrate Management

Will be published in 2022

Mike Mickley, P.E., Ph.D.
Mickley & Associates LLC

To get reports→ https://www.usbr.gov/research/dwpr/DWPR_Reports.html

Reason and Purpose for Project

Reason for report

1. Concentrate management is a major feasibility factor in considering new desalination facilities and one of growing impact
2. Several **major changes** have occurred in past decade that affect wastewater management

Purpose for report

The report both complements and updates previous reports dealing with concentrate and brine management. The timing of the report is in large part due to **major changes** that have occurred in the past several years that affect wastewater management.

CHANGES → INCREASED CONCENTRATE MANAGEMENT CHALLENGES

Changes include increased:

- **effects of climate change**
- **consideration of water reuse**
- **consideration of higher recovery processing**
- **consideration of brine mining (value-based recovery)**
- **Increased concerns for environmentally friendly and sustainable practices**
- **number of desalination facilities**
- **occurrence of contaminants in wastewater**
- **regulation of discharge and disposal**
- **costs of disposal options.**

Increased regulation
Climate change
Push toward sustainability

Concentrate/Brine/Wastewater Management
Three general categories:

- **DIRECT DISPOSAL** (5 general conventional options) – which might require minimal or no treatment, but no volume reduction:
  - Surface water discharge
  - Discharge to sanitary sewer
  - Deep well injection
  - Evaporation pond
  - Land application.
- **BENEFICIAL USE** - :
  - Direct beneficial use of wastewater (which might require minimal or no treatment)
  - Recovery of water for reuse
  - Value-based recovery of materials from wastewater.
- **VOLUME REDUCTION** – treatment (in some cases, such as for desalination concentrate, it represents additional treatment).

Report content

Report coverage

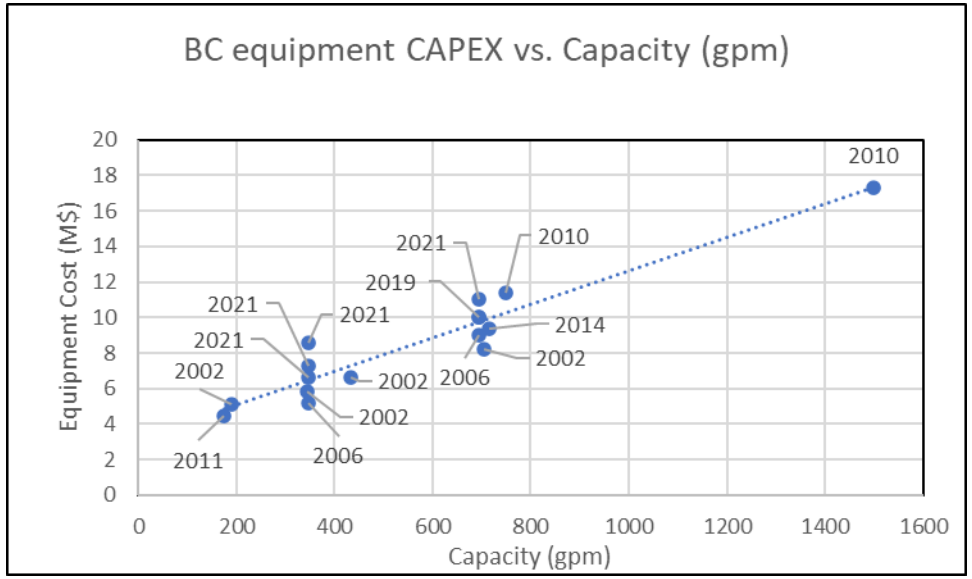
- *Disposal*
- *Beneficial use* – direct and recovery of water, and valued constituents
- *Volume reduction* (desalination treatment of concentrate and other wastewaters)
    - Reason for volume reduction = recovery of water, recovery of constituents, facilitate disposal
- **Not covered:** non-desalination treatment of concentrate and other wastewaters

Chapter coverage

- Feasibility barriers
- Advantages & disadvantages
- Design basis
- Environmental concerns
- Regulatory basis and permitting
- Operational issues
- CAPEX cost factors
- OPEX cost factors

Costs discussed where possible

EXAMPLE: brine concentrator equipment costs 2002-2021



PROJECT #4

Innovative Electro-Coagulation Membrane Pre-Treatment with Vacuum-Assisted Electro-Distillation Concentrate Management for Cooling Tower Blowdown

Will be published in 2022

BOR Pitch to Pilot project

GARVER

Red Rocks Community College

Mickley & Associates LLC

Several others

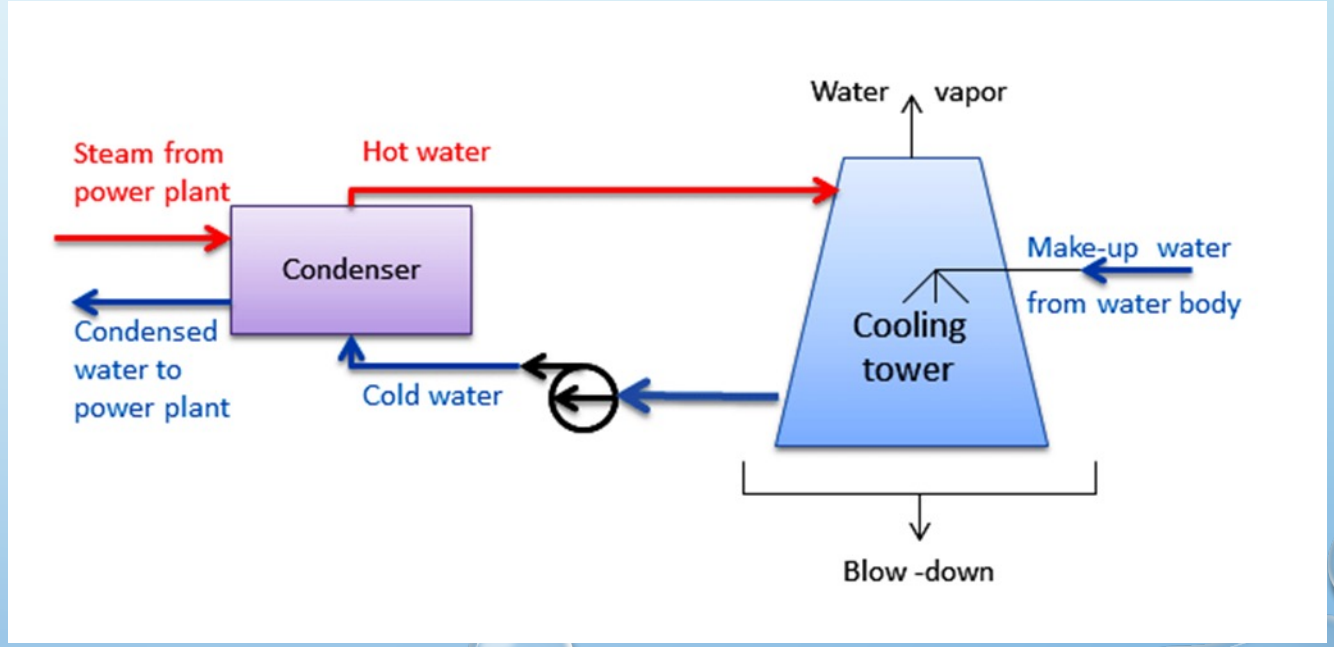
To get reports→ https://www.usbr.gov/research/dwpr/DWPR_Reports.html

THE PROBLEM

- Most industrial and commercial cooling systems utilize evaporative cooling towers.
- Cooling tower blowdowns are a major contributor to salt loading of local watersheds.
- In arid regions manufacturers can use 25-50% of their total water for cooling.
- CT typically operate a low cycles of concentration (3 to 4). As a result, TDS discharges to the sewer from the blowdown is 3 to 4 times higher than the source water level.

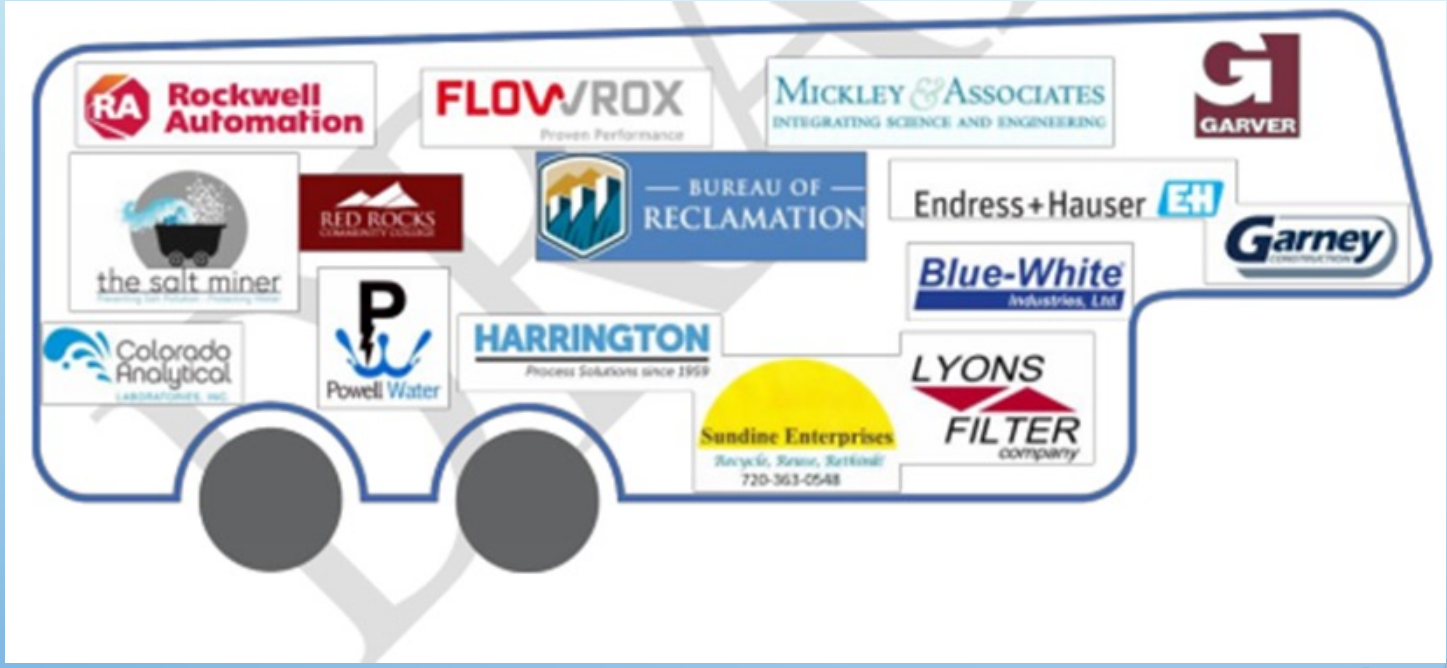
TECHNOLOGY GOALS

- Keep high TDS blowdown out of the sewer
- Return low TDS permeate to the CT
- Reduce make-up water - potable water demand
- Reduce chemical requirements of the CT system



THE PROJECT

- Bureau of Reclamation PITCH TO PILOT desalination research funding (2019) awarded to GARVER
- GARVER teamed with several partners – including **RED ROCKS COMMUNITY COLLEGE** that collectively donated over $500,000



RRCC

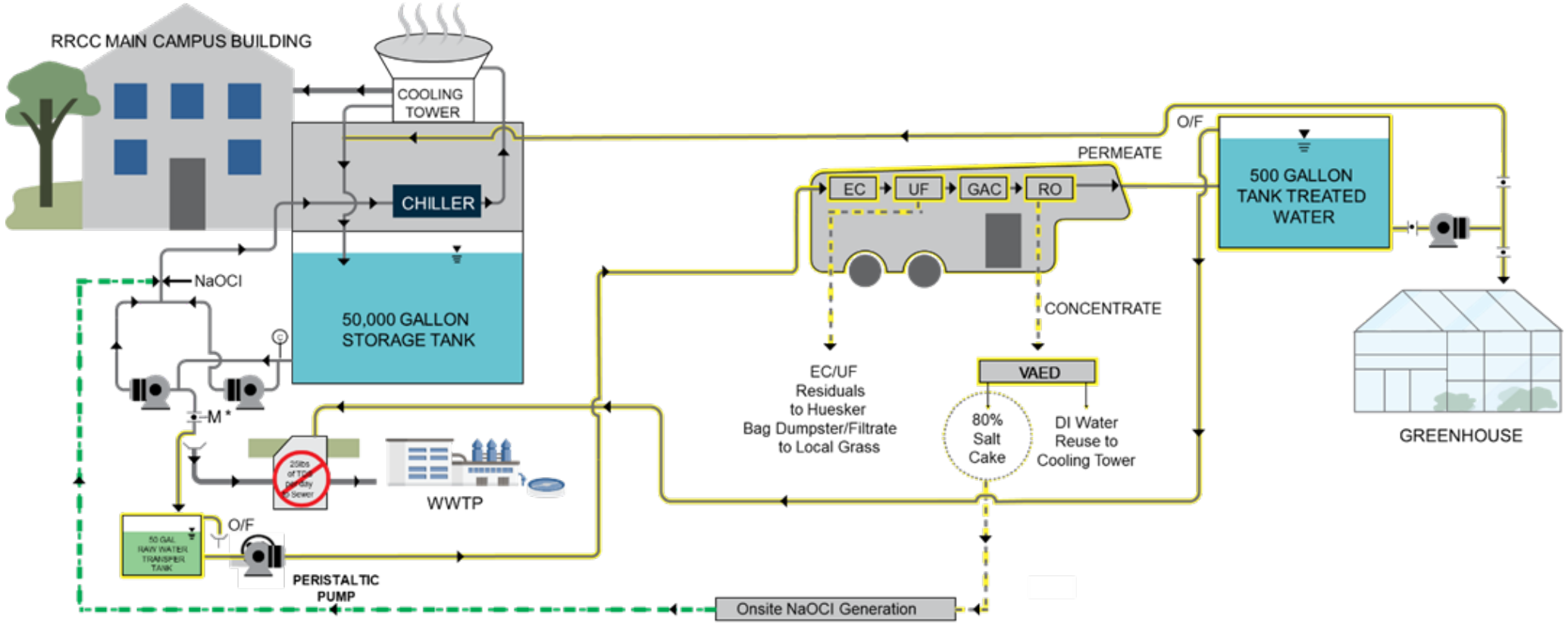
- **Offer the first Bachelor of Applied Science (BAS) degree in Water Quality Management Technology in Colorado**
- **Students to assist with design and operation of pilot trailer**
- **Facilities on-site to demonstrate the project**

VAED = Vacuum-Assisted Electro-Distillation

SYSTEM DESCRIPTION

Blowdown → EC → UF → GAC → RO → VAED

permeate



Quote from Peter Fiske (NAWI):

"This demo is an EXCELLENT opportunity to see the sort of small-scale, distributed desal system NAWI seeks to develop and advance with both its pilot program and our overall baselining and roadmapping"

STATUS

- Tests finished
- Draft report due in June

ACCOMPLISHMENTS

- Achieved proof of concept of the treatment system
- Explored effect of several system variables on results
- Produced a mobile test unit that can be used at other test locations
- Provided a learning opportunity for students at RED ROCKS WATER QUALITY MANAGEMENT PROGRAM

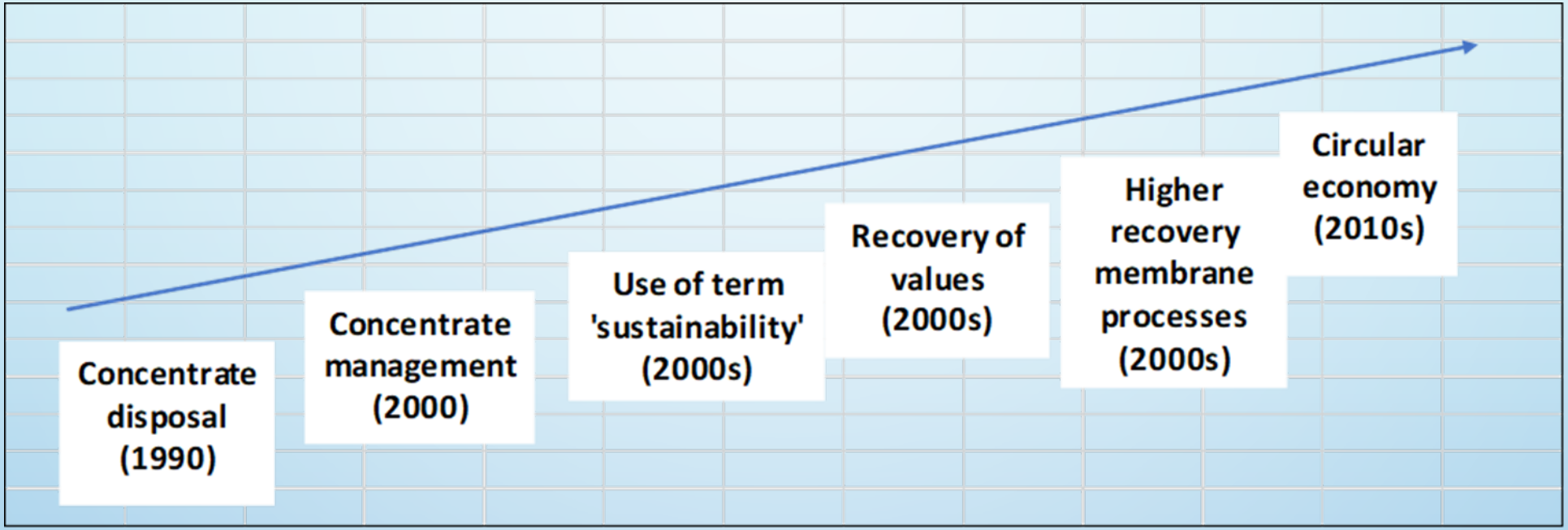
FUTURE WORK

- Optimization of system components
- Treatment of more challenging feedwaters
- Establishment of performance and cost envelopes

Current plans:

- **Testing in California with the trailer**
- **Testing at large nuclear power plant in Western U.S.**

Evolution of Brine Management Terms and Issues



Important other steps on the path include:

- Converting some constituents to less problematic forms
- Value-based recovery,
- Implementing circular economy solutions where possible,
- and in general - pushing toward greater sustainability.