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Managing Water in the West

Qualitative Comparison of Reverse Osmosis and Nanofiltration for Treating Brackish Groundwater in Texas

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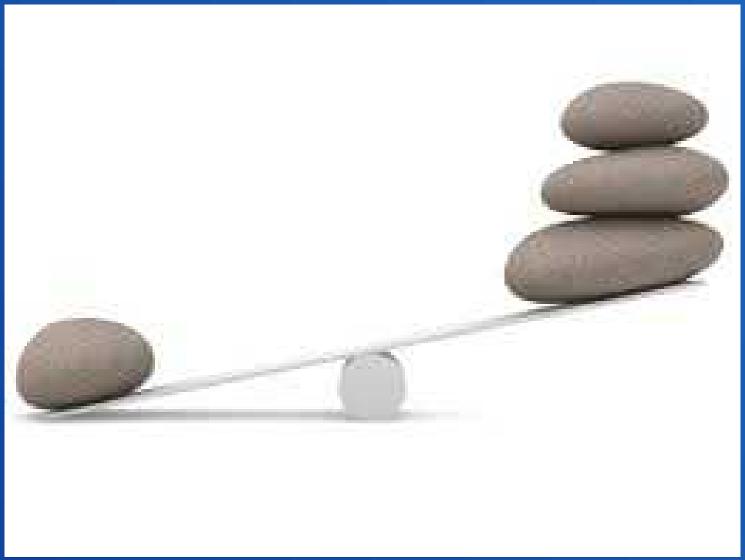
U.S. Department of the Interior
Bureau of Reclamation

Collaborative Effort

- Common agency objective: Increase the use of non-traditional water
- Three projects conducted in partnership with TWDB
  – Comparing NF and RO for Desalination in Texas
  – Estimating the Cost of Brackish Groundwater Desalination in Texas
  – Evaluate costs of RO cleaning

NF vs RO Project

- TWDB observation: Extensive use of RO membranes in Texas desalination plants
- Questions:
  - Can NF be used instead of RO?
  - Can NF meet finished water quality target?
  - Is NF more cost effective compared to RO?



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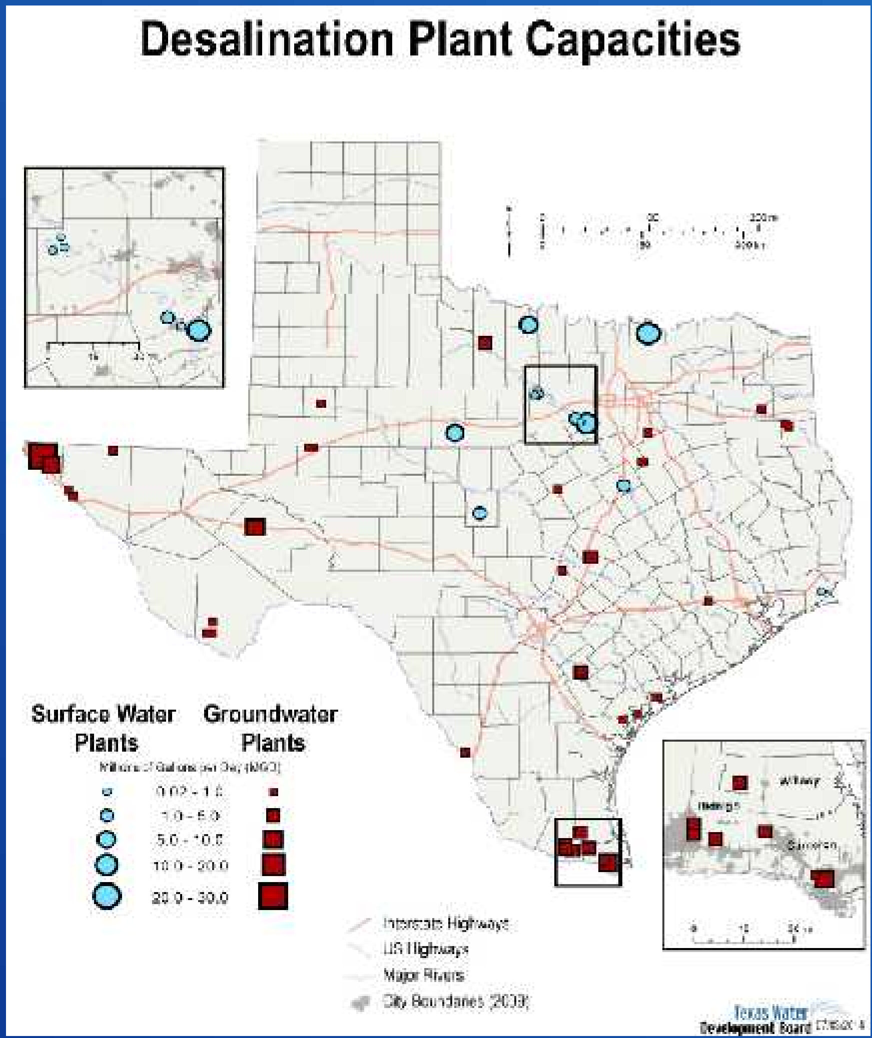
Desalination in Texas

- > 46 municipal water desalination facilities
- Total desalination capacity = 123 MGD
  - 73 MGD brackish groundwater
  - 50 MGD brackish surface water
- 90% of desalination plants in TX use reverse osmosis



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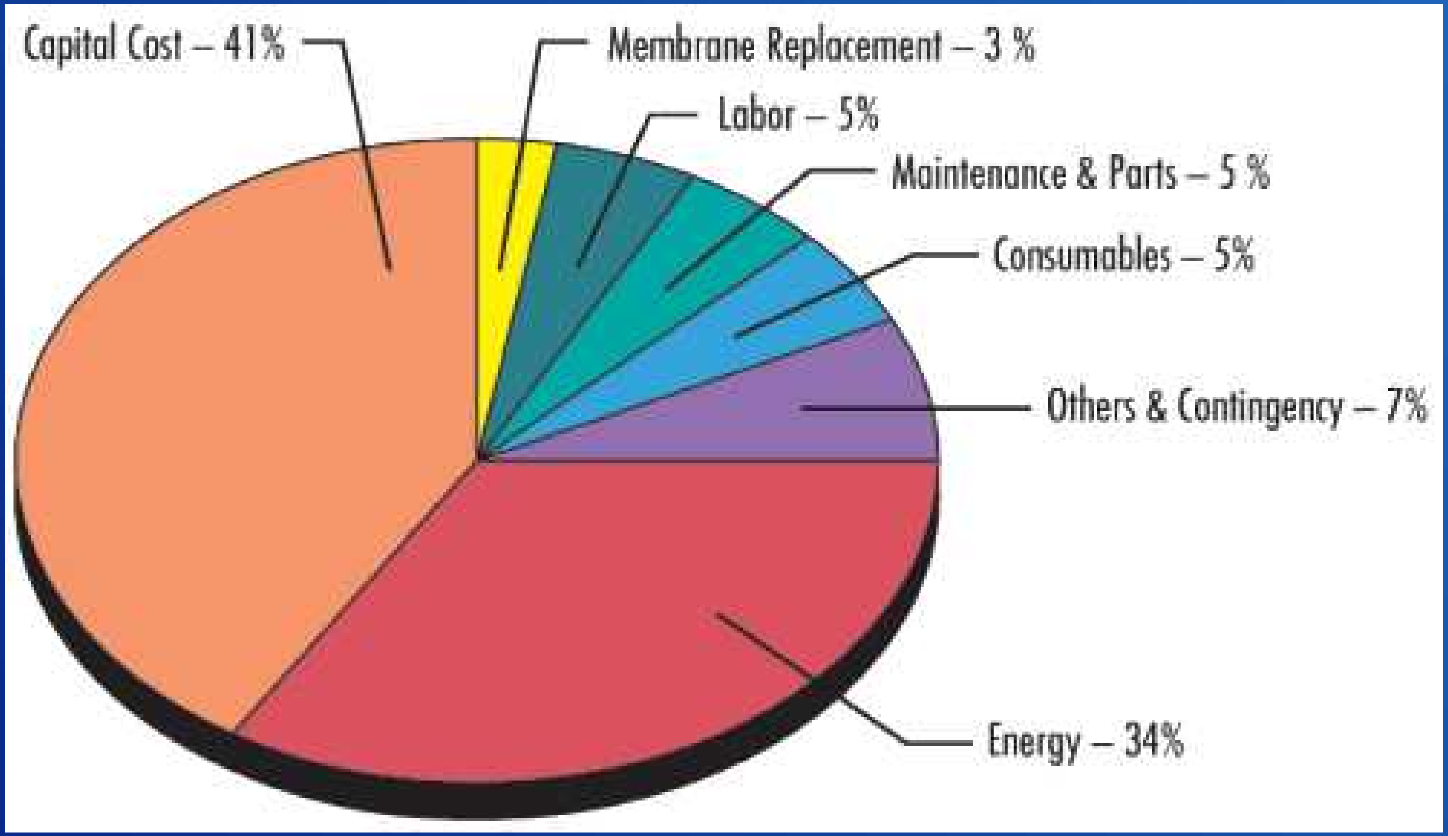
Membrane Desalination

- Most widely used desalination process in the US
- Many different types of membranes
- RO membranes produce higher quality permeate
- NF membranes
  - High rejection of di-valent ions
  - Moderate to low rejection of mono-valent ions
  - Lower operating pressure

Cost of RO Desalination



Source: http://arizonaenergy.org/News_10/News_Jan10/

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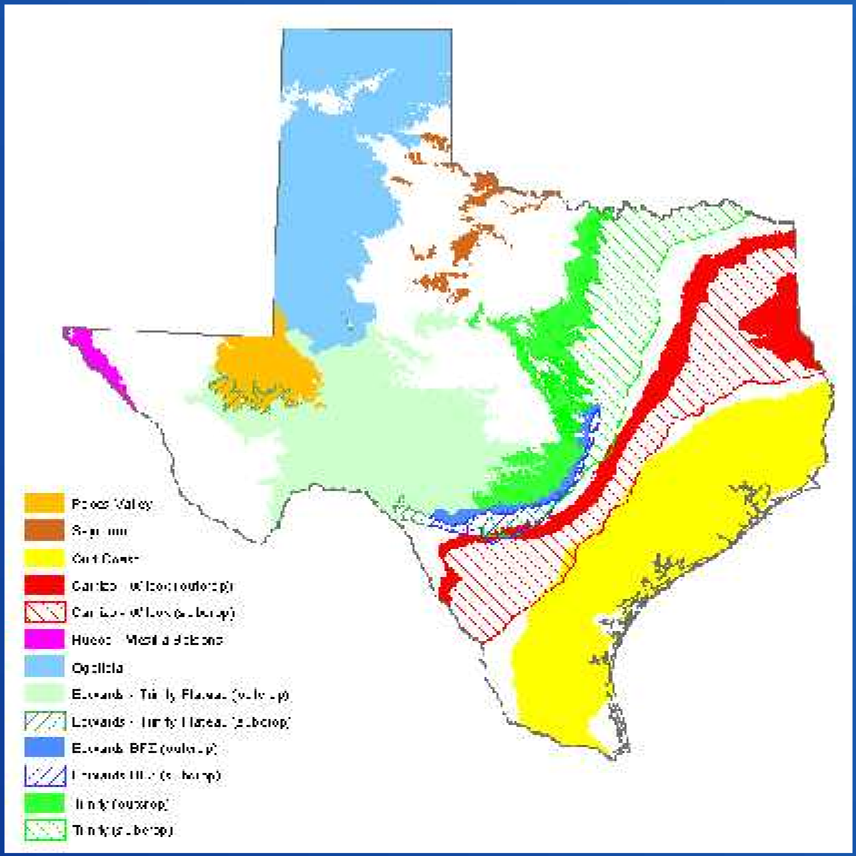
Project Overview

1. Water Quality Assessment
2. Identify Membranes
3. Define Plant Design Modeling
4. Software Simulations
5. Use simulation results to identify when NF is suitable
6. Compare system designs relative to cost

Water Quality Assessment: Texas Groundwater Database

- Created and maintained by Texas Water Development Board
- Used to generate sample set for study
- Over 100,000 entries
- Major ion analysis provided



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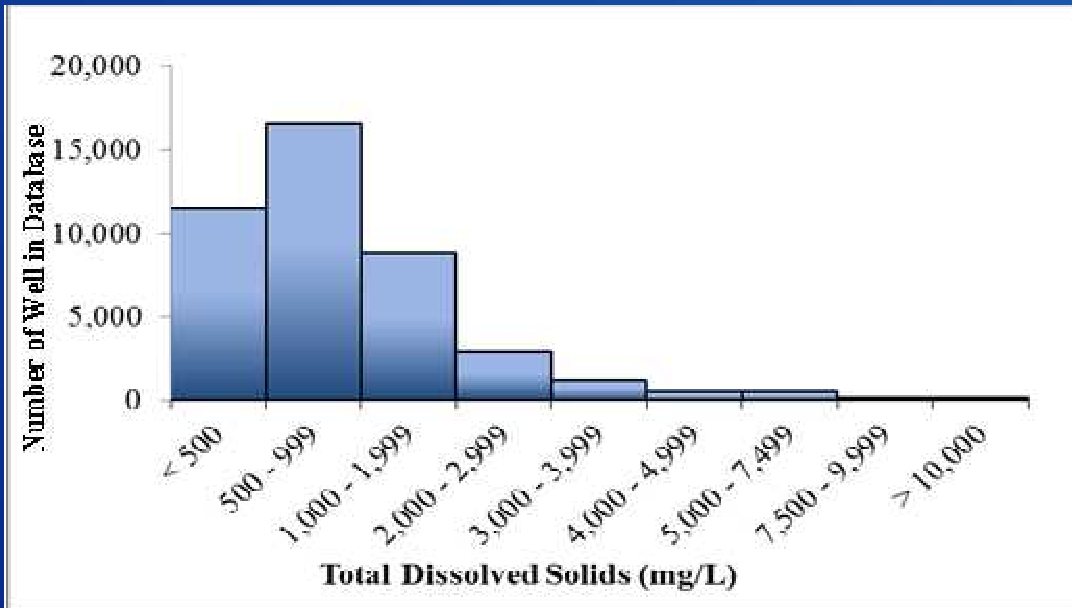
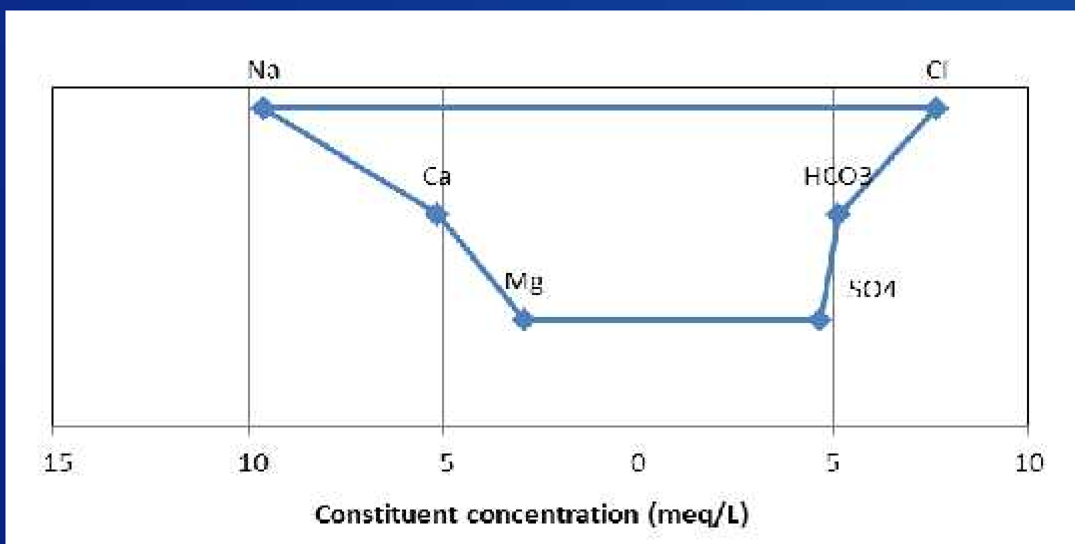
Groundwater Database Analysis





Majority of samples in database exhibit the following characteristics:

- NaCl is dominant salt
- Higher TDS samples have more NaCl
- Lower TDS have more divalent ions

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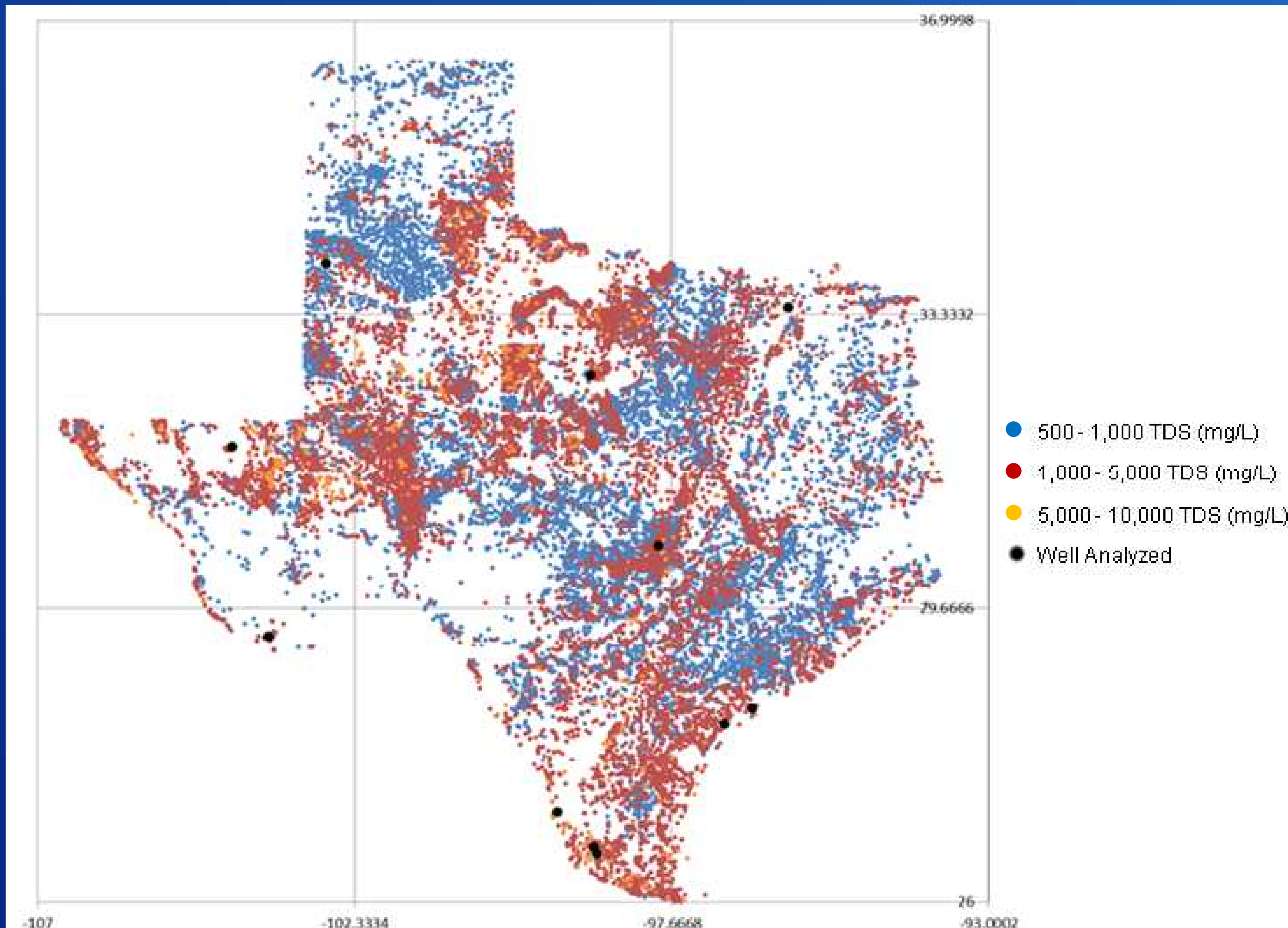
Water Quality Used for Analysis



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NF and RO Membrane Characteristics

Membrane	Type	Active Area (ft^2)	Salt rejection (%)			Pressure normalized productivity (gpd)/(psi)
			NaCl	$MgSO_4$	$CaCl_2$	
ESNA1-LF2	NF	320	77	NP	NP	111
NF90	NF	400	85-95	> 97	NP	107
ESNA1-LF-LD	NF	320	NP	NP	89	109
XLE	RO	440	99	NP	NP	112
ESPA1	RO	320	99.3	NP	NP	80
XFR LE	RO	400	99.4	NP	NP	77
BW30	RO	365	99.5	NP	NP	42

NP = Data not provided on manufacturer specification sheet

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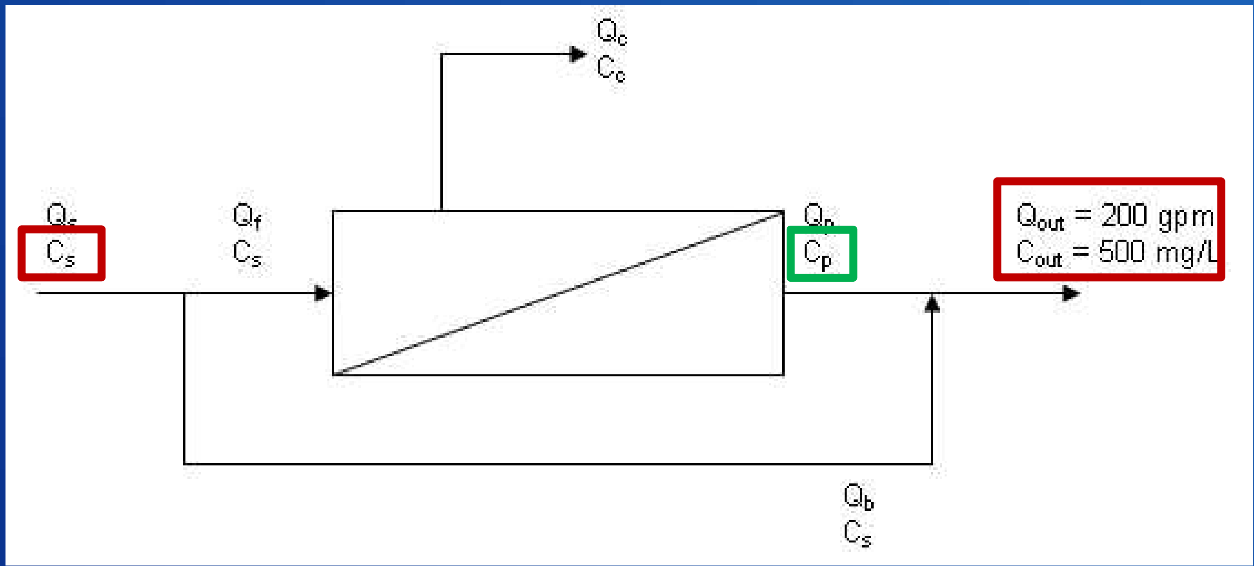
Membrane System Simulations



Software Modelling Inputs	Value
Delivered water flow rate (gpm)	200
Delivered water TDS (mg/L)	500
Water Quality	12 different samples
Membrane system design	Best engineering judgement, no design warnings

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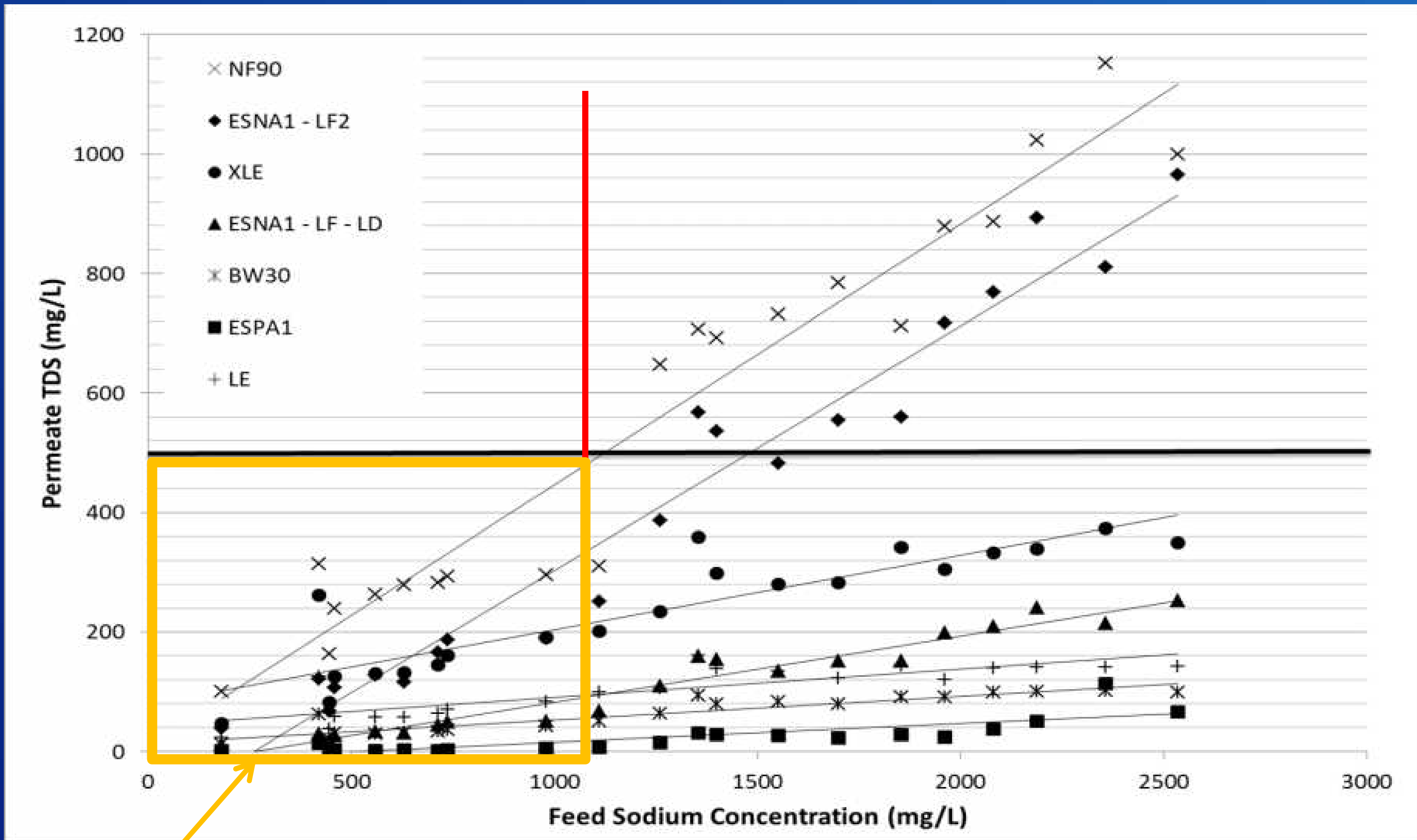
Permeate TDS Comparison



Waters with [Na] < 1,100 mg/L treatable with NF

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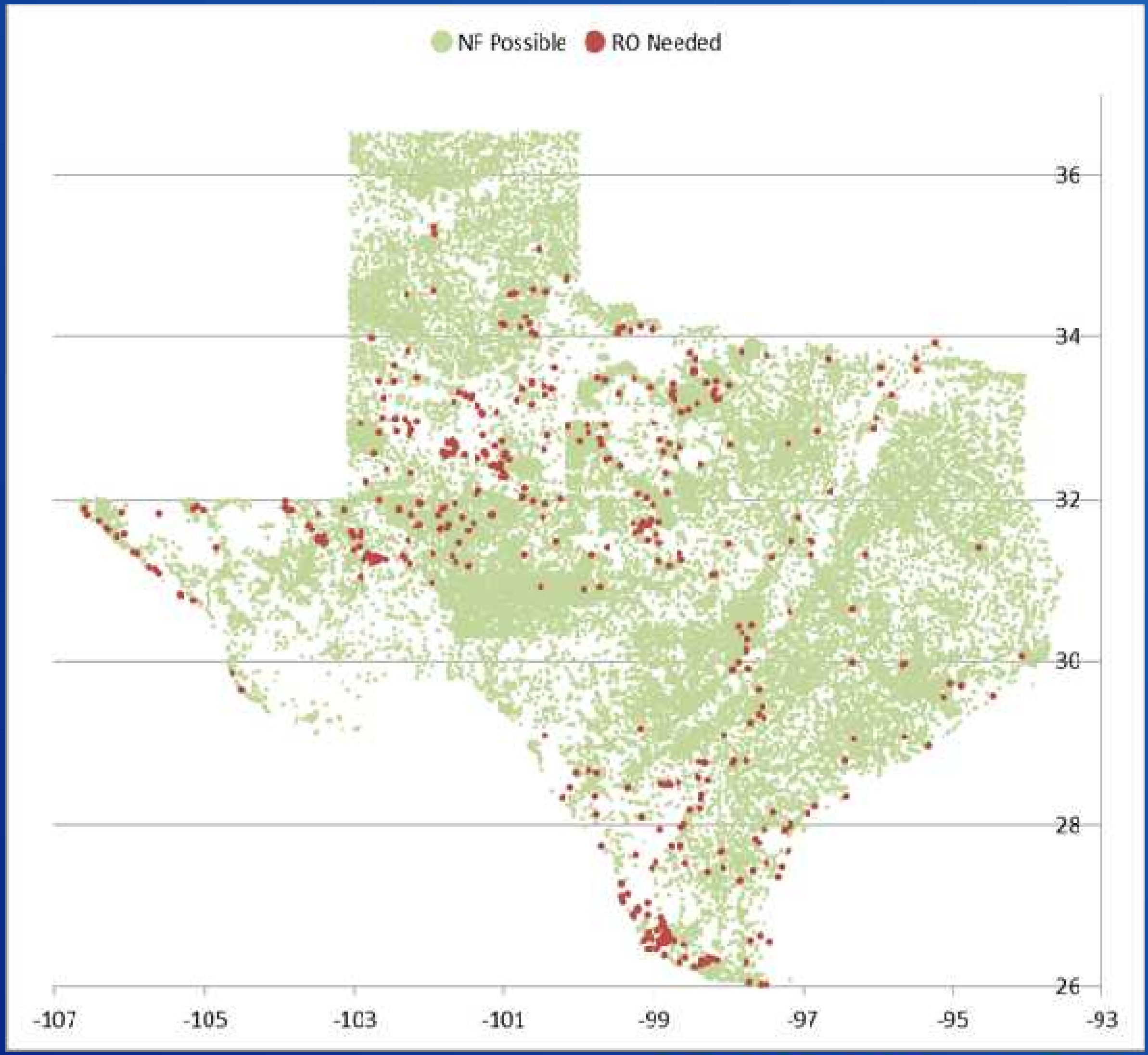
The majority of wells in the database can be treated to less than 500 mg/L TDS with NF



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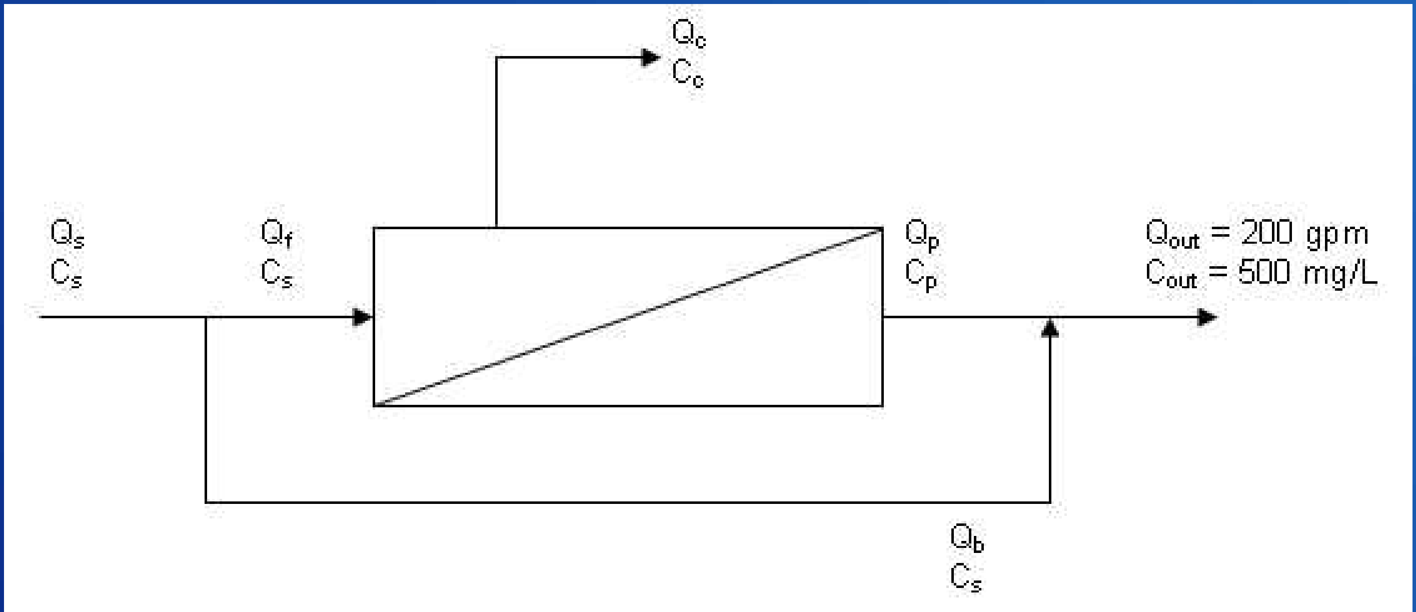
Design Comparison



- Software outputs: C_p, operating pressure
- Used mass balances to solve for Q_b, Q_s, Q_c, Q_f
- Conducted mass balance design and cost comparison for a sample with TDS 2200 mg/L
- Assumption: blending not limited by feed water quality

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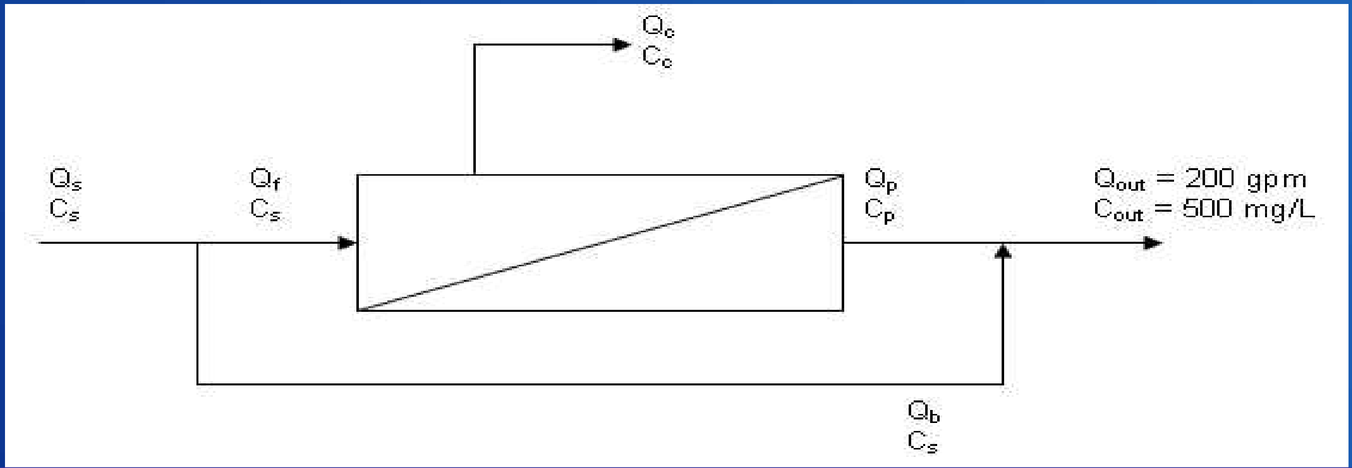
Design Comparison Results



	BW30	NF90	% Diff
Permeate concentration, C_p (mg/L)	47	325	591%
Permeate flow rate, Q_p (L/s)	10	11.4	14%
Membrane feed flow rate, Q_f (L/s)	11.7	13.5	15%
Blend flow rate, Q_b (L/s)	2.6	1.2	-54%
Raw water flow rate, Q_s (L/s)	14.3	14.7	3%
Concentrate flow rate, Q_c (L/s)	1.8	2.0	11%
Concentrate concentration, C_c (mg/L)	14,411	12,231	-15%
Feed pressure (psi)	150	124	-17%

Project Specific Considerations

RO	Consideration	NF
	Lower energy	✓
	Lower chemical demand/scaling potential	✓
✓	Lower capital cost	
✓	Lower raw water demand	
✓	Smaller concentrate volume	
	Lower salinity concentrate	✓

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Conclusions

- Software simulations showed that permeate TDS correlated with feed sodium concentration
- NF possible for feed waters with Na < 1,100 mg/L
- NF can be used to treat the majority of waters in the database to < 500 mg/L
- Detailed engineering analysis needed to determine most cost effective membrane design

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