Please Pass the Salt: Using Oil Fields for the Disposal of Concentrate from Desalination Plants

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The Problem

- Texas population will likely grow from 21M in 2000 to 40M in 2050
- Despite conservation measures, demand for water will grow from 17M AFY in 2000 to 20M AFY in 2050
- Municipal water needs will increase from 4.2M AFY in 2000 to 7.1M AFY in 2050

Source: Water for Texas, TWDB, 2002

A Solution: Desalination

- Desalination of brackish water / sea water is a drought-proof, mature technology
- Several cities have chosen desalination as a viable mean to fill their municipal needs (e.g., Fort Stockton, Sherman)
- Communities interested in desalination need a cost-effective and safe solution for disposing of concentrate.
- Current desalination municipal capacity is ~0.045 M AFY (~1% of demand), this produces a waste stream of ~5-10 MGD (to be compared to the more than 600 MGD of produced waters in Texas – 2/3 in the Permian Basin)

Current Desalination Facilities

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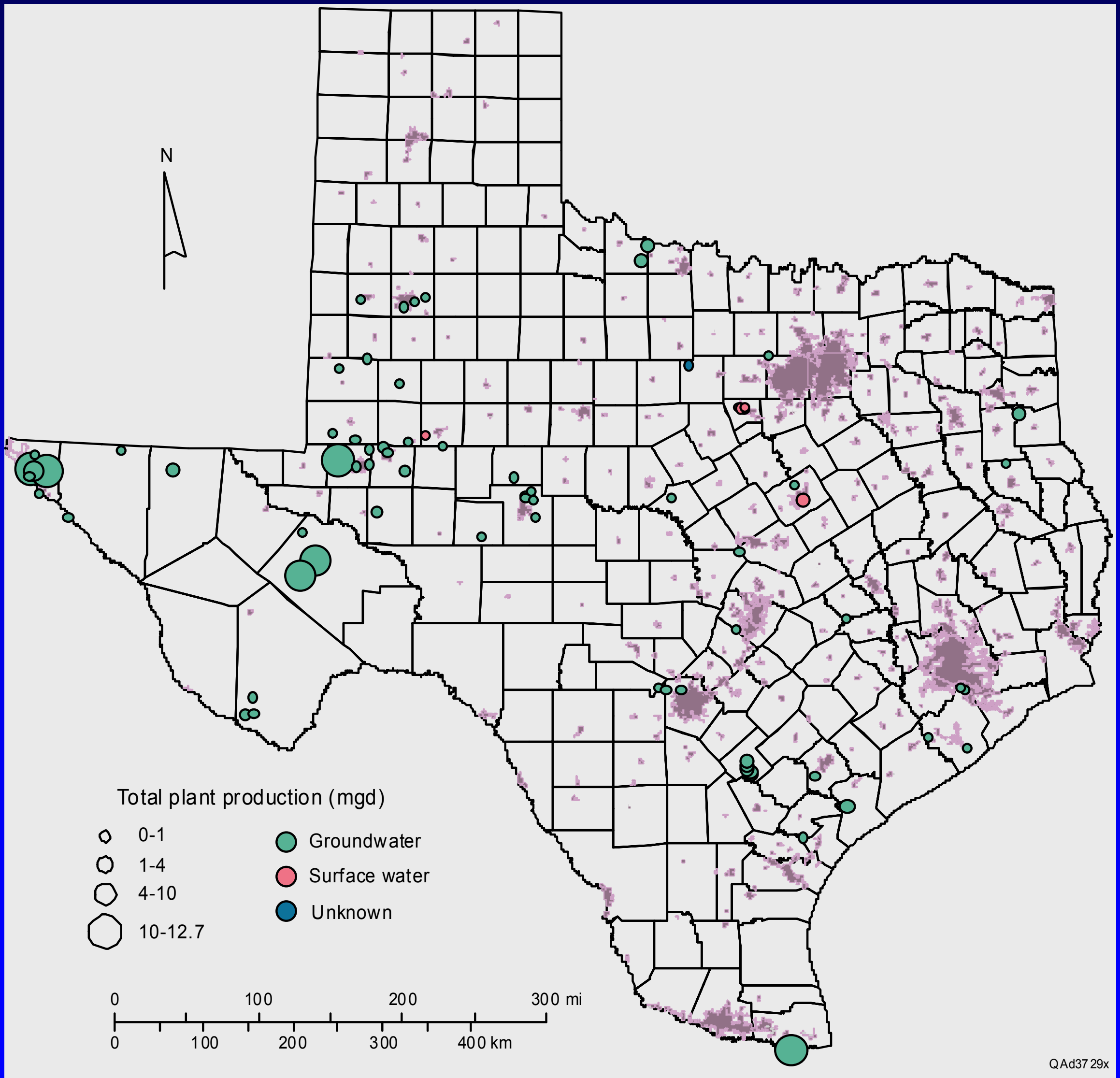

NOTE:

Plant production volumes may include blending and may be larger than true desalination permeate volumes (preliminary data from TCEQ). Some facilities may also be missing.

Source: TCEQ, 2004

Opportunities for the Oil Industry

- Limit drawbacks of reinjecting produced waters (presence of suspended solids, oil droplets…)
- Reduce need for fresh water as make-up water for waterflooding (Please pass the salt!) and potential conflicts with other fresh water consumers
- (Bring an extra source of revenue)

Approach

- Identify depleted oil and gas fields
- Historical perspective on fluid injection in oil and gas fields in Texas
- Choose analysis areas (source of brackish water, local water needs) and collect information
- Formation damage (scaling, water sensitivity)
- Injection rates
- Formation damage control
- (Permitting issues)

Major Oil and Gas Reservoirs

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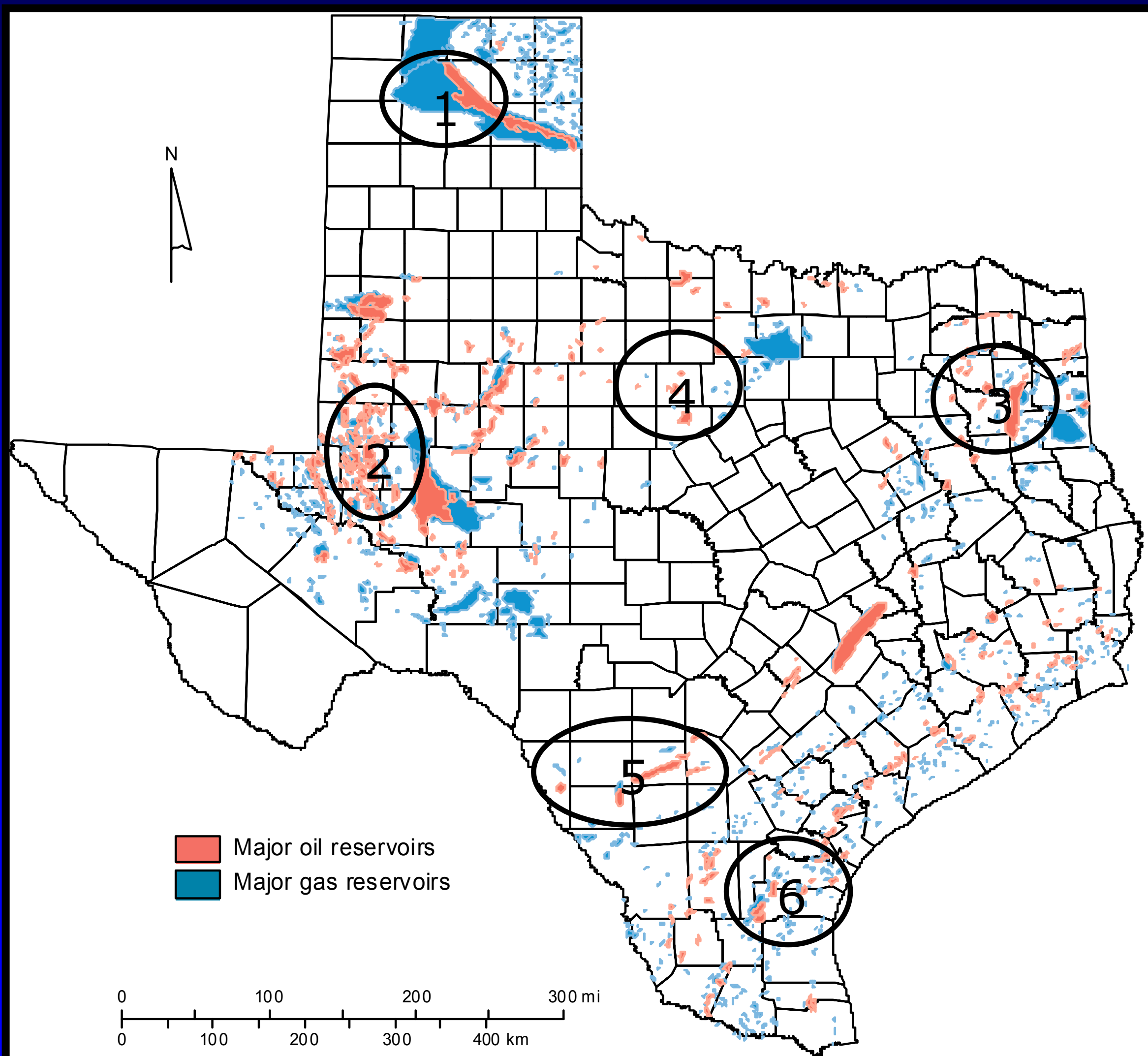

Analysis Areas

1 Anadarko
2 Permian
3 East Texas
4 Fort Worth
5 Maverick
6 Southern Gulf Coast

Pressure-depleted Fields

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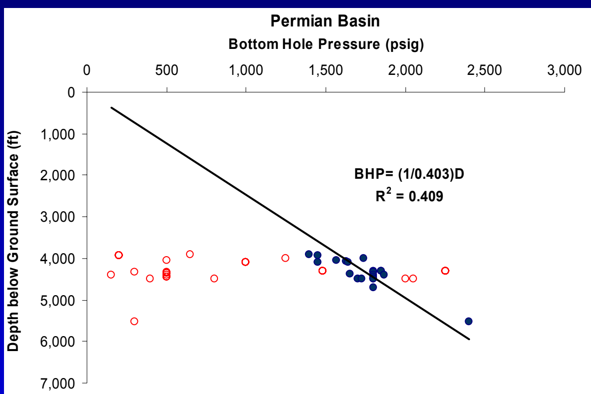

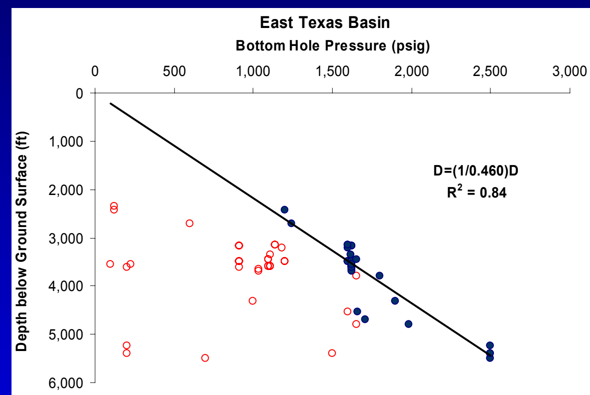

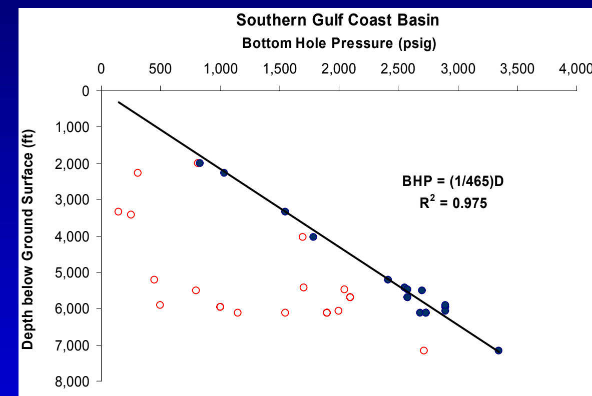

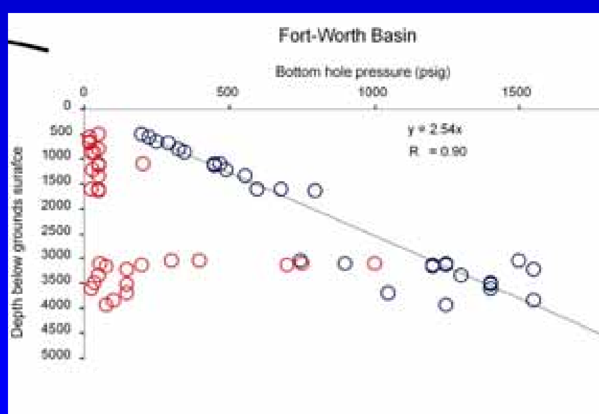

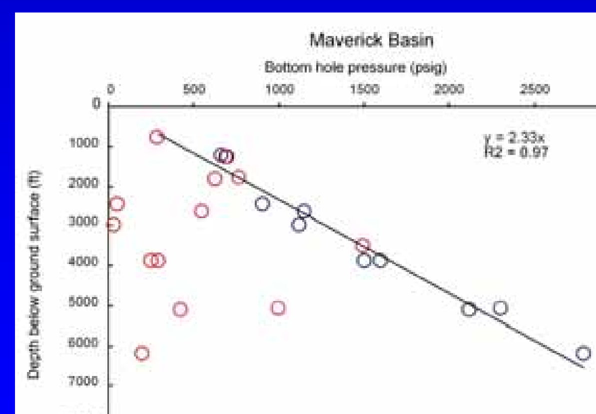

Injection Historical Data

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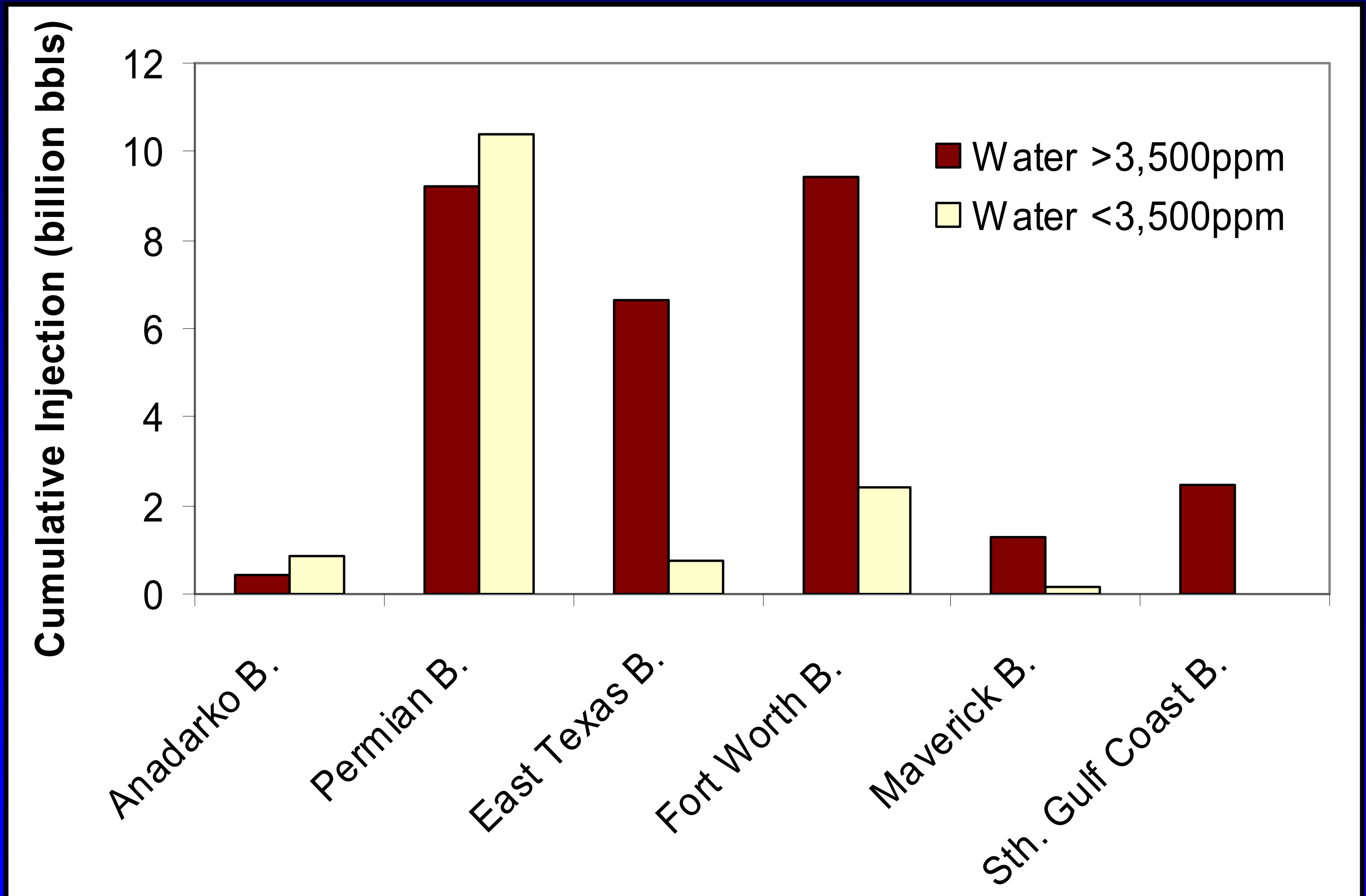

From RRC database (1982; last year with data compilation)

Important Parameters

- Lithology/Mineralogy:
  - Rock type
  - Clay content and nature
  - Mineral in contact with flowing fluids
- Concentrate / formation water composition
- Flow properties:
  - Porosity, permeability
  - Other fluid present (relative permeability)
- Field characteristics
  - Pay thickness
  - Geothermal gradient
  - Average pressure and depth

Approach to Test Water Compatibility

- Compute concentrate composition with PHREEQC using standard pretreatment and a factor of 4
- Mix in different proportions concentrate with formation water with SOLMINEQ (able to handle high salinity fluids)
- Choose randomly 2x5,000 samples to mix
- Analyze statistically (histograms) saturation index for relevant minerals of resulting combinations
- Determine the fraction of mixing combinations above the *SI* threshold beyond which antiscalants are not effective

Examples of *SI* Histograms

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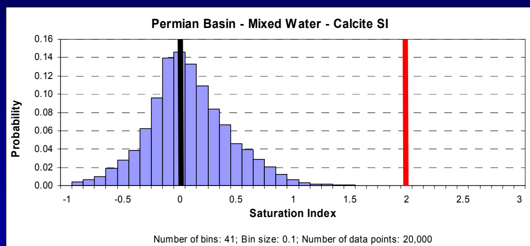

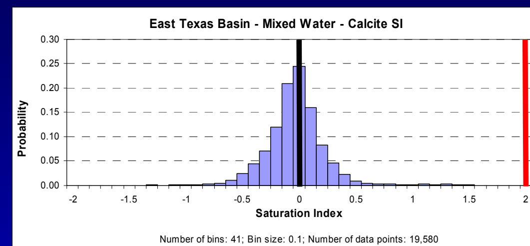

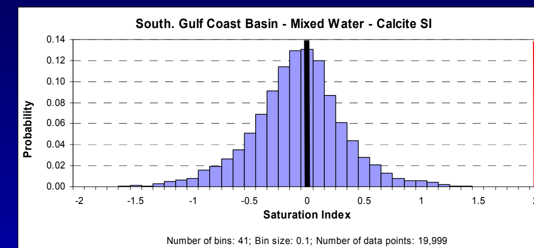

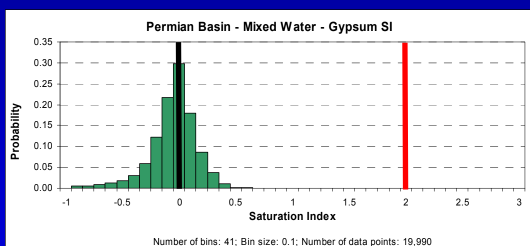

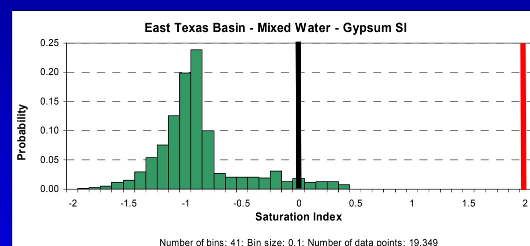

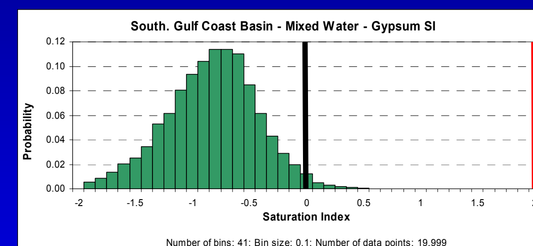

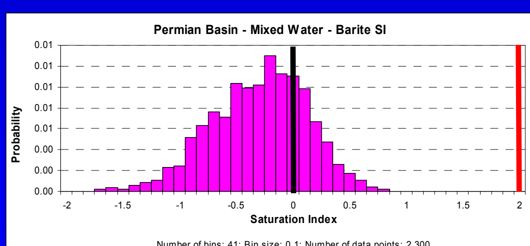

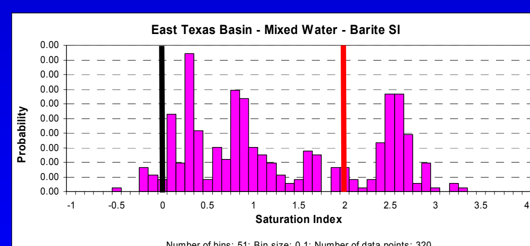

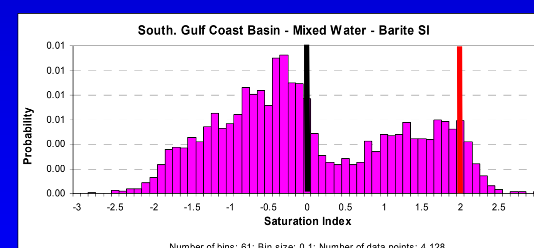

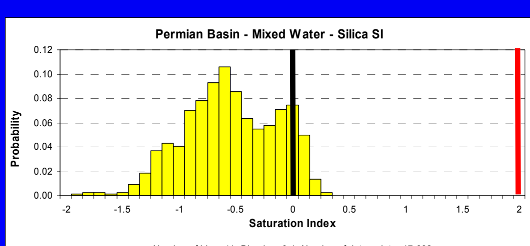

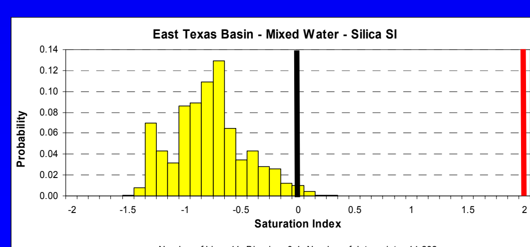

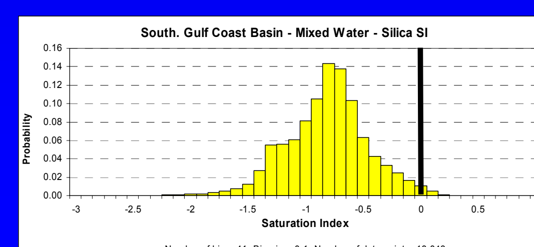

MAR Study: East TX B. Analysis A.

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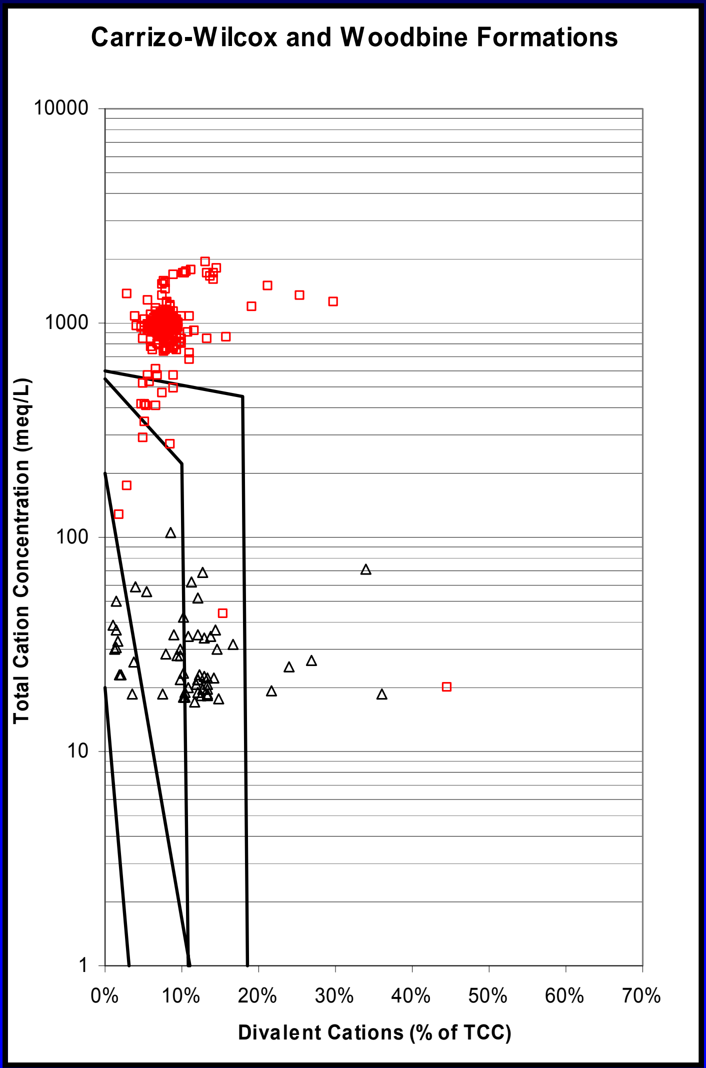

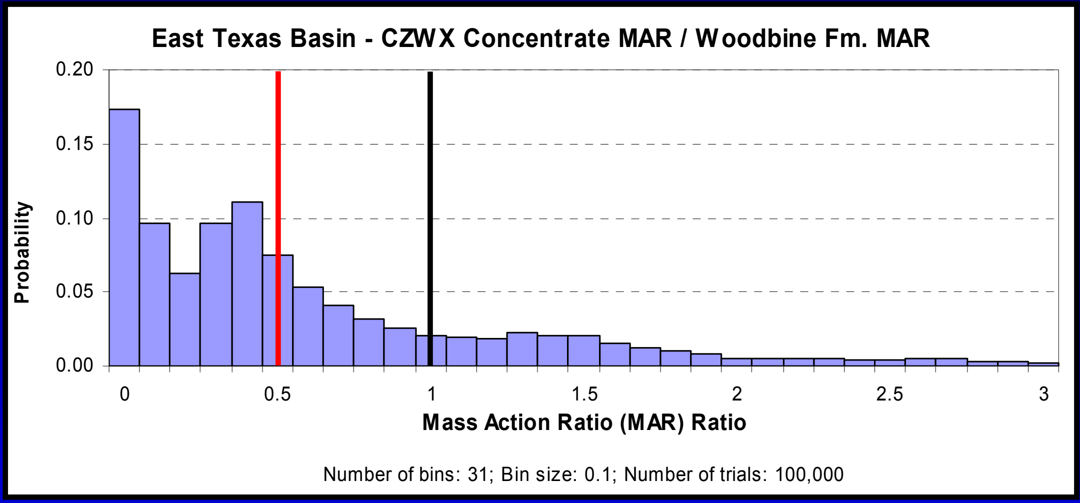

MAR Ratio = $\{[Na]^2/[Ca]\}_{conc}/ \{[Na]^2/[Ca]\}_{form}$

If MAR Ratio <0.5, problems are expected if smectite is present

Solutions to Formation Damage

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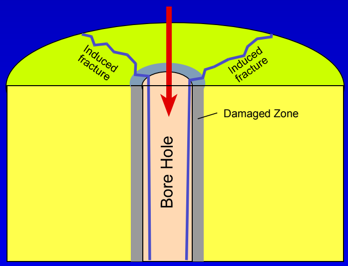
- Chemical:
  - Matrix acidizing by HCl, H_2SO_4 (both for carbonates), HF (for silicates), organic acids; Treatment with KOH and NaOH (for calcium sulfate)
  - $CaCl_2$ brine treatment. Buffer of NaCl and KCl. Clay stabilizers that bind clays to the substrate



- Physical: hydraulic fracturing
- Operational
  - Surface treatment to remove suspended solids
  - Lower flow rate, increase perforation density, Injection of a buffer solution
  - Gradual change in salinity to avoid salinity shock

Injection Rate Issues

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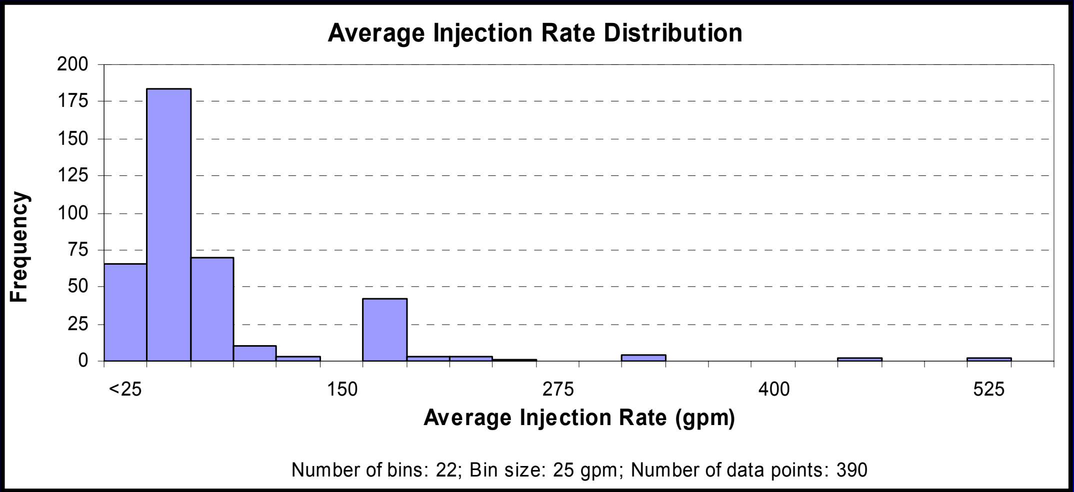
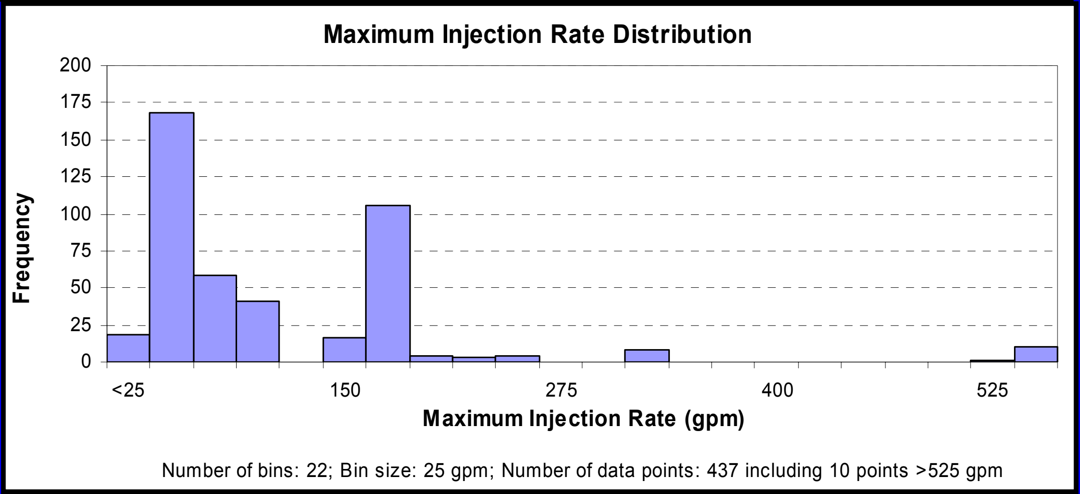
- Maximum injection rate controls number of wells needed
- Injection rate is dependent on formation parameters:

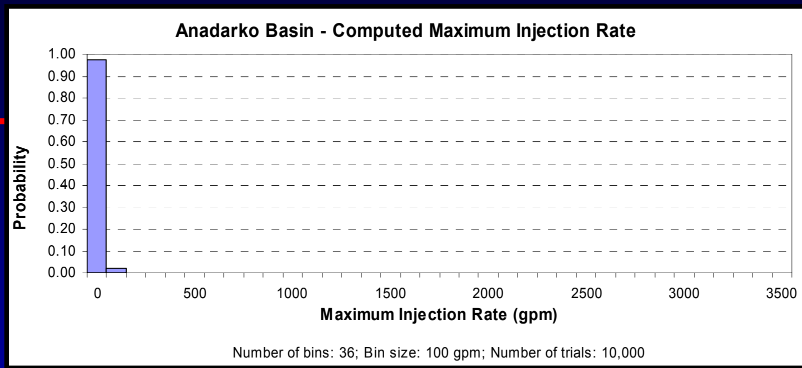
$$\Delta P = \frac{Q\mu}{4\pi k b}\ln\left(\frac{2.25kt}{\phi c \mu r^2}\right)$$



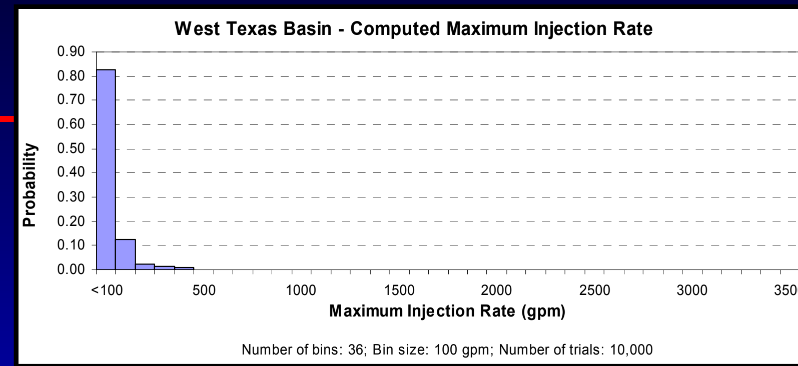


(Limited sampling of actual injection wells)

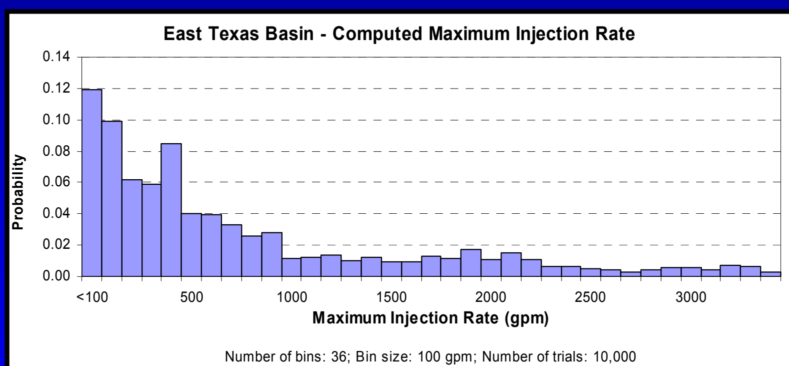
Computed Injection Rates



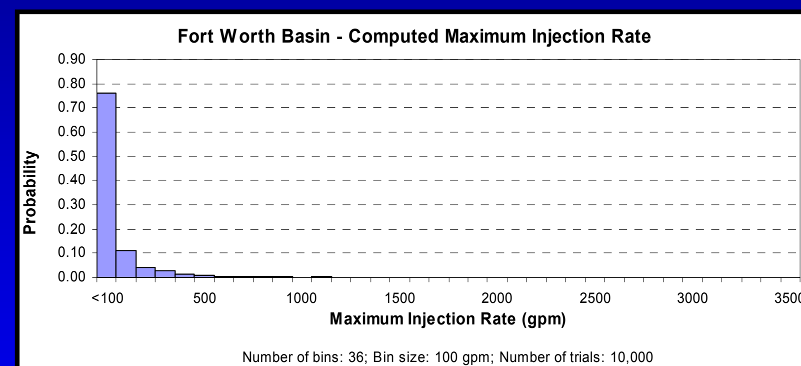
median = 7.3 gpm; 95th = 23 gpm



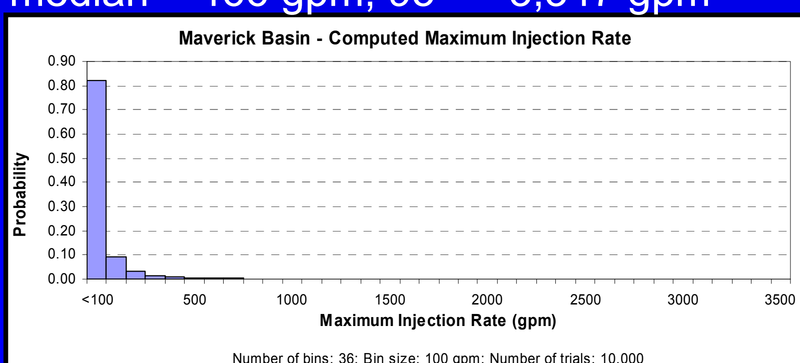
median = 13.2 gpm; 95th = 153 gpm



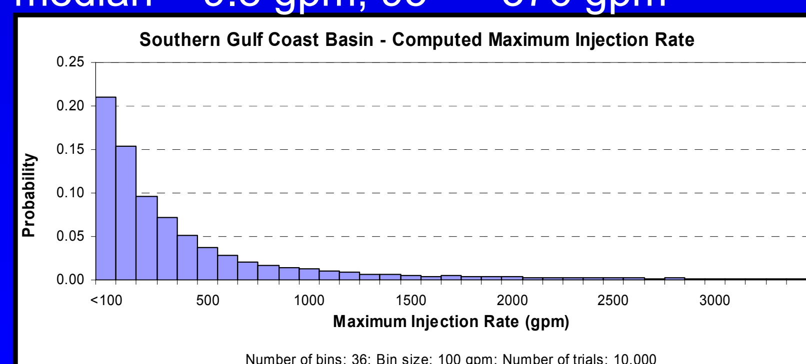
median = 466 gpm; 95th = 3,347 gpm



median = 9.8 gpm; 95th = 376 gpm



median = 6.3 gpm; 95th = 270 gpm



median = 278 gpm; 95th = 9,038 gpm

Summary of Technical Conclusions

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- Historical perspective is favorable
- Scaling can be mitigated with standard approaches (acidification, antiscalant)
- Clay sensitivity will be a (local) issue for several fields. It could be dealt with but at a price
- Multiple wells/well clusters are needed to accommodate concentrate output of a typical facility

Possible Permitting Paths

- Non-hazardous Class I
- Class II
- Class V
- Dual-permitted wells
- General permit, Class I
- Special Class I
- Change Federal regulations

Questions, Comments?

"…..And we must not only improve water conservation, but desalinate the saltwater that splashes upon our coast each day."

Governor Rick Perry

State of the State Address

February 11, 2003