Risk-based approach to assess CO_2 storage capacity

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Risk-Based Approach to Assess CO_2 Storage Capacity

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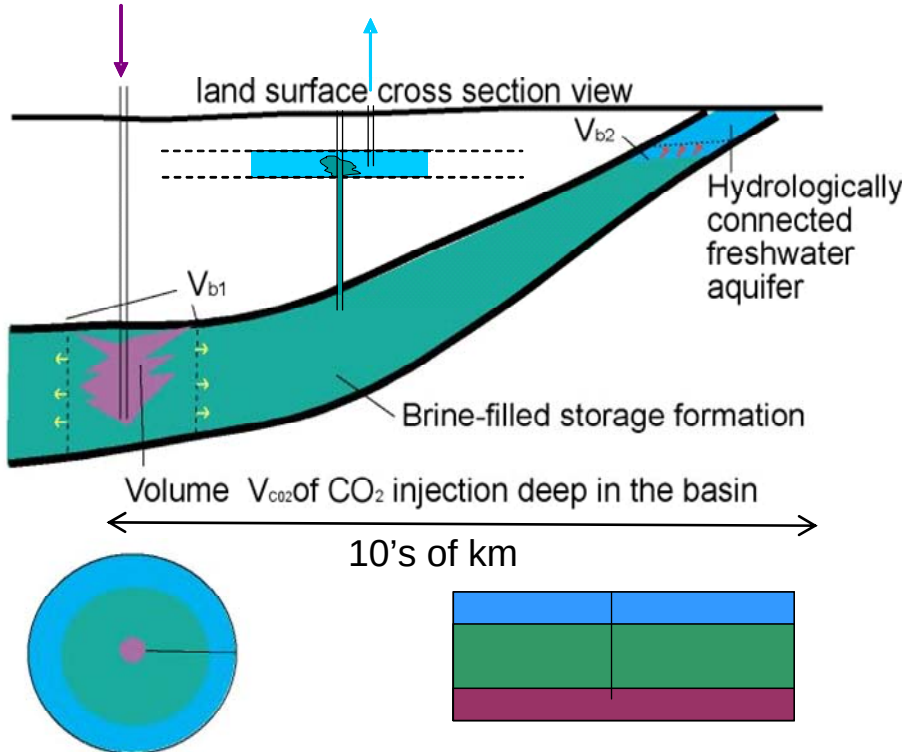
- Capacity is not an intrinsic absolute property. It depends on operations decisions (dynamic) and on risk tolerance
- If maximum pressure define capacity, capacity is operational (that is, function of cost, number of wells, H. vs. V.)
- How much CO_2 can be injected before unacceptable risks are realized?
- Capacity is a function of Boundary Conditions, pressure, in open systems water displacement as a limit on capacity

- Examples of risk impacting capacity:
  - Density of old wells: how willing to fix them (and find them all) before injection or assume damages if any
  - Water displacement: how willing to accept risk of water quality degradation by displacement of brackish water into fresh water section
- In addition to sweep efficiency and other coefficients, capacity of a formation depends also on factors external to the formation itself

Water Displacement: where does the water go?

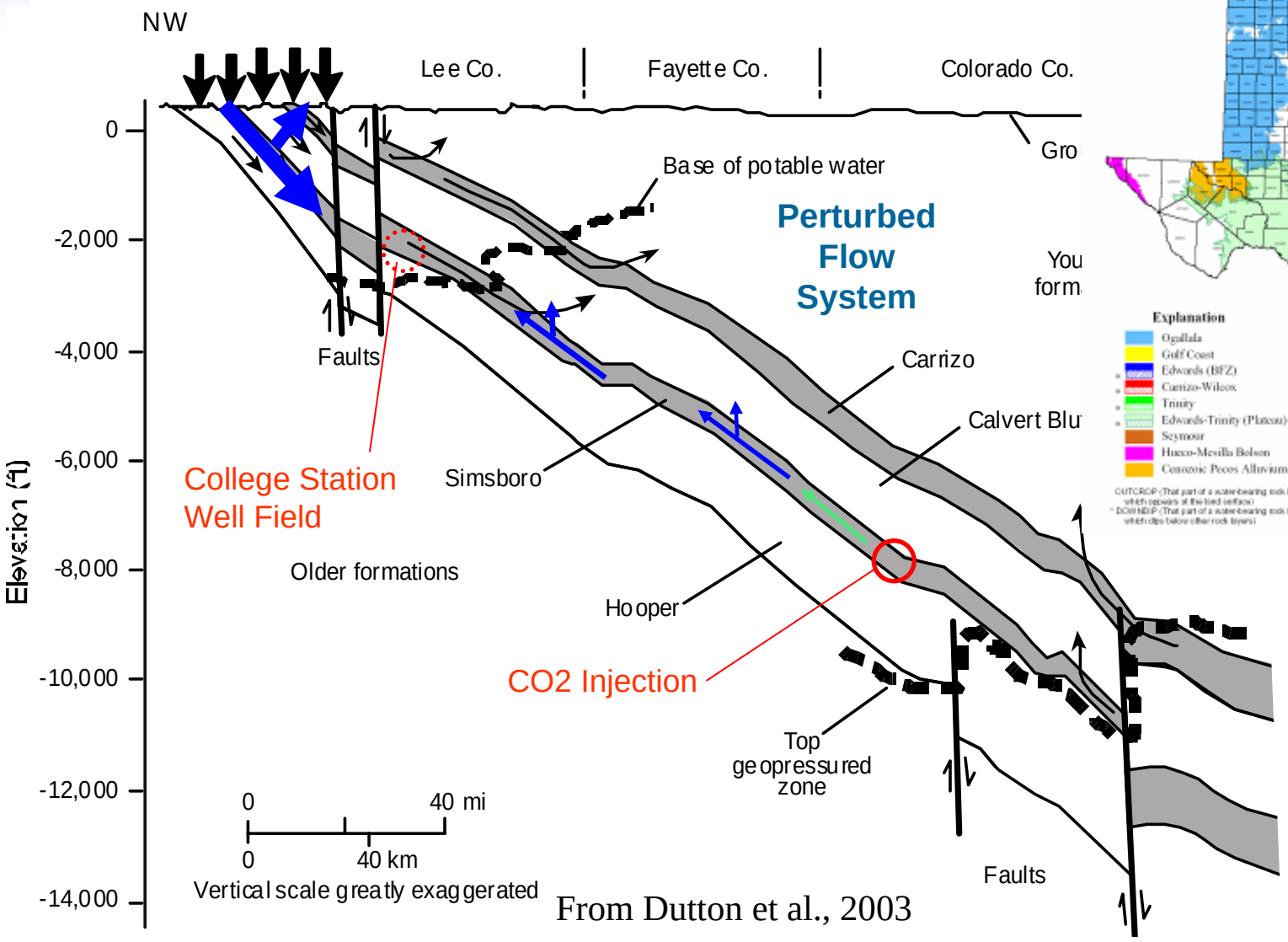
- Massive injection operations: elevated pressure footprint larger than CO_2 plume, need a regional perspective
- Pressure transient attenuation through:
- Compressibility of pore space and fluids in both:
  - Injection formation
  - Seals and other clay-rich formations
- Increased vertical leakage of water through seals (already occurring naturally)
- Lateral displacement of water likely in the updip direction
- [surface uplift / deformation]
- Open system; pressure pulse can travel to the surface but is attenuated. How fast? How much?

Water Displacement: where does the water go?

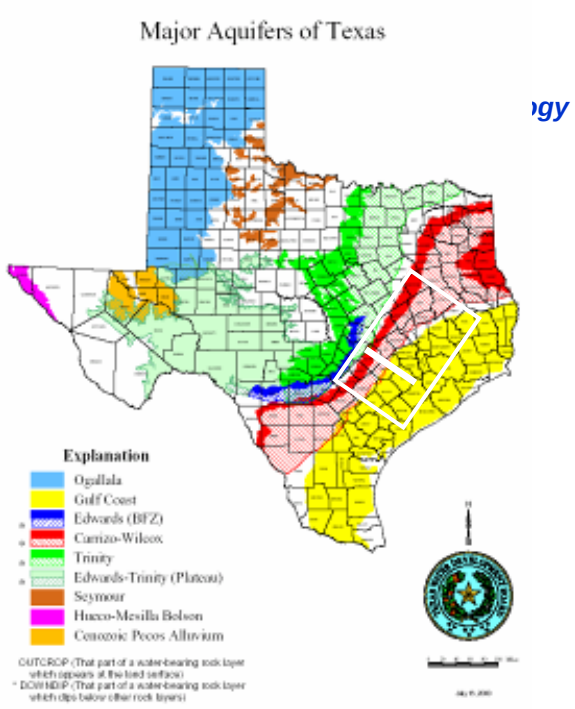


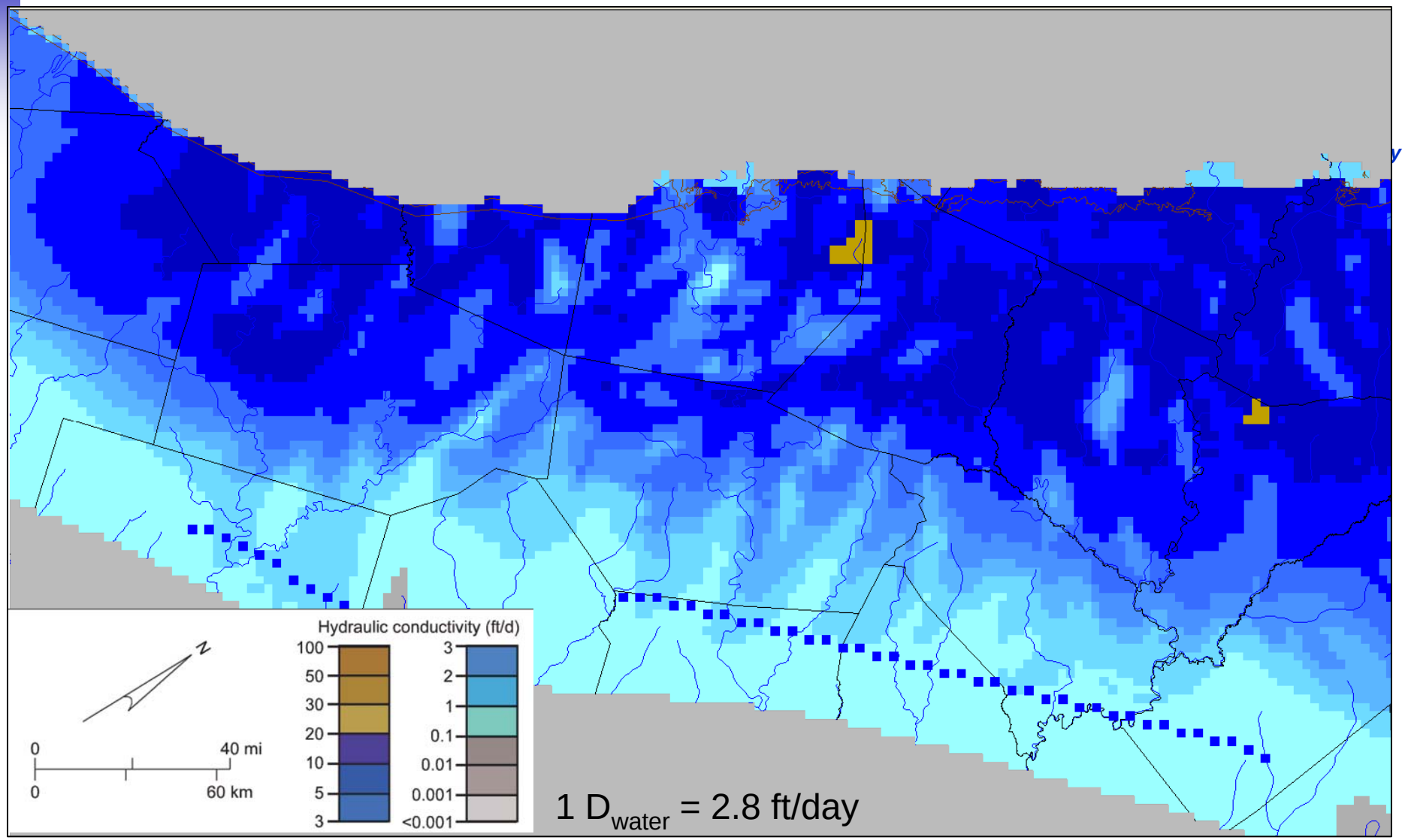
- Capacity could be defined as no CO_2 and (very) limited pressure increase past some vertical plane
- Capacity limited by brine, etc moving into an unacceptable volume
- Four variables to be considered to determine at when a displacement of brine is a significant issue:
  - the total volume of brine displaced (less than CO_2 volume injected – compressibility of fm. + “muds”)
  - the rate of displacement at the discharge area (=function of geometry of the basin)
  - the area over which discharge occurs (broad area OK, spring = maybe not)
  - the impact of the amount of brine on environment and resources at the discharge point.

Carrizo-Wilcox System in Central Texas



From Dutton et al., 2003




Hydraulic conductivity (ft/d)
100
50
30
20
10
5
3
3
2
1
0.1
0.01
0.001
<0.001
N
0
40 mi
0
60 km
1 D water = 2.8 ft/day

Impact Assessment

- Can capacity be assessed with a single-phase flow model?

- Small water table rise on average
- Increased ET and baseflow fluxes at the outcrop
- Small displacement of isosalinity contour lines

- Impact could be locally significant when focused flow (fault, springs, etc).

Nicot, 2008

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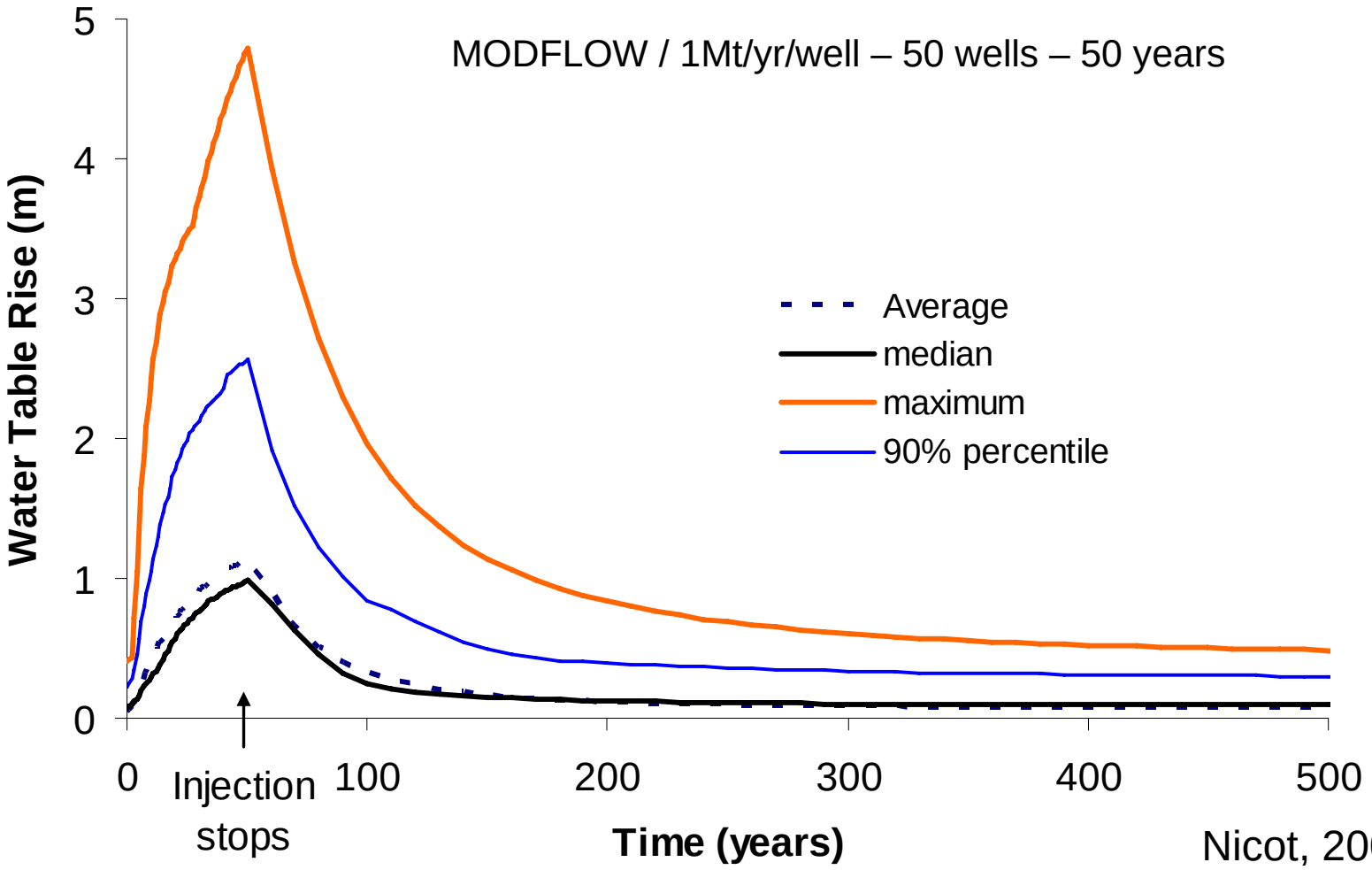
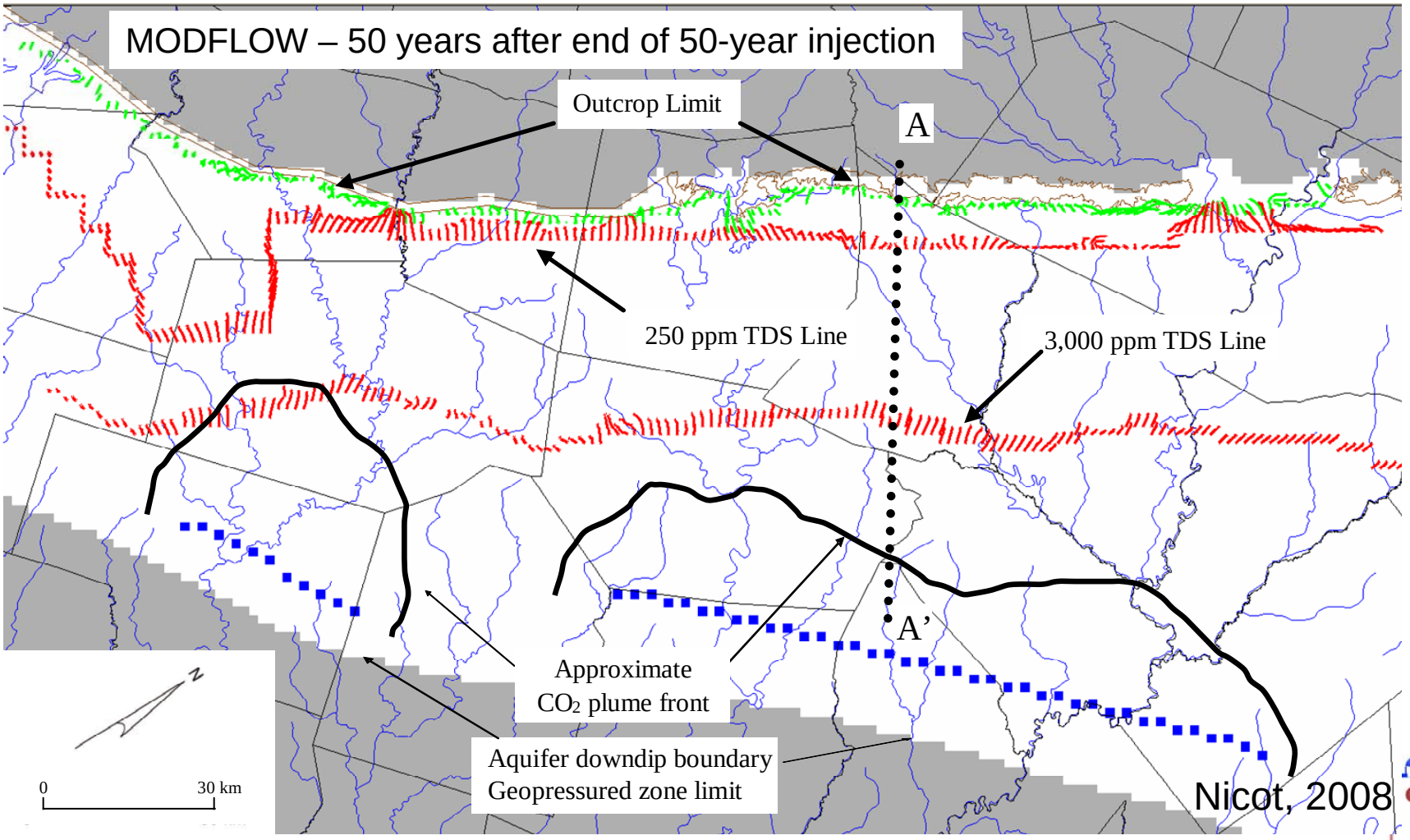
Impact Assessment



Impact Assessment



Conclusions

- Capacity estimation depends on:
  - Risk / consequence acceptance
  - Operational history
  - Basin characteristics
- Seals and overlying layers have a large impact on pressure attenuation and water displacement; they have to be included in capacity estimation