Carbon Storage Leasing Challenges

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Carbon Storage Benefits Texas Schoolchildren

- Offshore carbon storage could earn the State of Texas as much as $5 billion by 2050.
- The enhancement of energy resource-rich assets along the Texas coast helps to train the next generation of highly skilled workers.
- Royalties paid are deposited into the Texas Permanent School Fund, which currently collateralizes over $97 billion in K-12 school district bonds.

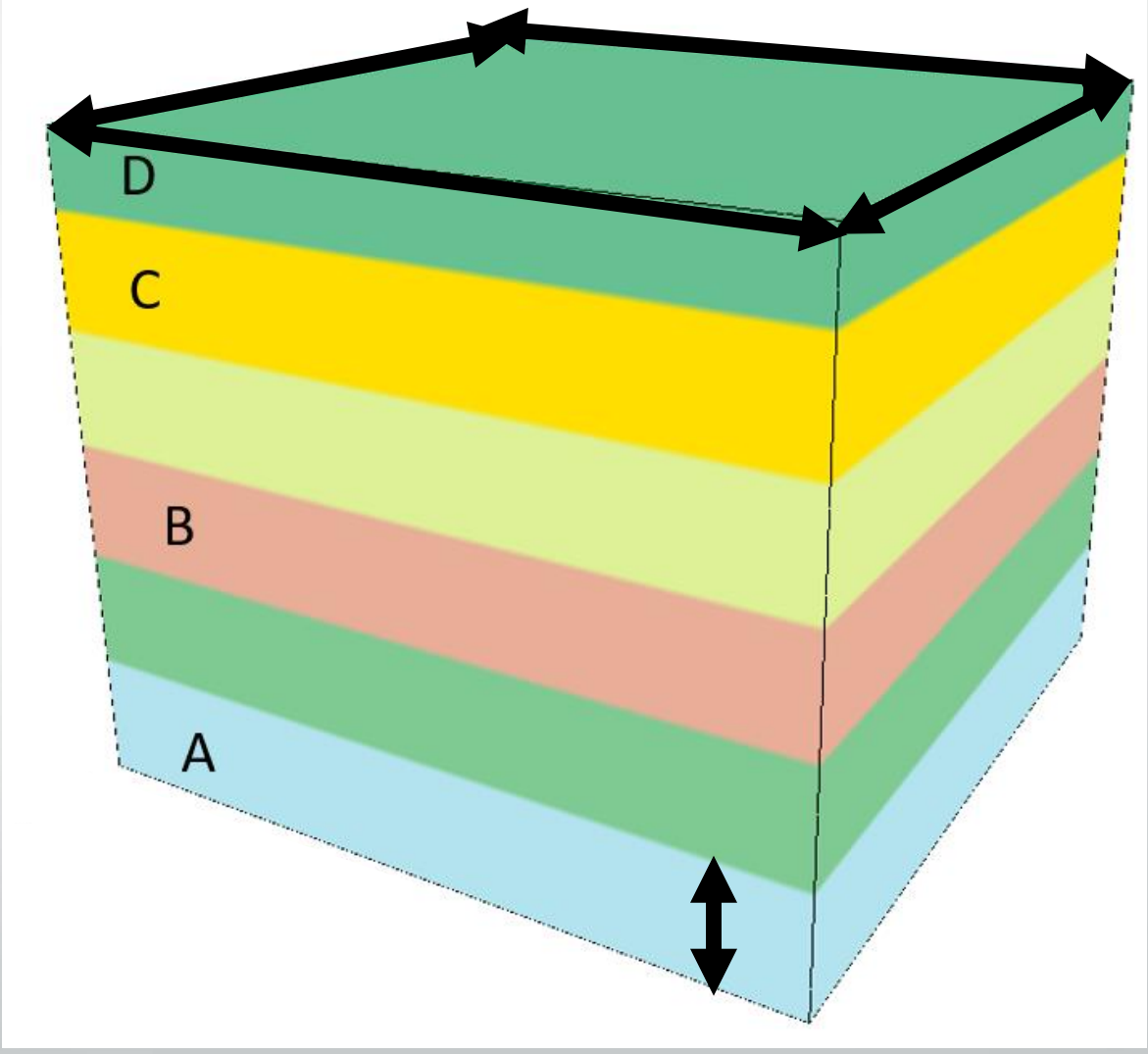
Accurate Capacity Expectations Inform Appraisals

- Leasing proposals often contain—and reinforce—revenue expectations based on overly optimistic capacity estimates
- Accurate appraisals of leasable tracts must reflect *practical* storage capacity and associated revenue projections
- Injection rates can affect capacity through poor reservoir sweep efficiency: bigger isn't always better, especially for the landowner
- Dynamic reservoir models frequently updated with new data are key to maximizing storage efficiency and revenue generation

Static (Volumetric) Capacity Is Only An Initial Estimate

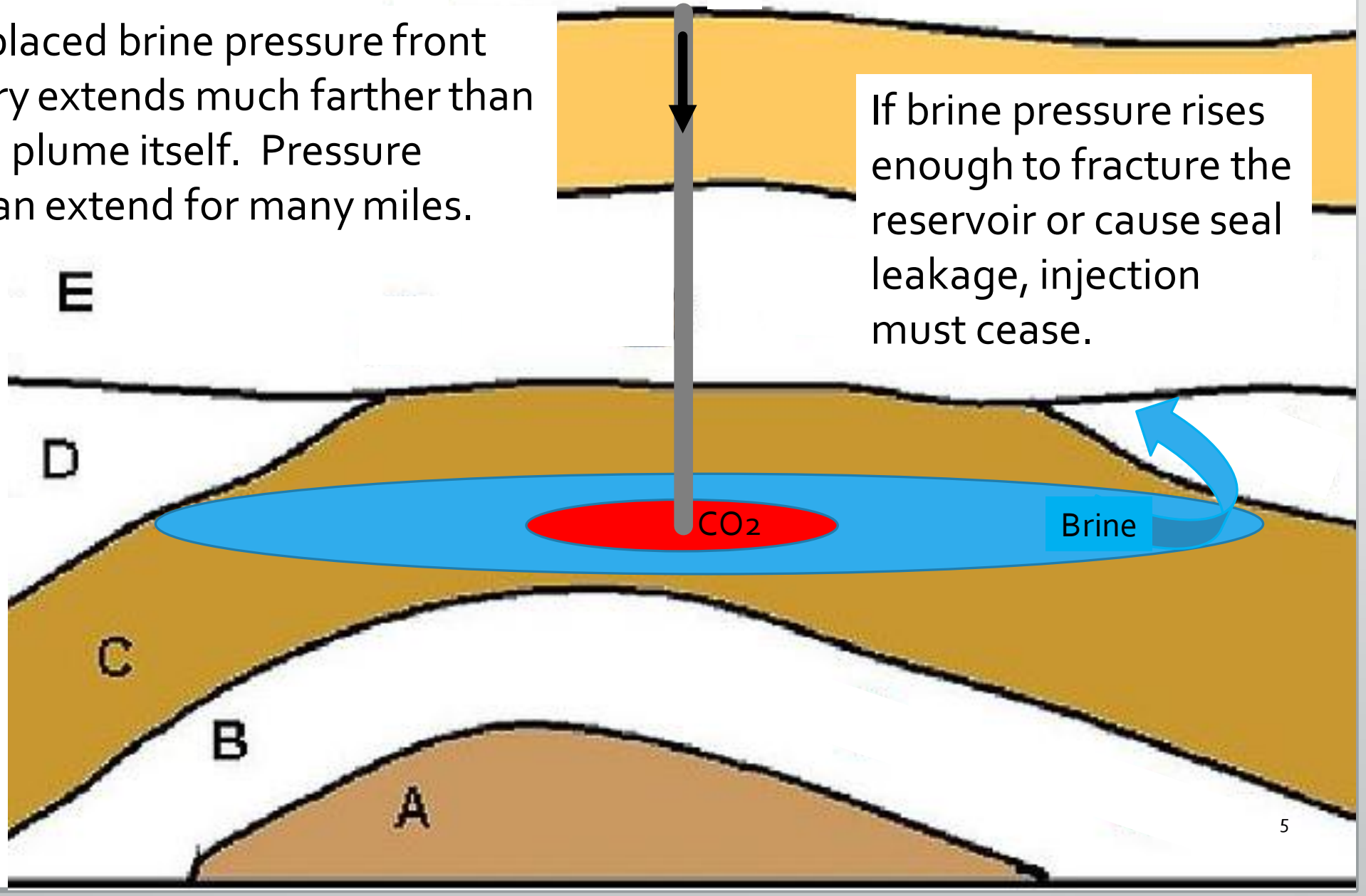
Static reservoir storage capacity is basically just the size of a box: net thickness x surface area x porosity

This does not account for limitations on capacity related to pressure increases. Reservoir fracture stress limits and seal leakage risks will reduce capacity from its static value to as little as a few percent of the initial estimate.

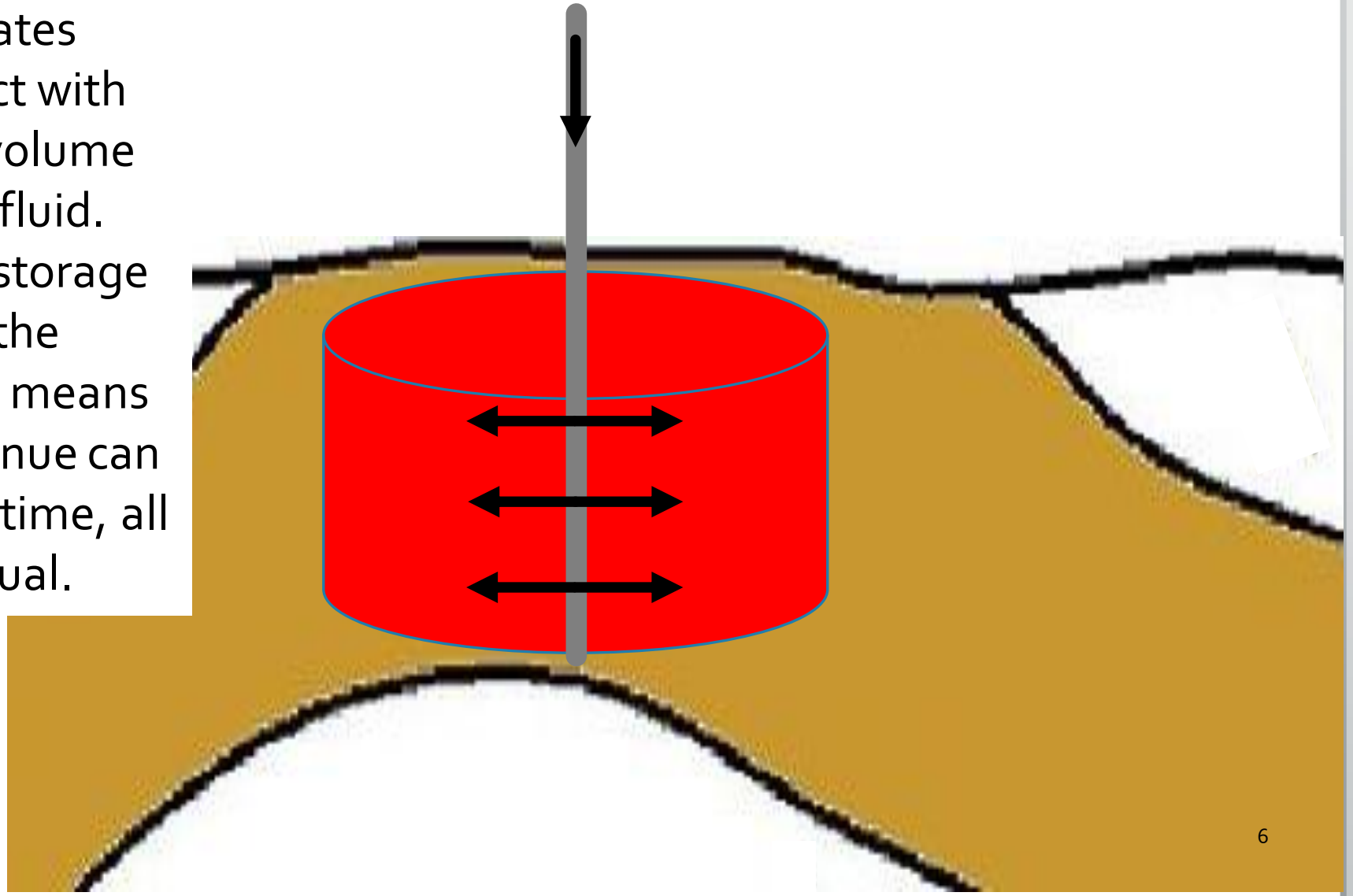


The displaced brine pressure front boundary extends much farther than the CO_2 plume itself. Pressure fronts can extend for many miles.

If brine pressure rises enough to fracture the reservoir or cause seal leakage, injection must cease.

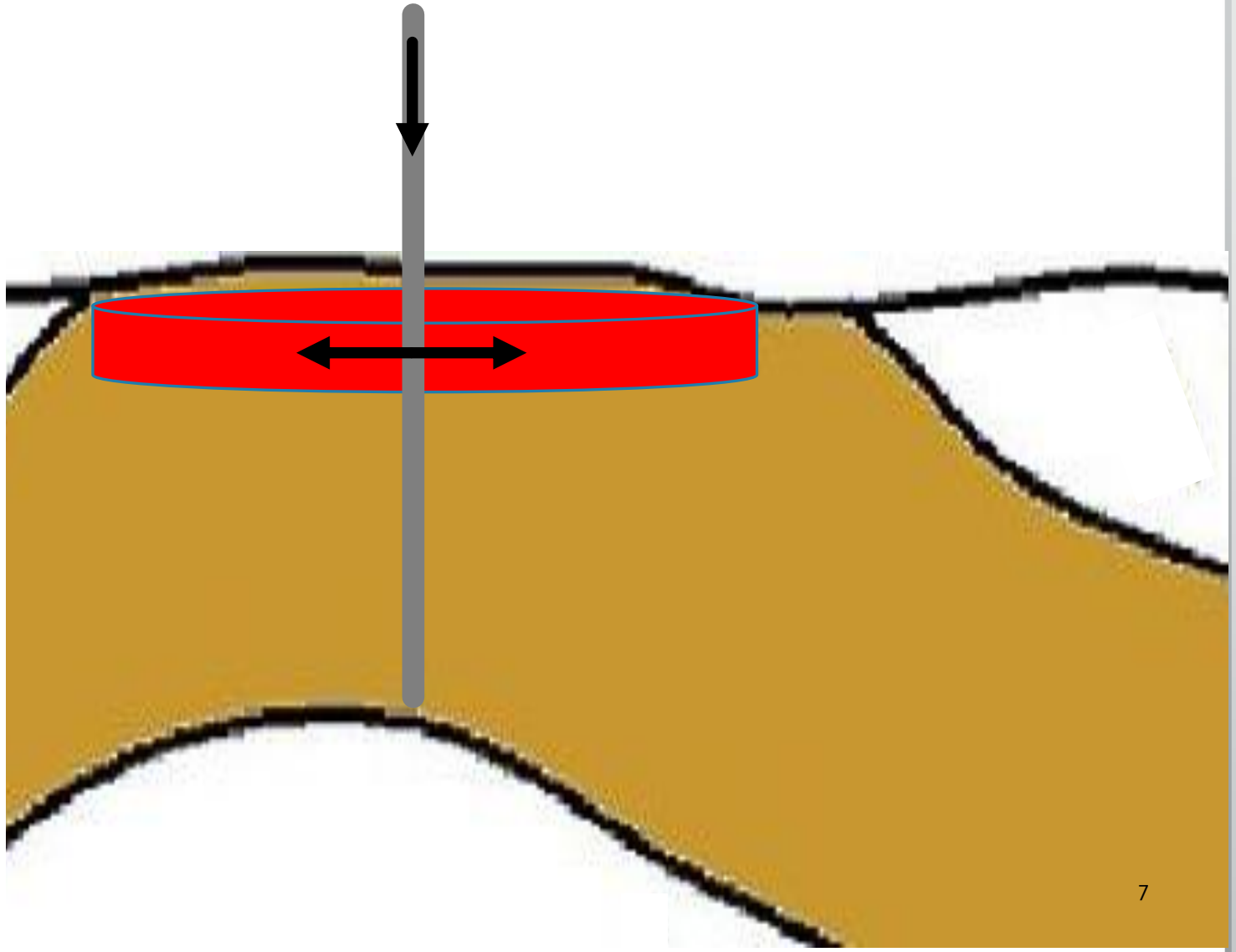


Good reservoir sweep efficiency indicates maximal contact with reservoir pore volume by the injected fluid. This optimizes storage efficiency. For the landowner, this means more total revenue can be earned over time, all other things equal.

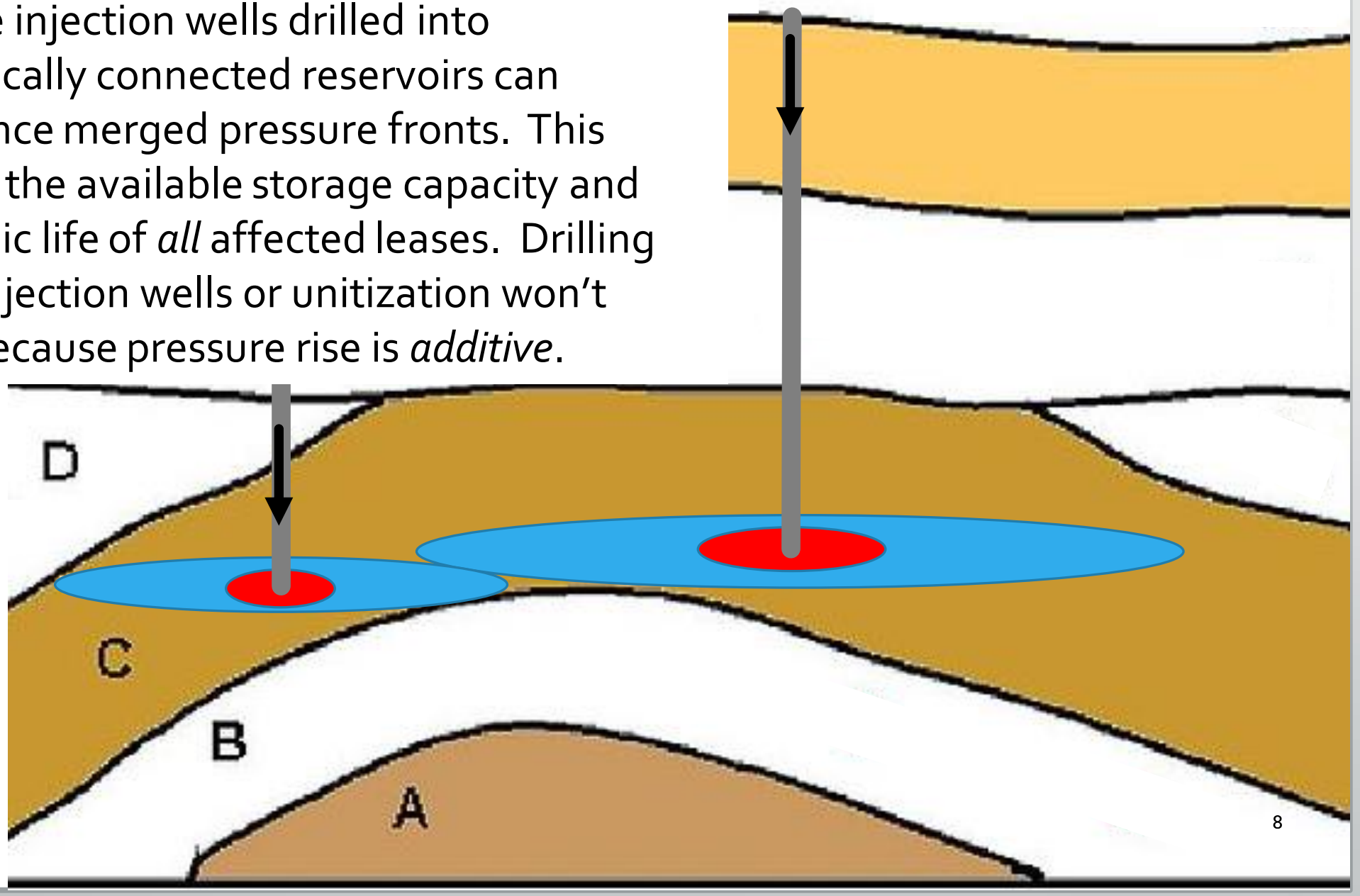


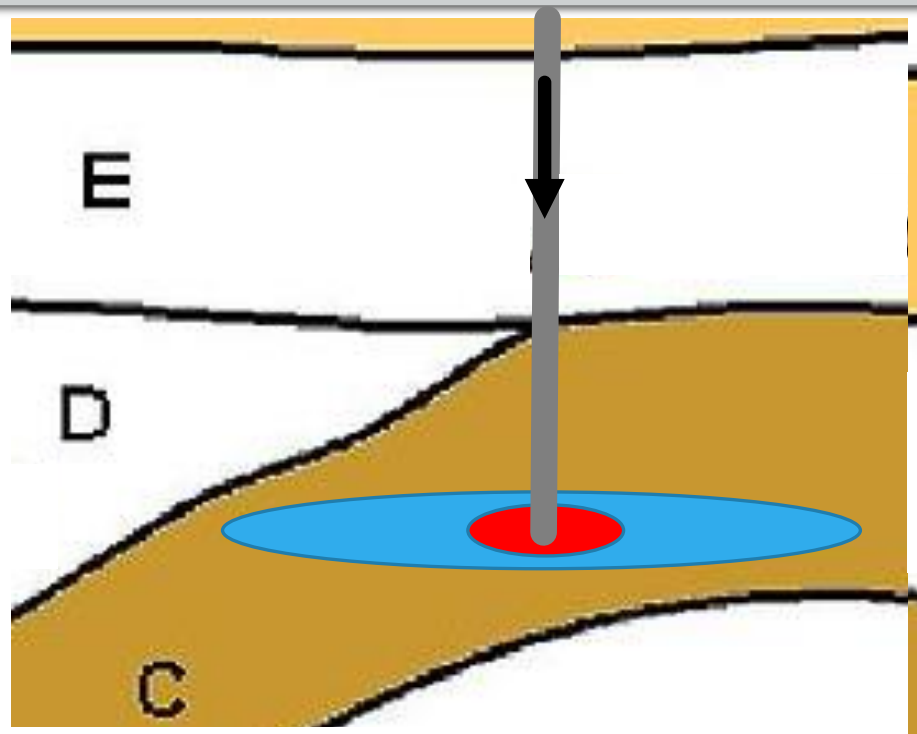
Poor reservoir sweep efficiency can result in a "pancake" of CO_2 rising to the top of the reservoir. This can cause the plume to migrate farther laterally than it otherwise would, and it also can reduce total storage capacity by limiting dissolution trapping.

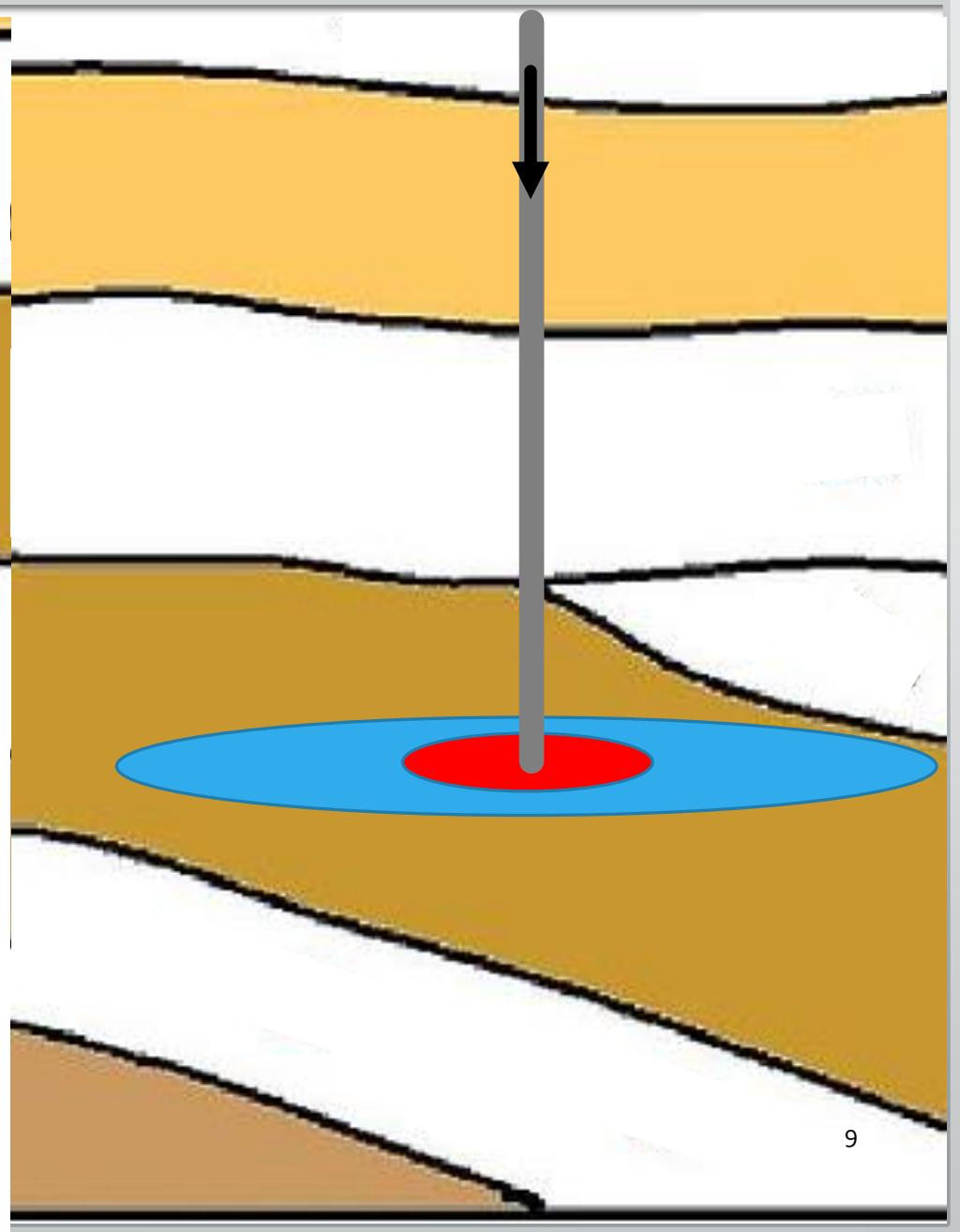
Sweep efficiency can be compromised if injection rates are too high. A lease should penalize poor storage efficiency.



Multiple injection wells drilled into hydraulically connected reservoirs can experience merged pressure fronts. This reduces the available storage capacity and economic life of *all* affected leases. Drilling offset injection wells or unitization won't work, because pressure rise is *additive*.



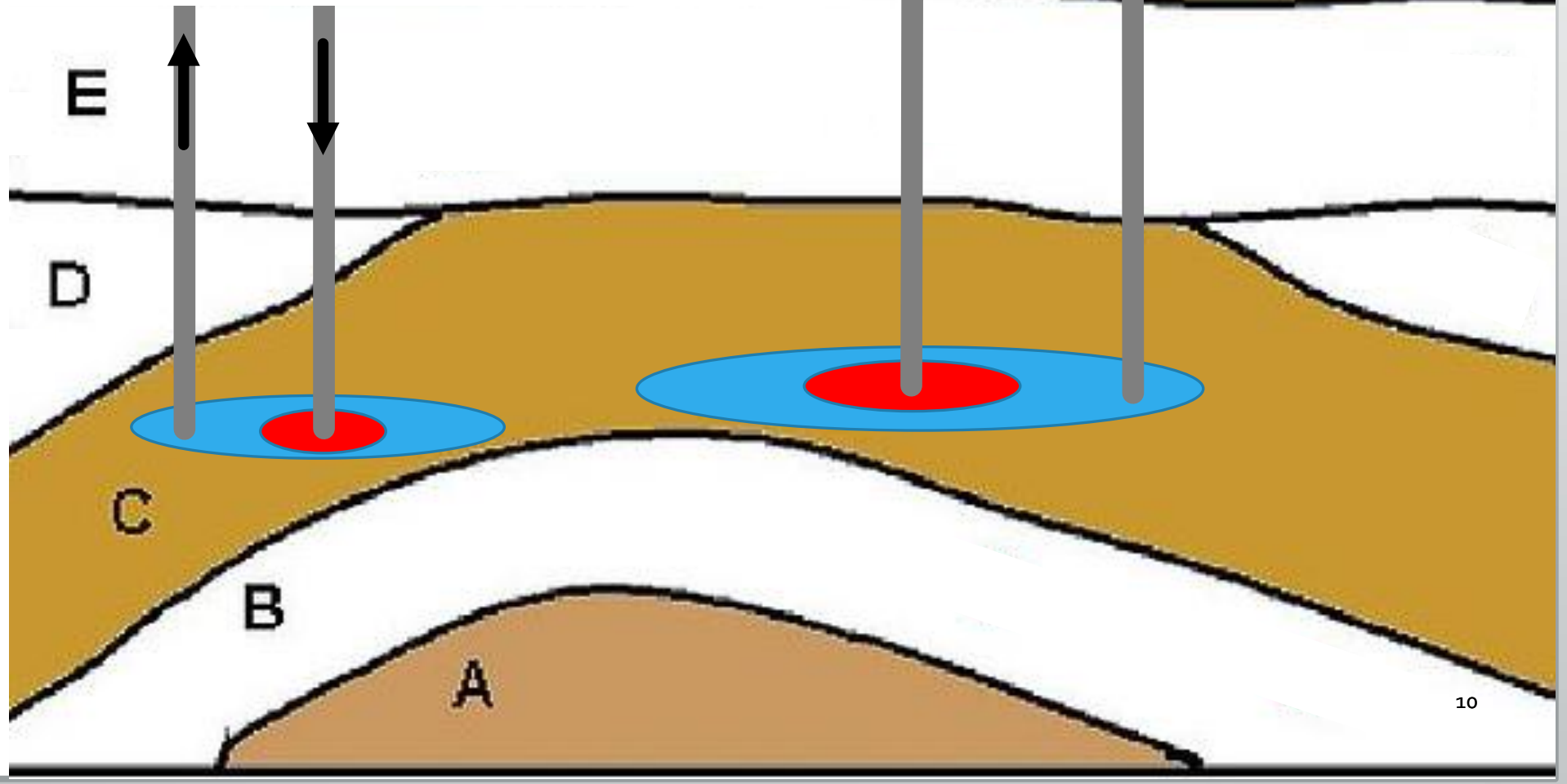




Restricting the number of leases per hydraulic unit, for instance by leveraging sealing faults, can help prevent future contract disputes over pore space

Unfortunately, true seal integrity and dynamic storage capacity are only fully revealed over time as operational data is obtained. Injection leases must be written to reflect and adapt to this uncertainty.

Also possible is requiring lessees to drill water production wells which can reduce pressures far from the carbon plumes and increase the carbon storage capacity within a hydraulic unit.



Storage Well Integrity is Crucial for Landowners

Injected CO_2 dissolves in reservoir brine to form carbonic acid. The acid leaches minerals from many cements used to seal storage wells against geologic formations.

Leaching action can cause the solid cement barrier to become porous and lose its ability to prevent CO_2 from leaking past corroded casing or malfunctioning packers

Leaking wells can't earn revenue for landowners. Leases should always stipulate strict Class VI standards.