Combining Quantitative Leakage Risk Assessment with Financial Liability for CO_2 Geologic Storage

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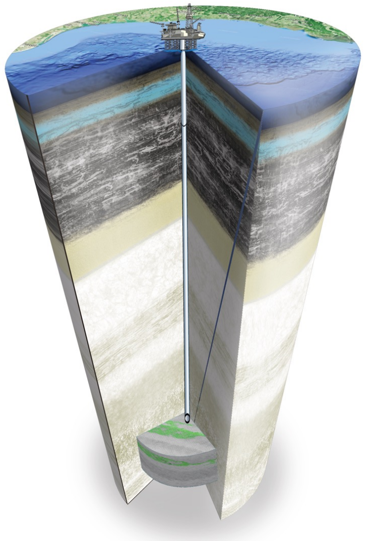
Geologic CO_2 Storage: Leakage Risk Assessment

Future Needs: A Robust Liability Regime

- Main investment concern: Cost risk
- Leakage of CO_2 and/or resident brine to the underground sources of drinking water (USDW) and atmosphere
- Legacy wells: major potential conduits for CO_2/brine leakage

- **Existing gaps**
  - Prediction of consequential events, their frequency and environmental impacts
  - Costs associated with their mitigation and environmental remediation
  - Quantifying the costs incurred by different stakeholders
  - Data to support a cost curve for designing commercial insurance



Geologic Carbon Storage

Methodology

Probabilistic leakage assessment → Environmental impacts → Stakeholders → Costs

Uncertainties

- Geology
- Operational parameters
- Well density
- Well integrity

Leakage outcomes

- Leakage only (remain isolated in the subsurface)
- Leakage to USDW
- Leakage reaches the atmosphere
- Interference with other subsurface activities

Affected stakeholders

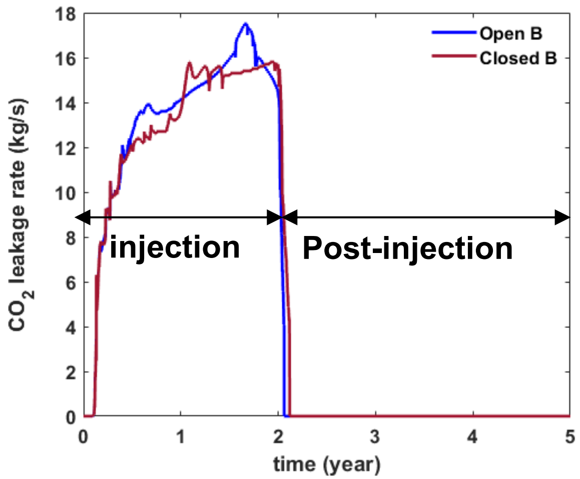
- Operator
- Regulator
- Groundwater user
- CO_2 producer
- Surface owner/resident

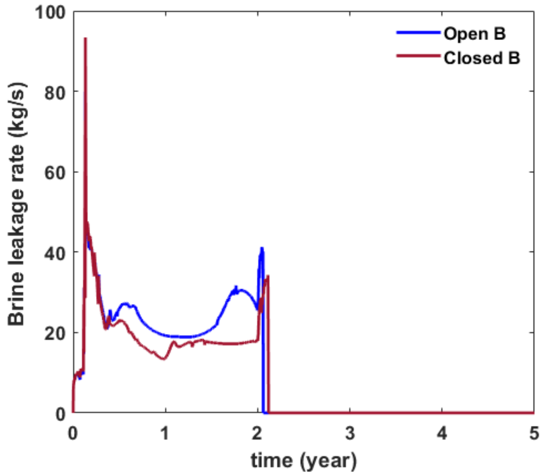
Cost categories

- Diagnostic monitoring
- Environmental remediation
- Injection interruption
- Business interruption to others
- Legal costs

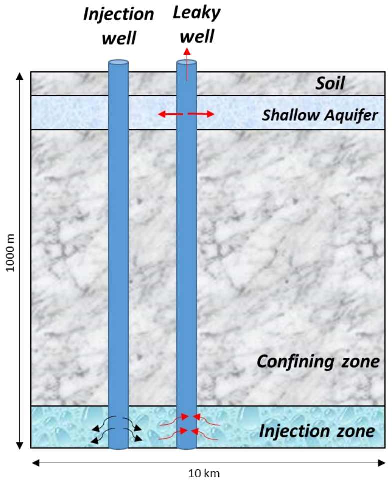
Results

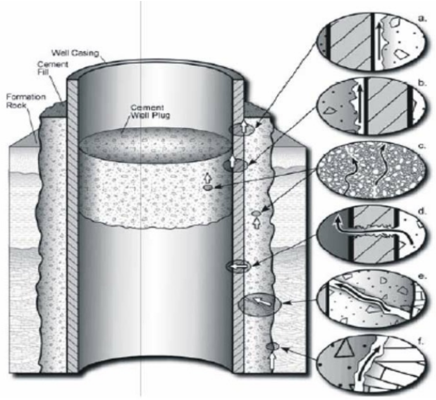
- ❑ **Leakage quantification**
- ❑ **Approach**: Coupled reservoir and wellbore modeling, Solving the equations of non-isothermal, multiphase, and multi-component flows
- ❑ Develop the probability distribution of leakage rates: considering a wide range of geologic/operational parameters





Parameter	Value
Res. permeability	100 mD
Res. porosity	0.2
Res. thickness	100 m
Res. depth	1000 m
Res. salinity	10,000 ppm
Res. extent	10 km × 10 km
Boundary condition	Open and closed
Location of leaky well	100 m, 500 m
Size of the leaky well	0.2 m
Injection rate	0.5 Mt/yr, 1 Mt/yr
Injection duration	2 yr
Shut-in period	3 yr
Shallow aquifer depth	25 m, 250 m
Geothermal gradient	0.025 °C/m





Considering different leakage pathways in a leaky well (Celia et al., 2005)

Future Directions

- ❑ Quantifying the **environmental impacts** of leakage events to different receptors such as shallow groundwater aquifers, soil, and atmosphere

$$\boldsymbol{Risk}\left(\frac{Consequence}{Time}\right) = \boldsymbol{Likelihood}\left(\frac{Event}{Time}\right)\times\boldsymbol{Impact}\left(\frac{Consequence}{Event}\right)$$

- ❑ Quantifying **monetary impacts** of leakage events

THANK YOU!

QUESTIONS?