Certification Framework for Geological CO_2 Storage

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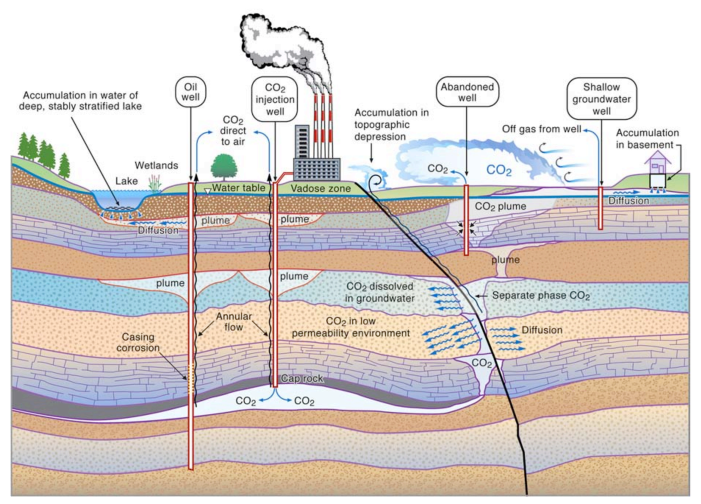
CO₂ Capture Project

INTRODUCTION

Critical to the large-scale deployment of CCS is a simple, transparent, and accepted basis for regulators and stakeholders to certify that the risks of geologic CCS projects to Health, Safety, and the Environment (HSE) and resources are acceptable.



The objective of this effort is to develop a simple framework for evaluating leakage risk for certifying operation and decommissioning of geological CO_2 storage sites.

BACKGROUND

The US EPA's Underground Injection Control (UIC) program is used successfully to regulate deep injection of liquids. Under the most stringent set of regulations, injected liquid is required not to migrate away from the injection zone for 10,000 years. This is the so-called **non-migration requirement**. There are fundamental differences between liquids regulated under the UIC program and geologic CO_2 storage that make a non-migration requirement inappropriate for CCS:

Liquid Disposal	CO_2 Storage
Liquid	Supercritical fluid, gas-like viscosity
Density often greater than brine	Density always less than brine
Single-phase flow	Multiphase flow
Small volumes, injection rates	Large volumes, injection rates

Implications for CO_2 Storage

- CO_2 immiscible with native fluids, highly mobile
- CO_2 has tendency to migrate upwards
- CO_2 may finger/bypass native fluids
- CO_2 Area of Review may be very large

Under the conditions applicable to CO_2 storage, we propose an **Effective Trapping requirement** analogous to the non-migration requirement of the EPA's UIC program.

In the CF, **Effective Trapping** is the overarching requirement for safety and effectiveness of a CO_2 storage site.

TERMINOLOGY

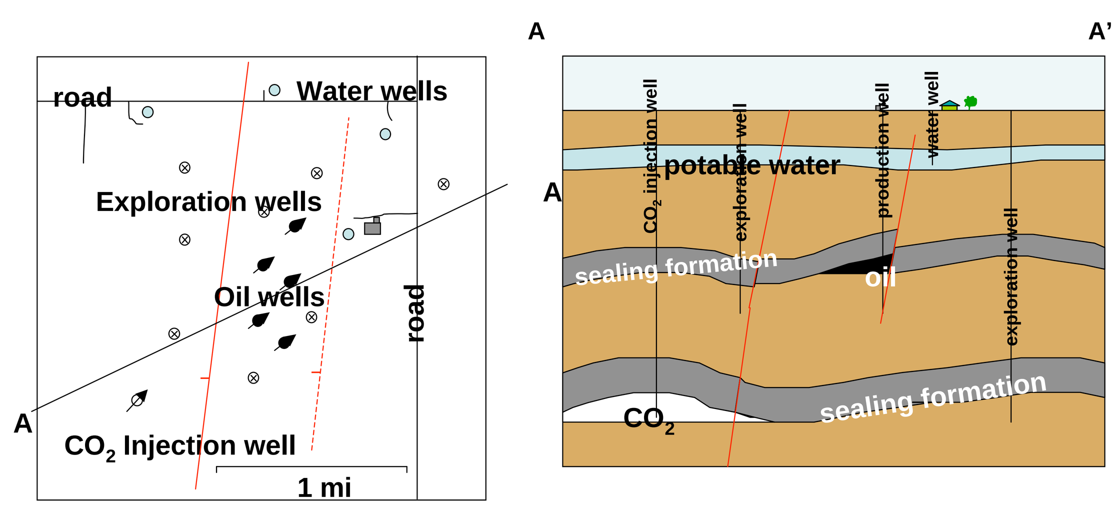
Effective Trapping implies that **CO_2 Leakage Risk** is below agreed-upon thresholds.
Storage Region is the three-dimensional volume of the subsurface intended to contain injected CO_2.
Leakage is migration across the boundary of the Storage Region.
Compartment is a region containing vulnerable entities (e.g., plants, animals, people, and resources).
Impact is a consequence to a compartment due to CO_2 leakage; it is evaluated by proxy concentrations or fluxes.
Risk is the product of probability and Impact.
CO_2 Leakage Risk is the probability that negative impacts will occur to compartments due to CO_2 migration.

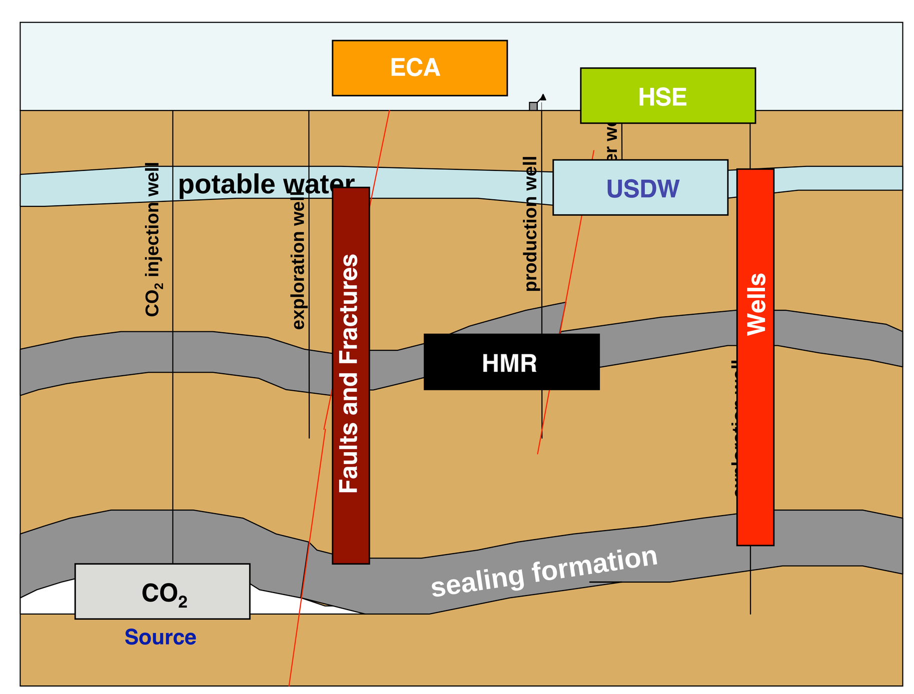
CERTIFICATION FRAMEWORK (CF)

The CF calculates the CO_2 Leakage Risk (CLR) for a given site based on input on subsurface properties, wells, faults, vulnerable assets, and injection parameters. If the CLR is below threshold values, then the CO_2 is considered effectively trapped meaning the storage site is safe and effective.

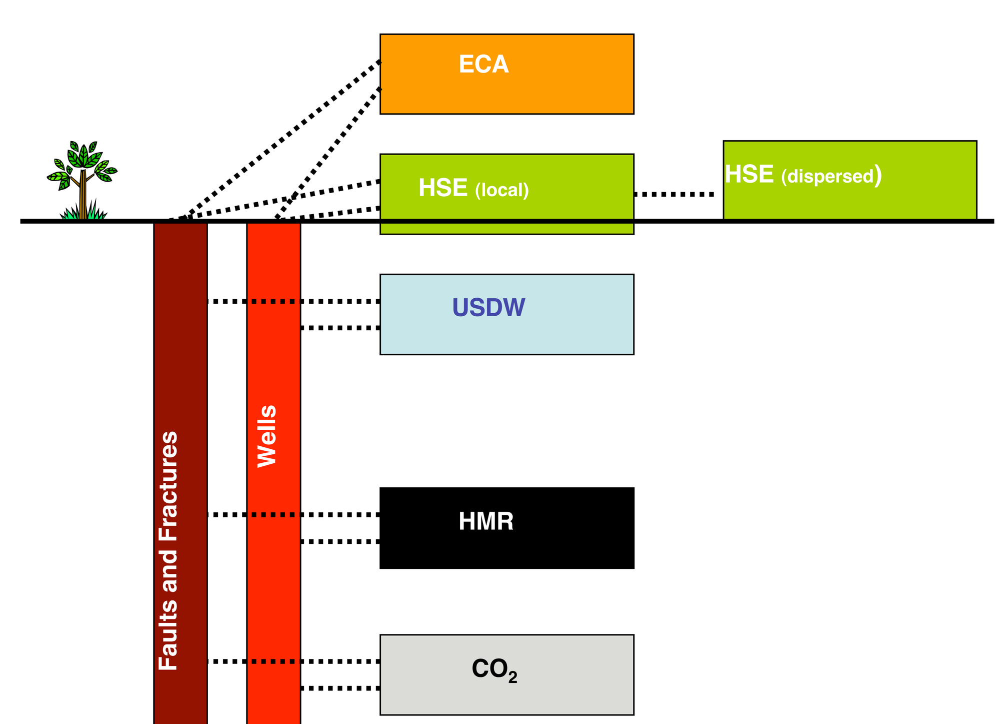
CO_2 Leakage Risk is defined as the product of Impact and Probability of impact (CLR = I x P)

CONTEXT FOR LEAKAGE AND IMPACT





COMPARTMENTS

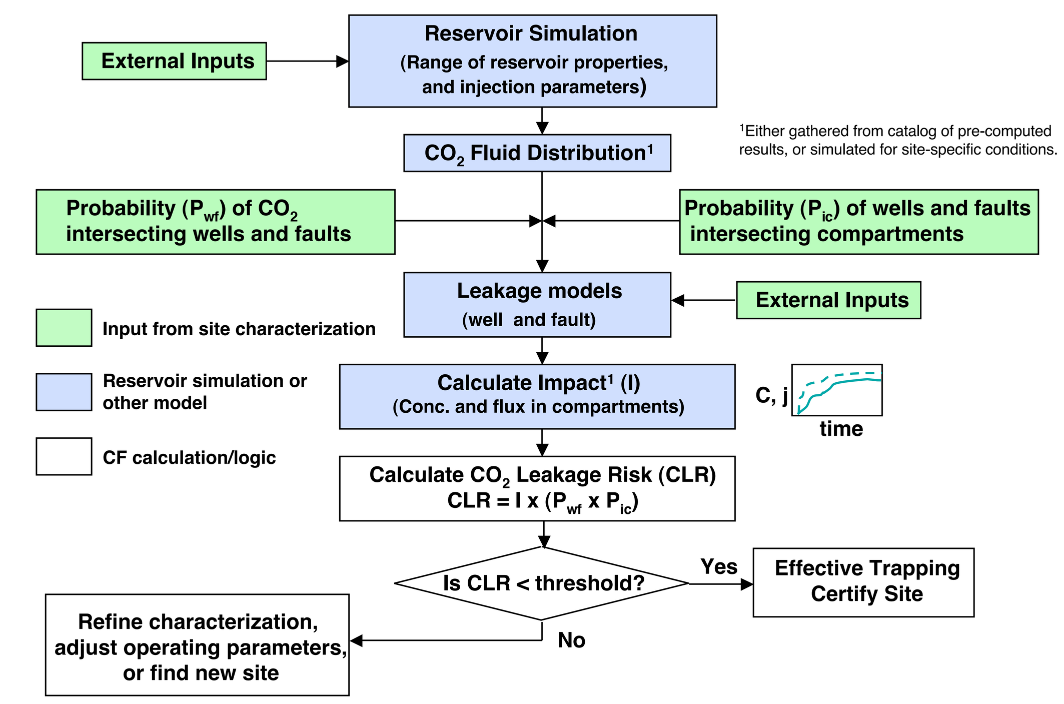


ECA = Emission Credits and Atmosphere
HSE = Health, Safety, and Environment
USDW = Underground Sources of Drinking Water
HMR = Hydrocarbon and Mineral Resources
CO2 = Injected CO_2 source

IMPACTS

Fluxes and concentrations (j, C) of CO_2 into/in compartments are proxies for impact to vulnerable assets.

CF FLOW DIAGRAM



Reservoir Simulation is used to calculate CO_2 fluxes and concentrations with time in compartments. Fluxes and concentrations are either read from catalog of pre-simulated results or computed on a site-specific basis.

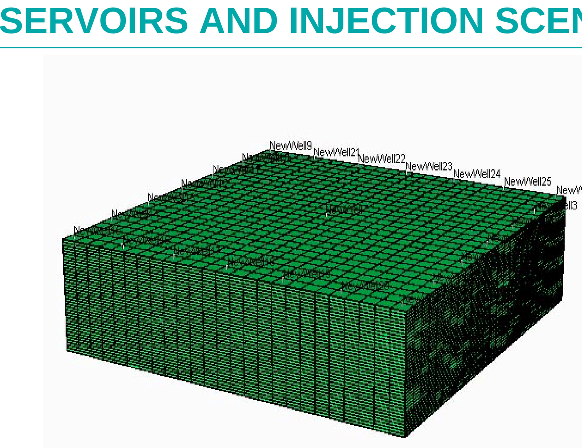
Probabilities of intersection of injected CO_2 plume with wells and/or faults, and of wells and/or faults with compartments are based on input data on well and fault density, along with computed CO_2 plume geometry.

CF is probabilistic in existence of flow pathway, and deterministic in flow along pathway

GENERIC RESERVOIRS AND INJECTION SCENARIOS

RESERVOIR PROPERTIES

- Porosity
- Permeability
- Anisotropy
- Dip
- Thickness
- Heterogeneity



OPERATIONAL PARAMETERS

- Type of well
  - Vertical
  - Horizontal
- Injection rate
- Injection Period

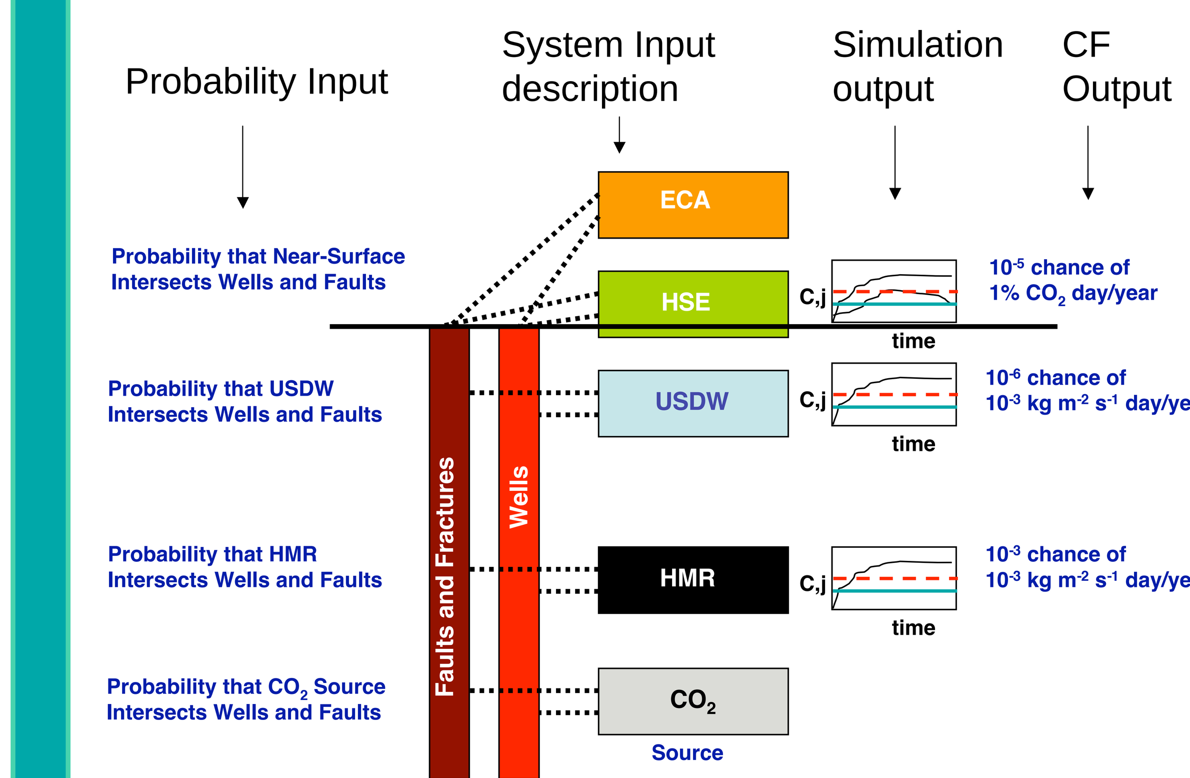
CMG-GEM is being used currently for subsurface simulation. Above-ground dispersion will be simulated using a version of ARPS (Oklahoma CFD model) currently under development.

Example matrix of properties for pre-simulation:

POROSITY	0.1	0.25	0.35
PERMEABILITY(md)	10	100	1000
ANISOTROPY	0.001	0.03	1
THICKNESS (ft)	100	500	1000
DIP	0	5	25
HETEROGENEITY	Low	Med.	High

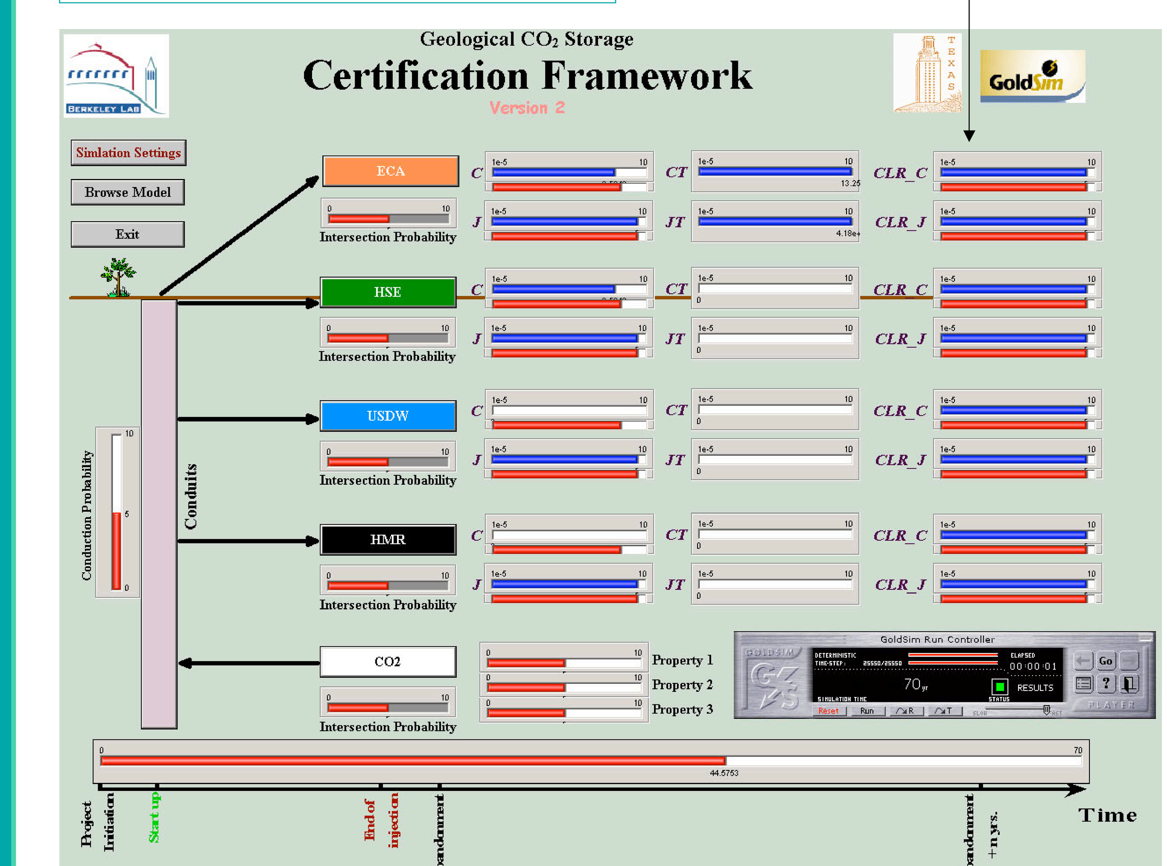
The CF uses broad classes of features, and a catalog of model results for simplicity.

EXAMPLE OF INPUT AND OUTPUT



CLR for concentration (C) and flux (j) for each compartment

GOLDSIM RAPID PROTOTYPE



SUMMARY OF CF

The CF project aims to develop a simple, transparent, and accepted approach to geologic CO_2 storage site certification.

Simplification
Certification based on CO_2 Leakage Risk (CLR)
Compartment and conduit concepts
Broad classes of features
Catalog of model results--but site-specific can be used also
CF is probabilistic in existence of flow pathway, deterministic in flow along pathway
Transparency
Model results are from sophisticated modeling of simplified systems
Process and I/O can be visualized in GoldSim application
Acceptance
Effective Trapping requirement analogous to UIC non-migration
International Advisory Board for continuous feedback

ACKNOWLEDGMENTS

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