

EASiTool : An Enhanced Analytical Simulation Tool for CO₂ Storage Capacity Estimation

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TEXAS Geosciences
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Outline

- CO₂ storage capacity estimation
- What is EASiTool?
- Assumptions and technical background
- Interface
 - Input
 - output
- Case study

Static methods

- Static methods (DOE, USGS, etc)

$$G_{CO_2} = A_t \times H_g \times \Phi_{tot} \times \rho \times E_{saline}$$

- Dynamic methods (Numerical simulations, analytical tools)
- EASiTool (**E**nhanced **A**nalytical **S**imulation **T**ool)
 - It uses analytical models (fast)
 - It is dynamic (time, number of wells, etc)
 - It does sensitivity analysis (tornado charts)

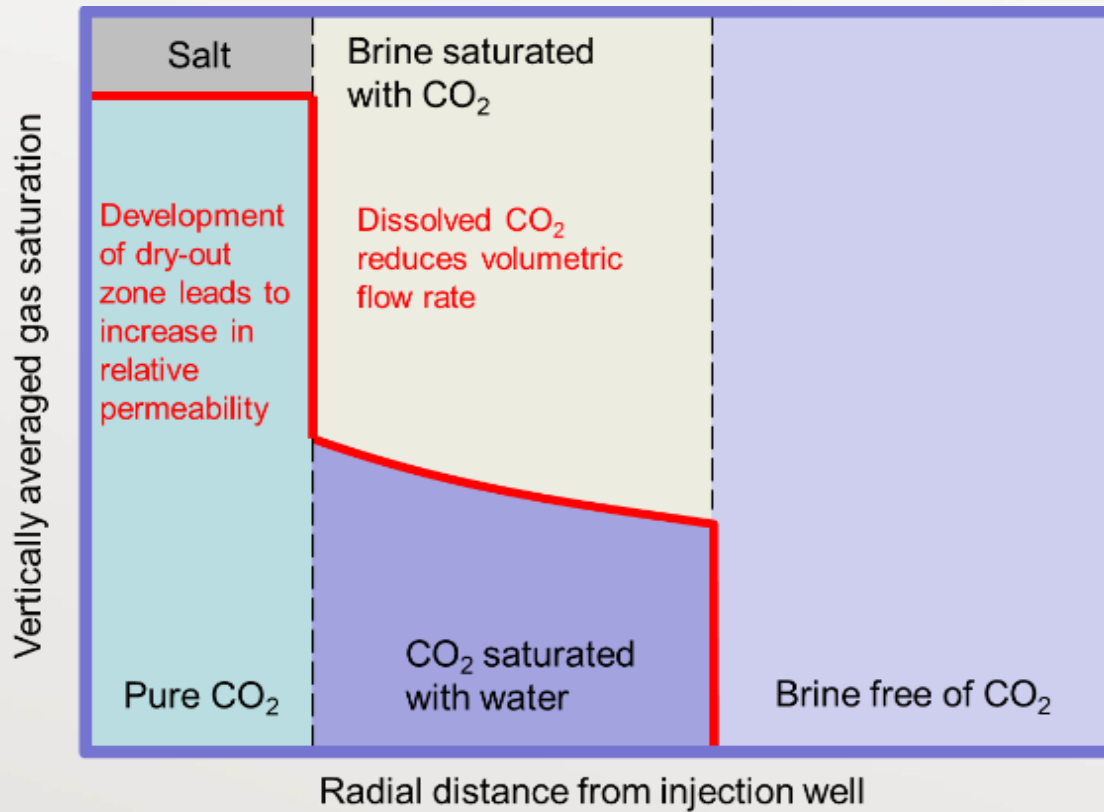
Methods Comparison

Tool/Approach Name	DOE/NETL	CSLF	USGS	EASiTool	Numerical Simulators
Reservoir scale	Yes	Yes	Yes	Yes	Yes
Accuracy	Low	Low	Low	Medium/High	High
Boundary conditions	No	No	No	Yes	Yes
Rock geomechanics	No	No	No	Yes*	Yes
Brine management	No	No	No	Yes	Yes
Required expertise	Low	Low	Low	Low	High
Cost of use	Low	Low	Low	Low	High
Computational speed	High	High	High	High	Low
Dynamic	No	No	No	Yes	Yes
Sensitivity Analysis	Simple	Simple	Simple	Yes	Yes

Assumptions

- Homogeneous/isotropic properties
- Constant rate injection
- No structure
- Two-phase flow (Brine and CO₂)
- Fluid properties are pressure dependent
- Uses superposition for multiwell scenarios

Analytical model



$$P - P_0 =$$

$$\frac{M_0}{4\pi\rho_c Hk} \begin{cases} \frac{\mu_c q_{D1}}{k_{rs}} \ln\left(\frac{z_T}{z}\right) + \mu_g q_{D2} F_2(z_T) + \mu_b q_{D3} F_1(z_L), & 0 \leq z < z_T \\ \mu_g q_{D2} F_2(z) + \mu_b q_{D3} F_1(z_L), & z_T \leq z \leq z_L \\ \mu_b q_{D3} F_1(z), & z > z_L, \end{cases}$$

Water Resources Research

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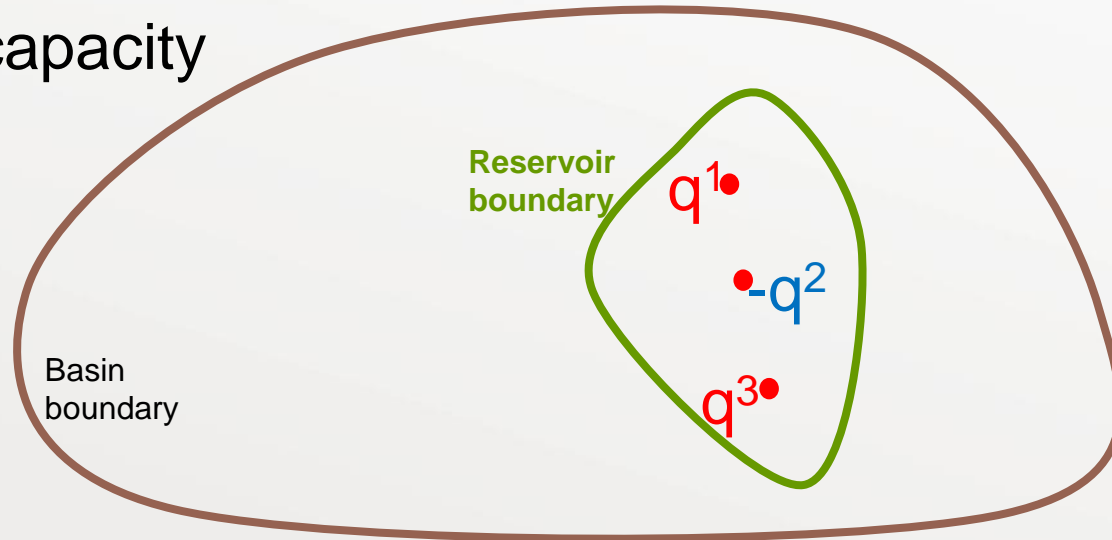
Regular Article

Role of partial miscibility on pressure buildup due to constant rate injection of CO₂ into closed and open brine aquifers

Simon A. Mathias, Jon G. Gluyas, Gerardo J. González Martínez de Miguel, Seyyed A. Hosseini

Multi-well injection & brine extraction

- Finding the maximum allowable rate to maximize storage capacity



$$\begin{bmatrix} \frac{1}{2}(\ln(t_D) + 0.80908) + S_a & -\frac{1}{2} \frac{\bar{\lambda}_g}{\lambda_w} E_i \left(-\frac{r_{D1-2}^2}{4\eta_{D3} t_D} \right) & -\frac{1}{2} \frac{\bar{\lambda}_g}{\lambda_w} E_i \left(-\frac{r_{D1-3}^2}{4\eta_{D3} t_D} \right) \\ -\frac{1}{2} \frac{\bar{\lambda}_g}{\lambda_w} E_i \left(-\frac{r_{D2-1}^2}{4\eta_{D3} t_D} \right) & \frac{1}{2}(\ln(t_D) + 0.80908) + S_a & -\frac{1}{2} \frac{\bar{\lambda}_g}{\lambda_w} E_i \left(-\frac{r_{D2-3}^2}{4\eta_{D3} t_D} \right) \\ -\frac{1}{2} \frac{\bar{\lambda}_g}{\lambda_w} E_i \left(-\frac{r_{D3-1}^2}{4\eta_{D3} t_D} \right) & -\frac{1}{2} \frac{\bar{\lambda}_g}{\lambda_w} E_i \left(-\frac{r_{D3-2}^2}{4\eta_{D3} t_D} \right) & \frac{1}{2}(\ln(t_D) + 0.80908) + S_a \end{bmatrix} \begin{Bmatrix} q^1 \\ -q^2 \\ q^3 \end{Bmatrix} = \begin{Bmatrix} \frac{2\pi h k \bar{k}_{rg}}{\mu_g} \Delta P_{\max} \\ \frac{2\pi h k \bar{k}_{rg}}{\mu_g} \Delta P_{\max} \\ \frac{2\pi h k \bar{k}_{rg}}{\mu_g} \Delta P_{\max} \end{Bmatrix}$$

Input- Output

EASiToolGUI Main Interface

GCCC GULF COAST CARBON CENTER | **BUREAU OF ECONOMIC GEOLOGY** | **JACKSON SCHOOL OF GEOSCIENCE**

1-RESERVOIR PARAMETERS

	Min	Ma	
Pressure [MPa]	20	15	25
Temperature [C]	65	50	80
Thickness [m]	100	50	150
Salinity [mol/Kg]	2	1	3
Porosity	0.2	0.15	0.25
Permeability [mD]	100	10	250
Rock Compressibility [1/Pa]	5e-10	3.5e-10	6.5e-10
Reservoir Area [km^2]	100		
Basin Area [km^2]	100		
Boundary Condition	Clos...		

2-RELATIVE PERMEABILITY (Brooks-Corey)

Residual Water Saturation	0.5	0.3	0.7
Residual Gas Saturation	0.05	0	0.1
m	3	2	4
n	3	2	4
Kra0	1	1	1
Krg0	0.3	0.20	0.4

3-SIMULATION PARAMETERS

Simulation Time [years]: 20

Injection Well Radius [m]: 0.1

Max Injection Pressure [MPa]: 30

Estimate Max Injection Pressure Internally

Density of Porous Media [Kg/m3]:

Total Stress Ratio (V/H):

Biot Coefficient:

Poisson's ratio:

Coefficient of Thermal Expansion [1/K]:

Bottom Hole Temperature Drop [K]:

Young's Modulus [GPa]:

Depth [m]:

Estimated Max Injection Pressure [MPa]:

Max Injection Rate [ton/day/well]: 2000

Max Number of Injectors: 100

Sensitivity Analysis (Slow)

4-NPV

Drilling Cost [\$M/well]: 1

Operation Cost [\$K/well/year]: 500

Monitoring Cost [\$K/year/km^2]: 50

Tax Credit [\$/ton]: 10

Extractors Drilling Cost [\$M/well]: 1

Extractors Operation Cost [\$K/well/year]: 500

5-EXTRACTION PARAMETERS

Number of Extractors: 4

Minimum Extraction Pressure [MPa]: 29

Maximum Extraction Rate [m^3/day/well]: 2000

Run

Simulation Time [sec]= 100.

6-RESULT CONTROLS

Number of Injection Wells: 3

Export Image and Output Files (Slow)

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Capacity, Mitons of CO2 vs **Number of Injection Wells**
X: 16, Y: 35.92

NPV, \$M vs **Number of Injection Wells**

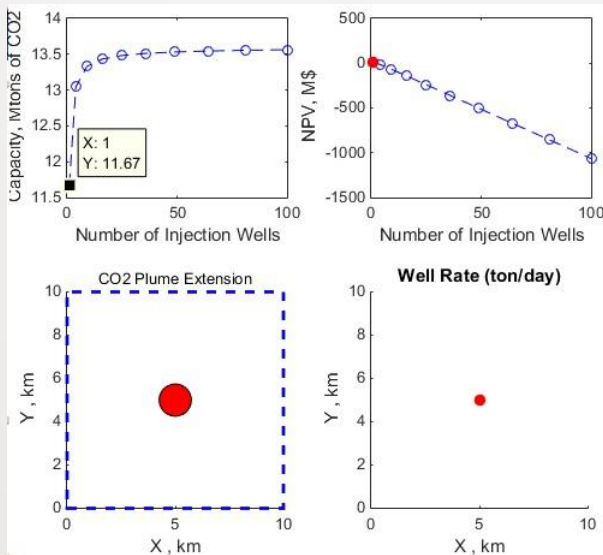
CO2 Plume Extension (X, km vs Y, km)

Well Rate (ton/day) (X, km vs Y, km)

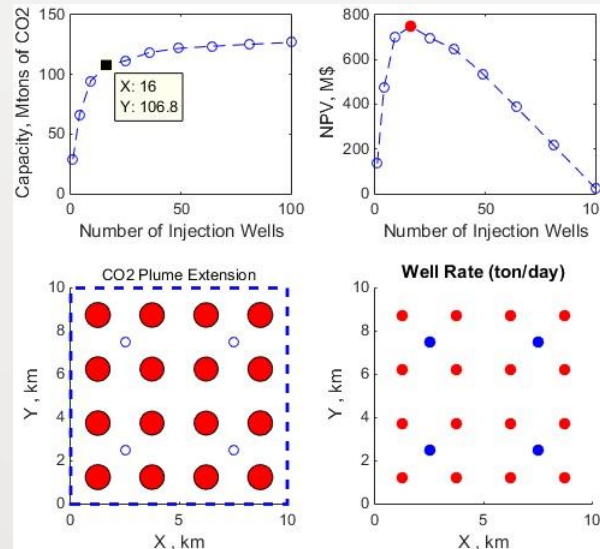
Permeability Thickness Porosity Rock Comp. Temperature vs **Capacity**

EASiTool
CO2 Geological Capacity Estimation

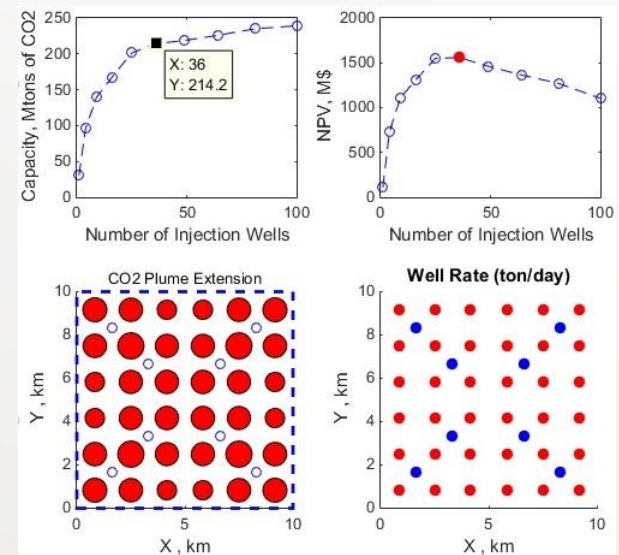
Output



0 Extractors
Capacity: 11.7 Mton
1 injector

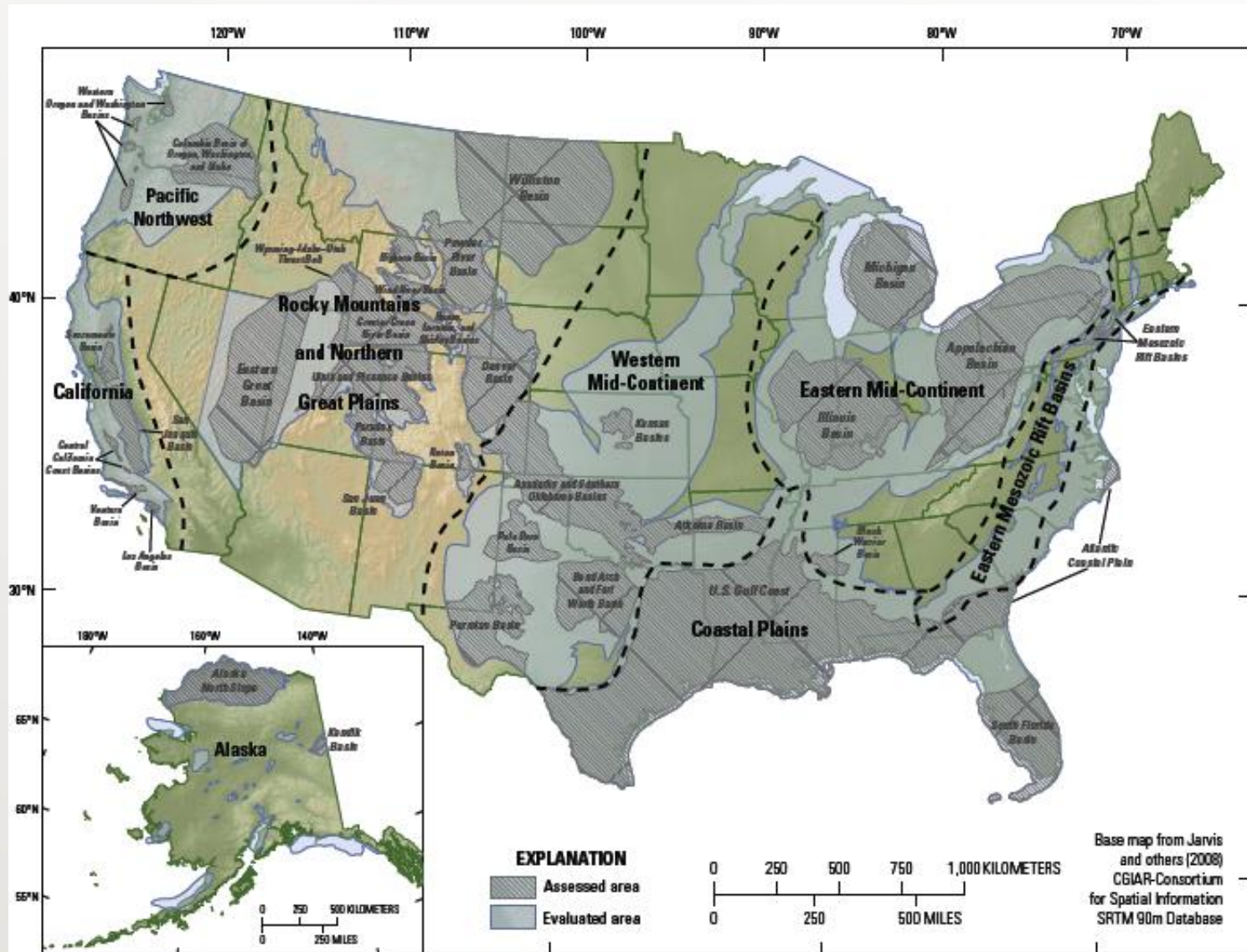


4 Extractors
Capacity 107 Mton
16 injectors

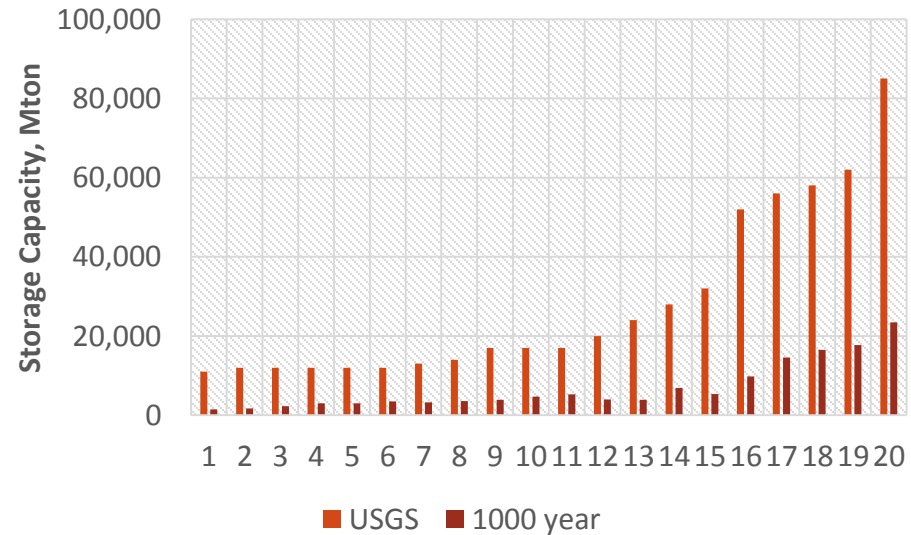
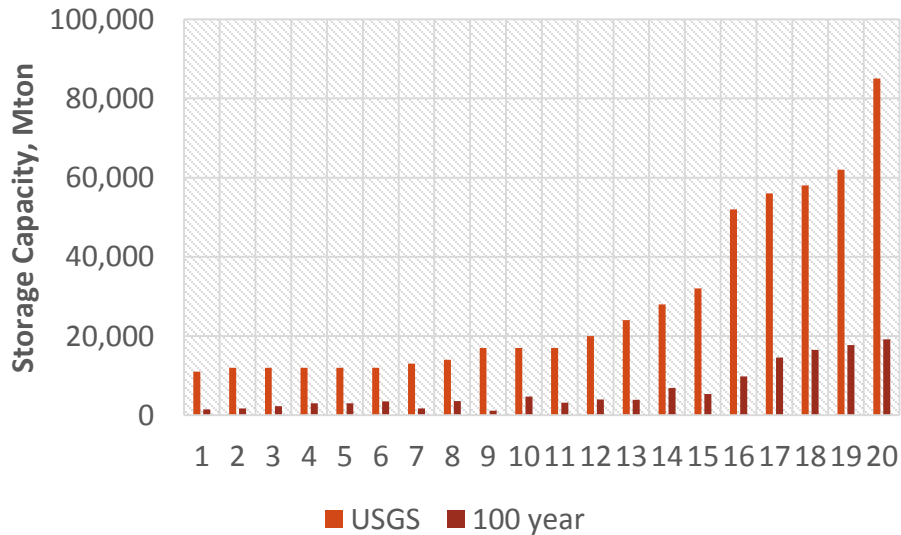
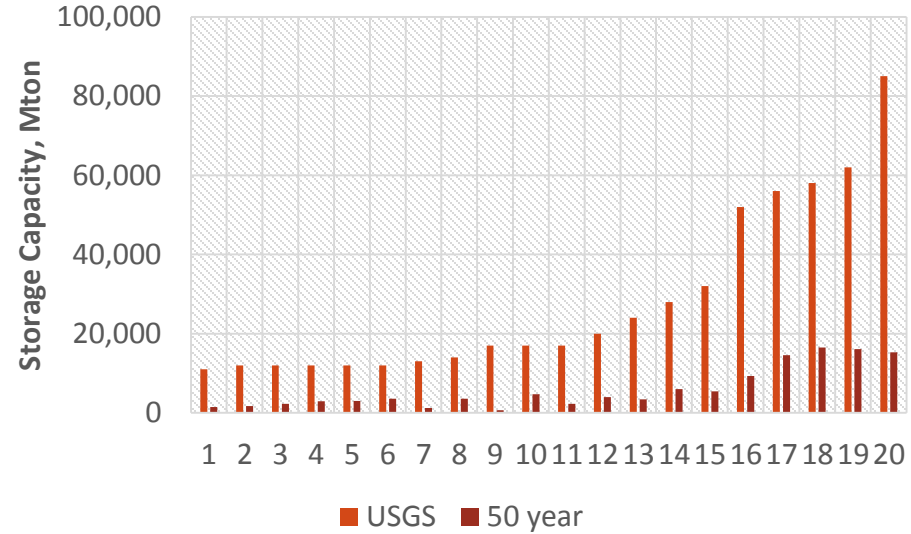
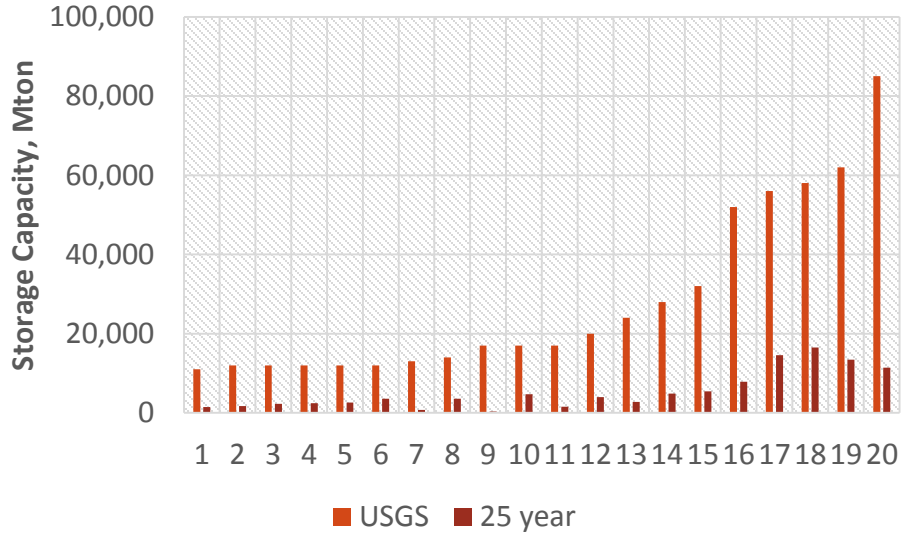


8 Extractors
Capacity: 214 Mton
36 injectors

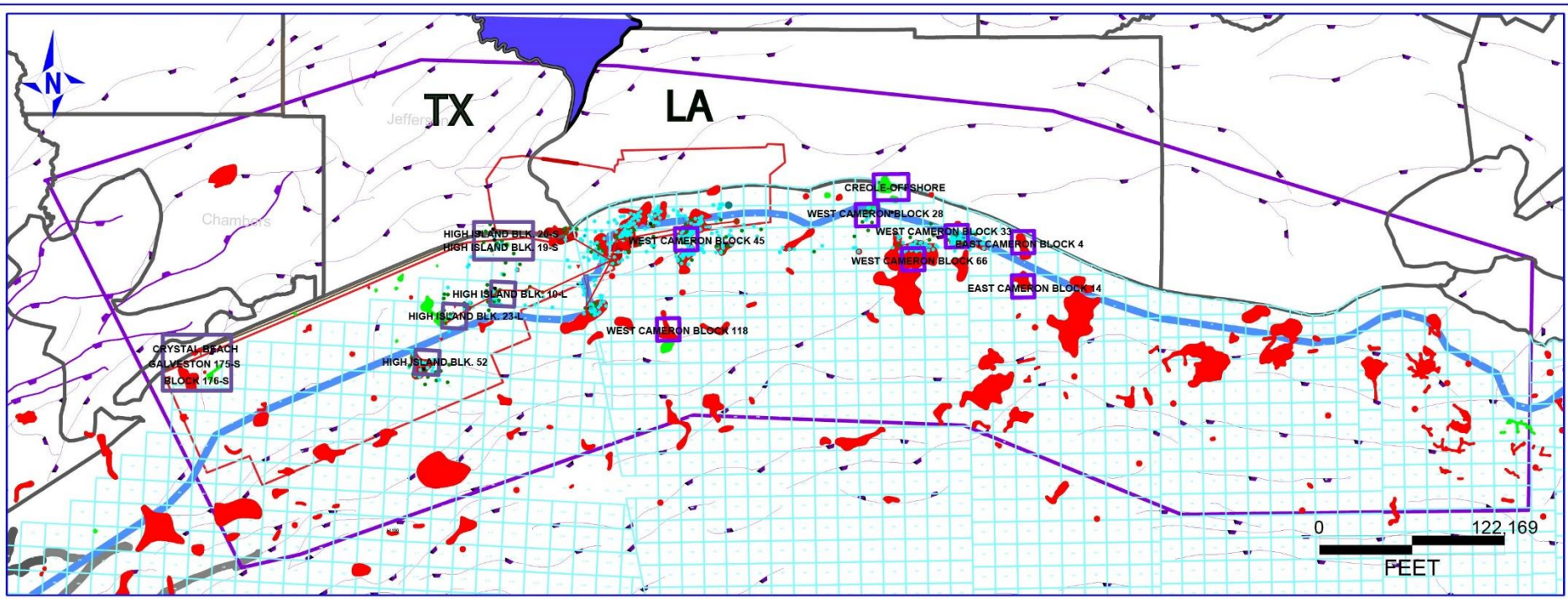
USGS Onshore Storage Capacity Assessment



EASiTool vs USGS Static Method



TX-LA offshore CO₂ storage



END