CCS

Seleção de Áreas e Estudos Associados

Milas Evangelista de Sousa
Renovar Consultoria
Set/2021

AGENDA

CCS - PANORAMA GLOBAL

SELEÇÃO DE ÁREAS E ESTUDOS ASSOCIADOS

EXEMPLO - PROJETO ADM

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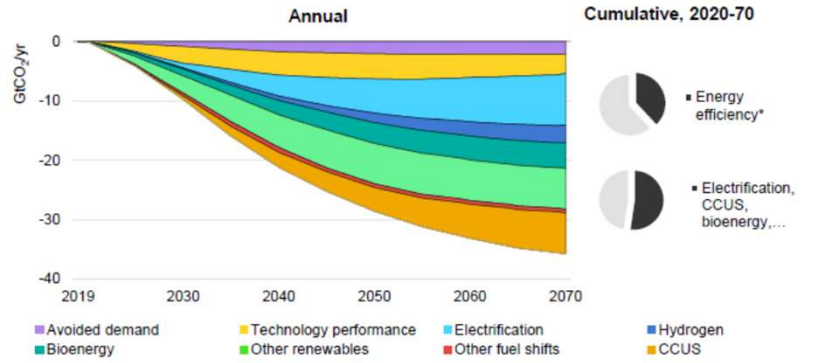
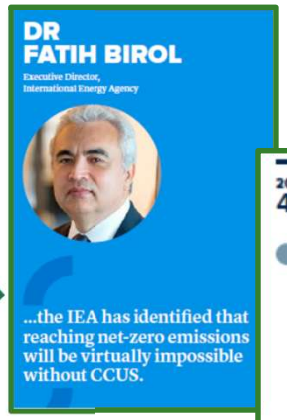
CCS – PANORAMA GLOBAL – RELEVÂNCIA PARA O "NET ZERO"

CCS É IMPRESCINDÍVEL PARA O "NET ZERO"

- Projeções do IPCC, **IEA** e IRENA mostram que para atingir **"Net Zero" emissions** até 2050 será **necessário** adotar mecanismos para **remoção de CO2 da atmosfera.**

Figure 2.1 Global energy sector CO_2 emissions reductions by measure in the Sustainable Development Scenario relative to the Stated Policies Scenario, 2019-70





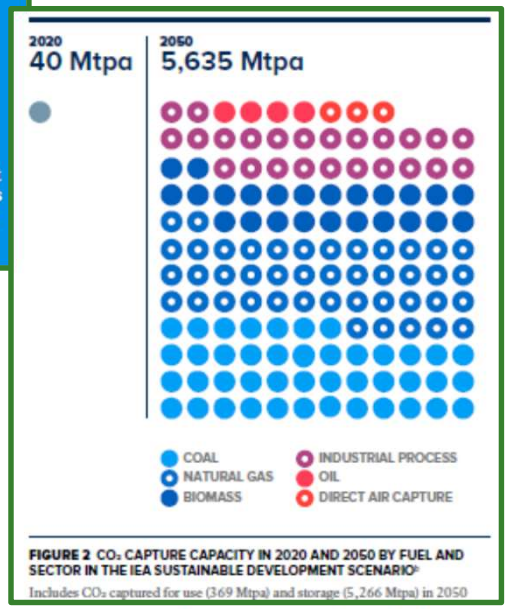
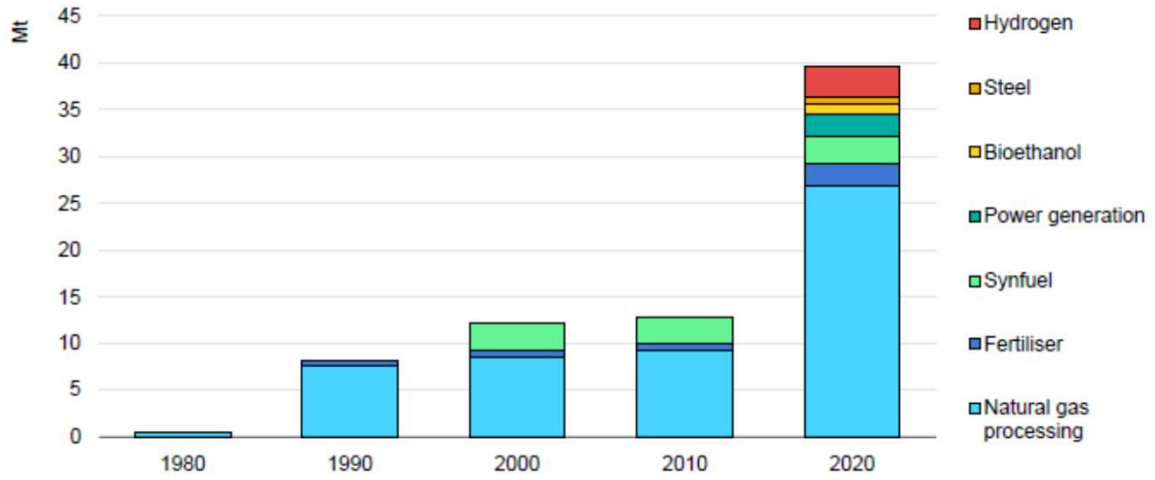


FIGURE 2 CO_2 CAPTURE CAPACITY IN 2020 AND 2050 BY FUEL AND SECTOR IN THE IEA SUSTAINABLE DEVELOPMENT SCENARIO

Includes CO_2 captured for use (369 Mtpa) and storage (5,266 Mtpa) in 2050

CCS – PANORAMA GLOBAL – CAPACIDADE ATUAL POR FONTE

Figure 1.2 Global CO_2 capture capacity at large-scale facilities by source



Source: IEA analysis based on GCCSI (2020), Facilities Database, https://co2re.co/FacilityData.

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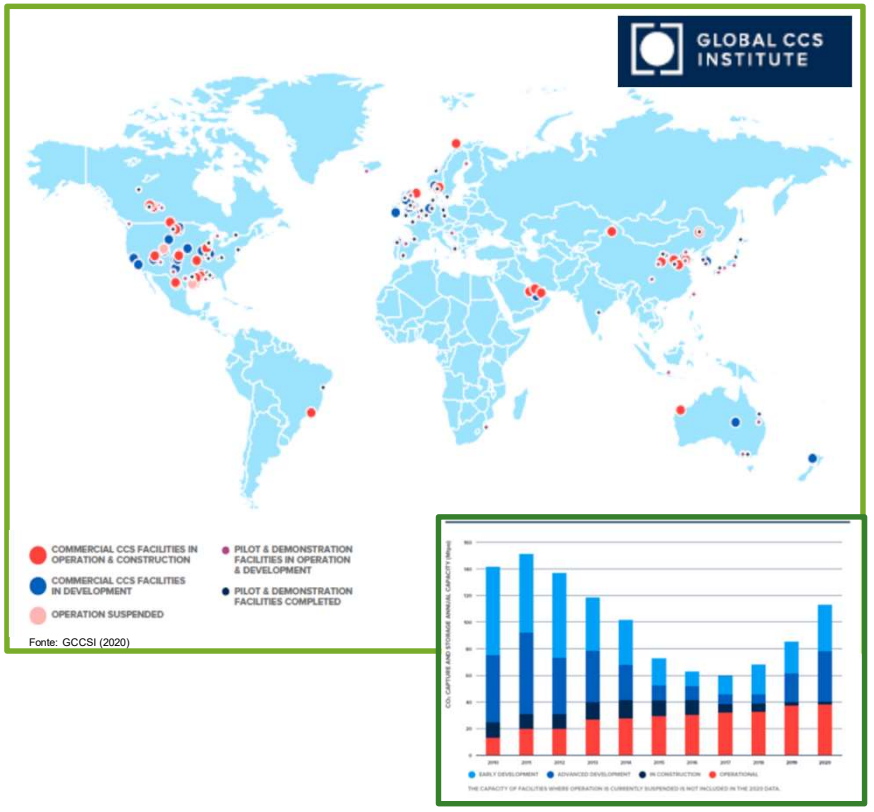
CCS – PANORAMA GLOBAL – PROJETOS CCS EM OPERAÇÃO

40 milhões de toneladas de CO2 injetadas por ano

65 PROJETOS COMERCIAS NO PLANETA (26 EM OPERAÇÃO)

- **21** projetos de **grande porte** (> 400 M tpa CO2)
- A indústria do **petróleo injeta CO2** para recuperação de petróleo e gás **há mais de 40 anos,** o maior operador é a **Occidental,** que **injeta 47 Mtpa;**
- Existem **5 projetos de BECCS** em usinas de **etanol de** milho no mundo, **4 nos EUA** e 1 no Canadá**;**



Fonte: GCCSI (2020)

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Table 1.1 Large-scale commercial CCUS projects in operation in 2020

Country	Project	Operation date	Source of CO_2	CO_2 capture capacity (Mt/year)	Primary storage type
United States (US)	Terrell natural gas plants (formerly Val Verde)	1972	Natural gas processing	0.5	EOR
US	Enid fertiliser	1982	Fertiliser production	0.7	EOR
US	Shute Creek gas processing facility	1986	Natural gas processing	7.0	EOR
Norway	Sleipner CO_2 storage project	1996	Natural gas processing	1.0	Dedicated
US/Canada	Great Plains Synfuels (Weyburn/Midale)	2000	Synthetic natural gas	3.0	EOR

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CCS – PANORAMA GLOBAL – PROJ. GRANDE ESCALA EM OPERAÇÃO

Country	Project	Operation date	Source of CO_2	CO_2 capture capacity (Mt/year)	Primary storage type
Norway	Snohvit CO_2 storage project	2008	Natural gas processing	0.7	Dedicated
US	Century plant	2010	Natural gas processing	8.4	EOR
US	Air Products steam methane reformer	2013	Hydrogen production	1.0	EOR
US	Lost Cabin Gas Plant	2013	Natural gas processing	0.9	EOR
US	Coffeyville Gasification	2013	Fertiliser production	1.0	EOR
Brazil	Petrobras Santos Basin pre-salt oilfield CCS	2013	Natural gas processing	3.0	EOR
Canada	Boundary Dam CCS	2014	Power generation (coal)	1.0	EOR
Saudi Arabia	Uthmaniyah CO_2-EOR demonstration	2015	Natural gas processing	0.8	EOR

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CCS – PANORAMA GLOBAL – PROJ. GRANDE ESCALA EM OPERAÇÃO

Country	Project	Operation date	Source of CO_2	CO_2 capture capacity (Mt/year)	Primary storage type
Canada	Quest	2015	Hydrogen production	1.0	Dedicated
United Arab Emirates	Abu Dhabi CCS	2016	Iron and steel production	0.8	EOR
US	Petra Nova	2017	Power generation (coal)	1.4	EOR
US	Illinois Industrial	2017	Ethanol production	1.0	Dedicated
China	Jilin oilfield CO_2-EOR	2018	Natural gas processing	0.6	EOR
Australia	Gorgon Carbon Dioxide Injection	2019	Natural gas processing	3.4-4.0	Dedicated
Canada	Alberta Carbon Trunk Line (ACTL) with Agrium CO_2 stream	2020	Fertiliser production	0.3-0.6	EOR
Canada	ACTL with North West Sturgeon Refinery CO_2 stream	2020	Hydrogen production	1.2-1.4	EOR

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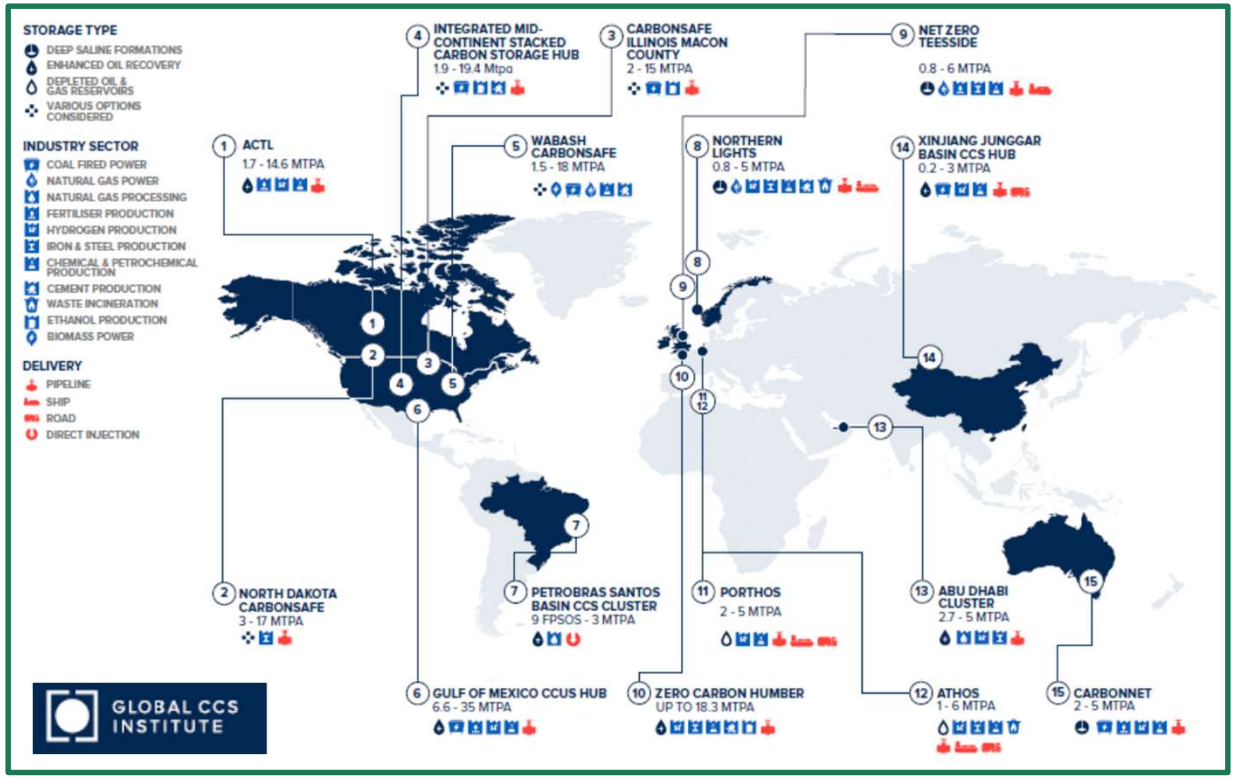
CCS – PANORAMA GLOBAL – HUBS SÃO UMA TENDÊNCIA

Hubs ou clusters em operação e desenvolvimento



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SELEÇÃO DE ÁREAS E ESTUDOS ASSOCIADOS

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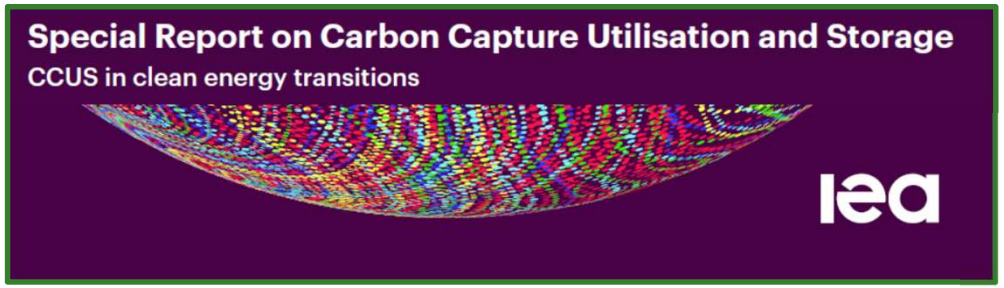
SELEÇÃO DE ÁREAS E ESTUDOS – REFERÊNCIAS ÚTEIS

carbon sequestration leadership forum

2021 Carbon Sequestration TECHNOLOGY ROADMAP

SPE International

CO_2 Storage Resources Management System



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SELEÇÃO DE ÁREAS E ESTUDOS – COMPORTAMENTO DO CO2

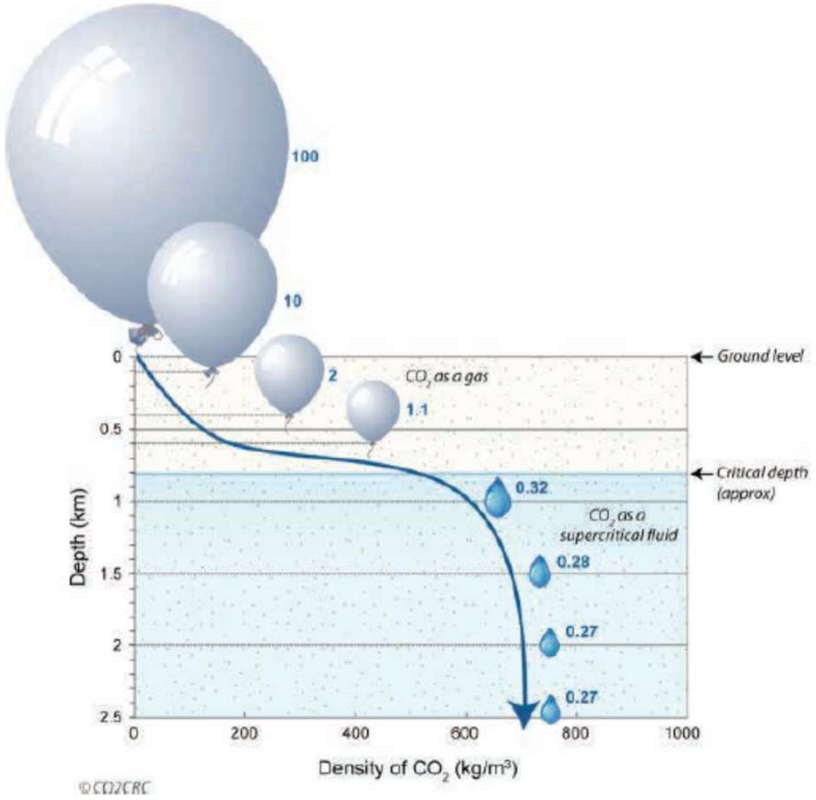

Figure 12: CO_2 density and state changes with depth.
Source: CO2CRC.

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SELEÇÃO DE ÁREAS E ESTUDOS – TIPOS DE INJEÇÃO DE CO2

Campos de petróleo/gás depletados
EOR
Aquíferos salinos

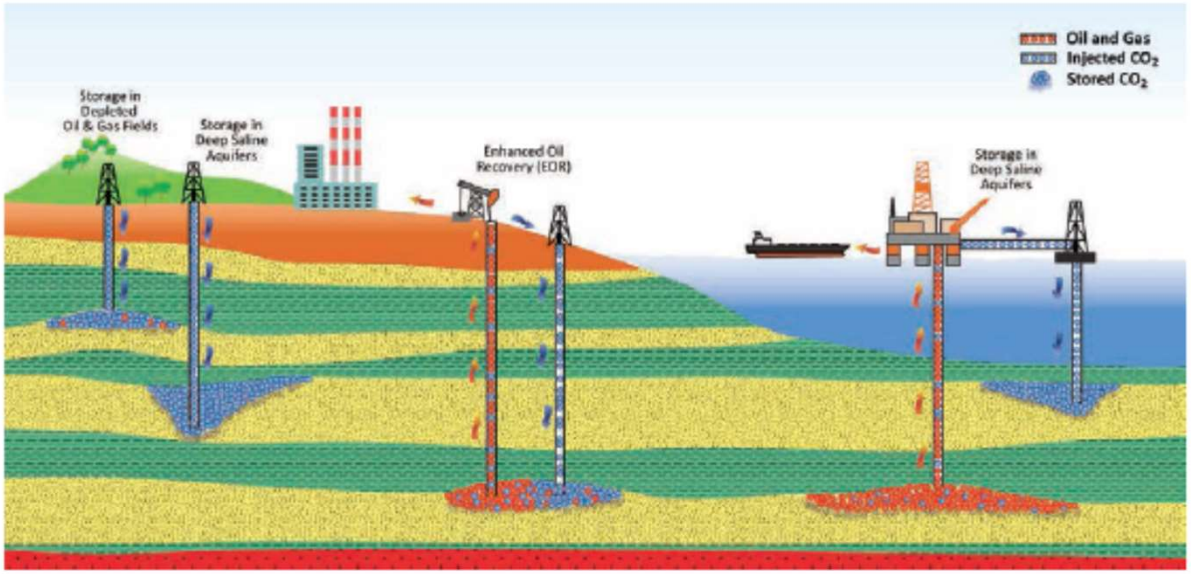

Figure 11: CO_2 geological storage options.
Source: CEPAC.

Como funciona o CCS?

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SELEÇÃO DE ÁREAS E ESTUDOS – QUAIS ÁREAS SÃO FAVORÁVEIS?

Bacias sedimentares do Brasil

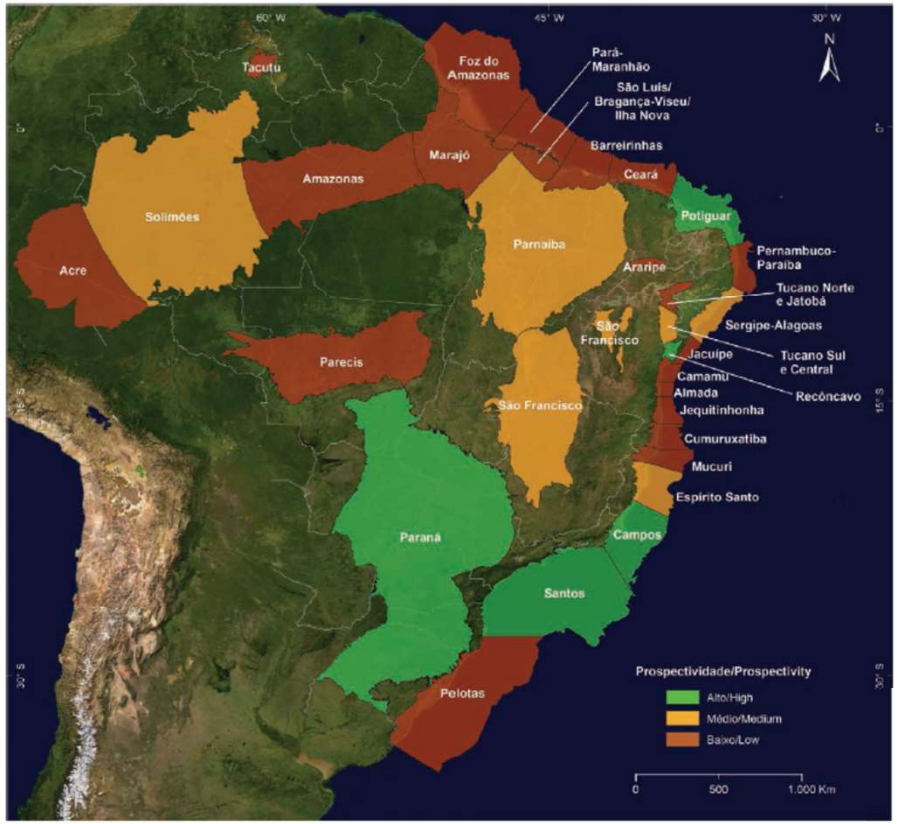

Figure 56: Prospectivity mapping for CCS

Ketzer et al (2014)

SELEÇÃO DE ÁREAS E ESTUDOS – PRÉ-REQUISITOS

Pré-requisitos para desenvolvimento de um Projeto CCS

- ✓ Identificação de áreas favoráveis e validação da capacidade de estocagem
- ✓ Caracterização da área escolhida para injeção
- ✓ Plano de Gestão da Estocagem
  - ➢ Integridade dos poços
  - ➢ Pressão do reservatório
  - ➢ Integridade do rocha selante
  - ➢ Plano de monitoramento
  - ➢ Plano de mitigação

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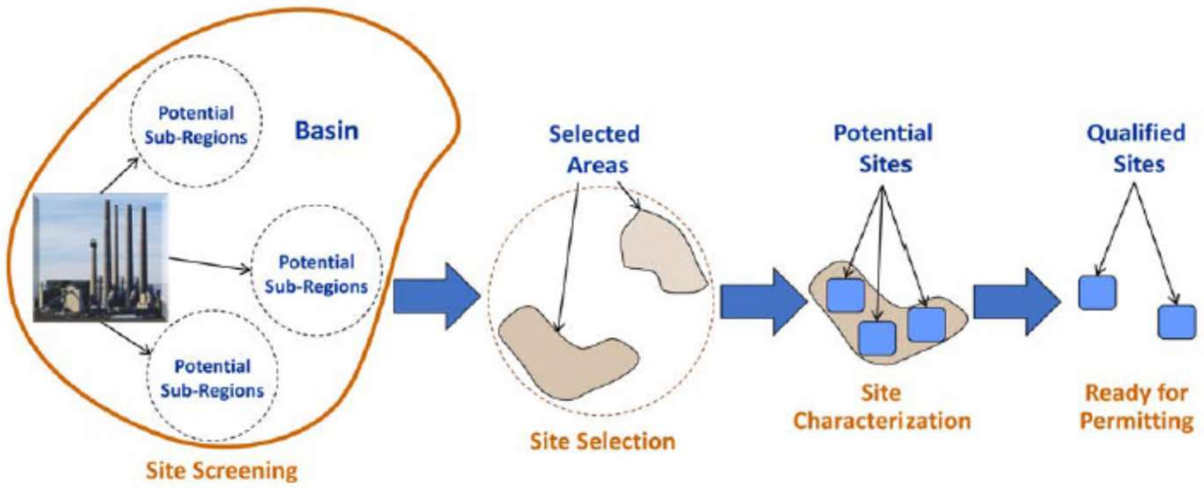
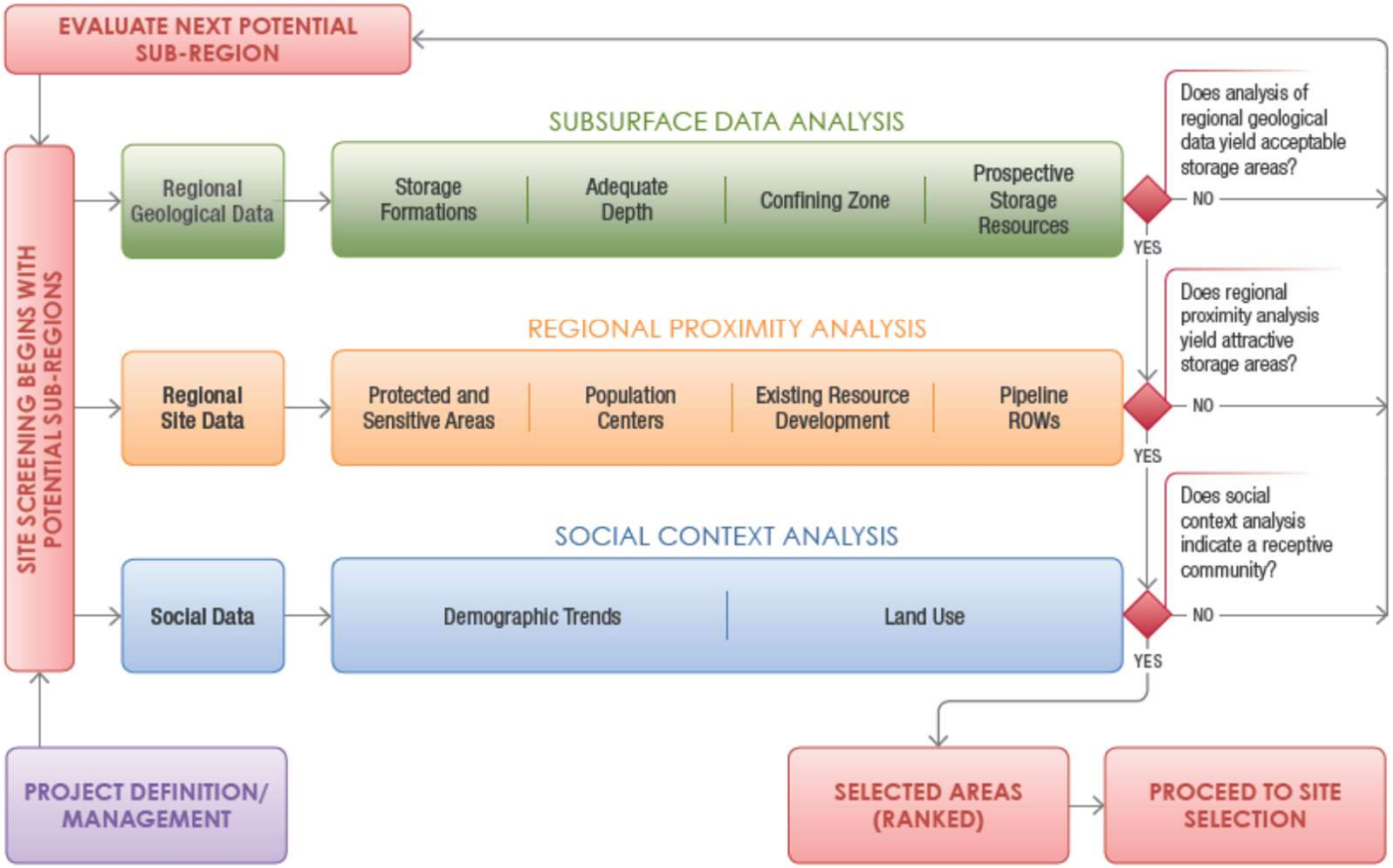
SELEÇÃO DE ÁREAS E ESTUDOS – FLUXO DE ATIVIDADES



NETL (2017)

SELEÇÃO DE ÁREAS E ESTUDOS – SELEÇÃO DE ÁREAS



NETL (2017)

SELEÇÃO DE ÁREAS E ESTUDOS – CRITÉRIOS RELEVANTES

REGIONAL GEOLOGICAL DATA	Subsurface Data Analysis	Storage Formations	Identify potential storage formations using sub-regional or basin-scale geological and geophysical data. Candidate formations should have geologic characteristics—including porosity, permeability, thickness, salinity, and pore pressure—that make them suitable for storage.
		Adequate Depth	For Potential Sub-Regions, assess minimum depth of injection for achieving adequate protection of USDWs, and evaluate depths at which injected CO_2 will be in a supercritical state for improved storage efficiency.
		Confining Zone	Identify confining zones in Potential Sub-Regions that will be effective for limiting vertical flow of injected CO_2 out of the storage formation.
		Prospective Storage Resources	Candidate storage formations should contain sufficient Prospective Storage Resources beneath a robust confining zone. Prospective Storage Resources for Potential Sub-Regions should be estimated utilizing existing data, including NATCARB and state geological survey data.

NETL (2017)

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SELEÇÃO DE ÁREAS E ESTUDOS – DADOS PRÉ-EXISTENTES

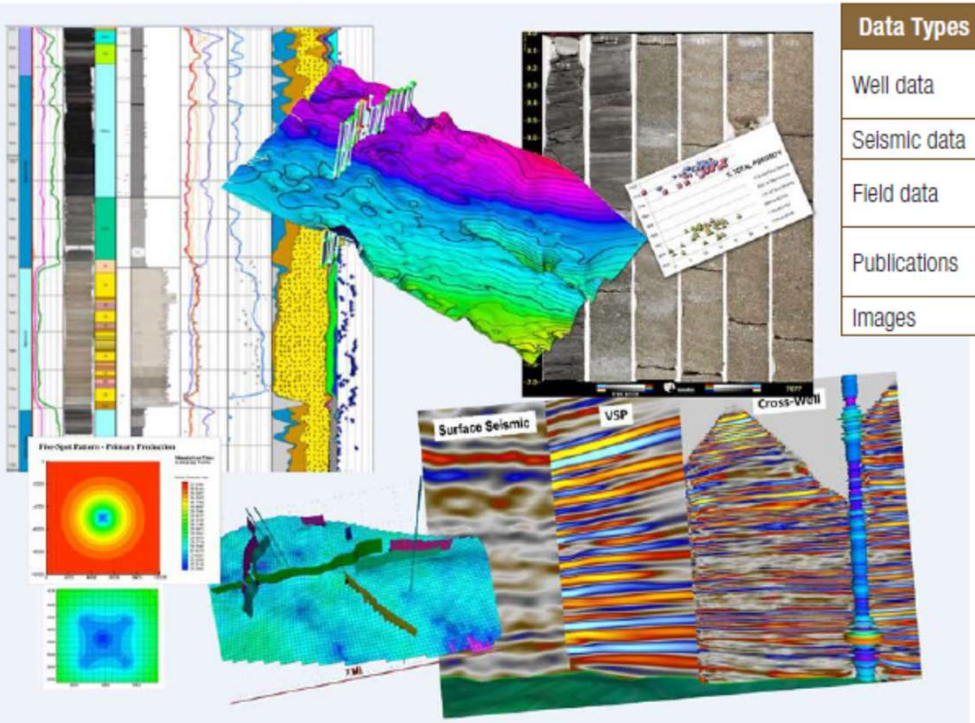

Figure A: Physical core, core analysis data, log data, 2D and 3D seismic data, VSP data, and reservoir simulations are just some examples of the data that must be both archived and made accessible to project partners.

Data Collected for Characterization

Data Types	Kinds of Information
Well data	Logs, core images, test data, sample data, physical samples
Seismic data	3-D, VSP, Crosswell,
Field data	Geocellular models, simulations, sample data, GIS data
Publications	Abstracts, presentations, publications, technical papers
Images	Photos and illustrations

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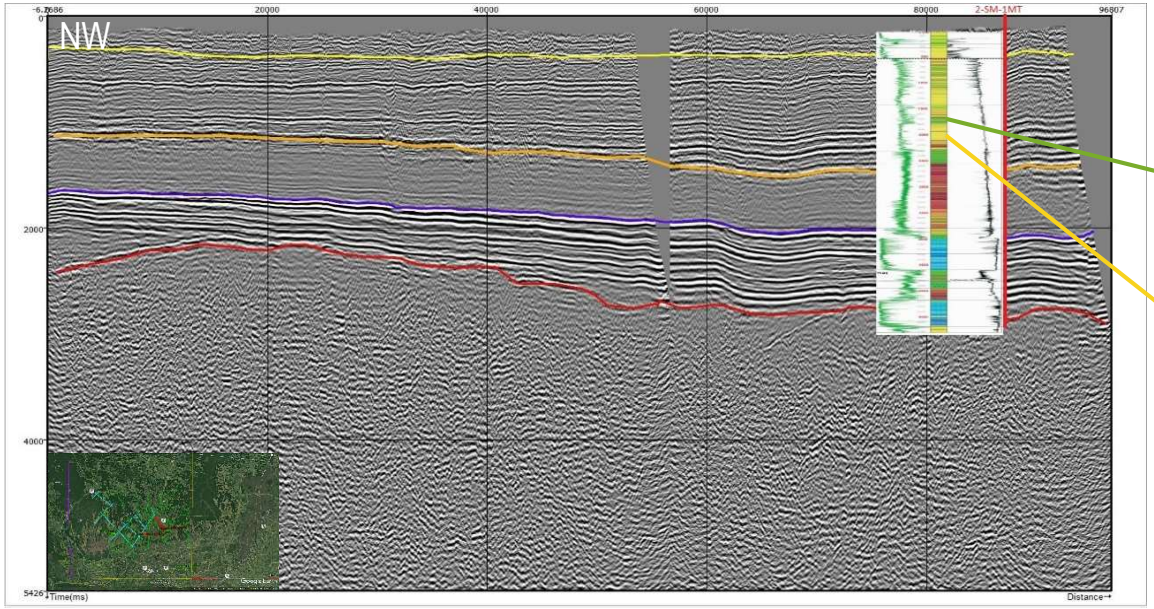
SELEÇÃO DE ÁREAS E ESTUDOS – DADOS PRÉ-EXISTENTES



Camada de rocha selante em verde

Camada de rocha reservatório em amarelo

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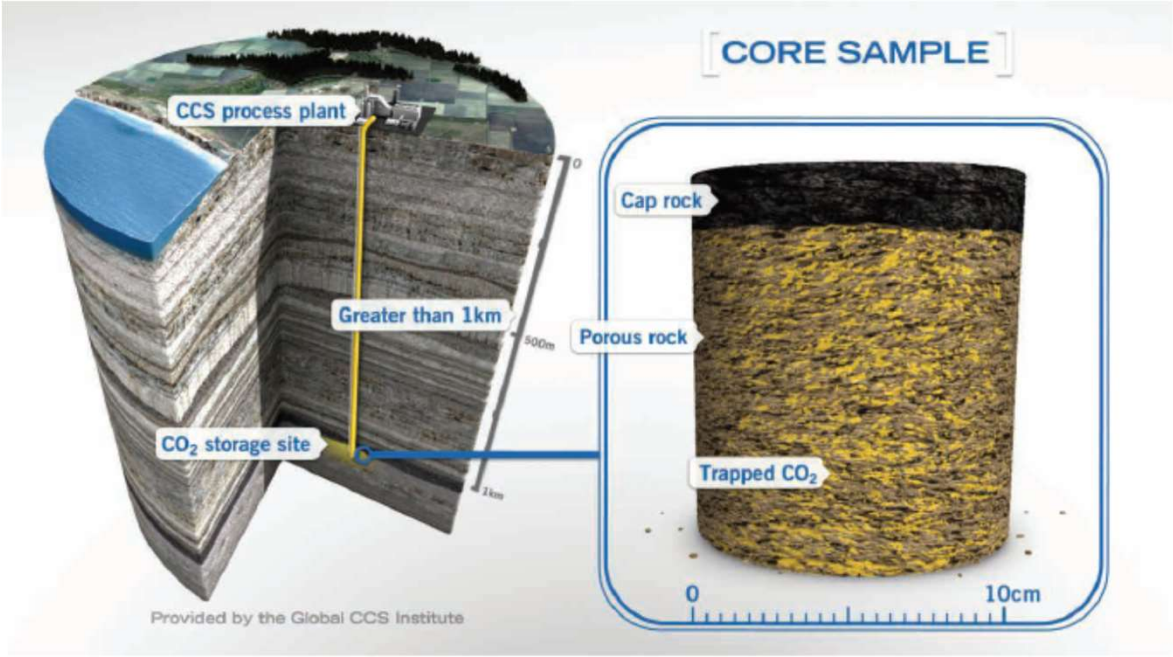
SELEÇÃO DE ÁREAS E ESTUDOS – DADOS PRÉ-EXISTENTES



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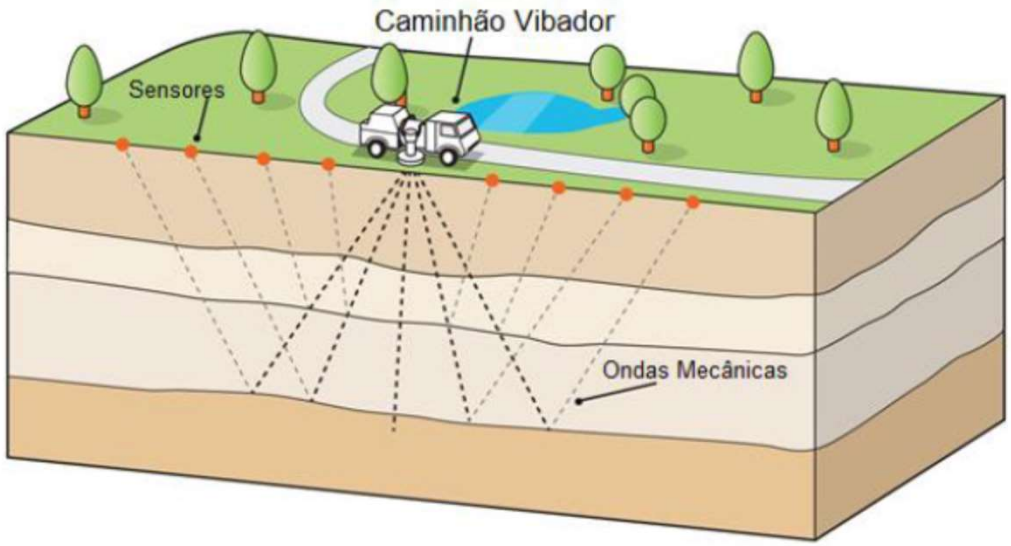
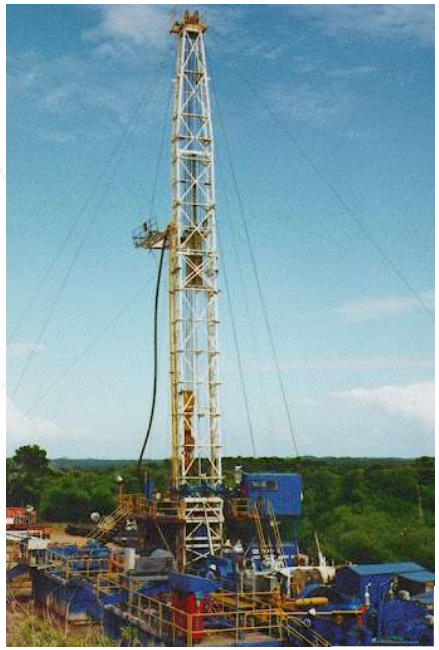
SELEÇÃO DE ÁREAS E ESTUDOS – AQUISIÇÃO DE NOVOS DADOS

Sísmica



Poço



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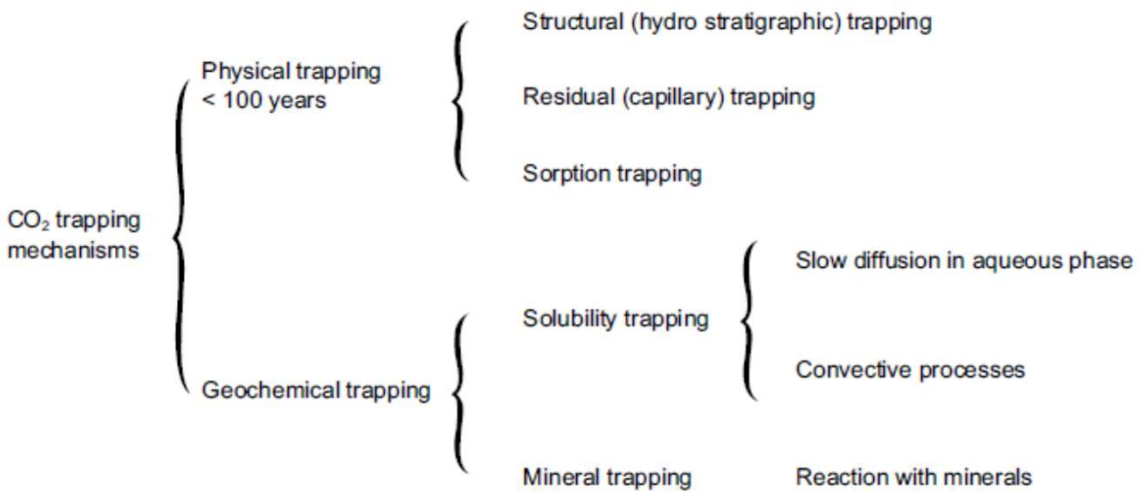
SELEÇÃO DE ÁREAS E ESTUDOS – MECANISMOS DE TRAPEAMENTO



Fonte: Ajayi et all (2019)

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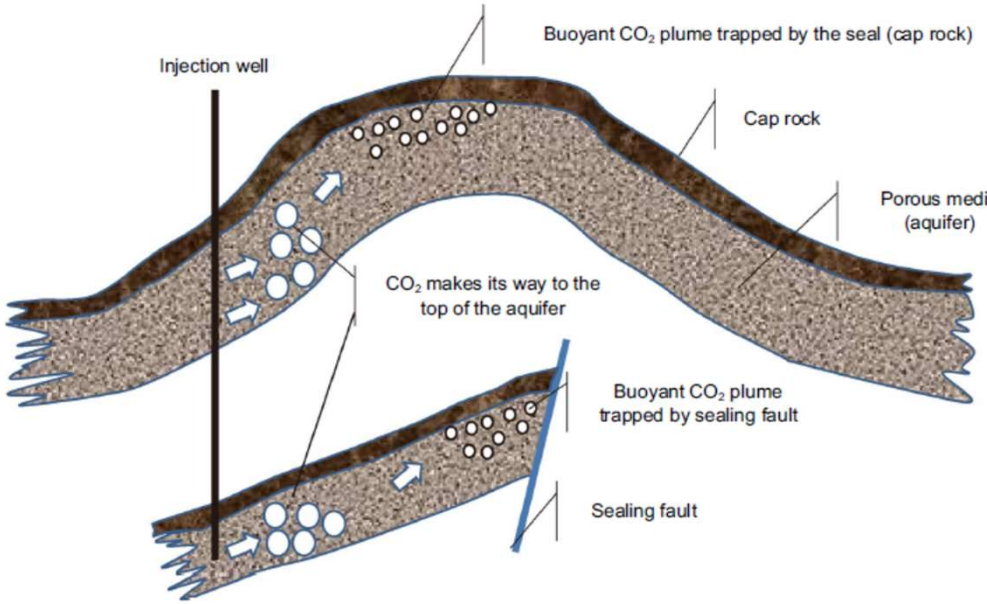
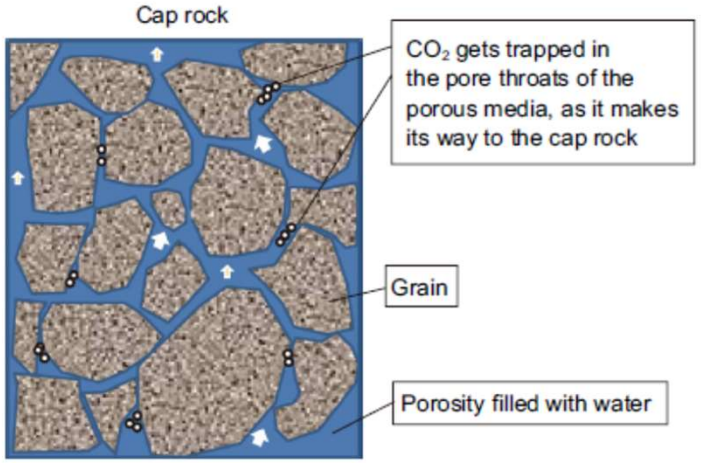
SELEÇÃO DE ÁREAS E ESTUDOS – MECANISMOS DE TRAPEAMENTO

Trapa física estrutural



Trapa física residual



Fonte: Ajayi et all (2019)

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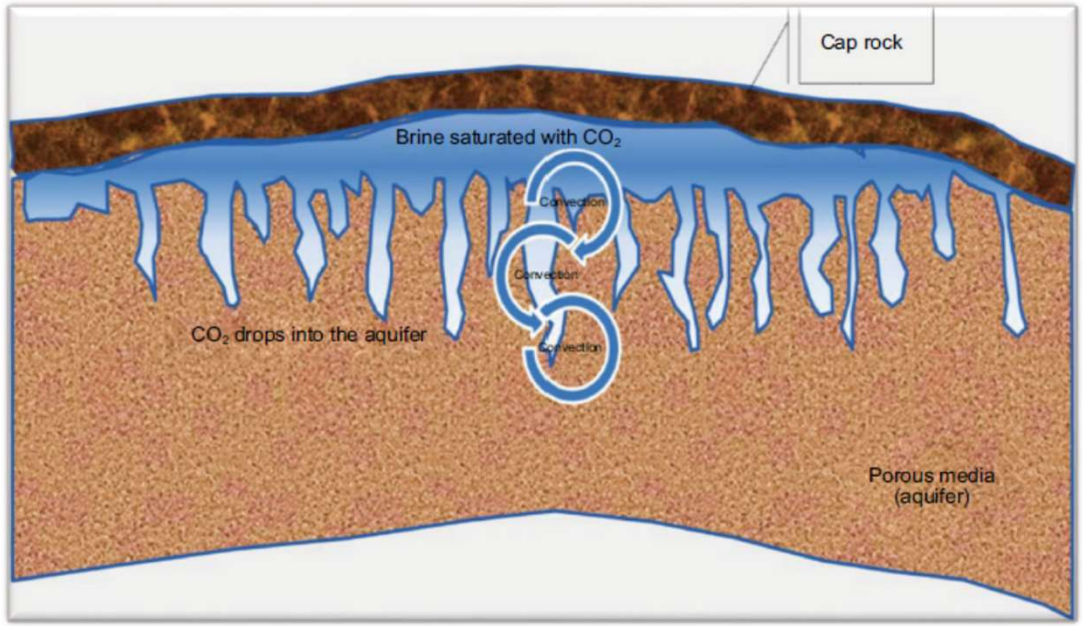
SELEÇÃO DE ÁREAS E ESTUDOS – MECANISMOS DE TRAPEAMENTO

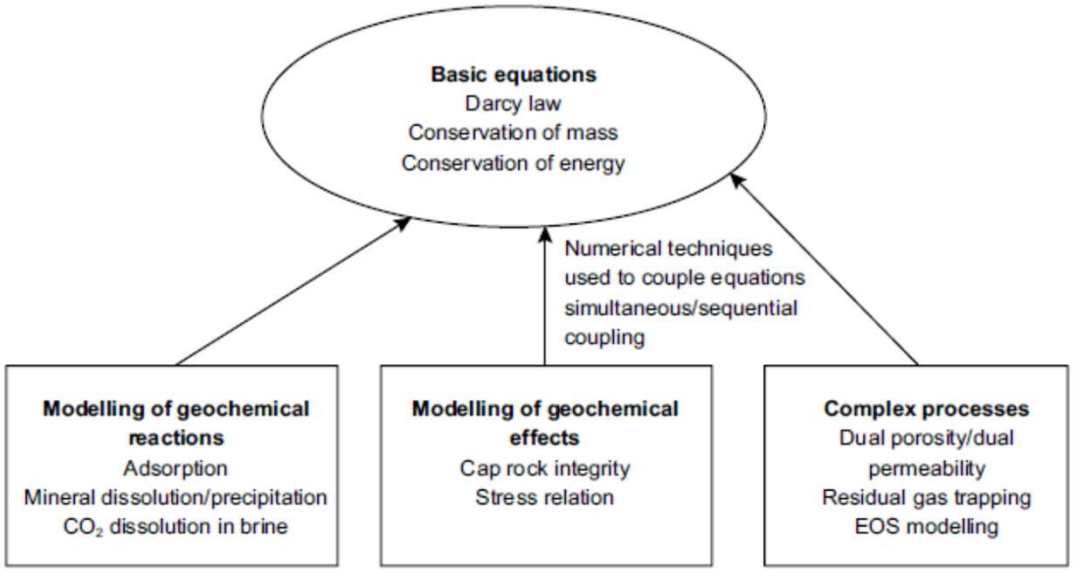
Trapa geoquímica



Fonte: Ajayi et all (2019)

SELEÇÃO DE ÁREAS E ESTUDOS – MODELAGEM DOS RESERVATÓRIOS

Modelagem dos reservatórios



Fonte: Ajayi et all (2019)

SELEÇÃO DE ÁREAS E ESTUDOS – CLASSIFICAÇÃO DOS RECURSOS

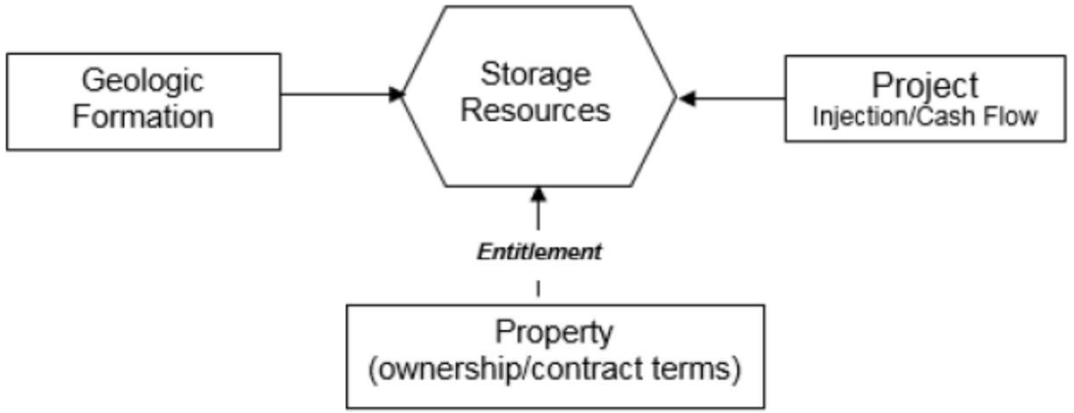


Fig. 1.2 – Resources Evaluation Data Sources

Fonte: SPE(2017)

SELEÇÃO DE ÁREAS E ESTUDOS – CLASSIFICAÇÃO DOS RECURSOS

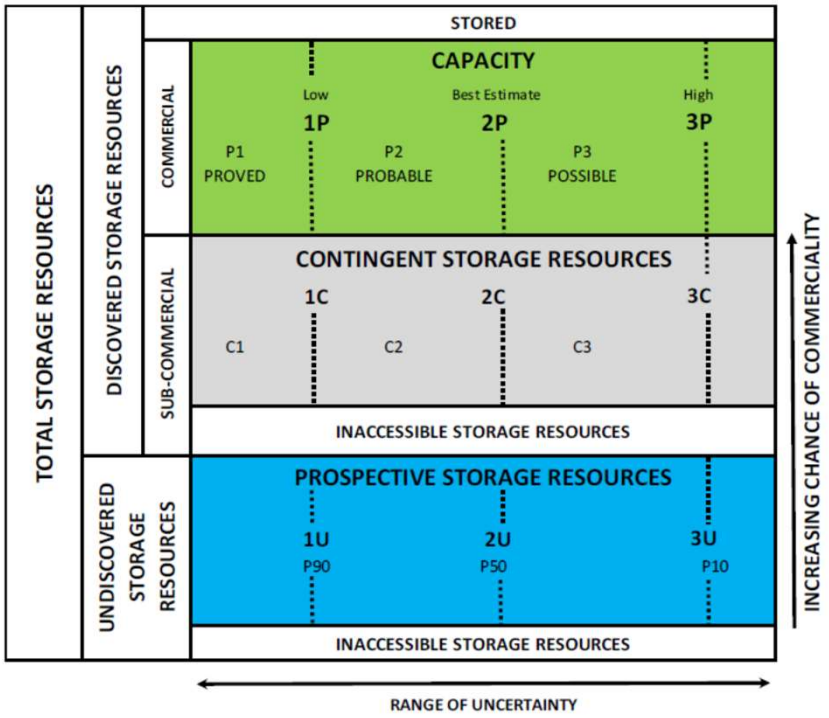


Fig. 1.1 – Resources Classification Framework

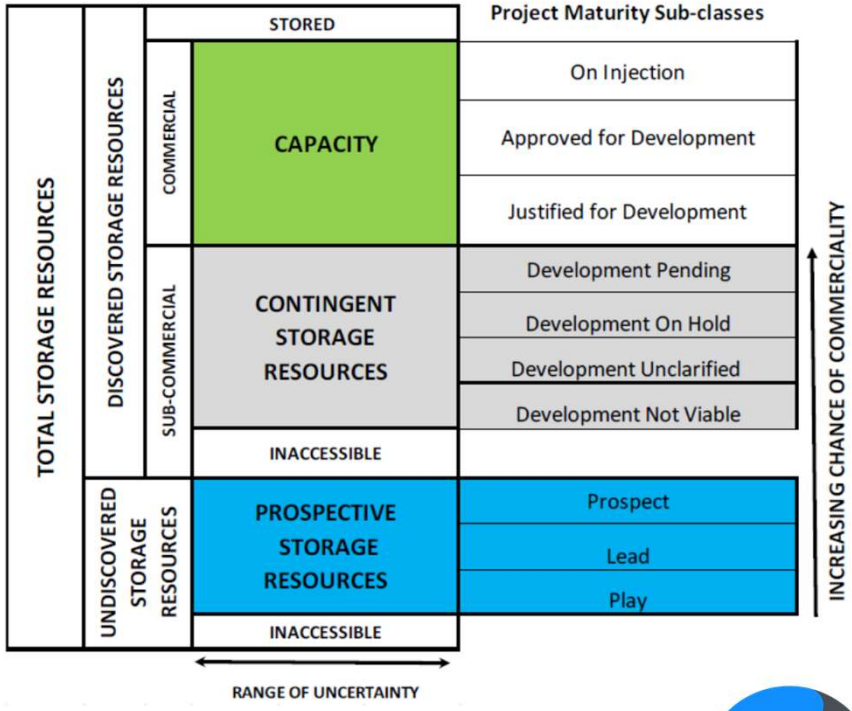


Fig. 2.1 – Subclasses based on Project Maturity

Fonte: SPE(2017)

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SELEÇÃO DE ÁREAS E ESTUDOS – CLASSIFICAÇÃO DOS RECURSOS

Petroleum Industry	CO_2 Geological Storage
Reserves	**Storage Capacity**
On Production	Active Injection
Approved for Development	Approved for Development
Justified for Development	Justified for Development
Contingent Resources	**Contingent Storage Resources**
Development Pending	Development Pending
Development Unclarified or On Hold	Development Unclarified or On Hold
Development Not Viable	Development Not Viable
Prospective Resources	**Prospective Storage Resources**
Prospect	Qualified Site(s)
Lead	Selected Areas
Play	Potential Sub-Regions

Prospective Storage Resources	
Project Sub-Class	**Evaluation Process**
Qualified Site(s)	Site Characterization
Selected Areas	Site Selection
Potential Sub-Regions	Site Screening

NETL (2017)

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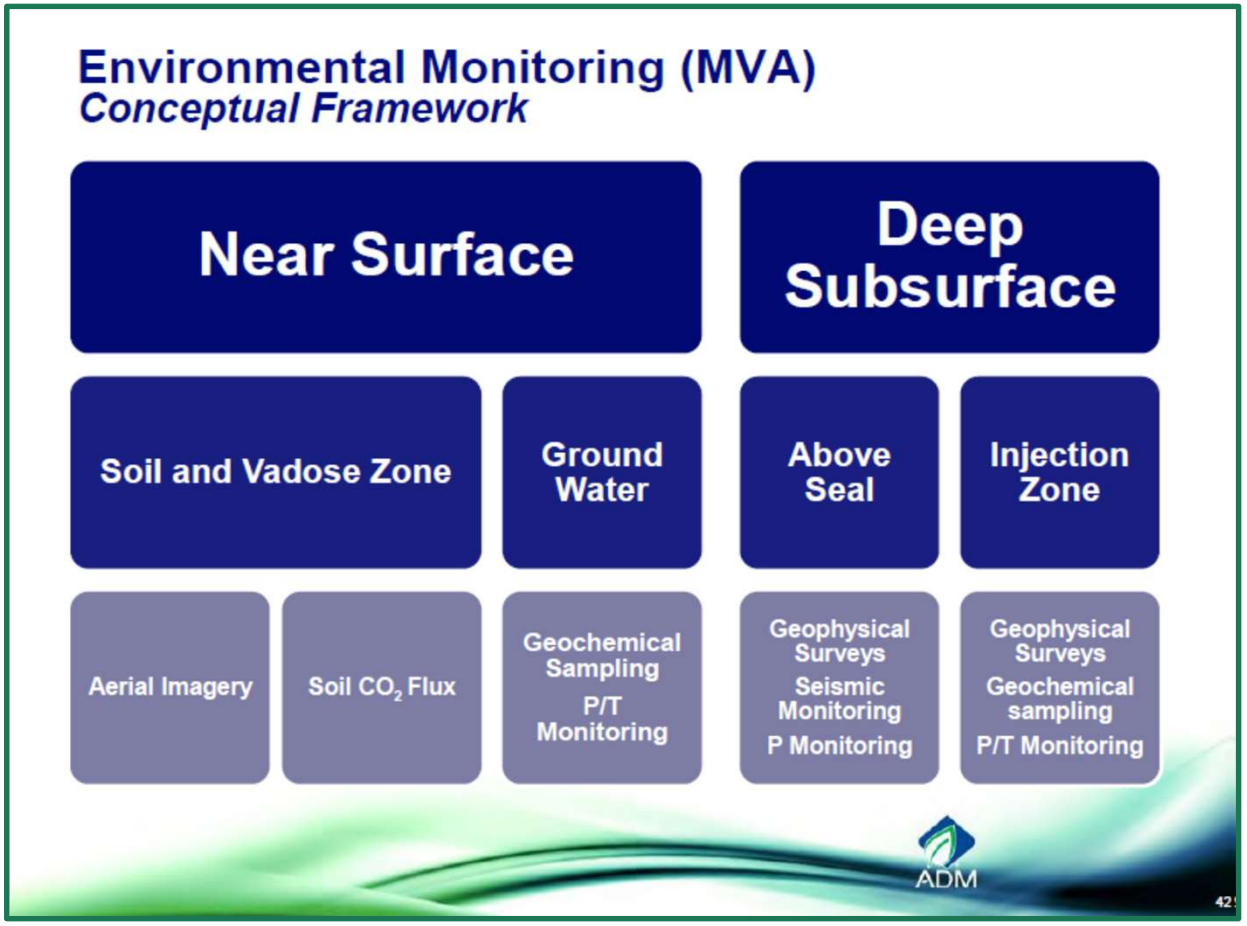
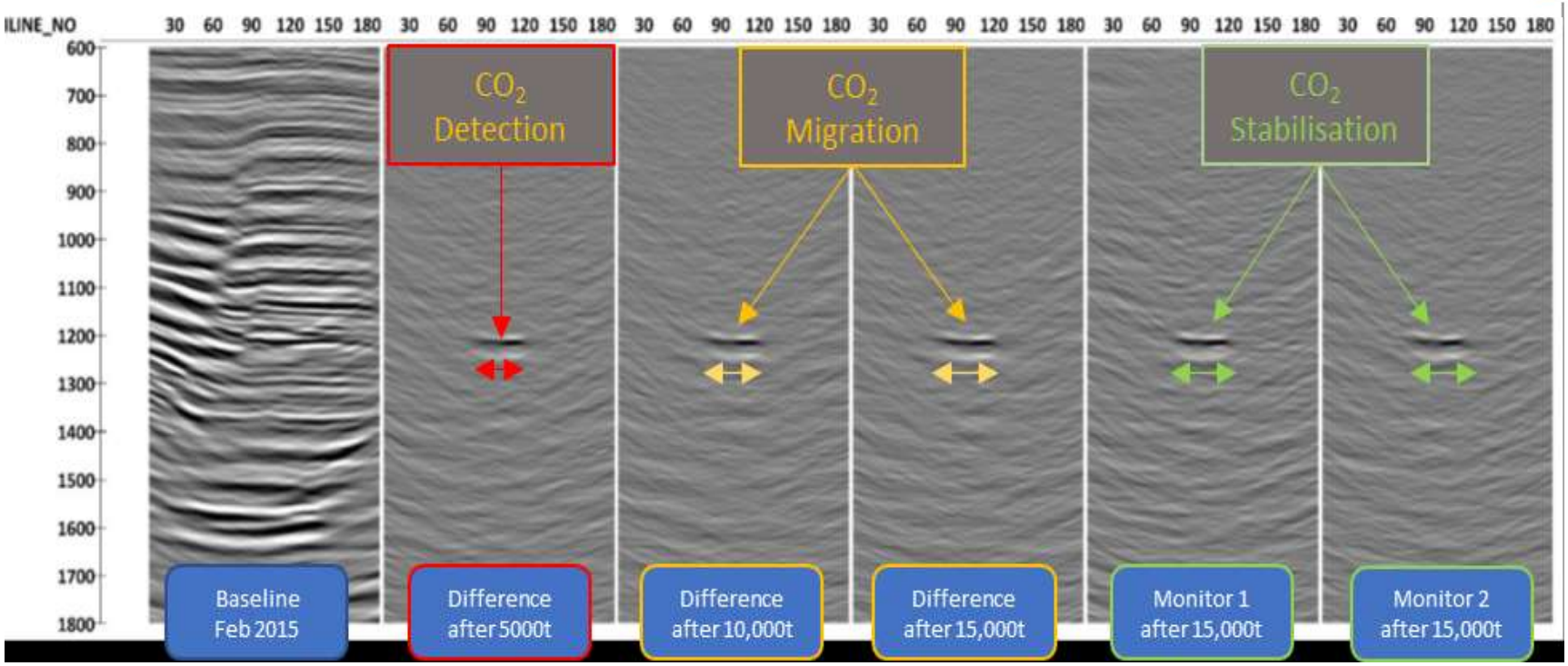
SELEÇÃO DE ÁREAS E ESTUDOS – MONITORAMENTO



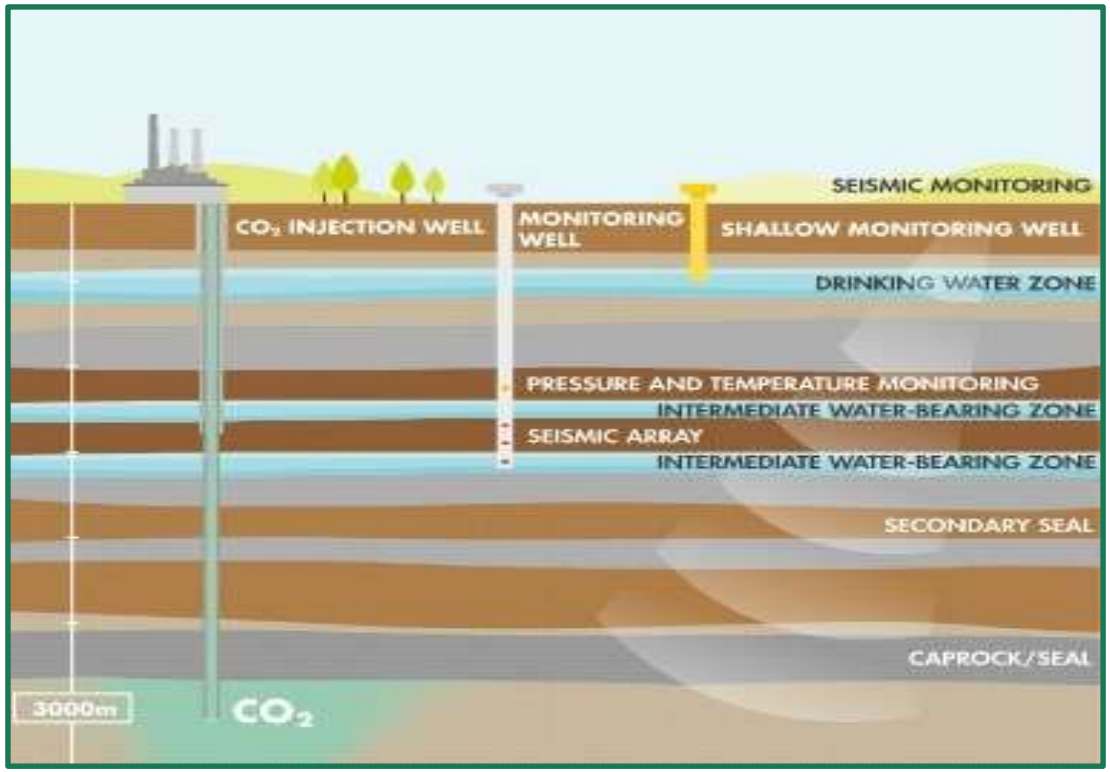
SELEÇÃO DE ÁREAS E ESTUDOS – MONITORAMENTO



Fonte:https://co2crc.com.au/

SELEÇÃO DE ÁREAS E ESTUDOS – MONITORAMENTO

Exemplo esquemático do Projeto de Estocagem



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SELEÇÃO DE ÁREAS E ESTUDOS ASSOCIADOS

EXEMPLO - PROJETO ADM

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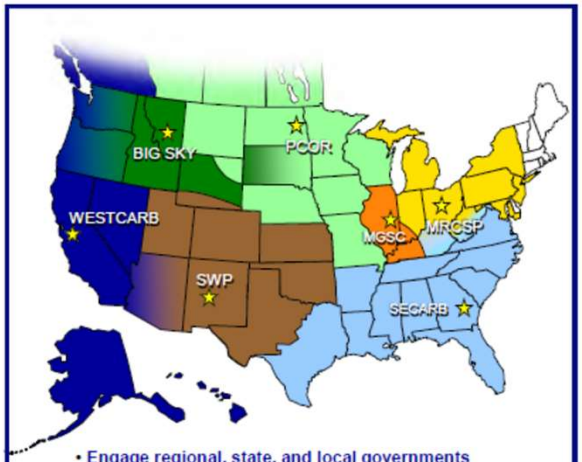
EXEMPLO – PROJETO ADM – DECATUR (ILLINOIS – EUA)

Site Selection
Regional Carbon Sequestration Partnerships

ICCS project site selection benefitted from the information developed through the Regional Carbon Sequestration Partnership Program.



- Engage regional, state, and local governments
- Determine regional sequestration benefits
- Baseline region for sources and sinks
- Establish monitoring and verification protocols
- Address regulatory, environmental, and outreach issues
- Validate sequestration technology and infrastructure

Characterization Phase (2003-2005)

Search of potential storage locations and CO_2 sources	Found potential for 100's of years of storage

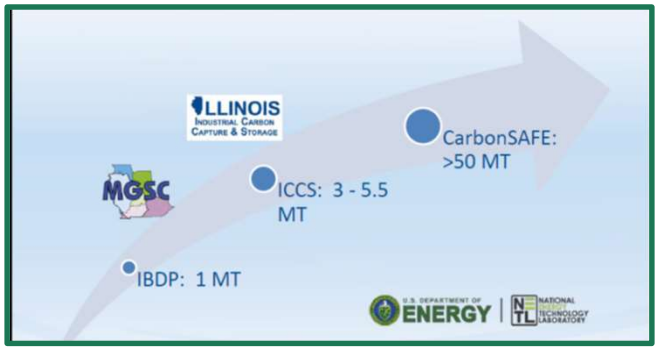
Validation Phase (2005-2010)

20 injection tests in saline formations, depleted oil, unmineable coal seams, and basalt

Development Phase (2008-2017+)

9 large scale injections (over 1 million tons each)	Commercial scale understanding	Regulatory, liability, ownership issues

ADM



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EXEMPLO – PROJETO ADM – DECATUR (ILLINOIS – EUA)

Illinois Basin Decatur Project (IBDP)
Project Overview

DOE - Regional Carbon Storage Partnerships (Phase 3)

Program Objective

Large scale geologic test to inject 1.0 million tons of CO_2 over a three year period (1,000 MT/day).

Project Team Members

ADM | Schlumberger Carbon Services | NETL

Schedule of Activities

- Engineering Q1 2008 – Q1 2012
- Permitting Q1 2008 – Q1 2013
- Construction Q2 2009 – Q3 2011
- Operation Q4 2011 – Q4 2014
- Monitoring Q1 2015 – Q4 2016

Knowledge Base

- Site Geological Characterization
- Risk Assessment & Reservoir Modeling
- Engineering Design & MVA

Breaking ground for anthropogenic CO_2 storage in a saline reservoir using cutting-edge sequestration technology

ADM

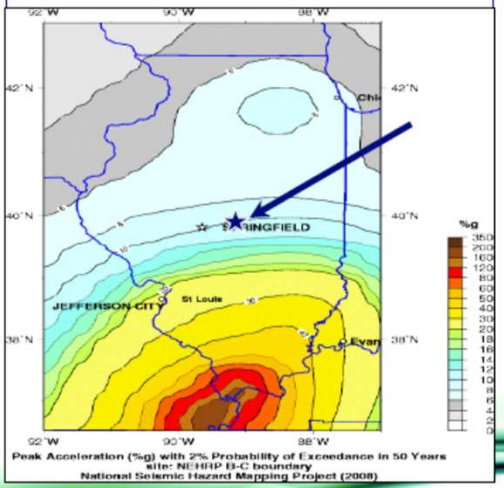
RENOVAR Consultoria

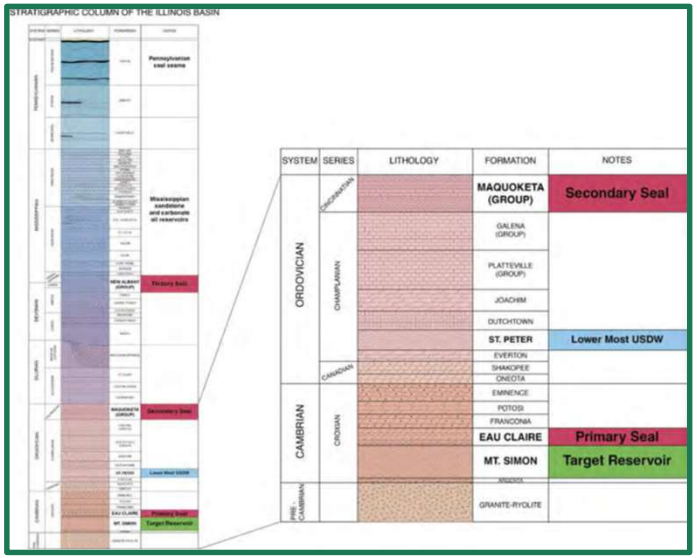
EXEMPLO – PROJETO ADM – DECATUR (ILLINOIS – EUA)

Site Selection
Regional Geologic Characterization

- Cratonic basin
- 60,000 square mile area
- Structurally complex to the south with faulting and seismicity

- ADM Decatur facility is located near the center of this geologic formation
- Estimated CO_2 storage capacity between 27 to 109 billion metric tons





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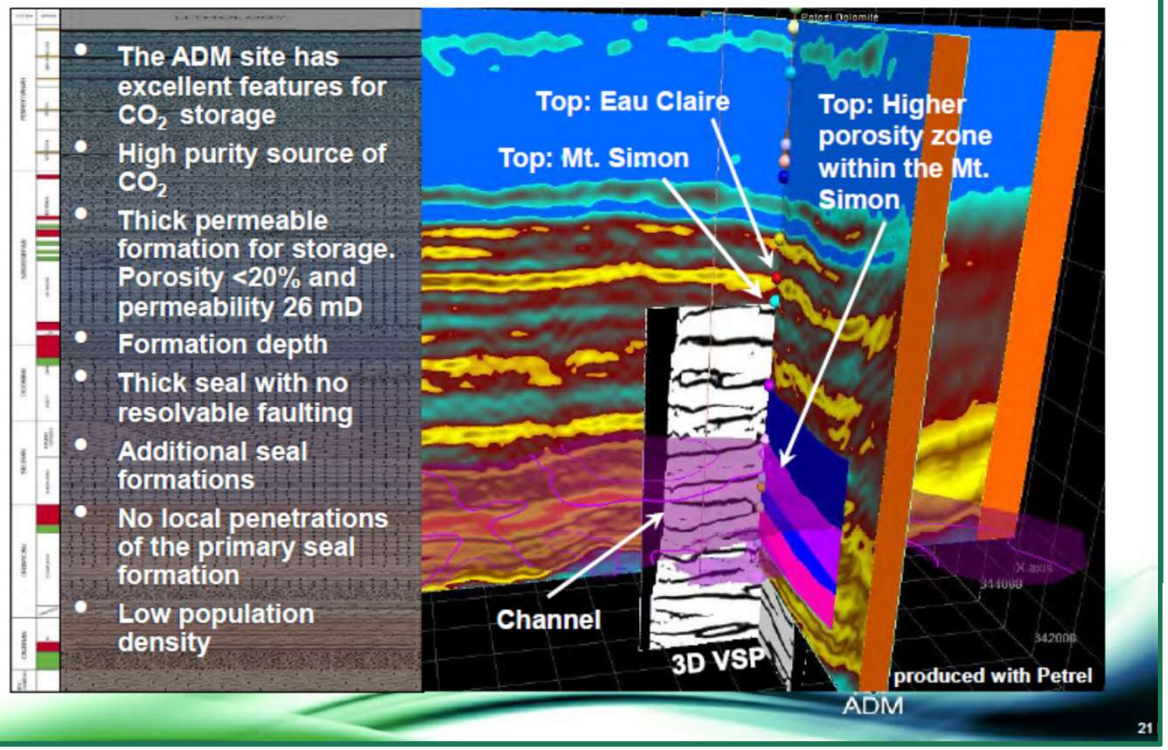
EXEMPLO – PROJETO ADM – DECATUR (ILLINOIS – EUA)

Site Characterization
Evaluation of the Decatur Site



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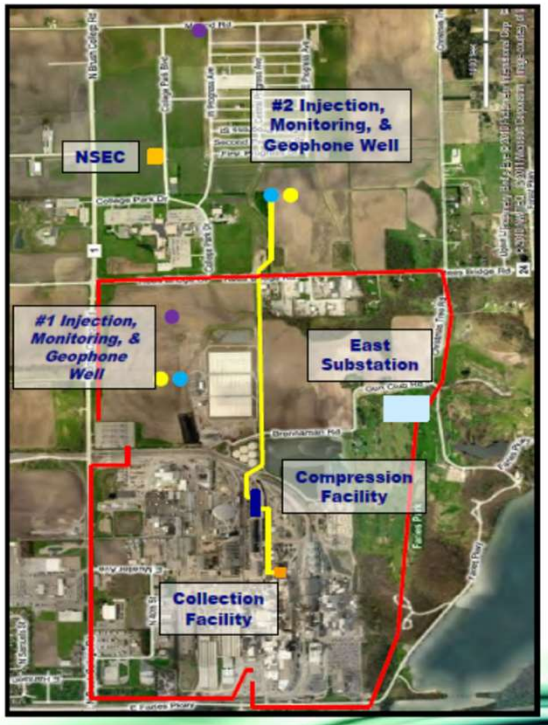
Engineering Design & Construction
Major Capital Elements



- Collection, Compression, and Dehydration Facility
- CO_2 Transmission System
- 100 MW Electrical Substation
- Electrical Distribution System
- Sequestration Site and Monitoring Facility
- National Sequestration Education Center (NSEC)

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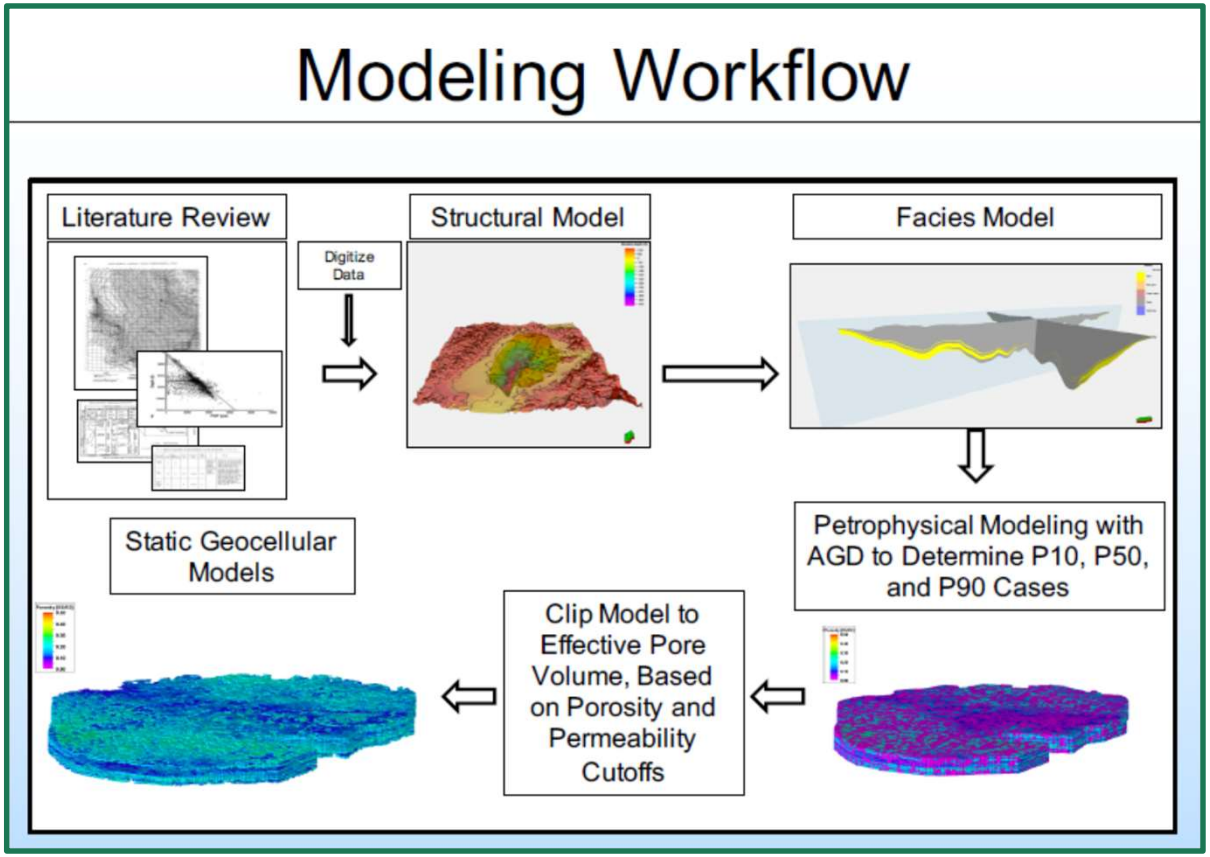

Source: US DoE (2015)

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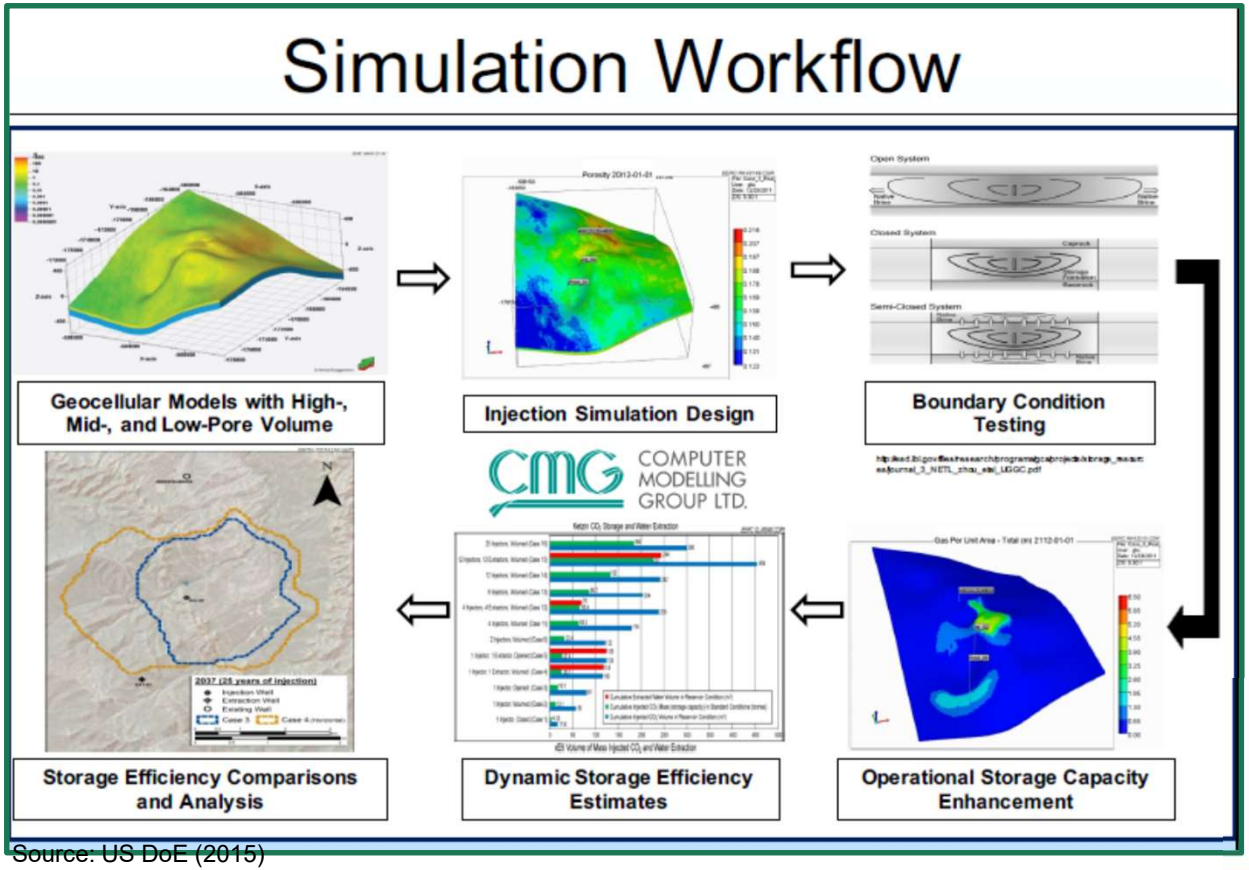

Source: US DoE (2015)

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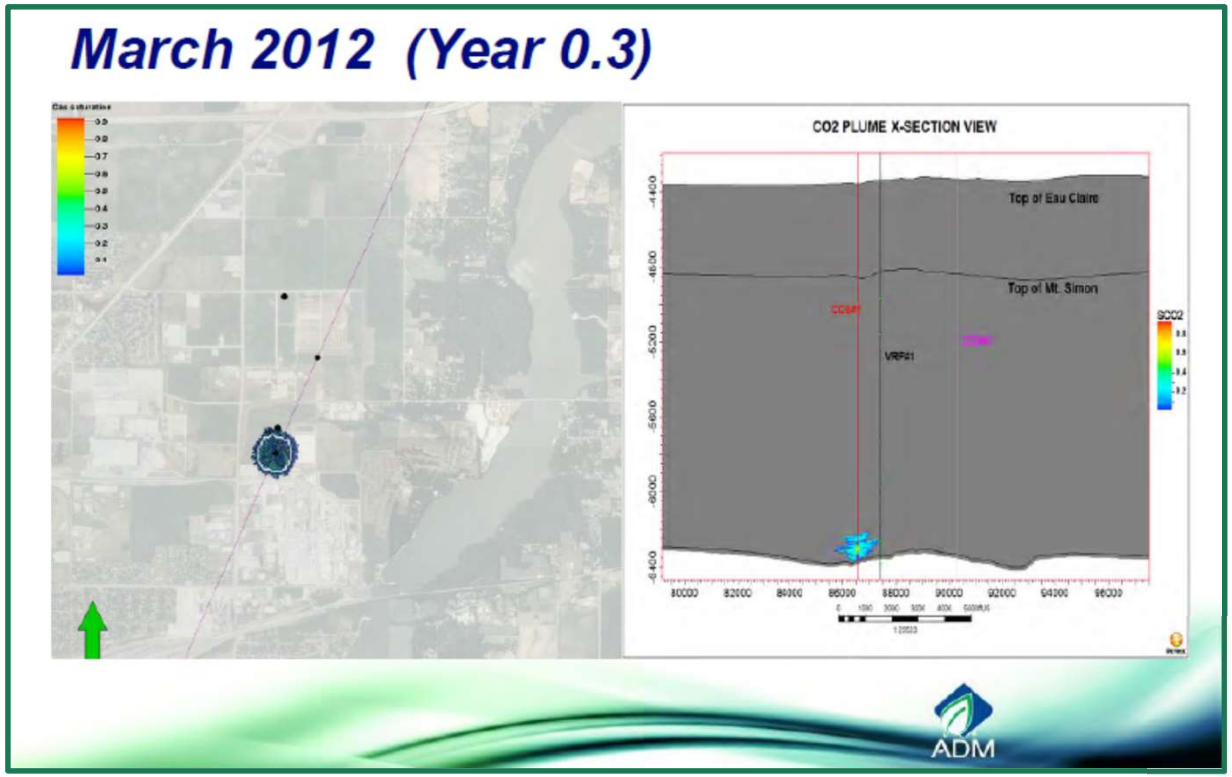
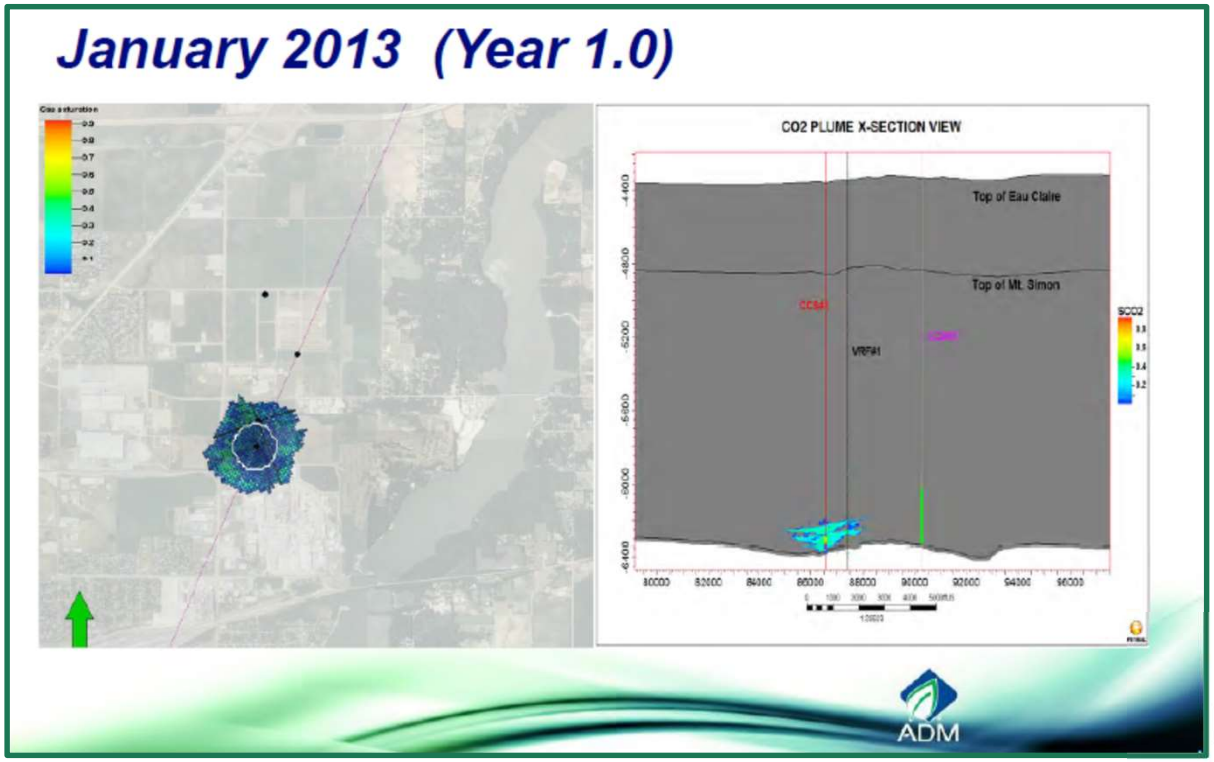


Source: ADM (2012)

EXEMPLO – PROJETO ADM – DECATUR (ILLINOIS – EUA)



Source: ADM (2012)

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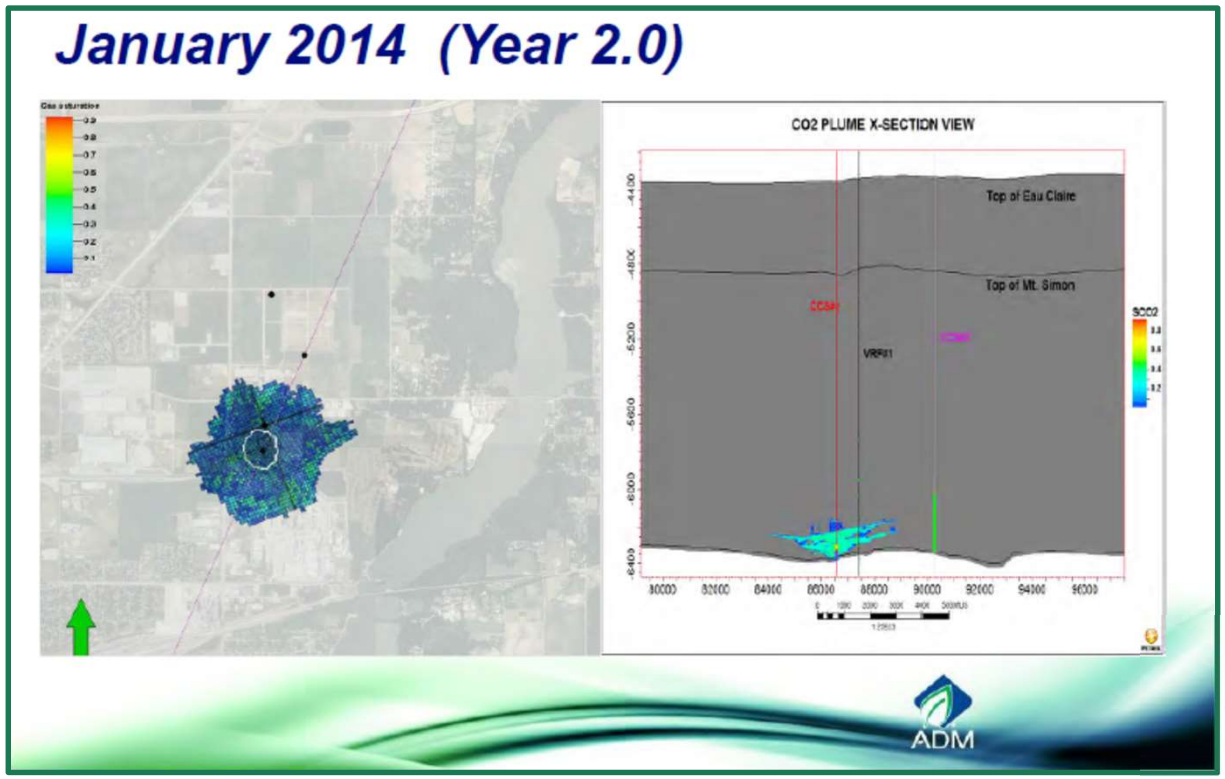

Source: ADM (2012)

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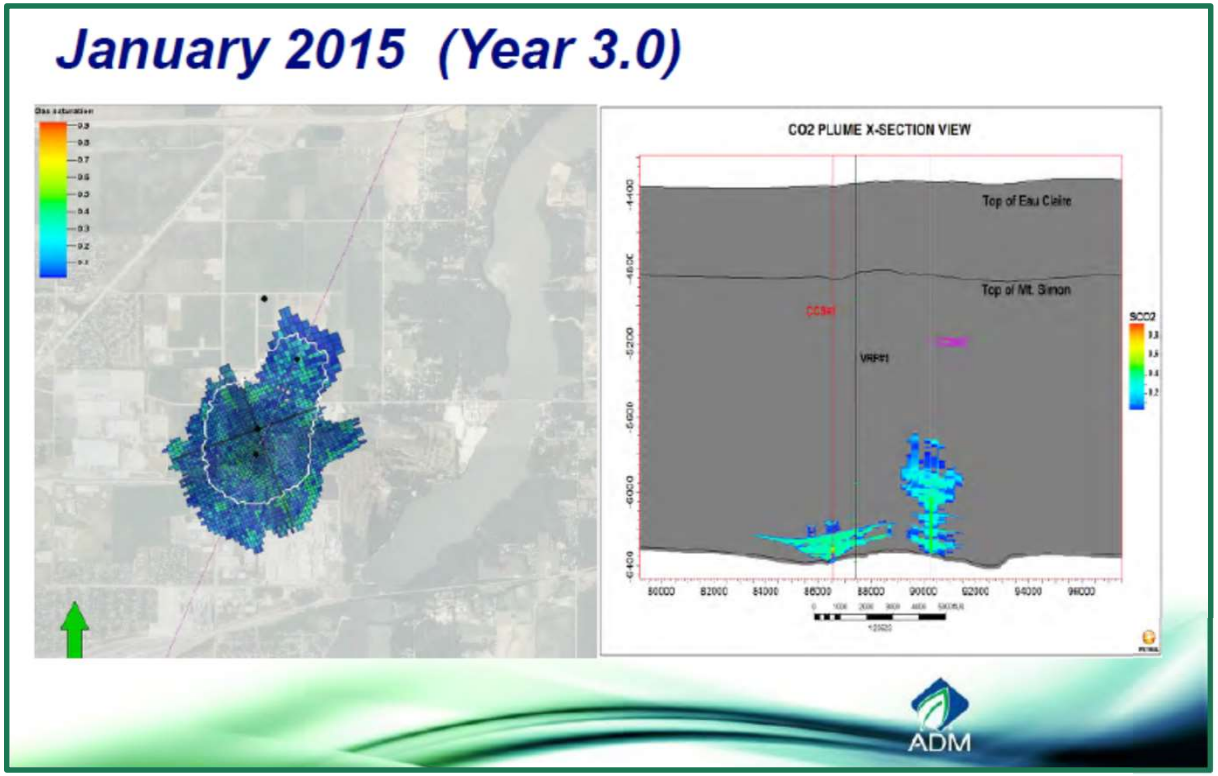
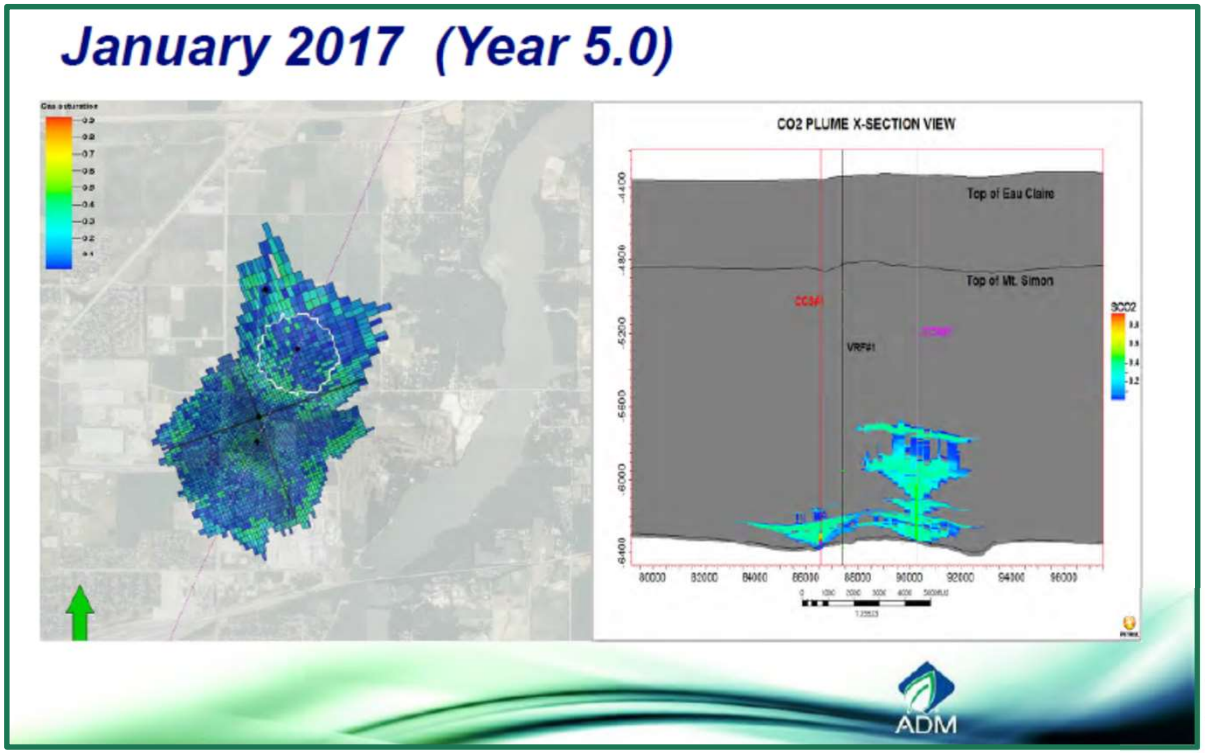


Source: ADM (2012)

EXEMPLO – PROJETO ADM – DECATUR (ILLINOIS – EUA)



Source: ADM (2012)

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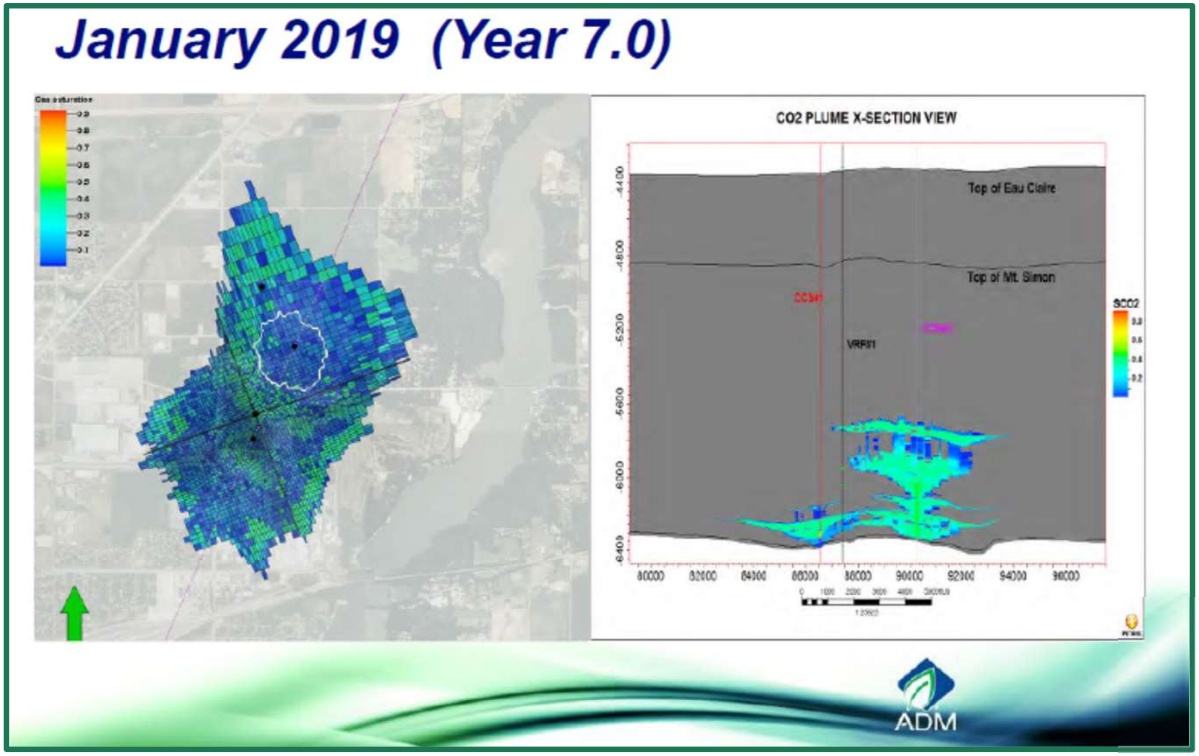
EXEMPLO – PROJETO ADM – DECATUR (ILLINOIS – EUA)



Source: ADM (2012)

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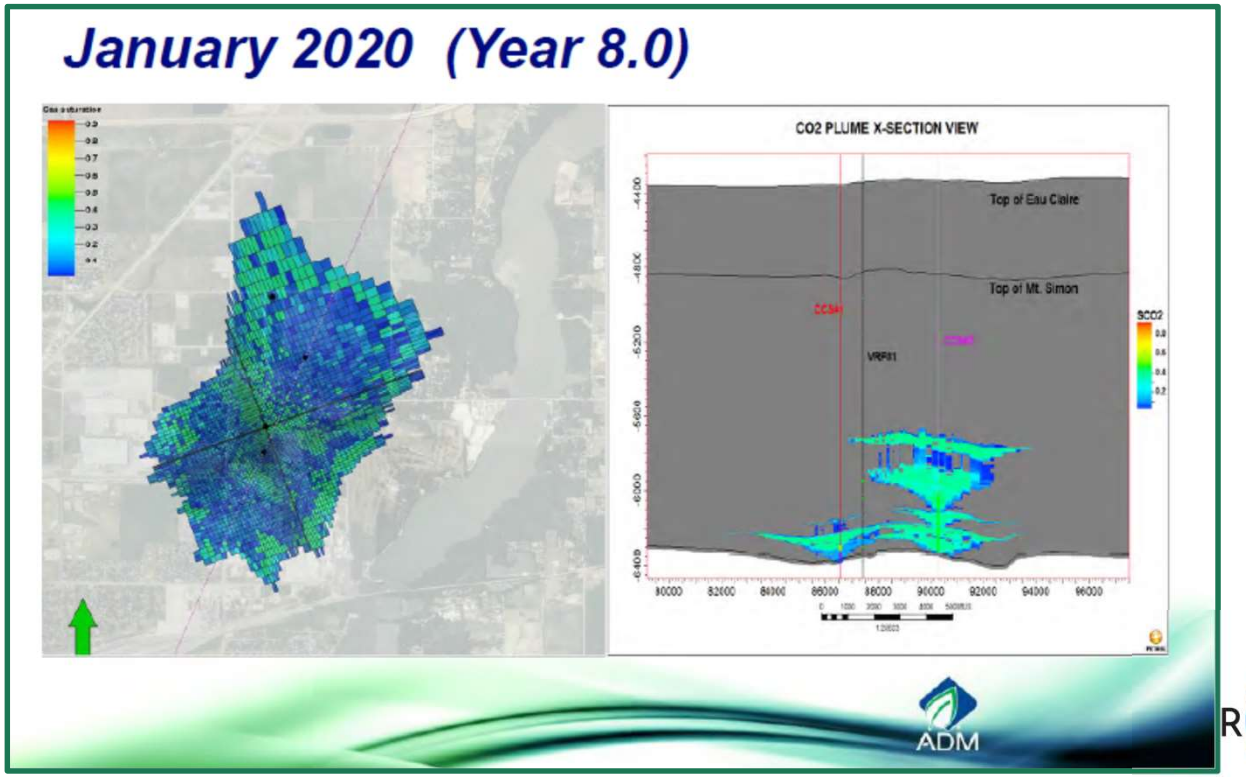

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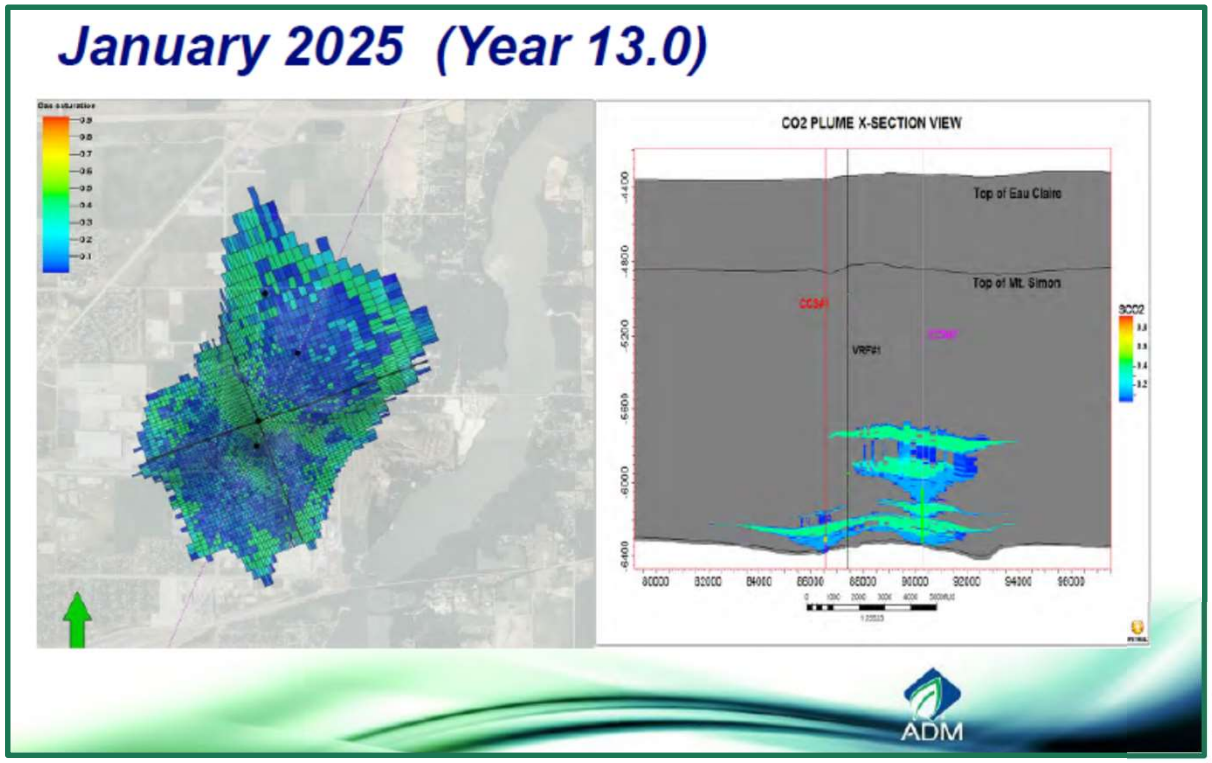

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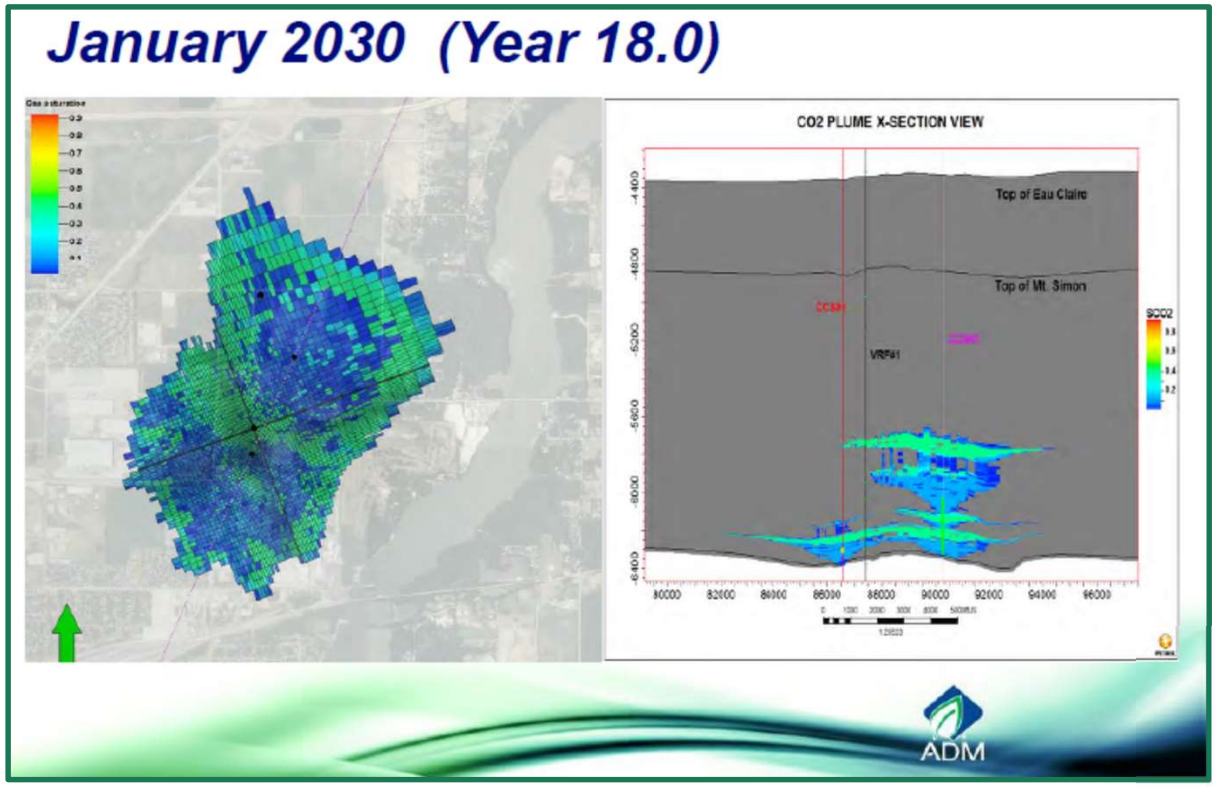

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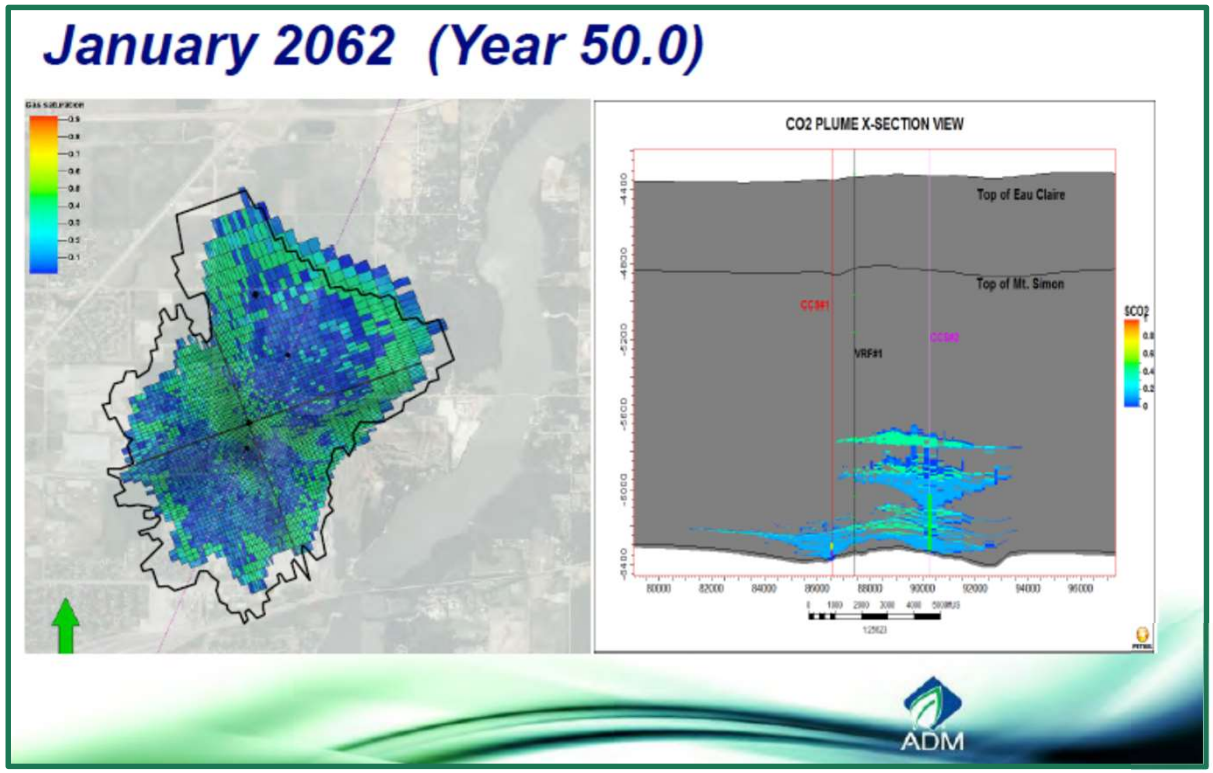

Source: ADM (2012)

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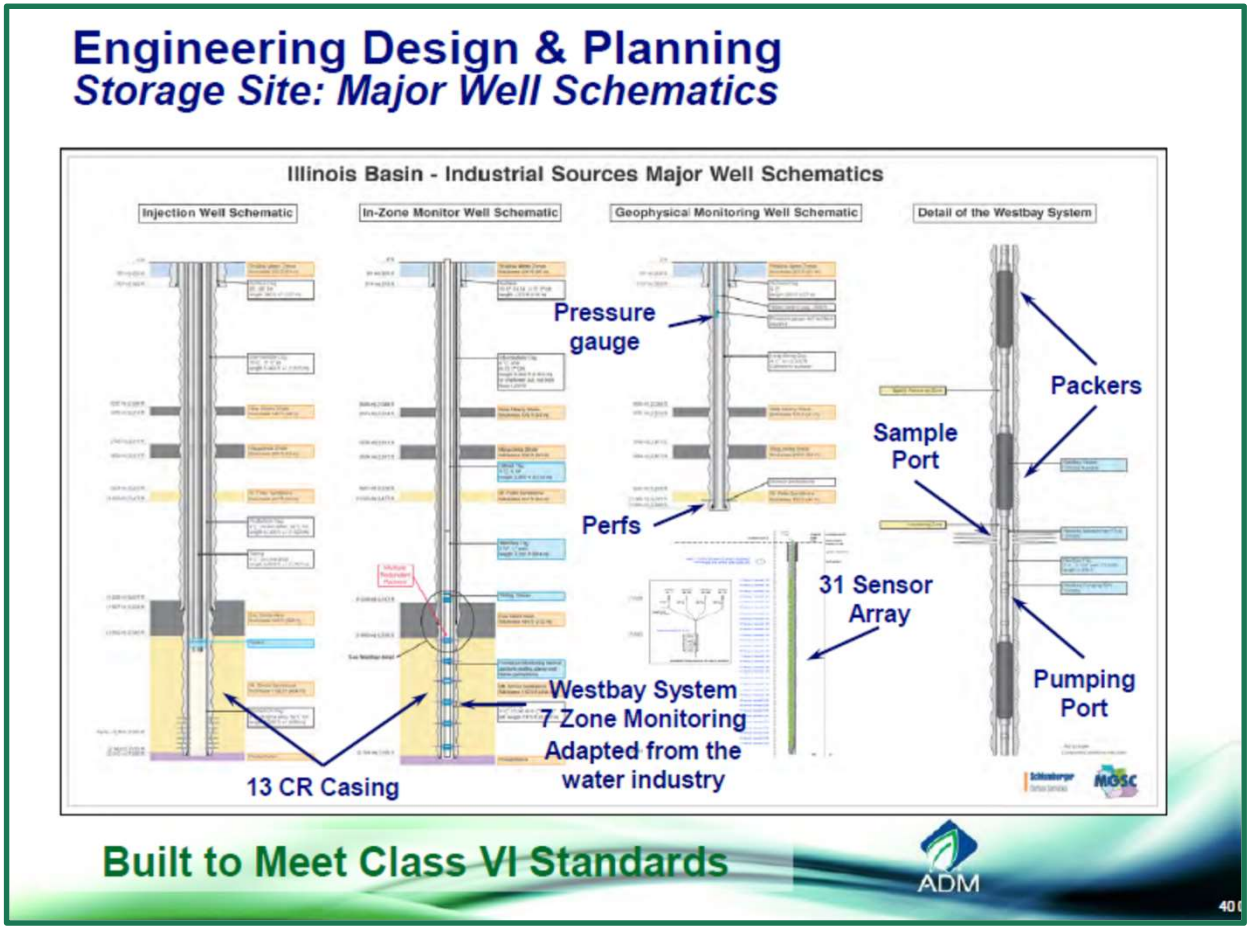

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Site Permitting
USEPA: UIC Class VI Permit

- UIC Class VI permit application submitted on July 25, 2011.
- US EPA Region V issued a notice of completeness on August 26, 2011.
- EPA issued an information request on December 21, 2012.
- The project team sent a response on January 25, 2012.
- The EPA issued a determination that stated the St. Peter Sandstone formation was the lower most USDW.
- The project team submitted revised permit application using new USDW on May 31, 2012.
- OG-7 application for construction of monitoring well submitted June 4, 2012.

1st UIC Class VI Permit Application Reviewed by the US EPA

ADM

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OBRIGADO!

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