DENR and CCS - Overview of Class VI Injection Wells

Office of Conservation

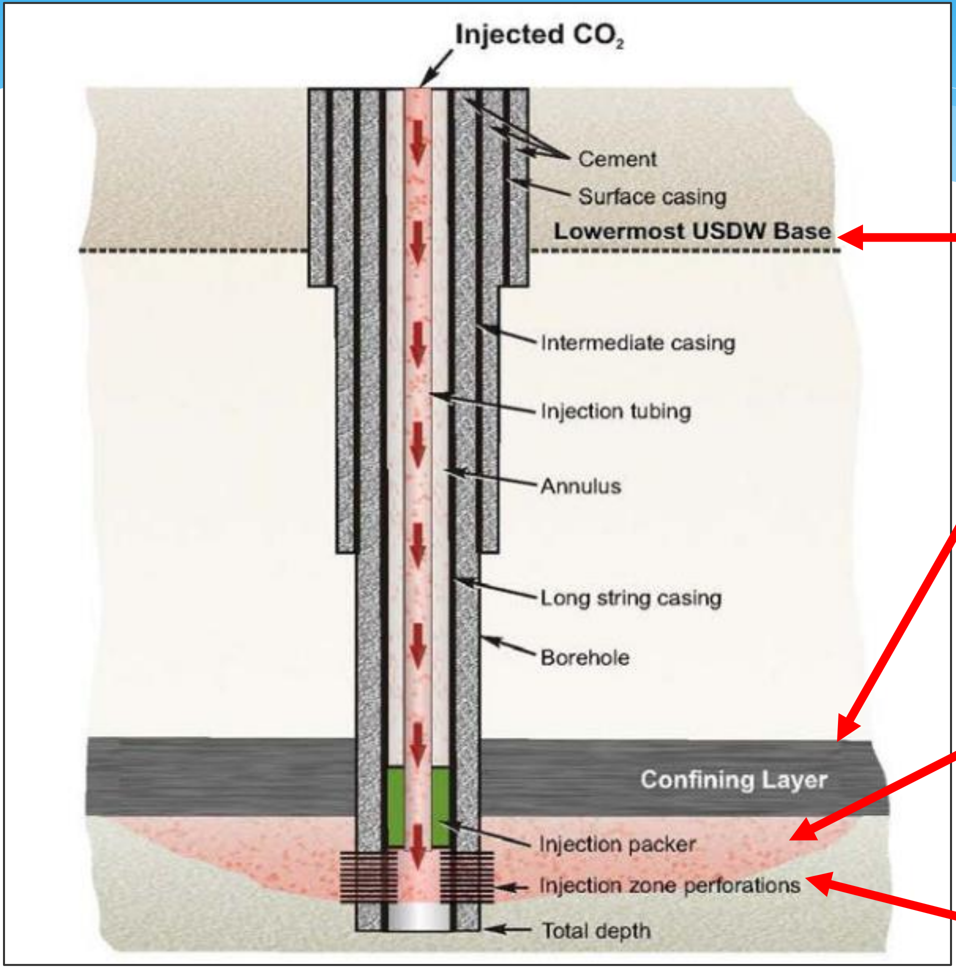
Injection & Mining Division

March 2025

Office of Conservation – IMD

* Office of Conservation - Injection & Mining Division (IMD) regulates Class I, II, III, and V injection wells as an EPA Primacy Program
* Primary responsibility is to prevent endangerment of the Underground Source of Drinking Water (USDW) and for permitting, compliance, and enforcement for all injection wells in Louisiana
* Class VI Primacy
  * Class VI injection wells - used for the geologic sequestration of man-made CO_2
  * EPA approved Louisiana for primacy in Class VI projects in January 2024, formal handoff was in February 2024

Basics of Underground Injection



Modified from EPA , "Underground Injection Control (UIC) Program Class VI Well Construction Guidance"

Base of the USDW – base of the lowermost aquifer with less than 10,000 mg/l TDS

Confining Zone – formation overlying the injection zone that acts as a barrier to fluid movement

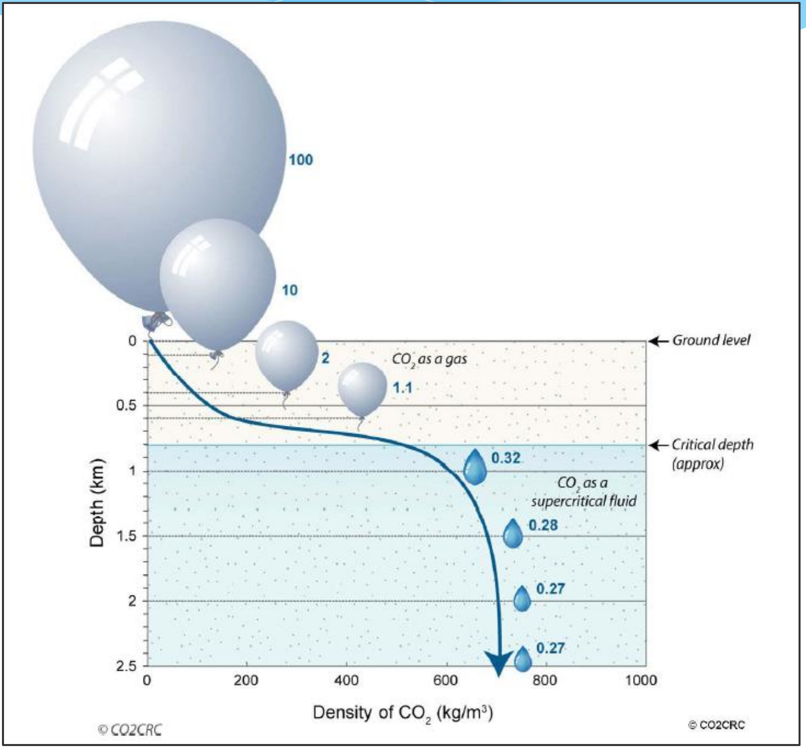
Injection Zone – formation receiving fluids through a well; must be of sufficient areal extent, thickness, porosity, and permeability

Injection Interval – part of the injection zone that is screened or perforated

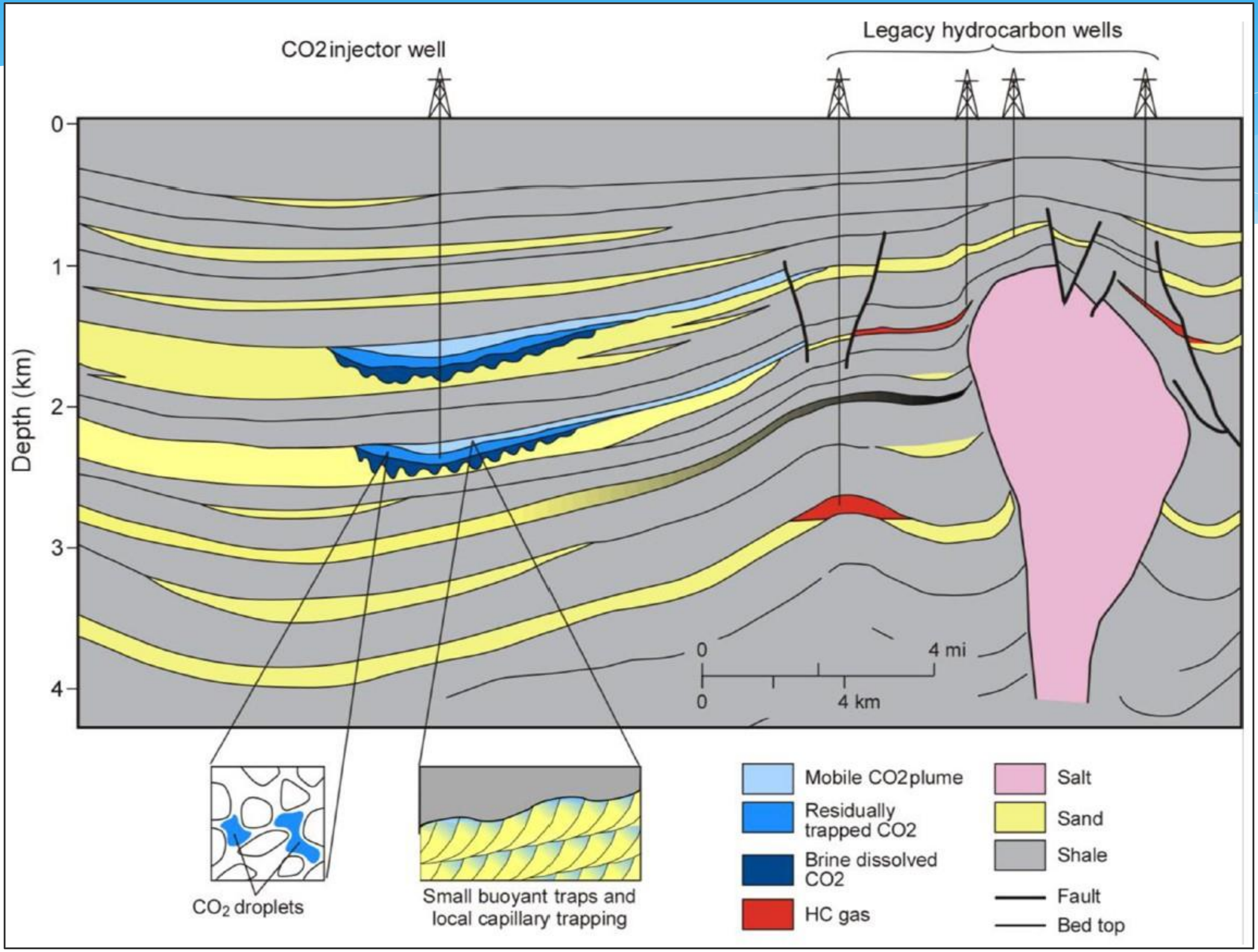
CO_2 Injection

How does injected CO_2 stay underground?

- Captured CO_2 gas is compressed to supercritical phase
- Supercritical phase – point above 87.7 degrees F and 1,070 psi where CO2 begins to share physical properties of liquid and gas
- Supercritical CO_2 can be injected underground and will remain in supercritical phase due to naturally high reservoir pressures of deep geologic formations



CO_2 Injection



Modified from Bump and Hovorka, 2023.

Regulatory Process

Pre-construction

- Site characterization
- AOR modeling
- Financial responsibility
- Well construction
- Proposed operating data and pre-injection testing
- Proposed project plans

Permit To Construct

Pre-injection

- Review revisions to plans (site characterization, corrective action, etc)
- Confirm background data is collected
- Verify adherence to Permit to Construct

Permit To Inject

Injection

- Review operating, monitoring, and testing data
- AOR updates at least every five years
- Annual financial responsibility updates
- Enforcement and compliance
- Permit modification

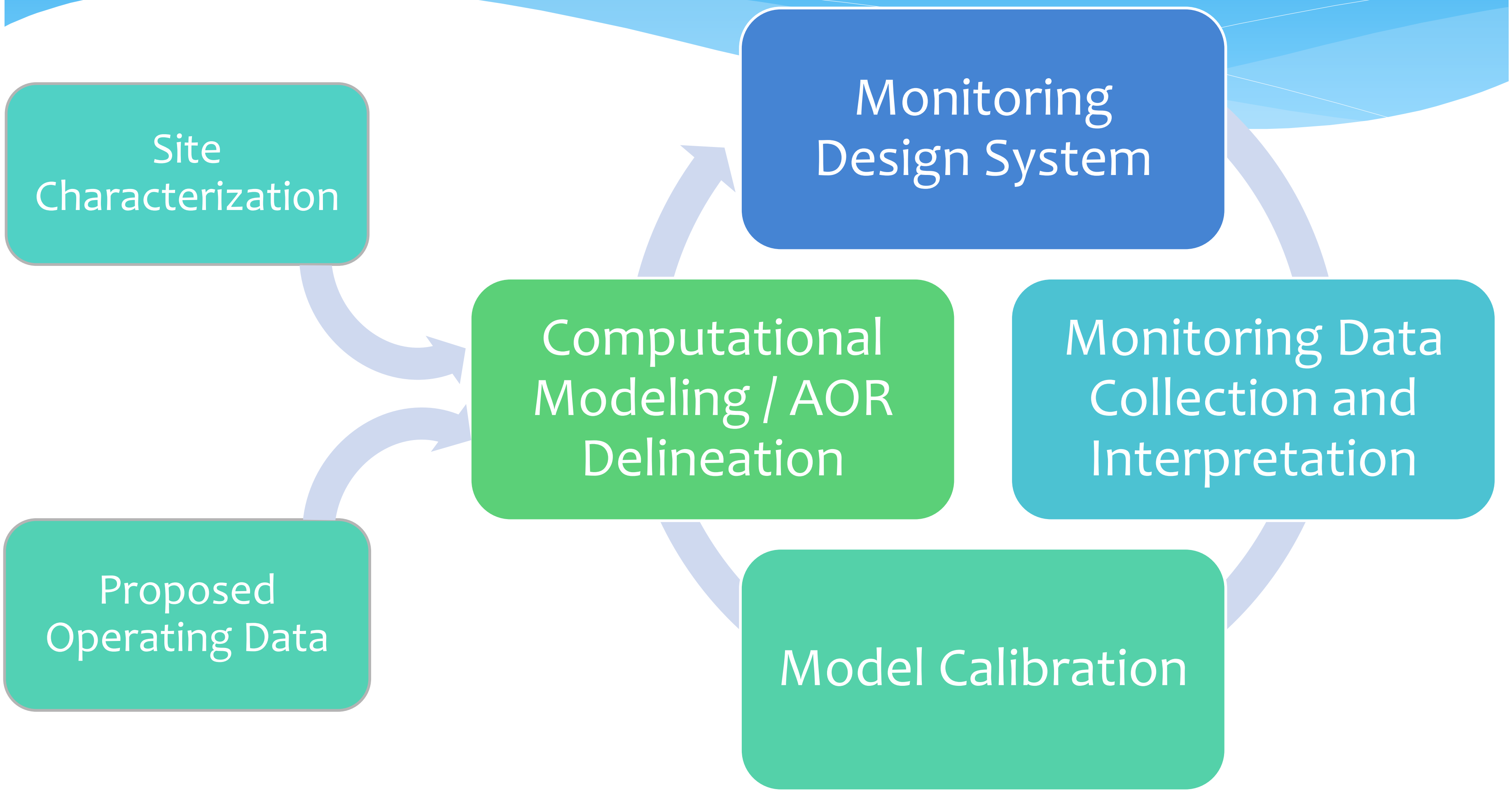
Injection Ceases

Post-injection

- Well P&A
- Post-injection site monitoring
- Emergency and remedial response
- Project and financial responsibility updates
- Non-endangerment demonstrations
- Site closure

The technical characterization required for a Class VI injection well, both during permitting and throughout the lifespan of the project, is an iterative process by design.

Permit Technical Content



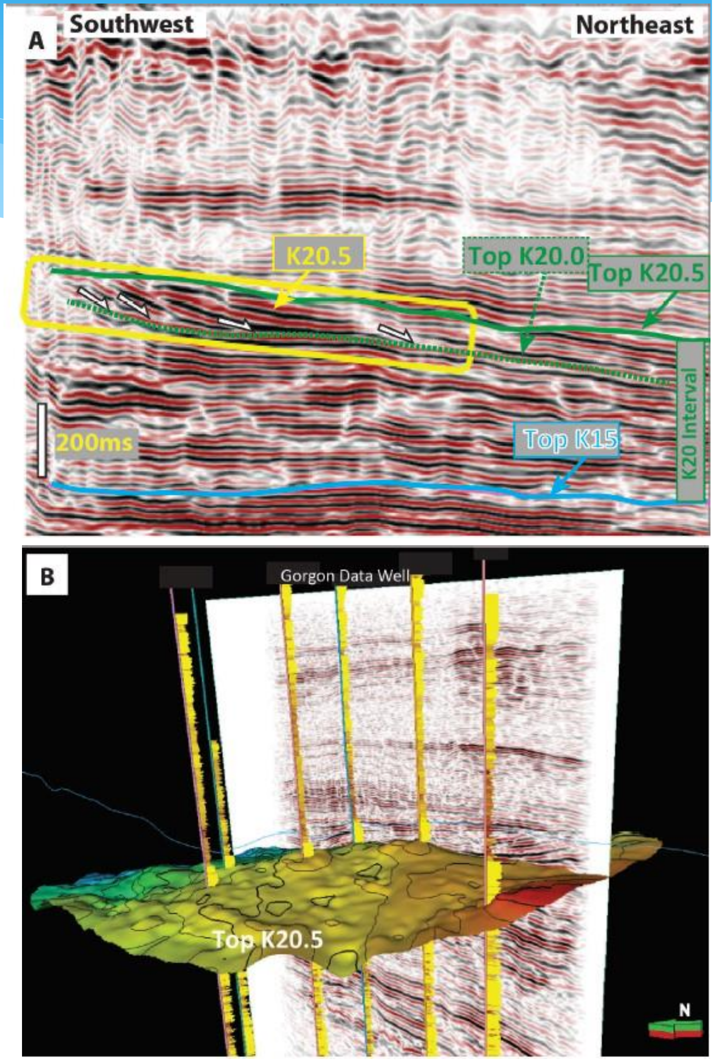
Permit Technical Content

Area of Review (AOR)

* "the region surrounding the *geologic sequestration project* where USDWs may be endangered by the injection activity, and is delineated using computational modeling that accounts for the physical and chemical properties of all phases of the injected *carbon dioxide stream* and displaced fluids, and is based on available site characterization, monitoring, and operational data as set forth in §§3615.B. and 3615.C." - LAC 46.XVII.3601.A
* <u>AOR = Plume Extent + Pressure Front</u>
* Pressure front is extent of sufficient pressure to force injection zone fluid into the USDW
* Must be reevaluated at least every five years, or when monitoring and operational conditions warrant
* Updates must incorporate monitoring data and any changes in operating conditions
* <u>**Importance of a fully characterized AOR cannot be overstated**</u>

Permit Technical Content

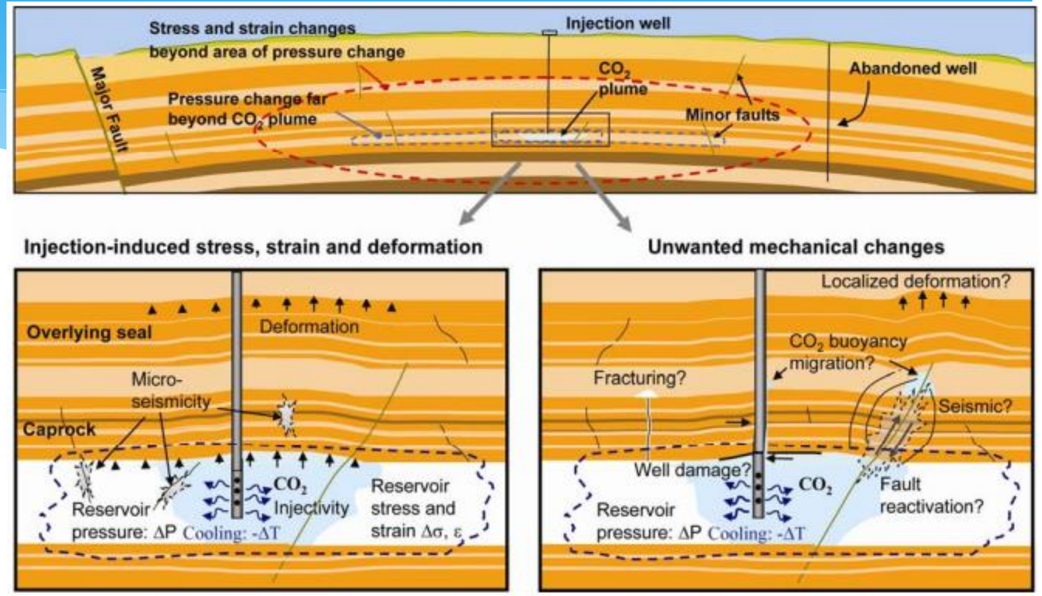
* **Site characterization** – Forms the basis of the design and calibration of models used to predict CO_2 plume extent
* Geologic maps - structure, cross-sections, isopachs, fault plane, etc.
  * Must account for regional geology, local geology with AOR, and hydrology
  * Must characterize all structure, stratigraphy, lithology, and faulting within confining and injection zones
* Reservoir characteristics - mineralogy, porosity, permeability, capillary pressure, formation fluid, etc.
  * Must be verified using core data from the confining and injection zones at the proposed site before a permit-to-inject is granted



Modified from Barranco et al, 2013.

Permit Technical Content

* **Geomechanical studies** – important for evaluating integrity of confining zones as well as safe operational parameters for the well
  * Important for determining maximum surface injection pressure (MASIP)
* Risks to be avoided
  * Fracturing that might lead to loss of containment
  * Activation of existing faults
  * Induced seismicity that can be felt at the surface
  * Localized deformation
  * Mechanical damage to injector
  * "Thou shalt not frack."



Modified from Rutqvist, 2012.

Types of geomechanical info	Potential tools to evaluate
Presence of existing fractures	Detection in wellbores using logs like microseismic, caliper, acoustic, or video logs.
Ductility – capacity of a rock to undergo plastic strain/deformation without fracturing	Triaxial load test on core samples
Rock strength – the ability of a rock to undergo differential stress	Triaxial load test on core samples
In situ stress field – the orientation and magnitude of stress in formation before being disturbed by outside influences	Evaluating density of the surrounding formations and performing formation stress tests

Investigation of	Seismic						Gravity		Electrical/Electromagnetic			Magnetic
	2D	3D	VSP	3D-VSP	Cross-well	Borehole microseismic	Aerial & surface gravity	Borehole gravity	Natural source	Controlled source	ERT	Aerial & surface magnetic
Near borehole and shallow subsurface			W	W	W	W		W		W		
Field-wide subsurface studies	W	W		W		P	W		W	W		W
Stratigraphy	W	W	W	W	W		W	W	P	P	W	P
Thickness	W	W	W	W	W			W			W	
Structure 0 - 100 m				P		P	P		P	P	P	P
Structure 100 m - 1 km	W	W		W	W	W	P	P	P	P	W	P
Structure > 1km	W	W		W	P	W	W	P	W	W	P	W
Fault/fracture	W	W		W	W	W	P		W	W	P	
Porosity							P	W	W	W	W	
Pore pressure	P	W	P		P							
Abandoned wells											W	W

Modified from EPA, "Underground Injection Control (UIC) Program Class VI Well Site Characterization Guidance"

W = well suited (already in use for site characterization with good results)
P = potential (could be used, but better alternatives available or results lack desired resolution)

* **Geophysical characterization** – uses indirect geophysical methods to provide information about the subsurface. Specific methods may vary in spatial scale and resolution but generally provide more information over a larger area that direct sampling of the formations may provide.
  * Four main types of methods: seismic, gravity, electrical/electromagnetic, and magnetic
  * Applicants must demonstrate that selected method(s) are will provide the needed levels of resolution at the depth that's being characterized

Permit Technical Content

* **Computational Modeling**
  * *Static/geologic model* – model of the physical framework of the earth using geologic structure, lithology, stratigraphy, facies distribution, porosity and intrinsic permeability distribution, reservoir characteristics, etc.
  * *Simulation/reservoir model* – models the flow of the multiphase CO_2 plume through the pore space. Accounts for any CO_2 phase transition (supercritical/liquid/gas), dissolution of CO_2 into reservoir fluids, density and thermal effects, chemical and physical changes over time, etc.
    * *Reactive transport modeling* – component of reservoir model that evaluates mineral dissolution and precipitation, potential effects of trace constituents in the CO_2 stream (e.g., H_2S, So_x), mineralization as a trapping mechanism, etc
    * Note regarding constituents in CO_2 stream – acid gas injection wells **will not** be permitted in Louisiana. The addition of any waste chemicals to the CO_2 injection stream is strictly prohibited.
  * All models and model inputs will be reviewed and verified by technical staff.
  * Must be updated **at least every five years** or as warranted by operating and monitoring conditions

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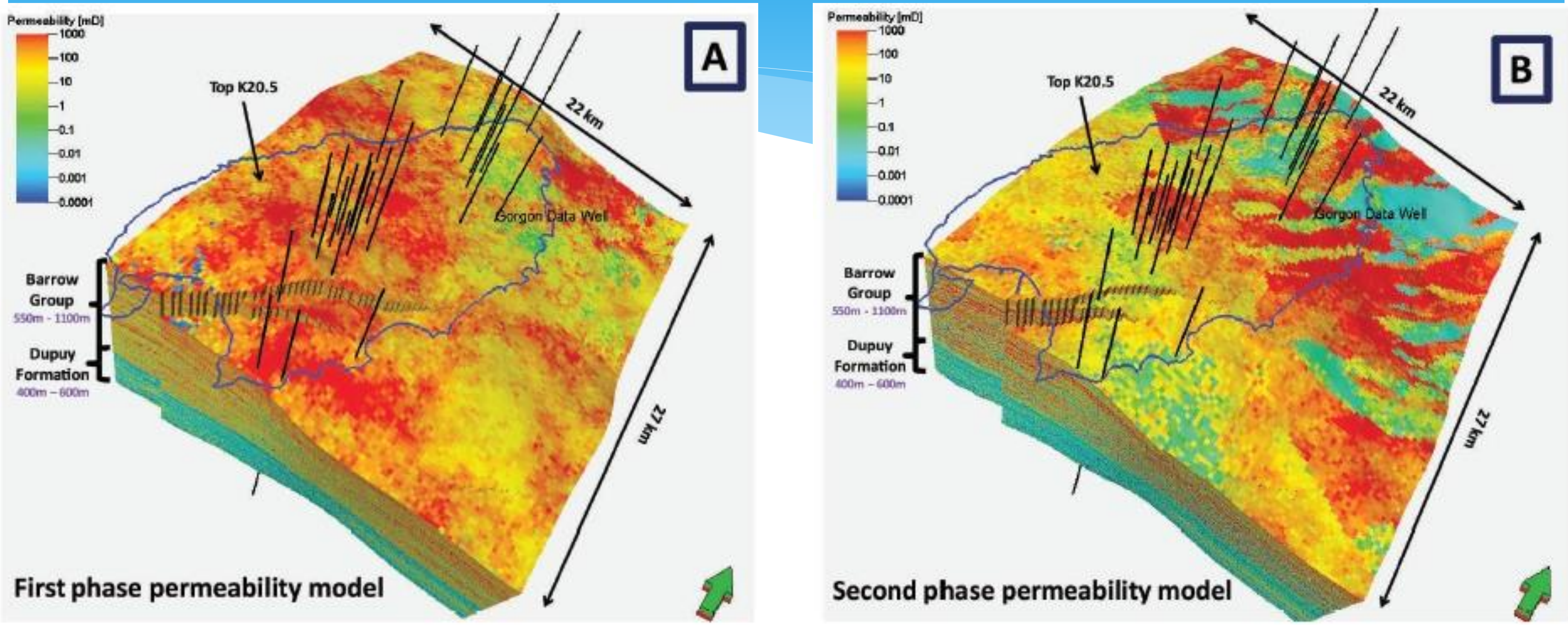
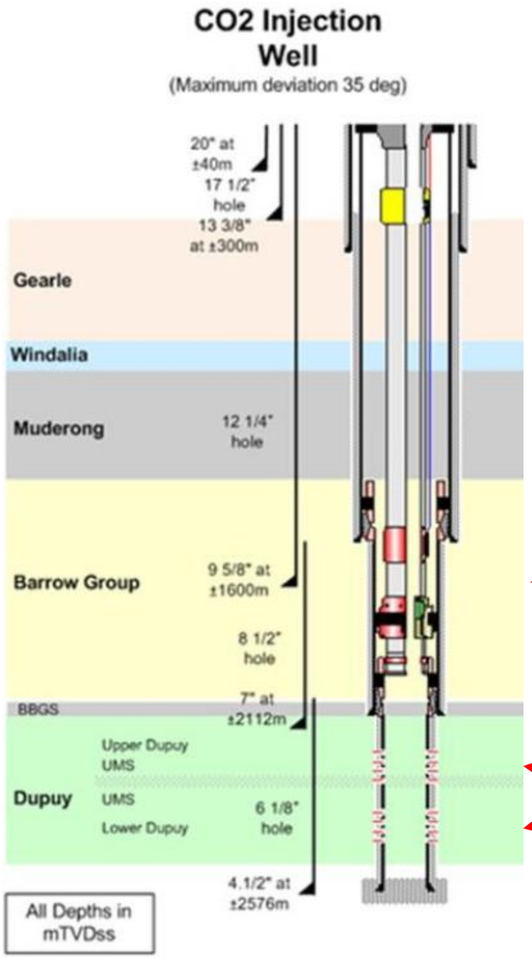


Modified from Barranco et al, 2013.

Modeling is an iterative process where applicants are required to update and refine their geologic and reservoir models with site specific data. A model is only as good as the data that's fed into it, so these revisions with up-to-date information are vital to ensure effective characterization over the lifespan of the project.

Engineering Considerations - Buoyancy



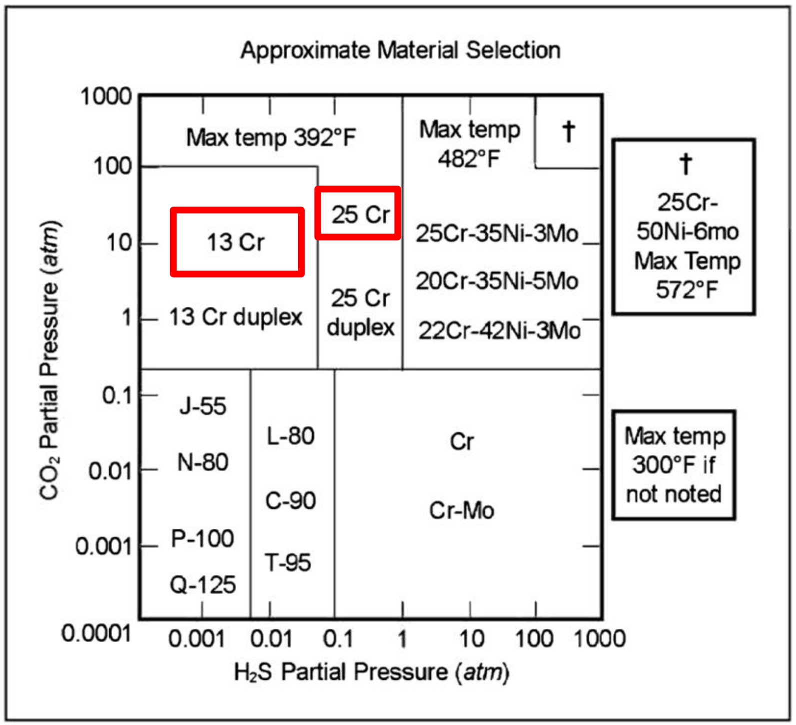
Modified from Trupp et al, 2021.

- Example of CO_2 injection well schematic from an ongoing CCUS project in Australia
  - Demonstrates that upward buoyancy on CO_2 must be accounted for in geologic assessment
  - CO_2 injected into the permeable sands of the injection zone is prevented from migrating upwards due to low permeability shales of the confining zone

Confining Zone – regional extensive deltaic shale

Injection Zone – multiple sandstone targets that include channelized slope deposits with massive sandstones and turbidites

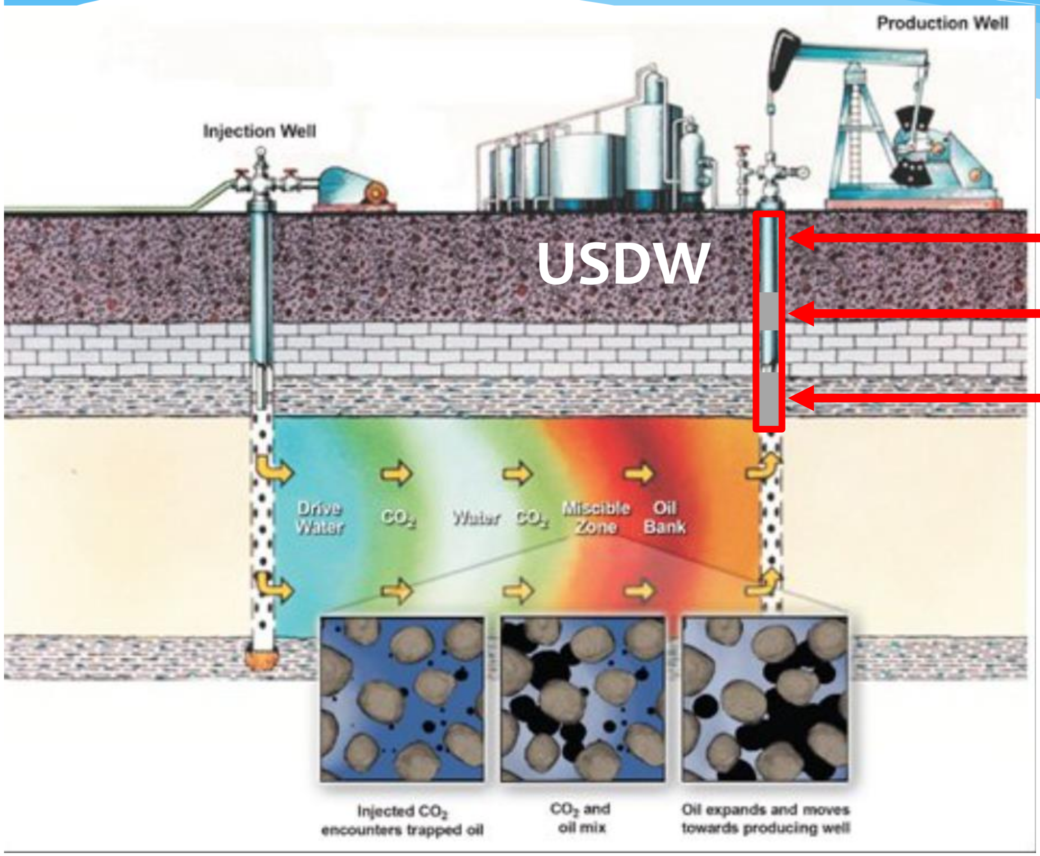
Engineering Considerations - Corrosivity



PE License Exam Reference Guide – Ali Ghalambor

- $H_2O + CO_2 \longrightarrow H_2CO_3$ (Carbonic Acid)
- Selections for wellbore materials through material compatibility studies must account for characterization of CO_2 injection stream
- Compatible materials will be required in any wellbore (whether injector or existing wellbore within the AOR) that may interact with the CO_2 plume
- Corrective action, such as replugging with compatible materials, may be required for existing wellbores

Engineering Considerations - USDW protection



Modified from www.energy.gov

- A generalized cross-section of a CO_2 enhanced oil recovery project shows what type of corrective action might be required for existing wellbores within a Class VI AOR even when no oil or gas is being produced
- **CO_2 compatible cement and casing would be required**

Monitoring After a Project Begins

- Groundwater Quality Above the Confining Zone
  - Testing to detect changes in groundwater chemistry that may indicate loss of containment; compare to baseline data collected during site characterization
- Plume and Pressure Front Tracking
  - Results necessary for model comparison and verification
  - *In situ fluid pressure monitoring* – e.g., pressure transducers in monitoring wells
  - *Indirect geophysical monitoring* – seismic, gravity, electromagnetic, electrical
  - *Groundwater geochemical monitoring* – detection of CO_2 plume in monitoring wells; adjusted sampling procedures for high temp/pressure conditions
  - *Computational modeling* – part of required AOR updates
- Surface Air/Soil Gas Monitoring
  - May be required to detect movement of CO_2 outside of the permitted injection zones
- Additional takeaways – just like the AOR updates, monitoring is a dynamic process that requires includes updates and revisions throughout life of project. Each monitoring plan is site specific where up-to-date information on CO_2 plume movement and CO_2 stream composition will be repeatedly updated in the reservoir model and AOR characterization.

Monitoring After a Project Begins

Testing and Monitoring Activities required by state and federal regulations	Siting/Evaluation	Well Construction	CO_2 Injection and Monitoring	Post-Injection Site Care (PISC)	Post-Closure
Mechanical integrity testing		↔	↔		
Analysis of CO_2 stream	↔	↔	↔		
Monitor injection pressure, rate, and volume			↔		
Corrosion monitoring			↔		
Monitor groundwater in zones above confining zone	↔	↔	↔	↔	
Monitor USDW	↔	↔	↔	↔	
Pressure falloff testing			↔		
Plume and pressure front tracking	↔	↔	↔	↔	

Modified from EPA , “Underground Injection Control (UIC) Program Class VI Well Testing and Monitoring Guidance”

Key Louisiana Takeaways

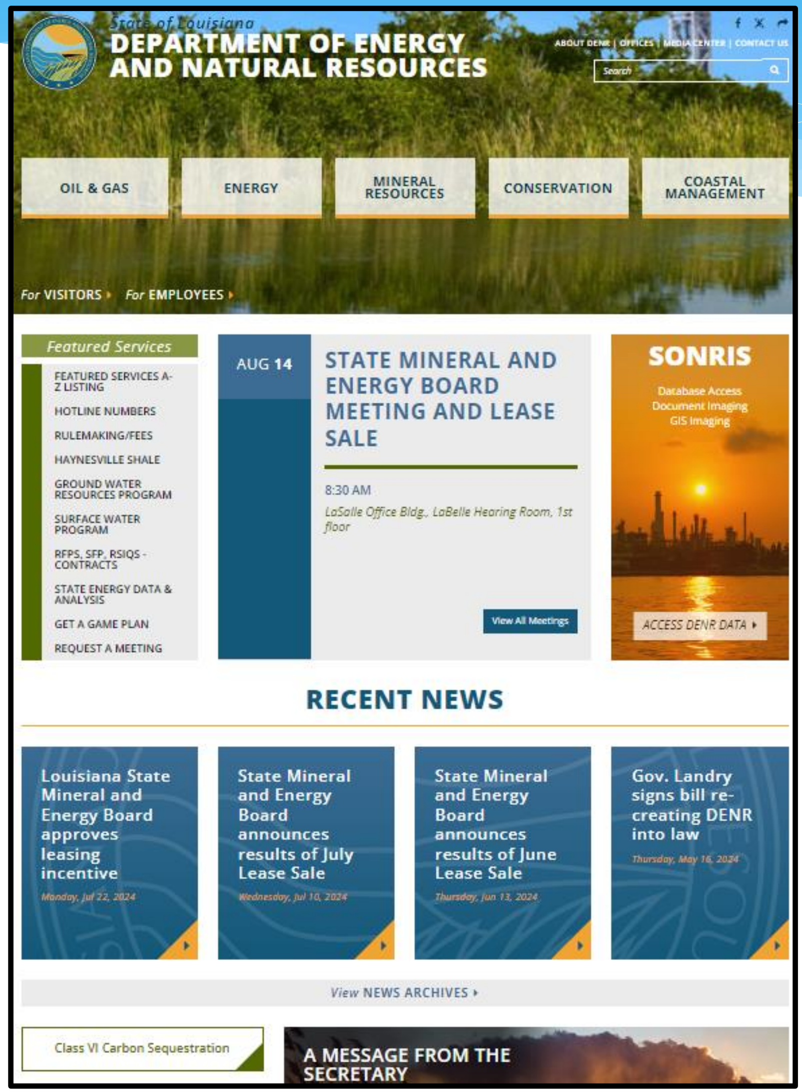
Additional things to know
Conservation IMD is reviewing 29 Class VI applications
Existing wells within AOR (artificial penetrations) will have to be addressed.
Sequestration in salt caverns will not be permitted.
“Thou shalt not frack.”
Due to concerns around some formations in NW Louisiana, we’ve encourage potential applicants in this area to speak with IMD sooner rather than later.
Any AOR that crosses or approached boundaries of other jurisdictions (e.g., neighboring states and federally recognized Tribes) may trigger additional review. IMD is currently working with Texas, Arkansas, and Mississippi on this process.
Some applicants drill Class V stratigraphic test wells to gather reservoir data.
Estimate of minimum time for review from fresh application submission to public comment – about 18 months

Current Class VI Applications

Louisiana Department of Energy and Natural Resources - Class VI Well Applications (3/14/2025)

Operator	Project Name	Parish	Number of Wells/Applications	Application Received by EPA	Declared Adminstratively Complete by EPA	Application Received by DENR	Declared Administratively Complete by DENR	Start of DENR Technical Review
Air Products Blue Energy, LLC	LCEC Carbon Sequestration Site South	St. John the Baptist	5	--	--	7/12/2024	7/17/2024	9/27/2024
BKVerde, LLC	Donaldsonville	Ascension	1	1/9/2024	1/25/2024	2/5/2024	7/25/2024	--
Capio Sequestration, LLC	Capio Sherburne CCS Well #1	Pointe Coupee	1	12/13/2022	2/16/2023	2/5/2024	4/30/2024	4/30/2024
Capio Maurepas Sequestration, LLC	Maurepas WMA Sequestration Project	St. John the Baptist	2	--	--	6/3/2024	7/10/2024	--
CapturePoint Solutions, LLC	CCS 1 - Wilcox	Rapides	6	6/24/2022	7/22/2022	2/5/2024	4/2/2024	4/2/2024
CapturePoint Solutions, LLC	CCS 2 - Wilcox 2	Vernon	6	3/14/2023	5/18/2023	2/5/2024	3/25/2024	3/25/2024
Cleco Power, LLC	Diamond Vault	Rapides	6	5/19/2023	8/9/2023	2/5/2024	3/7/2024	--
Denbury Carbon Solutions, LLC	Draco	Allen, Beauregard, and Vernon	6	7/6/2023	10/6/2023	2/5/2024	--	--
DT Midstream Holdings, LLC	LA CCS	Sabine	1	11/22/2022	3/27/2023	2/5/2024	6/5/2024	--
Evergreen Sequestration Hub, LLC	Evergreen Sequestration Hub	Beauregard	2	--	--	2/28/2024	3/19/2024	10/10/2024
ExxonMobil Low Carbon Solutions Onshore Storage LLC	Pecan Island Area Project	Vermillion	2	7/28/2023	9/6/2023	2/5/2024	--	--
Gulf Coast Sequestration	Minerva	Calcasieu	4	1/26/2022	3/10/2022	2/5/2024	8/14/2024	--
Gulf Coast Sequestration	Goose Lake	Calcasieu	2	8/31/2022	9/26/2022	2/5/2024	8/14/2024	--
Hackberry Carbon Sequestration, LLC	Hackberry Sequestration	Cameron	1	9/15/2021	11/9/2021	2/5/2024	3/15/2024	3/15/2024
Harvest Bend CCS LLC	White Castle	Iberville	3	10/25/2023	11/22/2023	2/5/2024	3/1/2024	--
Lapis Energy (LA Development), LP	Libra CO2 Storage Solutions Project	St. Charles	3	--	--	11/20/2024	12/2/2024	--
Live Oak CCS, LLC	Live Oak CCS Hub	West Baton Rouge and Iberville	8	--	--	11/7/2024	11/26/2024	--
Louisiana Green Fuels LLC	LGF Columbia	Caldwell	3	3/15/2023	4/24/2023	2/5/2024	3/26/2024	3/26/2024
Magnolia Sequestration Hub, LLC	Magnolia	Allen	4	7/20/2021	3/10/2022	2/5/2024	4/23/2024	4/23/2024
OnStream CO2, LLC	GeoDura	Cameron	6	--	--	12/18/2024	1/6/2025	--
Pelican Sequestration Hub, LLC	Pelican Sequestration Project	Livingston	2	8/11/2023	2/2/2024	2/5/2024	4/23/2024	--
River Parish Sequestration, LLC	River Parish Sequestration - RPN 1	Ascension	1	5/10/2023	6/15/2023	2/5/2024	3/1/2024	5/28/2024
River Parish Sequestration, LLC	River Parish Sequestration - RPN 2	Assumption	1	5/25/2023	6/15/2023	2/5/2024	3/1/2024	--
River Parish Sequestration, LLC	River Parish Sequestration - RPN 3	Assumption	1	6/19/2023	6/22/2023	2/5/2024	3/1/2024	--
River Parish Sequestration, LLC	River Parish Sequestration - RPN 4	Iberville	1	7/9/2023	8/1/2023	2/5/2024	3/1/2024	--
River Parish Sequestration, LLC	River Parish Sequestration - RPN 5	Iberville	1	7/9/2023	8/1/2023	2/5/2024	3/1/2024	--
River Parish Sequestration, LLC	River Parish Sequestration - RPS 1 & 2	Assumption	2	8/31/2023	9/20/2023	2/5/2024	3/1/2024	--
Shell U.S. Power and Gas, LLC	El Camino	St. Helena	2	12/12/2022	3/9/2023	2/5/2024	4/3/2024	6/14/2024
Venture Global CCS Cameron, LLC	Venture Global CCS Cameron LLC CO2 Sequestration Project	Cameron	1	7/25/2023	--	2/5/2024	6/12/2024	6/12/2024

Questions?



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STATE MINERAL AND ENERGY BOARD MEETING AND LEASE SALE
8:30 AM
LaSalle Office Bldg., LaBelle Hearing Room, 1st floor
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RECENT NEWS
Louisiana State Mineral and Energy Board approves leasing incentive
Monday, Jul 22, 2024
State Mineral and Energy Board announces results of July Lease Sale
Wednesday, Jul 10, 2024
State Mineral and Energy Board announces results of June Lease Sale
Thursday, Jun 13, 2024
Gov. Landry signs bill re-creating DENR into law
Thursday, May 16, 2024
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Class VI Carbon Sequestration
A MESSAGE FROM THE SECRETARY

Class VI Info Page

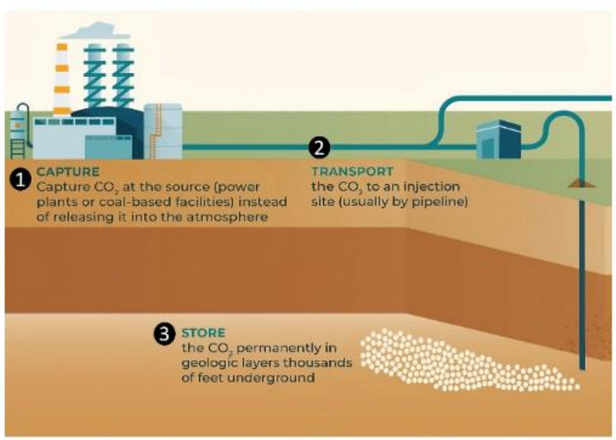
Class VI Carbon Sequestration Program

MAIN MENU:

Overview | Permits and Applications | Public Hearings | Applicant Information | Primacy

How Carbon Capture and Storage (CCS) Works:

CCS is a three-step process that involves capturing CO_2 at the source, compressing it for transport, and injecting it deep underground into rock formations. The first step, capturing the CO_2, involves separating CO_2 from other gases generated by industrial process facilities including fossil fuel-fired power plants, refineries, steel mills, and chemical plants. The next step, CO_2 transport, involves compressing the CO_2 for transport via pipelines or other methods to a suitable geologic storage site. Lastly, the remaining step is to store the CO_2 deep underground via injecting it into rock formations often at depths of one mile or more.



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