ELK PETROLEUM

CCS Technical Discussion Series: Well Mechanical Integrity

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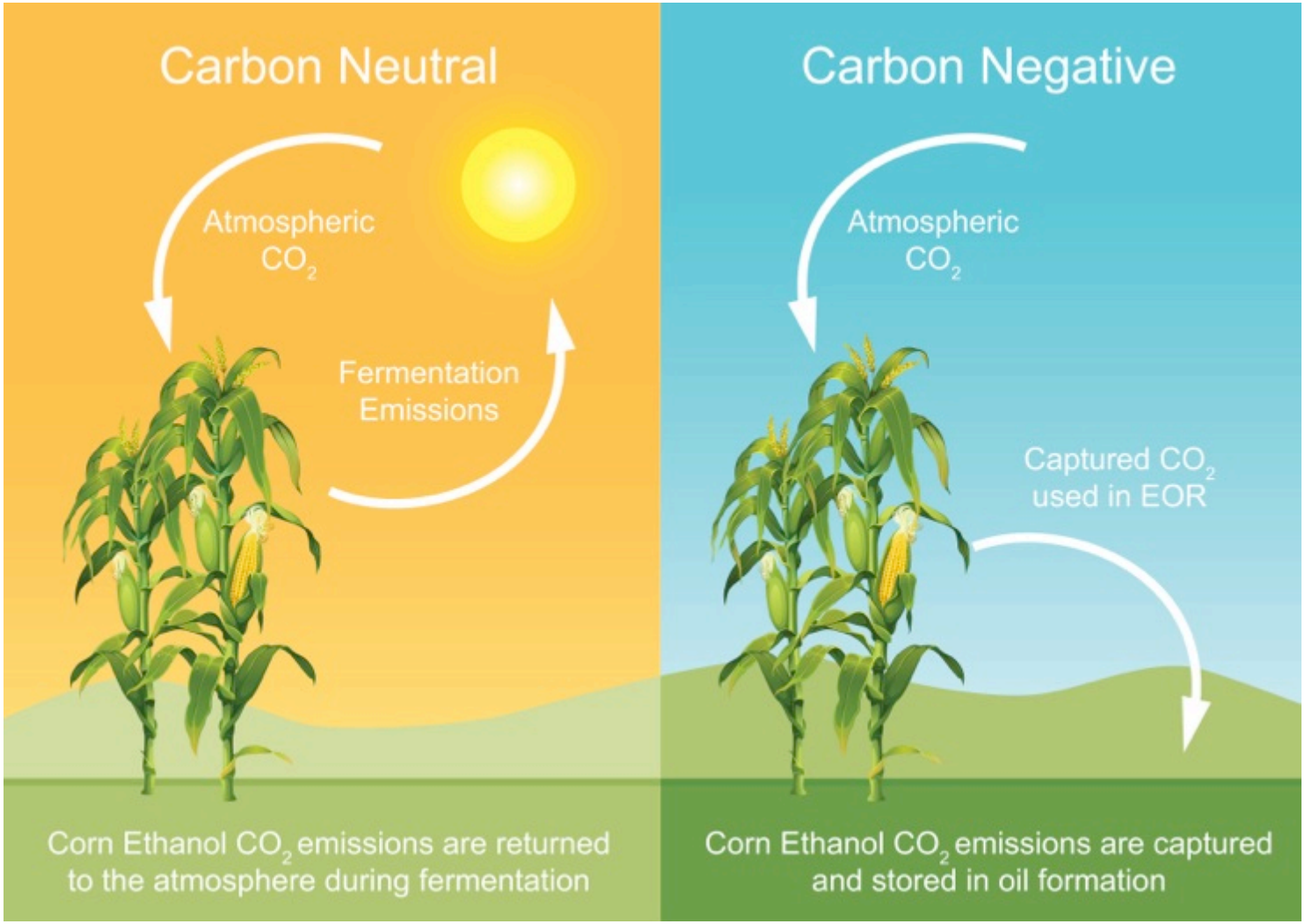
Panel Discussion at the California Air Resources Board on May 12, 2016

California CCS Program: Well Mechanical Integrity

Outline of Presentation

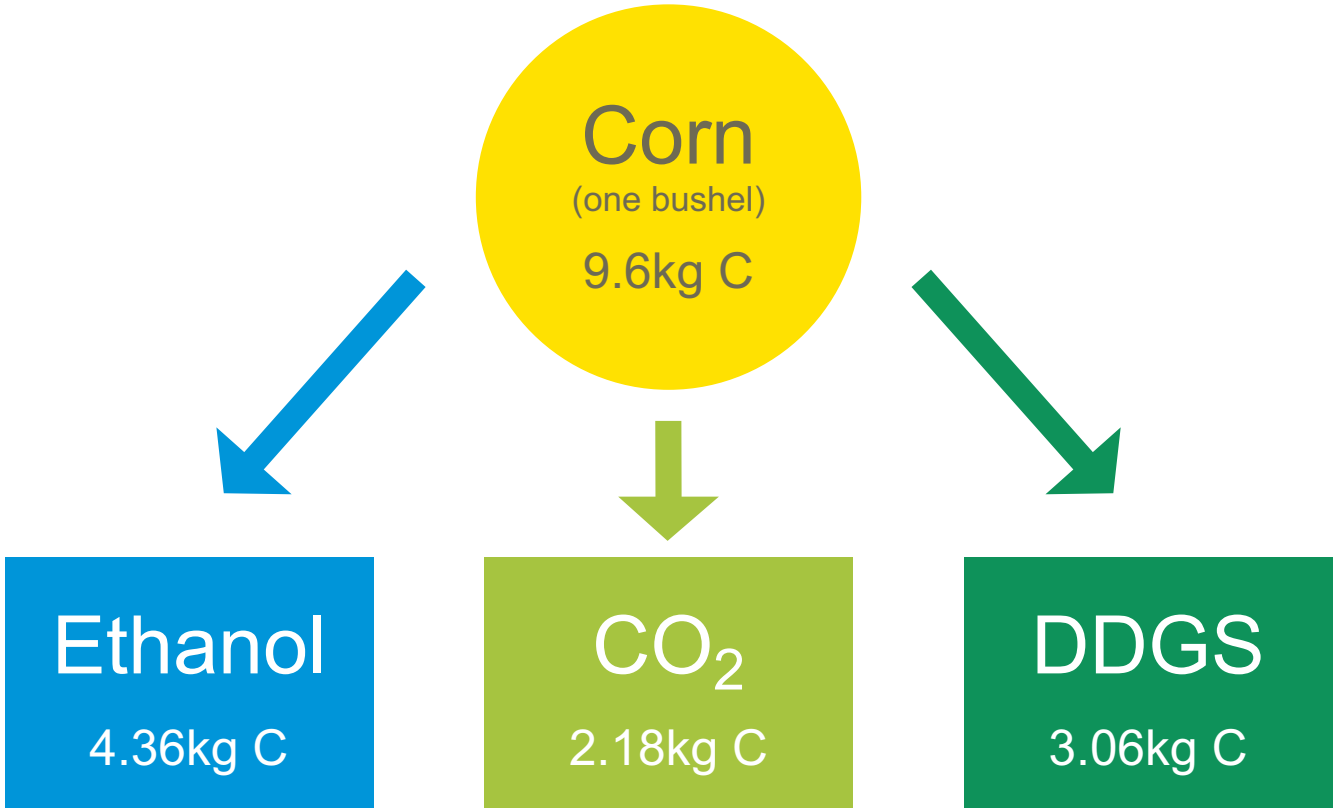
- Elk Petroleum's role as a stakeholder in the CCS rule making process
- CCS in oil vs. saline reservoirs
- Underground Injection Control (UIC)
- Class II vs. Class VI wells
- Legacy wells as candidates for CO2-EOR
- Best practices for CO2-EOR well configuration
- Best practices for CO2-EOR well abandonment
- Managing long-term liabilities with risk pools
- Recommendations

CORN ETHANOL CO_2 FERMENTATION EMISSIONS PATHWAYS



Source: Hornafius & Hornafius: Carbon Negative Oil, IJGGC (2015)

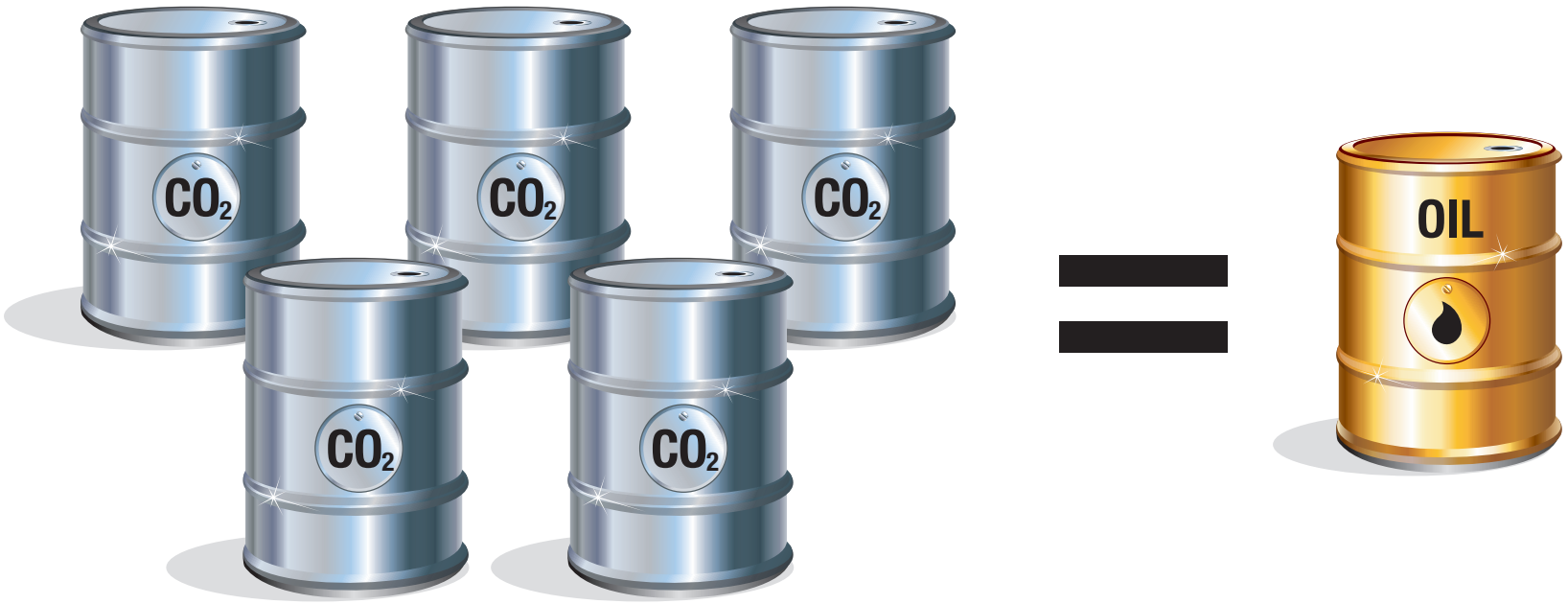
CORN ETHANOL CO-PRODUCT CARBON CONTENT



Source: Katherine Hornafius 13th Annual Carbon Capture, Utilization & Storage Conference - April 28-May 1, 2014 - Pittsburgh, PA

Carbon Negative Process with Bio-CO2-EOR

EOR with Corn Ethanol Fermentation CO2 is Carbon Negative:
CO2 sequestered > CO2 emitted by combustion



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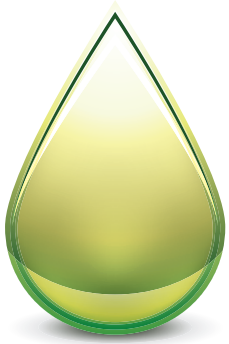
CARBON VALUE CHAIN FOR BIO-CO2-EOR

Ethanol

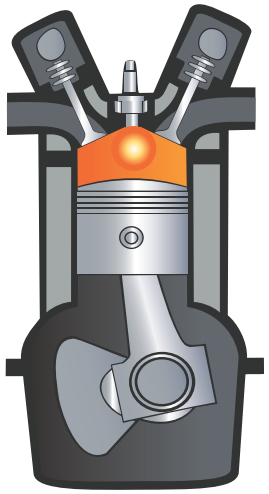
Carbon Capture

EOR



Storage

LCFS



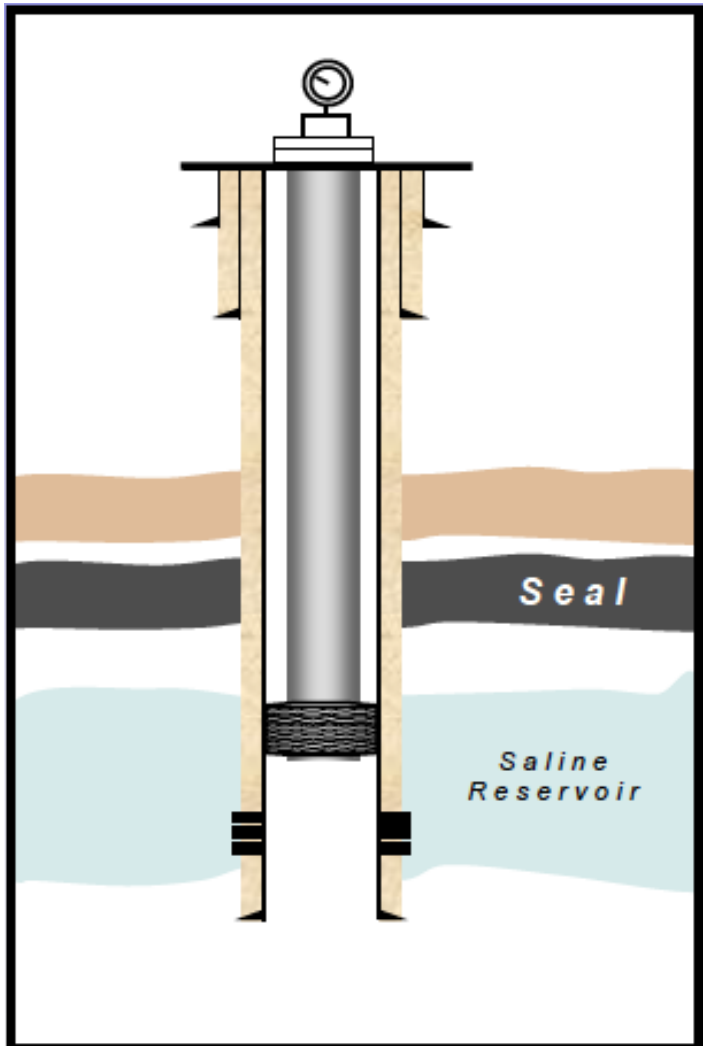
Utilization

Source: Katherine Hornafius 13th Annual Carbon Capture, Utilization & Storage Conference - April 28-May 1, 2014 - Pittsburgh, PA

CCS in Saline Reservoirs vs. Oil Reservoirs

Saline Reservoirs

- Saline reservoir is *unconfined*, so plume modeling and monitoring is required
- Integrity of the seal is **unknown**, so risk of geological confinement failure exists
- **Limited experience** with CO2 injection into saline reservoirs, so *no history* of potential problems to guide practices
- EPA requires **Class VI** well construction and monitoring for CO2 sequestration in saline reservoirs
- ***No commercial benefit*** to injecting into saline reservoirs without carbon credits or tax incentives

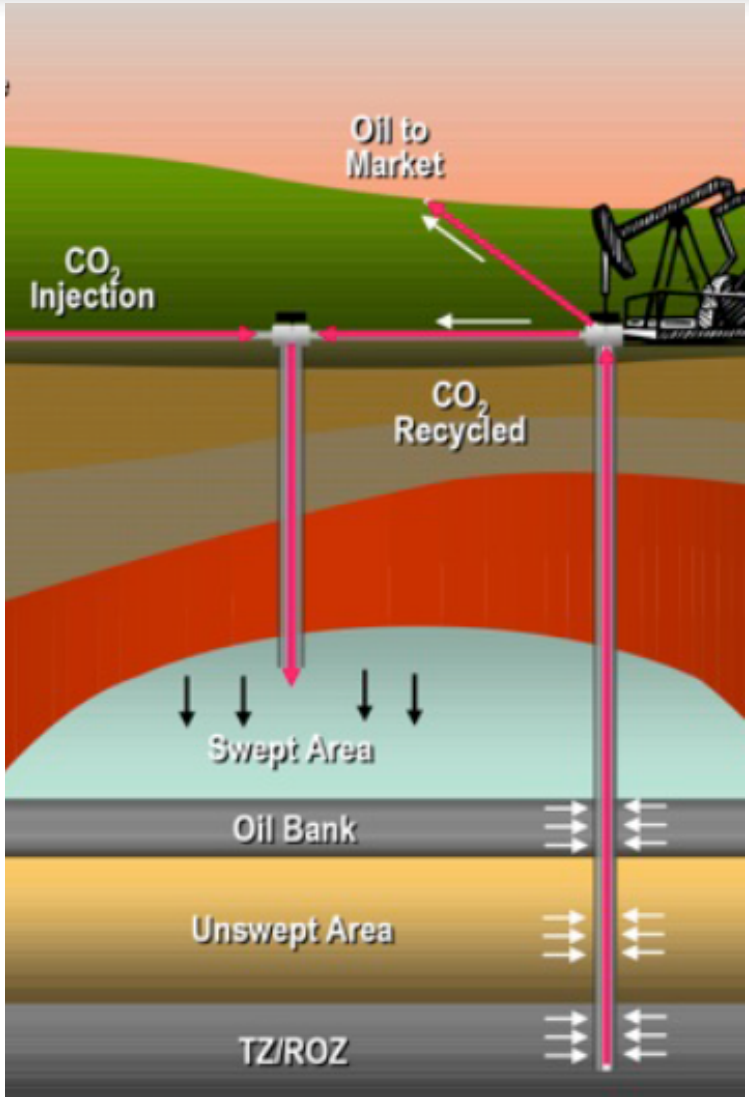


Source: Kuuskraa et al., Mississippi Saline Reservoir Test, CCS Conference, Pittsburgh, May 7-10, 2007

CCS in Saline Reservoirs vs. Oil Reservoirs

Oil Reservoirs

- Oil reservoir is *confined*, or hydrocarbon accumulation would not exist
- Integrity of the seal is **proven**, so low risk of geological seal failure
- **40 years of experience** with CO2 injection into oil reservoirs, so there is *extensive history* with potential problems to guide best practices
- EPA endorses use of **Class II** wells for CO2 storage until oil field is abandoned
- Oil revenue from sequestration makes projects ***commercially possible***, especially if no new wells are needed



Underground Injection Control (UIC)

- Regulations promulgated by the Safe Drinking Water Act (**SDWA**)
- EPA rules for UIC found in **Title 40 (Part 144-148)** of the Code of Federal Regulations
- Administered under **UIC Programs** in most states by that state's Department of Environment Quality (DEQ), Department of Natural Resources (DNR), or Department of Conservation (DOC), which also regulate the oil and gas drilling and production activities in that state
- UIC Program in California is administered by **DOGGR** (Department of Oil, Gas & Geothermal Resources) in consultation with **SWRCB** (State Water Resources Control Board)

Distinctions between Class II vs. Class VI Wells

Class II Wells (CO_2-EOR Projects)	Class VI Wells (Saline Reservoirs)
Class II wells are for fluids for EOR (CO_2, brine) and liquid hydrocarbon storage	Class VI wells are a new category instituted in 2010 for CO_2 long-term storage but not CO_2-EOR wells
Most states have primacy over UIC wells and use Class II well permits to regulate EOR	EPA currently regulates all Class VI wells, but is encouraging states to apply for primacy
Area of Review is minimum 1/4-mile radius around Class II injector or defined by limits of CO_2-EOR project	Area of Review is undefined for Class VI wells since the reservoir is uncontained (need to model plume)

Source: Durrant & Mowry, Applying Federal Environmental Laws to CO_2 Enhanced Recovery. May, 2015
Source: "Well Integrity in CCS/CCUS Projects, DOE Presentation"

EPA Memorandum Regarding Key Principles in UIC for CO2 Storage

Class II wells authorized for long-term CO2 storage

- Geologic storage of CO2 can continue to be permitted under the UIC Class II program
- CO2 can be safely stored where injected through Class II-permitted wells
- Class VI site closure requirements are not required for Class II CO2 injection operations
- EPA encourages states to apply for primacy for all well classes, including Class VI. States approved for primacy are expected to administer the program through their oil and gas program.

Source: EPA Memorandum from Peter Grevatt, Director of Ground Water and Drinking Water, April, 2015

Legacy Wells as Candidates for Conversion for CO2-EOR

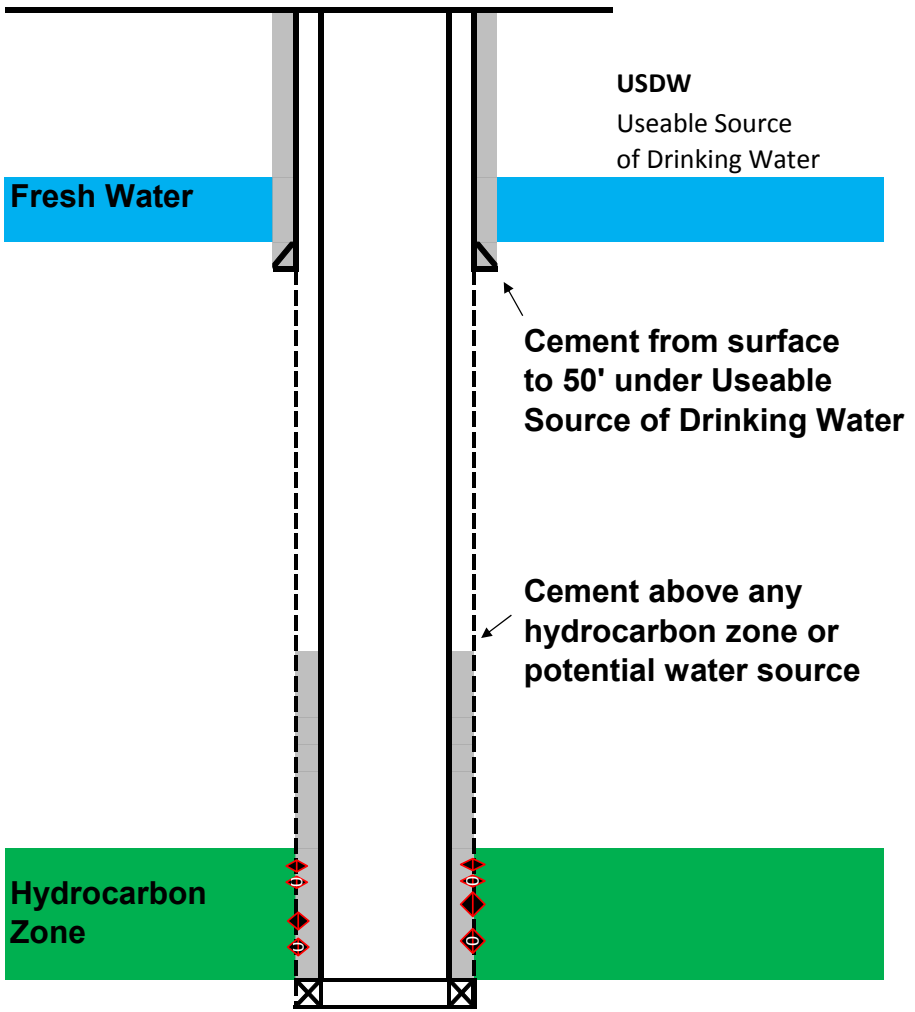
Criteria for Conversion from Oil Well to CO2 - EOR Well

- Surface casing set & cemented 50 feet below lowest Useable Source of Drinking Water (USDW)
    - This will protect all known fresh water aquifers
- Production casing should be cemented from TD to above any hydrocarbon zone or potential water source
    - This will protect other reservoirs from EOR processes

Mechanical Integrity Test (MIT)

- Required to demonstrate mechanical integrity of Legacy Wells

Casing and Cement Diagram



Best Practices for CO2-EOR Well Configuration & Monitoring

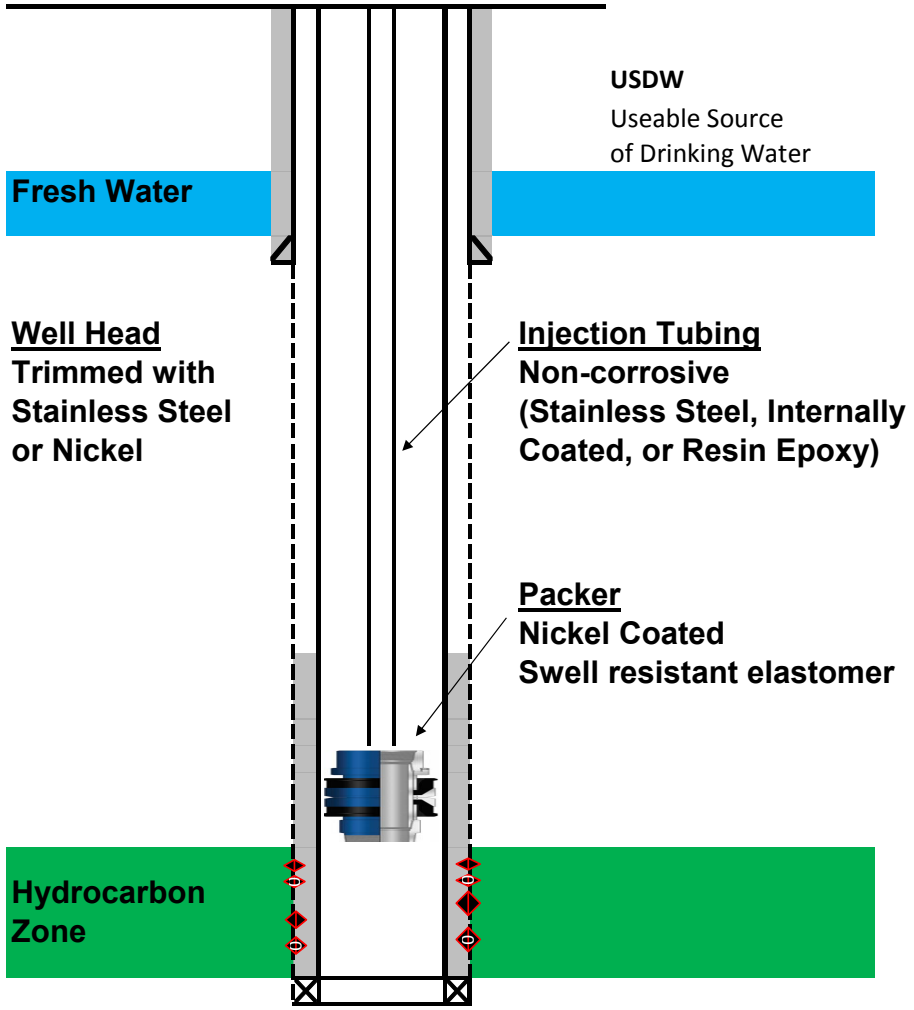
Configuration

- New non-corrosive tubing and packer for primary pressure barrier
- New well head with corrosion resistant materials

Monitoring

- Monitor pressure of the injection tubing (primary barrier), casing (secondary barrier), and annulus
- Provides identification of any potential leaks from the primary barrier to the secondary barrier
- Monitoring should continue for the life of the CO2-EOR project

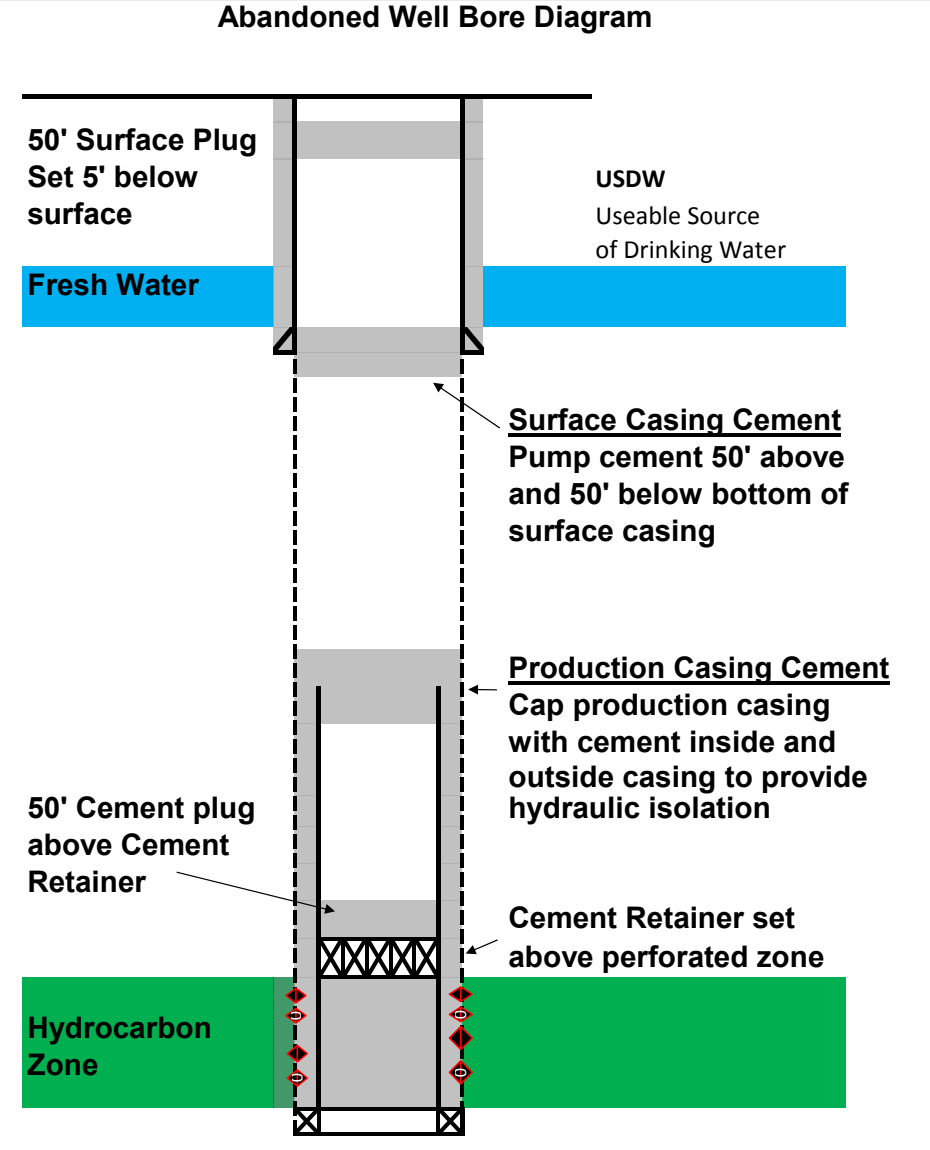
Tubing and Packer Diagram



Best Practices for P&A'ing a CO2-EOR Well (Class II)

Plugging and Abandonment

- Squeeze perforations with acid resistant cement under pressure from the Cement Retainer
- Cover the Cement Retainer with 50' of additional acid resistant cement
- Cut and pull production casing above perforations
- Cap the production casing with acid resistant cement for internal and external hydraulic isolation
- Fill the lower 50' of surface casing with acid resistant cement as well as the next 50' below the surface casing to provide internal and external hydraulic isolation
- Fill the upper 50' of surface casing with acid resistant cement to provide hydraulic isolation



Ownership, Management, and Liability for Sequestered CO2

- The fundamental challenge is that CO2 will remain sequestered infinitely, while corporate lifetimes are getting much shorter
- This has led to various proposed solutions to the problem of long-term stewardship for sequestered CO2

Issue	During CO2 Injection and Oil Production	After Oil Production Ceases
Ownership of CO2	EOR Company	Transfer to State, after 10 or more years (e.g., Texas, Montana, Louisiana)
Monitoring and Management of Sequestered CO2	EOR Company	Transfer to state or federal agency, after some period, paid for by Trust Fund created by sequestration operators
Liability for Sequestered CO2	EOR Company, covered by traditional insurance products	Lack of insurance market solutions leads to two tier solution, with industry Trust Fund taking first loss, and government taking residual loss

Recommendations on CCS Rules for Carbon Credit Qualification

In order to encourage the implementation of CCS the ARB should consider:

- Establishing a set of criteria under which CO2-EOR projects would qualify for CCS credits under AB32 before project start-up, so that the pathway to obtaining carbon credits is clear

- Allowing Class II wells to qualify for CCS credits in CO2-EOR projects until project abandonment (following the EPA ruling)

- Organizing an insurance pool to handle long-term CO2 leakage risk so that cost is spread over many projects and potential leakage of CO2 is accounted for in the carbon credit allocation methodology