Carbon Dioxide Enhanced Oil Recovery (CO_2-EOR):
A Threat to Drinking Water and the Environment

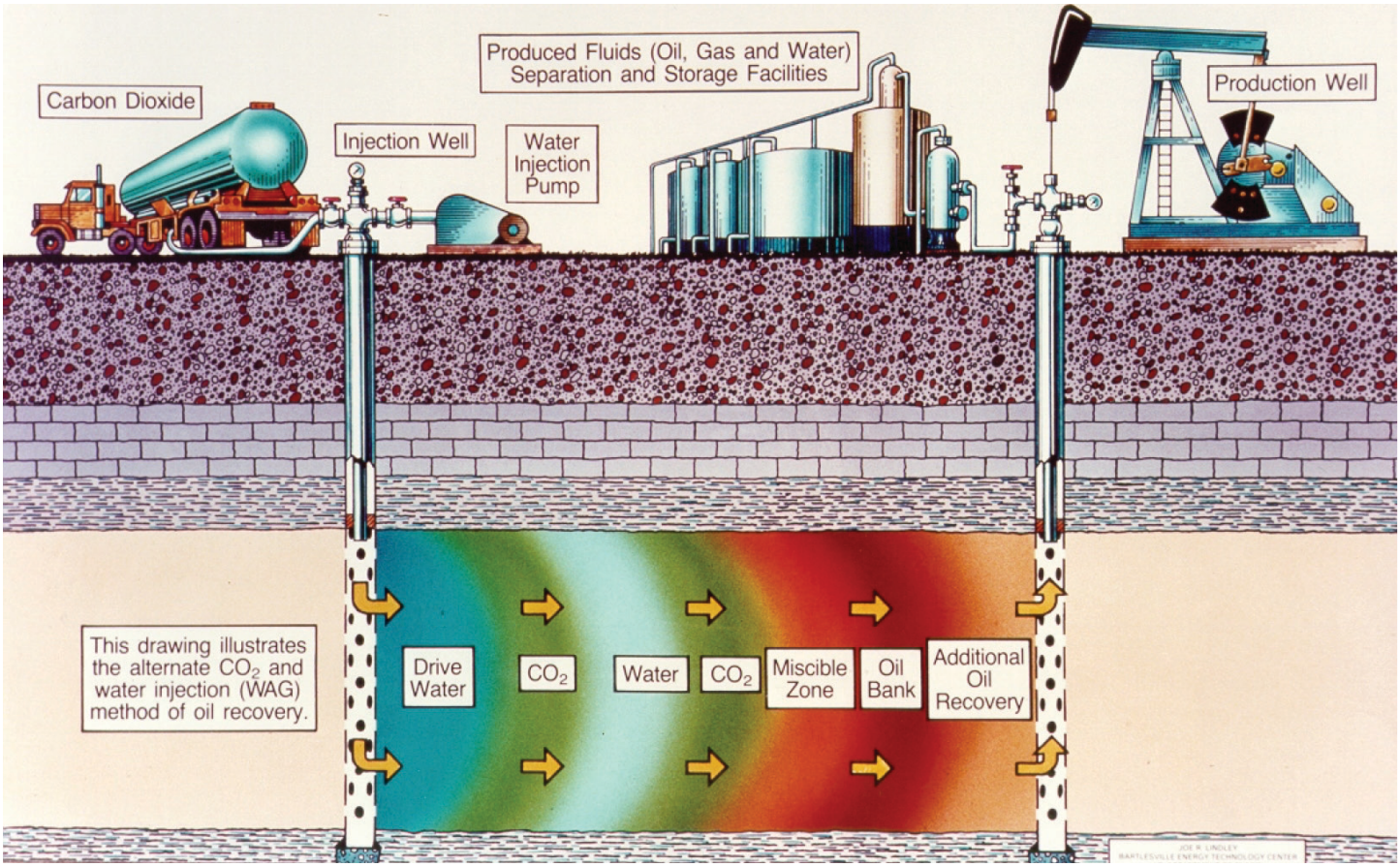
The most common use of captured carbon dioxide (CO_2) is enhanced oil recovery, or EOR. While carbon capture utilization and storage (CCUS) may prove to be a viable strategy for addressing climate change, using captured carbon to increase the production of fossil fuels — i.e. oil and gas — runs counter to, and undermines the climate mitigation goals of carbon capture and storage. At the same time, CO_2-EOR presents risks to groundwater, the surface environment, and the health of communities living near oil fields. As a known threat to drinking water sources, enhanced oil recovery is regulated by the federal Safe Drinking Water Act (SDWA) Underground Injection Control (UIC) program. Our research has found this program to be inadequate in protecting groundwater, relying on outdated rules, and insufficient data collection and staffing levels to ensure safety.

What is CO_2-EOR?

CO_2-EOR includes several specific oil production methods that involve the injection of CO_2 into oil-bearing formations through injection wells. Together these technologies account for approximately 5% of US oil production associated with more than 13,000 CO_2 injection wells.[1] The main CO_2-EOR technologies include:

- Continuous CO_2 injection;
- Continuous CO_2 injection followed by water injection;
- Water-alternating-gas (WAG) injection, the most common form of CO_2-EOR, in which either fresh water or produced water (oil field wastewater) is injected in intervals between CO_2 injections;
- WAG followed by gas, in which a cheaper gas such as nitrogen is injected following the CO_2 injection cycle.

Schematic of water-alternating-gas (WAG) CO_2-EOR operation



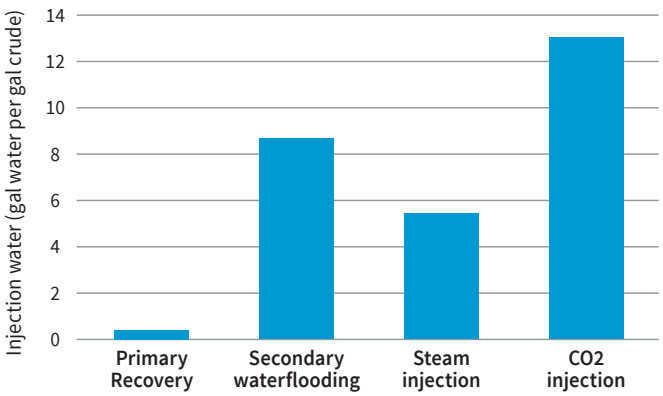
Source: Department of Energy, National Energy Technology Laboratory

1 Meyer, James P. American Petroleum Institute. *Summary of Carbon Dioxide Enhanced Oil Recovery (CO2EOR) Injection Well Technology.* American Petroleum Institute. http://www.api.org/~/media/Files/EHS/climate-change/Summary-carbon-dioxide-enhanced-oil-recovery-well-tech.pdf

Environmental Risks of CO_2-EOR

CO_2-EOR presents many of the same environmental risks and threats to drinking water as other oil and gas production activities including hydraulic fracturing and conventional drilling, such as:

- Improper disposal and spills of chemicals, produced water and other wastes impacting surface and/or groundwater, air, and land;
- Well failures, leaks or breaches causing groundwater contamination;
- Migration of chemicals, wastewater or oil and gas through natural pathways or idle/abandoned wells; and
- Water consumption, acquisition, and competition with other uses.



Water Injection Volumes by Recovery Technology[3]

CO_2-EOR also presents unique threats to water and the environment:[2]

- CO_2-EOR is one of the most water intensive forms of oil production, requiring an estimated 13 barrels of water for every barrel of oil produced on average, more than other forms of EOR.[3] EOR may utilize freshwater, which can present competing supply issues in water scarce areas. Most commonly though, EOR utilizes oil field wastewater, also known as produced water, which can be high in naturally occurring or added chemicals. Injecting, separating and disposing of high volumes of contaminated fluids presents risk of spills and leaks, and management challenges.
- Since EOR often occurs in older oil fields, outdated well construction standards not designed for CO_2-EOR conditions may increase risk of equipment or well failures.
- Blowouts from CO_2-EOR injection can and do occur. While there is a lack of comprehensive data on the risk or frequency of blowouts, numerous CO_2-EOR blowouts have been recorded over the last 30 years.
- When CO_2 reacts with water in oil-producing formations, carbonic acid is produced, creating a corrosive environment. This reaction increases the risk of degradation and corrosion of equipment, and amplifies the threat of leaks and blowouts.
- The acidic environment can mobilize and dissolve elements and compounds that can impact drinking water sources, such as boron, barium, calcium, chromium, strontium, depending on the formation.
- Blowouts can pollute the surface environment if produced fluids, oil, and drilling muds are brought up the well are discharged. In 2011, a 37-day long blowout of a Denbury Resources well in the Tinsley Field, Mississippi, resulted in the removal of 27,000 tons of contaminated soil and 32,000 barrels of contaminated fluids.
- Blowouts can also impact air quality. In addition to reversing any potential climate benefits of CO_2 injection, large CO_2 releases can harm local wildlife and people. The Tinsley Field blowout led to health impacts for first responders and oil field workers, and the asphyxiation of animals in the area.

Finally, since CO_2-EOR often extends the life of an oil field, sometimes by decades, the threats to water, air, land, and health, are all extended. Research has found that older oil fields have increased environmental (including climate) impacts, as dirtier, harder to reach oil is produced. More energy is required to extract and refine crude from older oilfields.[4] Additionally, as equipment ages, the likelihood of failures, spills, and leaks increases.

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2 For a deeper discussion of threats to water and regulatory issues with CO2-EOR, see the report *The Environmental Risks and Oversight of Enhanced Oil Recovery in the United States* available at: www.cleanwater.org/eor-risks

3 Wu, May and Yiwen Chiu. *Consumptive Water Use in the Production of Ethanol and Petroleum Gasoline – 2011 Update.* Argonne National Laboratory, 2011

4 Masnadi and Brandt. *Climate impacts of oil extraction increase significantly with oilfield age.* Nature Climate Change. July 17, 2017 https://www.nature.com/articles/nclimate3347