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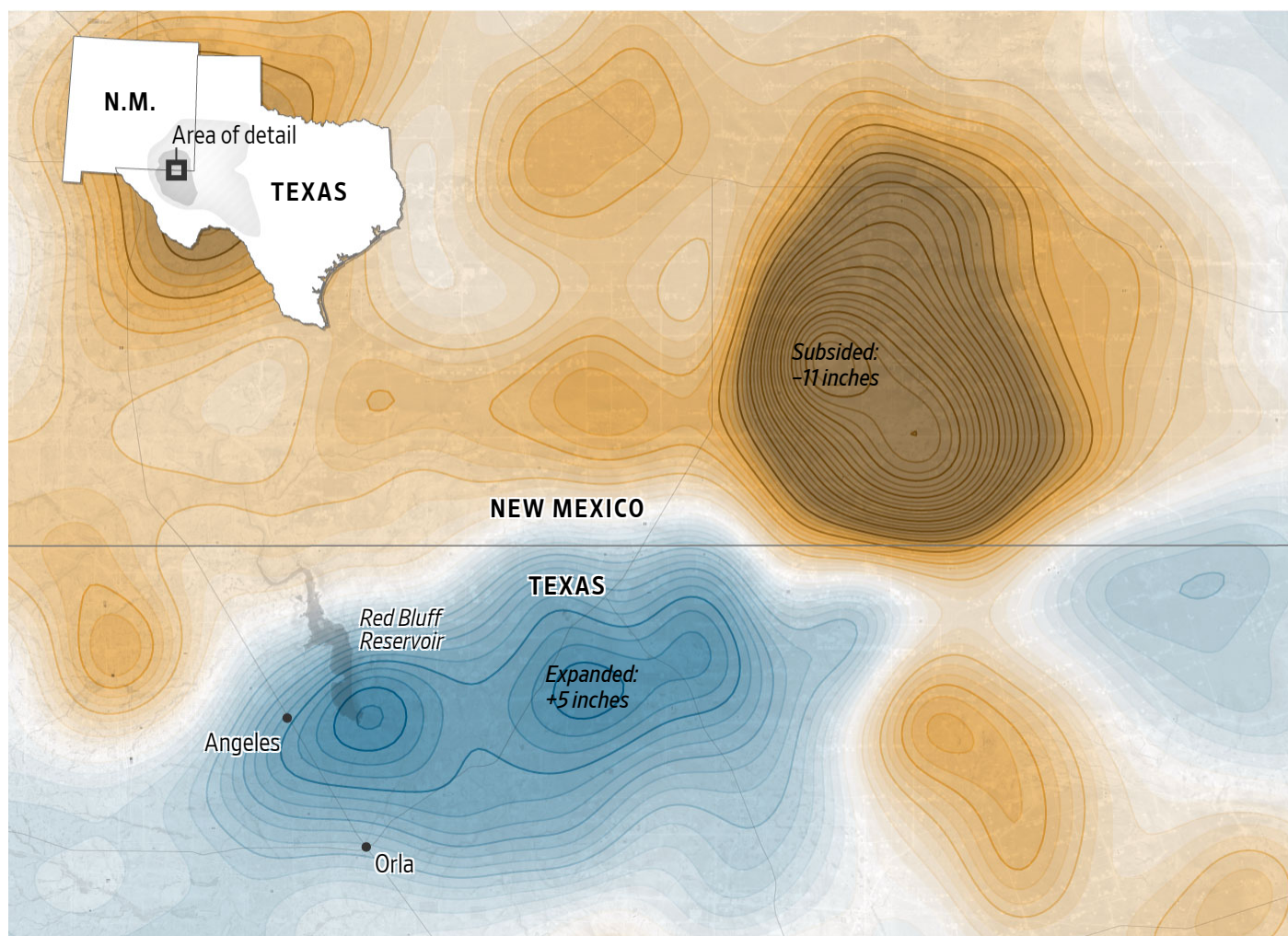
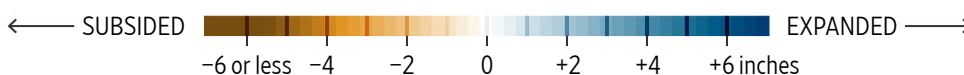
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BUSINESS | ENERGY & OIL

In America's Biggest Oil Field, the Ground Is Swelling and Buckling

Satellite data reveal the impact of oil and gas drilling on the Permian Basin's landscape; earthquakes, pressure increases have local communities worried

Surface displacement, May 2015 to January 2024



Source: SkyGeo

By *Benoît Morenne* [Follow](#) and *Andrew Mollica* [Follow](#)

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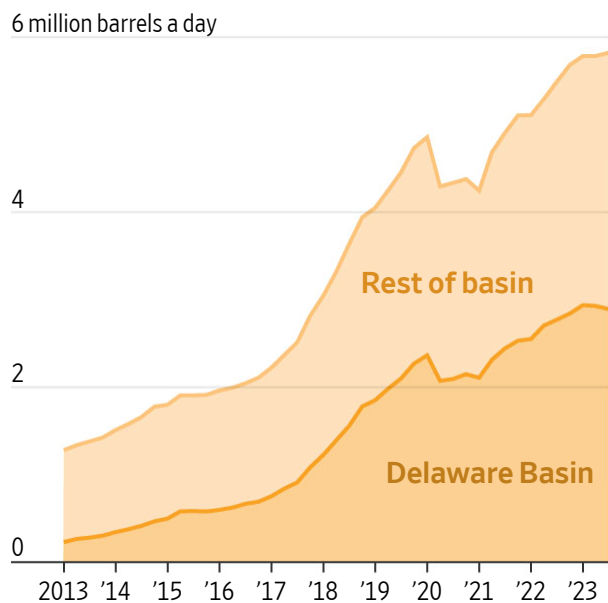
In a desolate stretch of desert spanning West Texas and New Mexico, drillers are pumping more crude than Kuwait. The oil production is so frenzied that huge swaths of land are literally sinking and heaving.

The land has subsided by as much as 11 inches since 2015 in a prime portion of the Permian Basin, as drillers extract huge amounts of oil and water, according to a Wall Street Journal analysis of satellite data. In other areas where drillers dispose of wastewater in underground wells, the land has lifted by as much as 5 inches over the same period.

The constant extraction and injection of liquids has wrought complex geologic changes, which are raising concerns among local communities long supportive of oil and gas. Earthquakes linked to water disposal have rattled residents and prompted state regulators to step in. Some researchers worry that wastewater might end up contaminating scarce drinking-water supplies.

“They’re affecting the geology of the ground, the surface,” Ty Edwards, a Pecos County, Texas, resident who helps manage groundwater in the region, said of oil producers. “That is pretty wild.”

Oil production in the Permian Basin



Source: Enverus

The tumultuous landscape is a direct result of industrial-scale drilling in the Delaware portion of the Permian Basin. Oil production has reached nearly three million barrels of oil a day there, cementing the U.S.’s status as an energy power and fueling the region’s economic engine.

Alongside crude, oil-and-gas companies are extracting gargantuan amounts of subterranean water—in the Delaware, between five and six barrels of water are produced, on average, for every barrel of oil. To dispose of it, they inject billions of barrels of putrid wastewater into underground disposal wells.

Some scientists say the ground displacement, shown in data provided by Earth observation company SkyGeo, could impact infrastructure such as roads. But what frackers and researchers are most concerned about

are the forces pushing the ground up.

Environmental groups say Texas regulators' oversight of the industry is falling short and that it is time for the federal government to intervene.

Oil executives, meanwhile, say the issue of water disposal is having an impact on their bottom line, driving up the costs for new wells. They also fear that, if left unmanaged, it could dent local support for their activities.

"Produced water management is probably one of the, if not the biggest, challenge in the Permian," said Cody Comiskey, an earth-science adviser at Chevron.

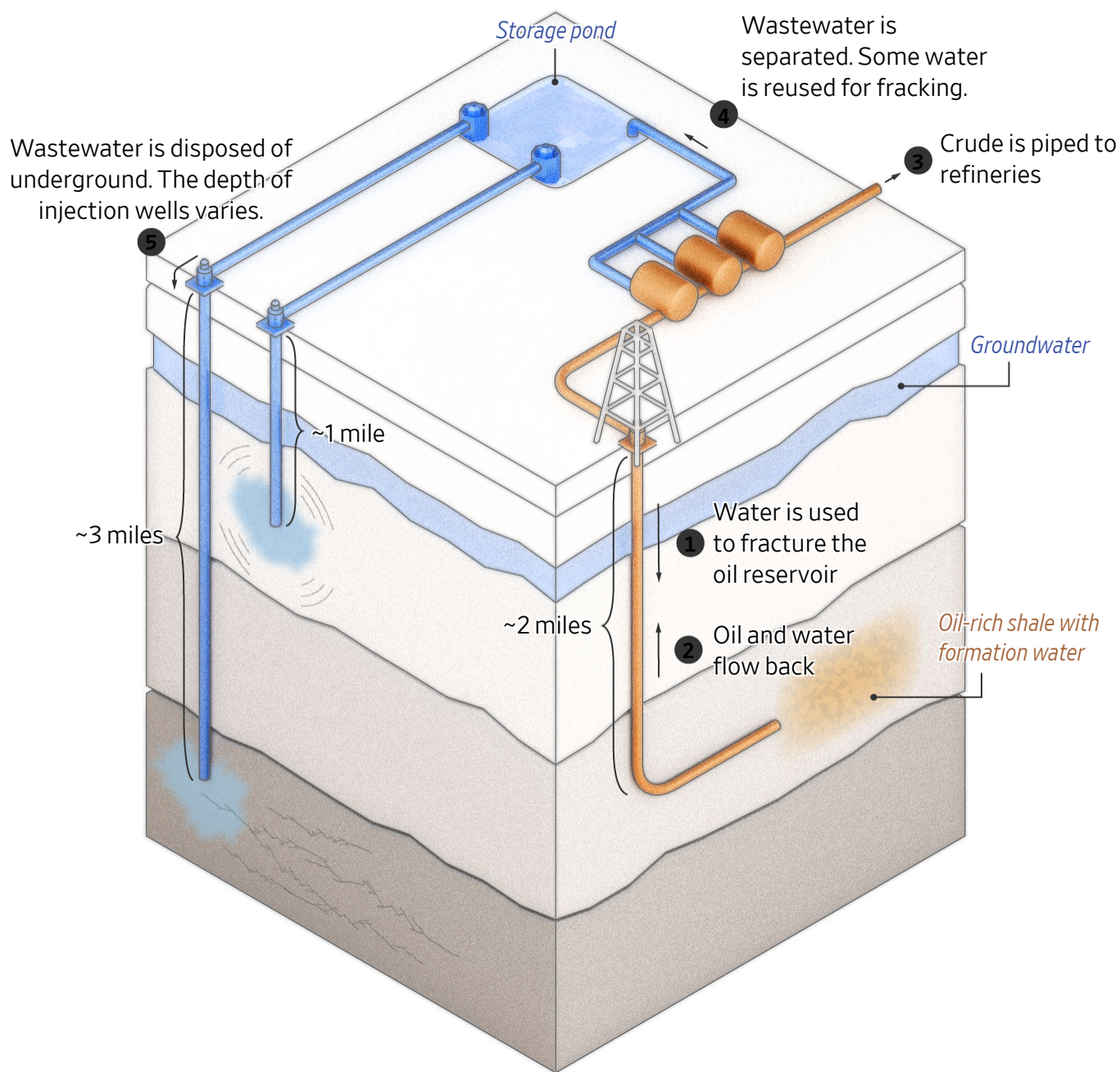
Oil and gas activities have long reshaped the landscape of energy-rich locales. In the last century, crude production caused the ground in and around California's Port of Long Beach to sink as much as 29 feet, causing billions in today's dollars in damages and repairs to public and private property. More recently, the Netherlands began shutting Europe's biggest natural-gas field after earthquakes tied to gas extraction led to a public outcry.

When the shale boom breathed new air into the Delaware about 10 years ago, the basin produced under 500,000 barrels of oil a day, according to analytics firm Enverus. Today, companies there churn out roughly a quarter of all U.S. crude production.

As a result, the volume of briny, polluted water that companies have to handle has skyrocketed. In 2013, companies discarded about 382 million barrels of water, according to water analytics firm B3 Insight. Last year, they injected about 3.4 billion barrels of water down disposal wells. That is about as much water as New York City consumes in roughly five months.

Frackers inject most of this water down wells that reach about a mile under the surface, which is convenient and relatively cheap. Drilling clusters of injection wells means companies don't have to build expensive pipelines to link disposal sites together. But concentrated volumes of water increase pressure underground, which then makes it more difficult for companies to drill down through those levels to shale rocks.

Oil extraction and wastewater disposal



Note: Not to scale.

Companies are having to make significant adjustments because of the pressure changes. Occidental Petroleum, for instance, is building more robust wells to account for increased pressure, said Jeff Simmons, the company's chief petrotechnical officer. One way Occidental is making wells sturdier is by adding strings of casing to reinforce the wells' structure.

Company executives didn't specify what the cost of re-engineering was. When Pioneer

Natural Resources, another producer, in 2017 reported encountering pressure changes in the Midland portion of the Permian, it said it was spending about an additional \$300,000 to \$400,000 per well.

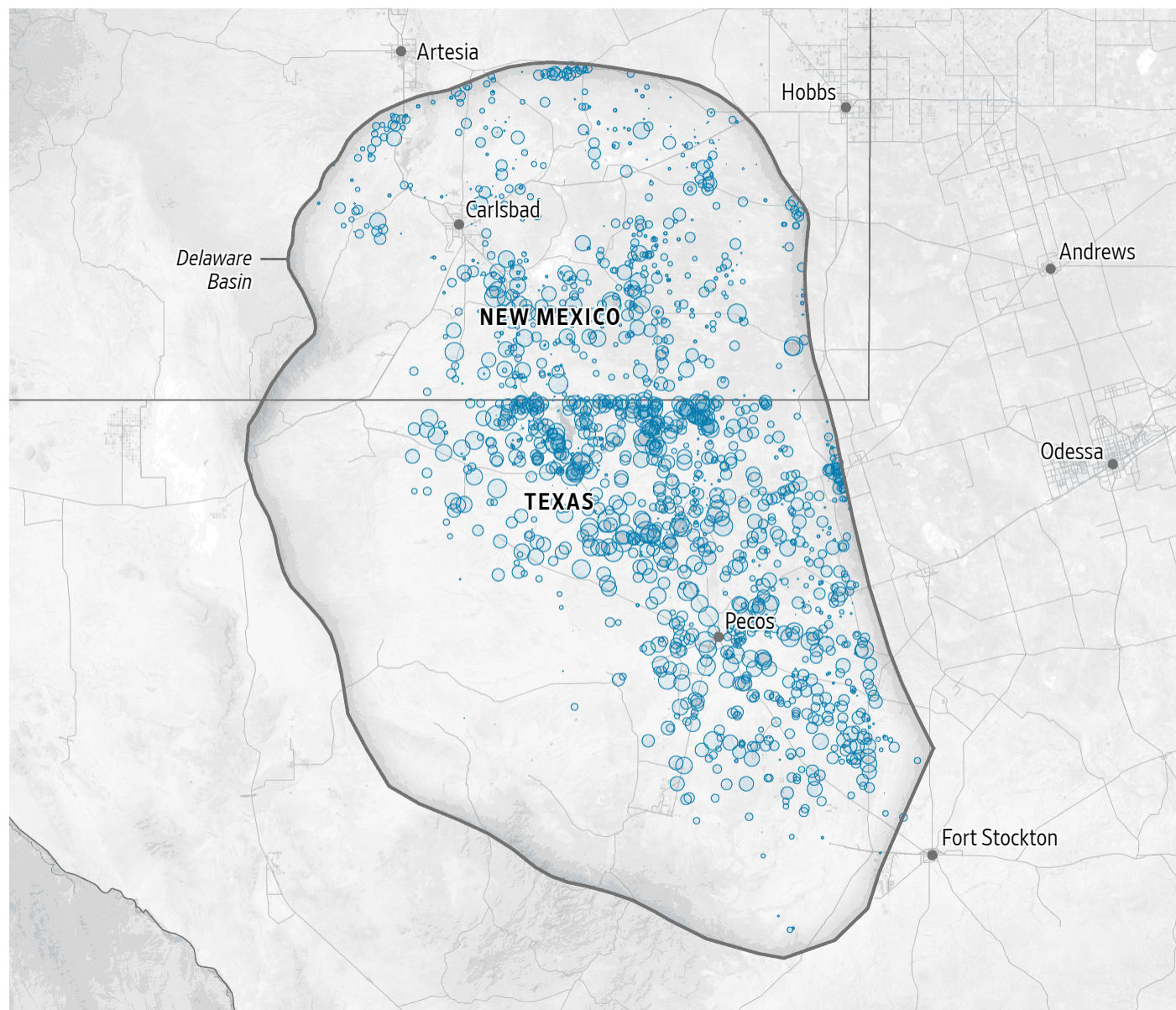
Mounting pressure also limits how much water companies can dispose of and forces them to use more energy to push fluids through, executives said.

Water-disposal injection wells in the Delaware Basin

Cumulative volume since start of 2010, millions of barrels

○ 75 ○ 50 ○ 10

2023



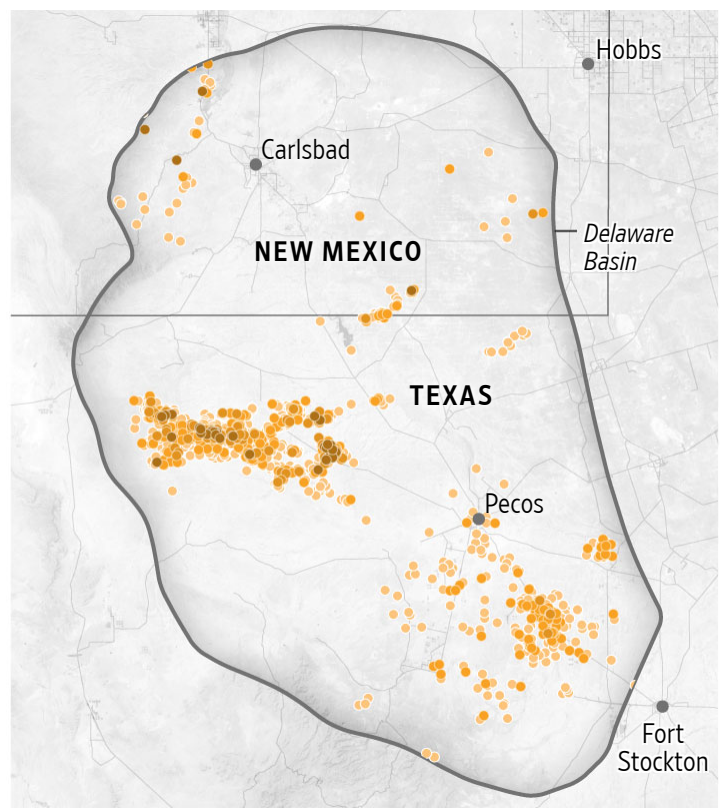
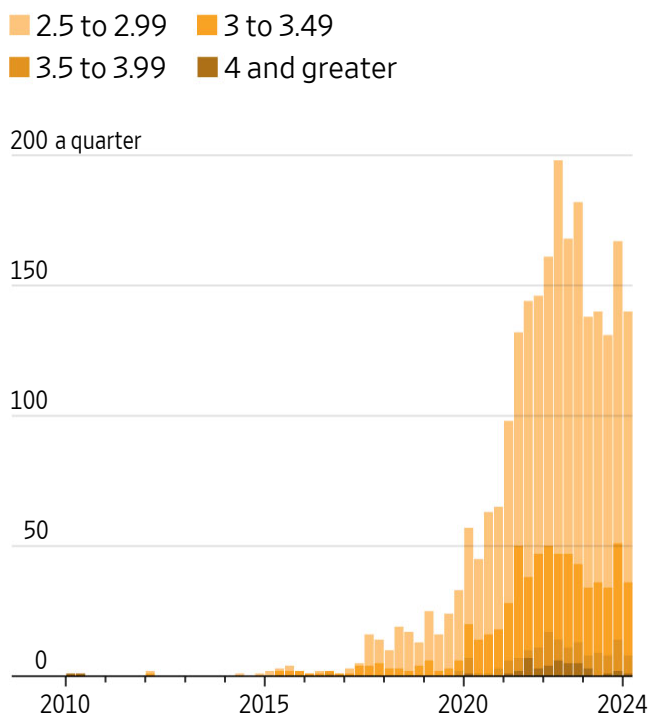
Source: B3 Insight (water disposal); U.S. Energy Information Administration (Delaware Basin)

Companies have also been injecting a smaller portion of the unwanted water well below

crude reservoirs, at deeper depths of around 3 miles. Deep injection wells are much more expensive than shallow ones, but they allow frackers to dump more water and do so in a way that doesn't affect subsequent drilling. But there is a catch: The water can cause deep-rooted faults to slip, creating earthquakes.

The number of earthquakes in the Permian with magnitudes greater than 2.5 jumped from 42 in 2017 to 671 in 2022, according to B3 Insight. In late 2022, a 5.4-magnitude earthquake in Reeves County, Texas, sent tremors felt as far as Dallas, El Paso and San Antonio, where it damaged a historical building.

Earthquakes in the Delaware Basin by magnitude, 2010-24



Note: Excludes earthquakes with magnitudes less than 2.5.
Sources: U.S. Geological Survey (earthquakes); U.S. Energy Information Administration (Delaware Basin)

Texas regulators have imposed restrictions on injection volumes in the region, and the number of magnitude-3.5 earthquakes and higher has come down. Local communities are gearing up for more shakes. In Pecos City, a city of about 13,000 in West Texas, around 145 municipal employees will receive earthquake-preparedness training, said City Manager Charles Lino.

“That is the necessity we have to live with,” he said.

Drillers said they are allocating more cash and brain power to navigate pressure and

seismicity issues. Chevron has formalized a team with a budget that conducts reservoir studies and looks at ways to reuse more wastewater, among other things, said Chevron's Comiskey.

A growing concern for residents and scientists is that wastewater could migrate into the aging, unplugged wells that litter the Permian by the thousands and contaminate drinking-water supplies or shoot to the surface, where the fluids could damage ranchland.

Advocacy groups have asked the federal government to review how the state is regulating water injection in the region. The Environmental Protection Agency has said it would review the groups' petition.

With shrinking options to discard wastewater, crude producers have to get creative. Some are looking for lower-risk formations to inject water into and ways to treat water so it can be reused for agriculture. Whether these efforts will pass regulatory muster or how much they will cost remains unclear.

"There's just no silver bullet," Comiskey said.

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