



**Moving Beyond Induced Seismicity  
in the Permian**

**Water Solutions for the Future**

**John Sullivan, P.G.-SCS Engineers**

# TOPICS

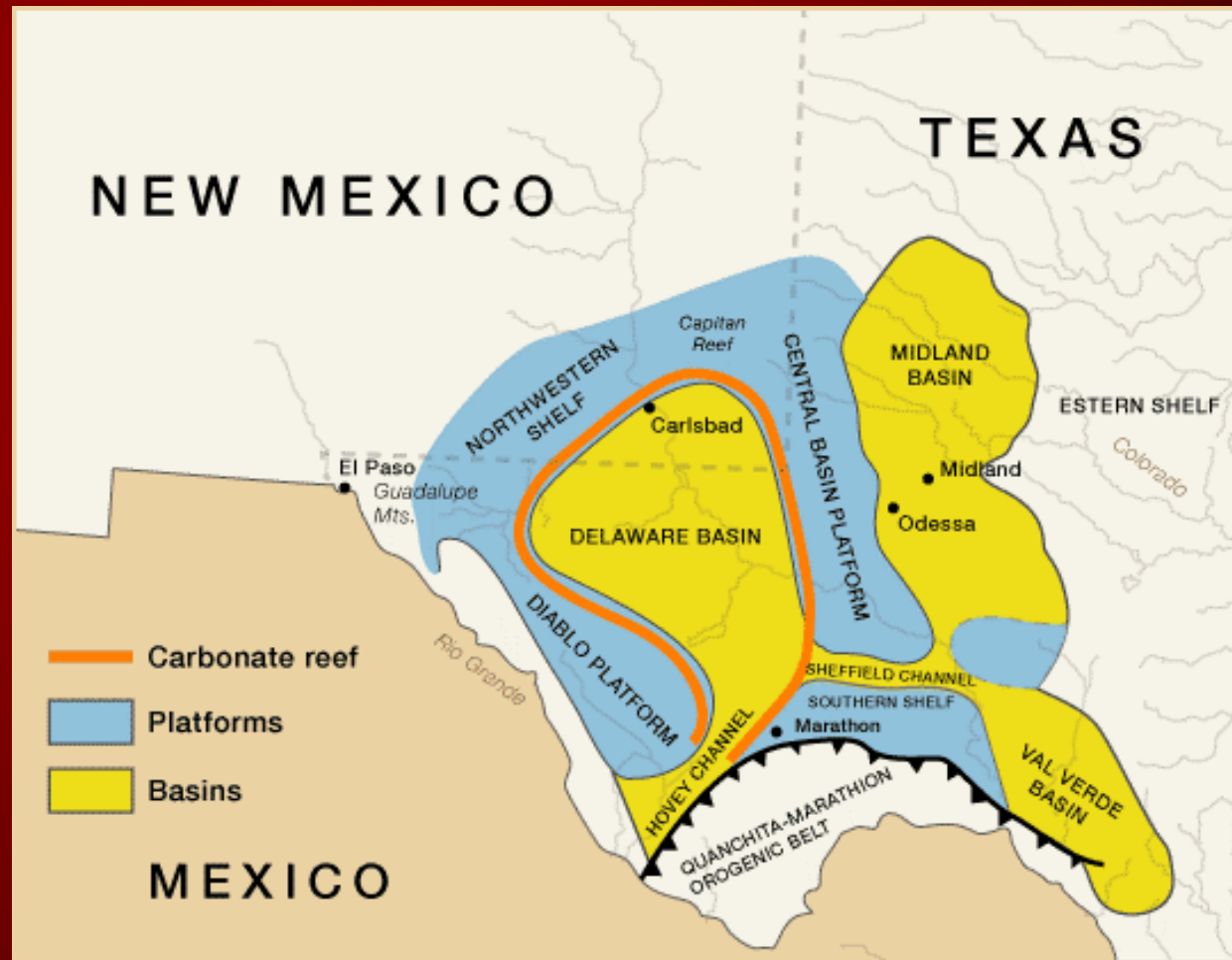
- Why is there so much water?
- Where can we put it when done?
- What does that do?
- Are there alternatives?
- How do we do it?



# THE PERMIAN BASIN

BUSIEST OIL PATCH IN THE US

HOSTS MORE  
THAN HALF  
THE RIGS IN  
THE US

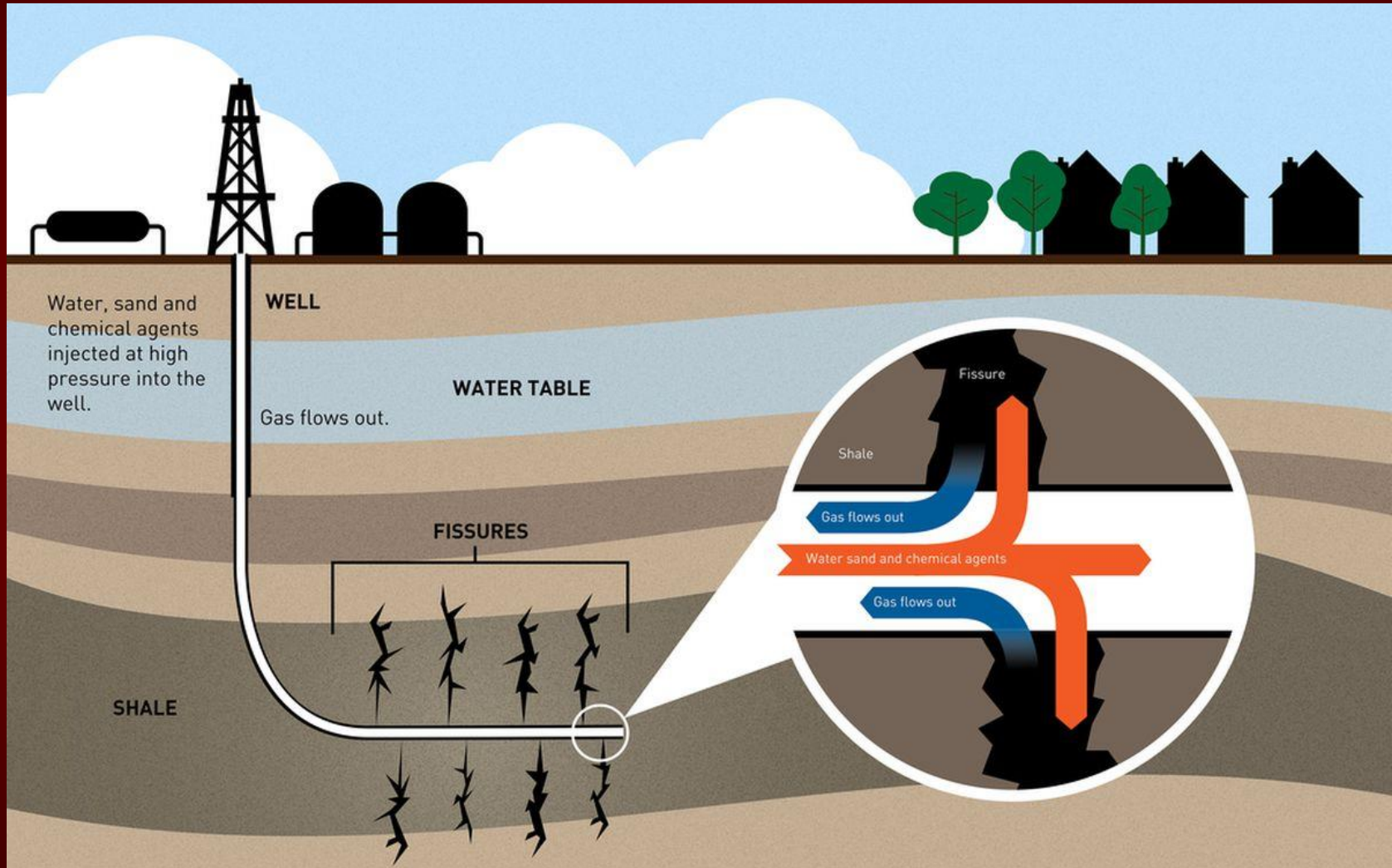




# PRODUCTION GENERATES PRODUCED WATER



# FRACKING HAS LED TO A BUSINESS EXPLOSION IN THE PERMIAN BASIN











# FRACKING HAS LED TO A BUSINESS EXPLOSION IN THE PERMIAN BASIN



**Texas, By Itself, Is Now The World's Third  
Largest Oil Producer**

**5 Millions Barrels/Day**



# THIS IS HOW WATER TRADITIONALLY GETS TO FRACK SITES





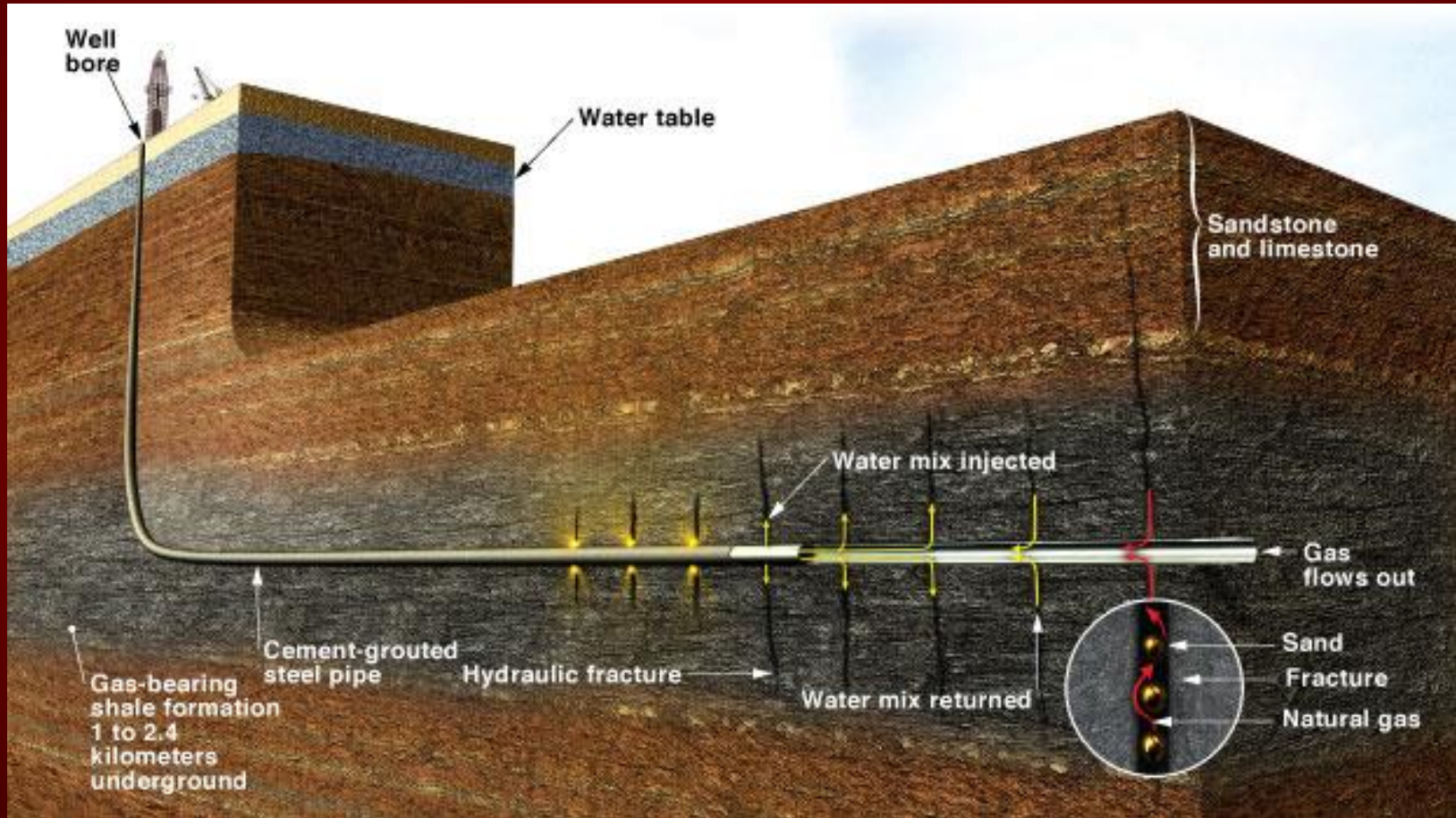


# WATER USE PER WELL IS RAPIDLY INCREASING

- First fracked wells required about 1 million gallons
- 10 million gallons per well is now common
- 100 million gallons is forecast

# WHY IS PER-WELL WATER USAGE RAPIDLY INCREASING?

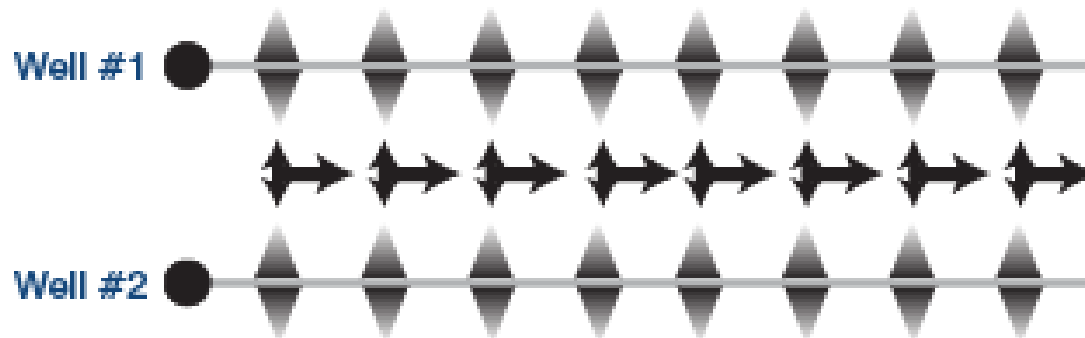
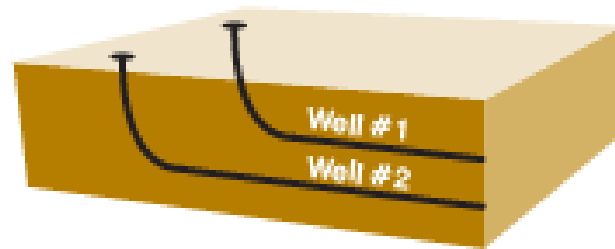
Laterals are growing in length....





# WHY IS PER-WELL WATER USAGE RAPIDLY INCREASING?

## ZIPPER FRACKING 2 WELLS AT THE SAME TIME



A photograph of an industrial site, likely an oil field, under a bright blue sky with scattered white clouds. In the foreground, there is a dirt road and some green grass. A chain-link fence runs across the middle ground. In the background, several oil pumps (jack-o'-lanterns) are visible, along with a power line tower and a substation. The text "NESTED LOCATION" is overlaid in the center of the image.

# NESTED LOCATION



# WHAT DO WE DO WITH OUR WASTES?

**OIL AND GAS WASTE FLUIDS HAVE HISTORICALLY BEEN DISPOSED IN CLASS II INJECTION WELLS**

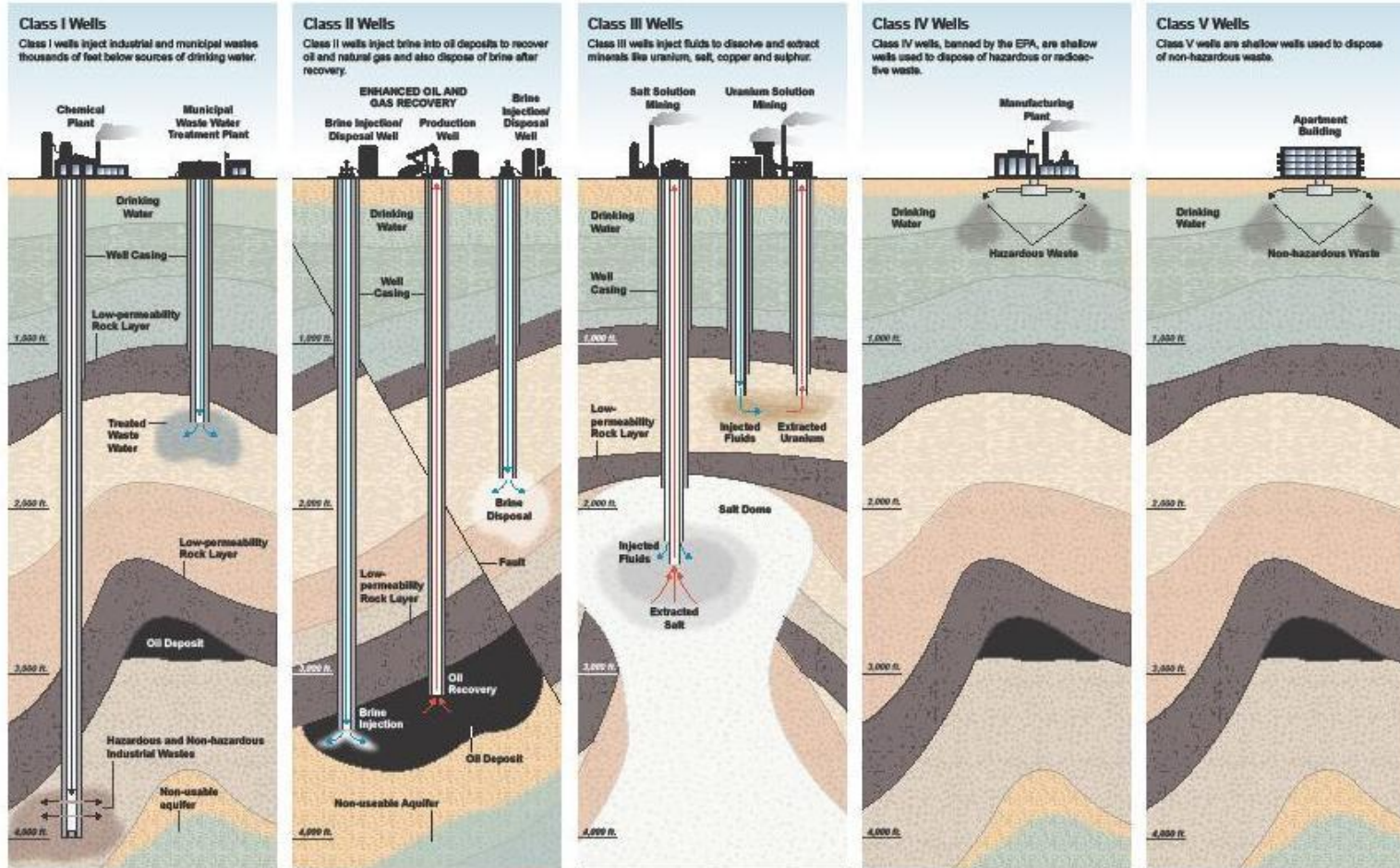


# SALTWATER DISPOSAL



# BASICS OF DEEP WELL INJECTION

## Classes of Injection Wells



Credit: Graphic by Al Granberg for ProPublica.

Source: R. Laurence Davis, Ph.D., University of New Haven; E.P.A.

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## Class II Wells



# INDUCED SEISMICITY

## **“EARTHQUAKES CAUSED BY HUMAN ACTIVITY”**

Oklahoma: Earthquakes measuring  $> 3.0$  surged from two in 2008 to about 900 in 2015

In the Permian Basin, earthquakes  $>2.5$  have tripled to more than 60 in a year

# WIKIPEDIA PAGE: 2009–19 OKLAHOMA EARTHQUAKE SWARMS



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## 2009–19 Oklahoma earthquake swarms

From Wikipedia, the free encyclopedia

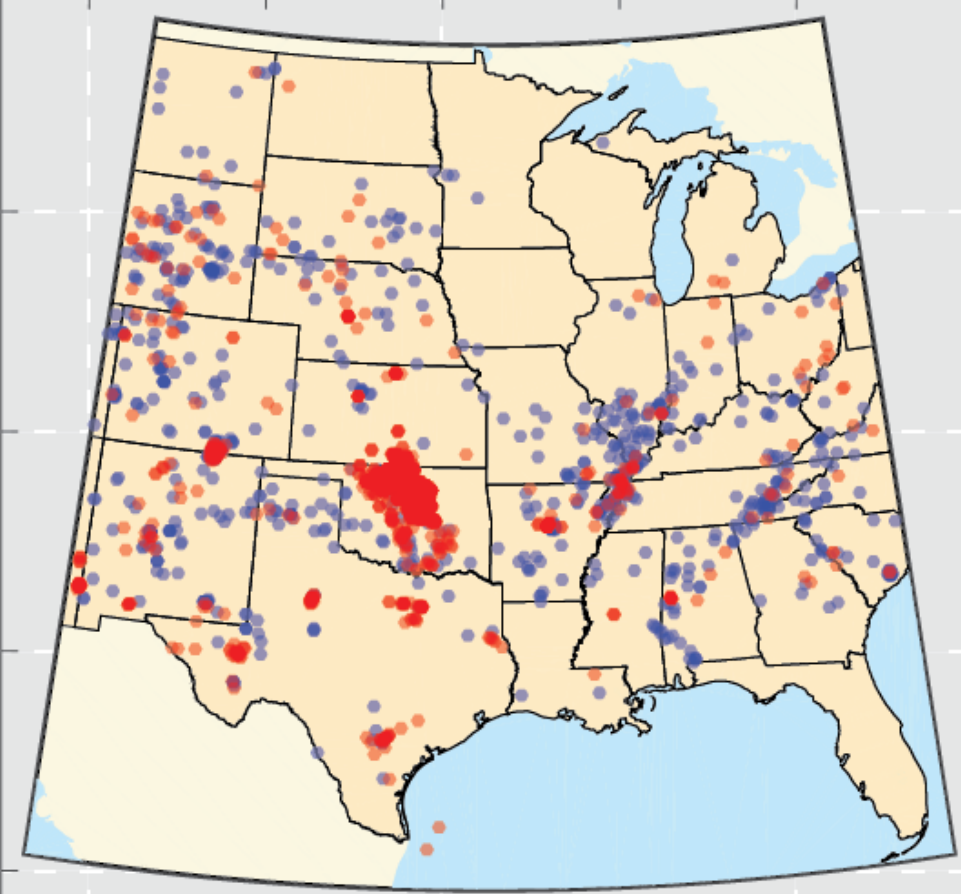
*This article is about earthquakes in Oklahoma and vicinity since 2009. For other pages related to Oklahoma earthquakes, see [Earthquakes in Oklahoma](#).*

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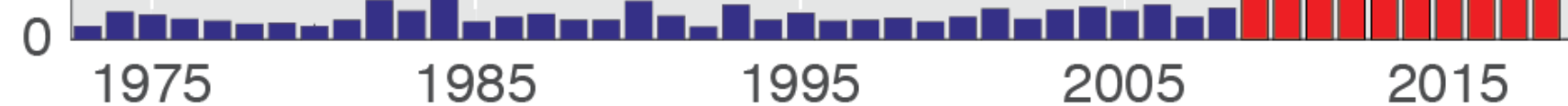


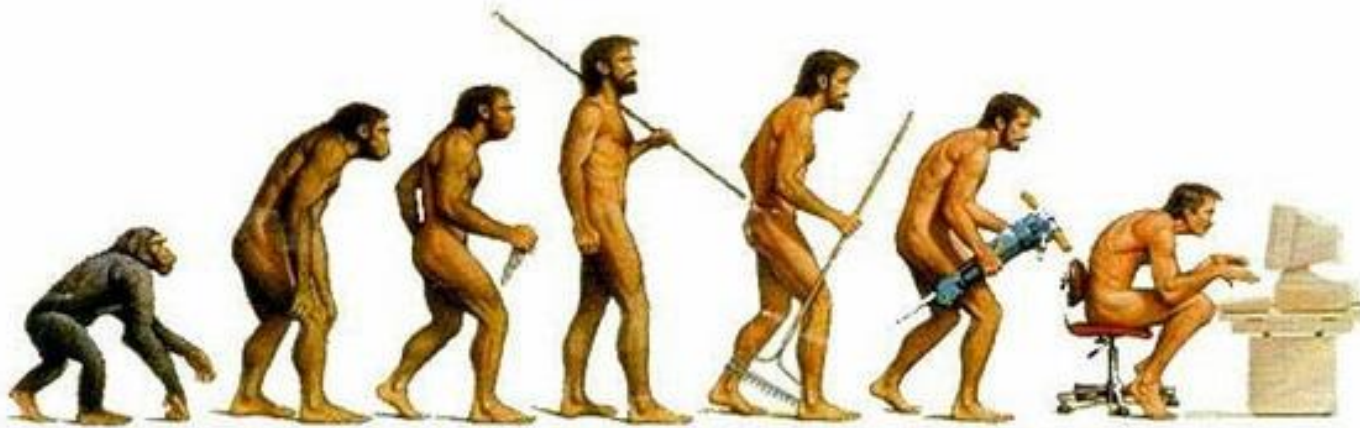
Number of M3+ Earthquakes

# Central U.S. Earthquakes 1973 - 8/2018



**852**  $M \geq 3$  Earthquakes 1973 - 2008  
**3427**  $M \geq 3$  Earthquakes 2009 - 8/2018





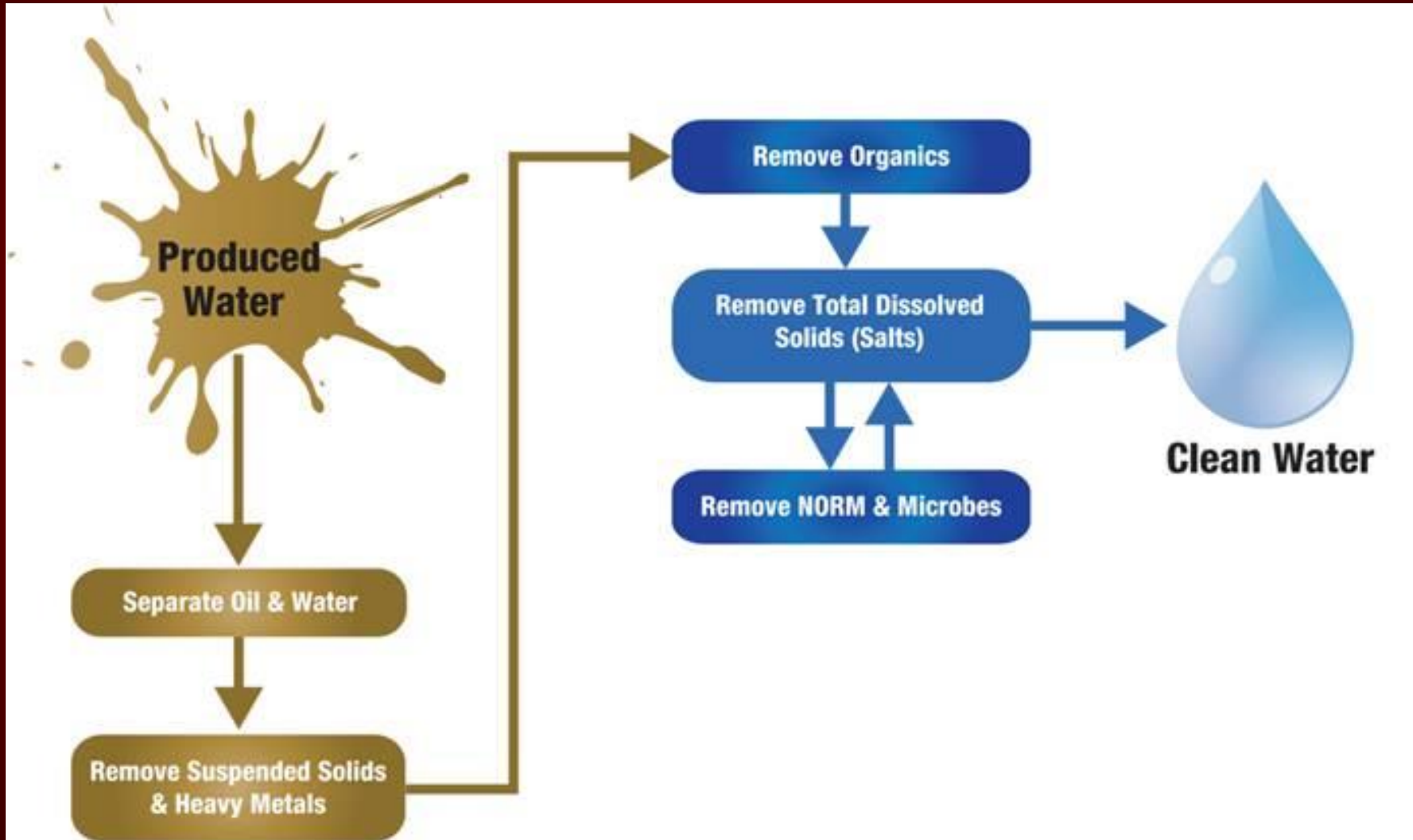
“It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change.” – Darwin

# PRODUCED WATER TREATMENT





# PRODUCED WATER TREATMENT



# INTEGRATED TREATMENT SYSTEM



# MOBILE TECHNOLOGY





# TREATMENT TECHNOLOGY

Minimum Frack  
Quality



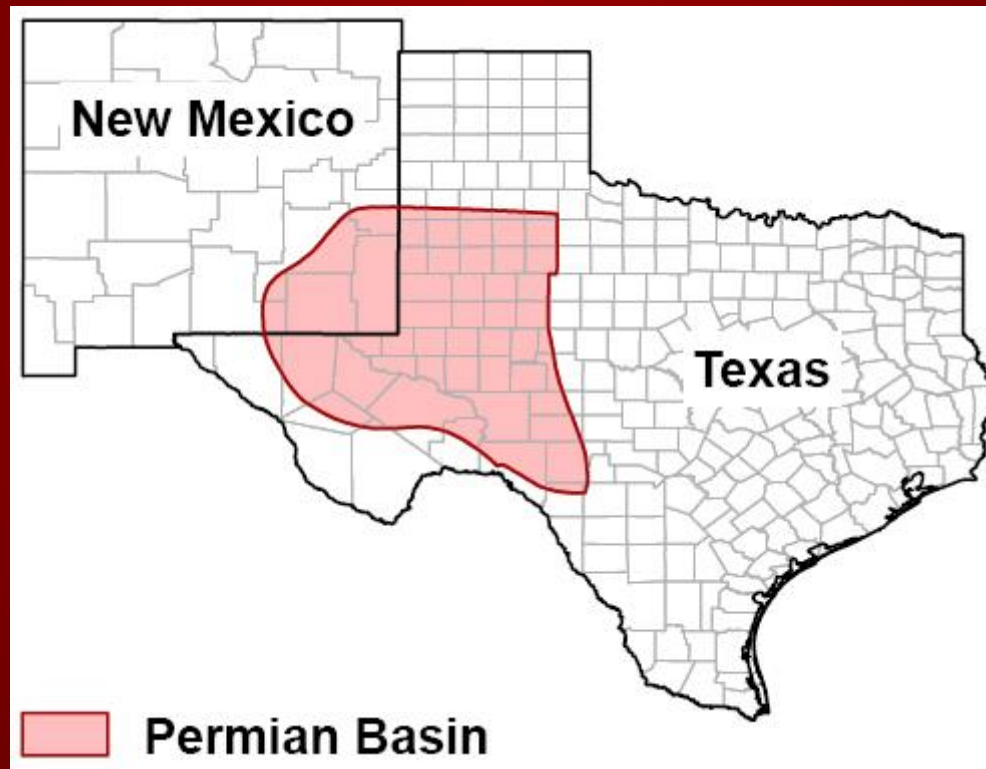
Ag Surface  
Irrigation Discharge



# WATER MIDSTREAM

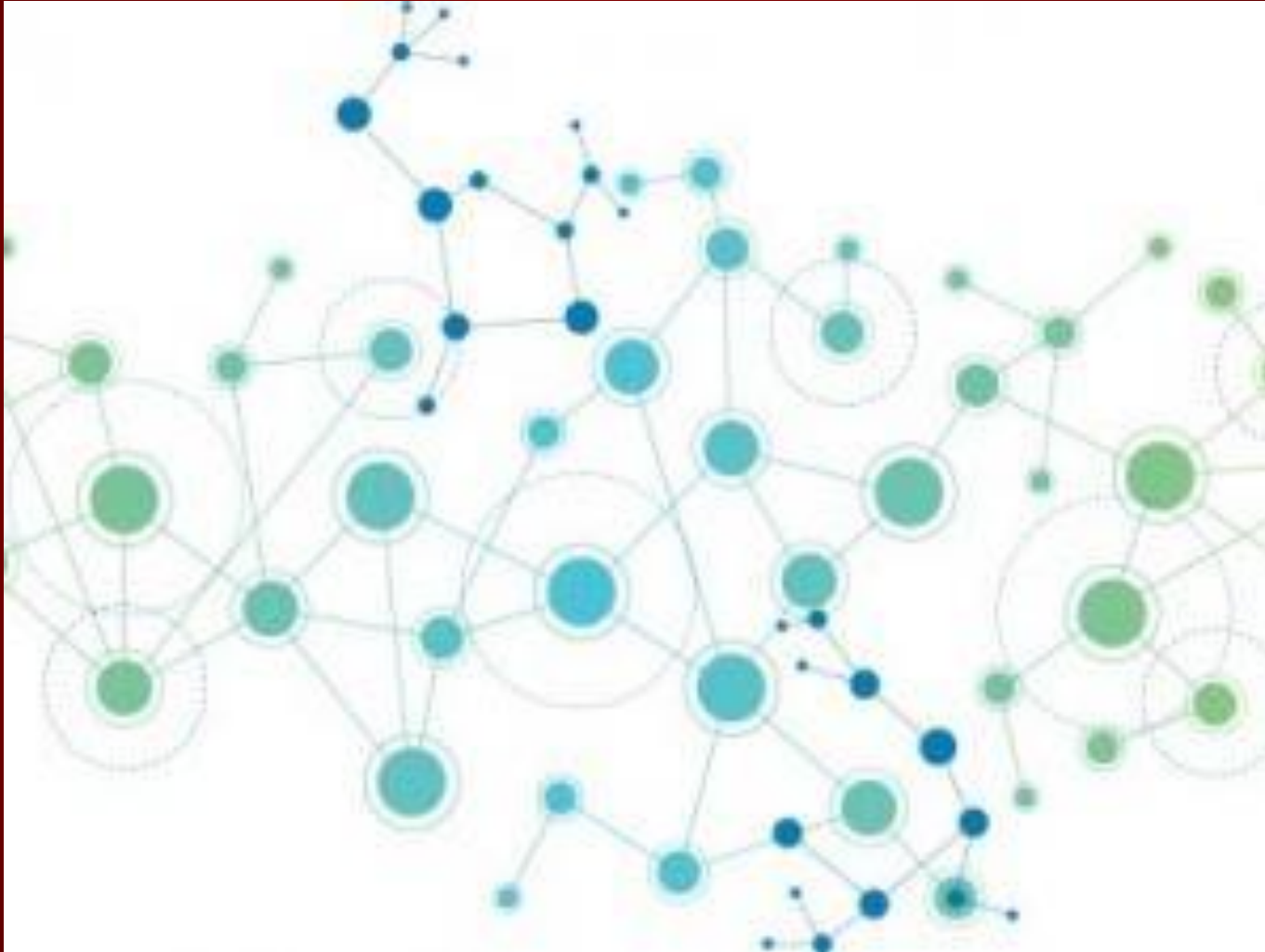
Water Midstream is all about transfer and storage of massive amounts of water for oil and gas industry use

**IT'S ALL HAPPENING IN THE PERMIAN BASIN,  
BUT THE INDUSTRY AND TECHNOLOGY IS EXPECTED TO  
SPREAD TO THE OTHER SHALE BASINS IN THE US**





# THE IDEA IS TO STRATEGICALLY CONNECT PIPELINES AND SURFACE IMPOUNDMENTS TO VASTLY IMPROVE WATER DELIVERY EFFICIENCY AND ALSO WATER RECYCLING

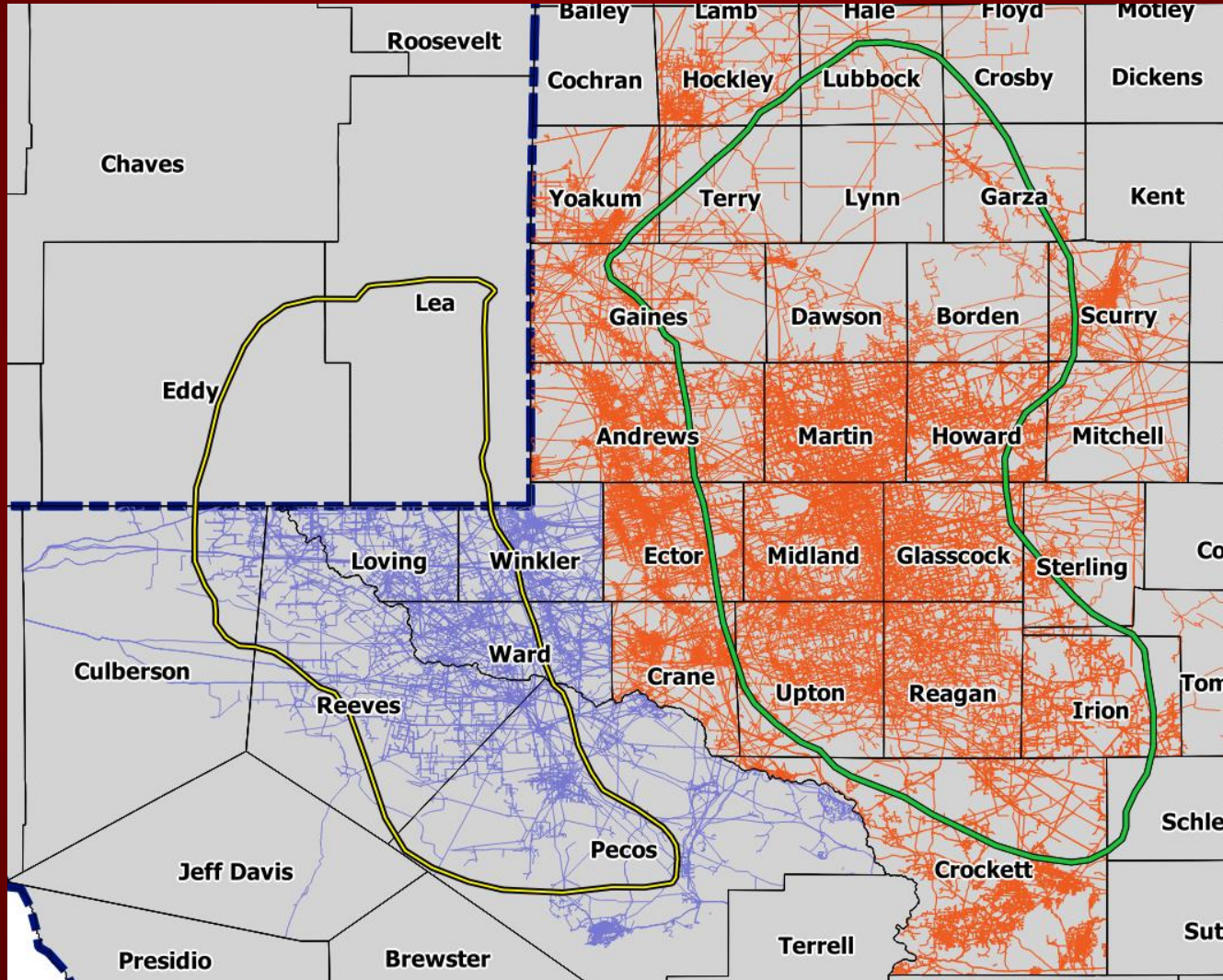


**AND GET THE TRUCKS OFF THE ROAD!**





# ACTIVE PIPELINES—PERMIAN BASIN





# SURFACE IMPOUNDMENTS ARE AN IMPORTANT PIECE OF THE PUZZLE



# WATER MIDSTREAM UTILIZES SURFACE IMPOUNDMENTS



- The surface impoundment liner designs are very similar to landfills
- Similar materials and designs using geosynthetics and sumps

## Required Services:

- Permitting
- Surveying
- CQA
- Construction Oversight
- Regulatory Liaison



# WATER MIDSTREAM NEEDS PERMITTING



- Permitting requires site characterization
- Permits are very similar to RRC surface waste disposal permits



# LINEAR PERMITTING





# COMMERCIAL WATER MIDSTREAM IMPOUNDMENTS MAY REQUIRE GROUNDWATER MONITORING



- Well Installation
- Sampling, analysis and reporting



# 500,000 BBL SURFACE RECYCLED FRAC WATER IMPOUNDMENT IN PERMIAN BASIN





# INSERT SHAMELESS PLUG

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