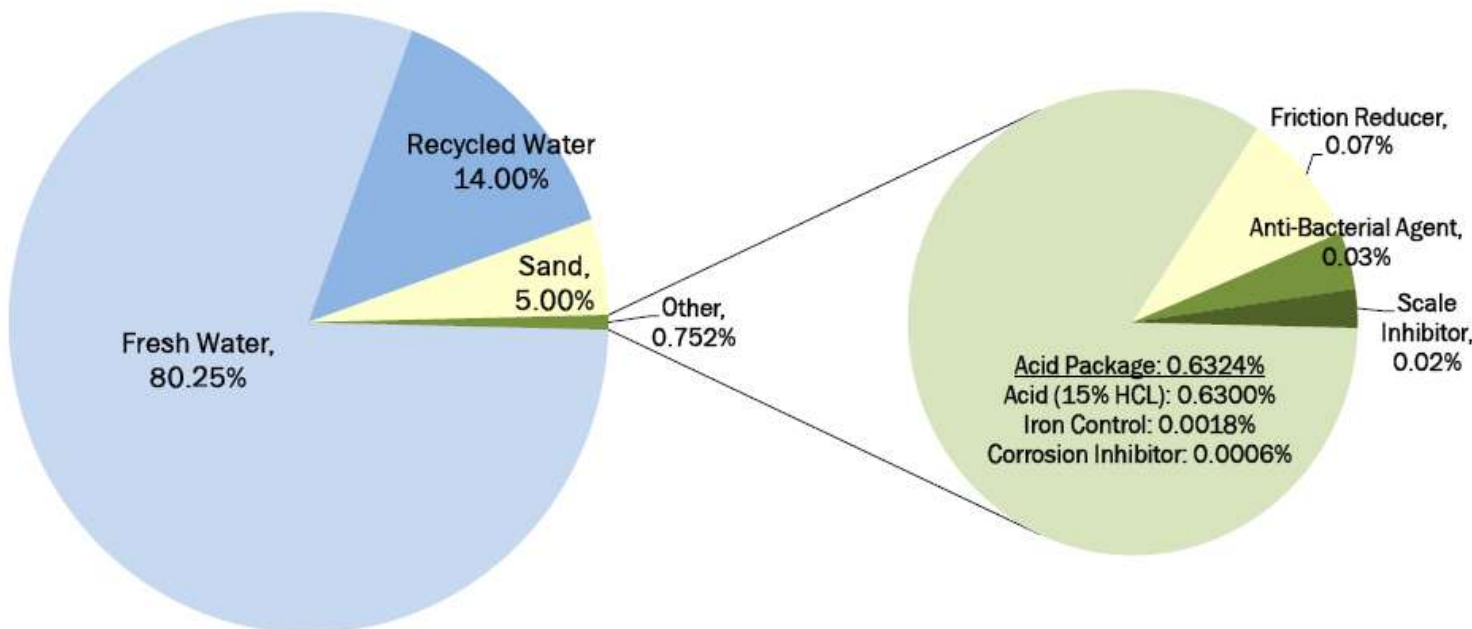


# **Shale Gas Flowback Water Treatment, Reuse, and Disposal**

**Presented by Dave Yoxtheimer, P.G.**

# Hydraulic Fracturing Process



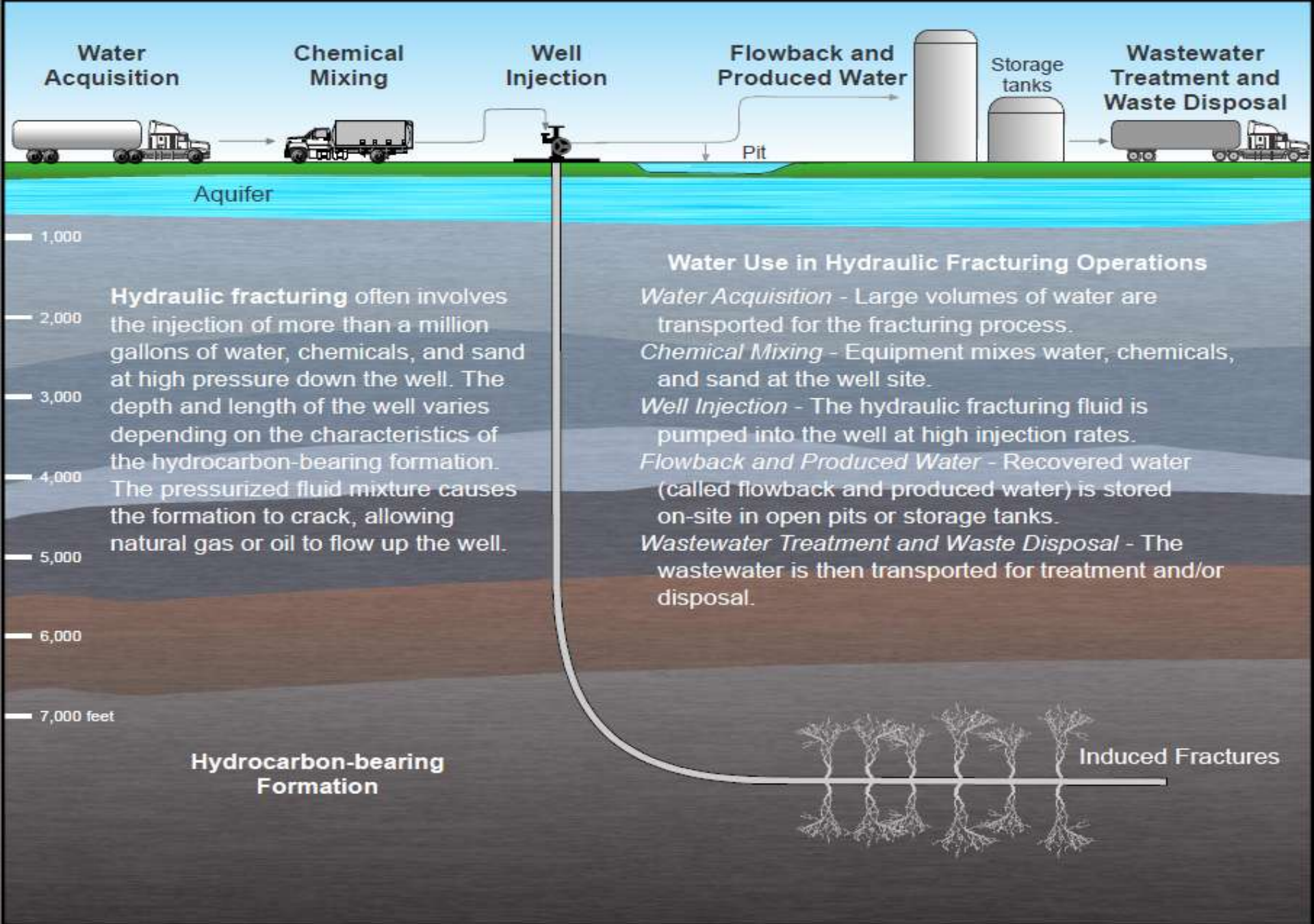
-Each well uses about 3 to 7 million gallons of water

-A range of 10% to >50% of the injected fluids return, known as flowback water

-Need proper fluids management

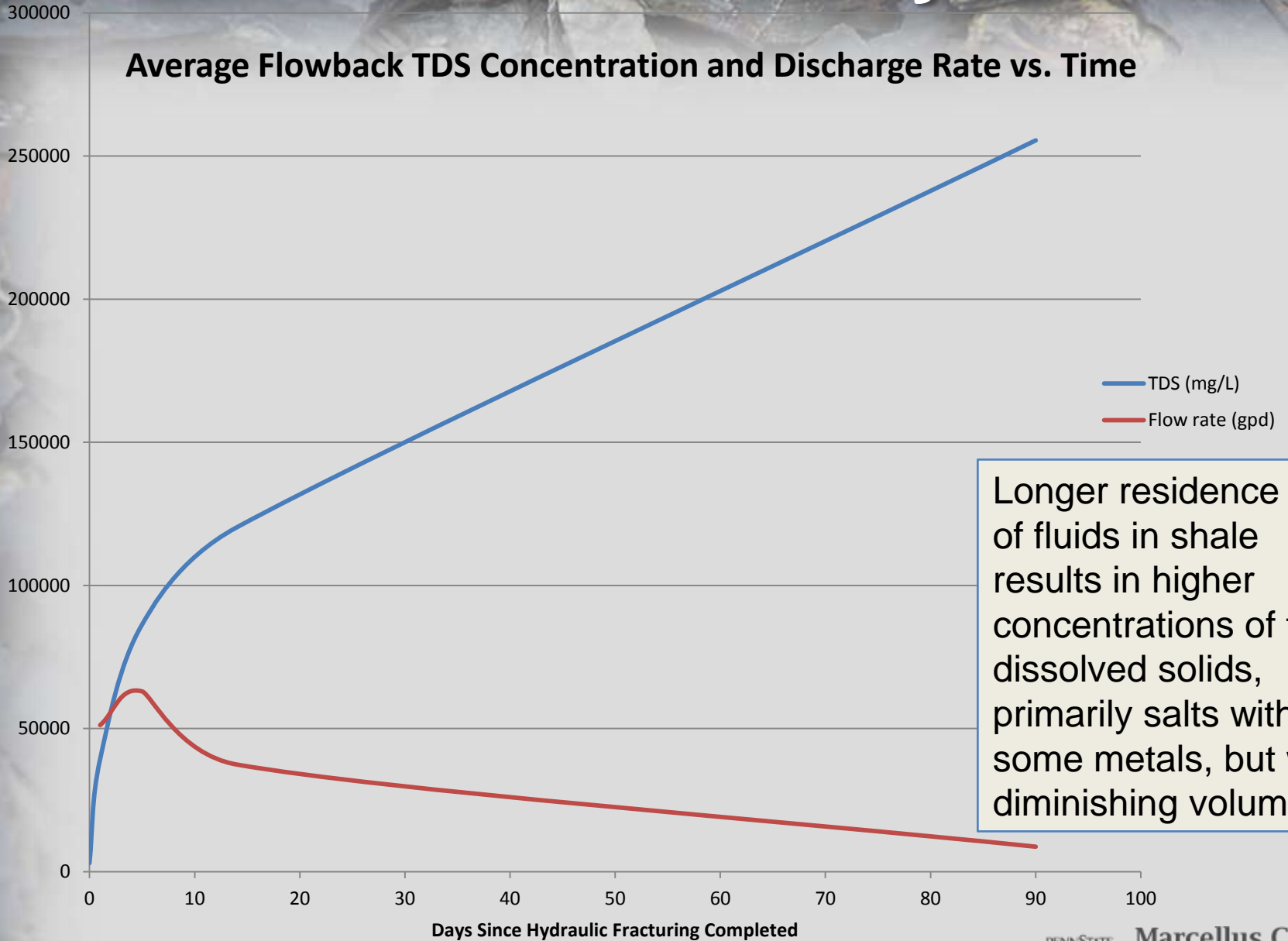
Source: Chesapeake Energy



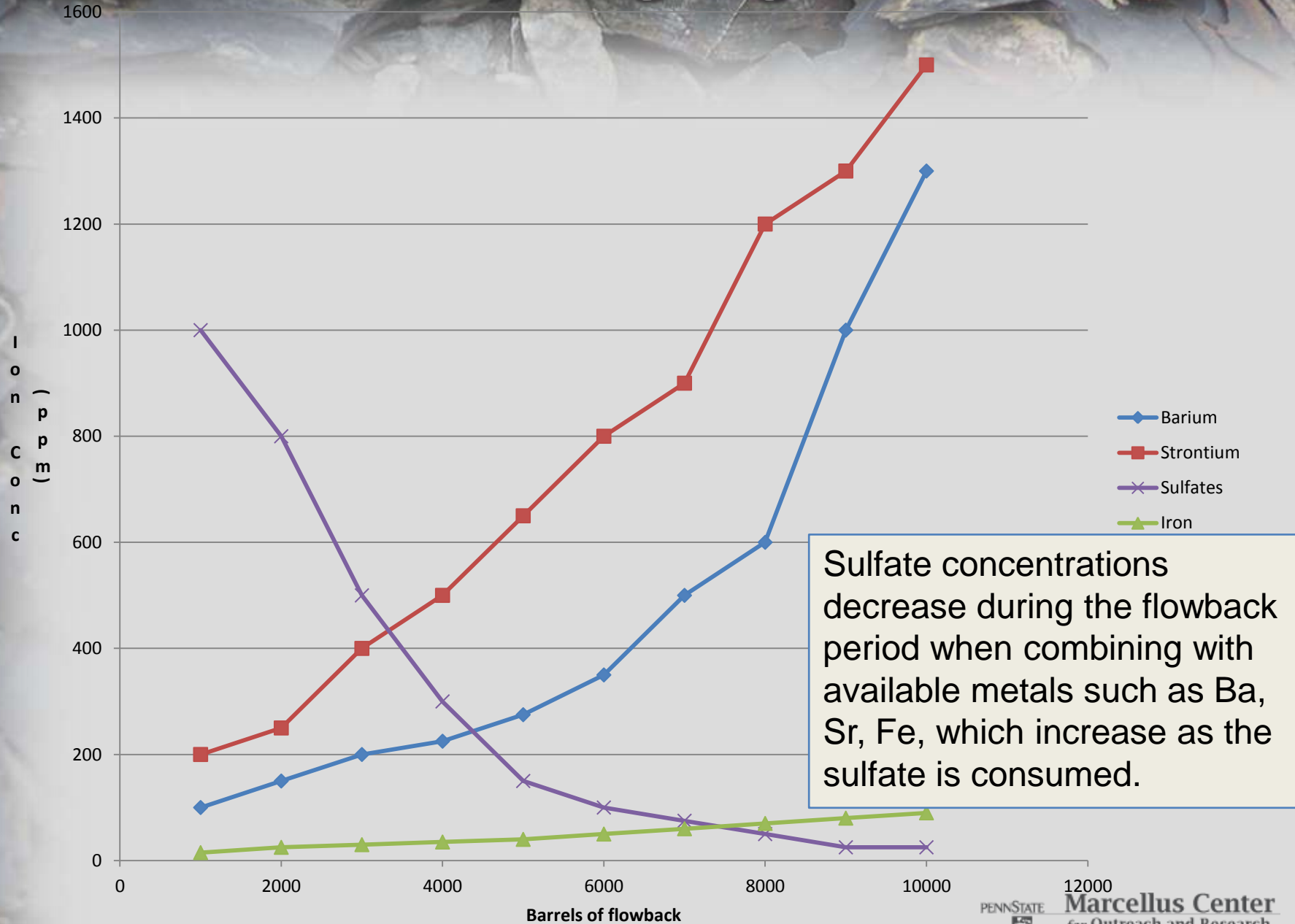


Source: Draft EPA Hydraulic Fracturing Study Workplan

# Flowback Water Quality Trends

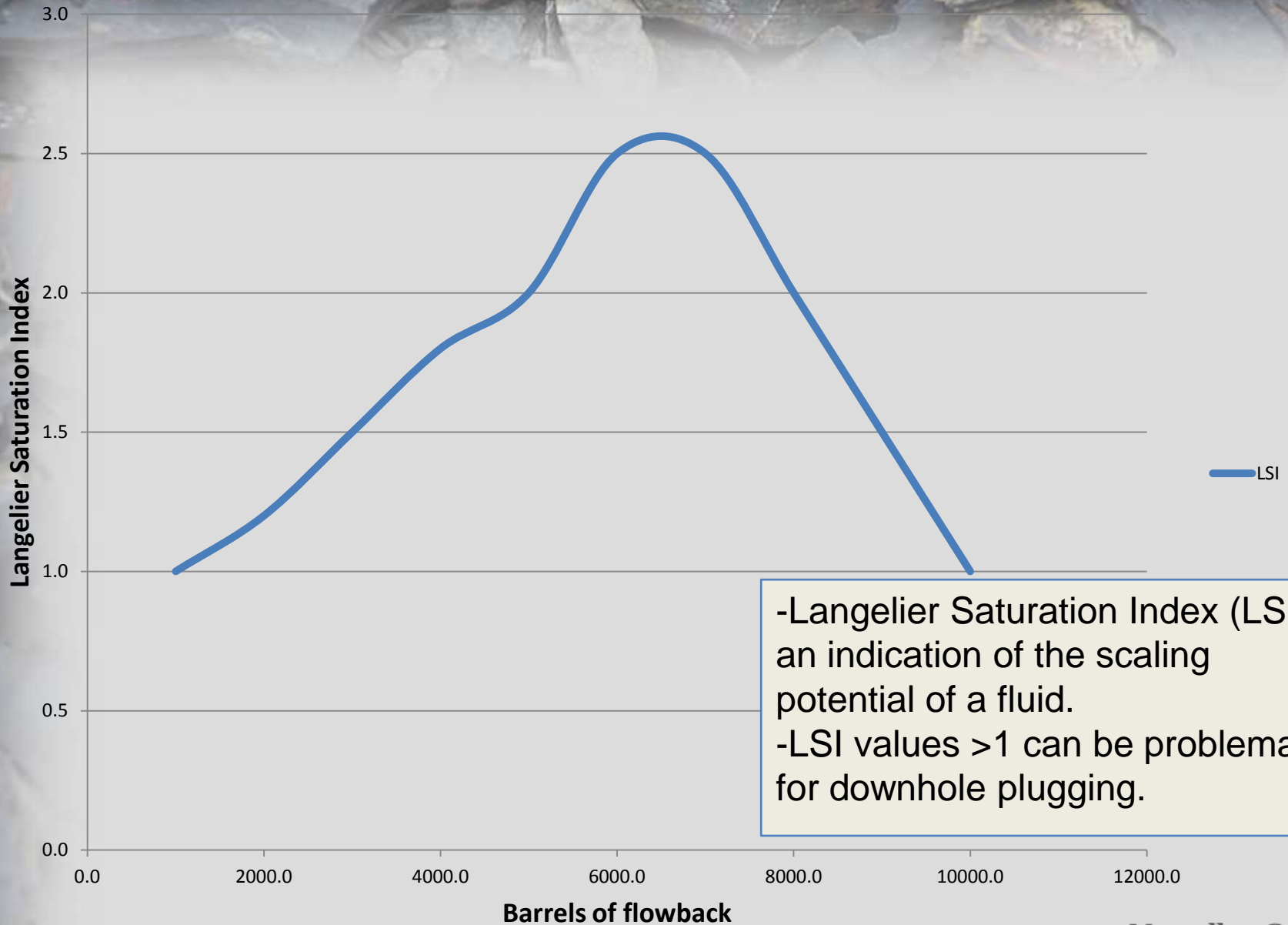


# Flowback Scaling Agent Levels





# Langelier Saturation Index



-Langelier Saturation Index (LSI) is an indication of the scaling potential of a fluid.  
-LSI values  $>1$  can be problematic for downhole plugging.

# Typical Flowback Scaling Agent Concentrations

<u>Cation</u>	<u>Concentration</u>
Barium:	2,000 - 5,000 mg/L
Strontium:	1,000 - 7,000 mg/L
Calcium:	10,000 - 25,000 mg/L
Magnesium:	500 - 1,000 mg/L
Manganese:	2 - 10 mg/L
Iron:	20 - 200 mg/L

These concentrations need to be reduced to minimize the potential for downhole scaling and plugging.

# Flowback Water Management Options

## ***Flowback management options***

- Direct reuse (blending)
- On-site treatment w/reuse
- Off-site treatment w/reuse
- Off-site treatment and disposal
- Chemical precipitation, evaporation, filtration technologies being utilized

***Approximately 70% of flowback being recycled in Marcellus***

## ***Pennsylvania treatment standards for discharge of flowback***

- TDS-500 mg/L
- Chlorides-250 mg/L
- Barium and Strontium-10 mg/L
- Only 1 plant in PA meet standards

***Flowback treatment for reuse designed to remove scaling agents but not usually salts***





# Flowback Storage



Flowback may be stored in lined impoundments for reuse

- Groundwater monitoring wells and leak detection
- Bird netting



Steel tanks are often used to store raw flowback or treated flowback

- Minimizes potential for spill

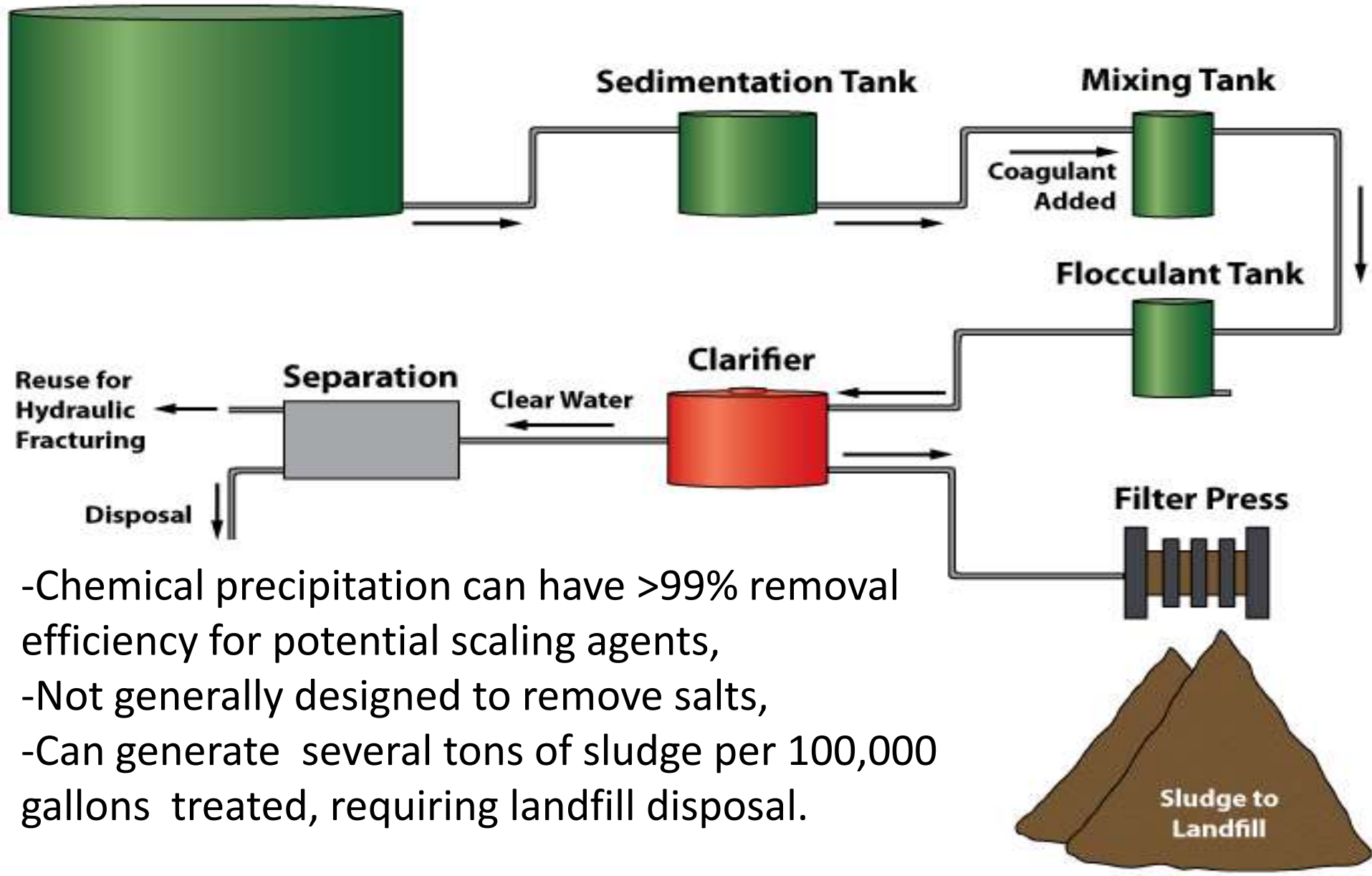
# Flowback Transport



- Flowback typically hauled via truck to treatment plants
  - Must use trucks with proper placards and drivers must have manifest paperwork
- Rail or pipelines sometimes used for transport to injection wells

# Typical Treatment Scheme for Reuse

Brine Water Storage Tank



- Chemical precipitation can have >99% removal efficiency for potential scaling agents,
- Not generally designed to remove salts,
- Can generate several tons of sludge per 100,000 gallons treated, requiring landfill disposal.



# High TDS Treatment Options

<u>Technology</u>	<u>Maximum TDS (mg/L)</u>
Reverse osmosis	45,000
Evaporation	100,000
Membrane distillation	250,000
Crystallizer	300,000



# Mobile Treatment Technology



Mobile treatment use increasing due to reduction in:

- Costs
- Trucking transport
- Fresh water use
- Environmental impact



# Marcellus Shale Analysis List for Treatment Facilities

d. **Wastewater Produced from the Drilling, Completion and Production of a Marcellus Shale or Other Shale Gas Well.** In lieu of the Trace Analysis described in subsection b., the chemical analysis of wastewater produced from the drilling, completion and production of a Marcellus Shale or other shale gas well must include the following:

Acidity	Calcium	Lead	Selenium
Alkalinity (Total as CaCO <sub>3</sub> )	Chemical Oxygen Demand	Lithium	Silver
Aluminum	Chlorides	Magnesium	Sodium
Ammonia Nitrogen	Chromium	Manganese	Specific Conductance
Arsenic	Cobalt	MBAS (Surfactants)	Strontium
Barium	Copper	Mercury	Sulfates
Benzene	Ethylene Glycol	Molybdenum	Thorium
Beryllium	Gross Alpha	Nickel	Toluene
Biochemical Oxygen Demand	Gross Beta	Nitrite-Nitrate Nitrogen	Total Dissolved Solids
Boron	Hardness (Total as CaCO <sub>3</sub> )	Oil & Grease	Total Kjeldahl Nitrogen
Bromide	Iron – Dissolved	pH	Total Suspended Solids
Cadmium	Iron – Total	Phenolics (Total)	Uranium
		Radium 226	Zinc
		Radium 228	

Additional constituents that are expected or known to be present in the wastewater.

\*Note - All metals reported as total.



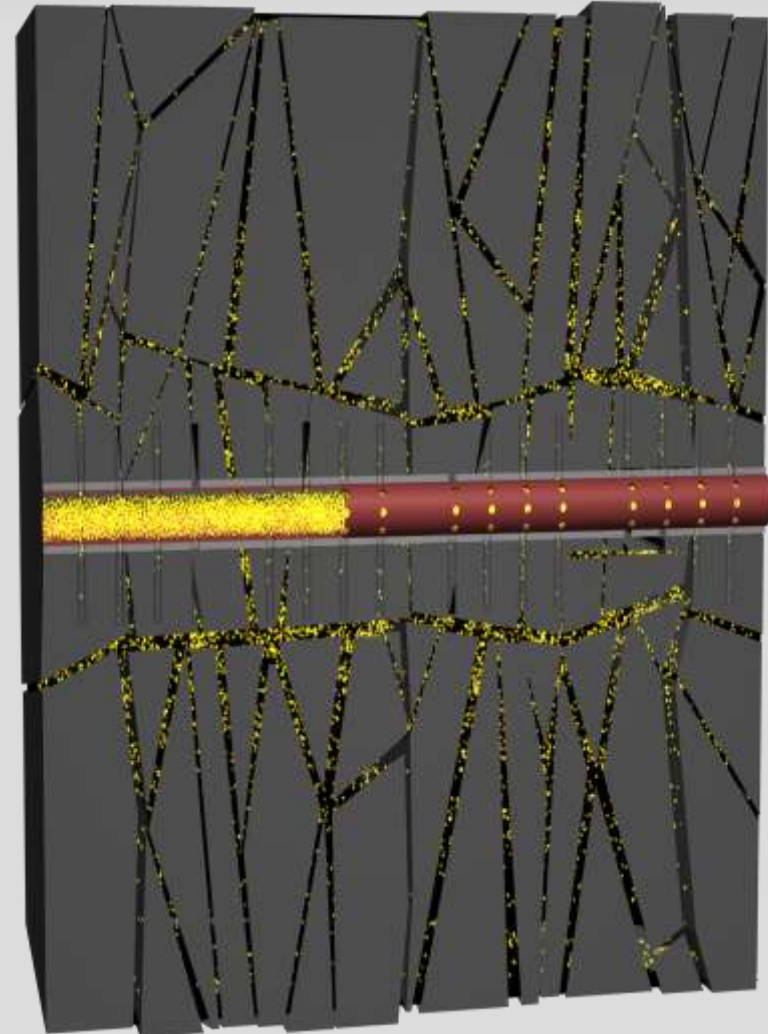
# Flowback Treatment Specifications

Example flowback treatment levels for recycling purposes per industry standards:

- Total cations 10 - 2,000 ppm range
  - Acceptable levels range from company to company
  - Primary focus on Ba and Sr, but Ca also a concern
  - Ba, Sr , Fe, Mn, Mg < 10 ppm
  - Ca <1,000 ppm
  - Hardness <2,500 ppm
- Processed water sulfates levels <30 ppm
- TSS <30 ppm
- TDS is variable, >50,000 ppm can be acceptable

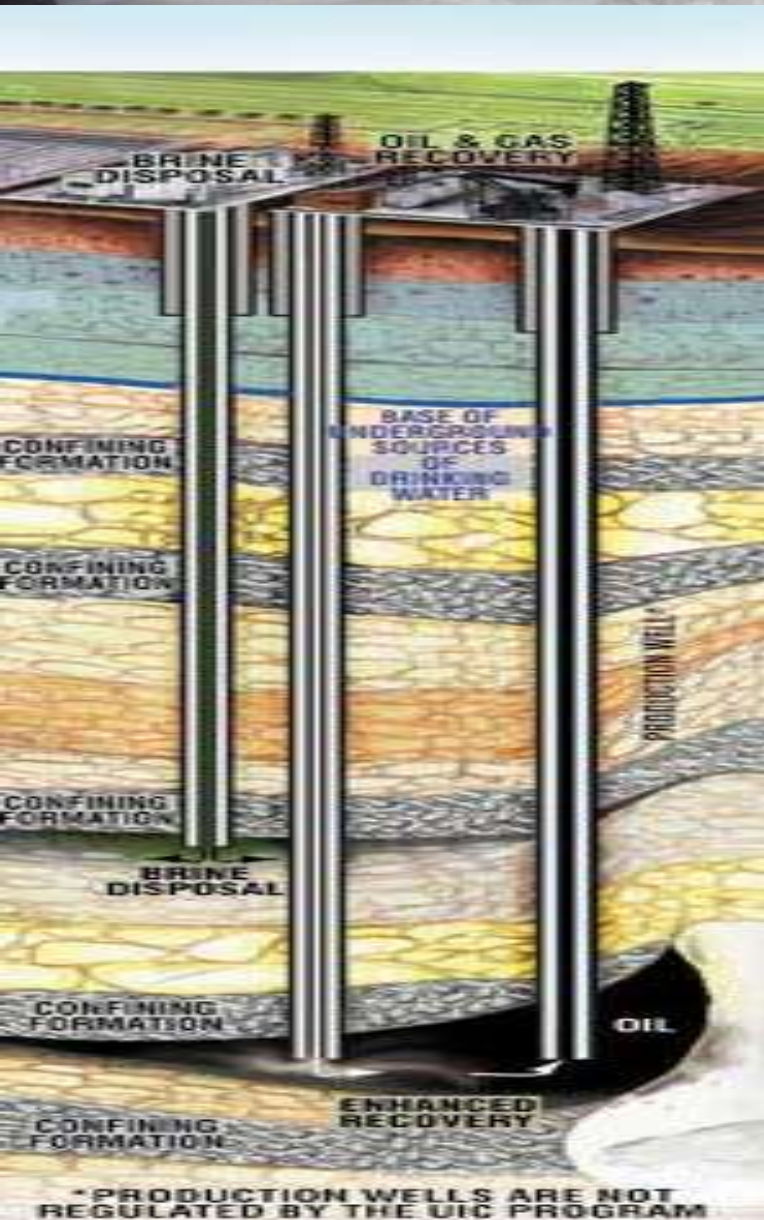
# Fracturing Fluid Characteristics

- Non-damaging
  - Minimal leak-off
  - High fluid efficiency
  - No scaling
  - Minimal skin effect
- Brine tolerant friction reducer
- Adequate scale and Fe control
- Sufficient viscosity to carry proppant
- Rapid clean-up
- Develop extensive fracture network
- Cost-effective





# Underground Injection Well Disposal



- Deep well injection utilized to dispose of water not being reused
- Amount of injection disposal governed by suitable reservoir
  - Texas has 50,000 injection wells
  - Pennsylvania has 7 injection wells with limited capacity (est. 3600 bpd/150,000 gpd)
  - Ohio has 170 injection wells, taking increasing amounts of Marcellus wastewater
- Injection wells may be challenging in certain gas play basins
  - May take several years to permit
  - Difficult to find target injection reservoirs
  - May be prone to plugging
  - Public opposition

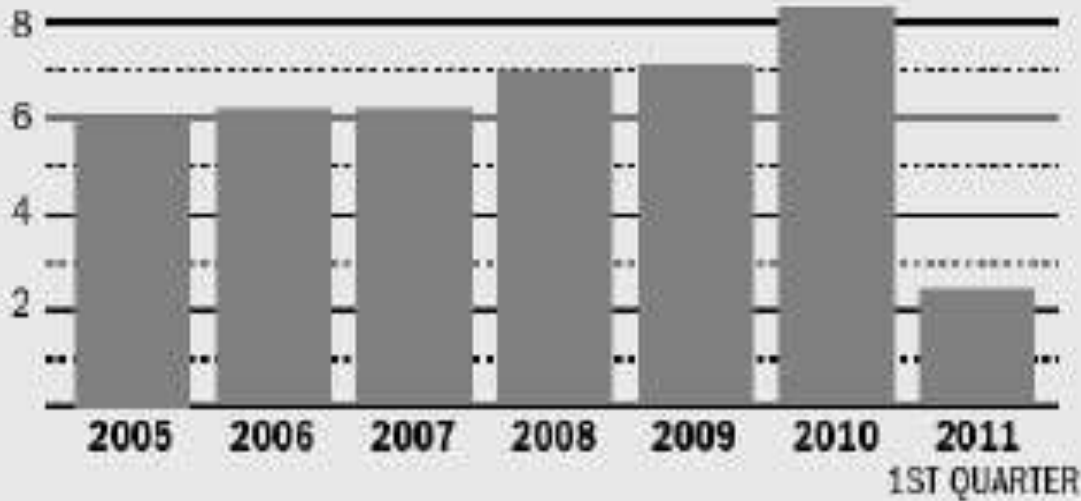


# Marcellus Injection Well Disposal

## Brine waste

The amount of wastewater, or brine, produced by natural-gas wells in Pennsylvania has created an influx at Ohio's 170 disposal wells. The well locations and the Ohio and Pennsylvania brine disposed in them each year since 2005:

### BARRELS OF BRINE DISPOSED OF MILLIONS



## DISPOSAL WELLS



Source: Ohio Department of Natural Resources

THE COLUMBUS DISPATCH

# Conclusions

- Significant efforts to recycle flowback fluids are underway (>70% recycling in PA)
- Flowback treatment is a growing industry in US
- Mobile treatment technologies are being utilized to reduce truck traffic and transport costs
- Best management practices being implemented to minimize potential for spills
- Deep well injection increasing in association with shale plays
- Flowback reuse can be cost-effective while reducing environmental impacts for shale gas development