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Water Management for Stimulation Operations

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Water

- **Water, like religion and ideology, has the power to move millions of people. Since the very birth of human civilization, people have moved to settle close to it. People move when there is too little of it. People move when there is too much of it. People journey down it. People write, sing and dance about it. People fight over it. And all people, everywhere and every day, need it.**

Mikhail Gorbachev

Why Is Water Important to the Petroleum Industry?

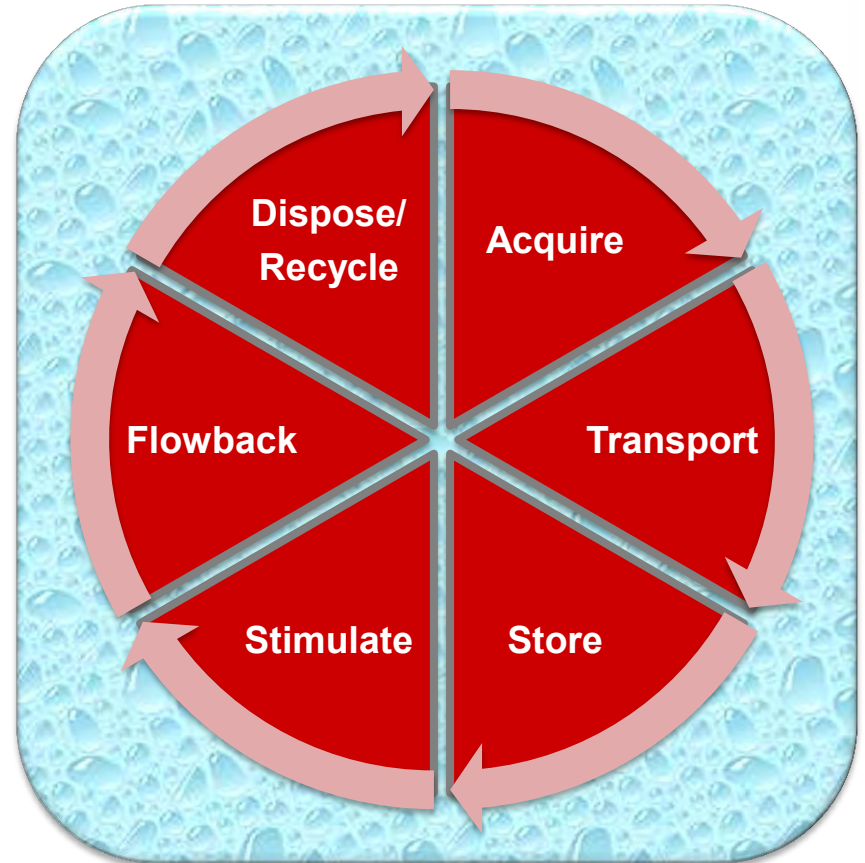
- Water is the most common and most heavily used fluid in the petroleum industry
- Water is produced along with oil and gas from nearly every well
- Water is used as a base fluid in production, drilling, and completion operations
- Water will be produced, recycled, injected, mixed, cleaned, and reinjected
- **Water's use and protection are emotionally charged subjects in many communities**

Significance of Water to Our Business

- **More than ever, water is an integral part of the success of oil and gas operations. So, think about this**
- **No Water**
- **No Fracturing**
- **No Oil and Gas Company' s – Resource Plays**

Water Management Cycle

- **Water source**
 - *Subsurface aquifers*
 - *Rivers, lakes or ponds*
 - *Rural or urban water supplies*
 - *Gray Water*
 - *Acid Mine Drainage*
- **Water transport**
 - *Pipeline*
 - *Trucking*
- **Water storage**
 - *Frac Tanks (500 bbls)*
 - *Modular Tanks (up to 40,000 bbls)*
 - *Portadam (size as required)*
 - *Pits or ponds (100,000+ bbls)*
- **Water treatment and reuse**
 - *Biocides*
 - *Settling*
 - *Ecosphere*
 - *Electrocoagulation*
 - *Distillation*
 - *Crystallization*
- **Water disposal**
 - *Evaporation*
 - *Water disposal wells*



Water Sources

- **Subsurface Aquifers using water wells**
- **Ground Water from naturally occurring or man made ponds**



Water Sources



Water Transportation



Water Transport – Pipeline and Pump



Water Transport - Trucking



Water Storage



Image courtesy of Mobile Aquatic Solutions

Why Is Water Storage Important?

- **Water is the base fluid and biggest component of any hydraulic fracturing operation**
- **Water volumes required for typical completions range from 100,000 to 500,000 barrels per well**
- **Water must be stored near the completion operation in sufficient quantities to finish a job at the desired pump rate**
- **In the first 90 days after fracturing a well can produce from 30 to 80% of its load back**
- **To recycle water there has to be enough storage for both the dirty water and the processed clean water**
- **Water must be stored in a manner that is economically and environmentally sound**

Frac Tanks

Capacity

500 BBL

Transported by Truck

Estimated Cost of Storage

\$0.06 to \$0.09/BBL/day

Number needed for a 250,000 BBL slick water frac

500

Normally use 15 frac tanks on a job



Fresh Water Impoundment – Lined

Size can vary

Operational Requirements
Terrain

Cost to Construct

\$150,000 to \$200,000

Estimated Cost of Storage

\$0.0012 to \$0.0016/BBL/d

Number needed for a 250,000 BBL slick water frac

1



Fresh Water Impoundment - Unlined

Impoundments can be

Naturally occurring

Man made

Size can vary

Operational Requirements

Terrain

Cost to Construct

\$75,000 to \$150,000

Estimated Cost of Storage

\$0.0006 to \$0.0012/BBL/d

**Number needed for a
250,000 BBL slick water
frac**

1



Large Capacity Above Ground Moveable Tanks

**Size Can Range by
type and make of tank**

Rectangular

2,200 to 15,400 BBL

Circular

4,500 to 42,000 BBL

Portadam

Determined by user



Rhinokore Tank

Capacity

2,200 to 15,000 BBL

Transported by Truck

Purchase or Lease Options

Estimated Cost of Storage

\$0.083 to \$0.089/BBL/d

Number needed for a 250,000 BBL slick water frac

16+



Large Capacity Above Ground Moveable Tanks

Capacity

4,500 to 42,000 BBL

Transported by Truck

Purchase or Lease Options

Estimated Cost of Storage

\$0.064 to \$0.080/BBL/d

Number needed for a 250,000 BBL slick water frac

6+



Portadam

Size can vary

*Storage Required (Larger
More Economical)
Terrain*

Good for Long Term Application

Estimated Cost of Storage

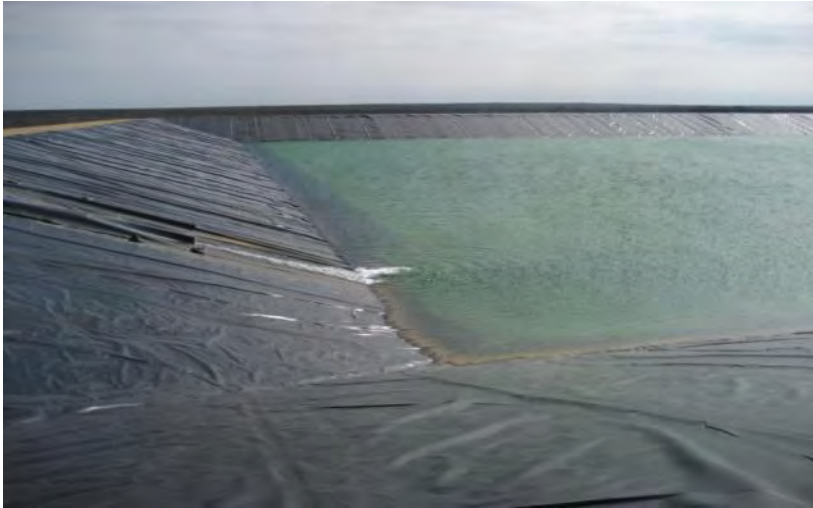
\$0.018 to \$0.04/BBL/d

Number needed for a 250,000 BBL slick water frac

1 or more depending on size



Water Treatment and Reuse



Recycling Challenge – Water Quality

- **Fresh water**
 - *No problems with frac*
- **Produced water & flow back water**
 - *Minerals can cause scale*
 - *Minerals can interfere with frac gel*
 - *Water quality varies widely*
 - *Newfield has fractured wells with 100% produced water with no problems*
- **Study to determine water quality limits for recycling**
 - *Results specific to portion of basin*
 - *Results will point to type of water treatment needed*
- **Regulations are becoming more stringent**
 - *Recycle or produced water pits have to be permitted*
 - *OK and TX require design and certification by a professional engineer*

Concerns with Produced Water Reuse



Formation Damage

- *Potential for solids to compromise fracture geometry*
 - *Improper fracture propagation*
 - *Potential for reduction in production*
- *Suspended colloids not removed by simple filtration*



Scaling

- *Increased potential with higher hardness*
- *Theoretical calculations and experiments required*



Fluid Formulation

- *Varied water quality*
- *Polymer hydration issues in high salinity water*
 - *Greater issue with polymer crosslinking*

Source: Halliburton

Treatment Options

There are a number of treatment options available to producers, with options including dilution, settling, chemical treatment, filtration, clarification, electro-coagulation, and distillation.

~\$1.50 - \$2.00/bbl	Dilution	<ul style="list-style-type: none"> • Involves blending flowback or produced water with freshwater during fracturing. • Not free - has a handling cost for frac tanks, containment, water transfer, etc.
~\$2.00 - \$2.50/bbl	Settling	<ul style="list-style-type: none"> • Must allow enough residence time in flow back pits or frac tanks for solids to settle. • Risks associated with storing raw water on location for long periods of time.
~\$2.00 - \$3.00/bbl	Filtration	<ul style="list-style-type: none"> • Bag filters, disk filters, or sand filters can be used. Other types available. • Issues can arise from expended filter sock disposal and bacteria introduction. • Water sources for back flushing system can be logistically difficult .
~\$2.50 - \$4.00/bbl	Chemical Precipitation	<ul style="list-style-type: none"> • Involves pH adjustment and the addition of polymers or other flocculants. • Issues can arise from excess sludge formation and sludge disposal. • Chemical drum or tote management can be logistically difficult on location.
~\$3.50 - \$4.50/bbl	Clarification	<ul style="list-style-type: none"> • Involves the use of equipment including DAFs or clarifiers. • Typically involves chemical precipitation in conjunction with clarification equipment • Advantages include few moving parts and less downtime
~\$4.50 - \$5.50/bbl	Electro-Coagulation	<ul style="list-style-type: none"> • Sacrificial plates create a hydrolyzed metal sweet floc that significantly lowers total suspended solids (TSS), greases and oil, and in some cases metals count. • High operating costs relative to other TSS treatment systems.
~\$5.50 - \$8.00/bbl	Distillation	<ul style="list-style-type: none"> • Highest effluent water quality. Can potentially be handled in freshwater impoundments with approved NPDES permits. • Highest operating costs due to energy requirements. • Energy cost can be mitigated by running off of compressor station waste heat or natural gas.

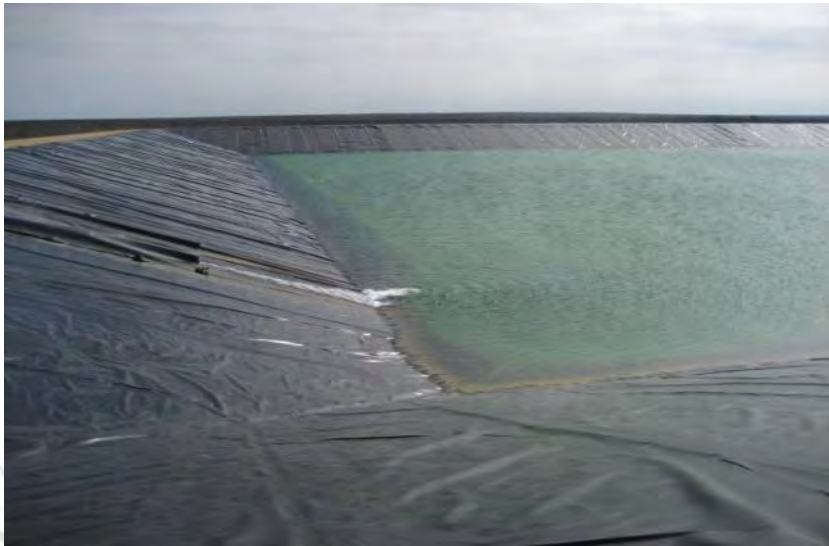
Why Newfield Recycles Water

- **Saving Fresh Water – 10 million barrels per year**
- **Saving Money – KCI savings of \$30 million per year**
- **Limited supply of fresh water due to drought**
- **Reduce the need to dispose of produced water**
- **Potential to reduce transportation costs**
- **Environmentally responsible**
- **Improved social license**

Load Recovery

Flow Back

- Using pipeline and transfer pumps
- Capacity over 500 BPH
- Replenish frac water supply



Trucking

- Could have 100 trucks per day to haul water from a well flowing 500 BPH
- Determine break even between pumping/pipeline changes and trucking costs plus disposal fees



Water Disposal

- **Evaporation**



- **Salt Water Disposal Well**



How Much Water Newfield Recycled

**For Newfield's Britt Ranch Fracturing
Operations**

50 Million Barrels

\$ 200 Million Saved

Questions!?!?!

