

Unconventional Resources



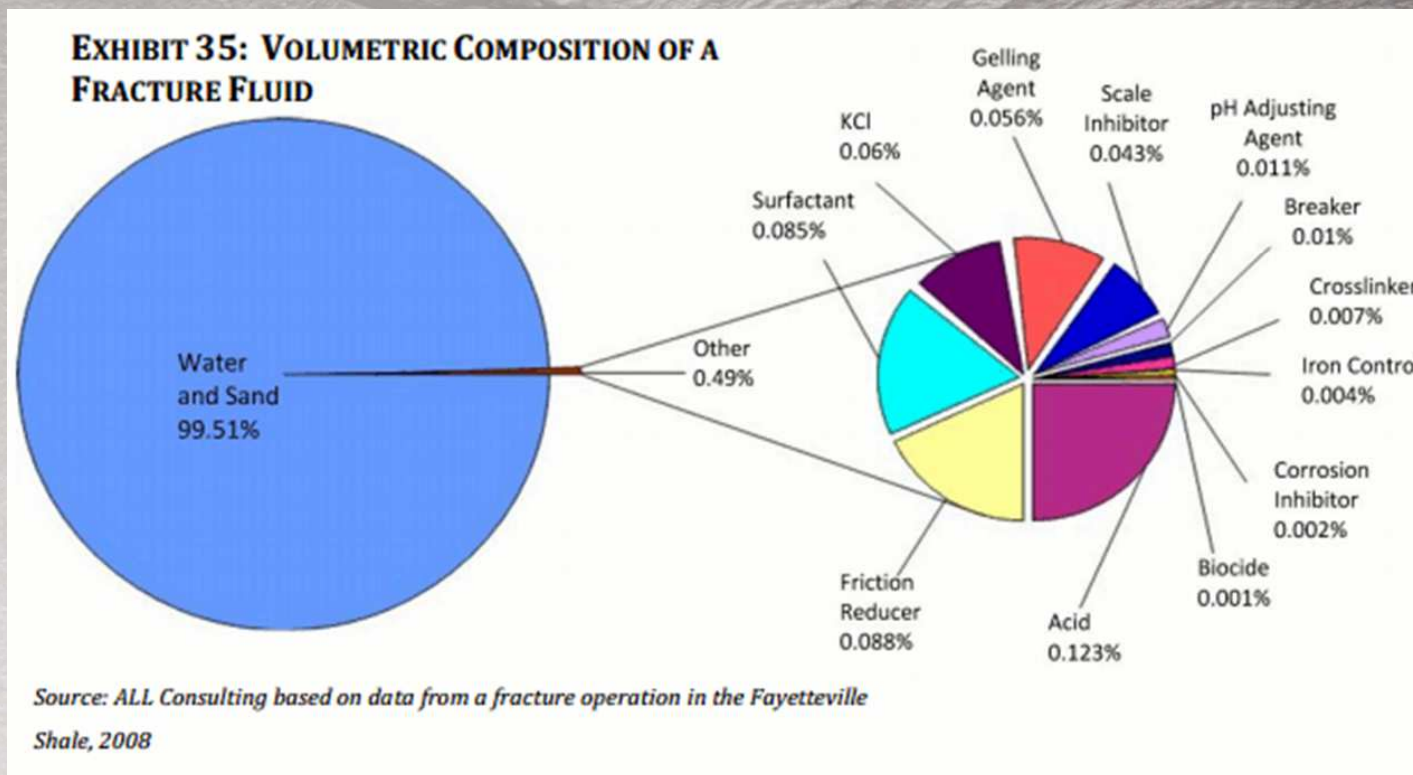
Dihydrogen Monoxide: The Paramount Stimulation Chemical

Ted Baudendistel, PMP, PE
Oilfield Water Management – Technical Manager
M-I SWACO – A Schlumberger Company

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Fracturing Fluid Composition

- Dihydrogen Monoxide (Water) predominates Stimulation Fluid Formulations
- Purpose to transport and place proppant and incompressible



Optimized Approach to Water Conditioning

- Comprehensive QHSE approach designed to reduce worker intervention with equipment, selection of more environmentally responsible chemical treatments, and minimizing chemical consumption
- **RESERVOIR CENTRIC**
 - Full understanding of the water requirements / specifications for Stimulation Fluids based on Schlumberger's Client Support Lab
 - Support from M-I SWACO's Environmental Solutions Applied Research (ESAR) division to identify new and improved technologies and solutions
 - Complete understanding of downhole effects with TerraTek's Core Analysis and Innovation Center (Petrologists, Geologists, GeoPhysicists)
 - "Technology Neutral" - Holistic Water Solutions vs. Treatment

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The Frac Fluid Story

- Freshwater dominated; limits defined
- Availability
- Limits pressed
- Balanced: Treatment vs. Fluid Recipe
 - Stimulation Fluid Chemistry origins in water treatment techniques
- Reservoir-Centered Approach



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Unconventional Hydraulic Fracturing Categories



Slickwater - SW



Linear Gel - WF

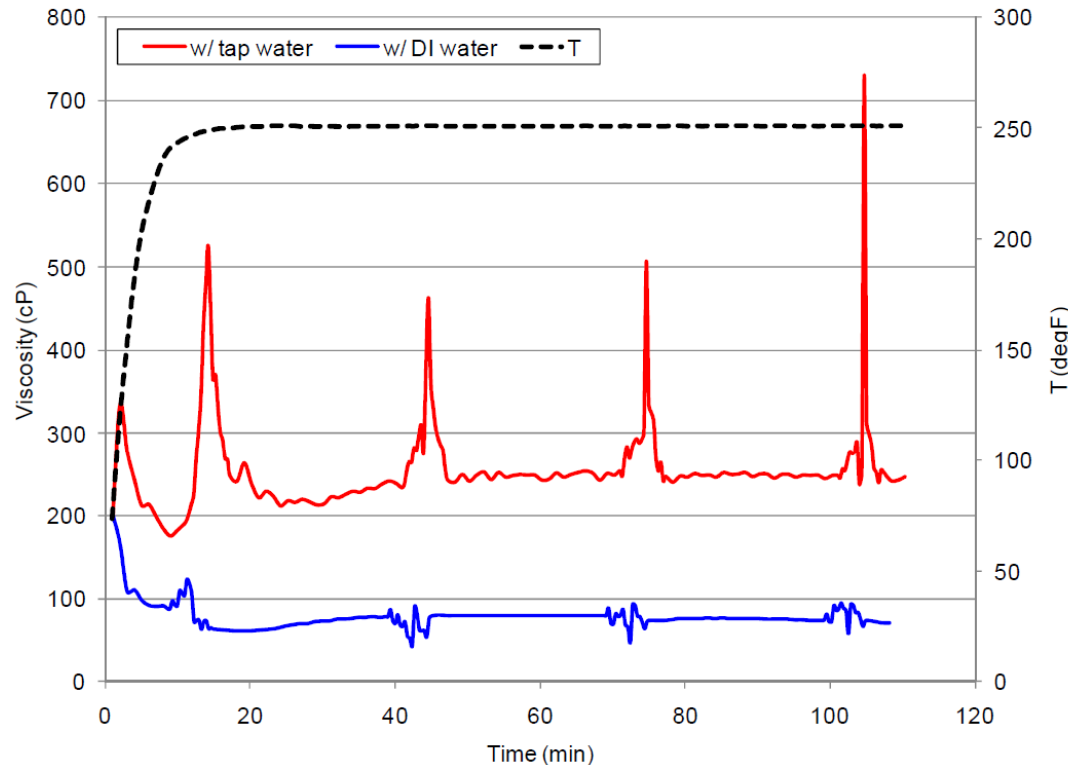


Cross-linked Gel - XL

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Is “Clean” Water Always Best?



No, some degree of salts in the water help stabilize our pH and maintain good fluid quality

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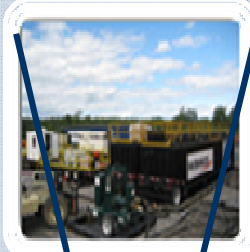
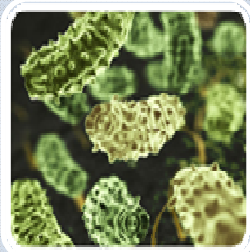
No Silver Bullet – No Single Technology Can Do It All

| Technology | Reverse / Forward Osmosis | Biological | Electro-Coagulation | Evaporation/ Distillation (MVR) | Advanced Filtration (UF, MMF) | Ozone / Ultra-Violet | Chemical Precipitation / Ion Exchange | Dissolved Air Flotation (DAF) |
|----------------------------------|--|---|---|--|--|--|---|--|
| Total Dissolved Solids (TDS) | ✗ | | | ✗ | | | Partial Removal | |
| Total Suspended Solids (TSS) | | Partial Removal | ✗ | | ✗ | Ozone Aids Removal | Partial Removal | ✗ |
| Total Organic Carbon (TOC) | ✗ | ✗ | Partial Removal | | Partial Removal | Partial Removal | | Partial Removal |
| Multivalent cations (Ca, Mg, Fe) | | | Minimal Removal | | Partial Removal | | ✗ | Partial Removal |
| VOCs / HAPs | Partial Removal | ✗ | Minimal Removal | | | Ozone Aids Removal | | Partial Removal |
| Bacteria | ✗ | ✗ | | ✗ | Partial Removal | ✗ | | |
| Limitations | Rigorous Pre-Treatment Required. RO<40K, FO <120K ppm TDS; FO still experimental | Not suitable for high TDS; susceptible to upsets & colony regeneration takes time | Requires very consistent / stable influent water quality ; Can have high (\$) electrical requirements | High Energy Required, Cost, Rigorous Pre-Treatment. Can handle <150K ppm TDS | Pretreatment required; backwash water to reprocess | UV not applicable in turbid waters; high demand for O3; neither provide residual | Can have large chemical demand and solids processing / landfilling \$ | Requires consistent / stable influent water quality; Provides good first cut |

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Water Conditioning vs. Treatment



Solids

- Settleable & Suspended Solids

Disinfection

- Bacteria Control

Organics Removal

- Oil and Grease

Inorganics Removal

- Multivalent Cations
- Res. Linker

Total Dissolved Solids

Impact on Frac Operations

Fines damage in proppant pack; equipment damage

Prematurely breaking the fluid; reservoir souring

Fluid instability; lost revenue; storage issues

Scale of proppant pack; unable to create XL fluid

Minimal if any impact; conveyance?

Technologies

Sock Filters, Multimedia Filters, Dissolved Air Flotation

Biocides or Mixed Oxidant Solution & ClO₂

Dissolved Air Flotation, Absorbent Media, Biological

Chemical Precipitation, NF or Ion Exchange

Distillation (MVR) and Reverse Osmosis (RO)

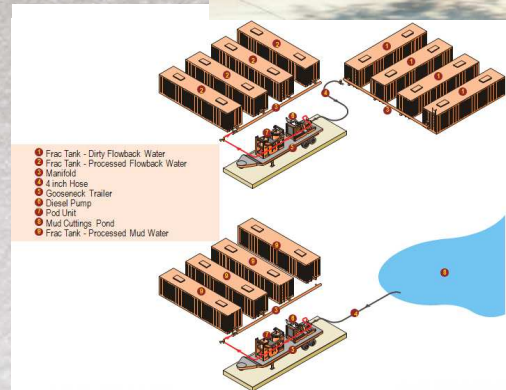
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Filtration

Sock/Bag Filters

- Filters suspended solids
- Accommodates micron cutpoint of 10 to 100 microns
- Recovers 99.9% of feed water
- Minimizes energy consumption
- Allows for high mobility – 24’ enclosed goose neck trailer
- No special transportation permits
- Small footprint - 35’ x 12’
- Rig up time: 2 hours



Backwashable Media Filters

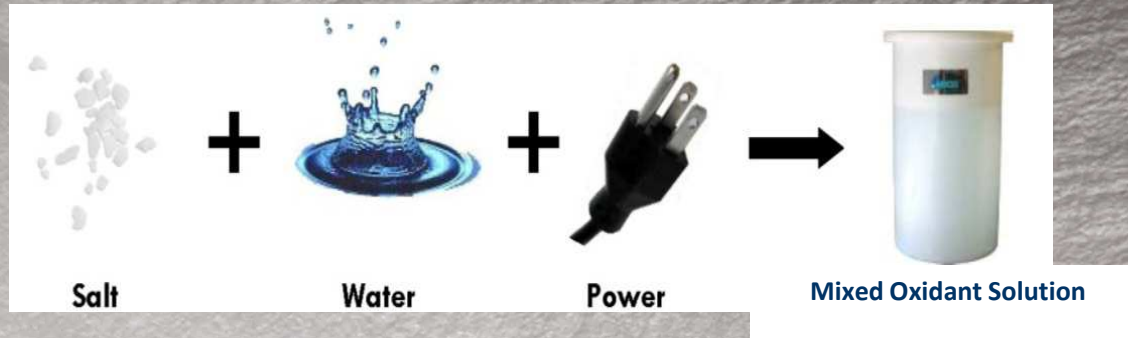
- Automates renewal of media
- Reduces waste, less bags to landfill
- Removes a first cut of solids
- With given potential for breakthrough; barrier filtration typically follows.



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Disinfection (On the Fly)



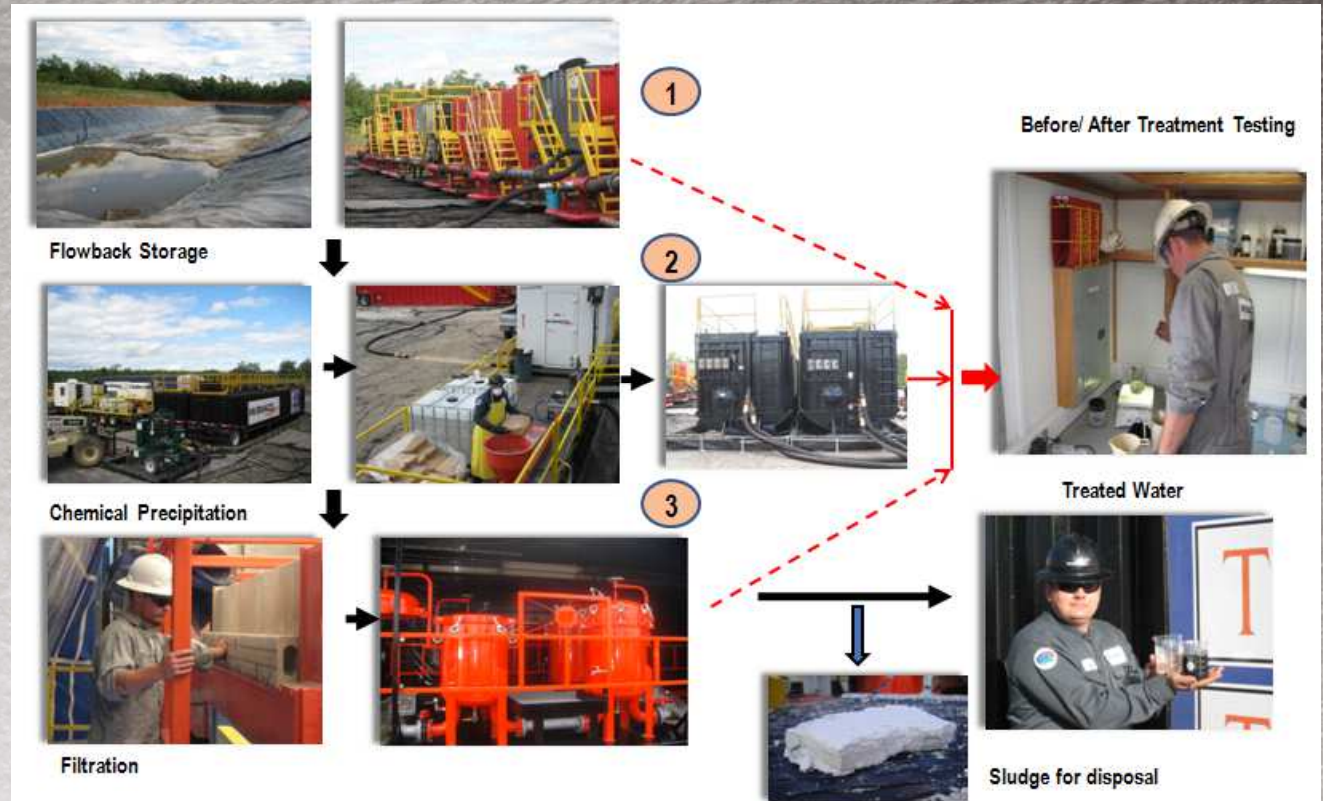
- Located on the Frac Site
- Injected MOS at Suction Manifold on working frac tanks
- Live feedback sample loop on low pressure side of missile and POD Unit

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Inorganics Removal

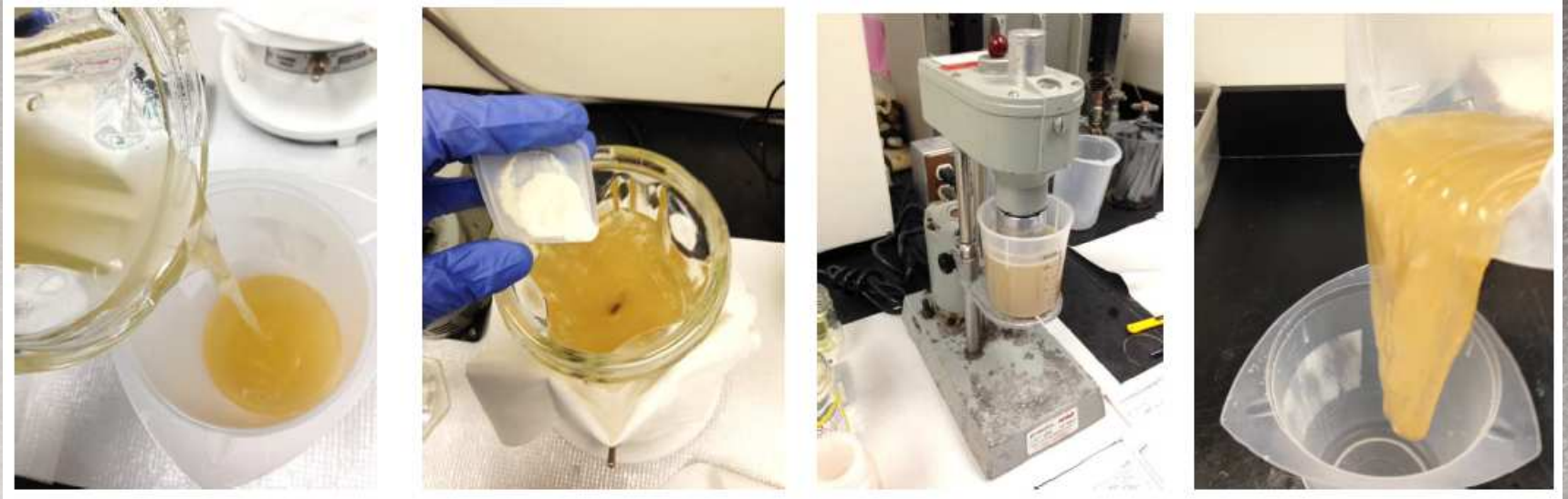
- Chemical precipitation and filtration of heavy metals, hardness and TSS
- Price depends on influent & specifications for reuse
- Adaptable to changes in feed water chemistry



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Bench Study and Compatibility Testing



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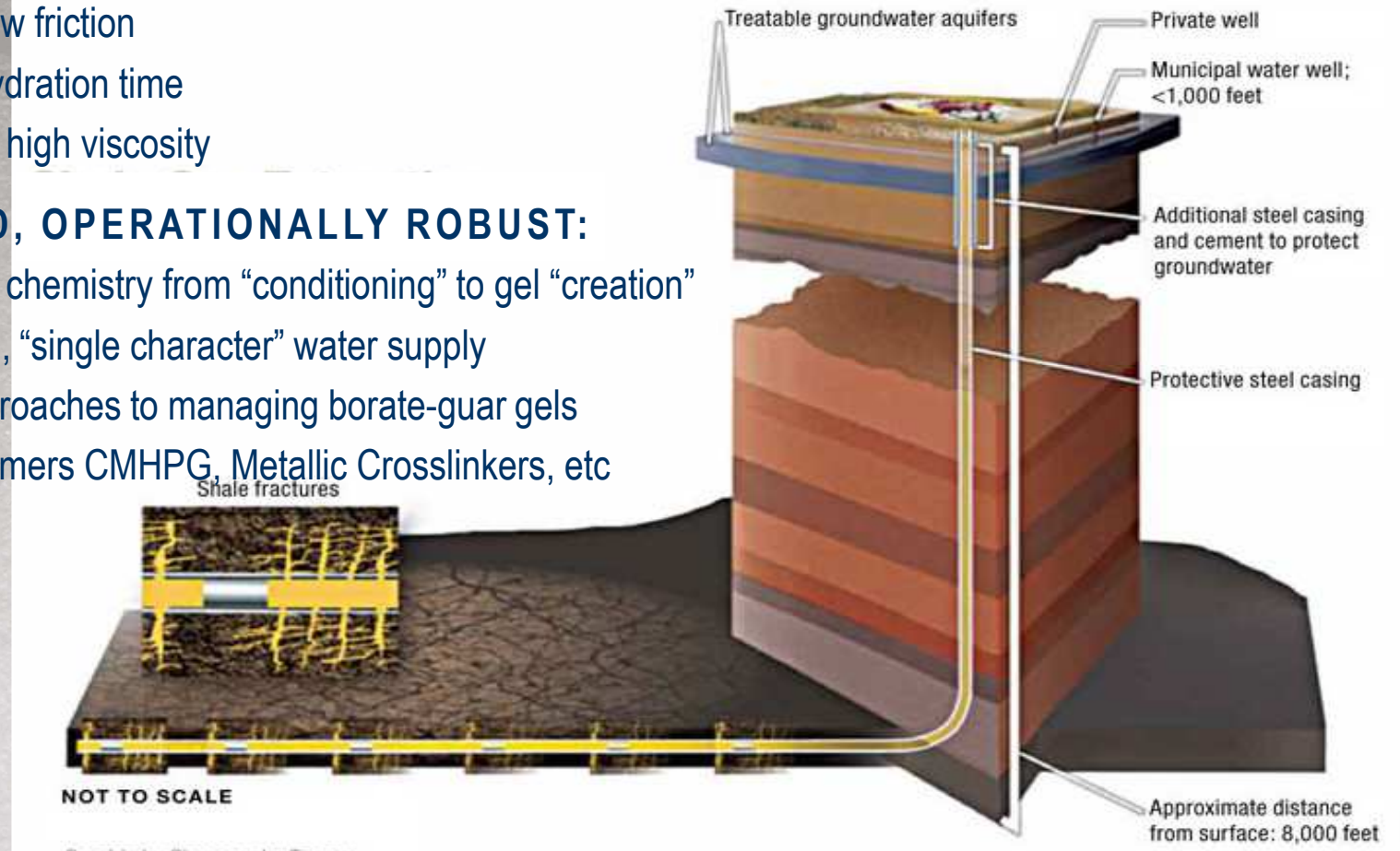
Fluid quality in fracturing operations

ENGINEERING OBJECTIVES:

- Slickwater: low friction
- Linear gel: hydration time
- Gelled fluids: high viscosity

INTEGRATED, OPERATIONALLY ROBUST:

- Synchronized chemistry from “conditioning” to gel “creation”
- Homogenized, “single character” water supply
- Improved approaches to managing borate-guar gels
- Alternate polymers CMHPG, Metallic Crosslinkers, etc



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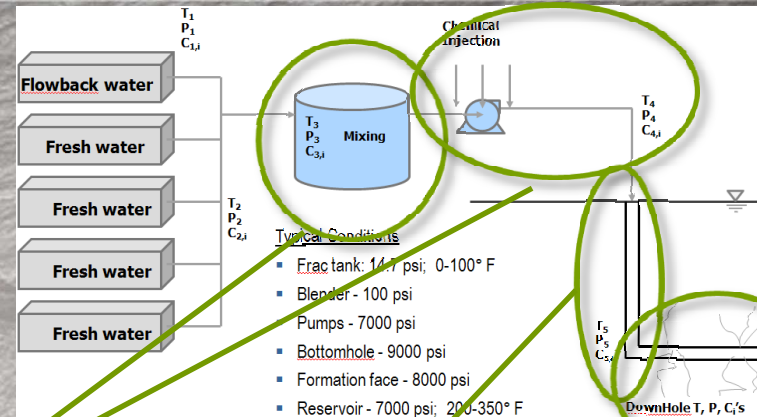
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Reservoir-Centric: Maximizing Completion Quality

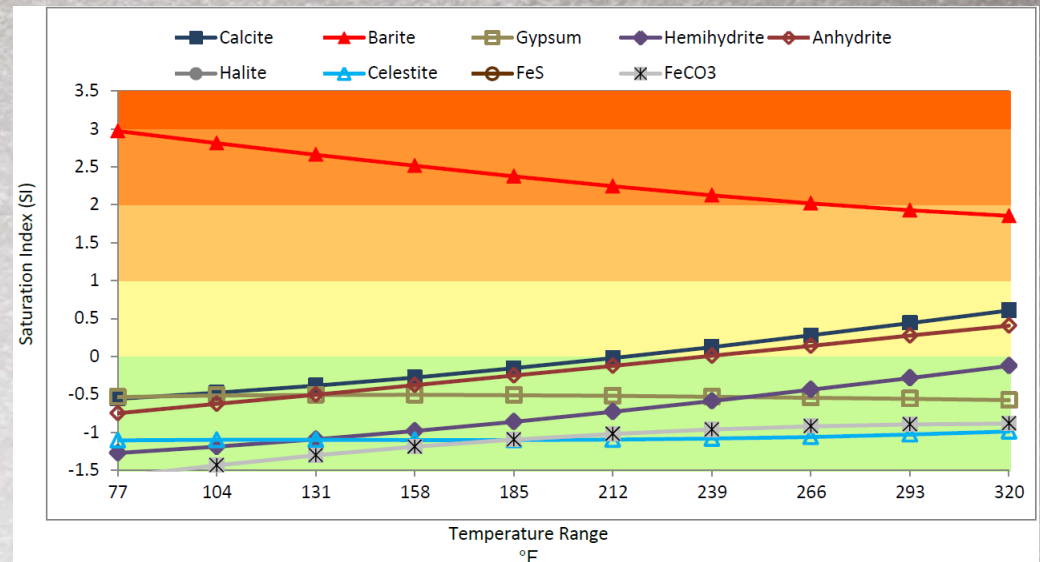
BEYOND FRAC FLUID QUALITY:

LONG TERM PERFORMANCE

- Solids: oxidation & removal
- Scale: prevention & inhibition
- Bacteria: solids removal & biocide residual



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Summary and Conclusions

- Address environmental challenges via:
 - Innovative technologies to deliver gains in efficiency
 - More value, less resources
 - Modern water management and chemistry portfolios to conform with most stringent environmental regulations
 - Industry leading expertise coupled with holistic water management solutions equals optimized long term production
 - Rock-Fluid, Stimulation, Conditioning, & Protection
- **LATEST STIMULATION FLUIDS ALLOW FOR ALL PRODUCED WATER TO BE ECONOMICALLY REUSED**

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Thank you for your attention

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