

New Horizontal Producer in Existing Waterflood: Mitigating Water Breakthrough

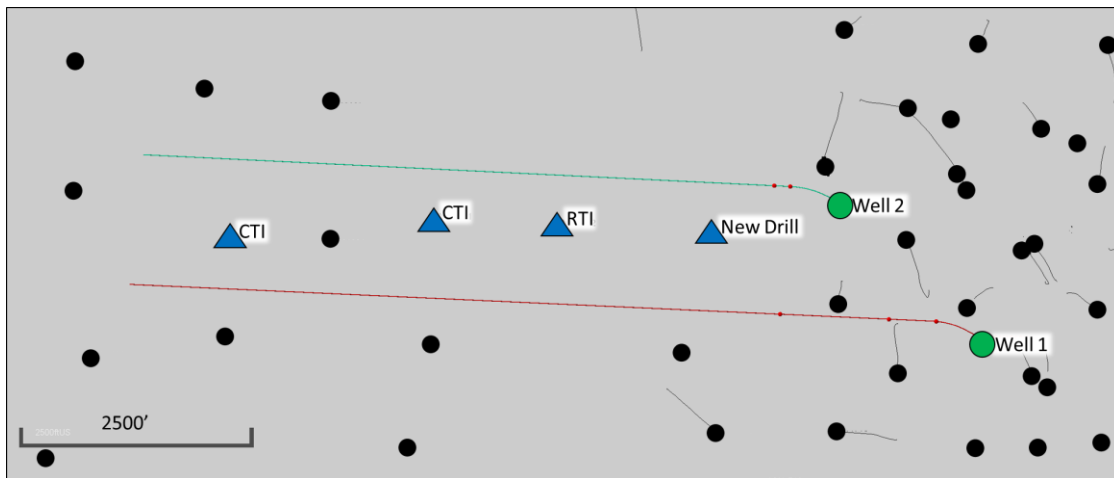
Colton Bell P.E., Oxy

December 12, 2019



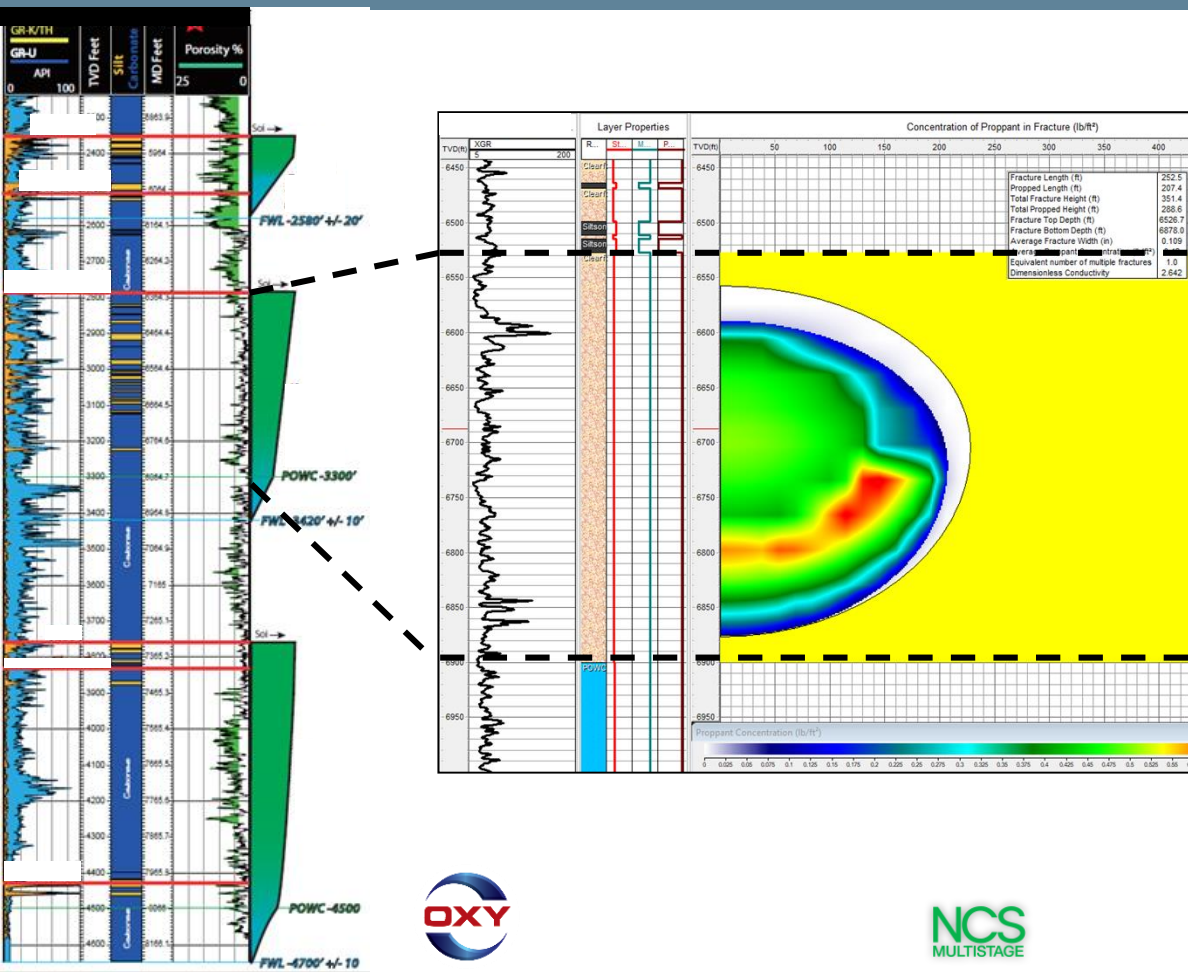
- **Background**
 - Project
 - Completion Design
- **Initial Production Results**
 - Well 2 Flowback
 - Well 2 and Well 1 Flowback Comparison
- **Data Gathering**
 - Initial Tracer Data
 - Production Log Data
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 - Remediation Plan
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 - Production
 - FFI Tracer
 - OST Tracer
- **Summary**





- Actively waterflooded carbonate reservoir
 - > 6% average net porosity
 - > 2.3 mD average net permeability
 - > Discovered in 1955
 - > Waterflood in 1982
- Two ~6,500' horizontal producers
 - > Well 1
 - > Well 2
- Four vertical injectors
 - > Convert to injection x 2
 - > Return to injection x 1
 - > New drill injector x 1

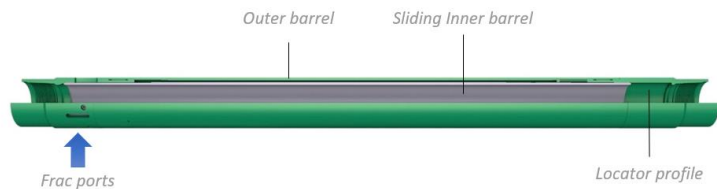
Completion Design



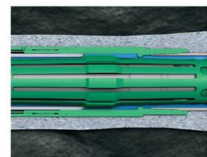
- Risk of tying into water inflows
 - > Production / injection history
 - > Reservoir complexities
 - > Out of zone frac propagation
- Modeled frac length ~250'
- Low rates
- Low sand volumes
- Cross linked gel
- Resin coated sand



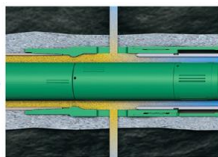
Casing-Installed MultiCycle Frac Sleeve



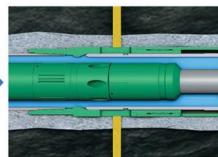
Downhole Frac-Isolation Assembly on Coiled Tubing



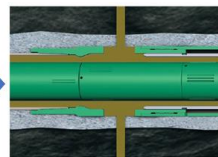
Locate the sleeve



Open sleeve & frac



Close sleeve, let frac heal



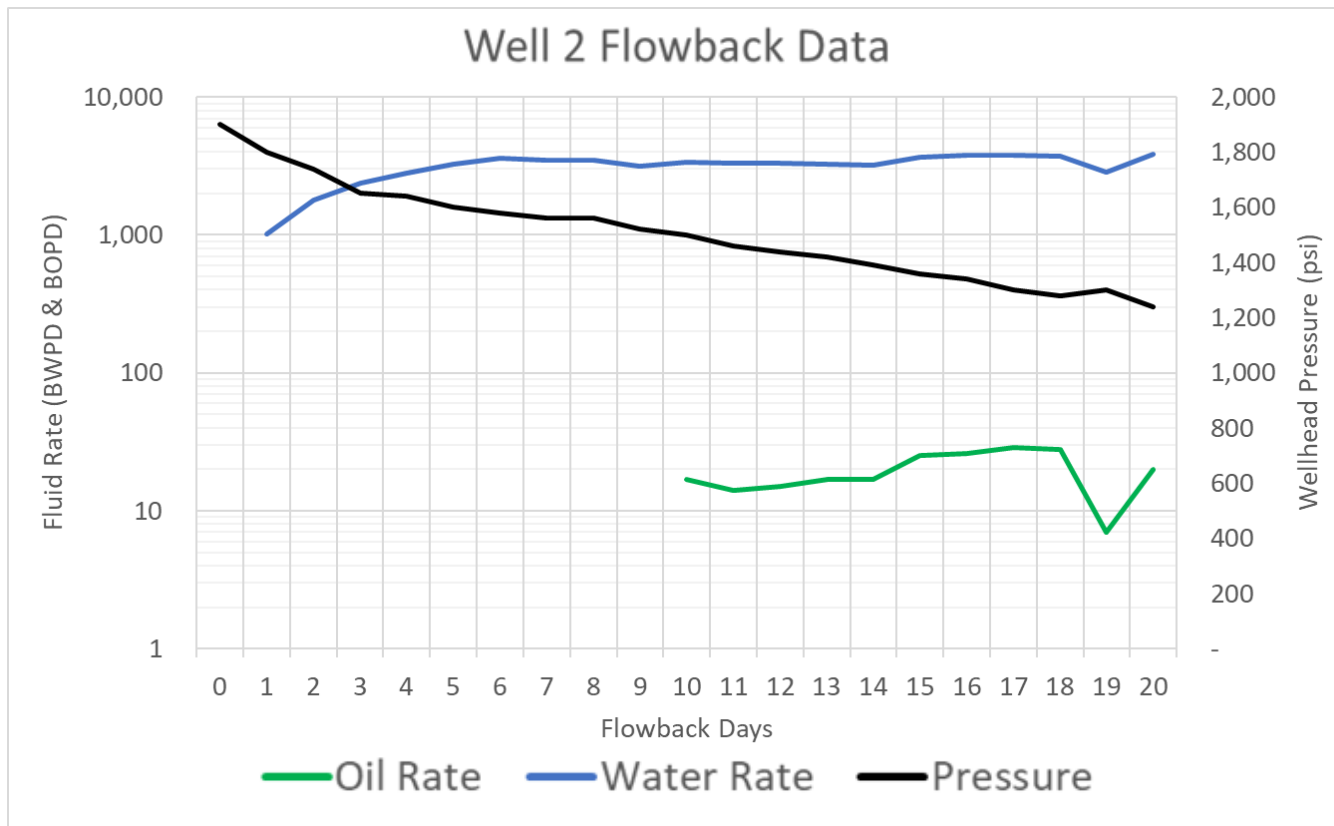
Open sleeves, produce well

Advantages of MultiCycle® Sleeves:

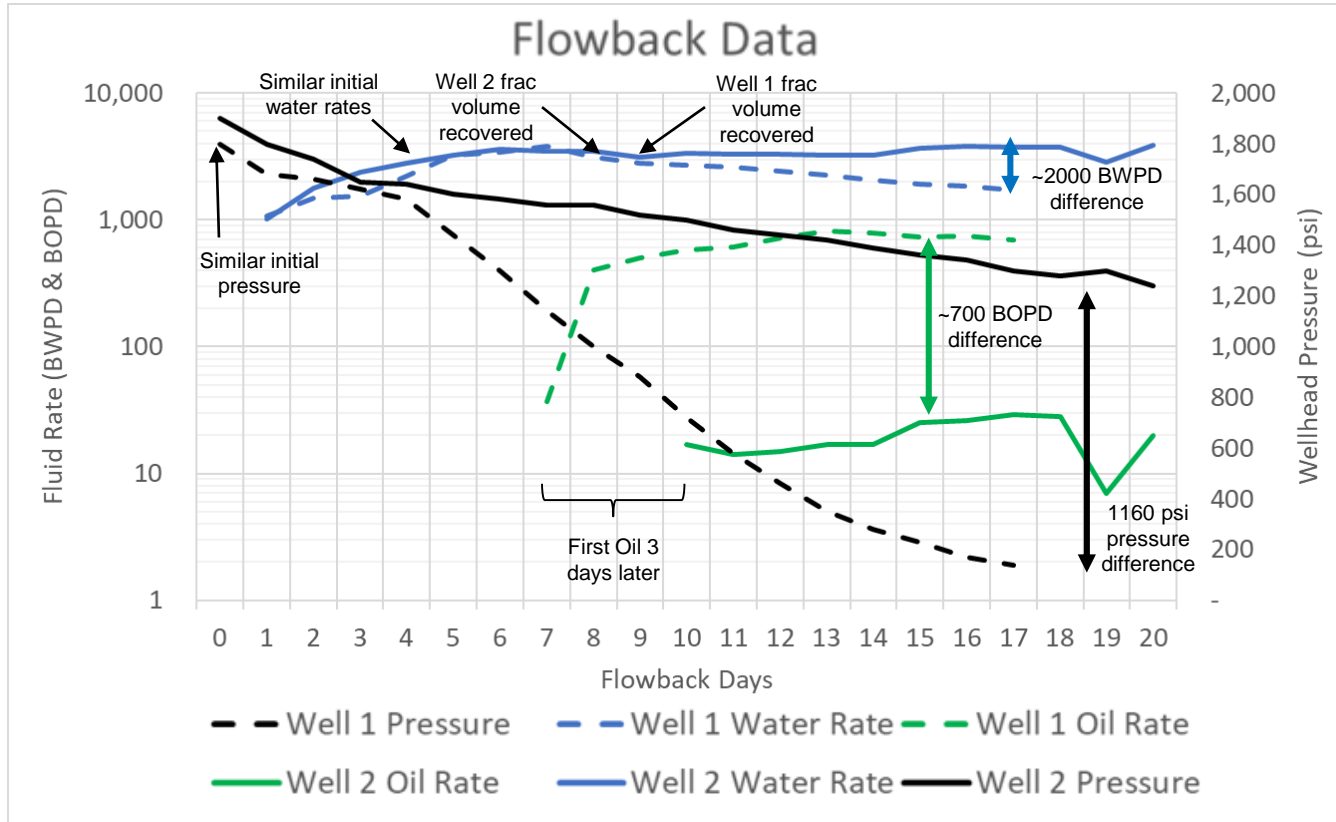
- NCS MultiCycle® sleeves allow re-isolation of specific zones along the wellbore to eliminate water breakthrough
- Individual zone stimulation allows for proper frac spacing and consistent placement
 - Design and execute fracs for optimum frac height and length
 - Ensure breakdown in carbonate formation
- Screen out mitigation via coil circulation

Initial Production Results





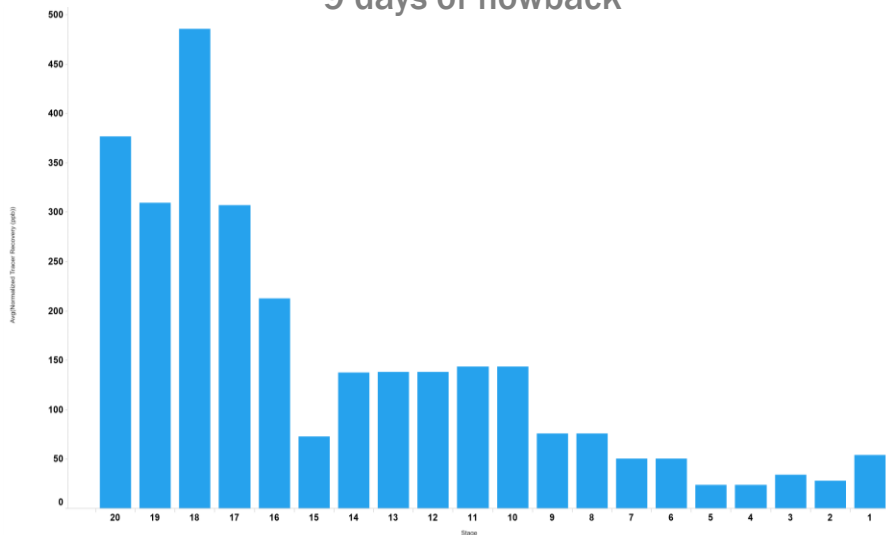
Well 2 and Well 1 Flowback Comparison



Data Gathering

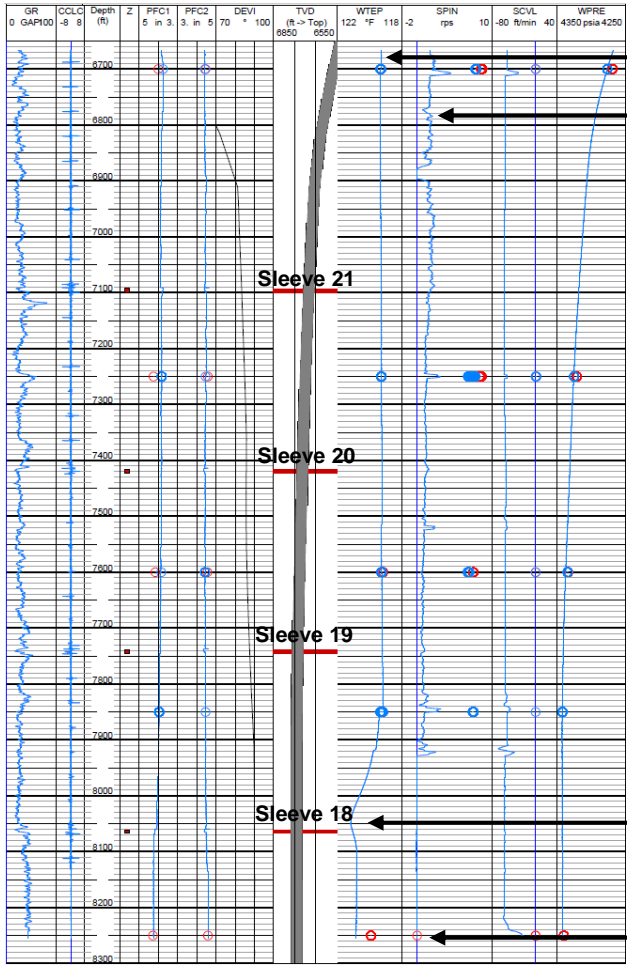


Tracer Recovery from 9 days of flowback



- Frac Fluid Indicator (FFI™) tracer pumped during the completion
 - > FFI™ is pumped as a liquid with the frac fluid to determine where the most fluid is coming from
- Majority of tracer recovery from the heel (stages 16-20)
 - > Stage 18 shows largest recovery
- Low tracer recovery from the Toe

While the full lateral is contributing fluid, there is more fluid coming from the heel than is typically seen in heel dominated flow during flowback



Temperature

Spinner

Sleeve 21

Sleeve 20

Sleeve 19

Sleeve 18

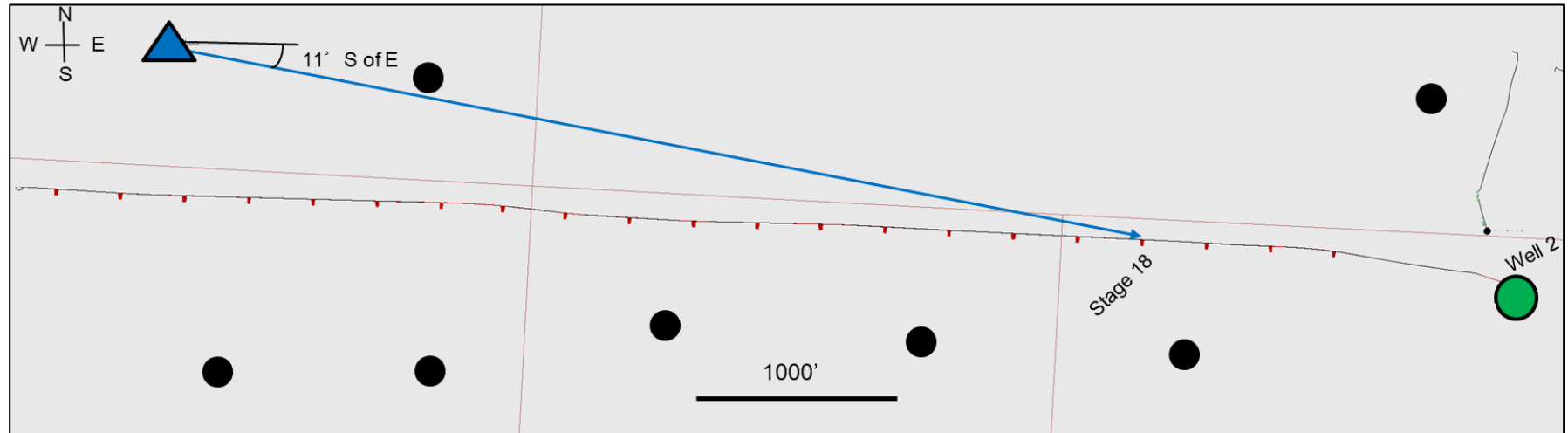
Temperature response from sleeve 18 inflow

Down pass station indicates no flow beyond sleeve 18

- Ran Production Log while flowing back
- Down pass station below sleeve 18 indicates no/minimal inflow
- Temperature indicates significant inflow from sleeve 18
- Tool issues / foreign debris issues resulted in being unable to log the entire lateral

Production Log supports tracer data in that a majority of the fluid is coming from the heel section of the lateral.



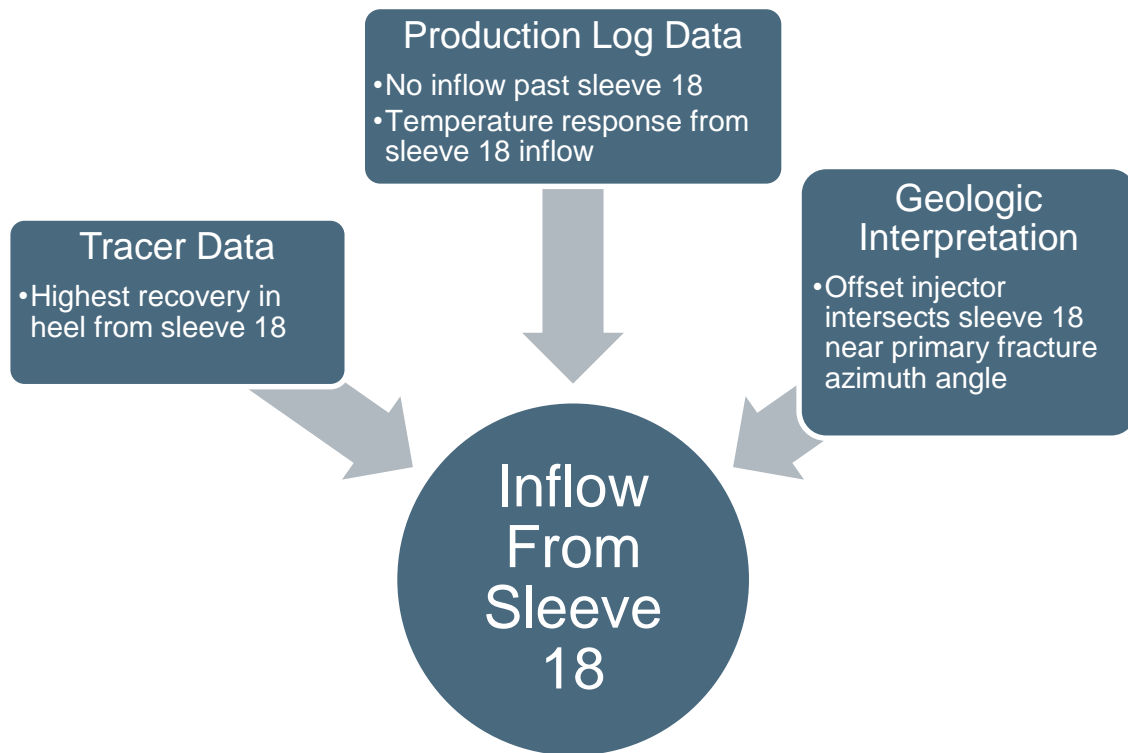


- Field primary fracture azimuth is $\pm 15^\circ$ S of E propagating longitudinally along the wellbore
- Injector intersects sleeve 18 at 11° S of E
- Injector has been on injection since 1982 and has injected cumulatively ~ 4.8 MMBBL

Geologic interpretation gives a potential explanation for significant tracer recovery in the heel section, specifically at sleeve 18.

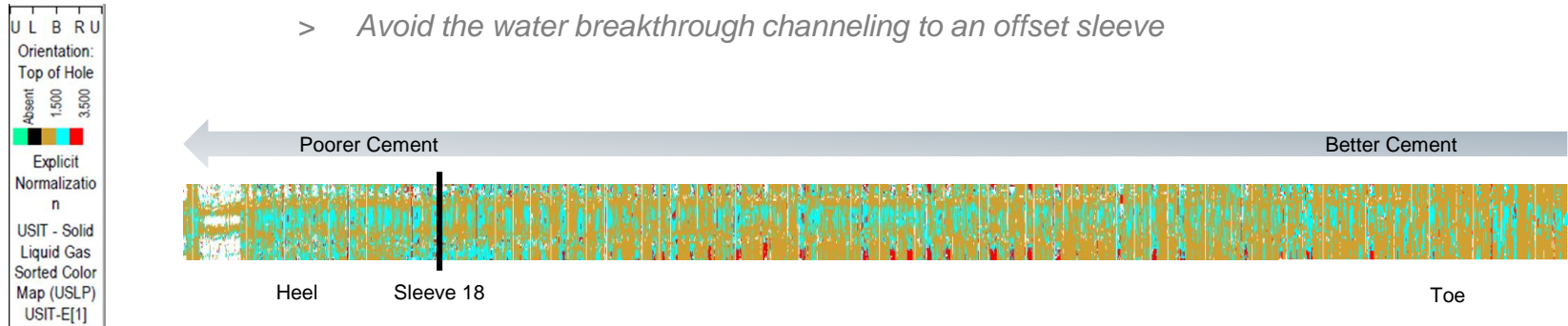
Remediation Plan





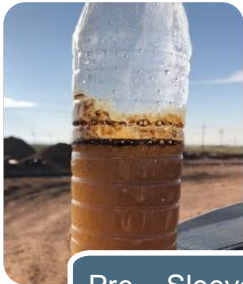
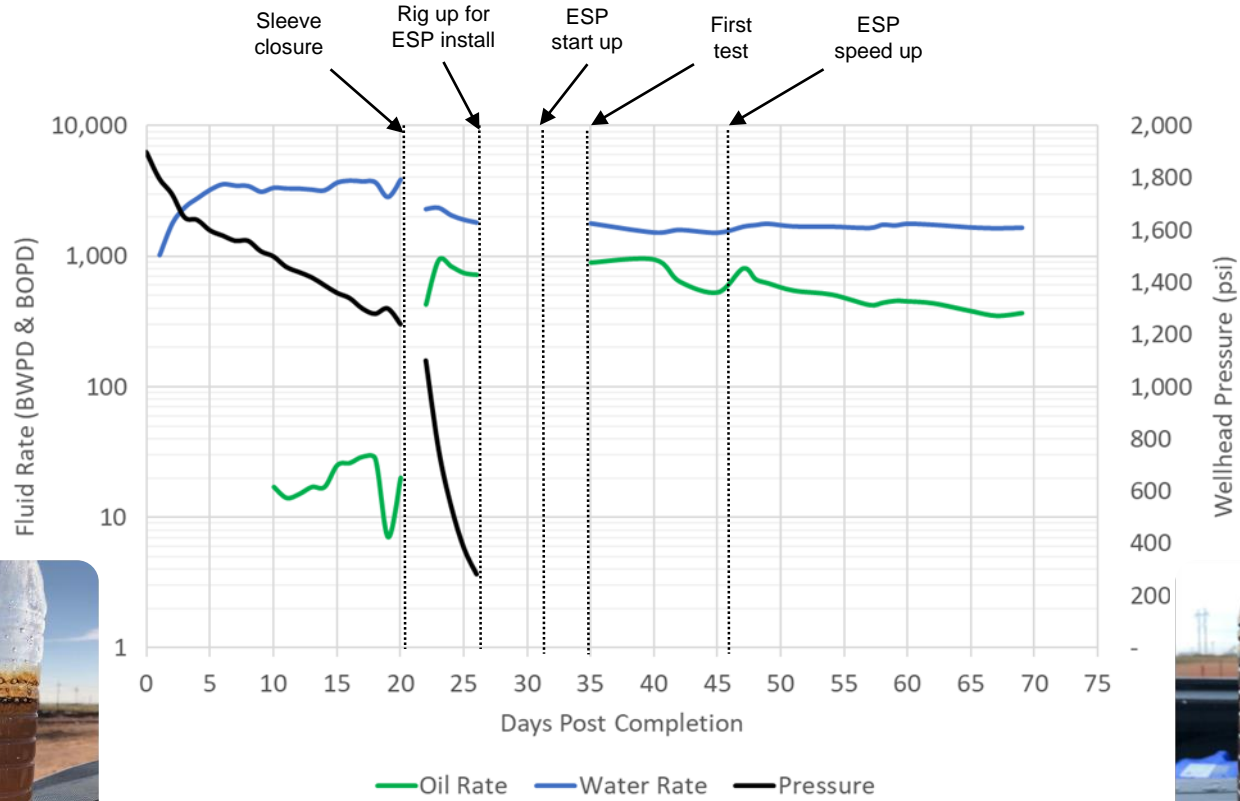
Goal: *Shutoff water from heel dominant stage(s) and get meaningful contribution from the rest of the well. Lower water production and increase oil cut.*

- Utilize MultiCycle® sleeves to close and re-isolate zones
- Evaluated USIT log to determine cement integrity near identified water producing stage.
- Elected to close all heel sleeves based on poor cement quality toward the heel (Stages 17-21)
 - > *Avoid the water breakthrough channeling to an offset sleeve*



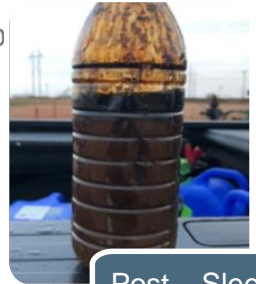
Post Job Results





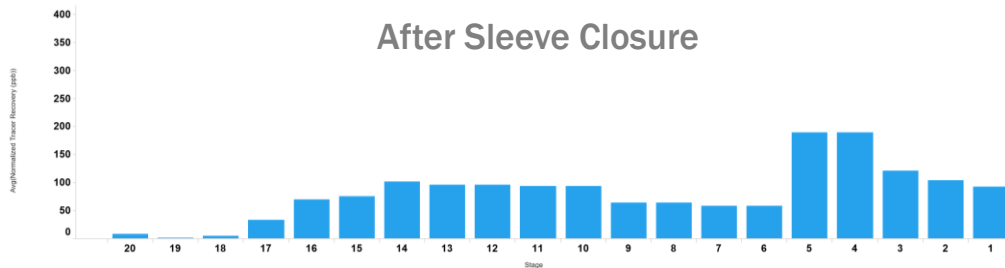
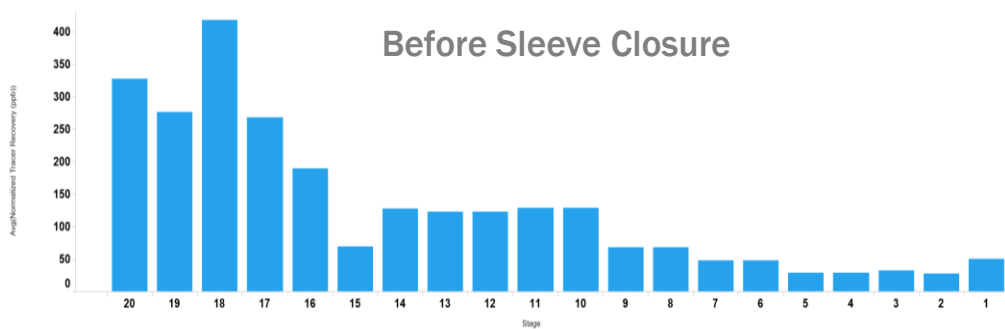
Pre – Sleeve Closure

• Day 16



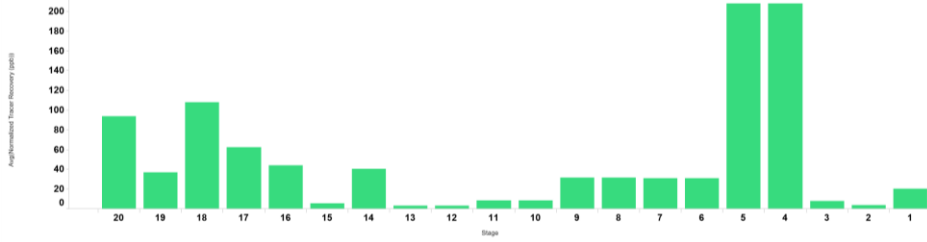
Post – Sleeve Closure

• Day 23

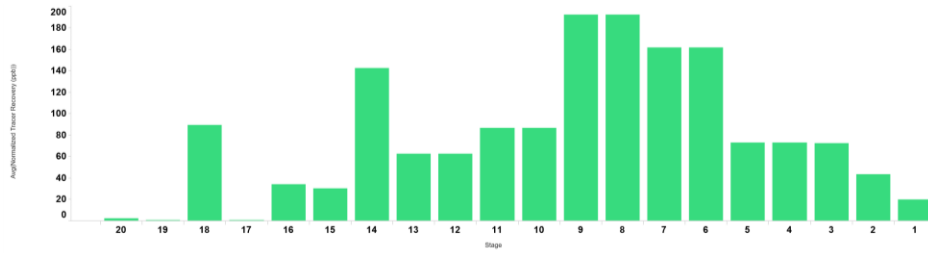


- Frac Fluid Identifier (FFI™) tracer results showed an immediate drop in FFI™ recovery from Stages 18-20 and minimal recovery from Stage 17
 - > Good indication that sleeve closure shut off production
- FFI™ results showed much more even distribution of production across the rest of the lateral
- The FFI™ results immediately after sleeve closure showed large increases in concentration.
 - > The stages hadn't been adequately drawn-down prior to closing sleeves 17-21

Before Sleeve Closure



After Sleeve Closure



- Oil Soluble Tracer (OST™) was pumped alongside the FFI™ during the completion
 - > OST™ is a particulate oil tracer pumped with the proppant that is used to determine where the most hydrocarbon is coming from
- Samples analyzed after sleeves 17-21 were closed indicated a more consistent OST™ contribution throughout the lateral.
 - > Cumulative OST™ recovery increased in-line with increased oil production, indicating the second half of the lateral was not adequately drawn down

Water Shutoff

- MultiCycle® sleeves were used to close a portion of the lateral and successfully reduced production from water producing stages while improving overall oil production and reducing water cut.
- Diagnostics (chemical tracers and production log) were key in identifying the location of water breakthrough
- Post-job tracer results showed positive increases in production across the remaining producing lateral

Project Significance

- Use of MultiCycle® sleeves has de-risked new horizontal producers in existing waterfloods where water breakthrough is a common technical concern
- Pinpoint completions is necessary to design and execute a frac that controls fracture height within the target reservoir, specifically limiting growth into higher water saturated zones

