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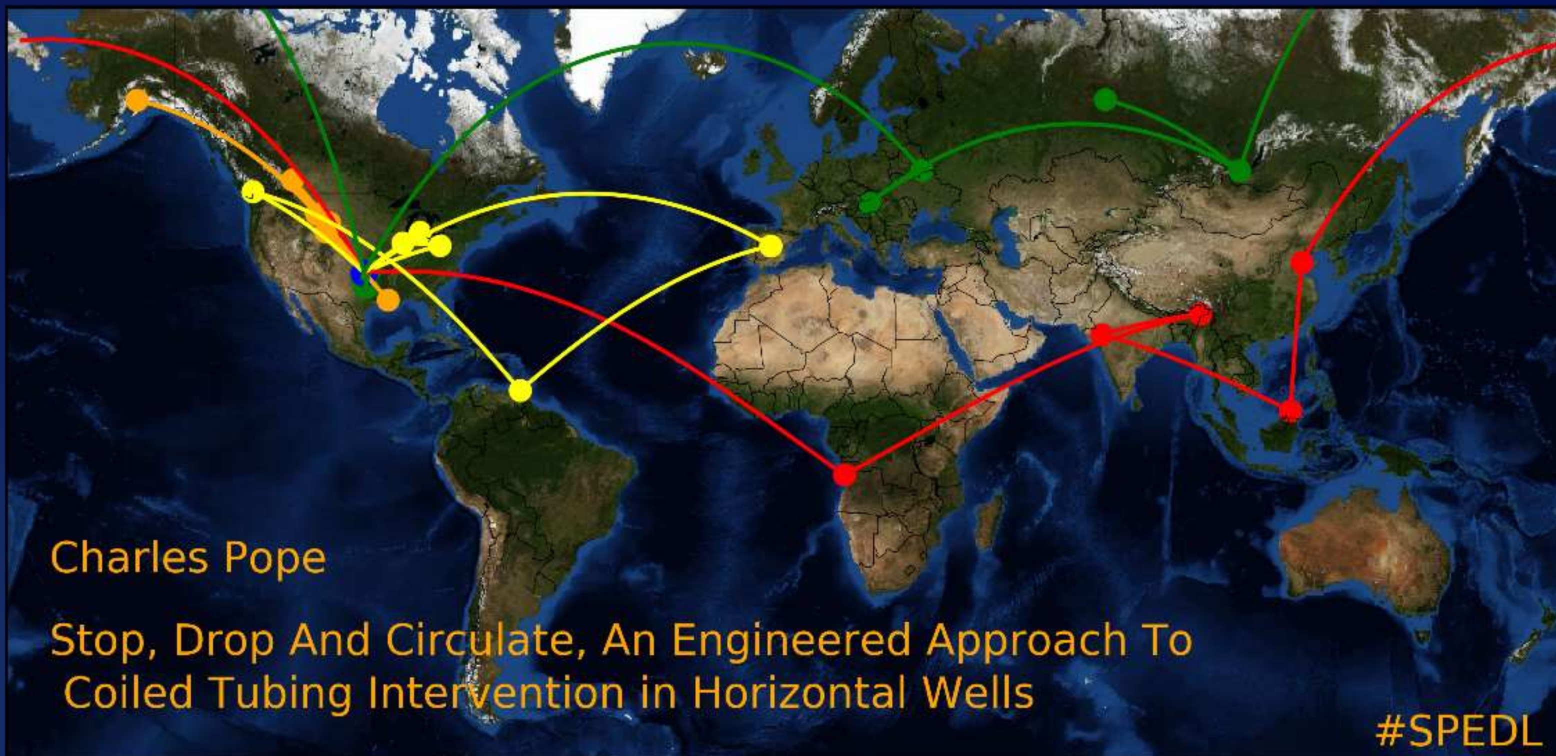


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# Stop, Drop And Circulate An Engineered Approach To Coiled Tubing Intervention in Horizontal Wells

Charles Pope
Complete Shale

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# Agenda

- Global coiled tubing usage
- Problems with historical practices
- Results from a few case histories
- Take away

# Where and how coiled tubing is used

# Coiled Tubing Intervention

**Initial Completion:**

- Well Prep
- Perforating
- After Frac Drillouts
- Coiled Tubing Fracs

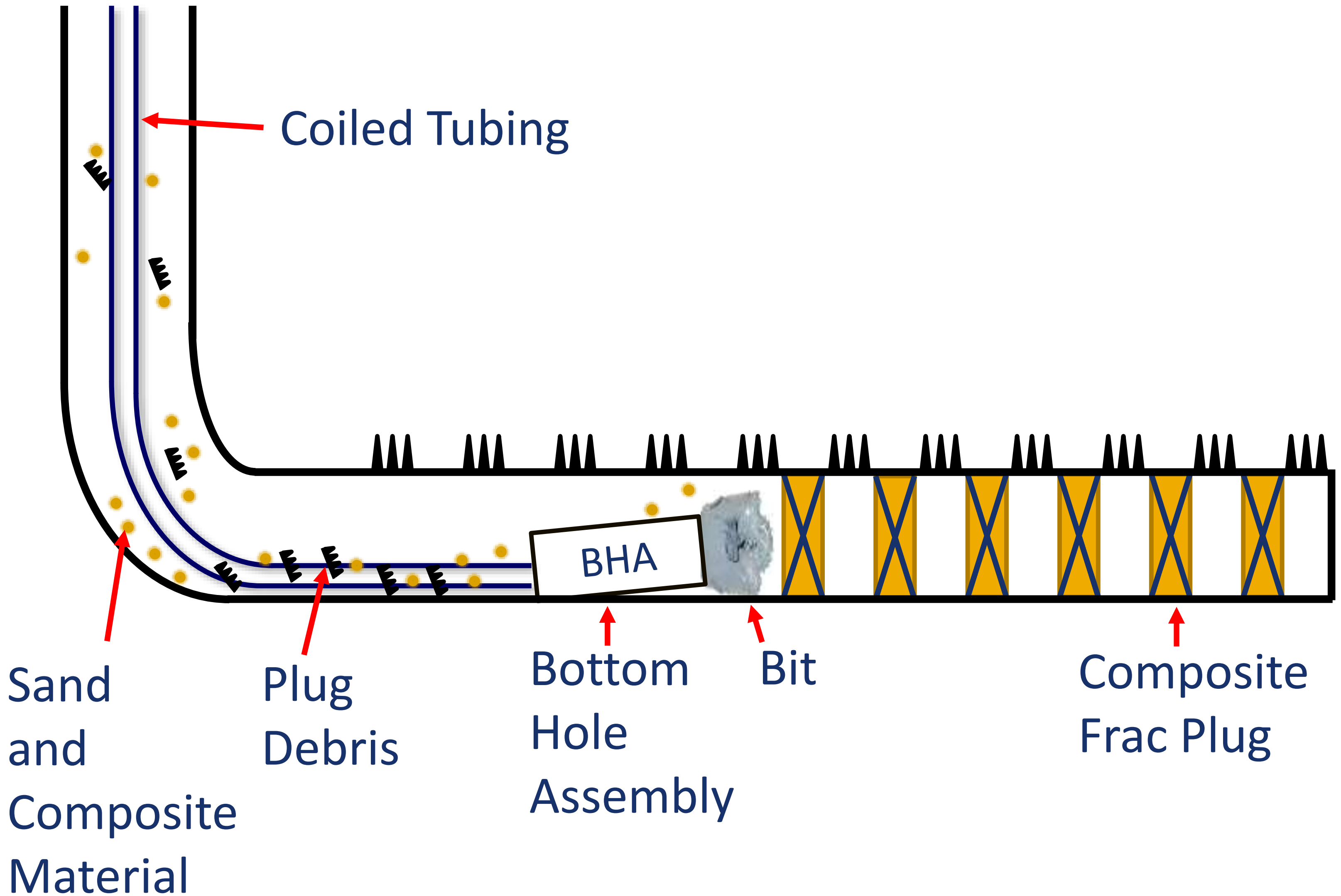
**Cleanouts Prior to:**

- Acid Stimulation
- Chemical Treatments

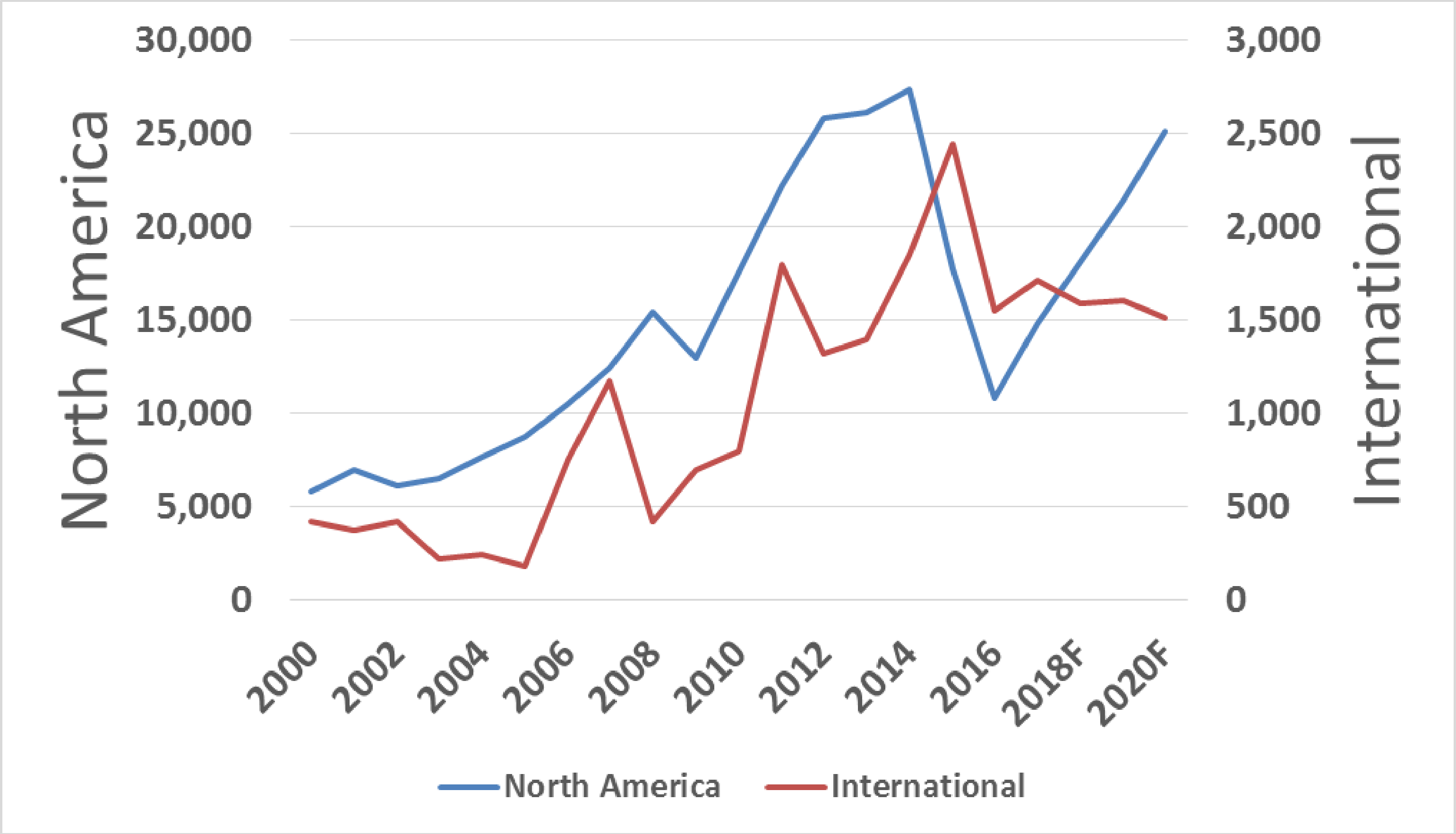
**Also used for:**

- Logging
- Fishing
- P&A

# Typical Wellbore Configuration

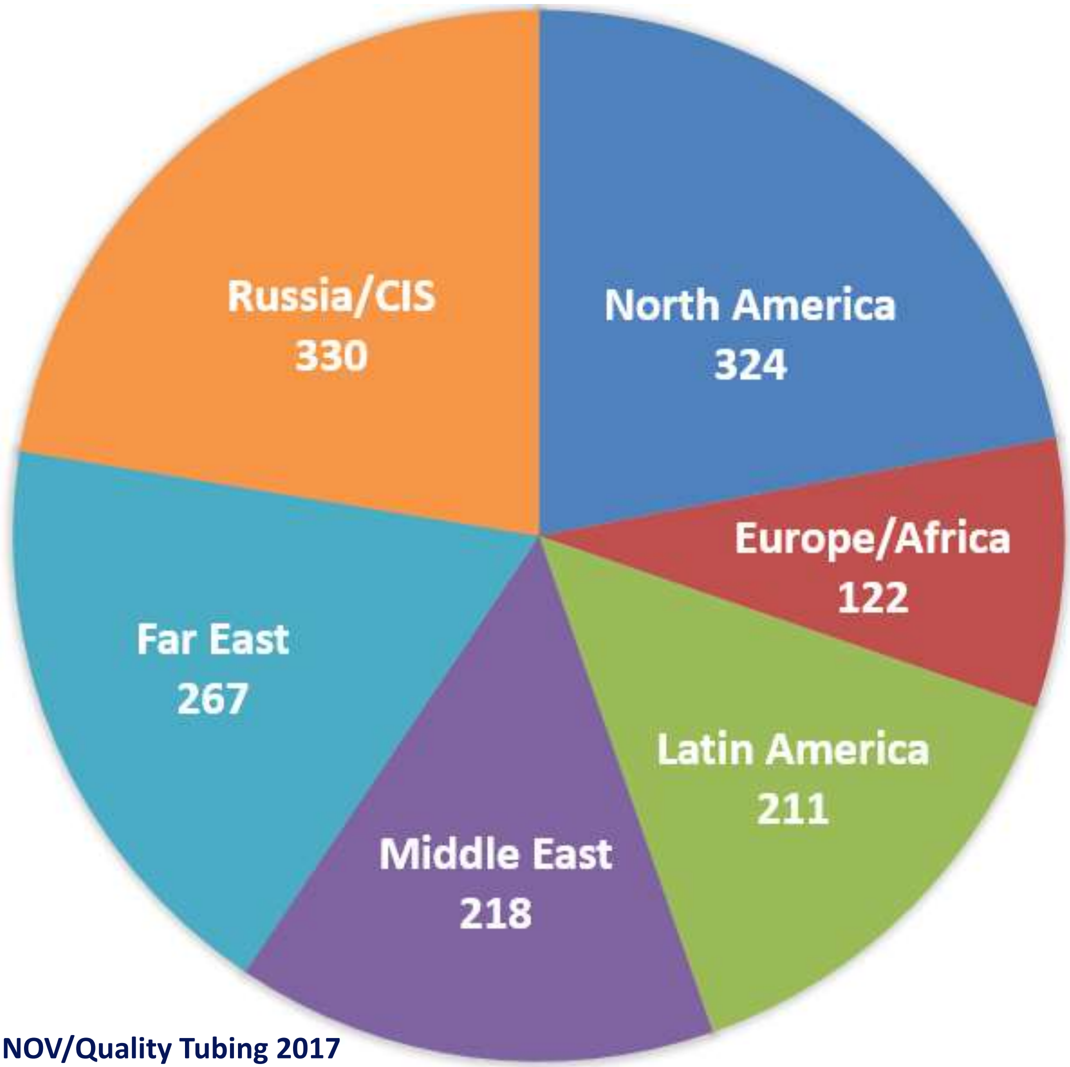


# Annual Horizontal Wells Drilled




- Sources: Rystad Energy, 2017; Baker Hughes

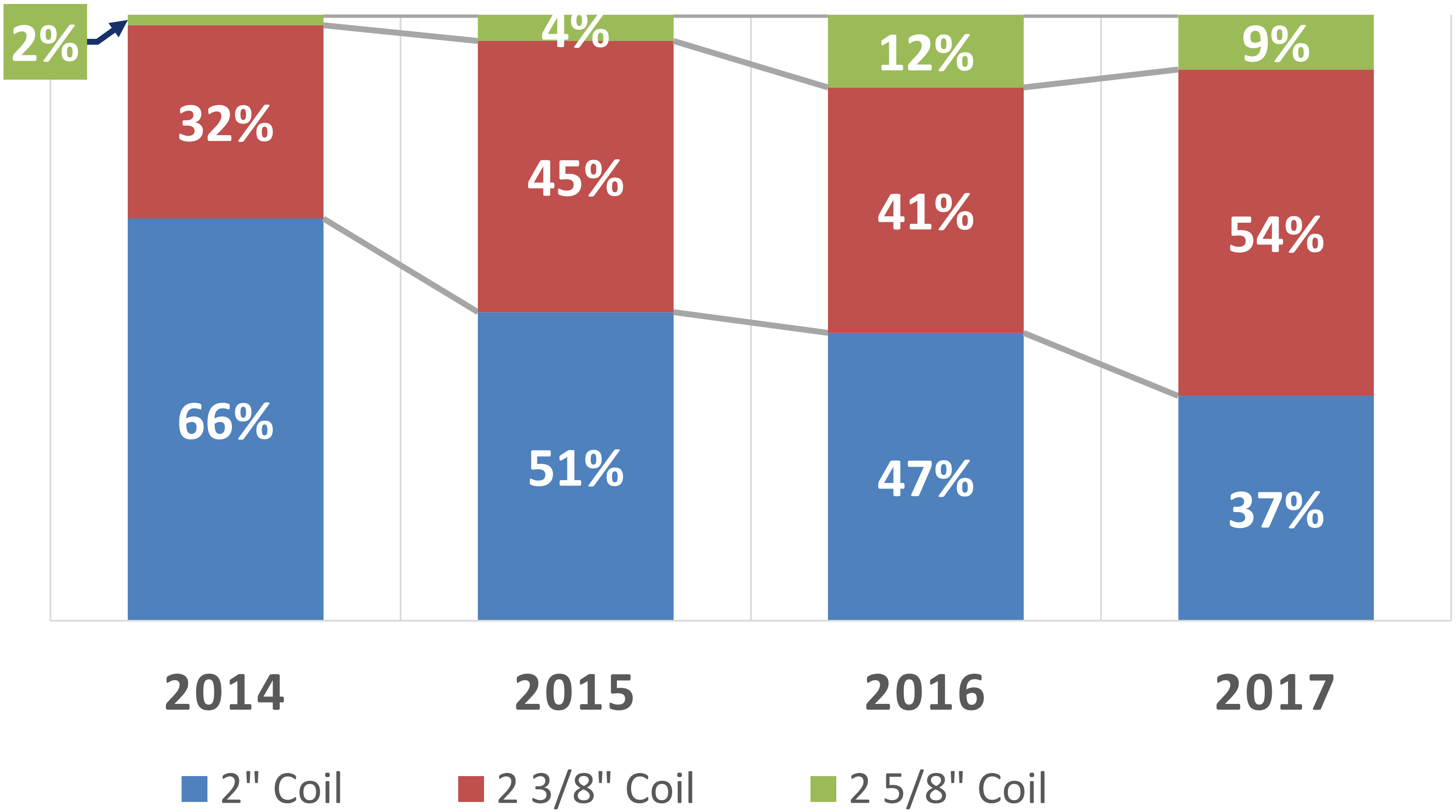
# Active Coiled Tubing Units




**1472 Active Units**

NOV/Quality Tubing 2017

# Horizontal Wells Drive Larger Pipe



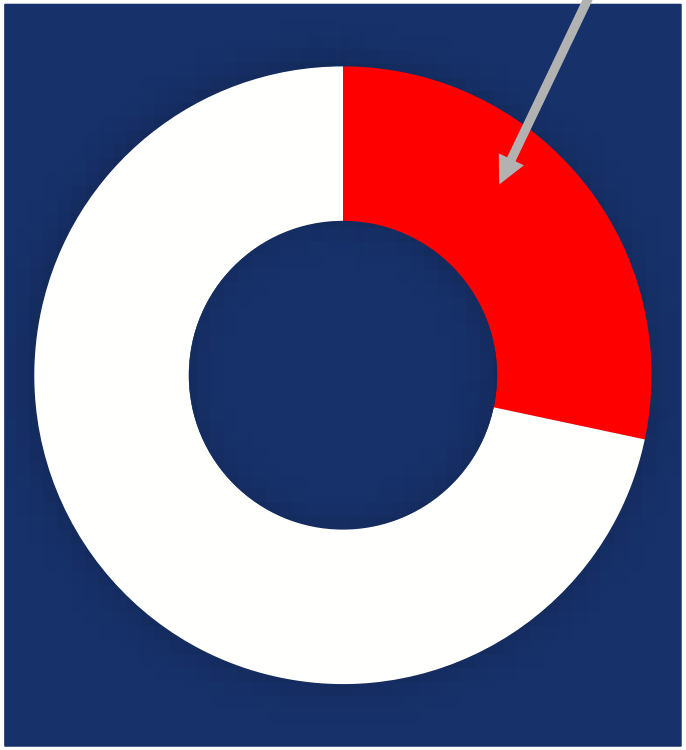

NOV/Quality Tubing 2017

# Why is this Important?

Spent $60MM

Average costs $250k

28% of spend



2015

Top 10 drillouts cost $17MM

Cost overruns on 30% of wells

Stuck pipe: 1 well in 16

SPE 187337-MS

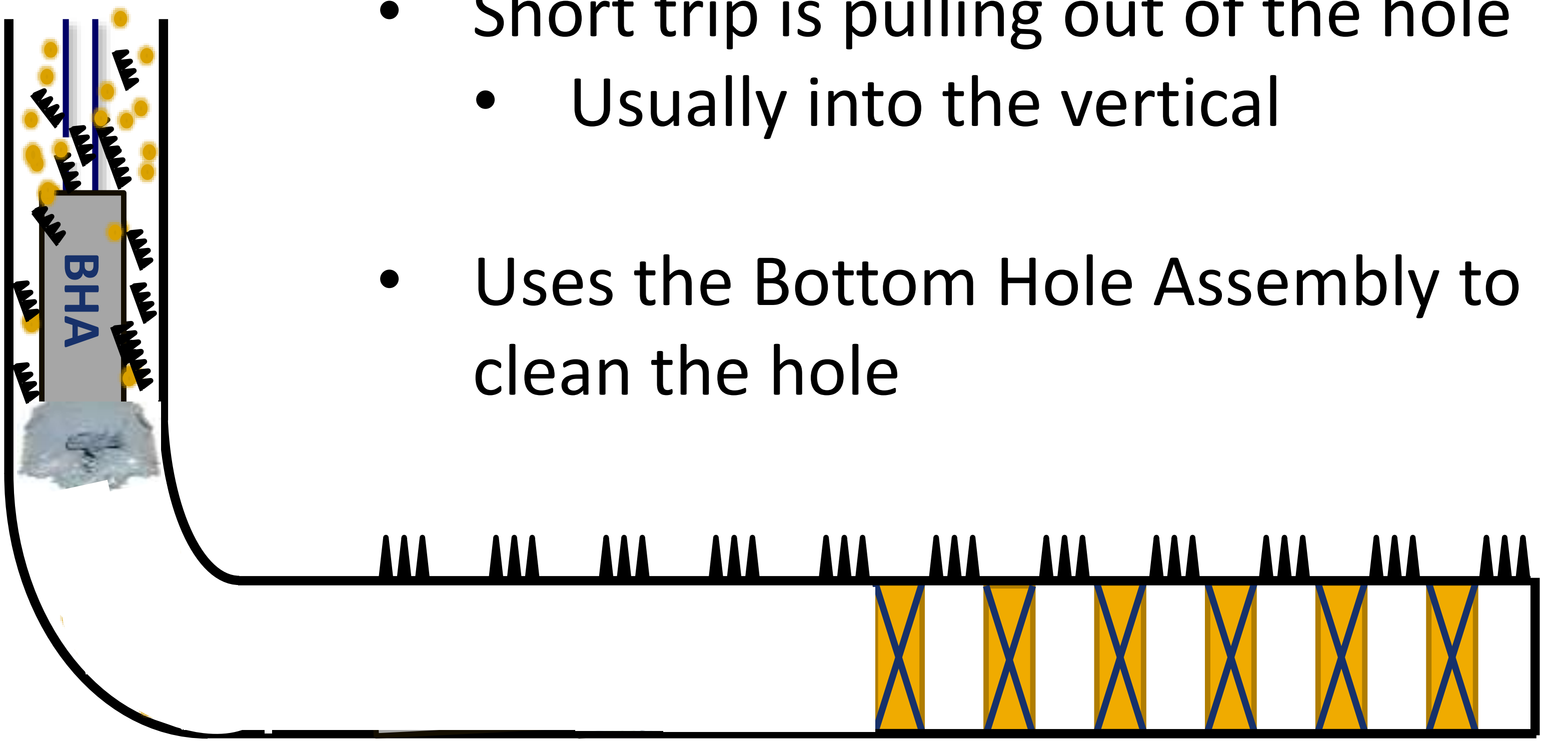
# Historical Practices

- Very little engineering support
- Applied vertical well techniques
- Short trips
- Gel sweeps
- No digital data gathered

# Short Trips

- Short trip is pulling out of the hole
  - Usually into the vertical

- Uses the Bottom Hole Assembly to clean the hole



# How Common is Stuck Pipe?

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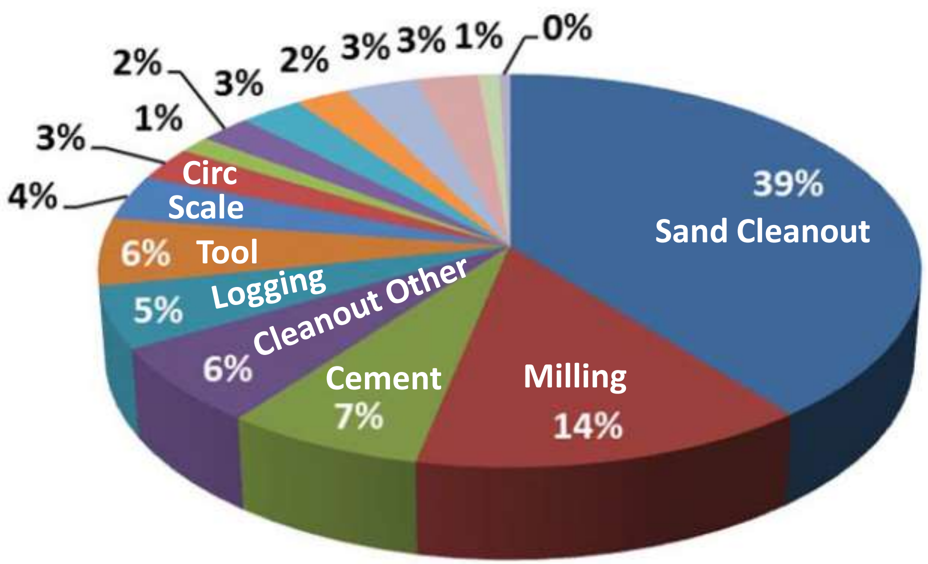
- From 2001 to 2010: stuck pipe incidents increased 43%. (Burgos, SPE 163914)
- 2012 in BC: stuck ~0.25 hrs per plug. (Lyndsey, SPE 178644-MS)
- From 2013 to 2015: 600 interventions, stuck 14 hrs per well. (Pope, SPE 187337-MS)

“An ounce of prevention is worth a pound of cure.” Benjamin Franklin

# Causes of Stuck Pipe




- Sand cleanouts represent biggest hazard
- Routine interventions account for 77%

SPE 163914

# Where do we get Stuck?

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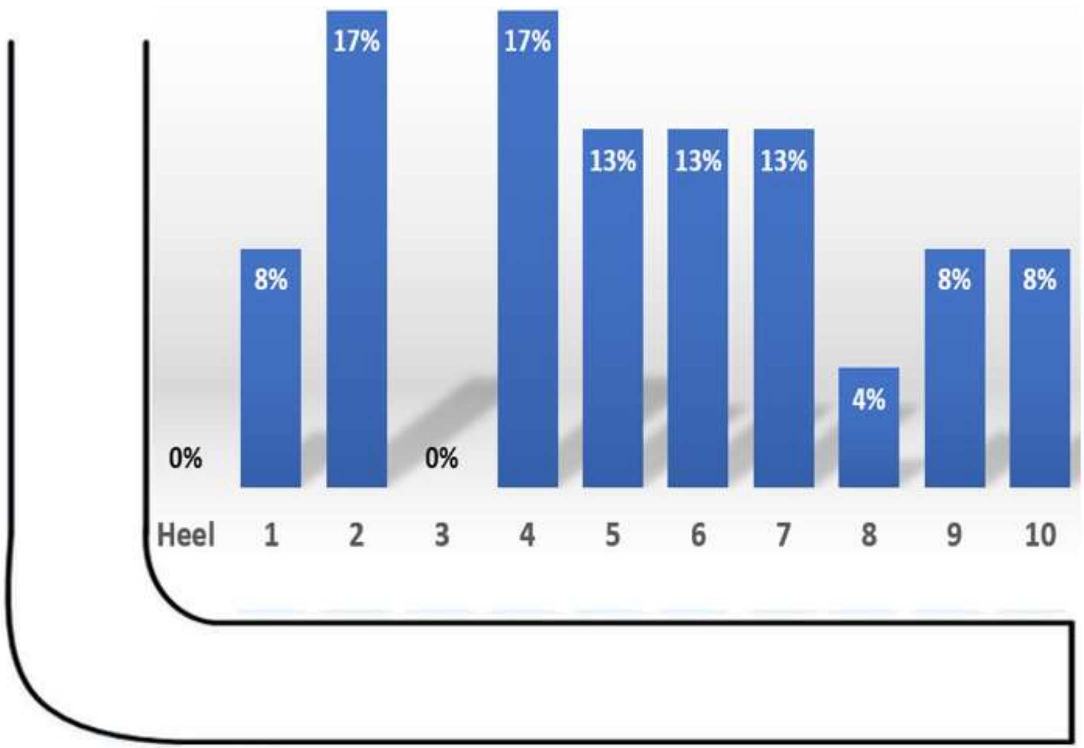
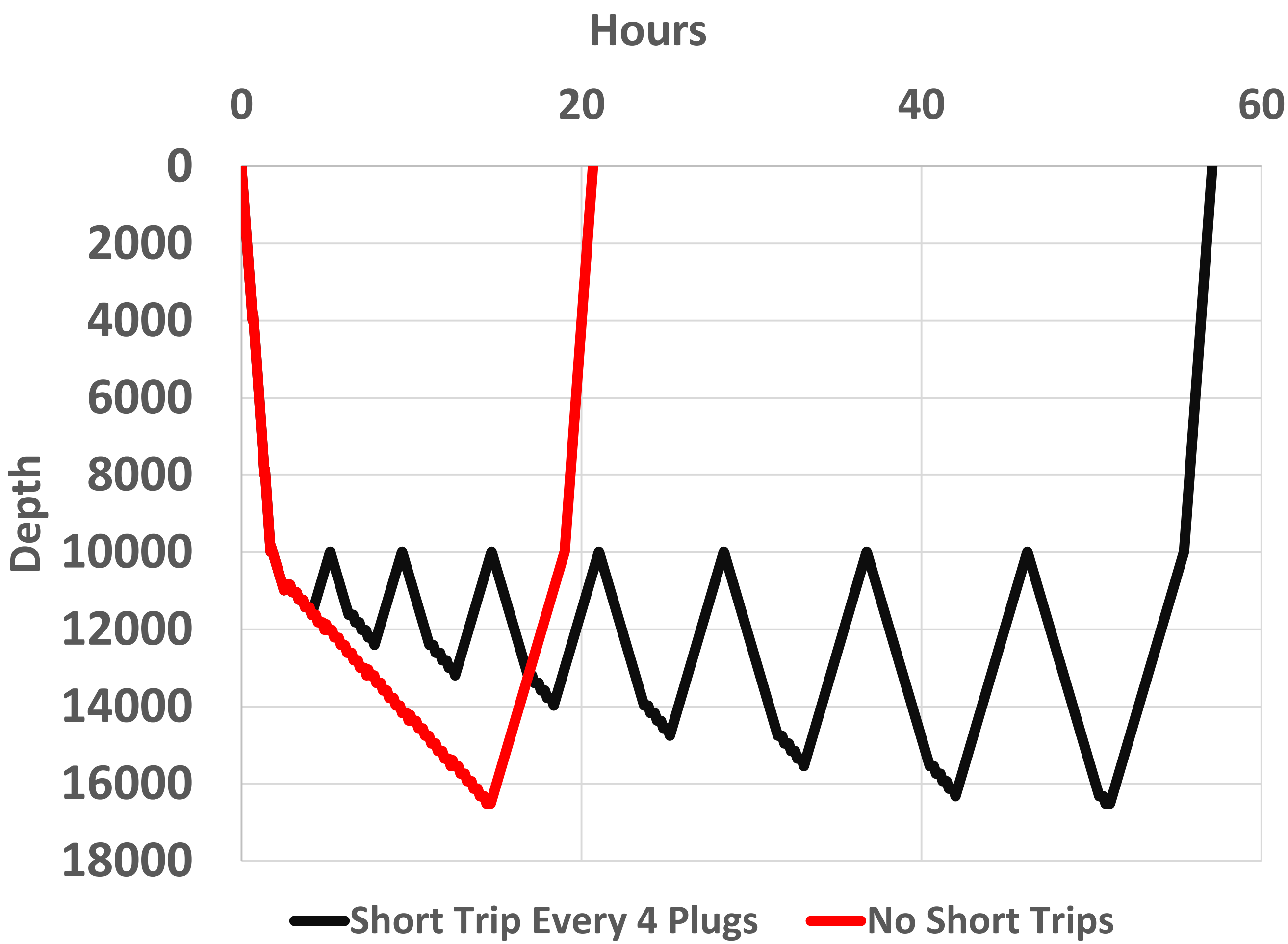



**Location of stuck pipe event normalized by lateral length**

- 26 confirmed events
  - 22 short trips
  - 2 when picking up off bottom
- No stuck events in curve
- 85% of time stuck pipe is related to the short trip

**SPE 187337-MS**

# Effect of Short Trips on Time



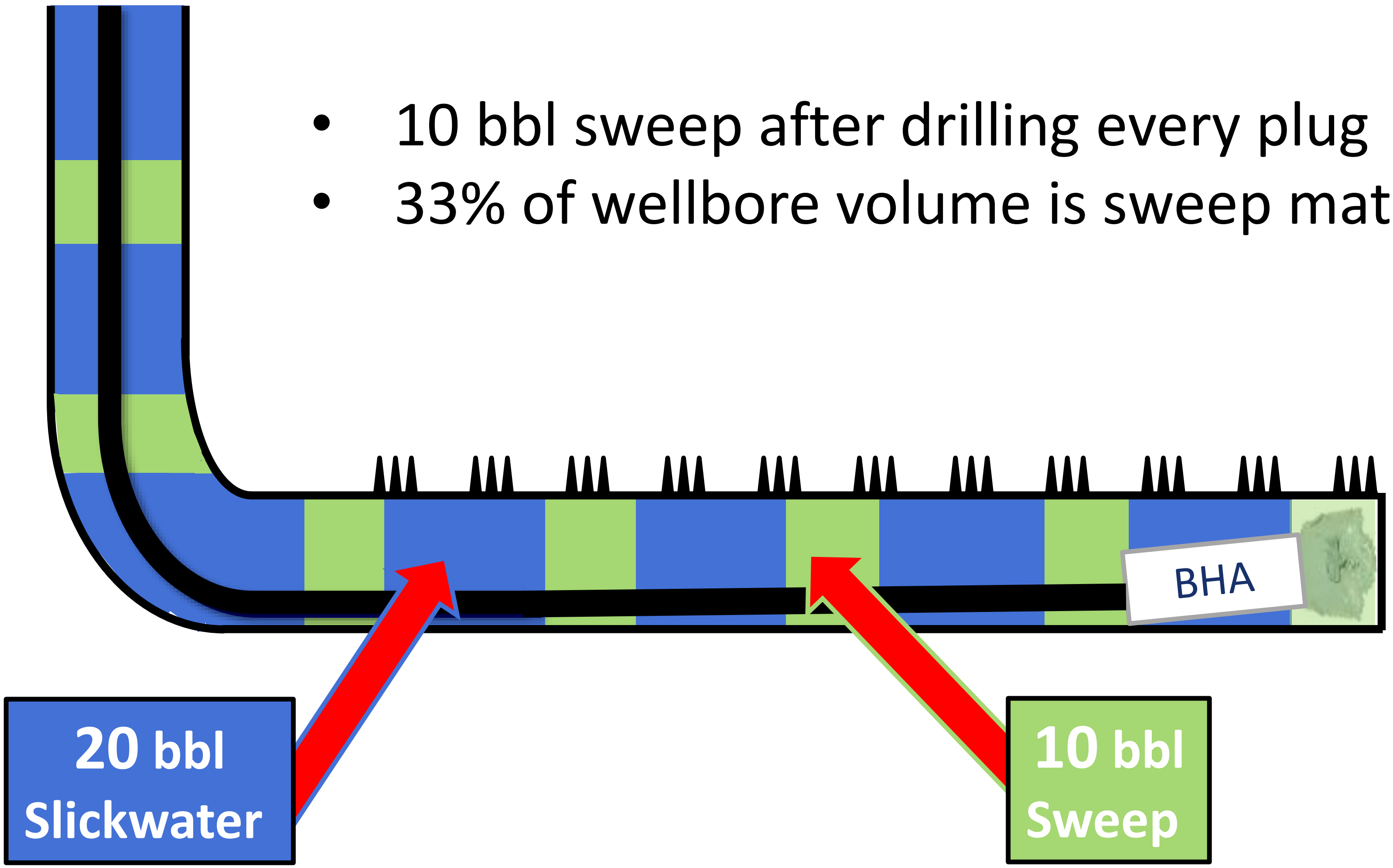

Example:

16,500 ft

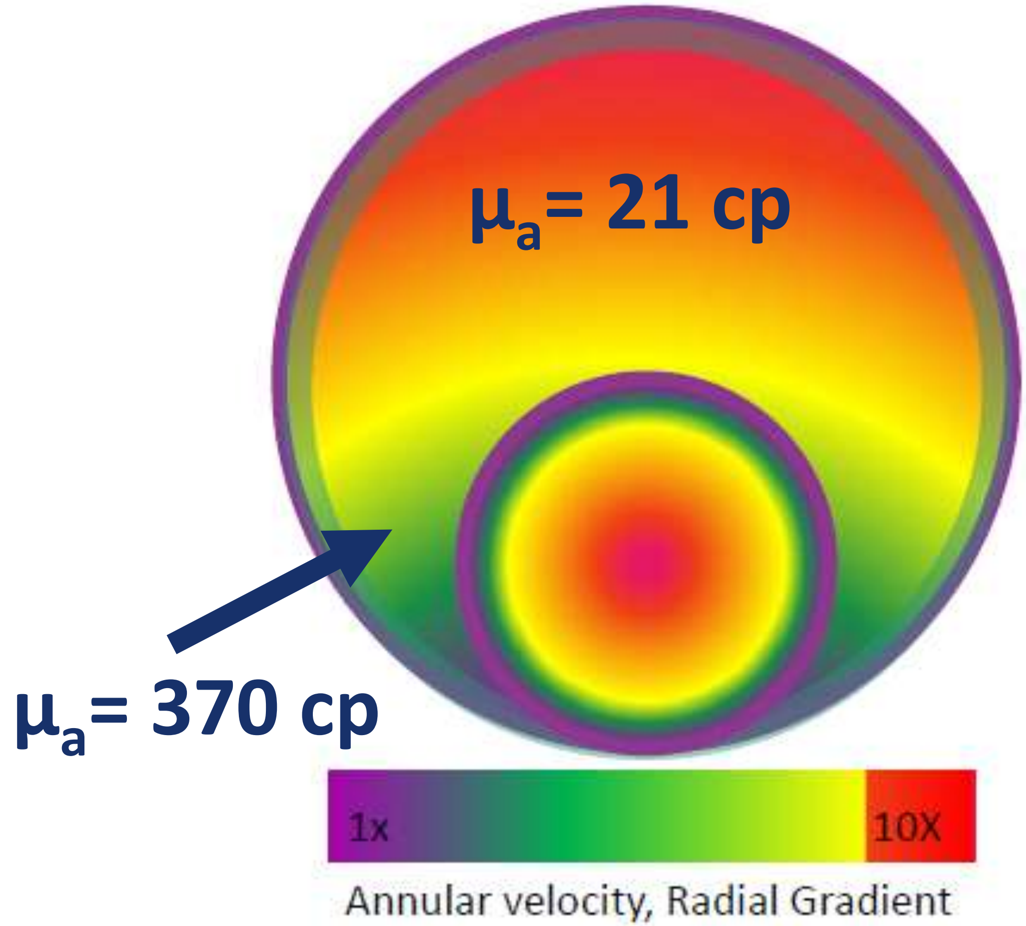
30 Plugs

# Sweeps

- 10 bbl sweep after drilling every plug
- 33% of wellbore volume is sweep material



# Velocity and Viscosity




**Modified from Hutchings (2013) and Chin (2001)**

Model Parameters:

5 ½" Casing

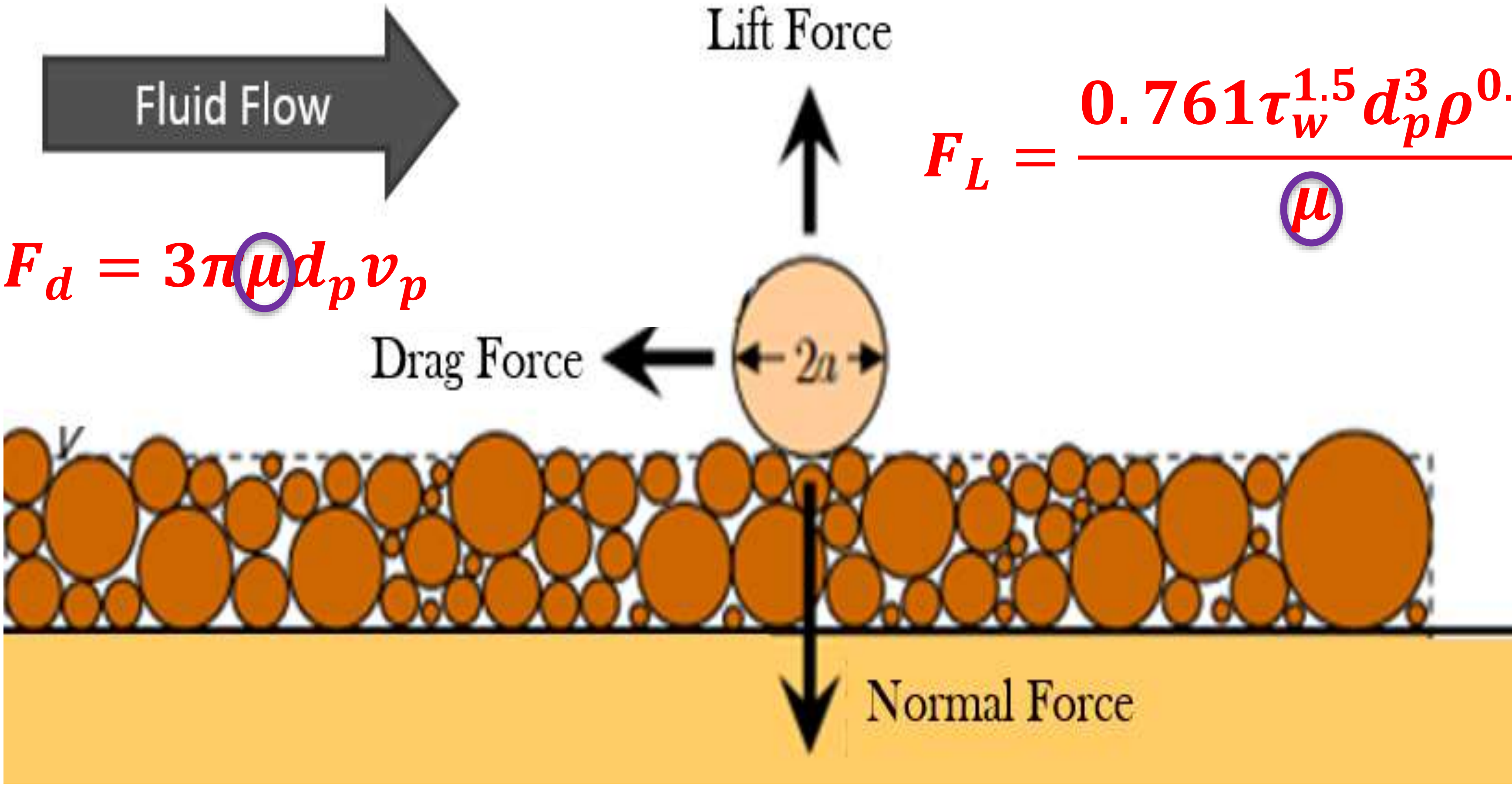
2" Coiled Tubing

3 BPM

175 fpm

108 cp

# Lift and Drag Forces




$$F_L = \frac{0.761\tau_w^{1.5} d_p^3 \rho^{0.5}}{\mu}$$

$$F_d = 3\pi\mu d_p v_p$$

Modified from Farajzadeh, 2004

# Investigate Laboratory Results



- Observe the fluid-debris interaction
- Are basic assumptions about hole cleaning valid?
- Many service companies have flow loops
- Several Universities have horizontal flow loop consortiums

# Debris Movement Viscous Fluid

*200 Funnel vis, 3 BPM, 260 fpm*

Emerald Surf

# Debris Movement in Slickwater

*27 Funnel vis, 3 BPM, 260 fpm*

# Annular Velocity and Reynolds Number

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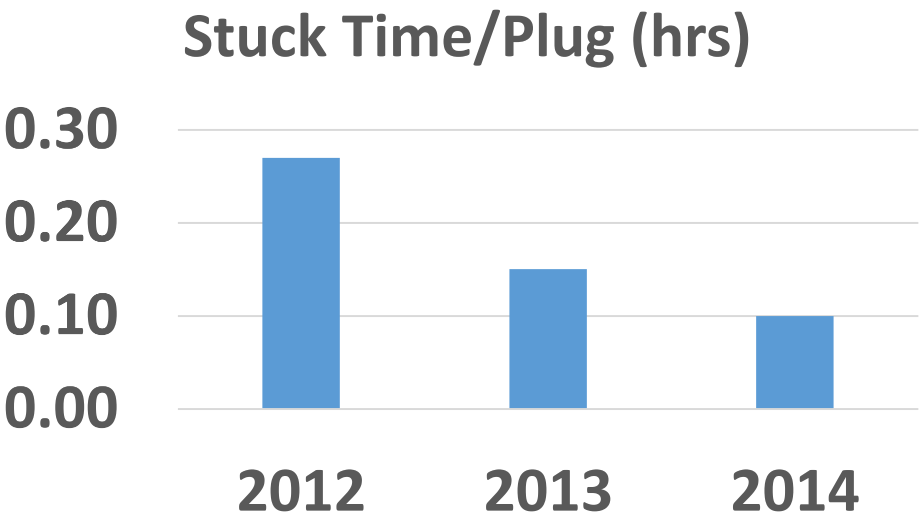
$$Re = \frac{928*\rho*v*(d2-d1)}{60*\mu}$$

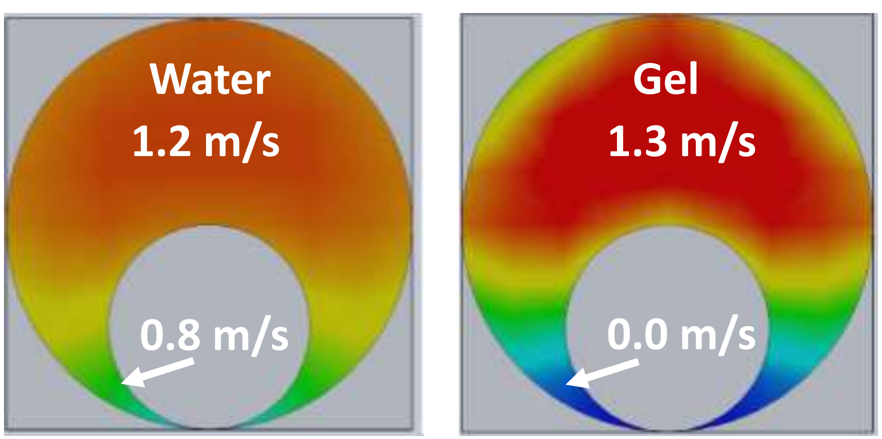
| | | | Funnel Vis | | |
|---|---|---|---|---|---|
| | | | 27 | 36 | 200 |
| BPM | AV, fpm | | | | |
| 3 | 260 | Re | 66,982 | 6,698 | 385 |

# Sweep Displaced by Slickwater

Emerald Surf

# British Columbia Case History

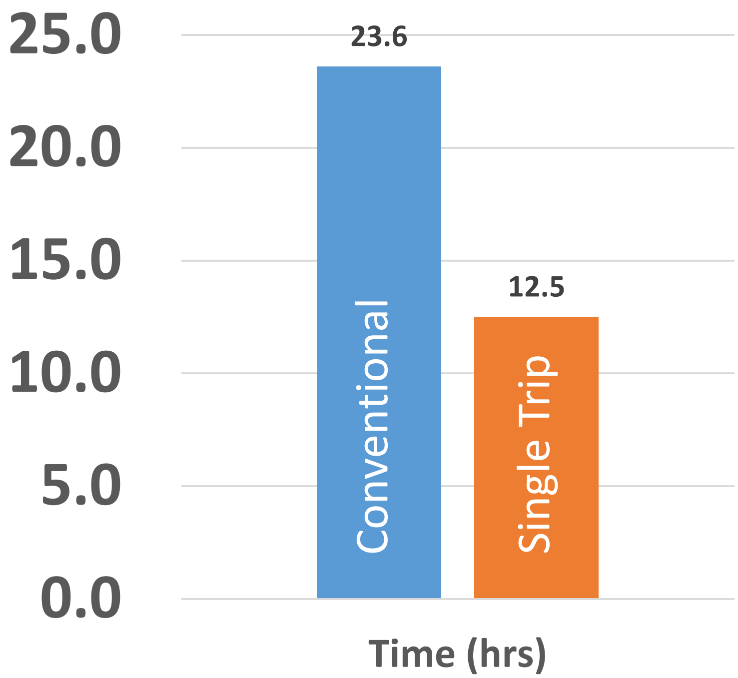



- Wiper Trip Matrix
- Stuck pipe: every well
- Fluid Costs > $40k
- Re-entrainment of solids a function of Reynolds number

SPE 178644-MS/URTeC:2155463 (2015)

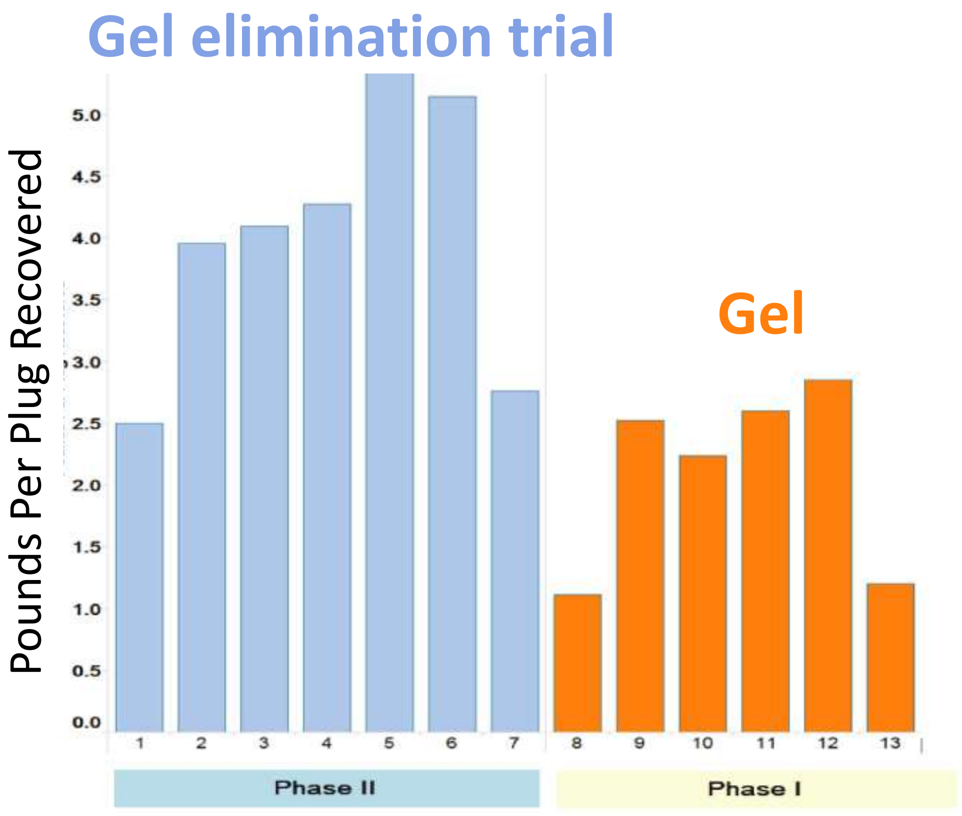
# DJ & Williston Basin Case History




- Single Trip Cleanouts (some wiper trips)
- Gel Sweeps minimized
- Chemical usage down 95%
- Reynolds number >20,000

SPE179090–MS (2016)

# Eagle Ford Shale Case History




- Single Trip Drillouts
- Non-Viscous Fluids
- ~2x plug recovery

SPE179070–MS (2016)

# Woodford Case History

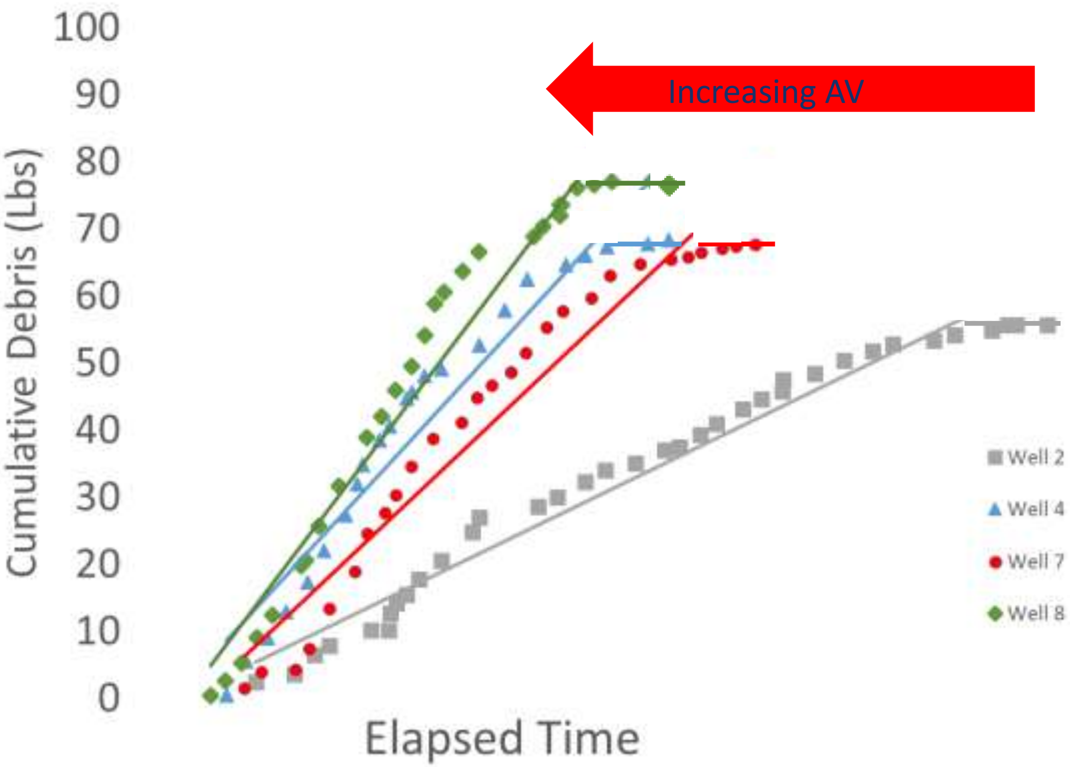
- 33 similar wells
- 2” Coiled Tubing, 5 ½” Casing
- 5000 ft laterals
- 30 or more composite frac plugs
- 1 coiled tubing vendor
- 1 chemical vendor
- No short trips
- No gel sweeps

SPE 187337–MS (2017)

# Debris at Surface


- Weigh Debris
- Record Time
- Plot Data

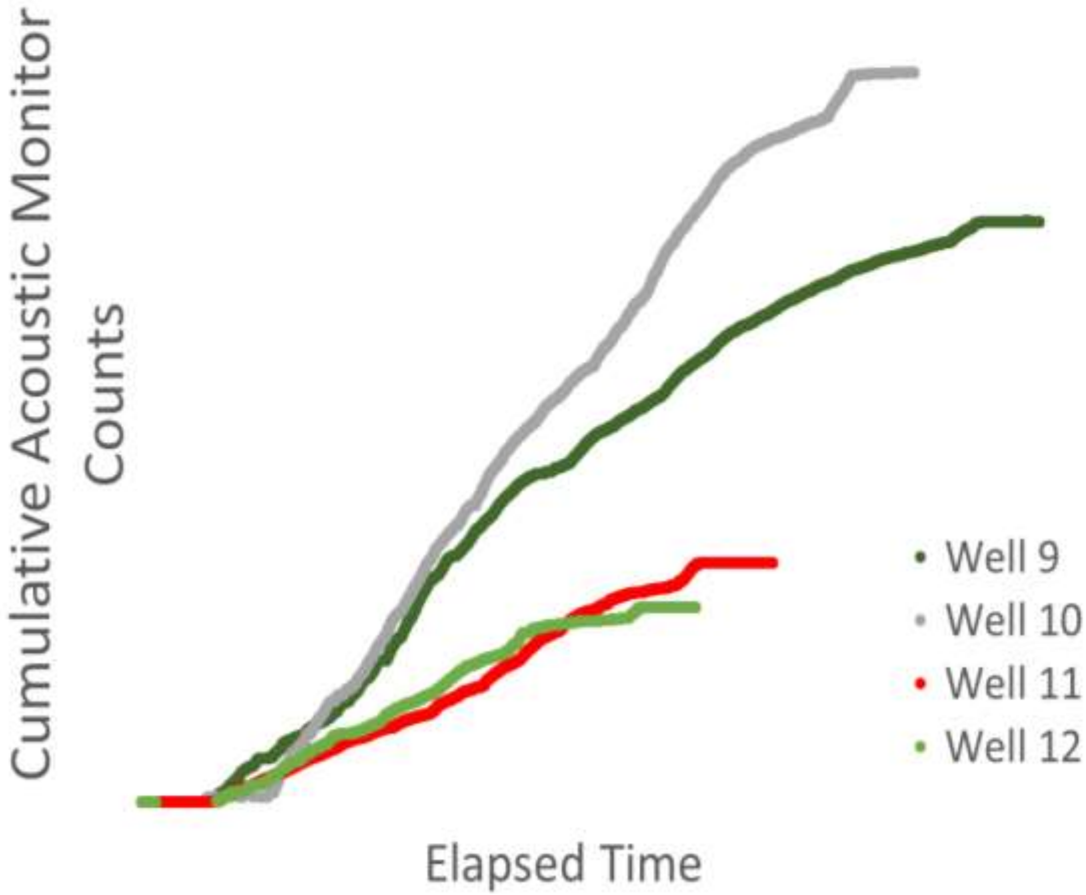
# Debris Monitoring




- Better hole cleaning
  - Higher AV's up to 300 fpm
  - Higher Re up to 50,000
- BHA is not bringing up additional debris

SPE 187337–MS (2017)

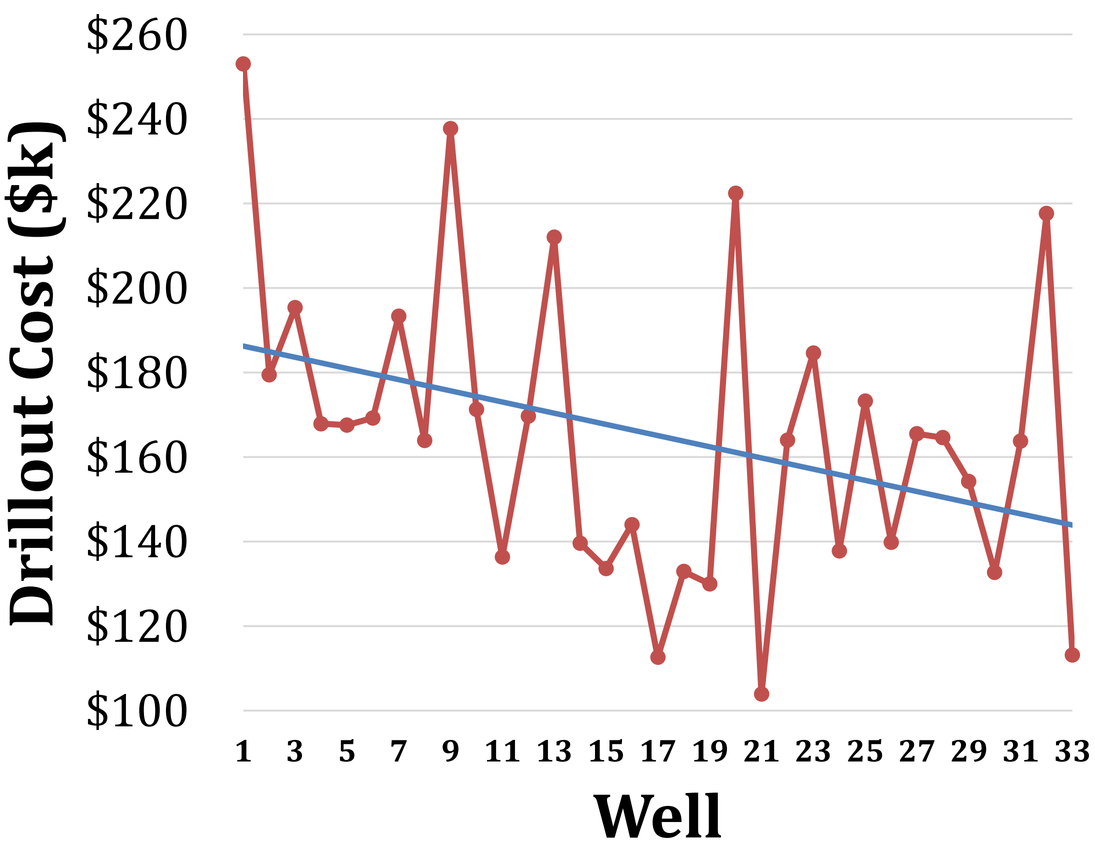
# Sand Monitoring




- Acoustic meters provide continuous sand measurement
- Good hole cleaning
  - Linear response
  - Curve flattens as a BHA nears the surface

SPE 187337–MS (2017)

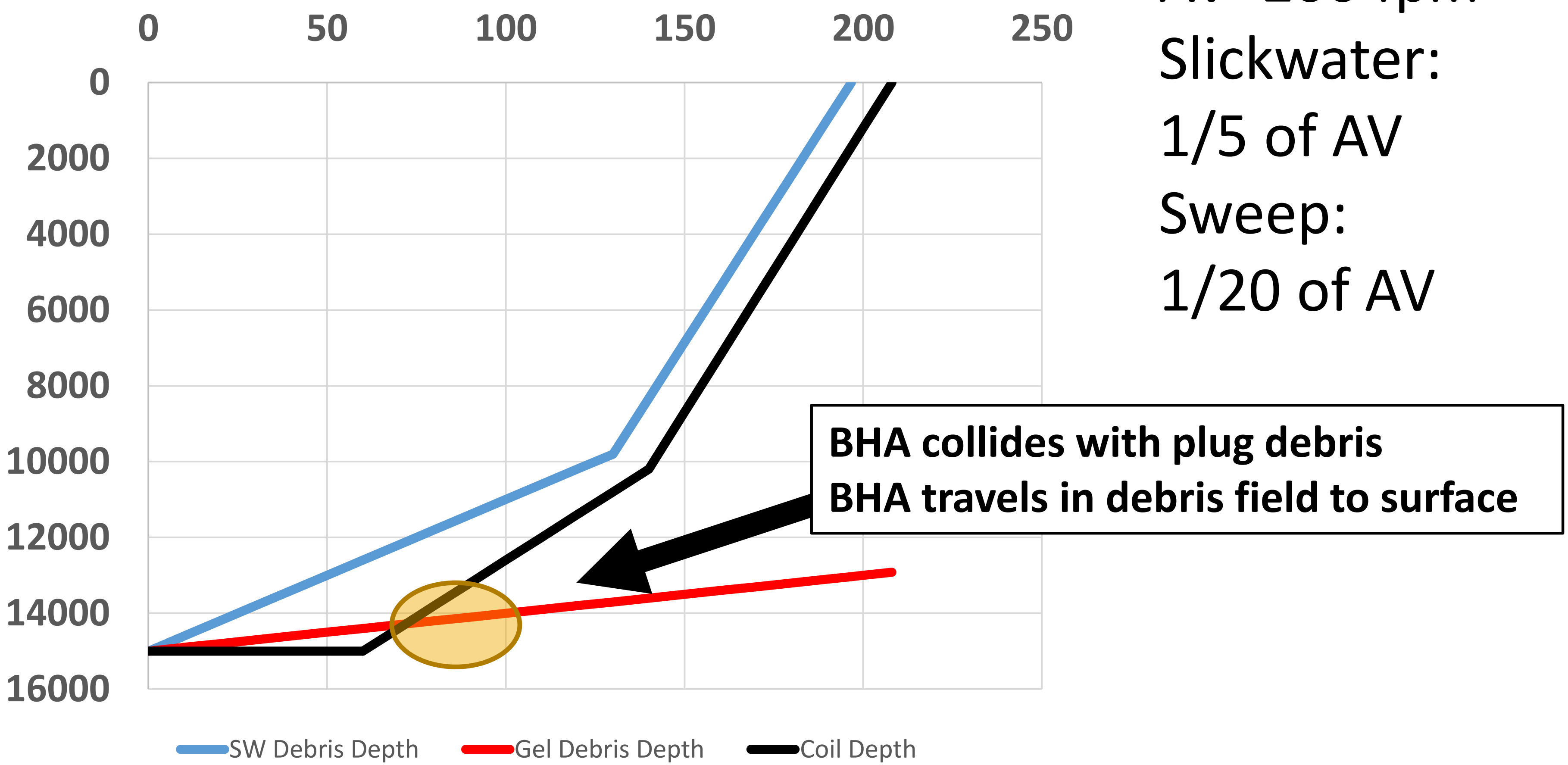
# Woodford Results




- No stuck pipe
- Costs decreased 50%
- Time on location improved 50%

SPE 187337–MS (2017)

# Location of Plug Debris




AV=200 fpm

Slickwater:

1/5 of AV

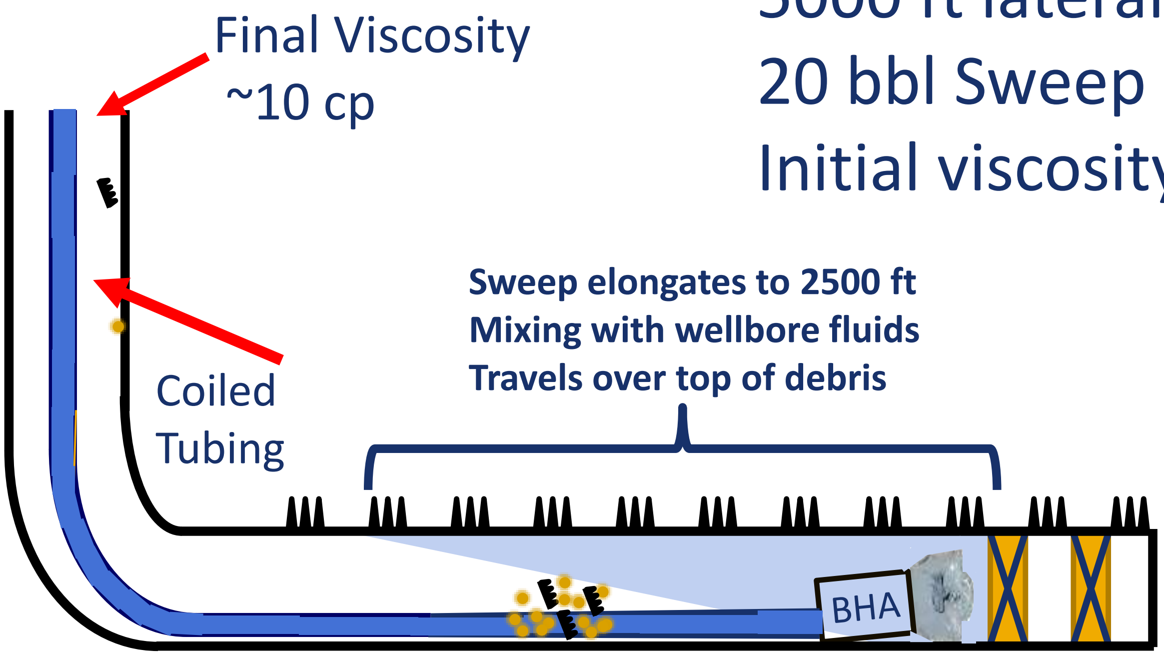
Sweep:

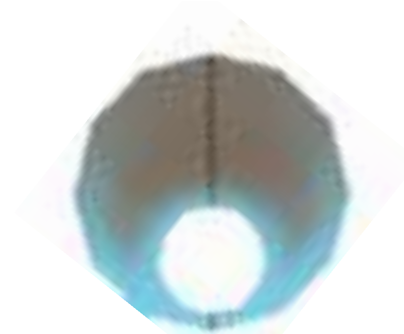
1/20 of AV

# WHAT HAPPENS TO A GEL SWEEP WHEN IT IS PUMPED DOWNHOLE?

# What happens to a gel sweep downhole?

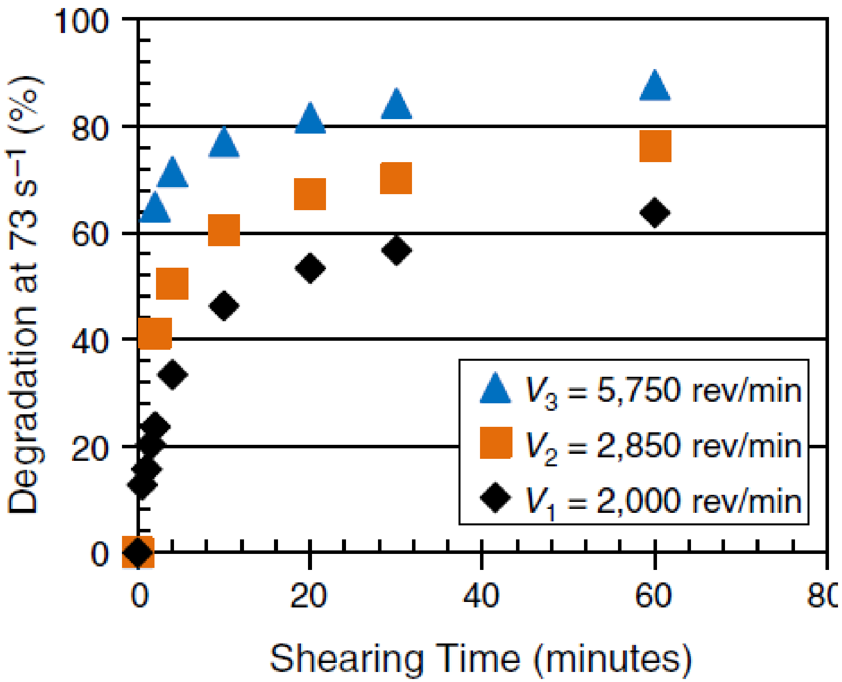
Commercial Cementing Simulator
2” Coil in 5 ½” casing
5000 ft lateral
20 bbl Sweep
Initial viscosity 150 cp



Flow Profile

# Polymers Breakdown




- Mechanical forces
  - Pumps, motors, bit jets, etc.
- Chemical Reactions
  - O2
- Fluid loses 65-85% of original viscosity

SPE Journal Feb 2017 "Polymer Stability After Successive Mechanical-Degradation Events"

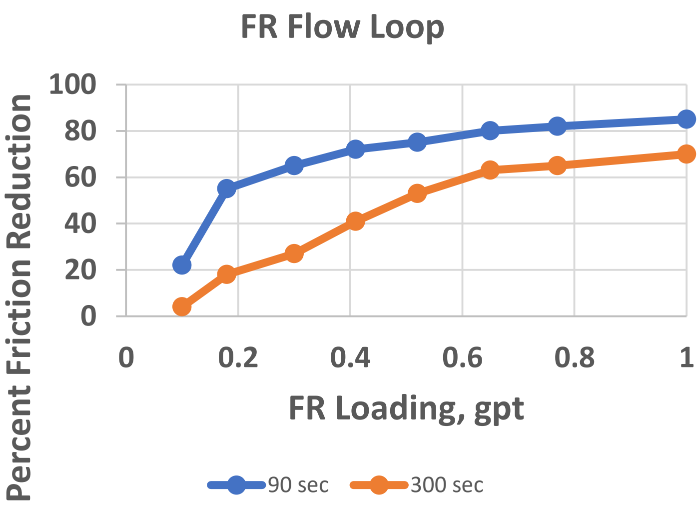
# OTHER CRITICAL ISSUES

# Low Bottomhole Pressure

- Information Gap
  - Bottomhole pressure
  - Required N2 injection rate
  - Engineers do not recommend N2 injection rates
- Field is expected to just know the correct N2 rate
  - Results in over injection
  - Drives costs higher
- Wait too long to start N2
- Several commercial models are available
- Use gas lift curves to estimate circulation bottomhole pressure

# Friction Reducers

- Reduces the pumping pressure
- Polyacrylamide is most common
- Does not extend reach
- More is not better
  – Lab based loading
- Will not prevent stuck pipe
- Check effectiveness
  – Pump pressure before and after
  – Discontinue if not effective



# Metal to Metal Friction Reducers

- Often called "Pipe on Pipe" (POP)
- Only works where there is:
  - **metal to POP to metal contact**
- Usually batch treated
- Usually applied too late
- Will not prevent stuck pipe
- Check effectiveness
  - Weight check before and after
  - Discontinue if not effective

Flow Profile

# Warning Signs of Stuck Pipe

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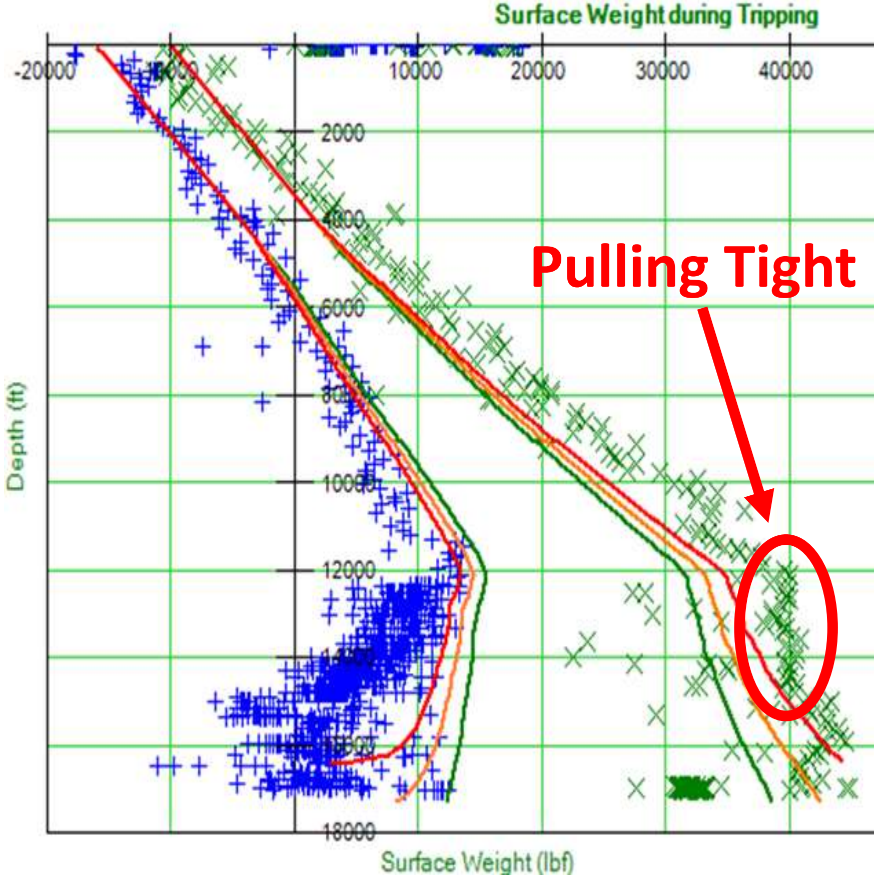
- Reduced or lost returns
- Abnormal weight check
- Erratic pump pressure/motor stalls
- Loss of plug debris being collected in plug catcher
- Reduction in produced sand at the surface

# Preventing Stuck Pipe

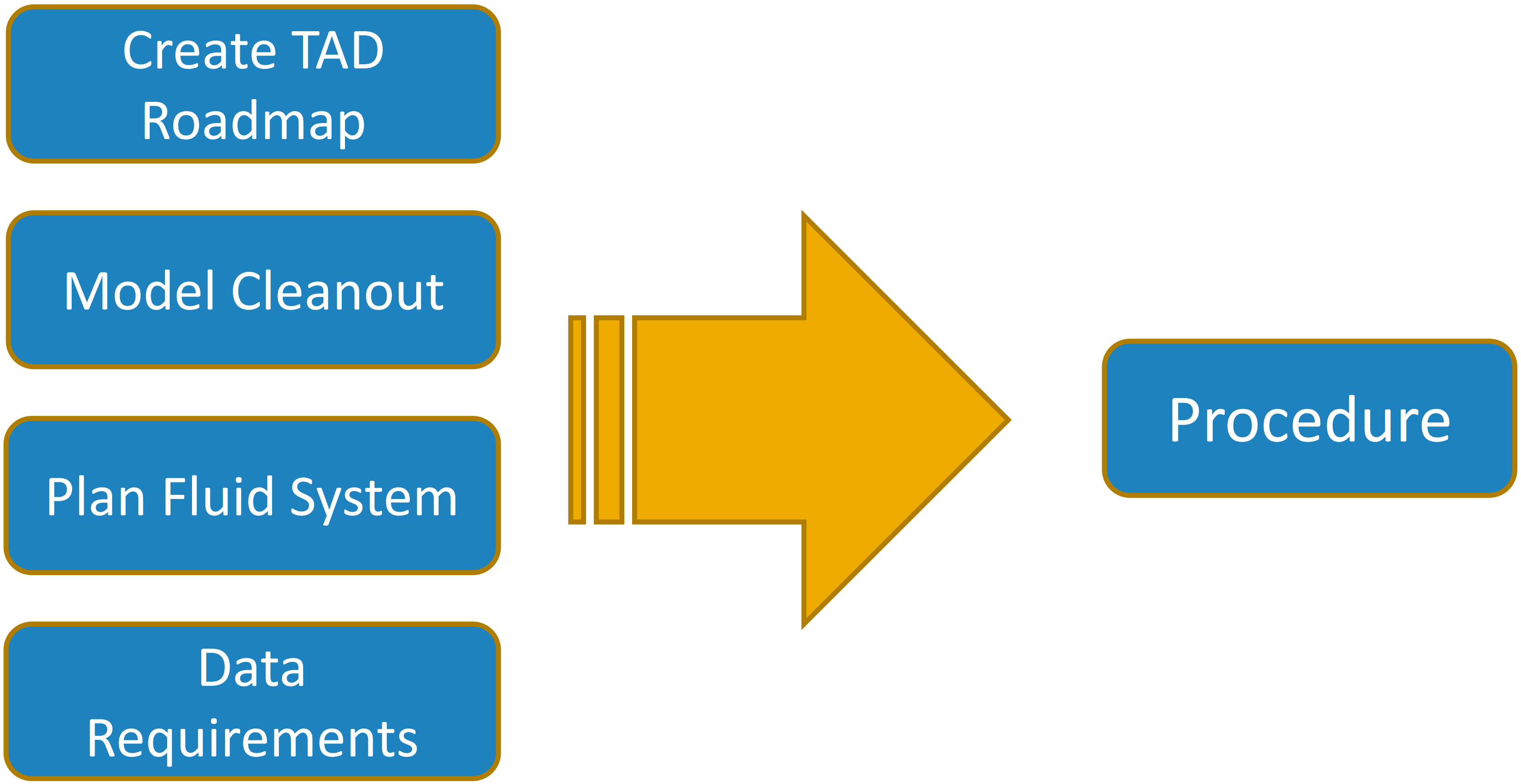



**Torque and Drag (TAD) Plot**

## What to do:

- **Stop, Drop and Circulate**
  - –Do not continue to pull into tight spot
- Circulate 1 hole volume
- Perform a weight check
- Repeat until surface weight returns to trend

# Increase Engineering Involvement



# Take Away

*An Engineering Approach*

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- Use bit/BHA to drillout debris
- Use fluid to clean the hole
- Improved hole cleaning
  - High annular velocities
  - High Reynolds numbers
- Electronically record all the data
- Learn from the data
- Observe warning signs of getting stuck
  - **Stop, Drop and Circulate**

# Thank You

- Complete Shale
- Drillout Group
- Industry Partners
- My Family
- SPE Foundation

# Thank You!

Questions?

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