ICoTA
2015 Roundtable

Wednesday, October 21, 2015
Hotel Arts
119-12th Ave SW Calgary, AB

Permanent Plug Milling with Coiled Tubing: Success and Challenges

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STEP
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Outline

- Overview of plug technology
- Introduction to the project
  - String and well specs
  - Downhole environment
- Initial success
- Unique problems encountered throughout the project
- Conclusions and recommendations

Permanent Plugs – The Reasoning

Composite frac plugs

Tried and true method

Relatively consistent application

Mill out operation required

Effort to reduce costs,
eliminate milling process

Permanent Plugs – The Reasoning

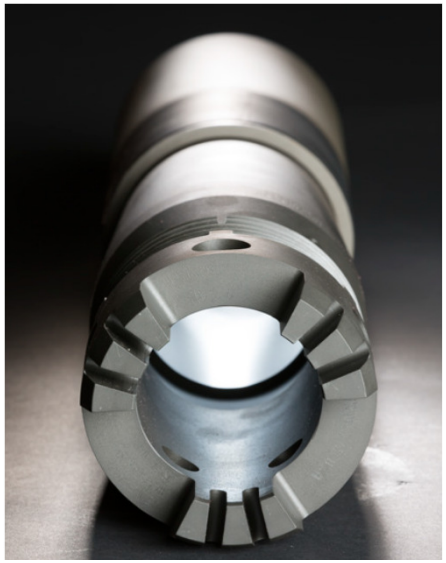
Stop milling, start producing

Large flow through ID, no mill out operation required

Not limited by coiled tubing reach

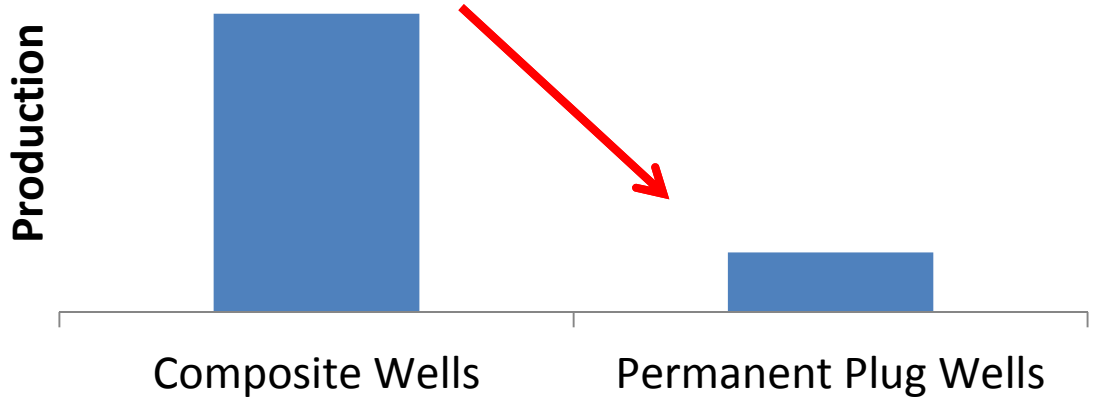
Very similar application to composite plugs

Permanent frac plug installations

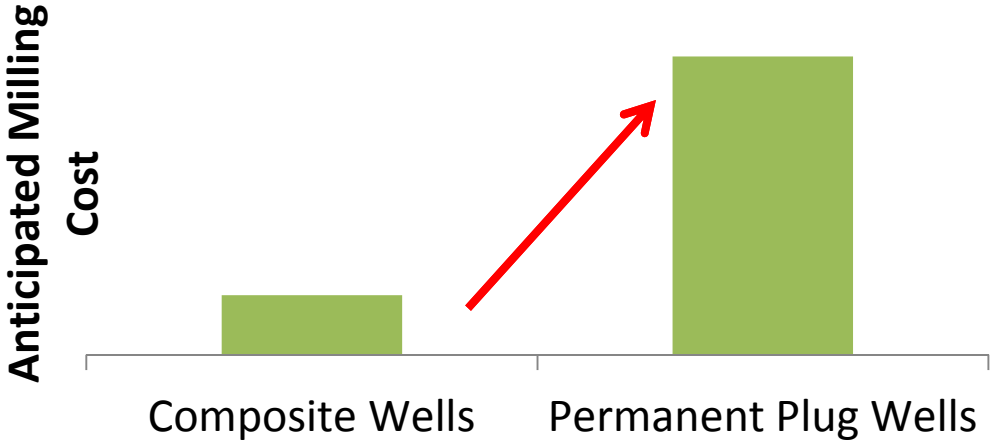


Permanent Plugs – The Issue

- [illegible] milling. Start pr[illegible]ing
- Refrac opportunity



- Large reductions in production as plugs restrict the wellbore and prevent flow from zones deep in the well.

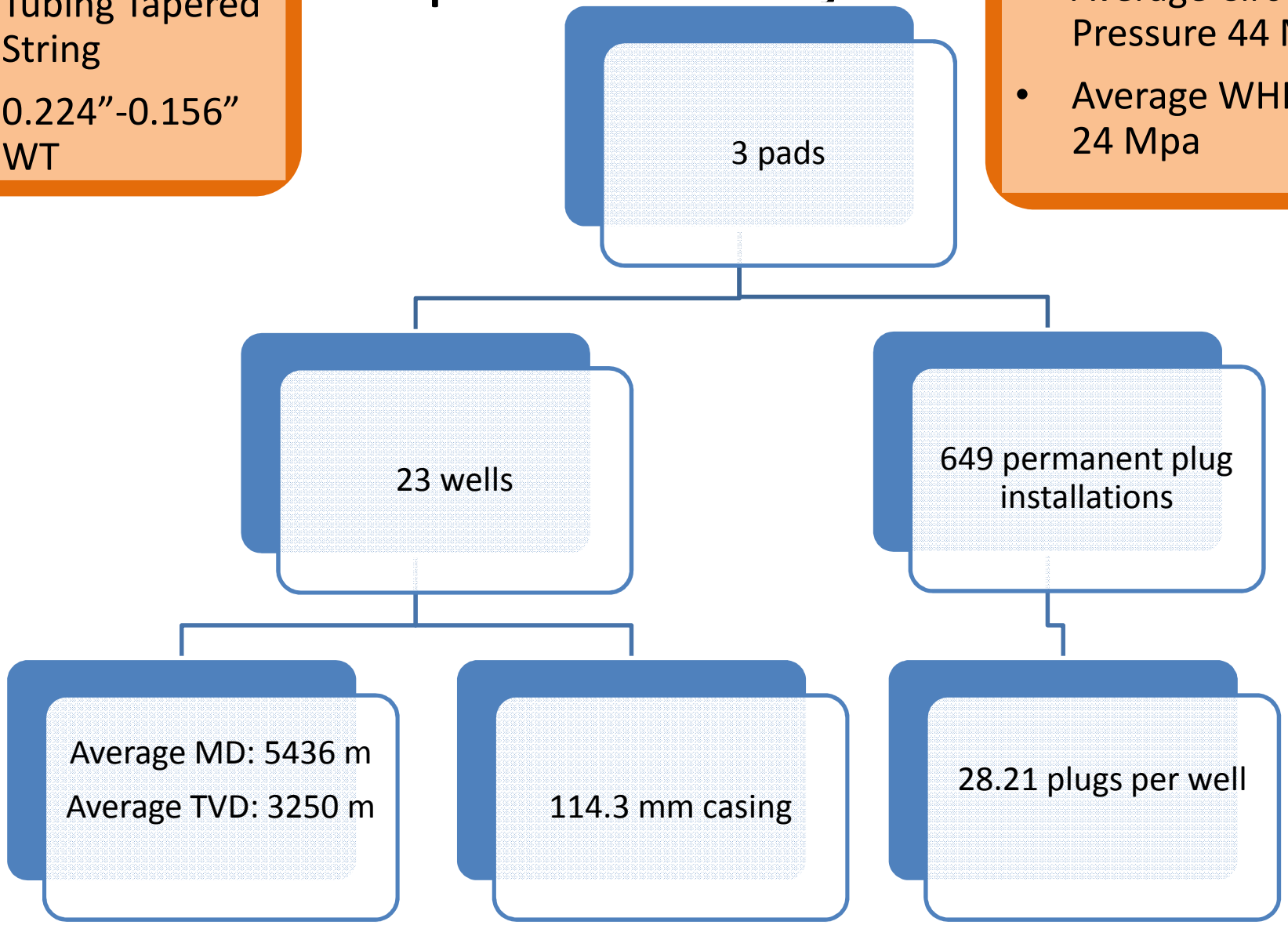


- Material of permanent plug
- Very difficult to remove with standard procedures

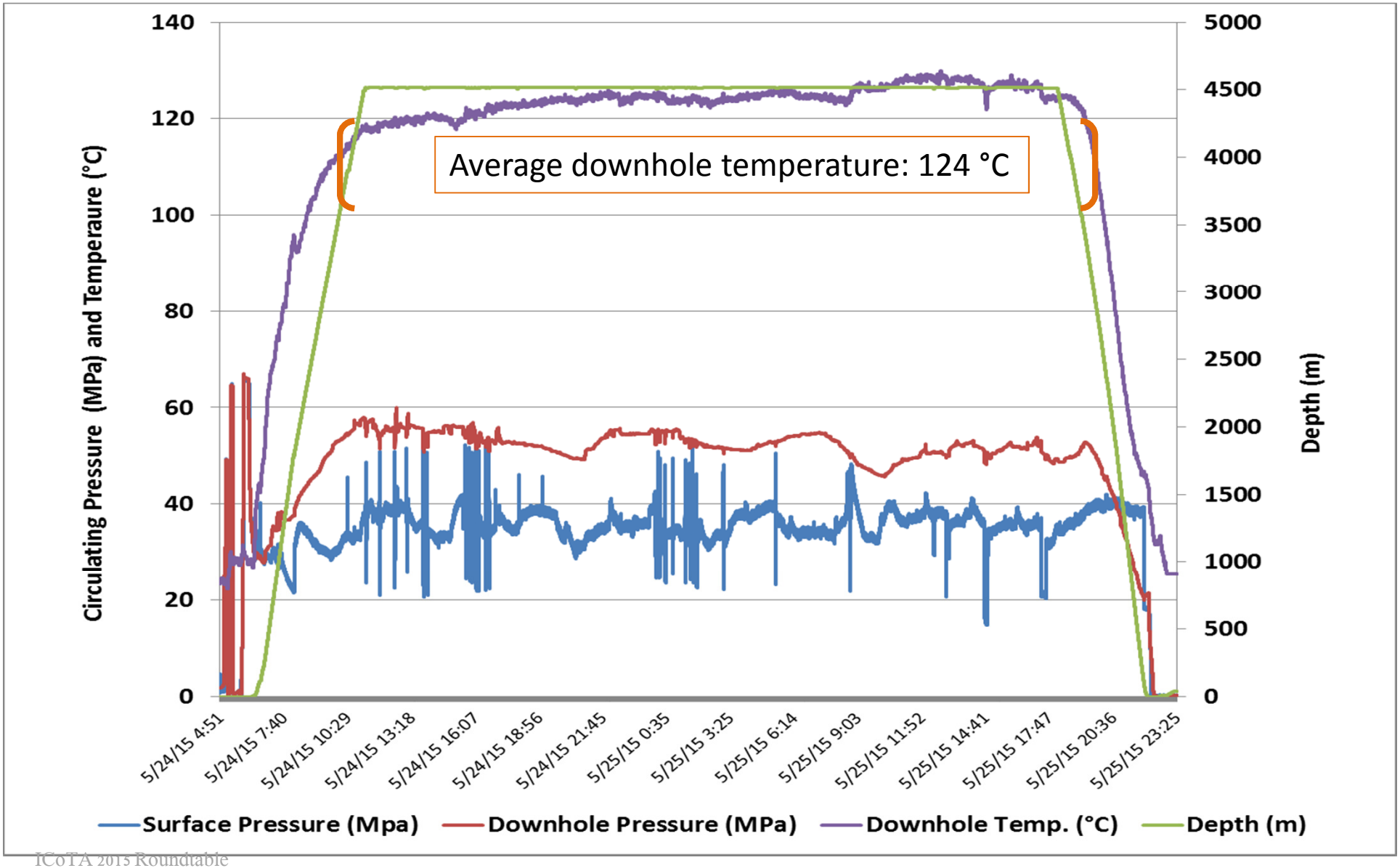
Scope of the Project

- 60.3mm Coiled Tubing Tapered String
- 0.224”-0.156” WT

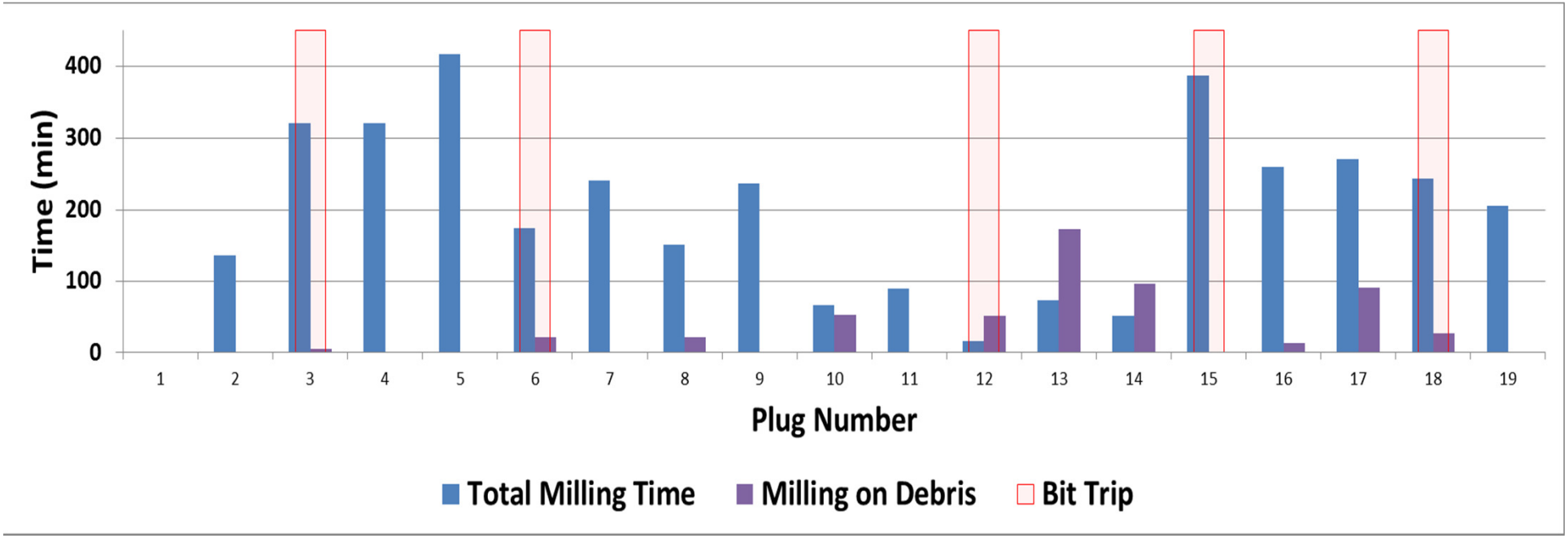
- Average Circ Pressure 44 MPa
- Average WHP 24 Mpa



Milling Operations Begin



Initial Outlook = Positive

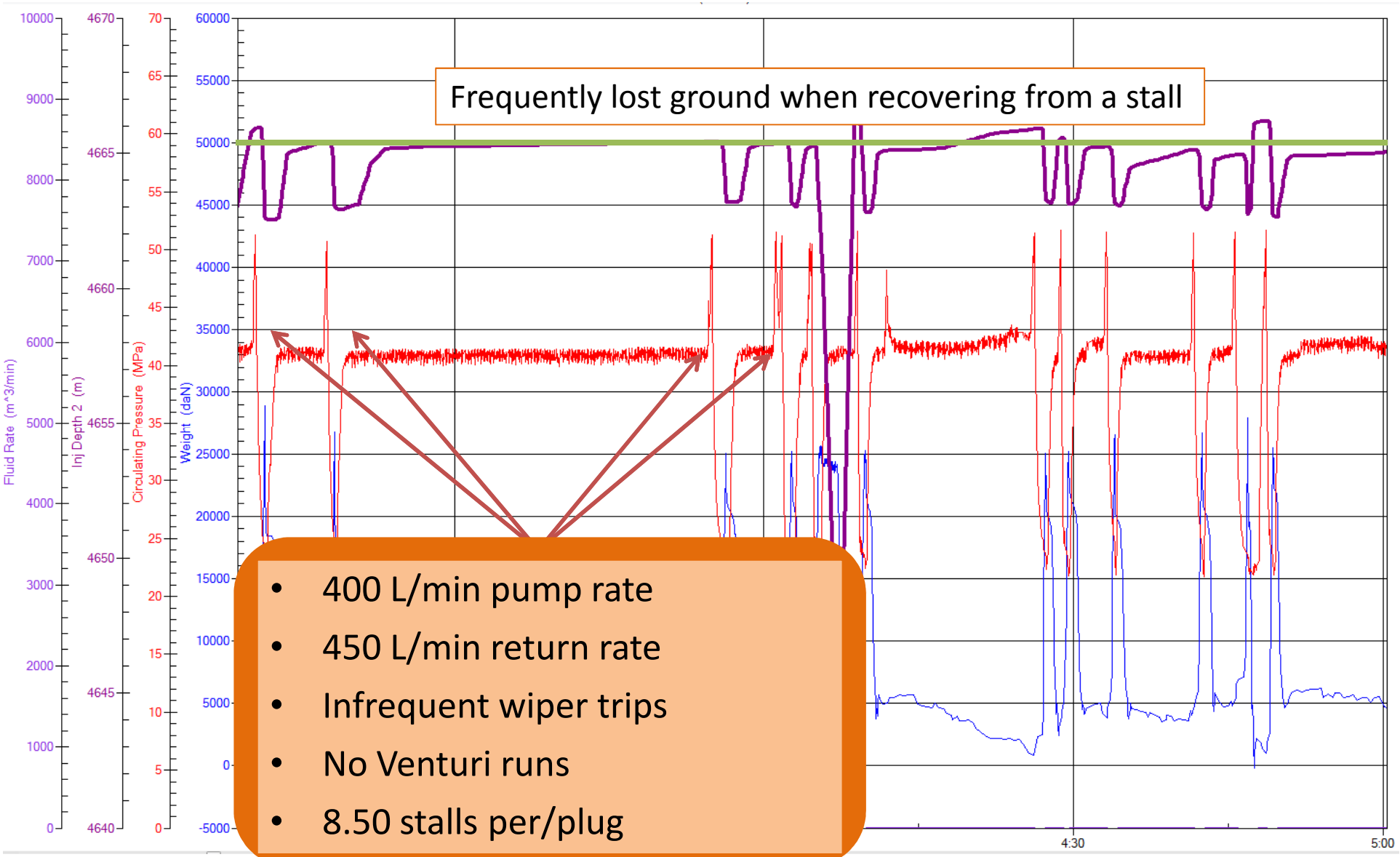


Target was as many plugs as possible with each mill/motor.

- Average mill time: **249 minutes/plug (4.15 hrs)**
- Average plugs per tool: **3.17**
- Average time milling on debris: **29.16 min**
- **Six plugs with one tool string**
- Total well time: **247 hrs (10.29 days 0.54 days per plug)**

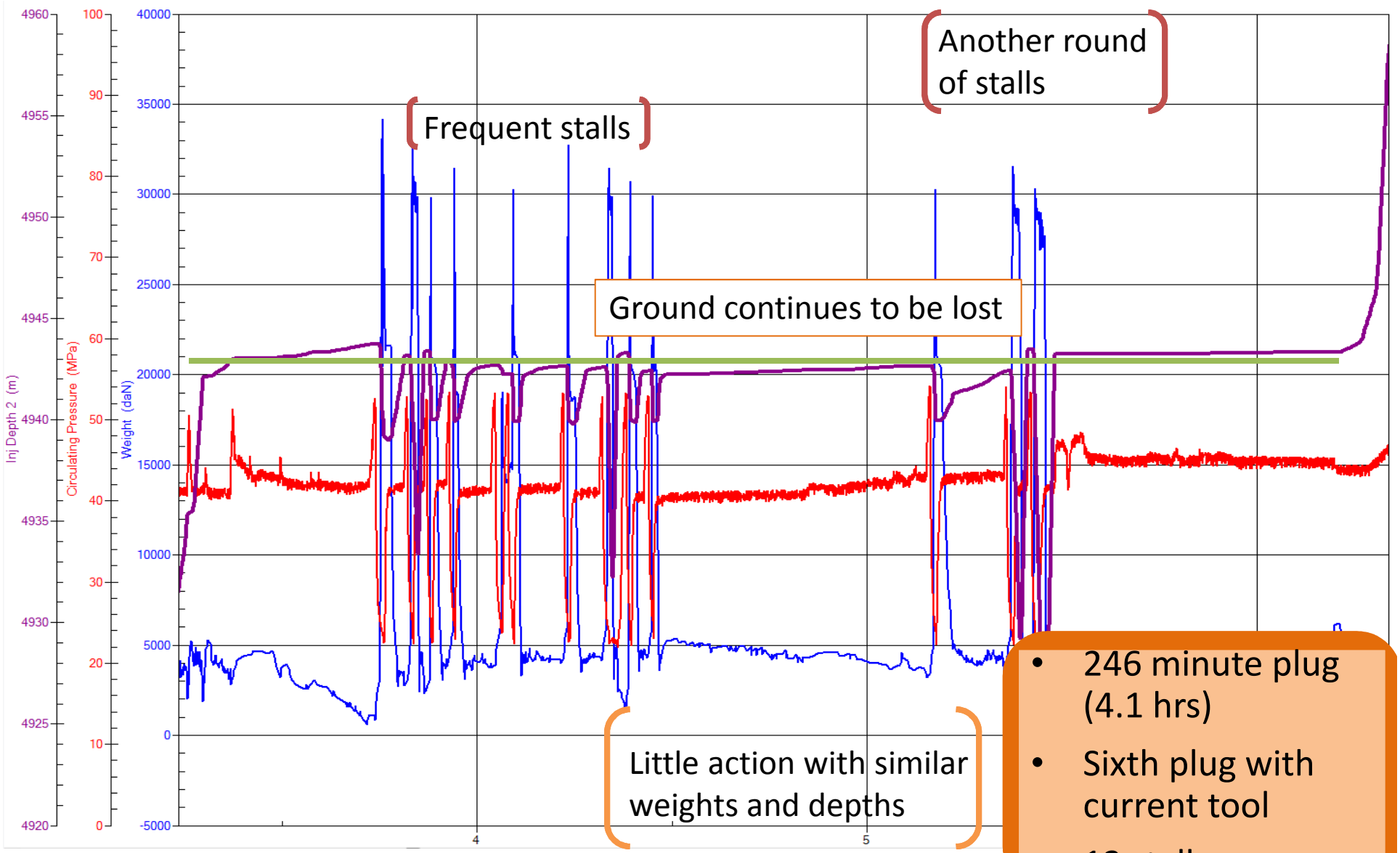
- 649 plugs completed in 350 total rig days
- 5 rigs = 70 days required

Initial Practices



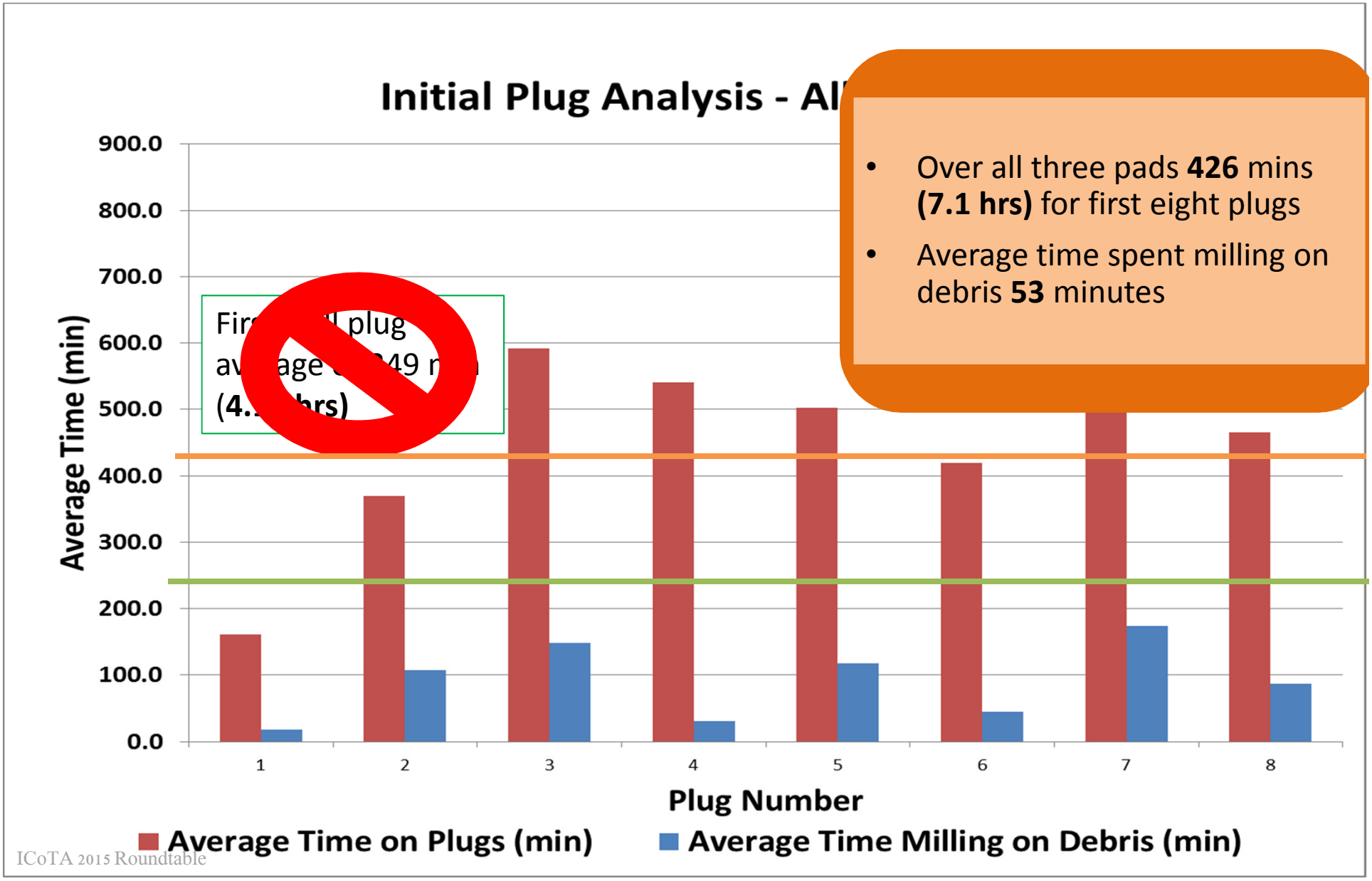
- 400 L/min pump rate
- 450 L/min return rate
- Infrequent wiper trips
- No Venturi runs
- 8.50 stalls per/plug

Pattern Developing



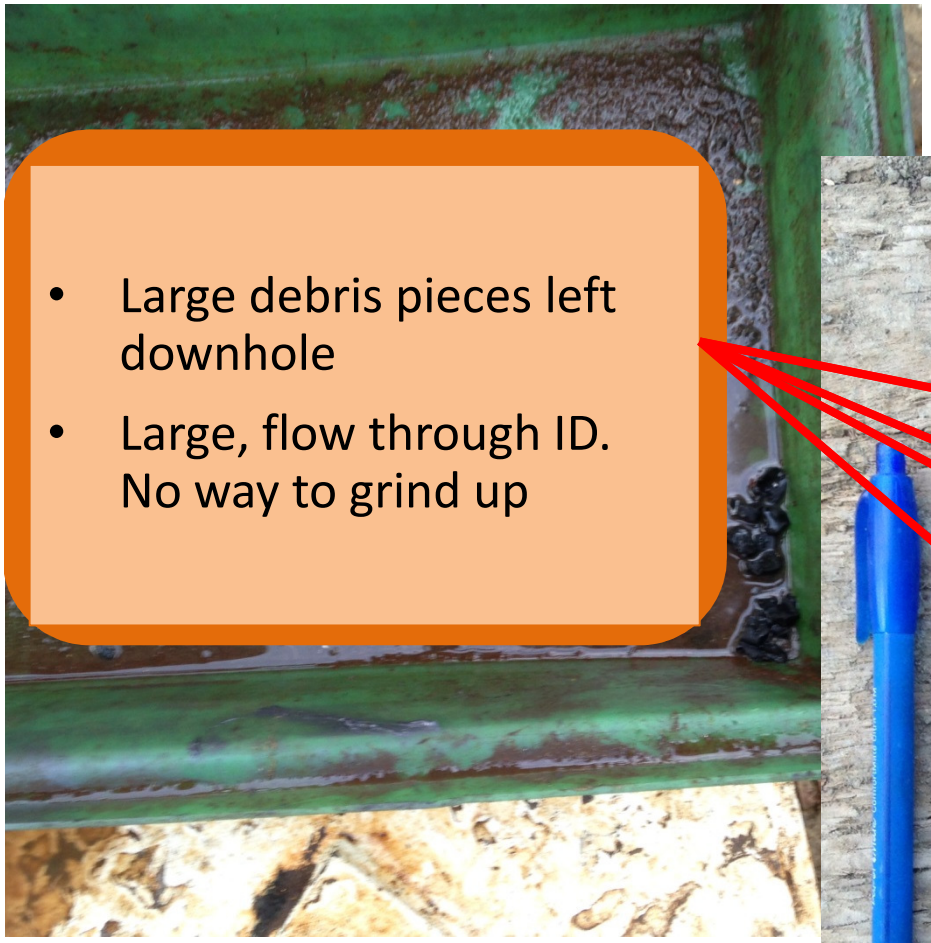
- 246 minute plug (4.1 hrs)
- Sixth plug with current tool
- 13 stalls

Initial plugs



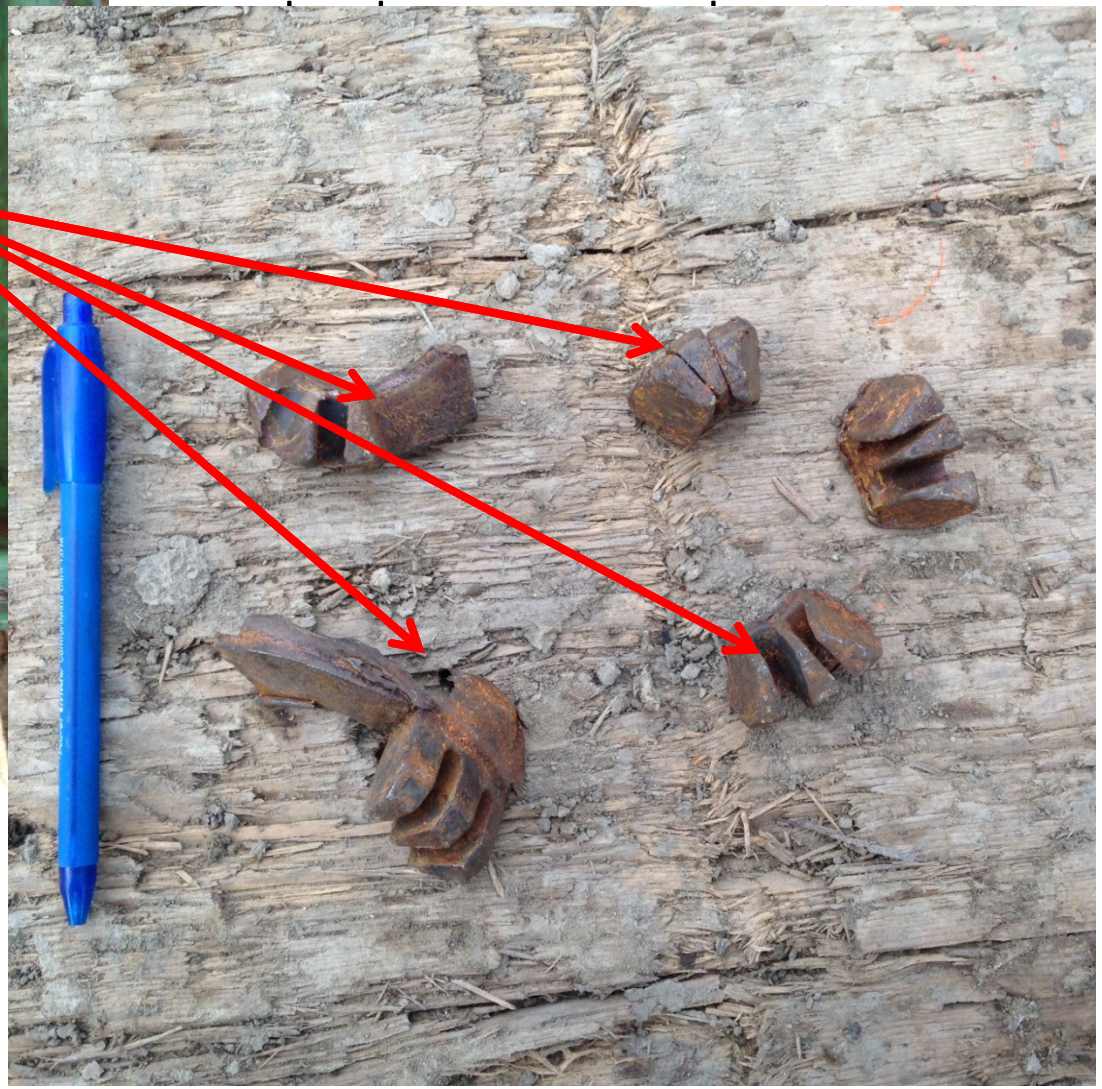
- Over all three pads **426** mins **(7.1 hrs)** for first eight plugs
- Average time spent milling on debris **53** minutes

Problems Start to Arise

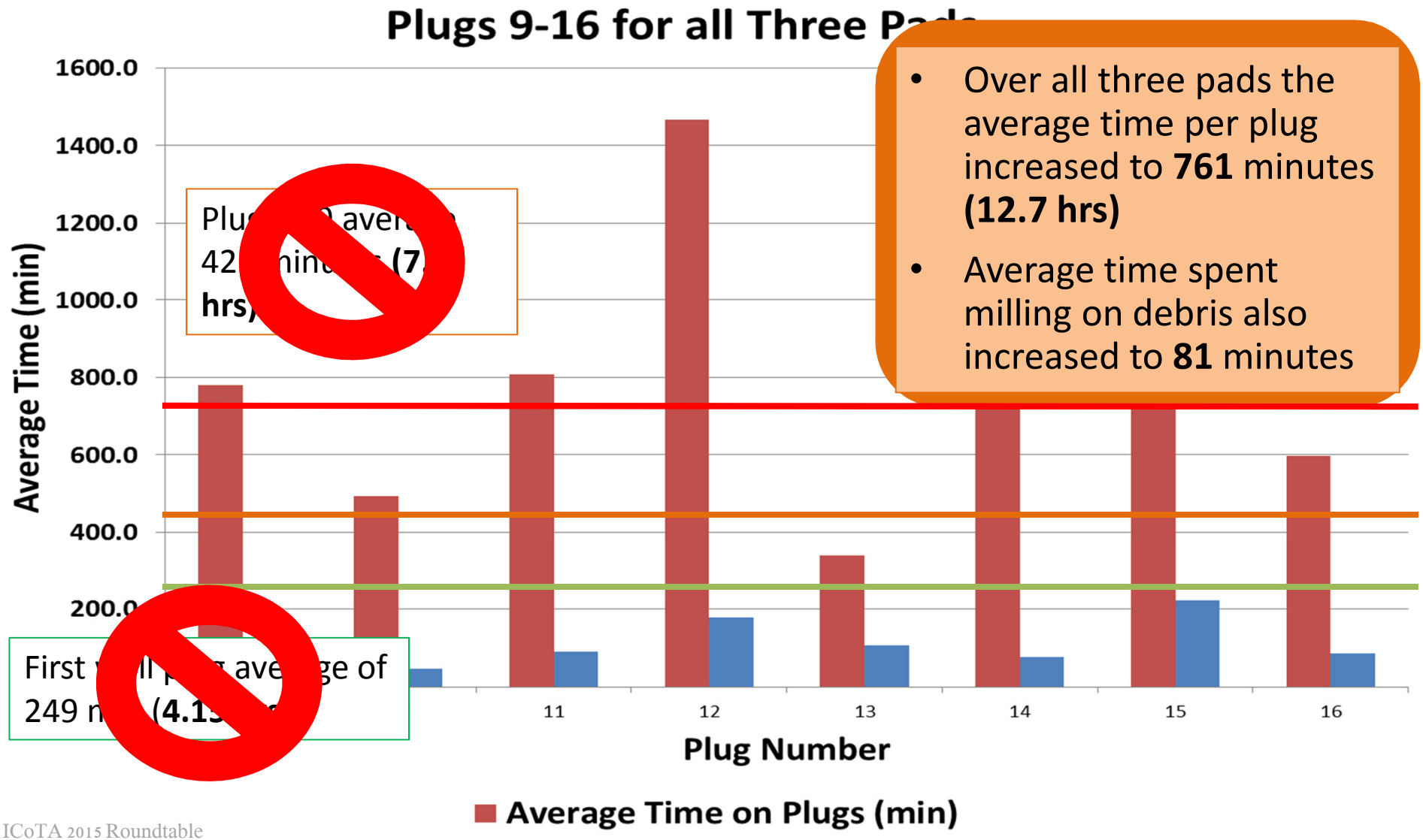


- Large debris pieces left downhole
- Large, flow through ID. No way to grind up

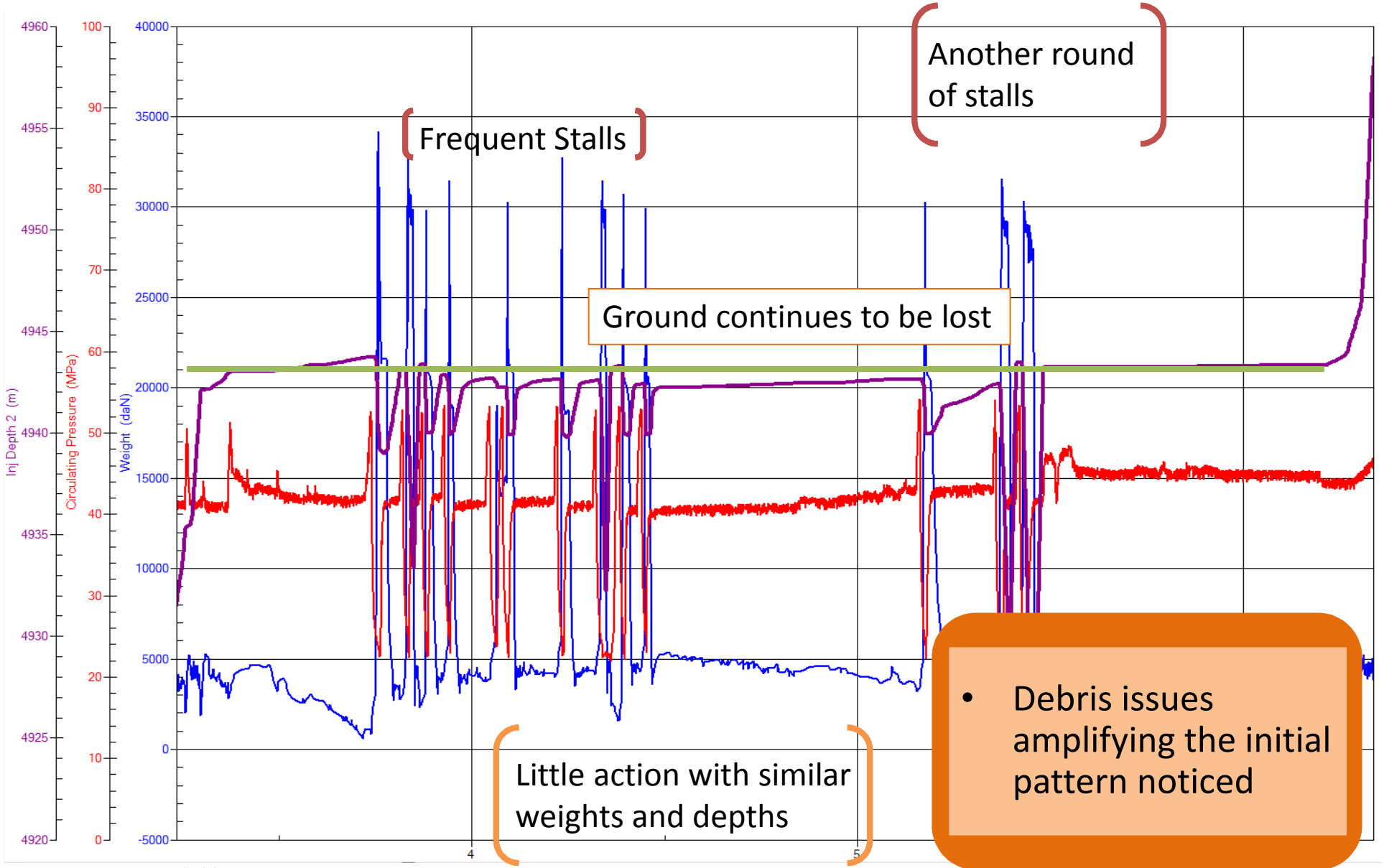
- Very minimal debris brought back with



Plugs 9-16, Trend Continues

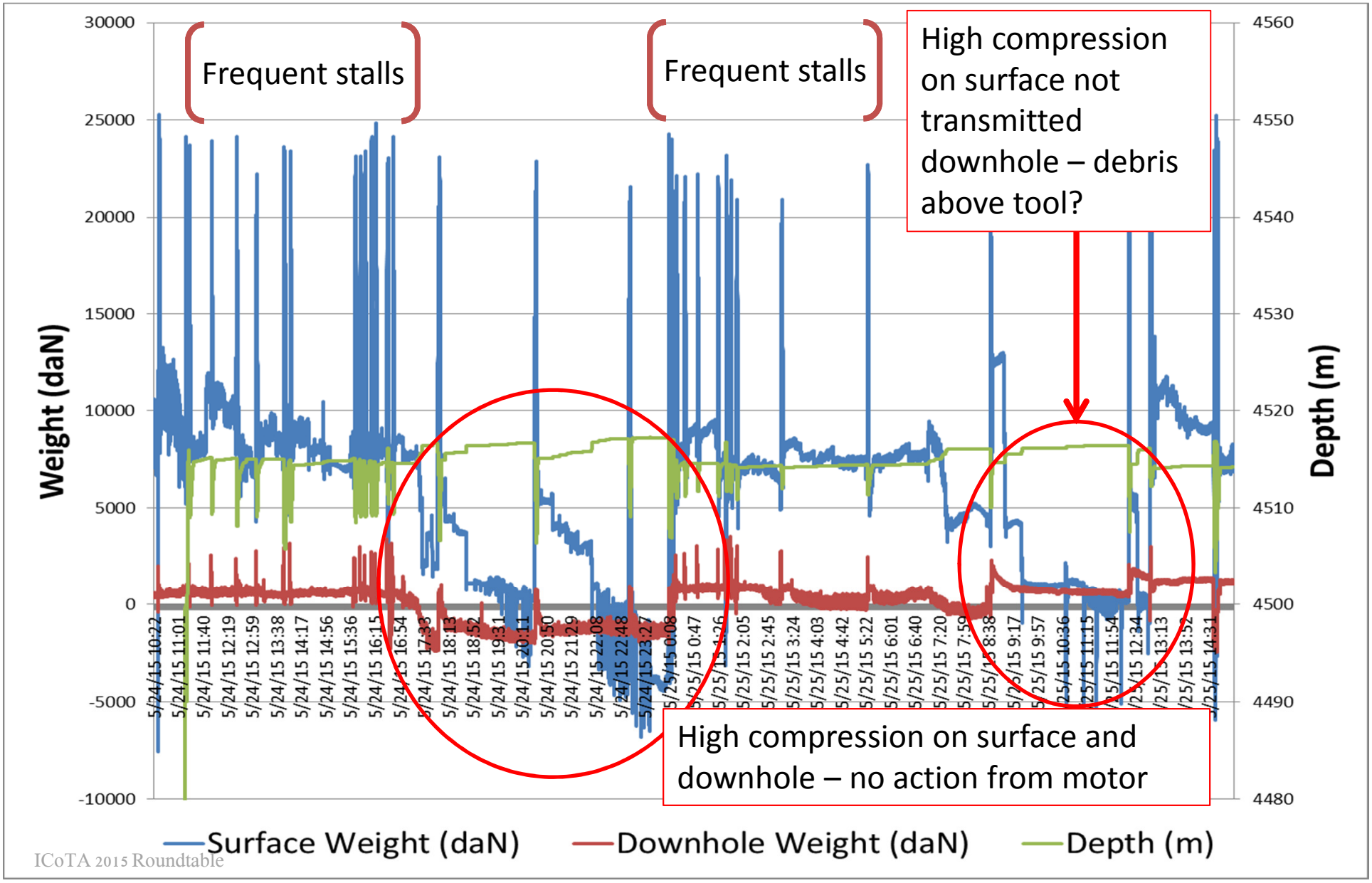


Debris Management – Downhole Analysis



- Debris issues amplifying the initial pattern noticed

Downhole Analysis – Weight on Bit Sub

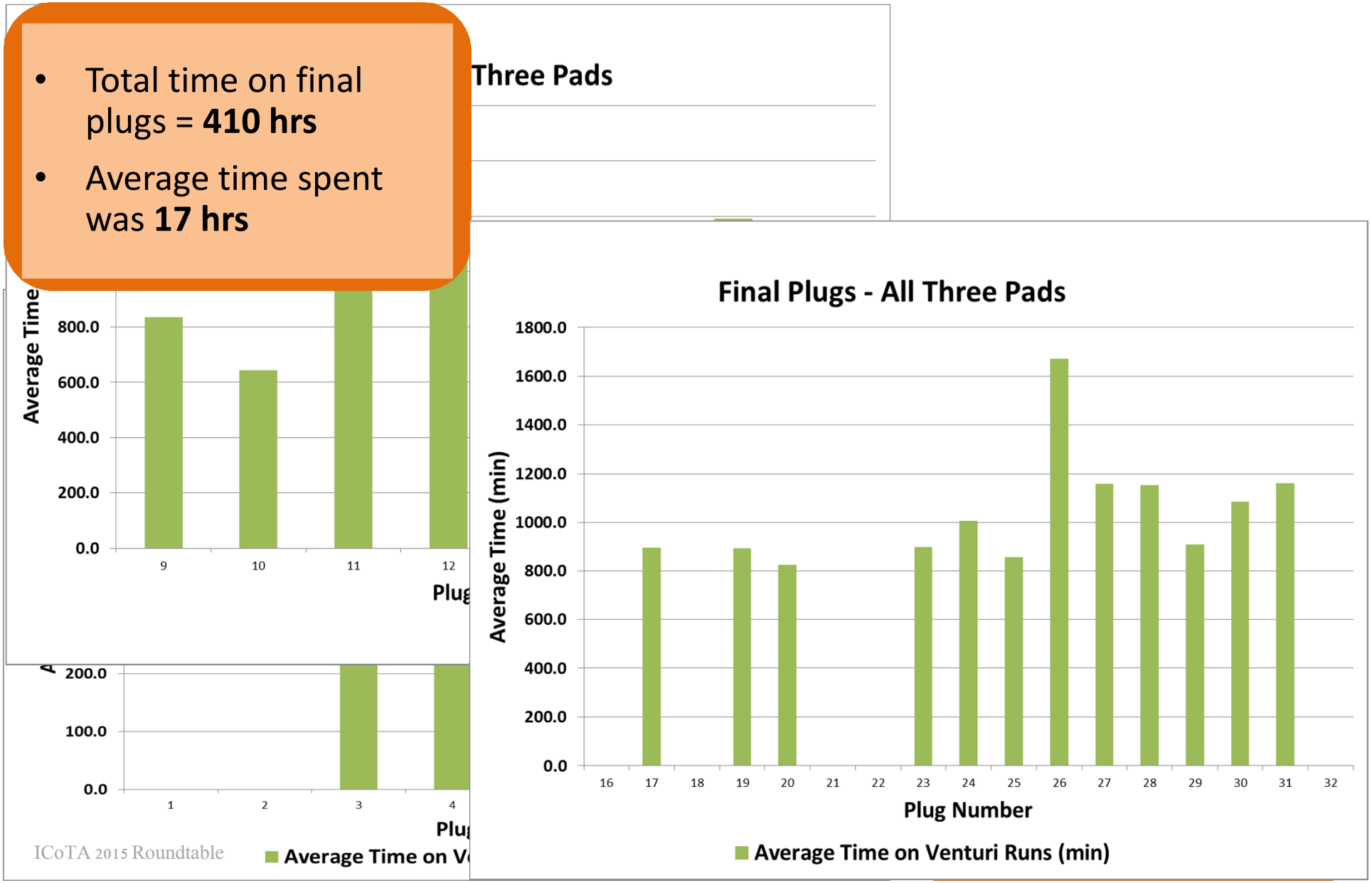


Debris Management - Venturi

- Program changed, three plugs then a Venturi run
- Brought back significantly more debris than initial program
- However large amounts of time lost
- Average time to perform a Venturi was 13 hours
- Issues arose when Venturi encountered too many obstructions/the plug
- Number of fishing runs conducted

Debris Management - Venturi

- Total time on final plugs = **410 hrs**
- Average time spent was **17 hrs**



Debris Management - Magnet

- Another method trialed was magnet runs to try and grab all the debris left down hole
- Fine shavings from the plug coated magnet before any large chunks could be obtained
- Very little success, not a lot of time attributed to magnet runs: **12.7 hrs**
- Smaller magnets run on most Venturi BHAs however
- This issues with the fine shavings also highlighted another issue that was occurring with the fluid system

Debris Management – Fluid Issues

The constant introduction of steel into the fluid system caused a number of issues that were not predicted.

- Dissolved iron in the system caused:
  - Motors to be destroyed
  - Settled in the coil, required acid pickles
  - Chemical incompatibility
  - Damage to pumping equipment

Debris Management – Fluid Issues

Compatibility issues with different chemical systems

Fluid friction reducers

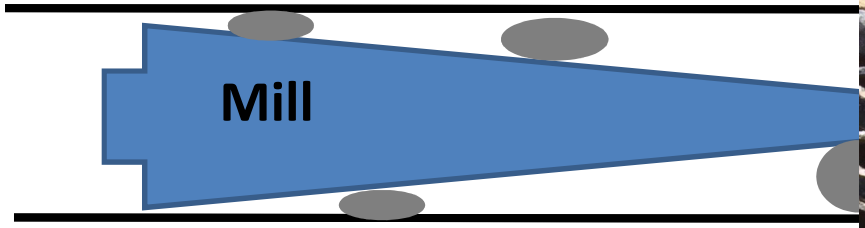
High circulating pressures

Reduced coiled tubing life and pump damage

Metal to metal lubricants

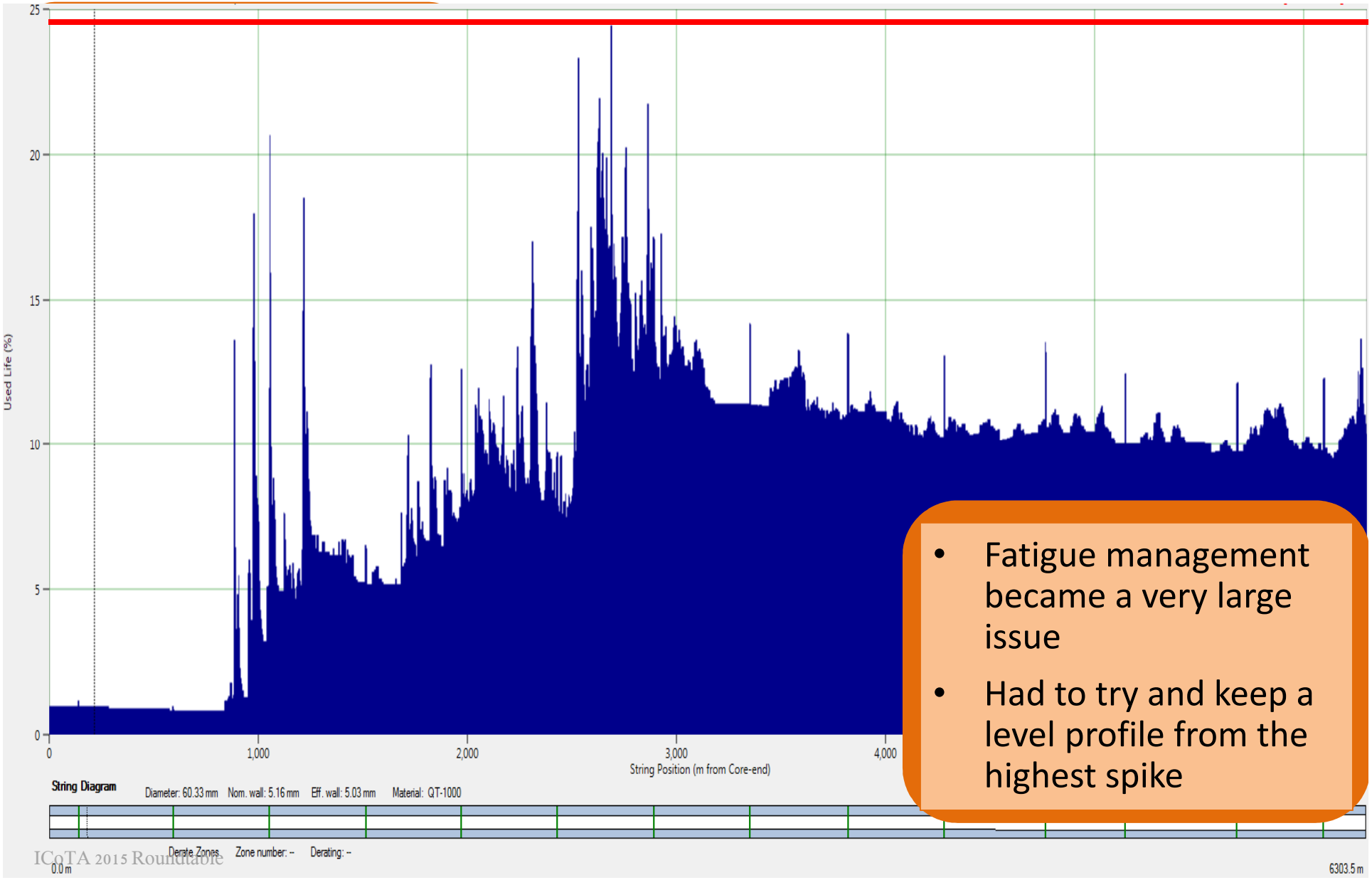
Less weight on bit and difficulty moving downhole

Debris Management – Tapered Mill



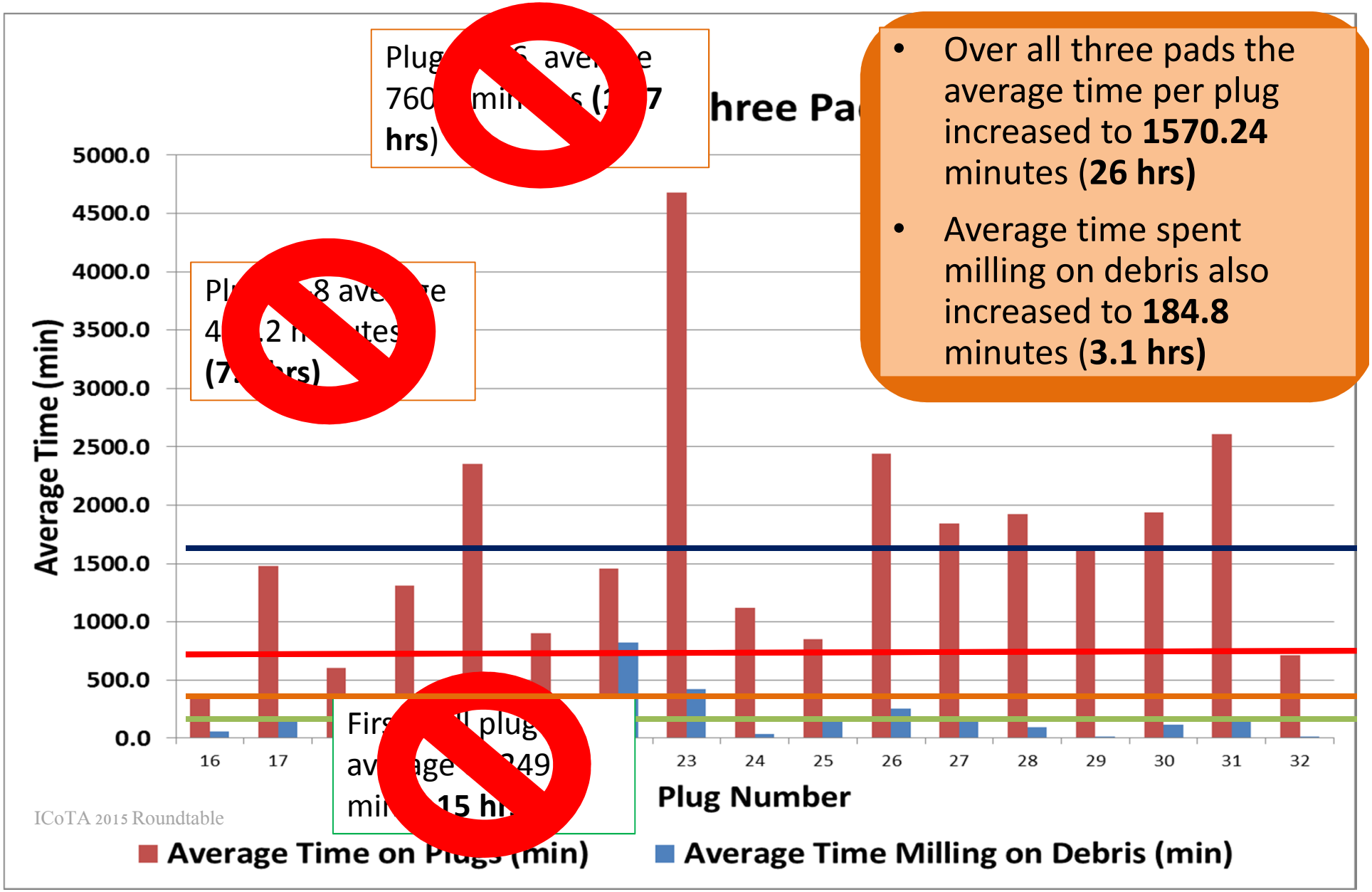
- Tapered mills were also run in an effort to trap debris and remove it
- Limited success was exhibited
- If the mill encountered a plug could compromise slips, cause it to spin
- Difficult to determine when this occurs = time lost

Fatigue Management



- Fatigue management became a very large issue
- Had to try and keep a level profile from the highest spike

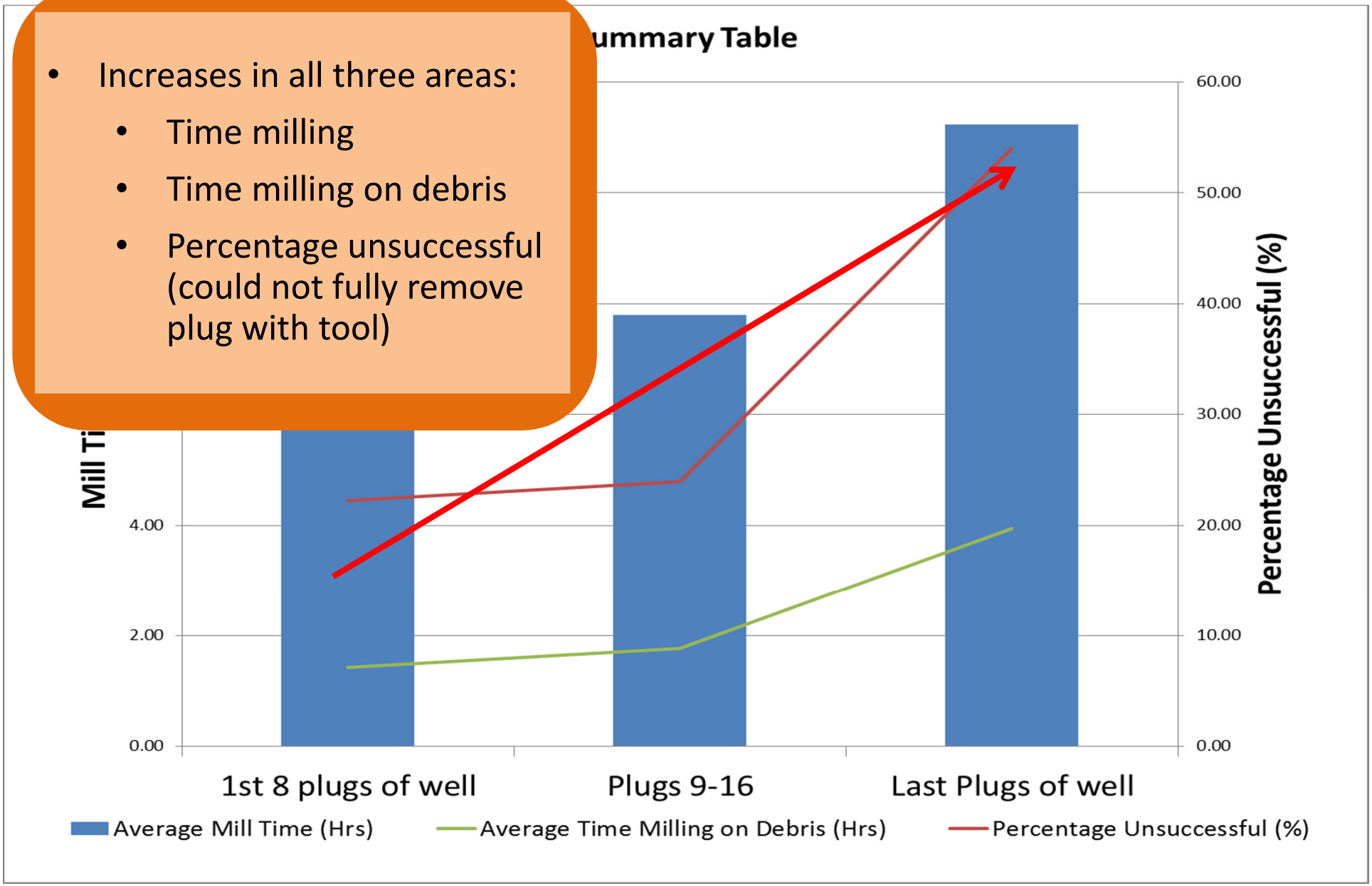
Final plugs in well



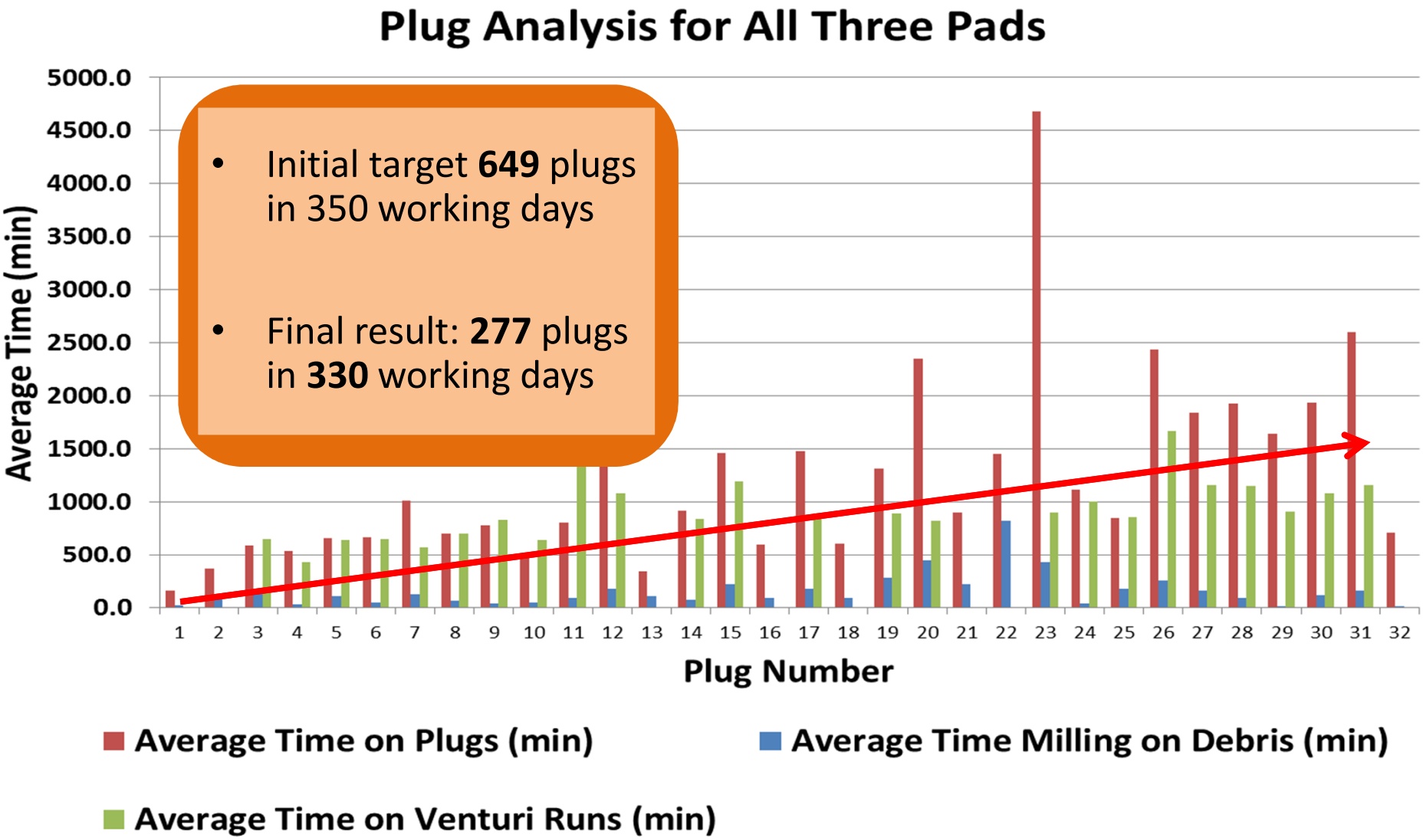
- Over all three pads the average time per plug increased to **1570.24** minutes (**26 hrs)**
- Average time spent milling on debris also increased to **184.8** minutes (**3.1 hrs)**

Could not break the trend

- Increases in all three areas:
  - Time milling
  - Time milling on debris
  - Percentage unsuccessful (could not fully remove plug with tool)



Could not break the trend



Conclusions and Recommendations

Permanent flow through plugs, eliminate the need for a mill out operation.

Incredibly costly and time consuming operation to remove these plugs, however there are ways to reduce the length and price of the operation by controlling:

- The actual milling of the plugs
- Debris management
- Fluid management
- Fatigue management

Conclusions and Recommendations

Milling of plugs:

- Proper weight application
- Recognize and address pattern

Debris management:

- Grind up debris downhole
- Get past the mill and p hole

Fluid managemer

- Treat fluid to reduce iron content
- Understand and control the reaction with chemical systems

nent:

- Typical milling practices do not apply
- Attempt to maintain a consistent level

Preparation
Not Reaction

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Thanks very much to all the field professionals that participated in this challenging project

Questions?

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