



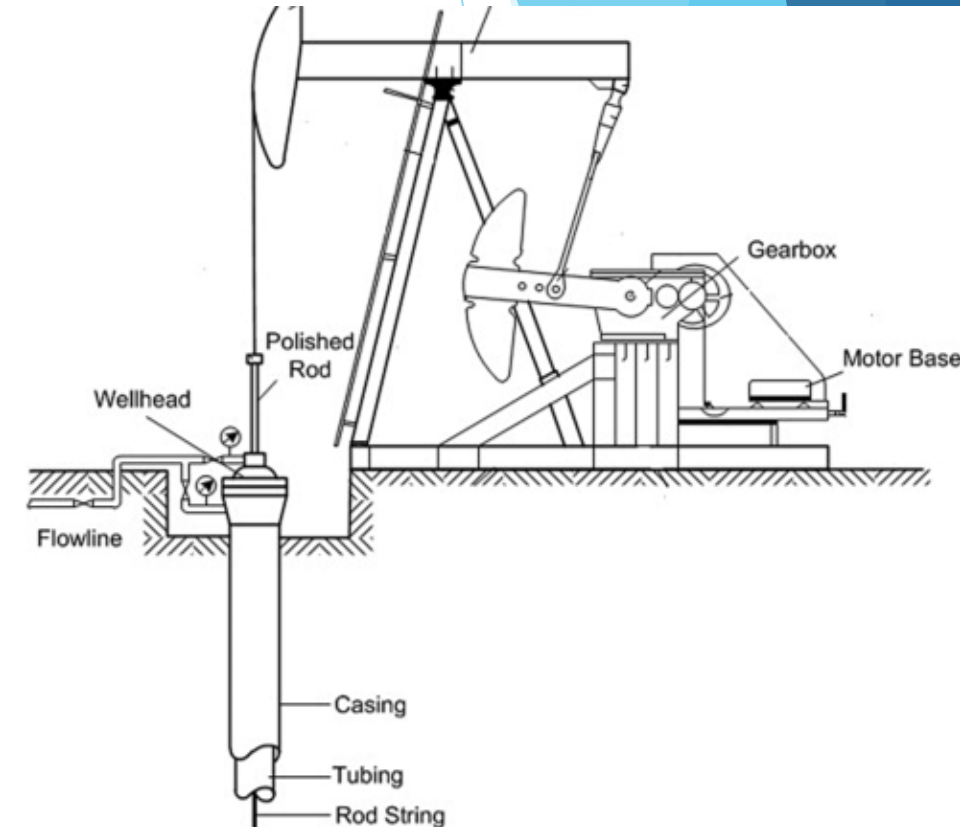
Utilizing Algorithms to Determine Production Increases on Wells Operating with a Fluid Level Above the Pump

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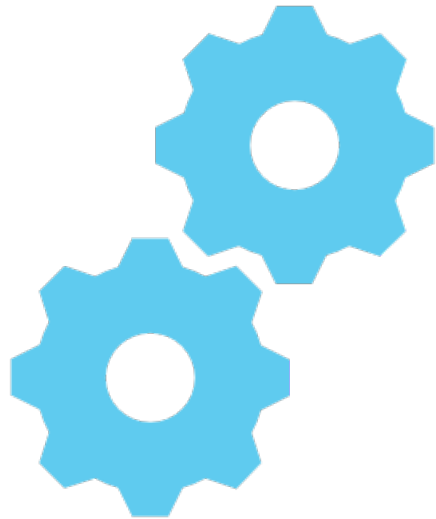
ALRDC Artificial Lift Workshop
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Problem Statement

- ▶ Mature asset with several thousand rod pump wells
- ▶ Utilizing a manual process of diagnosing well with potential production increases
- ▶ Utilizing a manual process for designing wells with potential production increases
- ▶ Challenging to prioritize which wells should undergo redesign first
- ▶ Limited resources to spend time on this manual process



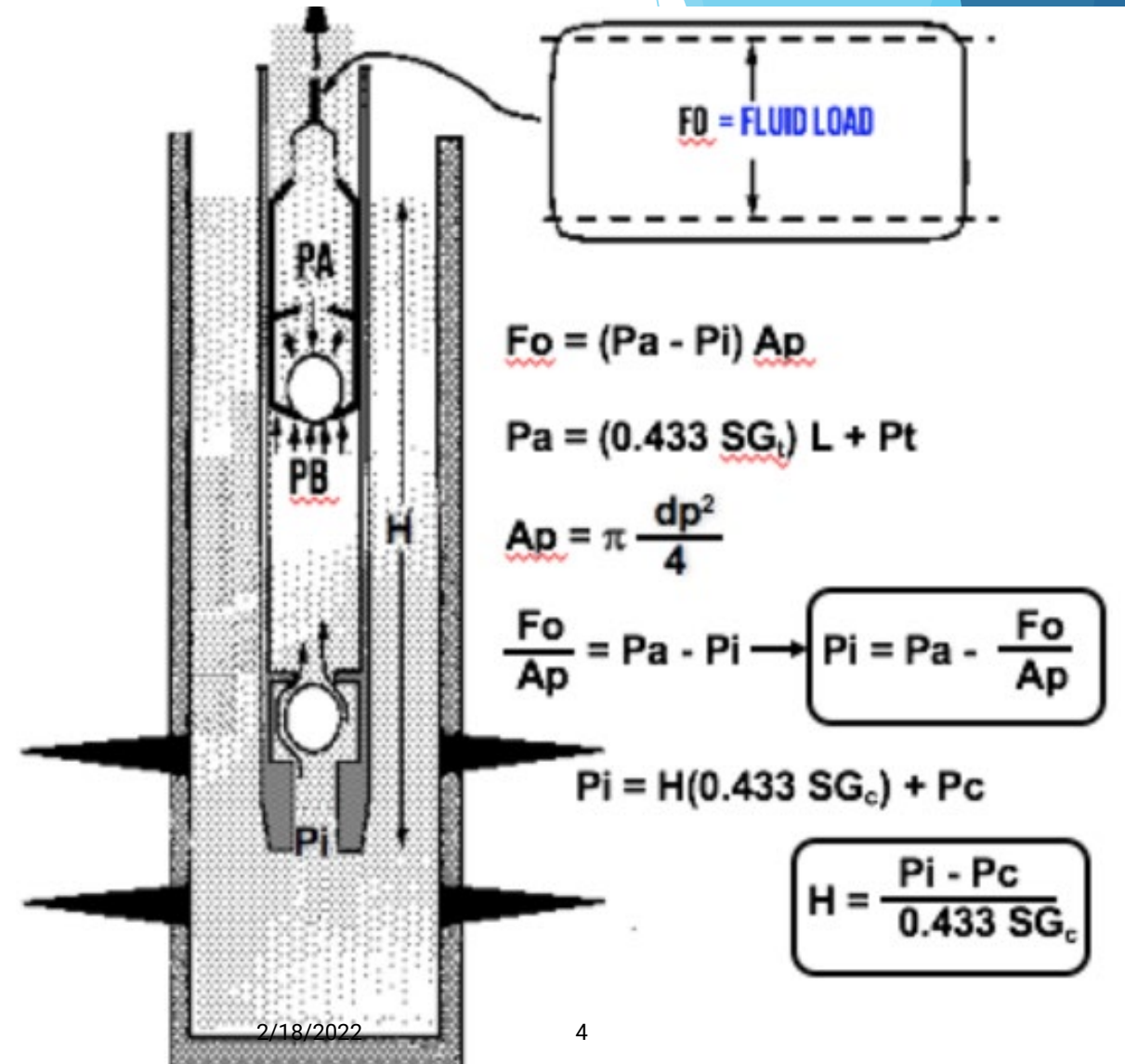
Objectives



- ▶ Using a host software solution develop algorithms that:
 - Determine which wells are capable of production increases
 - Automatically runs design cases to determine equipment capacity
 - Prioritize wells based on the greatest economic impact with improved design
 - Solution must run fully autonomous and not require any human intervention once input requirements are met

Rod Pump Theory

- ▶ Rod pump artificial lift draws down the fluid level reducing back pressure and allows maximum production flow
- ▶ Rod pump wells operating 24 hours a day with fluid over the pump are capable of increasing production
- ▶ Operating a rod pump with the fluid level at the pump provides highest production and optimal equipment loading



Solution: Host Software



- ▶ Develop algorithms to determine wells that are capable of increased production
- ▶ How to determine if a well is a good candidate:
 - Running 24 hours per day on a consistent basis
 - Consistently operating with a significant fluid level above the pump (500 ft. or more)
 - Pump is consistently full
 - Not currently overloaded



Solution: Predictive Software



- ▶ Once a well was determined to be a good candidate a predictive software solution was required
- ▶ **Goal:** Ability to increase well speed and production without overloading:
 - Pumping unit structure
 - Pumping unit gearbox
 - Rod string or causing compression
- ▶ Other design considerations:
 - Pump efficiency
 - Predicted fluid level
 - Tubing and casing pressure



Solution: Host & Predictive Software Utilized Together



All done within and by the host software:

- ▶ Determined wells that were candidates for production increases
- ▶ Iterated through speed changes and determined the maximum capacity of the existing equipment
- ▶ Prioritized wells according to maximum potential production increases and showed users:
 - Potential production increases
 - New SPM required to obtain production increases
- ▶ Deployed to thousands of wells to identify the best opportunities for production increases



Trial Summary



- ▶ San Joaquin Valley California
- ▶ 7,000 heavy and light oil vertical wells
- ▶ 1,000-2,000 ft deep (300 – 600m)
- ▶ 80 potential opportunities identified by software
- ▶ 60 opportunities verified by users as uplift opportunities
- ▶ 95% success rate

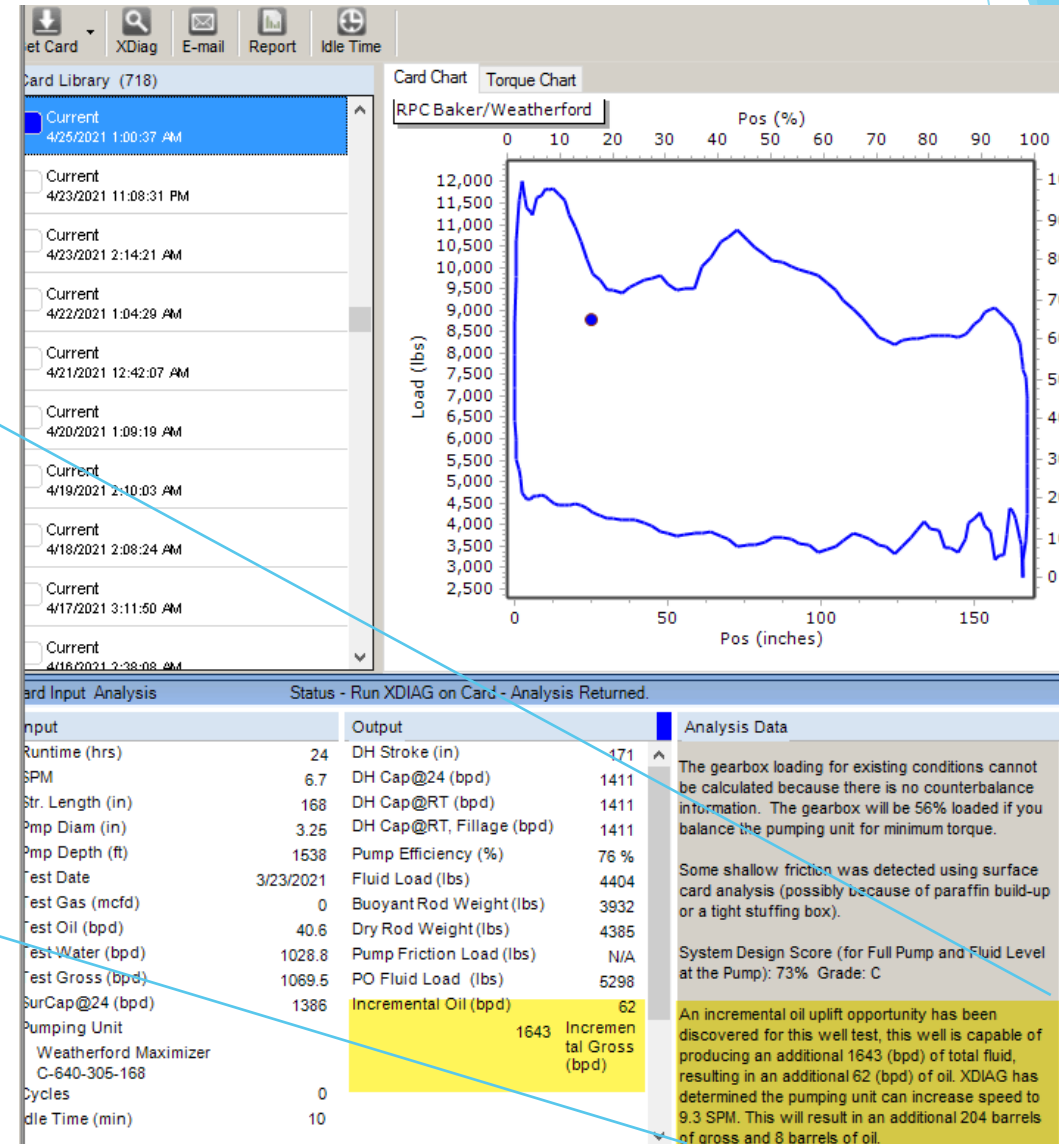




Case Study #1

- ▶ Card shows well is not pumped off
- ▶ Algorithms determined current pumping unit can be sped up

An incremental oil uplift opportunity has been discovered for this well test, this well is capable of producing an additional 1643 (bpd) of total fluid, resulting in an additional 62 (bpd) of oil. XDIAG has determined the pumping unit can increase speed to 9.3 SPM. This will result in an additional 204 barrels of gross and 8 barrels of oil.



Case Study #1

- ▶ IPR analysis determined there is significant incremental gross production available

IPR Correlation Composite

Static Bottomhole Pressure 337 psi

Bubblepoint Pressure 1750 psi

Water cut

☐ Manual Input %

☒ From most recent Well Test 96.2 %

Gross Rate

☐ Manual Input bpd

☒ From most recent Well Test 1069.5 bpd

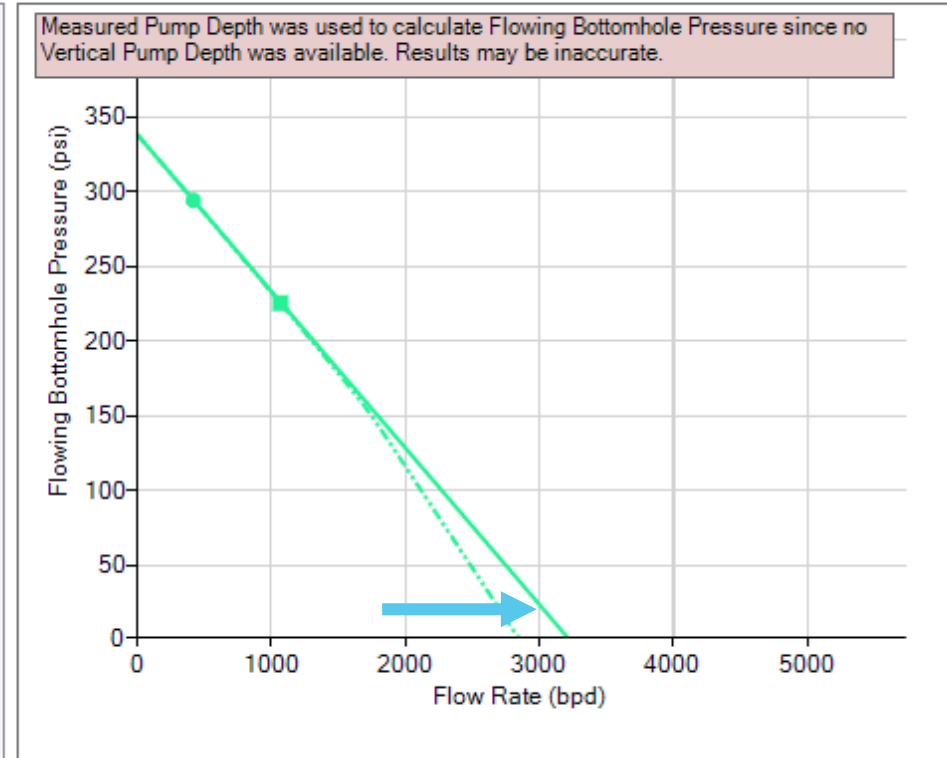
Flowing Bottomhole Pressure

☐ Manual Input psi

☒ Calculated From XDIAG PIP 224 psi

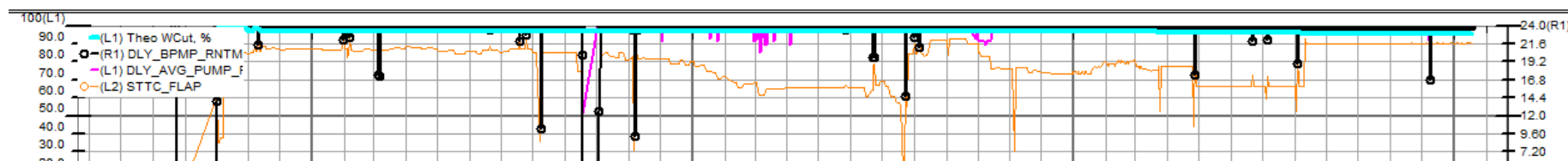
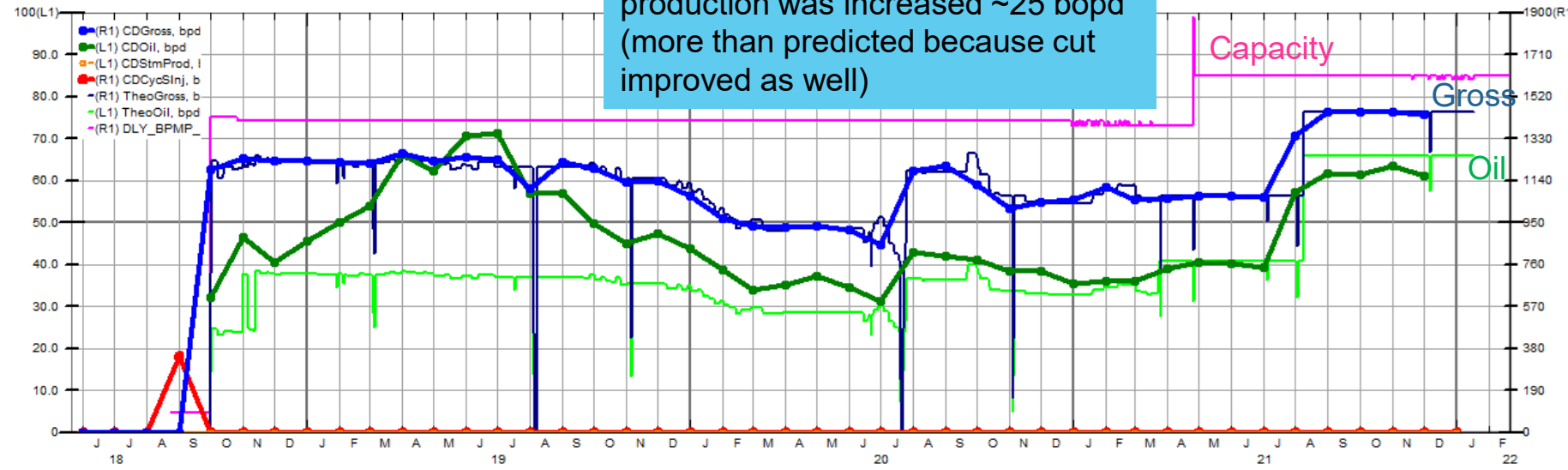
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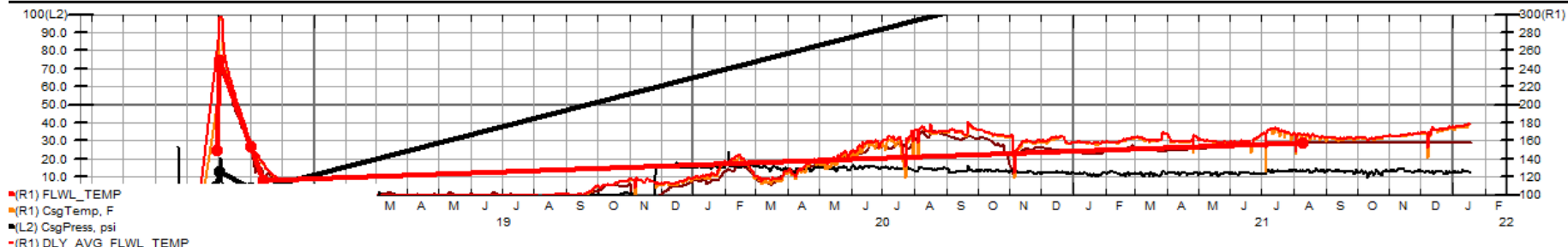


Case Study #1

Utilizing equipment in place,
production was increased ~25 bopd
(more than predicted because cut
improved as well)



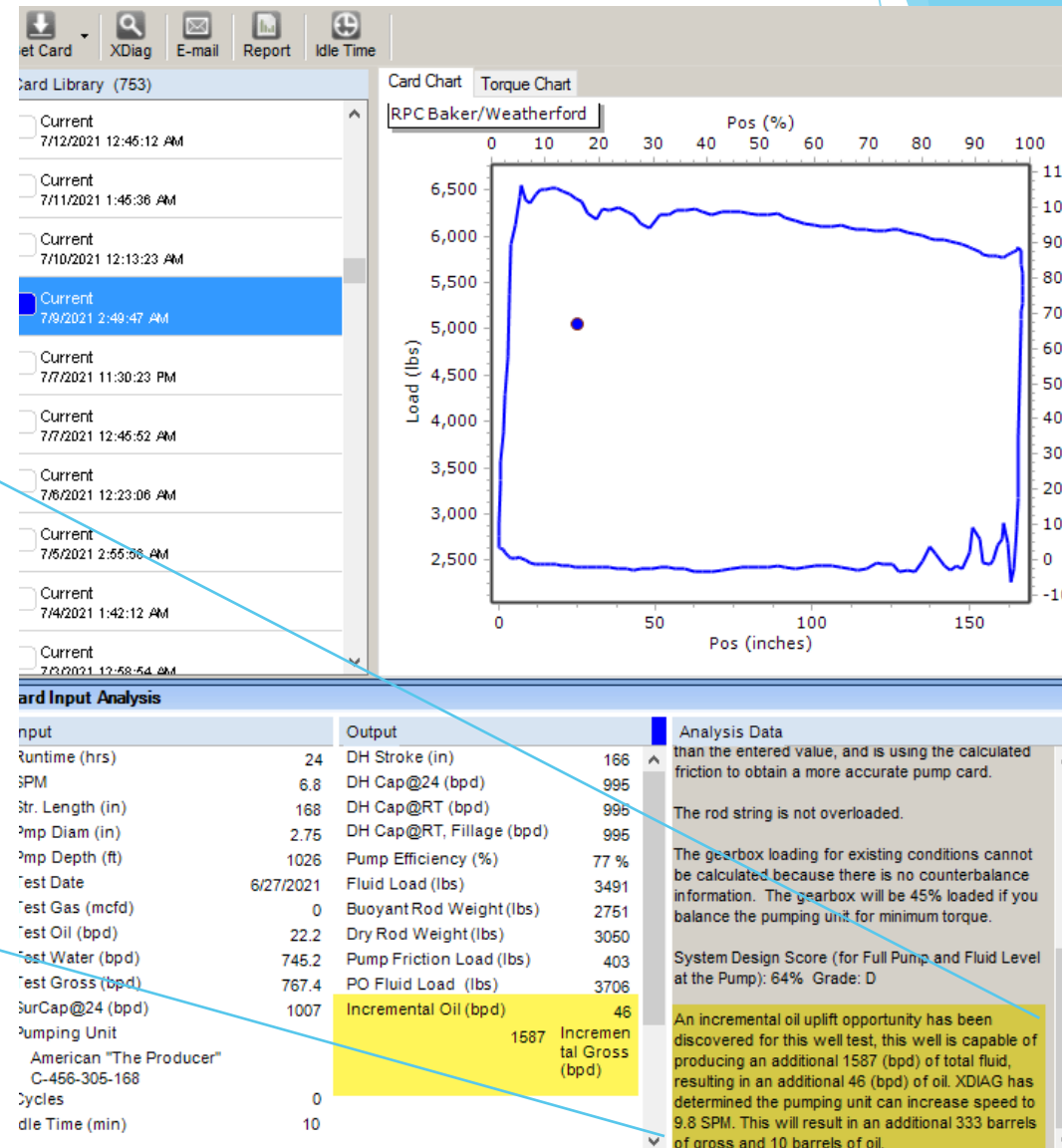
Fillage (above pink) and temperatures (below orange/red) suggest that traditional analysis methods might determine there is no uplift opportunity here



Case Study #2

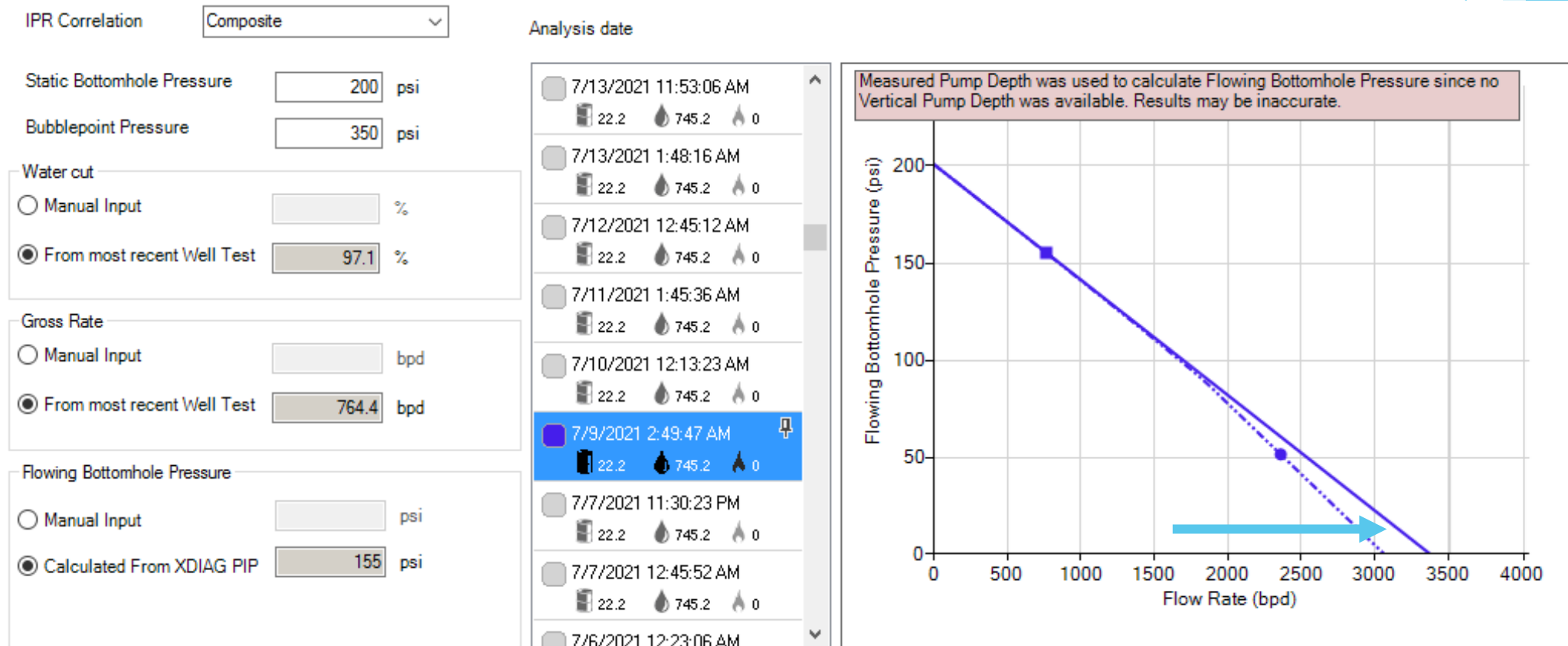
- ▶ Card shows well is not pumped off
- ▶ Algorithms determined current pumping unit can be sped up

An incremental oil uplift opportunity has been discovered for this well test, this well is capable of producing an additional 1587 (bpd) of total fluid, resulting in an additional 46 (bpd) of oil. XDIAG has determined the pumping unit can increase speed to 9.8 SPM. This will result in an additional 333 barrels of gross and 10 barrels of oil.



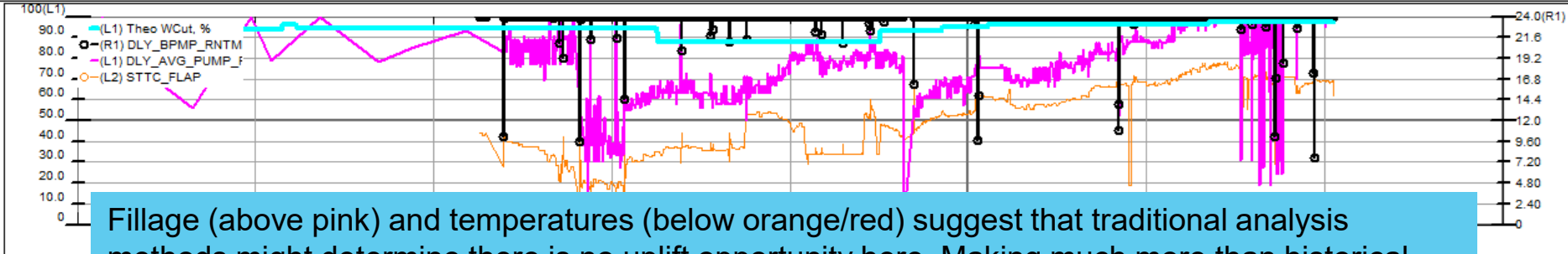
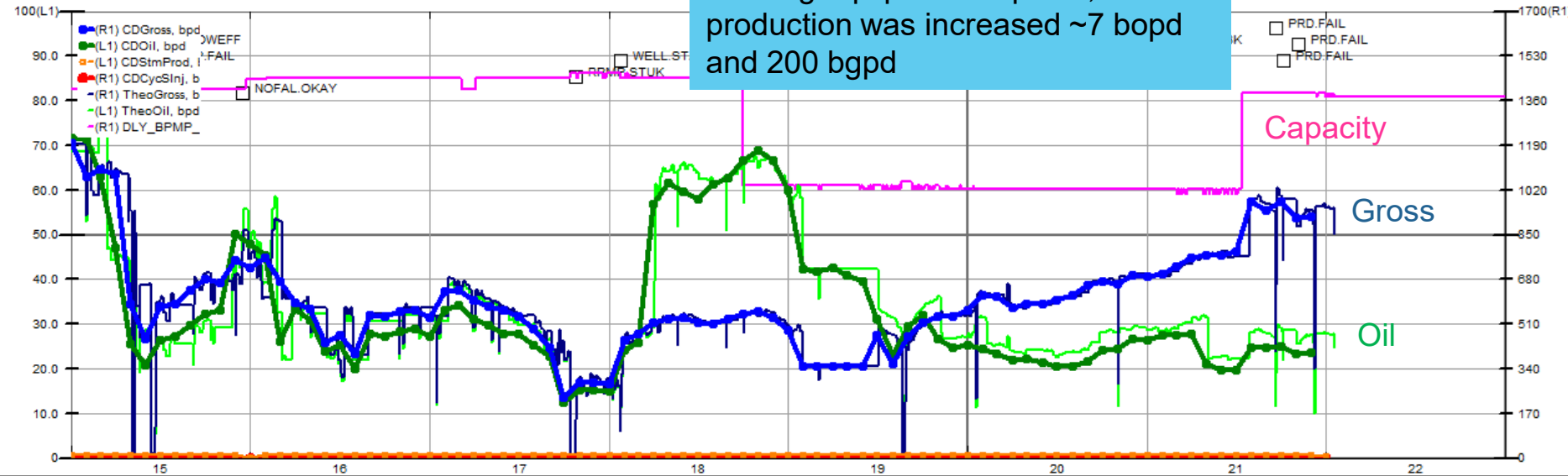
Case Study #2

- IPR analysis determined there is significant incremental gross production available

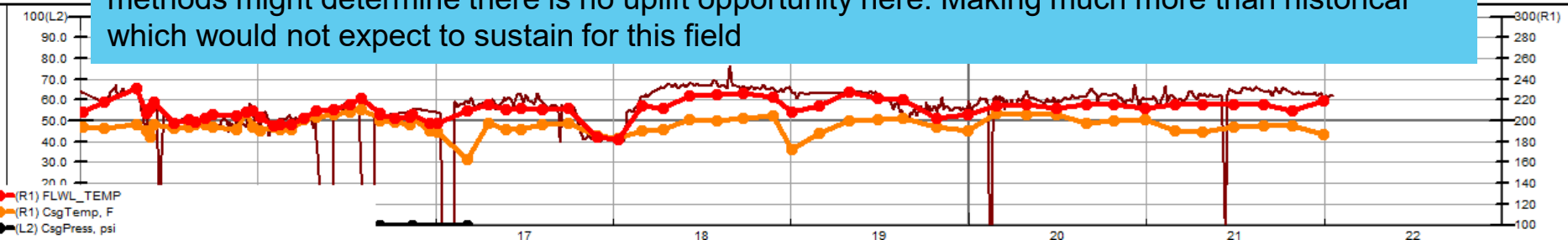


Case Study #2

Utilizing equipment in place,
production was increased ~7 bopd
and 200 bpgd



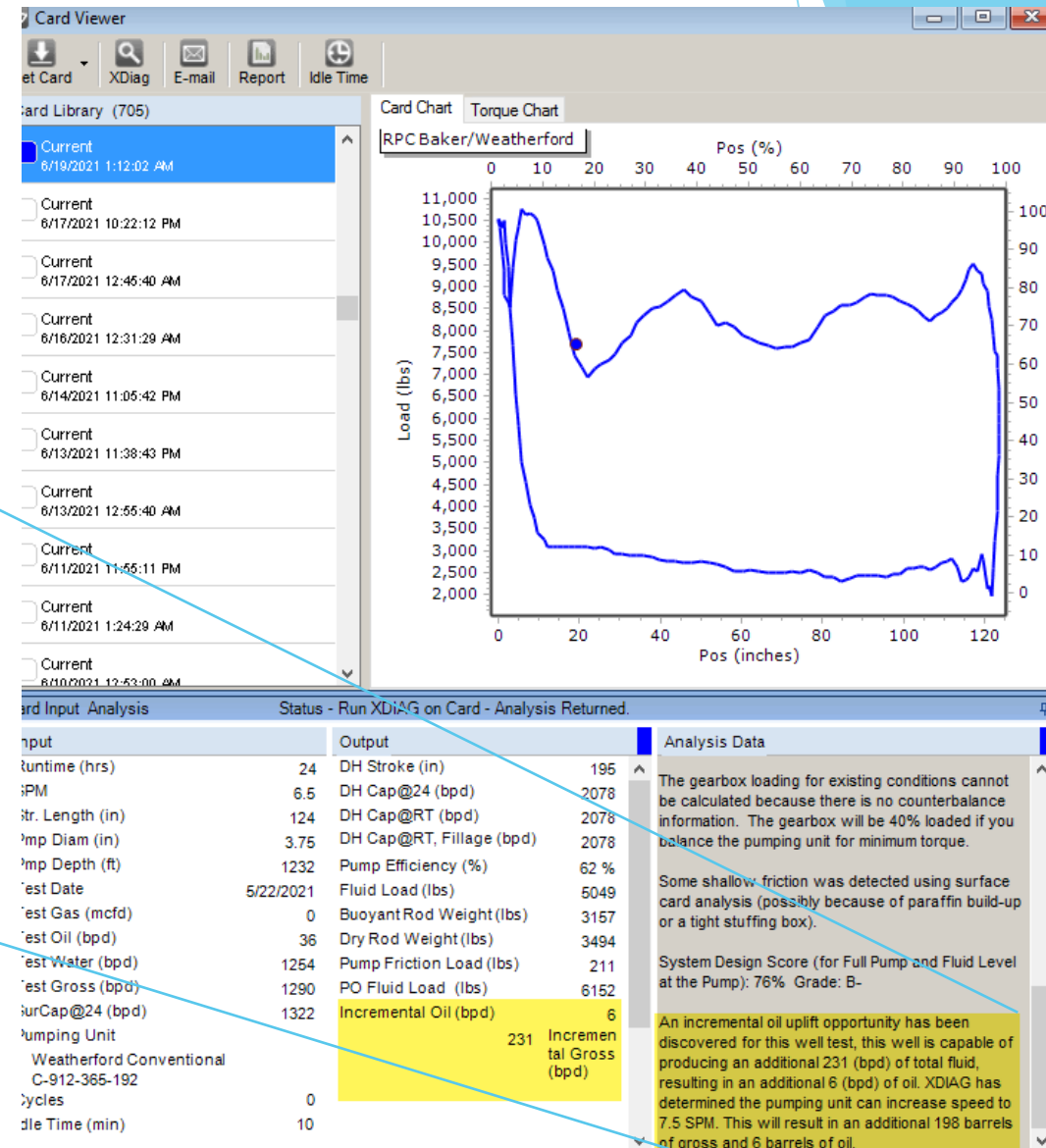
Fillage (above pink) and temperatures (below orange/red) suggest that traditional analysis methods might determine there is no uplift opportunity here. Making much more than historical which would not expect to sustain for this field



Case Study #3

- ▶ Card shows well is not pumped off
- ▶ Algorithms determined current pumping unit can be sped up

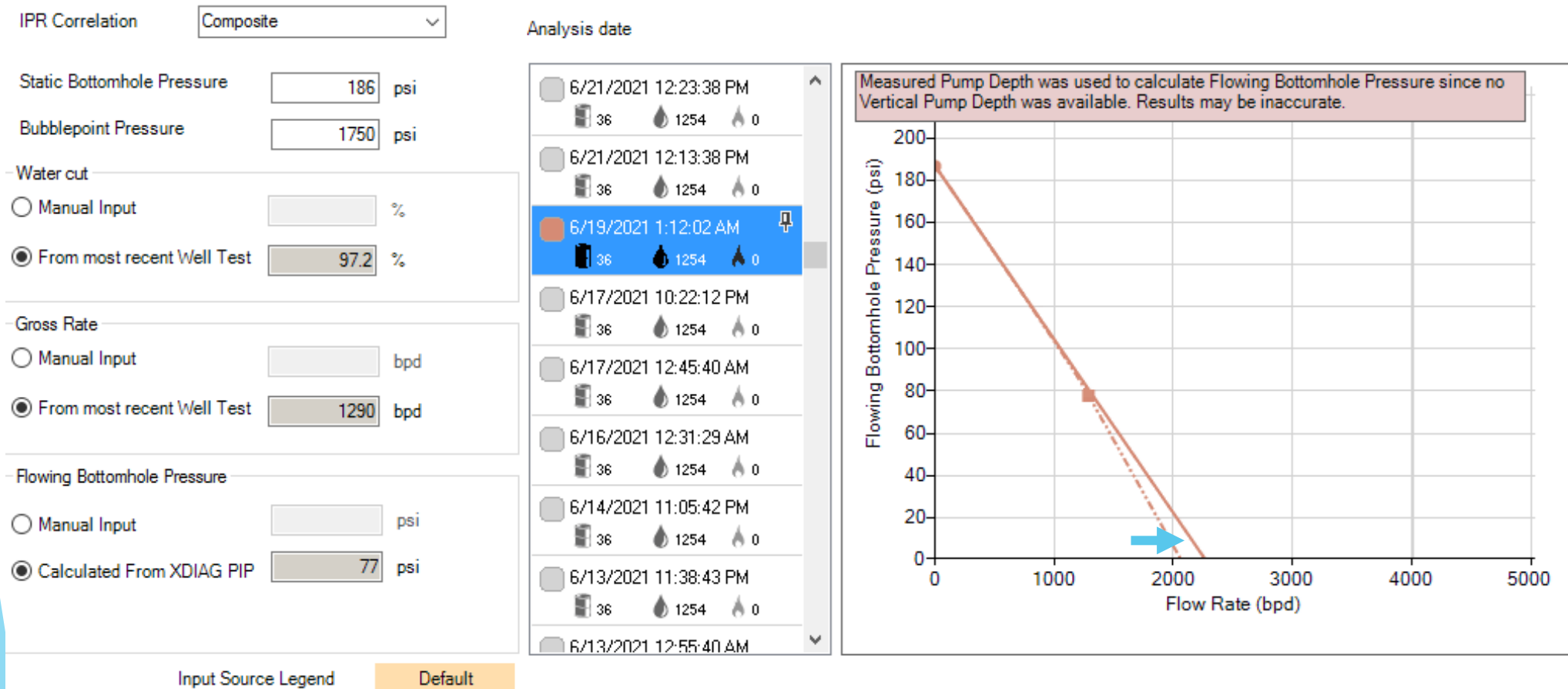
An incremental oil uplift opportunity has been discovered for this well test, this well is capable of producing an additional 231 (bpd) of total fluid, resulting in an additional 6 (bpd) of oil. XDIAG has determined the pumping unit can increase speed to 7.5 SPM. This will result in an additional 198 barrels of gross and 6 barrels of oil.





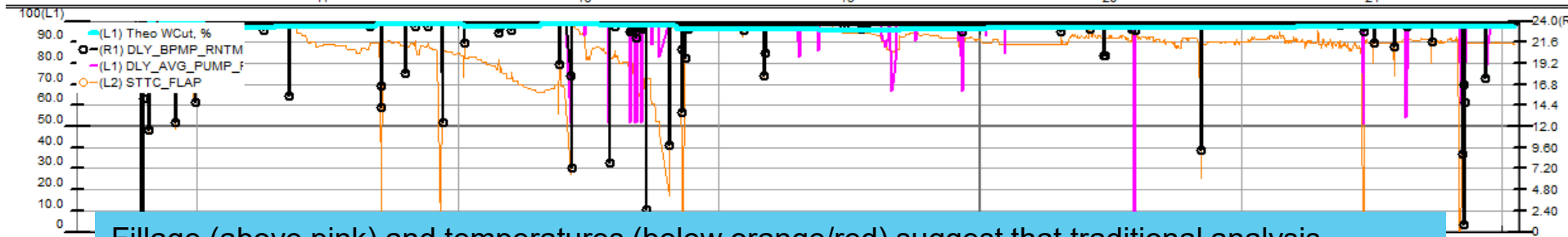
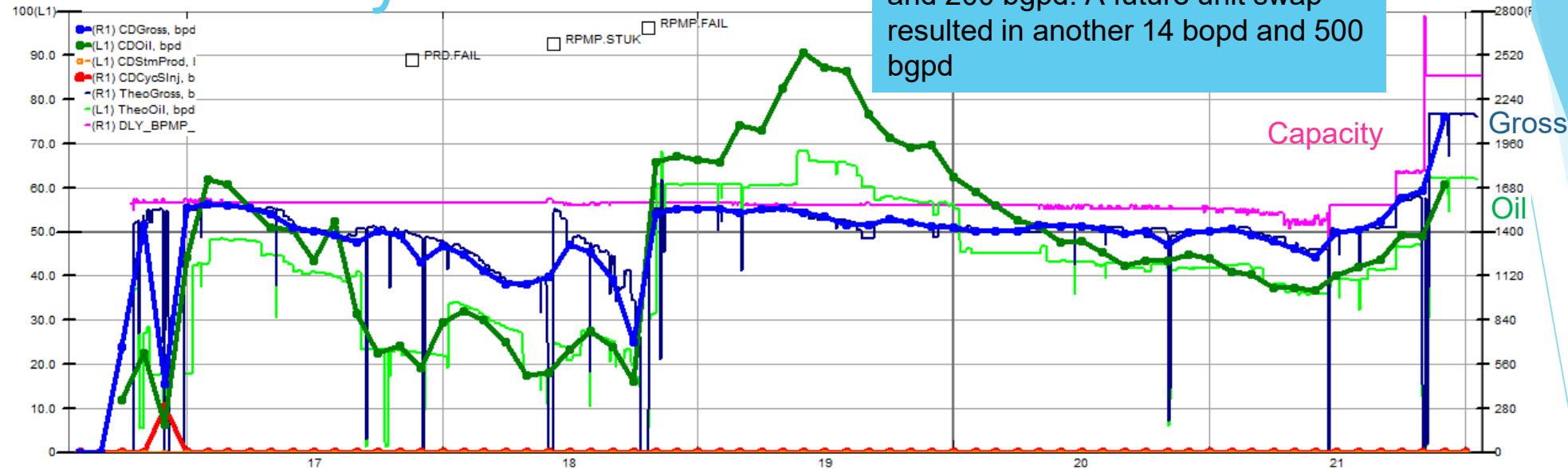
Case Study #3

- ▶ IPR analysis determined there is significant incremental gross production available

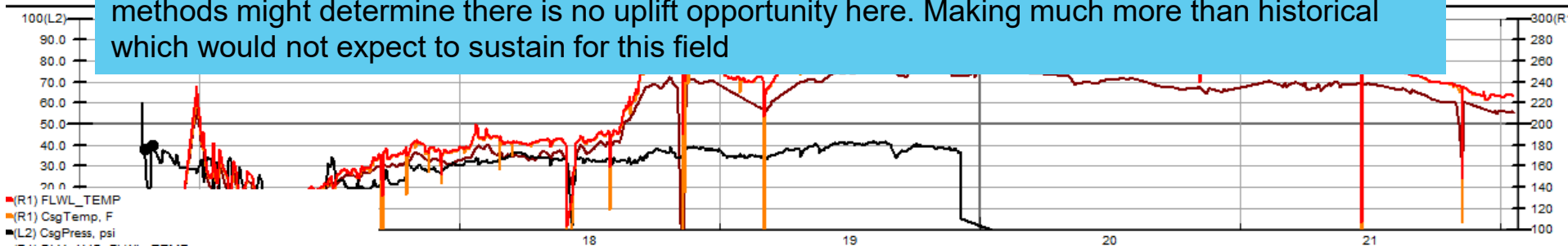


Case Study #3

Utilizing equipment in place, production was increased ~7 bopd and 200 bopd. A future unit swap resulted in another 14 bopd and 500 bopd



Fillage (above pink) and temperatures (below orange/red) suggest that traditional analysis methods might determine there is no uplift opportunity here. Making much more than historical which would not expect to sustain for this field



Conclusion and Continuing Development

- ▶ Accurately identifies wells with uplift opportunities
- ▶ Predictive design allows host to calculate the maximum speed
- ▶ Automatically prioritizes wells with uplift opportunities
- ▶ Attaining reliable SBHP values
- ▶ Matching calculated and sonic fluid level values
- ▶ Accommodating gas separators
- ▶ Deviated wells



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Sources

- ▶ *Rod Pumping System*. Rod Pumping System - an overview | ScienceDirect Topics. (n.d.). Retrieved January 20, 2022, from <https://www.sciencedirect.com/topics/engineering/rod-pumping-system>



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