Power Analysis of Solids in Wells

Mueez Mughal

Firebag Exploitation

09.26.25

Roadmap

Motivation

- Detrimental effects of sandy and scaly wells
- Better predict sands and scales in wells

Analysis

- Physics behind analysis
- Gathering data for a power analysis

Results

- Case studies
- Using engineering judgment

Solution

- More accurate predictions in sand and scale wells for potential workovers
- Further development

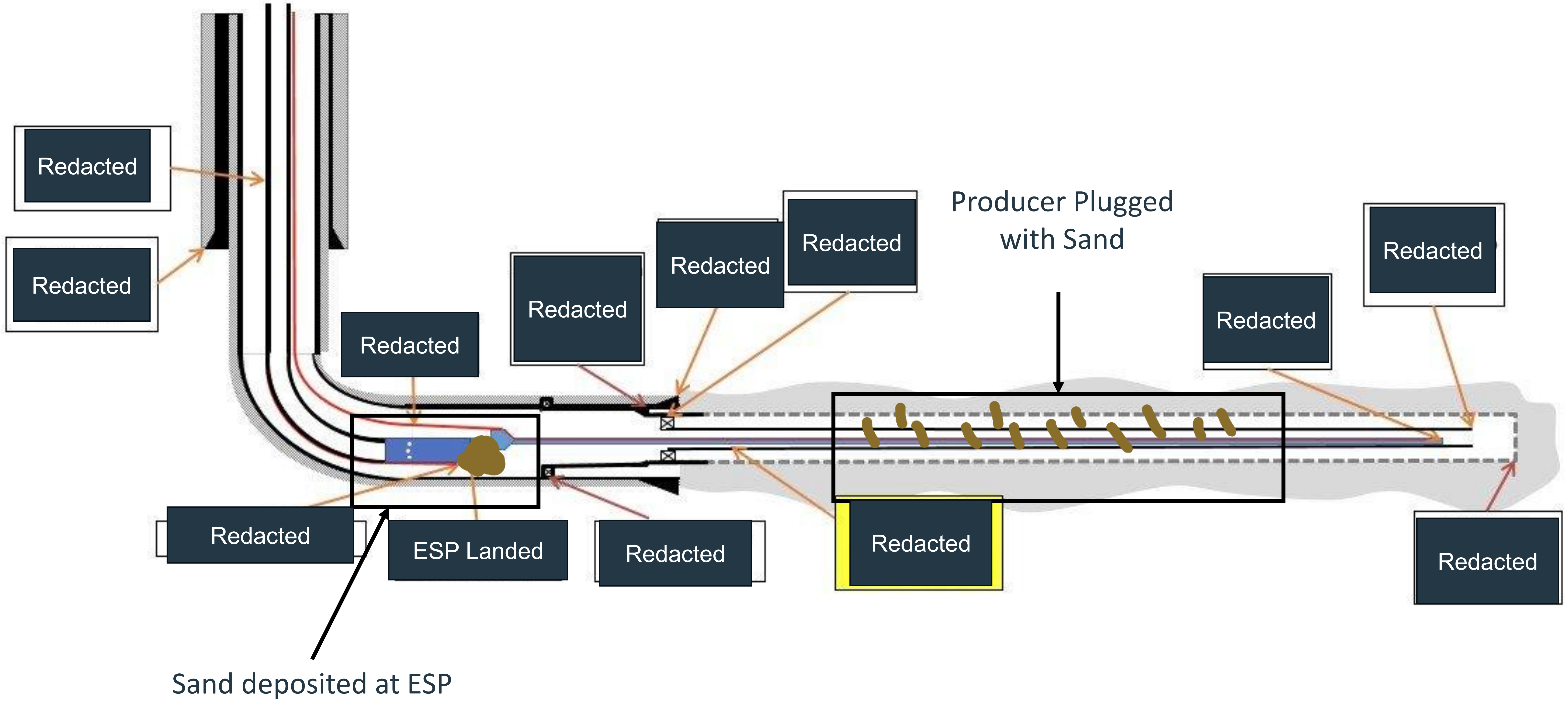
Motivation

Detrimental Effects of Sandy Wells

Sandy wells cause inefficient well performance since they plug the ESP and slotted liners. They also increase the effective density of the fluid flowing through.

The combination of these phenomena create high pressure losses within the well causing the ESP to run inefficiently.

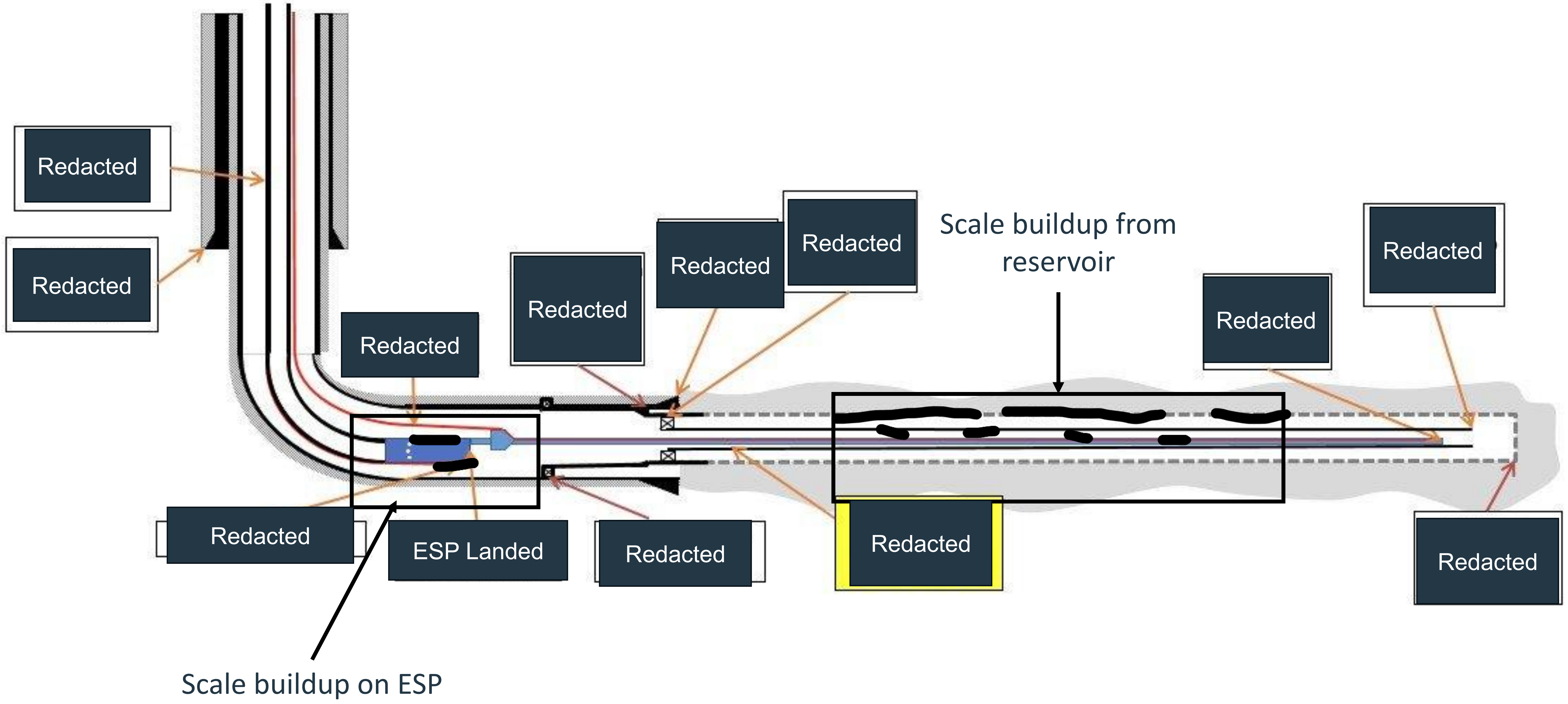
When wells fail due to sand, it is unpredictable and causes us to spend a lot of money on ESP changes, boiler feedwater flushes (BFW), magnet runs, and chemical stimulations.



Detrimental Effects of Scaly Wells

Like sandy wells, scale can lead to inefficient performance by restricting flow paths and damaging subsurface equipment. It commonly accumulates in the ESP, tubing and slotted liners, reducing the effective diameter and increasing frictional losses.

Scale gradually accumulates in the well and is unpredictable. Costly interventions are like that of sand



Current Methodology to Identifying Sandy or Scaly Wells

Currently for sandy or scaly wells we look at well history, geology, and a few well key point indicators

- If a well is historically a known sand or scale producer, then the odds of it still producing sand or scale after intervention are **extremely** high

- Well geology is key when determining sandy or scaly wells. Reservoir with **high concentration of minerals** can correlate to an increase in scale production

- Key point indicators are also vital in determining sand or scale in wells
  - **Pressure drop** (Dp) between chamber and bottom hole (BHP) can indicate solids
  - **Motor temperature** increasing could mean scale depositing around the ESP or sand depositing inside
  - **Normalized drawdown** is Dp per production unit which can correlate to solids
  - **Current fluctuations** can also be attributed to solids which can come in slogs

- We have a few methods in determining solids in wells, however, none of them are **completely reliable** making it difficult to perform workovers on wells we predict have solids

- Additionally wells with solids **might not show any of these signs at all or show all the signs and not have any solids**

- Our most reliable method is **pulling the ESP** and checking manually
  - This is **costly** and there is no point in doing this unless we need to do an ESP replacement
  - The well will **progressively perform worse** until the ESP is replaced or a workover is enacted

- It is also **challenging to distinguish** between sand and scale

Redacted

Analysis

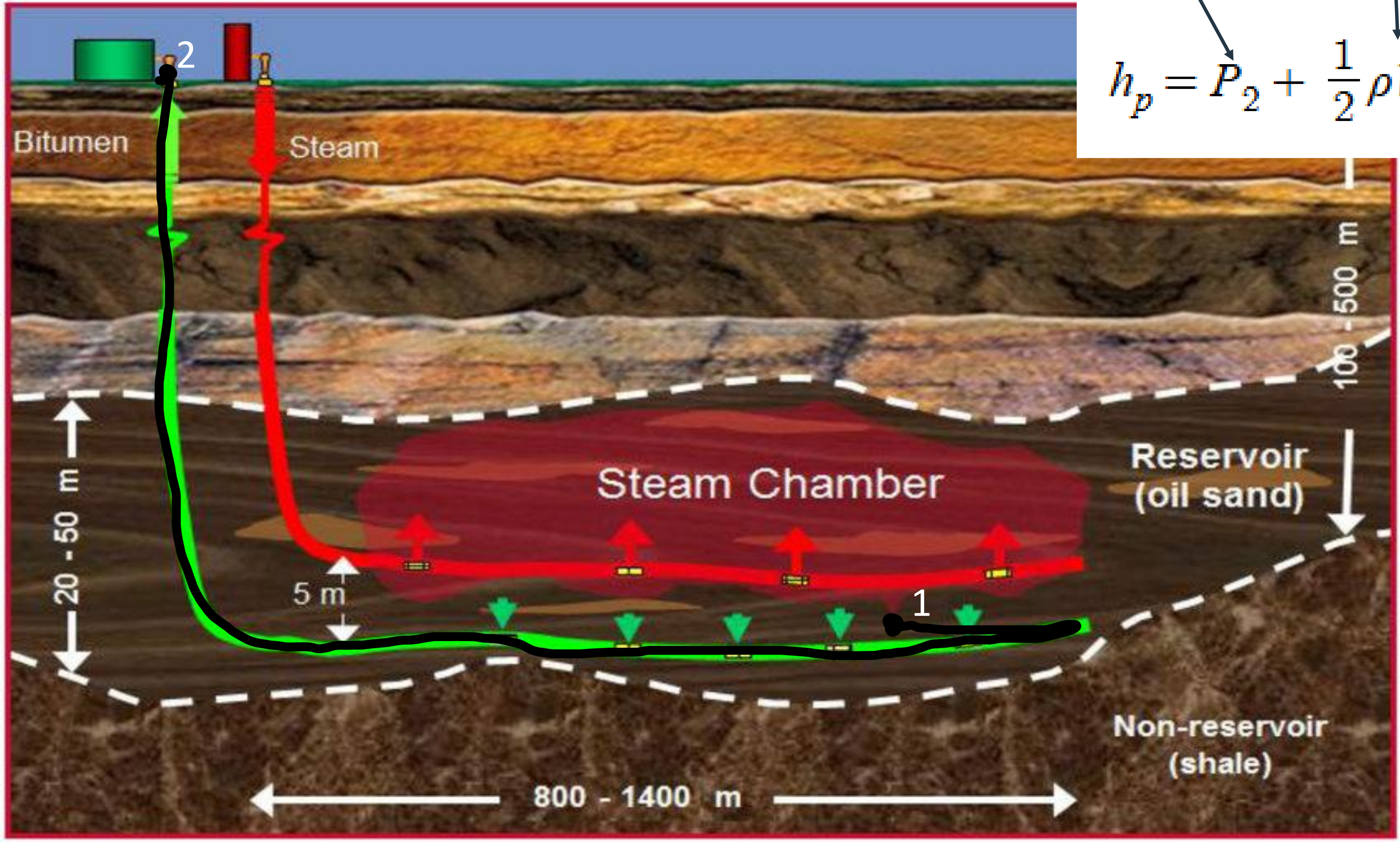
The Energy Equation

The energy equation is widely used in fluid mechanics to determine the pump head

Pressure head　Velocity head　Gravitational head　Pump head　Friction head

$$P_1 + \frac{1}{2}\rho V_1^2 + \rho g z_1 = P_2 + \frac{1}{2}\rho V_2^2 + \rho g z_2 - h_p + h_f$$

Setting up the Equation



Tubing Pressure

V = Q/A

ESP TVD

$$h_p = P_2 + \frac{1}{2}\rho V_2^2 + \rho g z_2 - \left(P_1 + \cancel{\frac{1}{2}\rho V_1^2} + \rho g z_1\right)$$

Chamber Pressure

Surface of liquid level approximation V~0

You may notice something is missing…

Frictional Losses

Now we want to find the ideal power output from the ESP

$$P_p = \rho g h_p Q$$

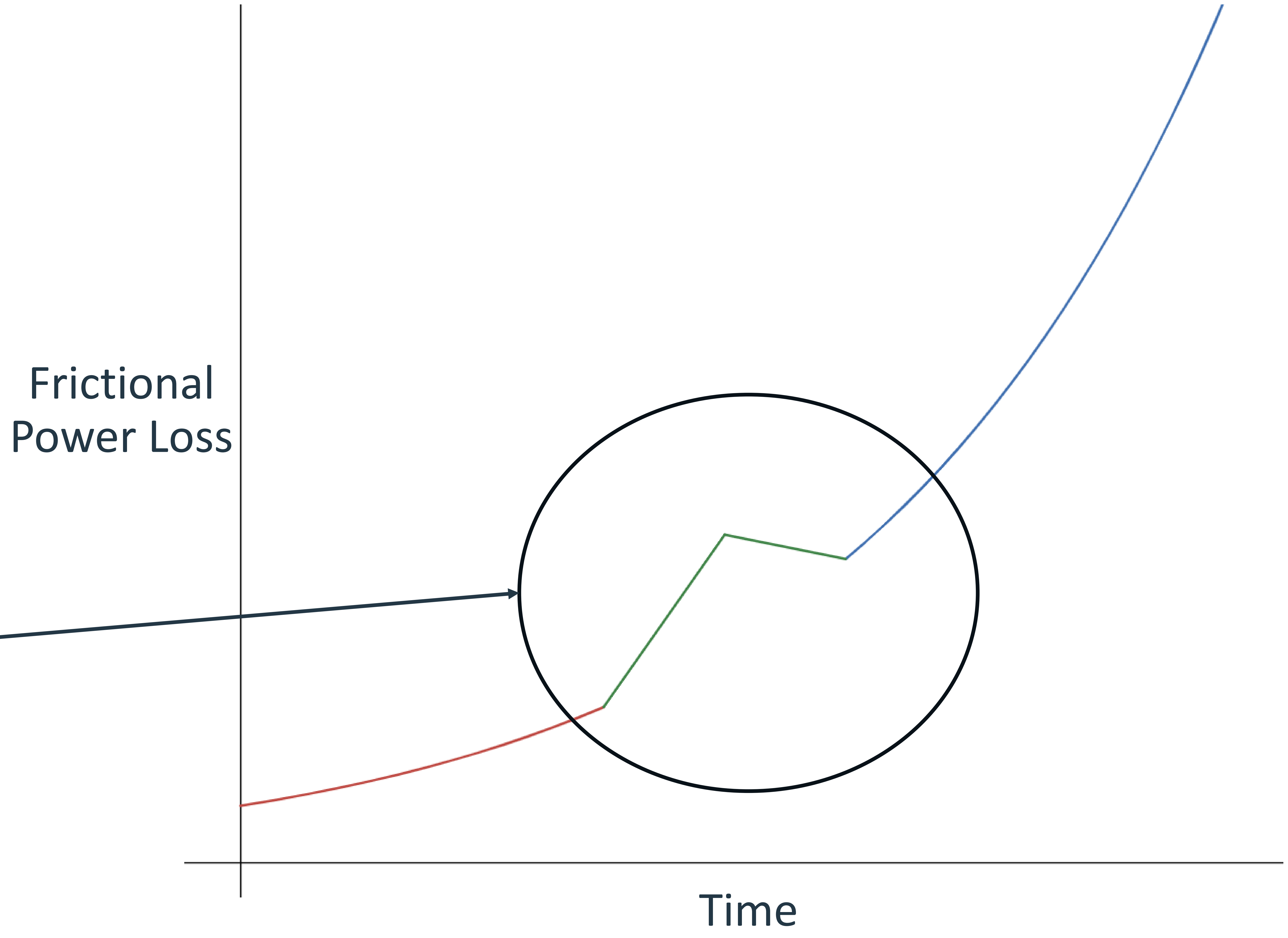
Finally, we have a PI tag that measures the output power of the ESP reliably and thus we can subtract the ideal power from the PI tag to find the power discrepancy. This is the power loss due to friction.

$$P_a - P_p = P_f$$

Gathering Data

PI Tags and Excel

- Looked at pump life for start and end date
- Looked at before and after chemical stimulations
- Gathered all the data in Excel then used Python to aggregate, do math, and plot efficiently



Expected Result

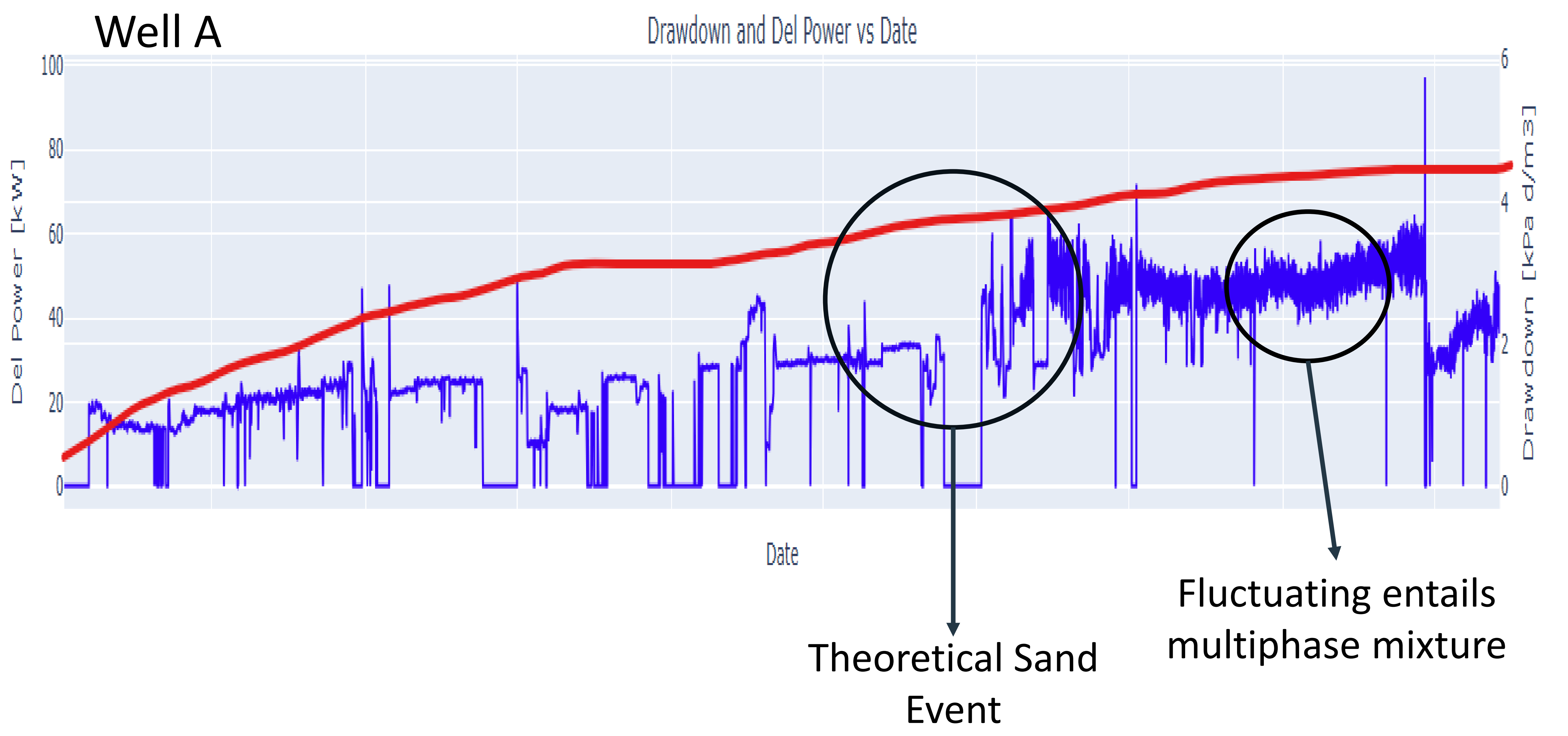
- Gradual increasing showing scale buildup over time
- Spike indicates sand event
  - Sand comes in slogs

SUNCOR

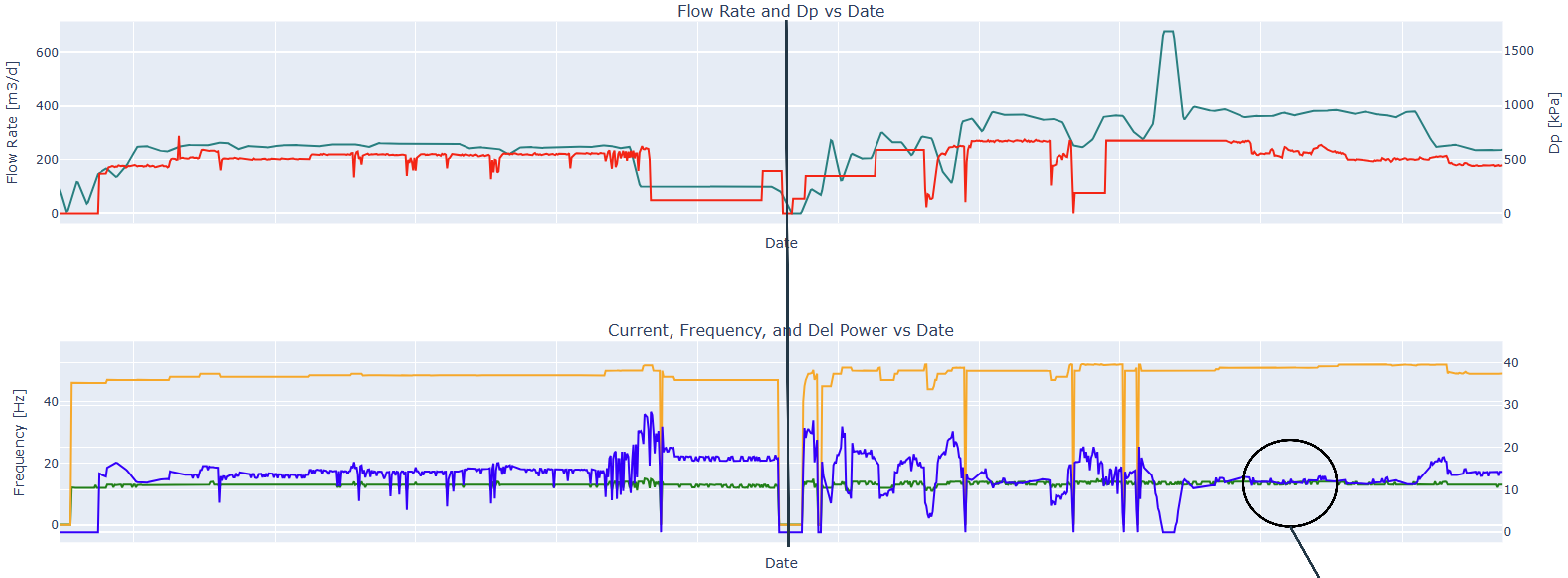
Results

Differing Expected and Actual

- Initially I though the graph would be exponential, however, they came out to be more logarithmic
- This makes sense as scale, sands, and ESP wear are more gradual rather than a snowballing effect
- Eventually they hit a certain limit where the ESP is at maximum operating conditions
  - Frequency
  - Current
  - Power Draw
- The ESP may also have reached “max” solid where it physically cannot deposit more
  - ESPs often trip around this region



Chemical Stimulation Verification



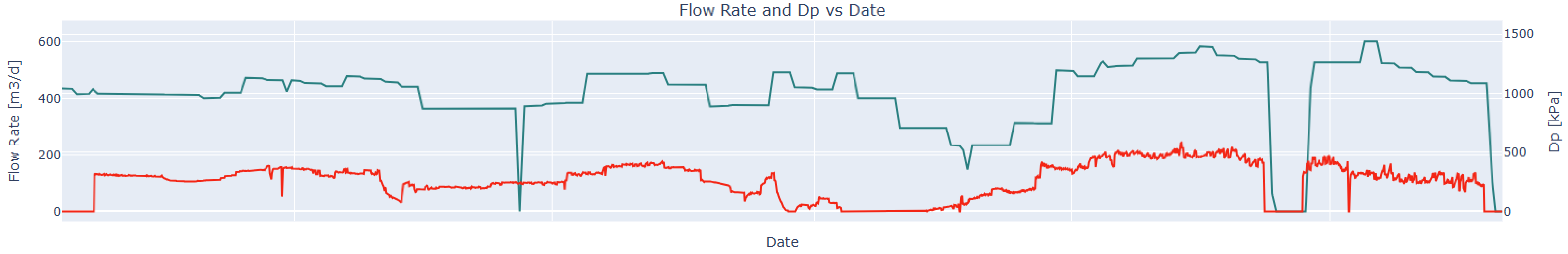
Chemical stimulation proved model can accurately depict solids

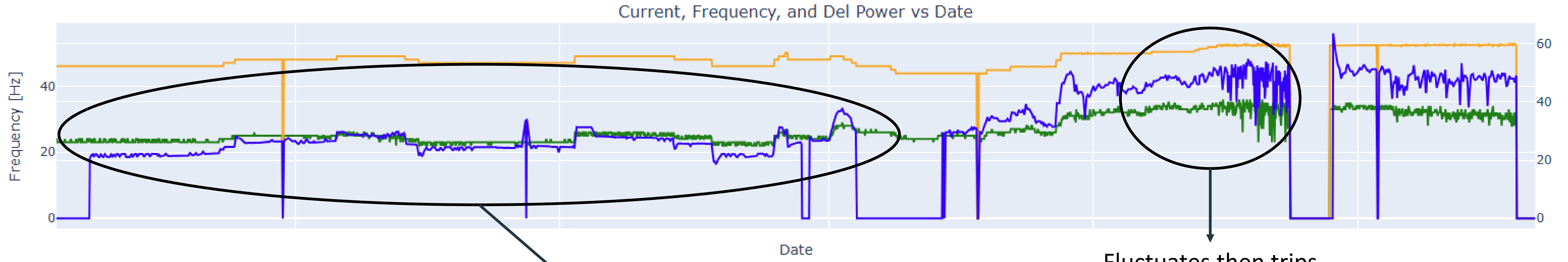
Not fluctuating

SUNCOR

Control

Well B DIFA had no scale but high wear and tear



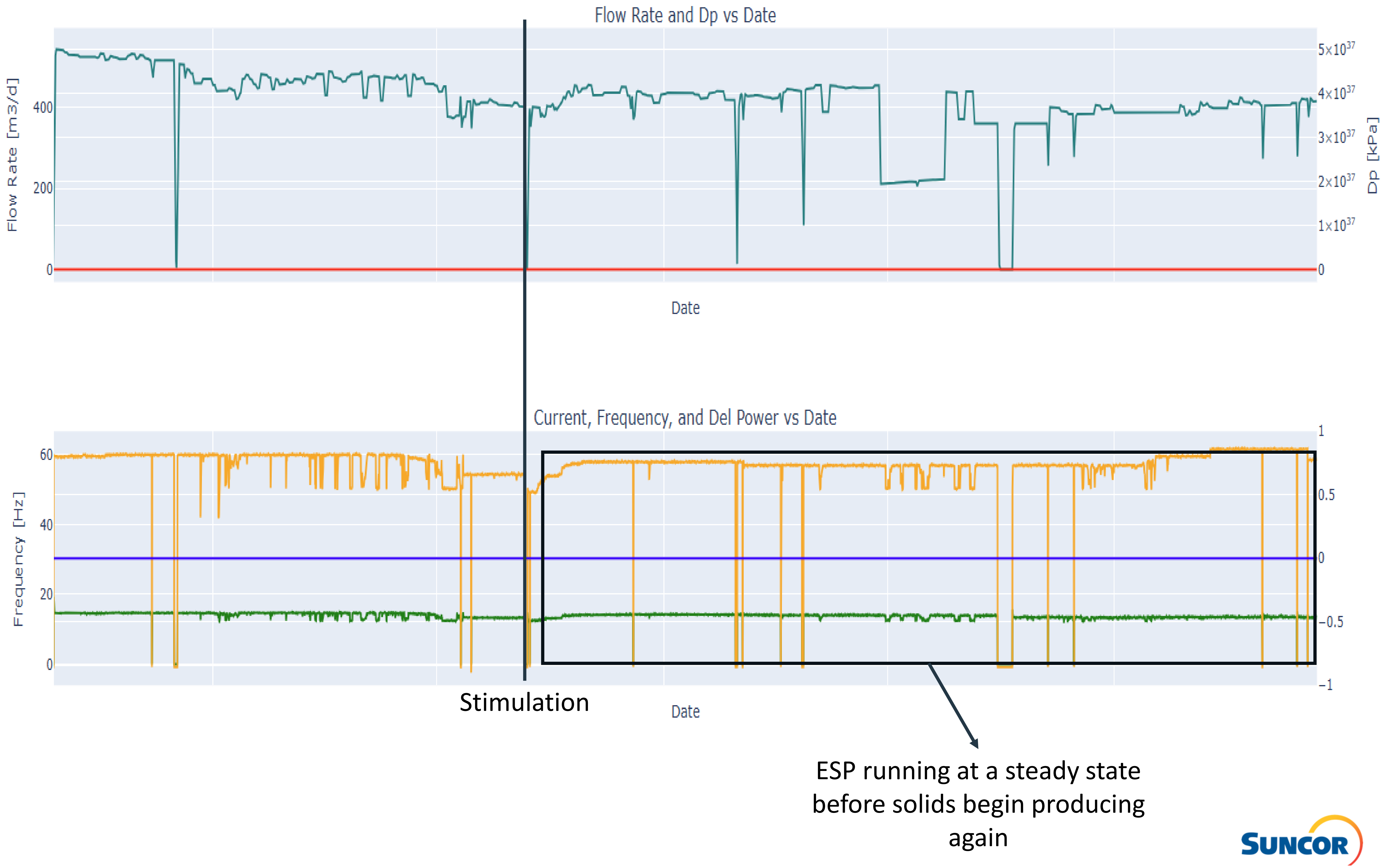


Little to no fluctuation

Fluctuates then trips

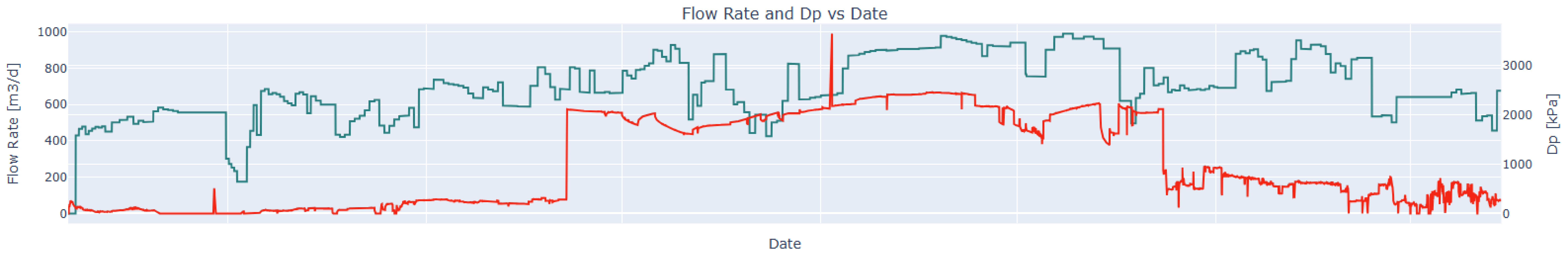
Chemical Stimulations with ESP Integrity

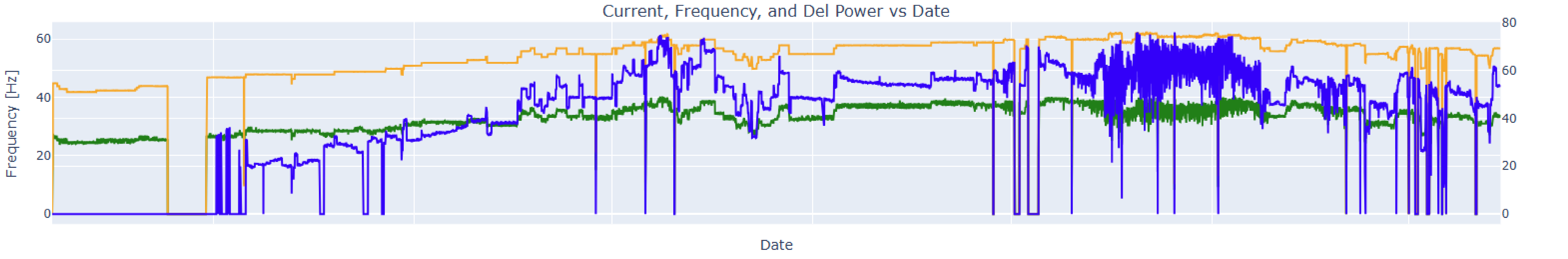
Much older wells don't measure power



- Before the chemical stimulation, the well was on steady decline
- Post stim, the well got a small boost and remained at a constant rate for ~1.5 years
- This improves well integrity as the ESP has a longer run life
  - Proactively replacing the ESP due to declining flow rate would have cost more money and wouldn't have solved the root issue of solids

Solution

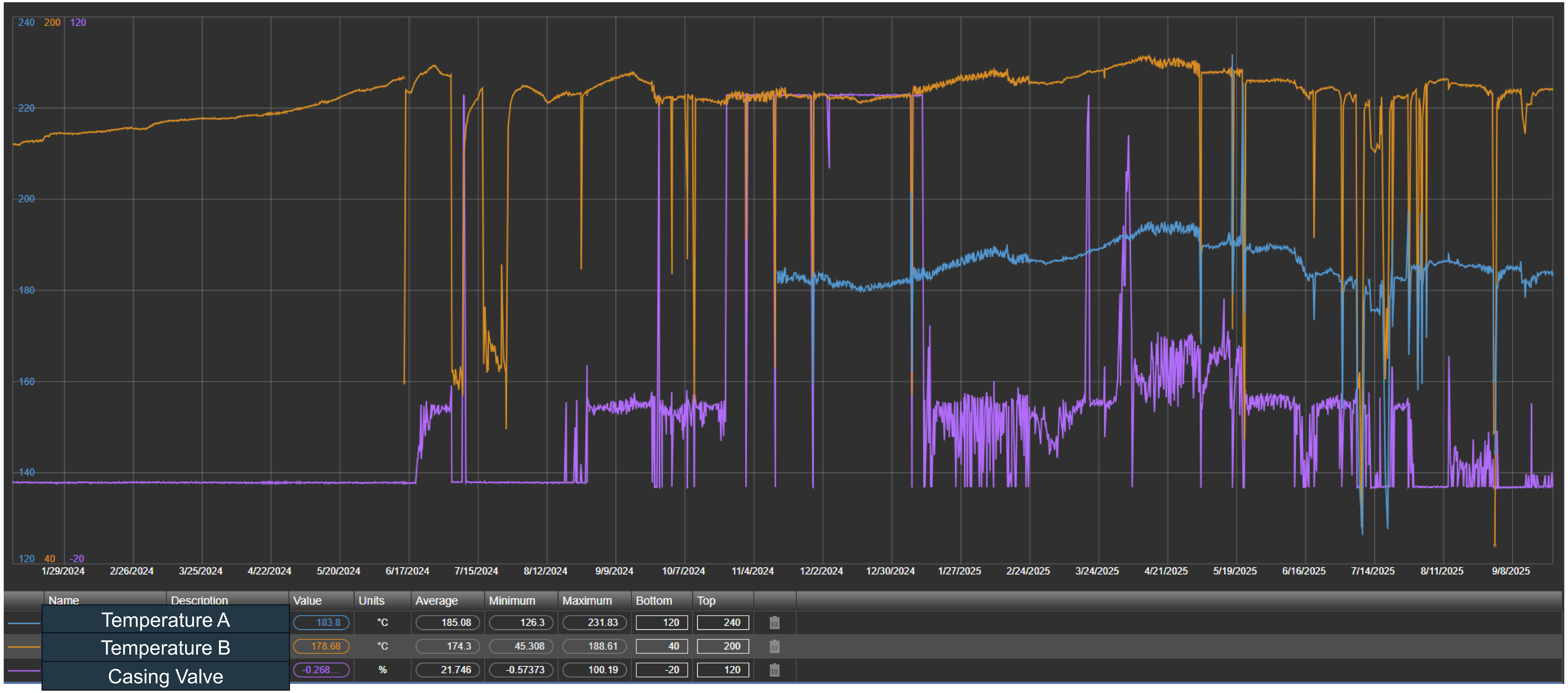




Well C looks like the ideal stim candidate as the power difference is slowly rising, then suddenly massive power and amp flux indicating some sort of solids event…

Confirmation of Gas Events

This was a gas event as going through PI you see the casing valve open, and the temperatures go up



Further Steps

- Looking at well geology and looking for relationships
  - Lean zones
  - Mud zones
  - Varying concentrations of minerals
- Missing KPIs
  - Higher density -> solids
  - Casing temperature -> gas events
    - I did choose wells that are known to not be gassy, but this is a good sanity check
  - Better automate this tool

Thank you