Real Time Drilling Fluid Instrumentation

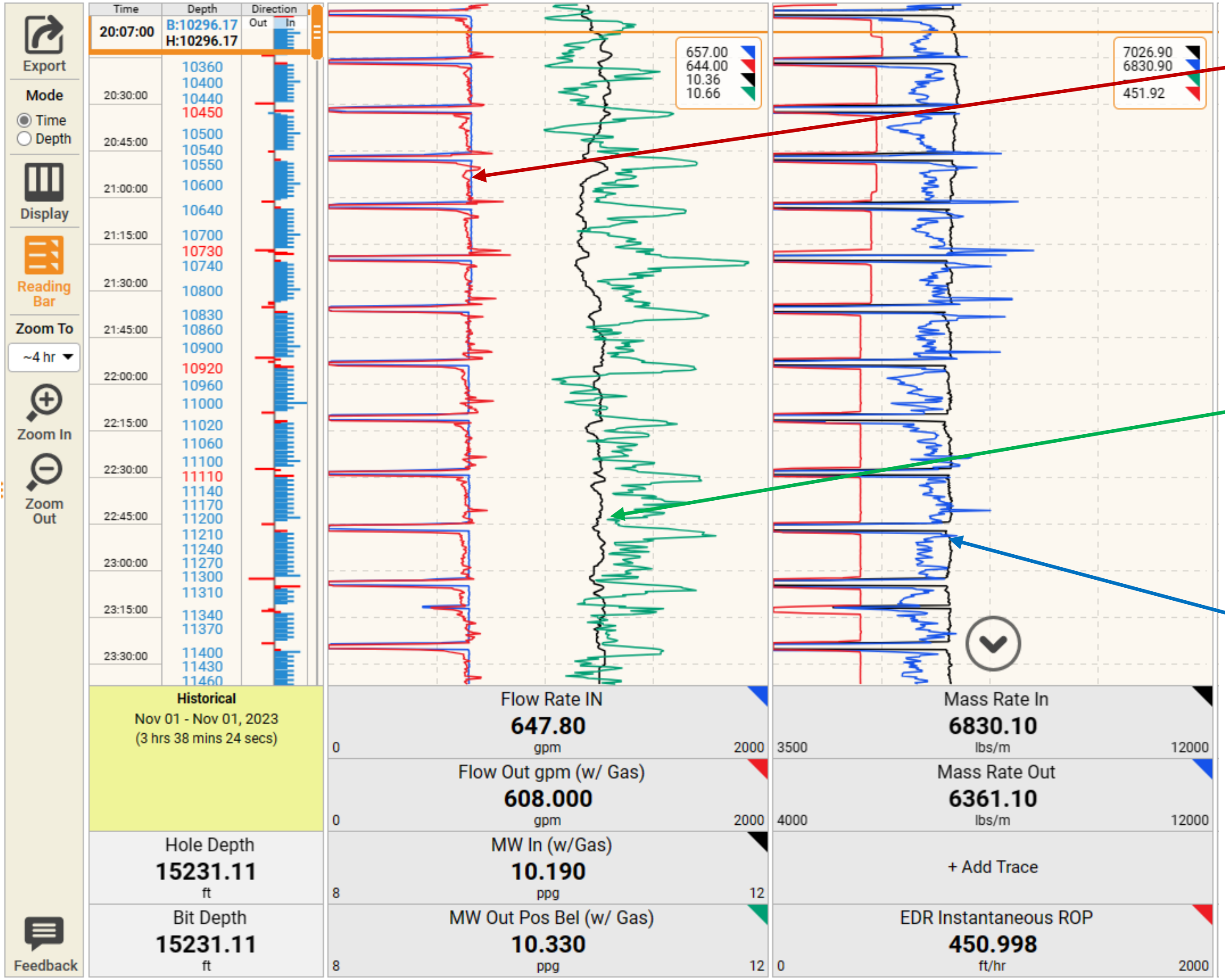
Form Factor & Data

3 Density measurements:

- Mud Density In – TPA Active Mud Tank
- Mud Density Out – AFH Shaker Effluent
- Mud Density Possum Belly – PBD Sensor

Leveraging Real Time Data

New Data Traces – Flow Rate & Density In & Out



Flow Rate In vs Flow Rate Out:

- Conventional flow paddle is used to calculate real time gpm readings for flow out.
- Flow Rate In minus Flow Rate Out can capture formation fluid loss rate, loss circulation severity, and can help distinguish a ballooning event from a well control incident.

Mud Density In vs Mud Density Out:

- Unprecedented measurement solution at the flowline provides rea time density exiting the well directly in the possum belly.

Mass Flow Rate In vs Mass Flow Rate Out

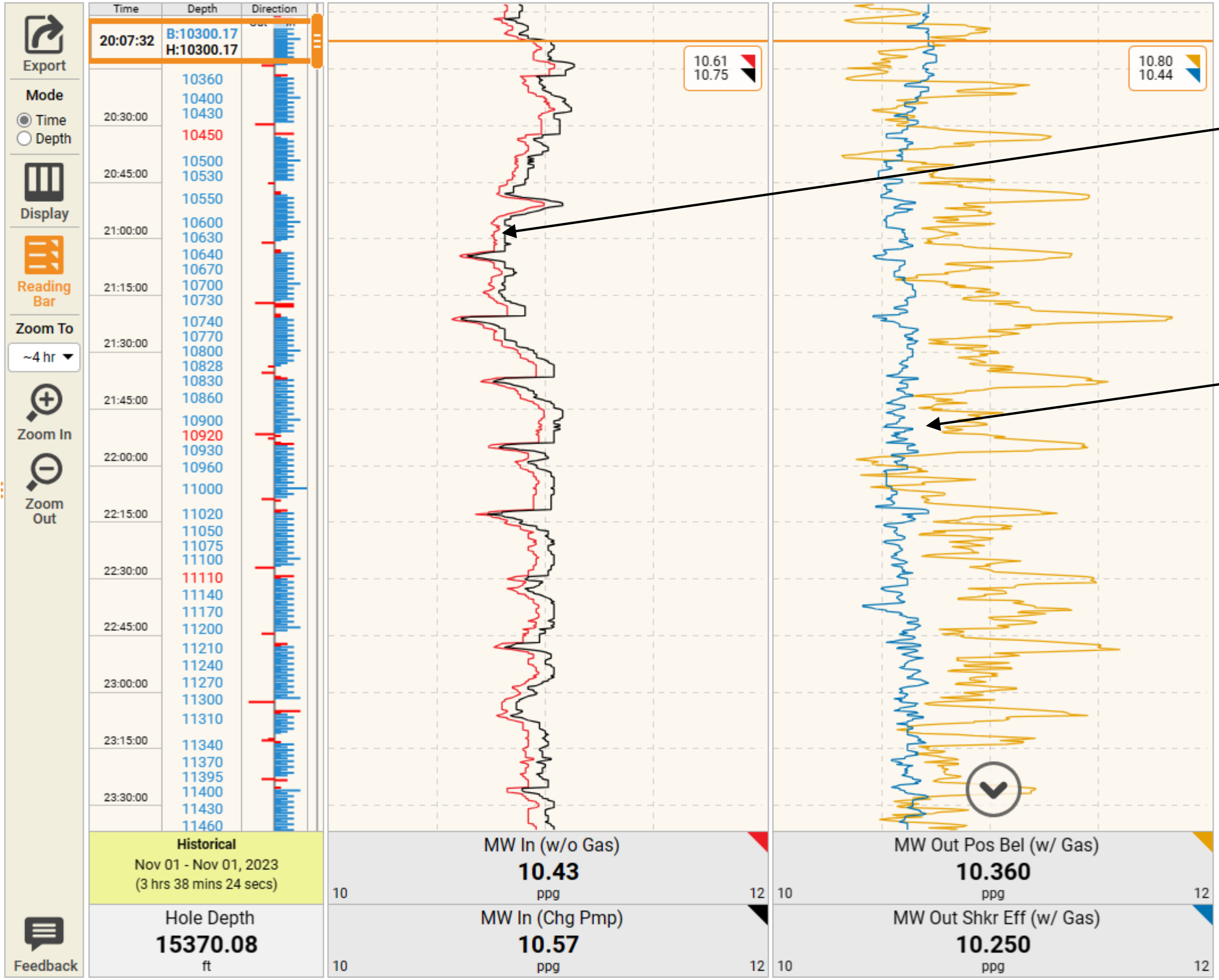
- Key parameters to quantifying hole cleaning efficiency and quantifying bottoms up effectiveness

Hole Cleaning Efficiency (HCE):

- HCE is a function of the mass of drill solids generated vs the mass of drill solids removed
- Compositional material mass balance

Key Performance Indicators

Mud Density – Compensated for Gas & Compressibility



Density in the Active Mud Tank vs Density at the Charge Pump:

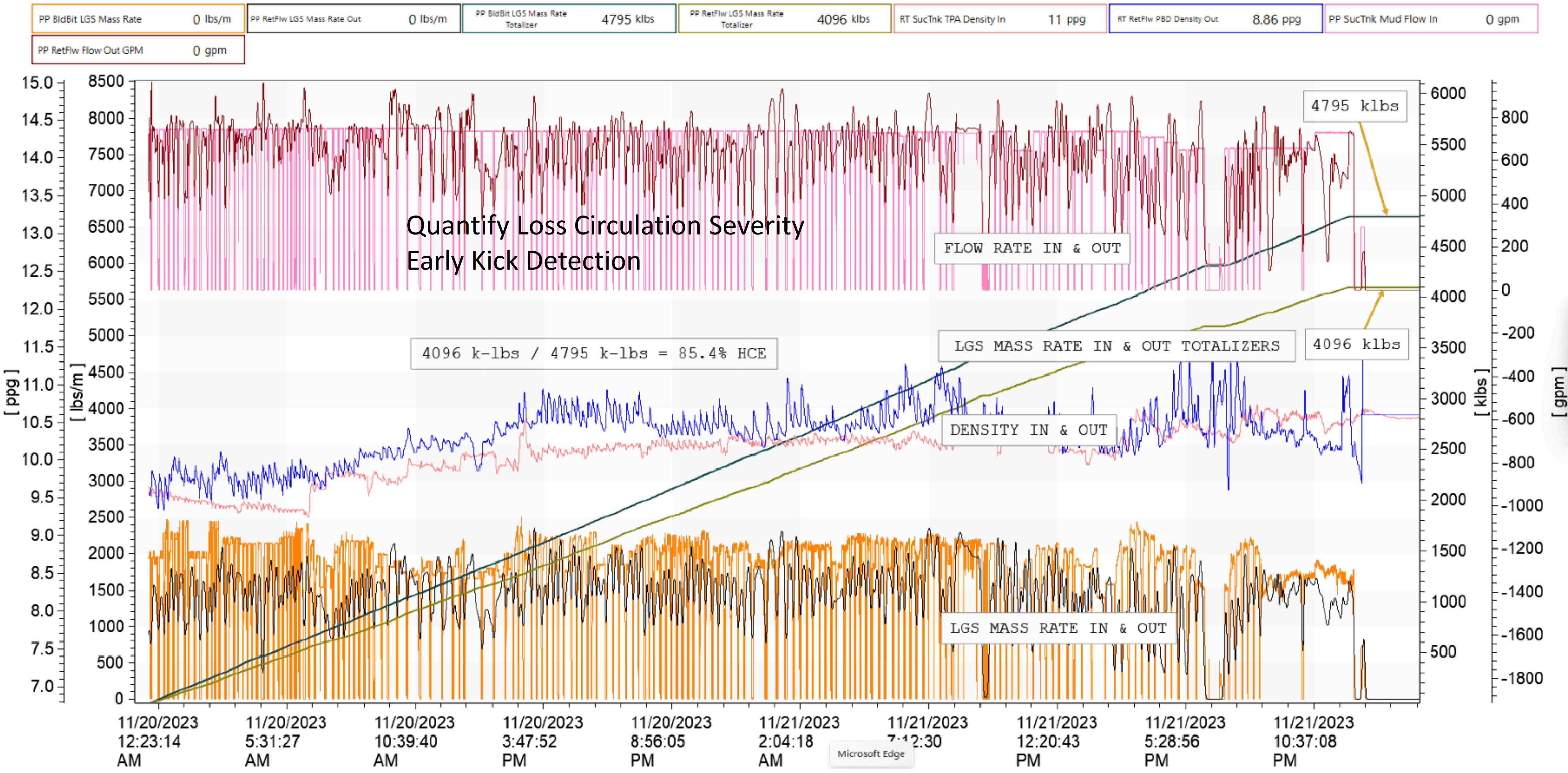
- The density used in the material mass balance algorithm has compressibility factored into the output based on the % oil, % Water and % Solids.

Mud Density Out at the Flowline vs Mud Density at the Shale Shaker Effluent Tank:

- The material mass balance between upstream & downstream of the shale shakers helps determine the efficiency of the shaker screen selection, allows for optimization for best cut point.

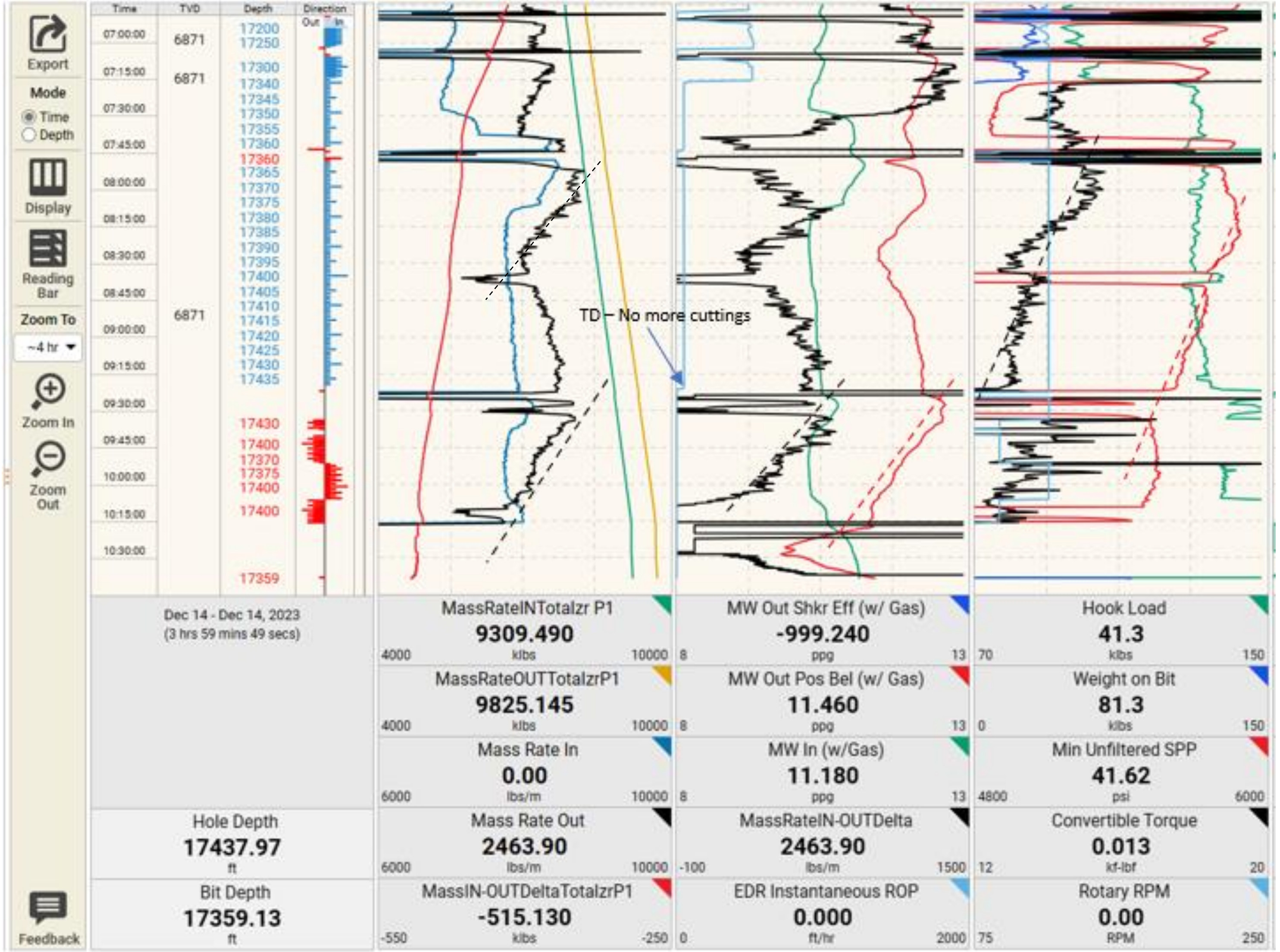
Good solids removal efficiency starts with the right screen selection to maximize the cut point as a first line of defense.

HOLE CLEANING EFFICIENCY USING MATERIAL MASS BALANCE



Key Performance Indicators

Pason Traces – Bottoms Up Circulating Time



Mass Rate out at the Possum Belly:

The mass rate out has a clearly identifiable trend downward as the well cleans up

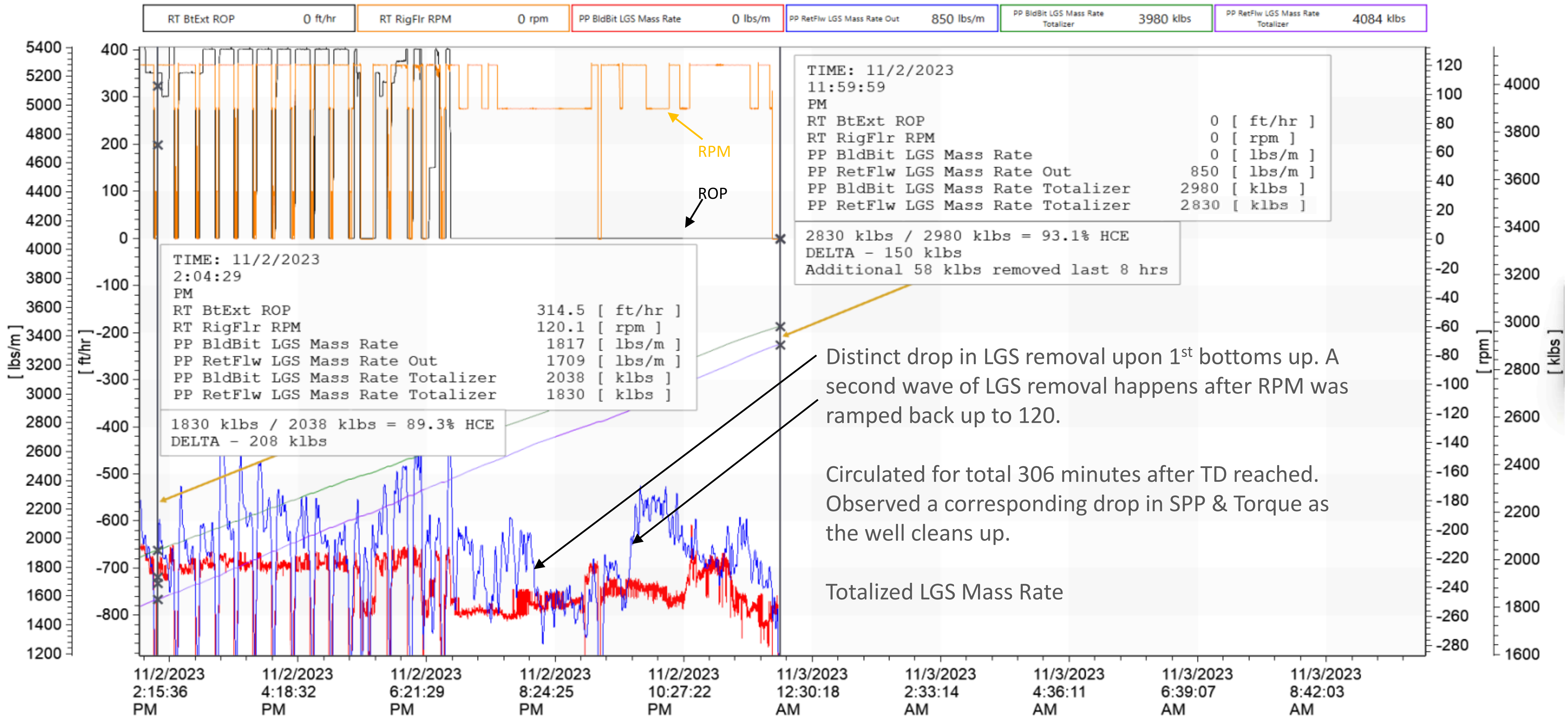
- Notice the distinct trend downward on bottoms up when the ROP was reduced from 500 ft/hr to 50 ft/hr.
- Notice the distinct trend downward once TD was reached and no additional drilled cuttings were generated.
- Sharp downward slope on the Density Out in the possum belly
- As validation, notice the Torque & SPP at a downward trend as the well cleans up.

Discussion Topic:

Notice the flattened inflection point on the mass rate out. Could that have been the point in the well where circulation could have stopped, slug pipe, POOH.

Compositional Material Mass Balance

Bottoms Up Cleanup Cycle – Well # 1

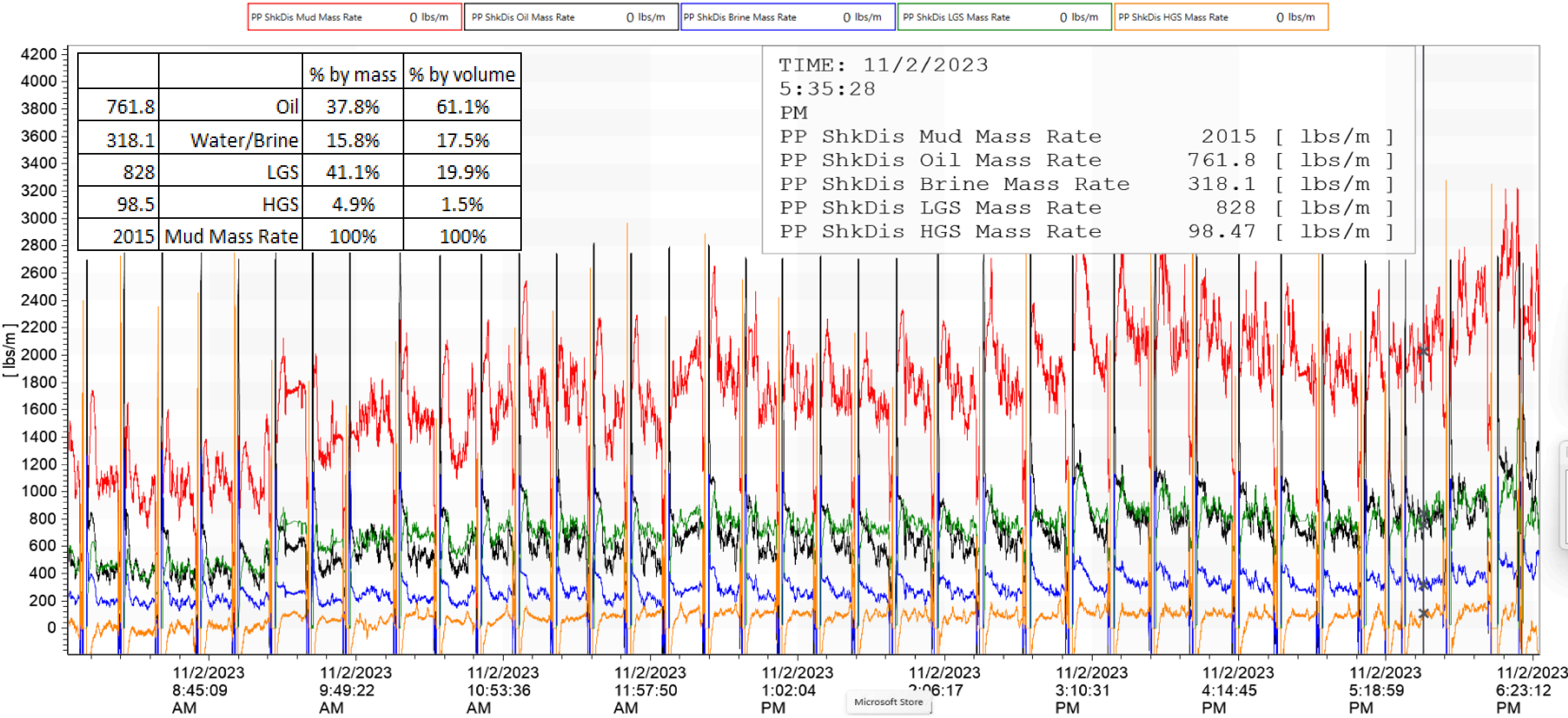


Distinct drop in LGS removal upon 1st bottoms up. A second wave of LGS removal happens after RPM was ramped back up to 120.

Circulated for total 306 minutes after TD reached. Observed a corresponding drop in SPP & Torque as the well cleans up.

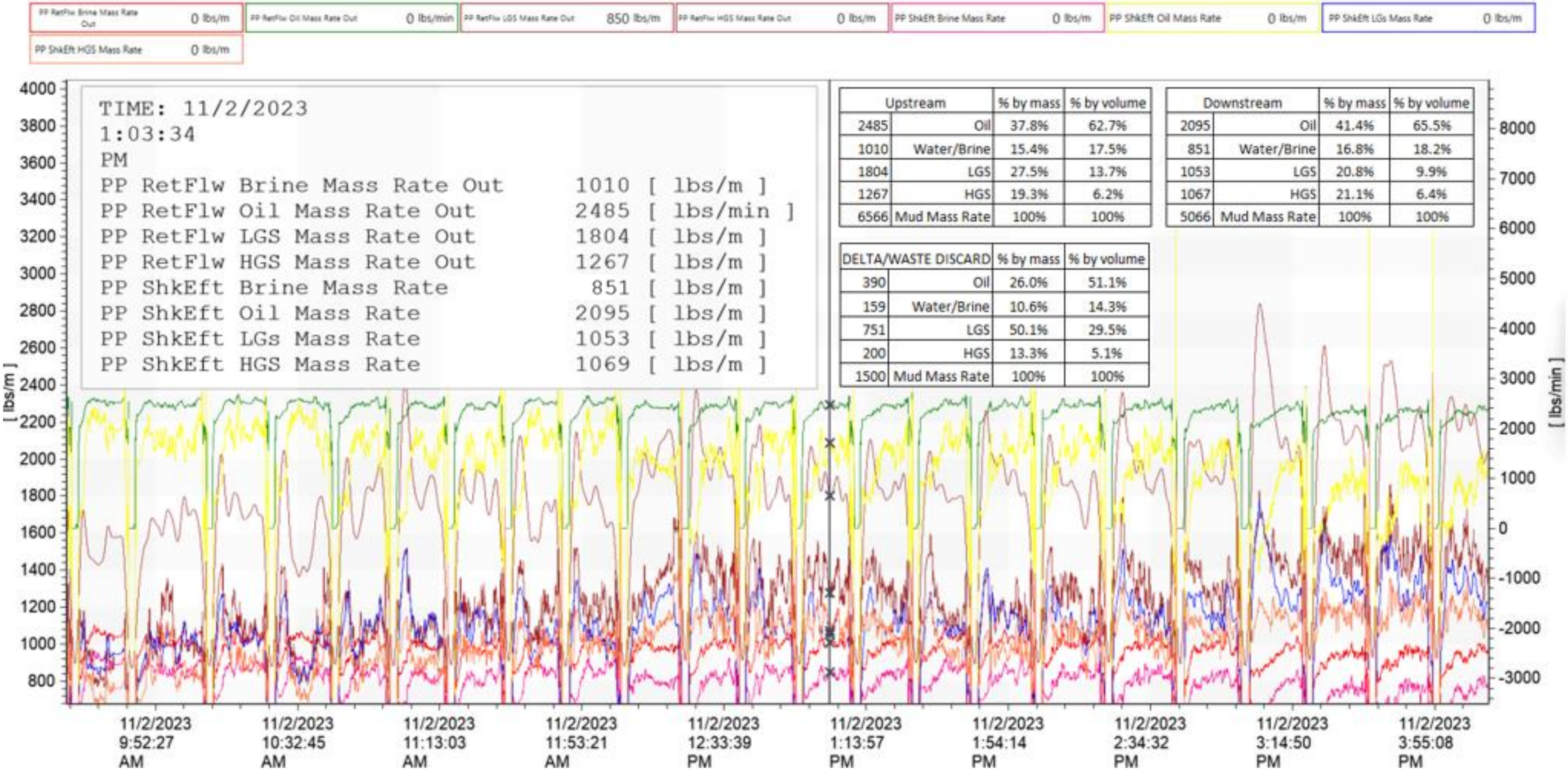
Totalized LGS Mass Rate

Waste Stream Composition



		% by mass	% by volume
761.8	Oil	37.8%	61.1%
318.1	Water/Brine	15.8%	17.5%
828	LGS	41.1%	19.9%
98.5	HGS	4.9%	1.5%
2015	Mud Mass Rate	100%	100%

Upstream & Downstream of Shaker



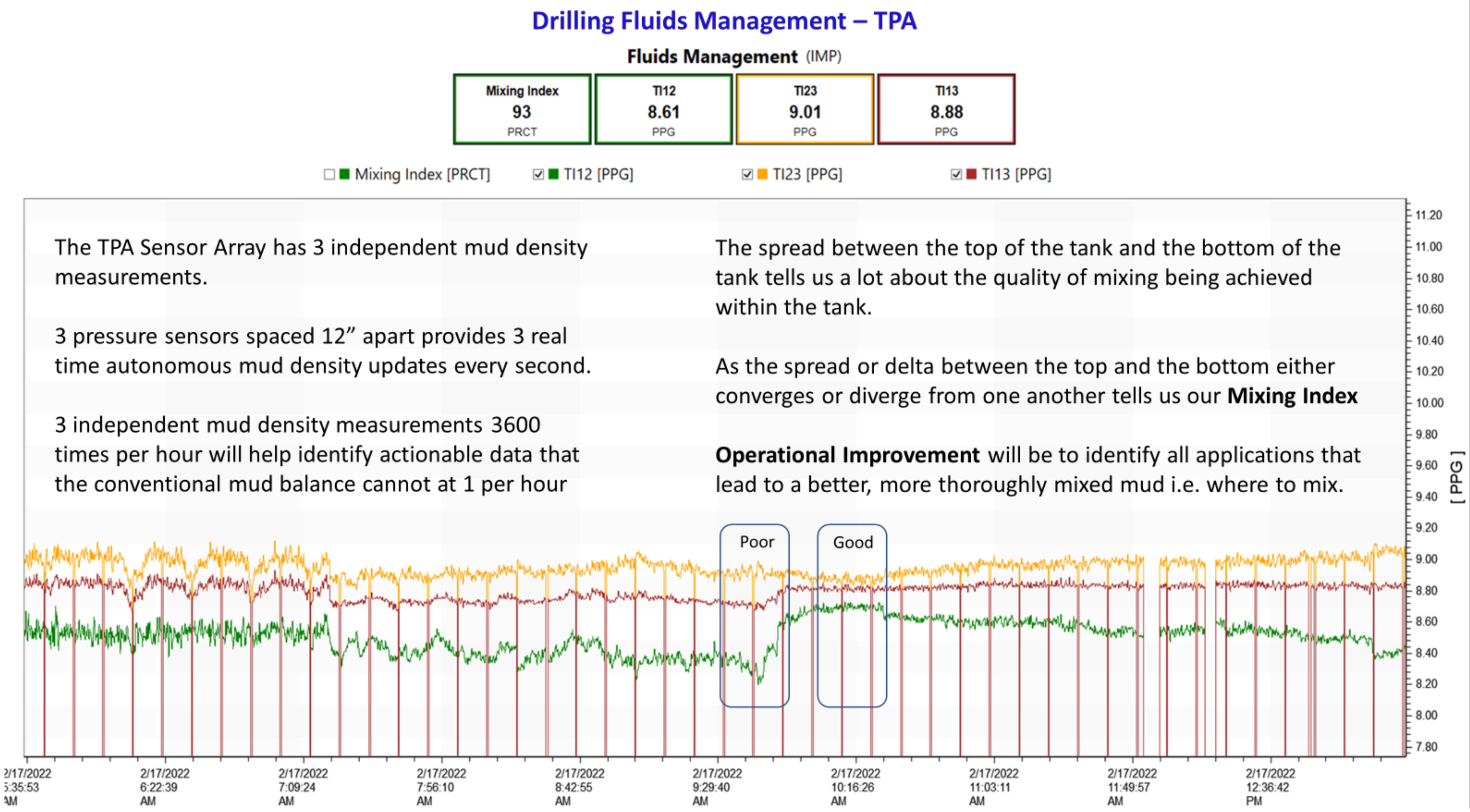
	Upstream	% by mass	% by volume
2485	Oil	37.8%	62.7%
1010	Water/Brine	15.4%	17.5%
1804	LGS	27.5%	13.7%
1267	HGS	19.3%	6.2%
6566	Mud Mass Rate	100%	100%

	Downstream	% by mass	% by volume
2095	Oil	41.4%	65.5%
851	Water/Brine	16.8%	18.2%
1053	LGS	20.8%	9.9%
1067	HGS	21.1%	6.4%
5066	Mud Mass Rate	100%	100%

	DELTA/WASTE DISCARD	% by mass	% by volume
390	Oil	26.0%	51.1%
159	Water/Brine	10.6%	14.3%
751	LGS	50.1%	29.5%
200	HGS	13.3%	5.1%
1500	Mud Mass Rate	100%	100%

Key Performance Indicators

Mixing Index – Quality fluid going down the pipe



The TPA Sensor Array has 3 independent mud density measurements.

3 pressure sensors spaced 12" apart provides 3 real time autonomous mud density updates every second.

3 independent mud density measurements 3600 times per hour will help identify actionable data that the conventional mud balance cannot at 1 per hour

The spread between the top of the tank and the bottom of the tank tells us a lot about the quality of mixing being achieved within the tank.

As the spread or delta between the top and the bottom either converges or diverge from one another tells us our **Mixing Index**

Operational Improvement will be to identify all applications that lead to a better, more thoroughly mixed mud i.e. where to mix.

Three Independent Density Traces:

The 3 density measurements can diverge or converge as the quality of the mix reveals itself.

- When product is mixed too fast.
- When mud is being transferred from the frac tanks to the active.
- Poor agitation due to a faulty agitator motor.


VOLVO