

**Reservoir
Engineering
and Simulation
Unconventional
Session in Progress**

Integrated Fracture Stimulation Design using Kinetix;
to Improve Water Injectivity
In Lower Burgan Raudhatain Field in North Kuwait

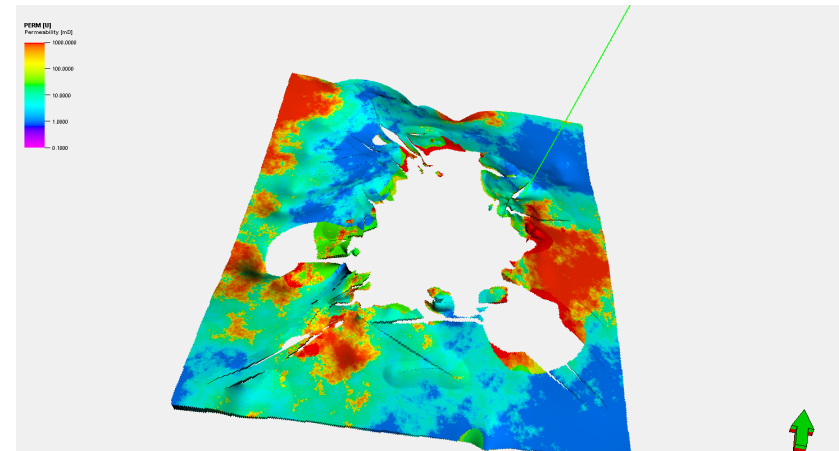
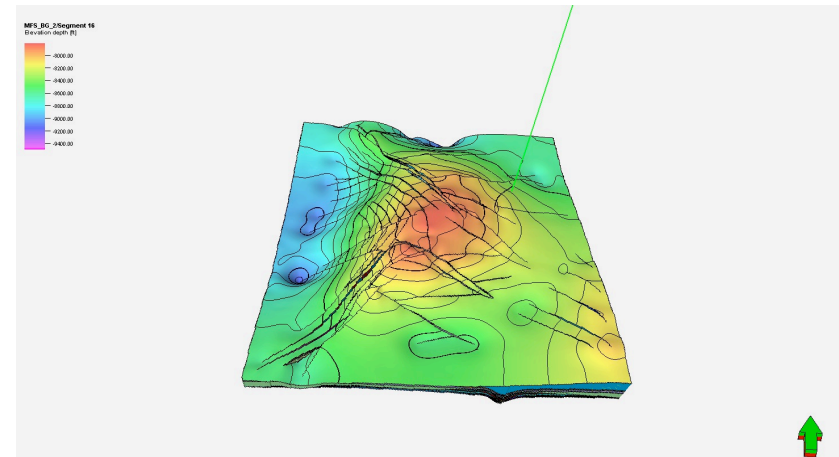
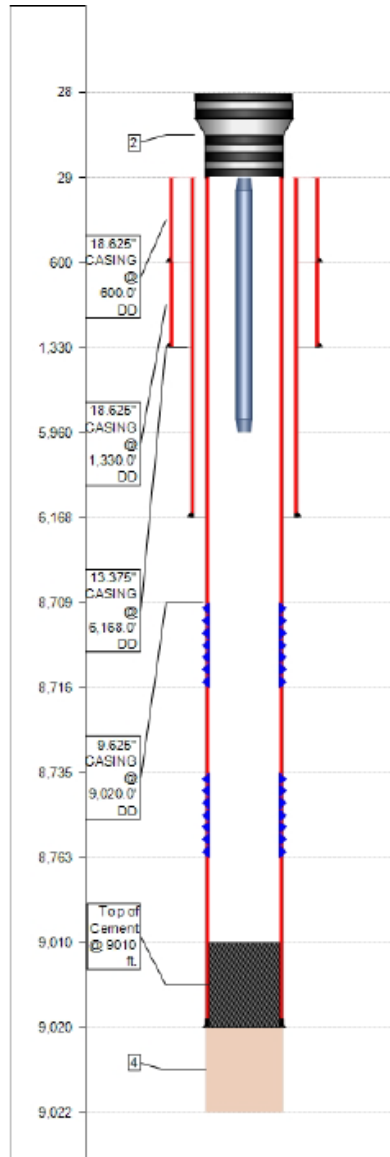
Integrated Fracture Stimulation Design Using Kinetix

Agenda

- Background & Well Data
- Challenges
- Fracturing Design workflow in Petrel / Kinetix
- Proposed Solutions
- Conclusion & Recommendations

Background & Well Data

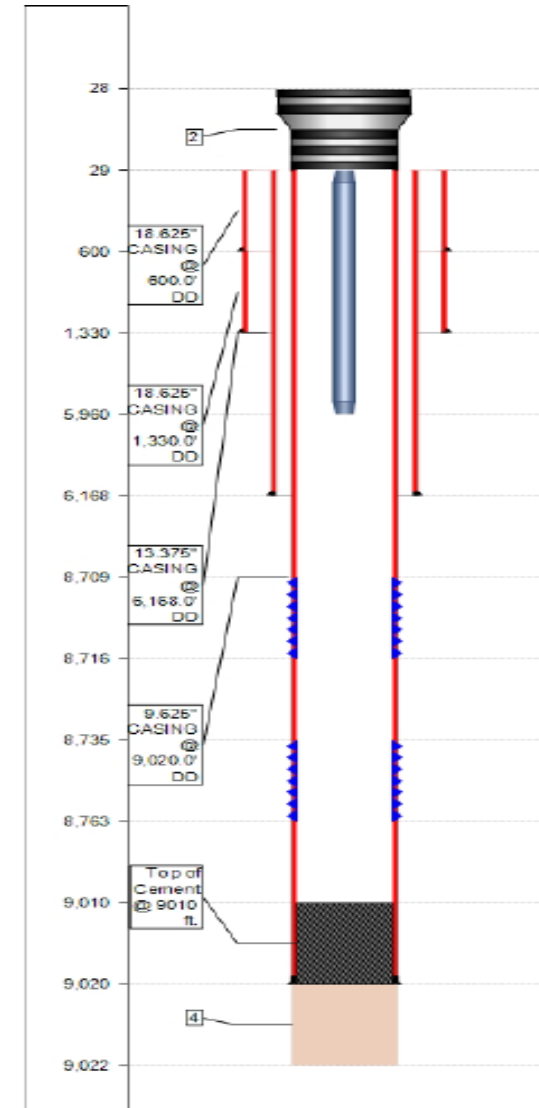
- Well Depth MD (ft) / TVD (ft): 9020ft MD
- Fracturing String 4 ½ at 8600ft MD
- Current Res. Pressure (psi): 2400 psi
- Reservoir Temperature(oF): 192
- Formation Permeability (mD): ~1000mD
- Formation Effective Porosity (%): 21%
- Perforation Intervals MD (ft): 8709-8716 / 8735-8763
- Perforation Shot Density (spf): 12 spf
- Type of Formation: Coal 1 & 2, UCH T & LCH T



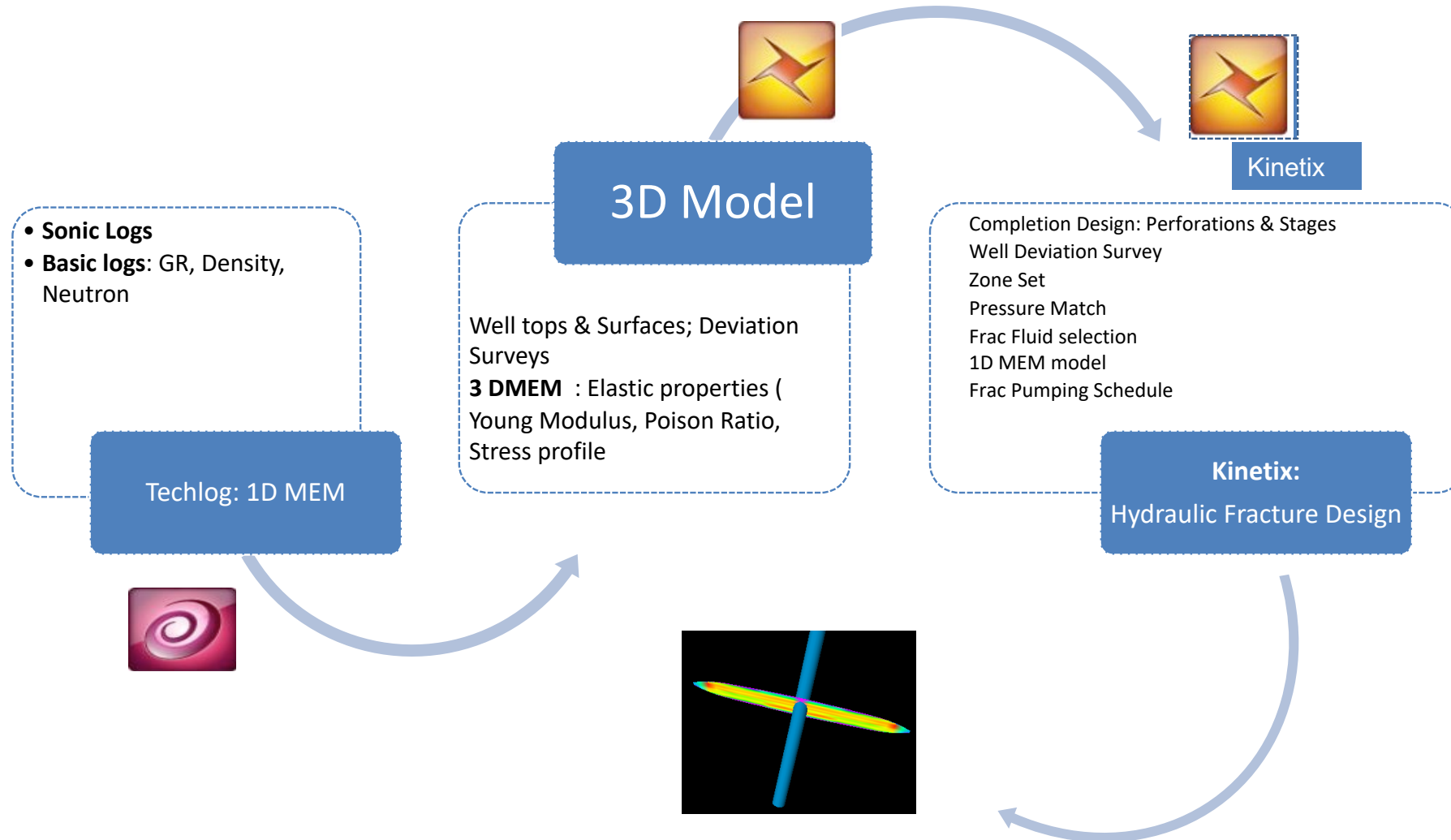
Challenges

Challenges

- Achieve water Injection Rate of > 7000Bpd @
WHPinj < 5000psi
- Pressure limitation of Surface Equipment / Facilities
- Existing of 02 Sets of Perforations
- Creating a Contained Frac Height

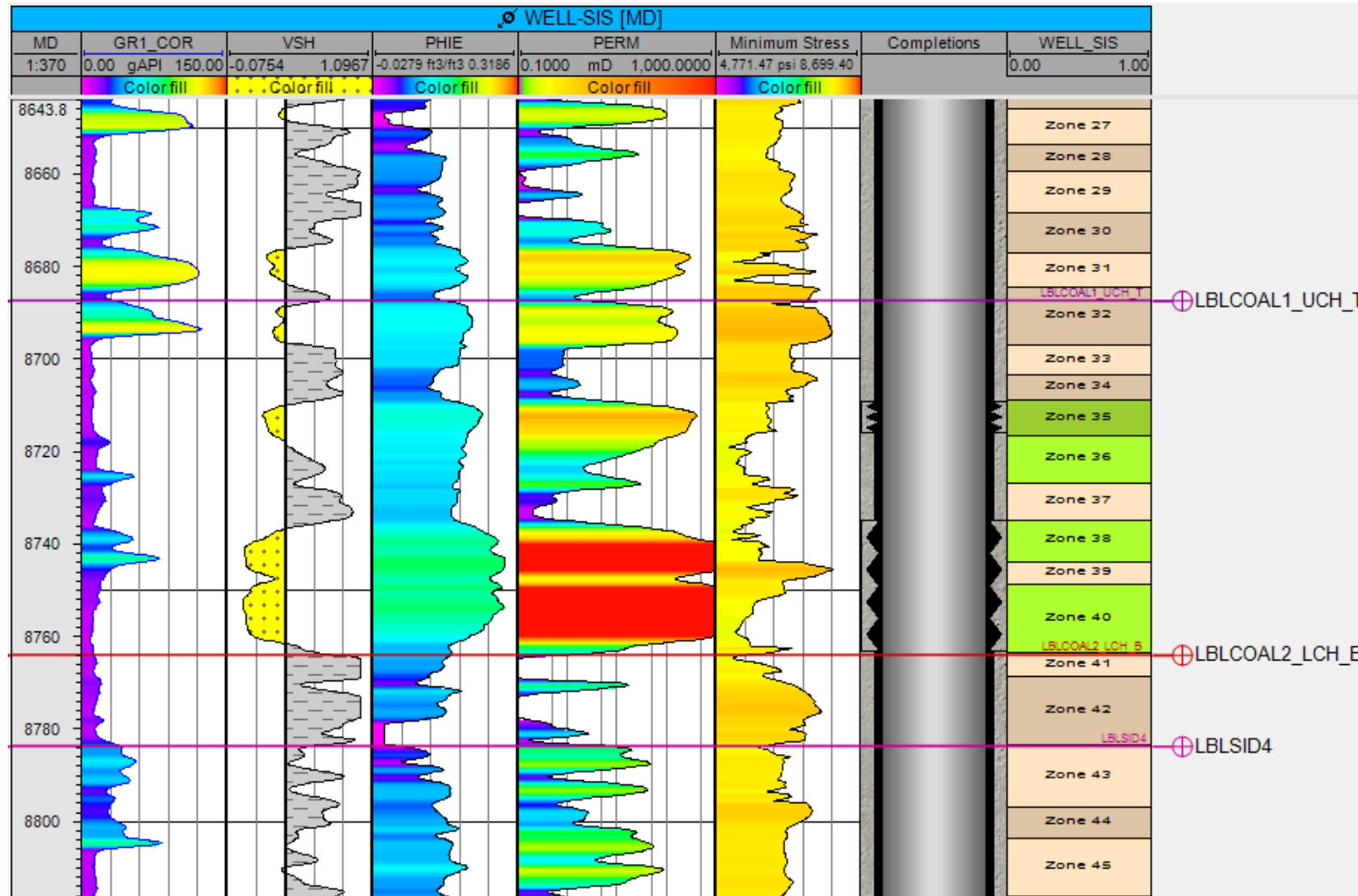


Fracturing Design Work-Flow in Petrel / Kinetix



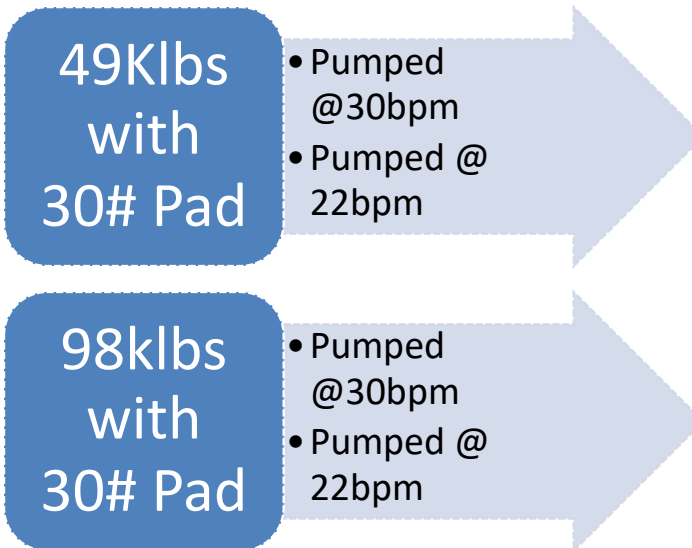
Fracturing Design Work-Flow in Petrel / Kinetix

Generated OH logs



Proposed Solution

Scenarios Definition



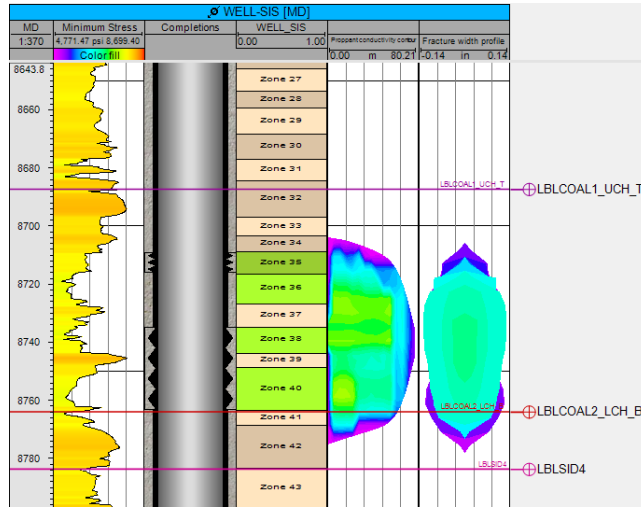
Step name	Pump rate (bbl/min)	Fluid name	Fluid volume (gal)	Proppant	Prop. conc (PPA)	Prop. mass (lb)	Slurry volume (bbl)	Pump time (min)	Step type
Pad	30	YF130FlexD	7000	None	0	0	166.67	5.56	Pad
1 PPA	30	YF130FlexD	2016	Prop 20/40	1	2016	49.81	1.66	Slurry
2 PPA	30	YF130FlexD	1932	Prop 20/40	2	3864	49.47	1.65	Slurry
3PPA	30	YF130FlexD	1890	Prop 20/40	3	5670	50.09	1.67	Slurry
4 PPA	30	YF130FlexD	1806	Prop 20/40	4	7224	49.48	1.65	Slurry
5 PPA	30	YF130FlexD	1764	Prop 16/30	5	8820	49.65	1.66	Slurry
6 PPA	30	YF130FlexD	1680	Prop 16/30	6	10080	48.75	1.62	Slurry
7 PPA	30	YF130FlexD	1638	Prop 16/30	7	11466	48.95	1.63	Slurry
Flush	30	Brine	5647	None	0	0	134.46	4.48	Flush

	Fluid volume (gal)	Fluid volume (bbl)	Prop. mass (lb)	Slurry volume (bbl)	Pump time (min)
Total No flush	19726	470	49140	513	17.1

Simulation Results: Fracture Geometry

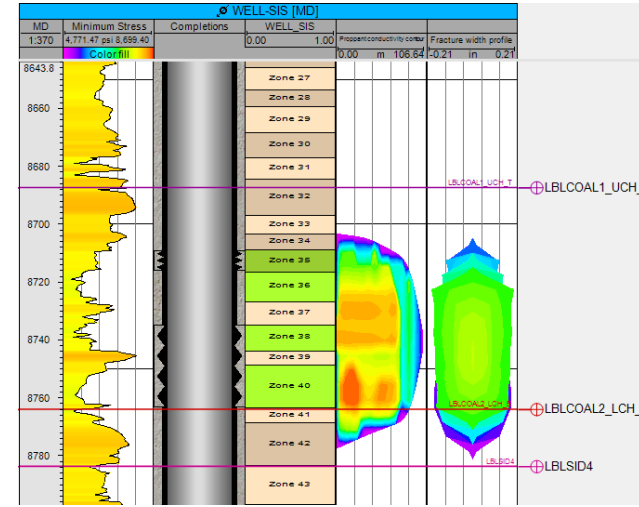
49k at 30bpm

- Xf 262ft
- Fc 8212mD.ft



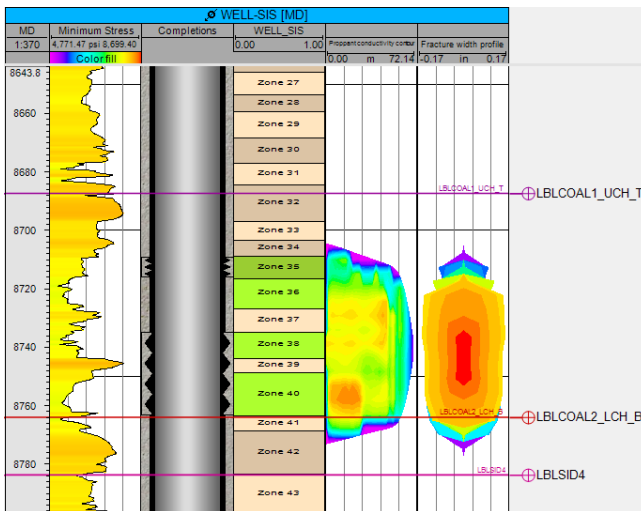
98klbs @ 30bpm

- Xf 336ft
- FC 13405mD.ft



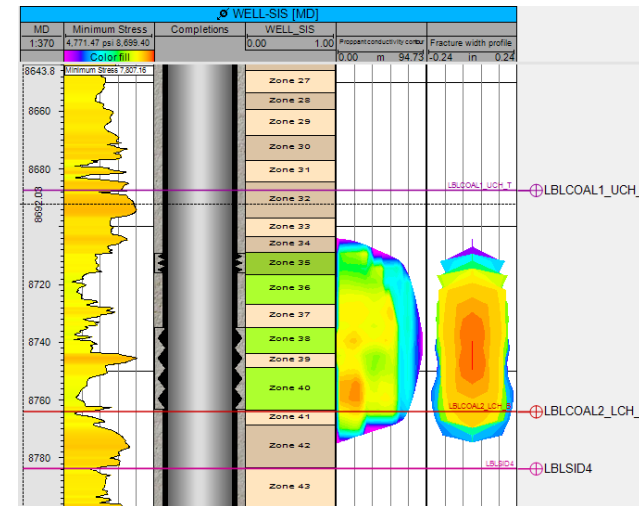
49k at 22bpm

- Xf 232ft
- FC 9569mD.ft



98klbs @ 22bpm

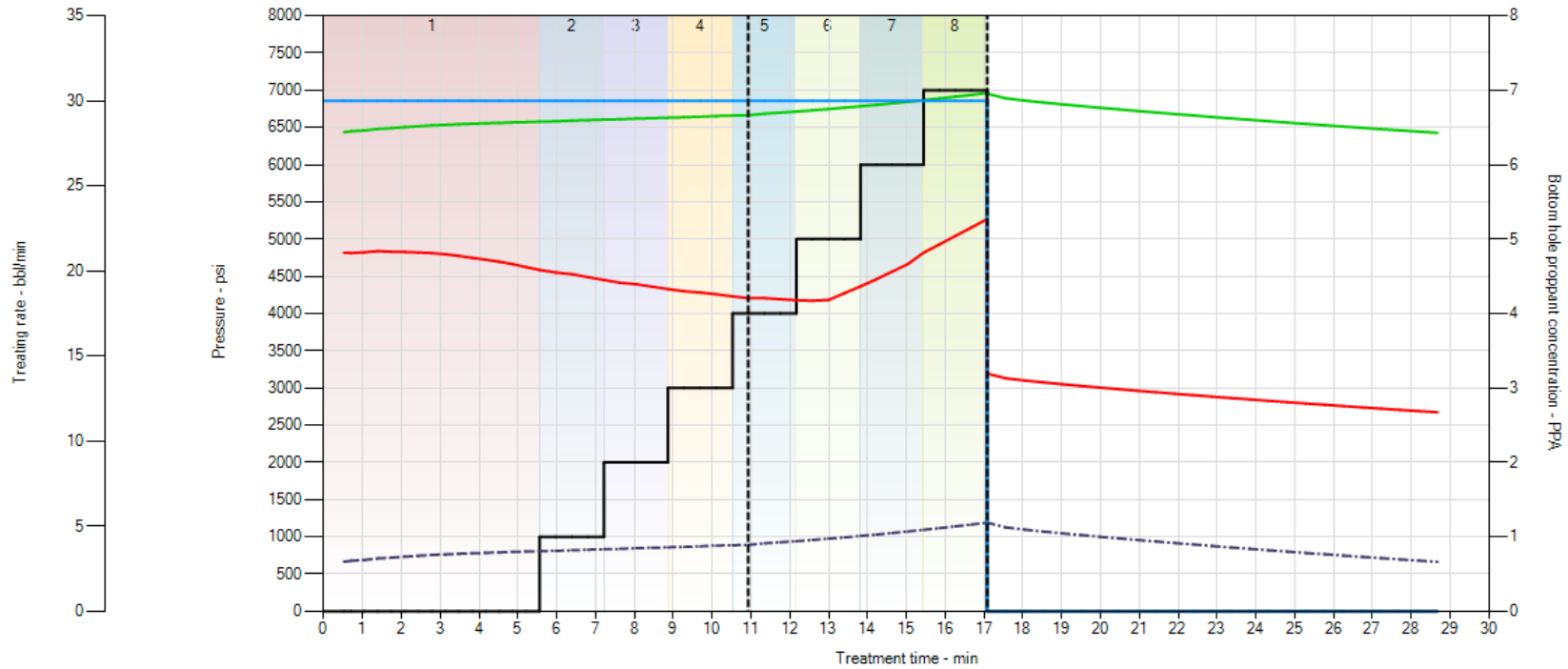
- Xf 297ft
- FC 15641mD.ft



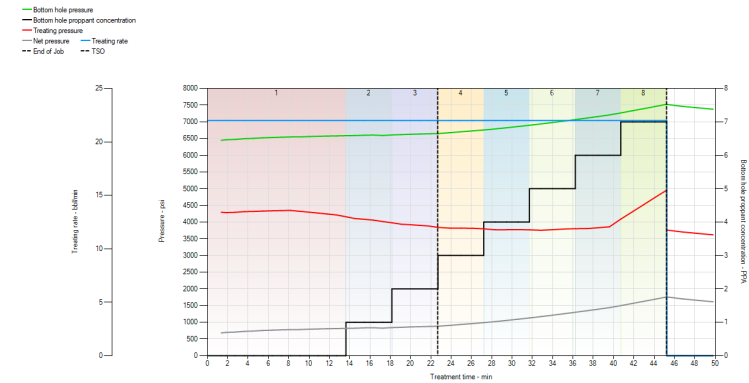
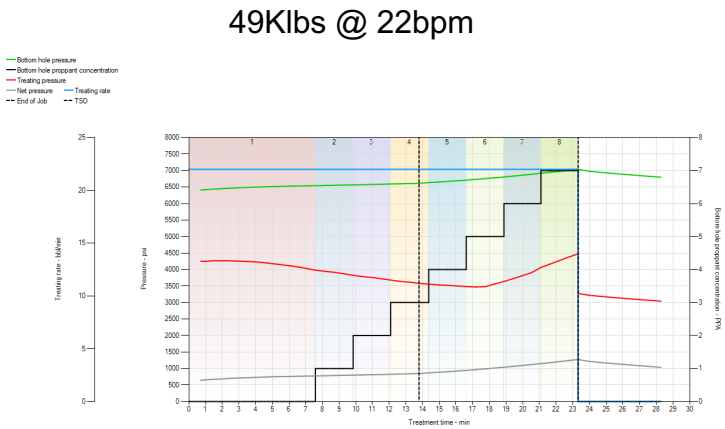
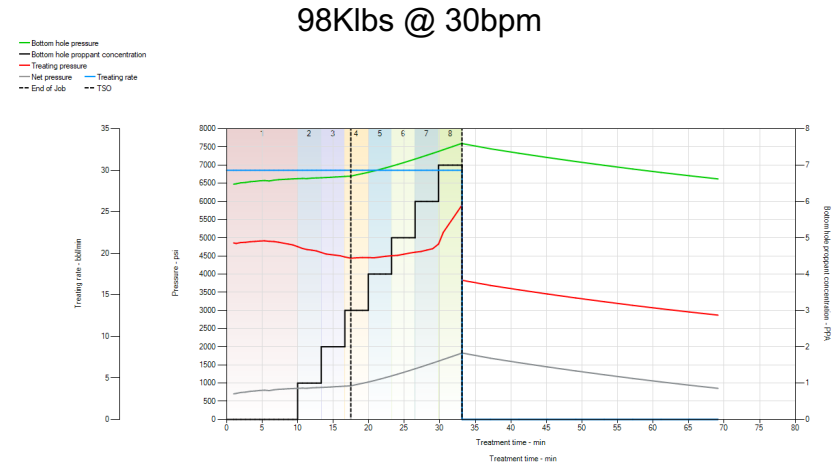
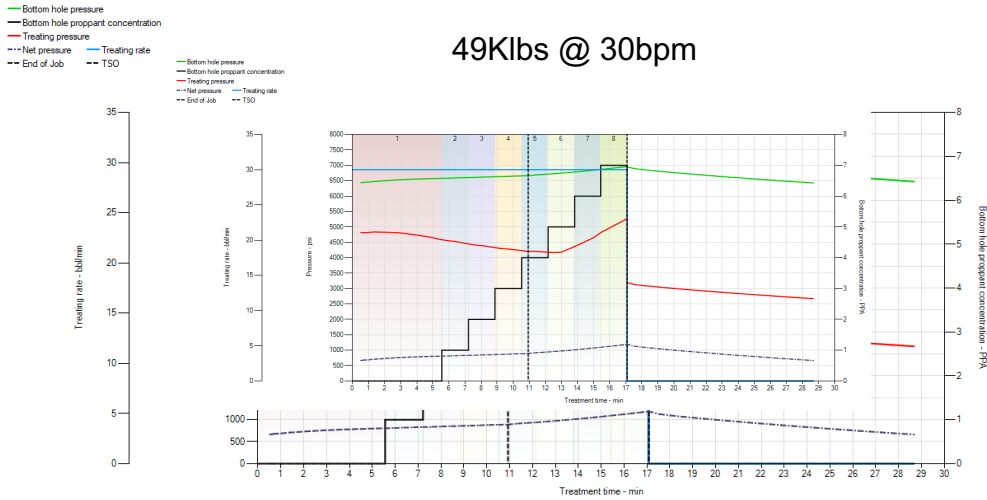
Simulation Results: Pressure Profile

49klbs @ 30bpm

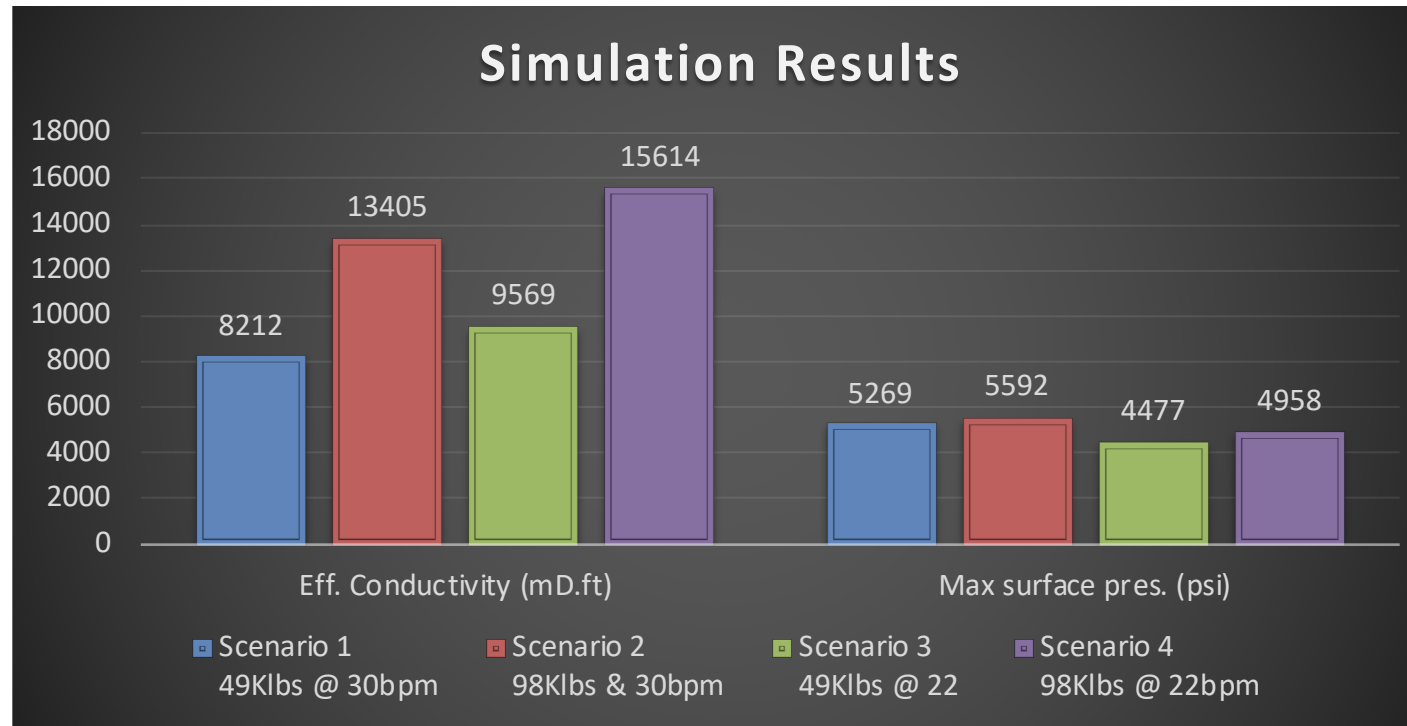
- Bottom hole pressure
- Bottom hole proppant concentration
- Treating pressure
- - - Net pressure
- Treating rate
- - - End of Job
- - - TSO



Simulation Results: Pressure Profile



Summary Results



Summary Results	Scenario 1	Scenario 2	Scenario3	Scenario 4
	49Klbs @ 30 bpm	98Klbs @ 30 bpm	49Klbs @ 22 bpm	98Klbs @ 22 bpm
Propped Frac half length Xf (ft)	262	336	232	297
Average Propped width Wf (in)	0.16	0.25	0.19	0.27
Effective conductivity (mD.ft)	8212	13405	9569	15614
End of Job net Pressure (psi)	1189	1506	1272	1759
Fluid Efficiency (%)	35	36	34%	33
Max surface pressure (psi)	5269	5592	4477	4958
Estimated closure time (min)	12	28	16	37

Conclusion & Recommendations

- ❑ The scenario of pumping 49klbs of proppant @ 22bpm would be the best due to:
 - ❑ Pressure limitation at surface
 - ❑ Sufficient to bypass near wellbore damage
 - ❑ Cost effective
- ❑ Frac fluid with delaying system helps to reduce the surface treating pressure
- ❑ Kinetix can provide 3D fracturing geometry
- ❑ Kinetix provides a full picture of frac propagation with regards to offset wells
- ❑ Geological model can be combined into Kinetix to optimize fracturing design
- ❑ Production forecast can also be performed under kinetix

- Data Frac is a recommended to calibrate the stress model and fluid properties
- Introduction of fluid leakoff control agent would improve the fluid efficiency
- Multiple Perforation cluster is not recommended for uniform Frac propagation and proppant placement