MARCELLUS SHALE ENERGY AND ENVIRONMENT LABORATORY

MSEEL

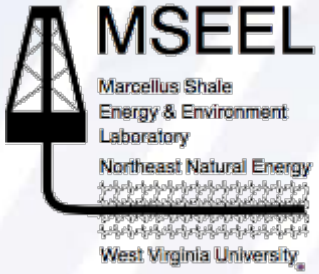
Department of Geology and Geography

Presented by: Tim Carr
West Virginia University
NACBM– April 12, 2017

MARCELLUS SHALE ENERGY AND ENVIRONMENT LABORATORY

MSEEL

The objective of the Marcellus Shale Energy and Environment Laboratory (MSEEL) is to provide a long-term collaborative field site to develop and validate new knowledge and technology to improve recovery efficiency and minimize environmental implications of unconventional resource development

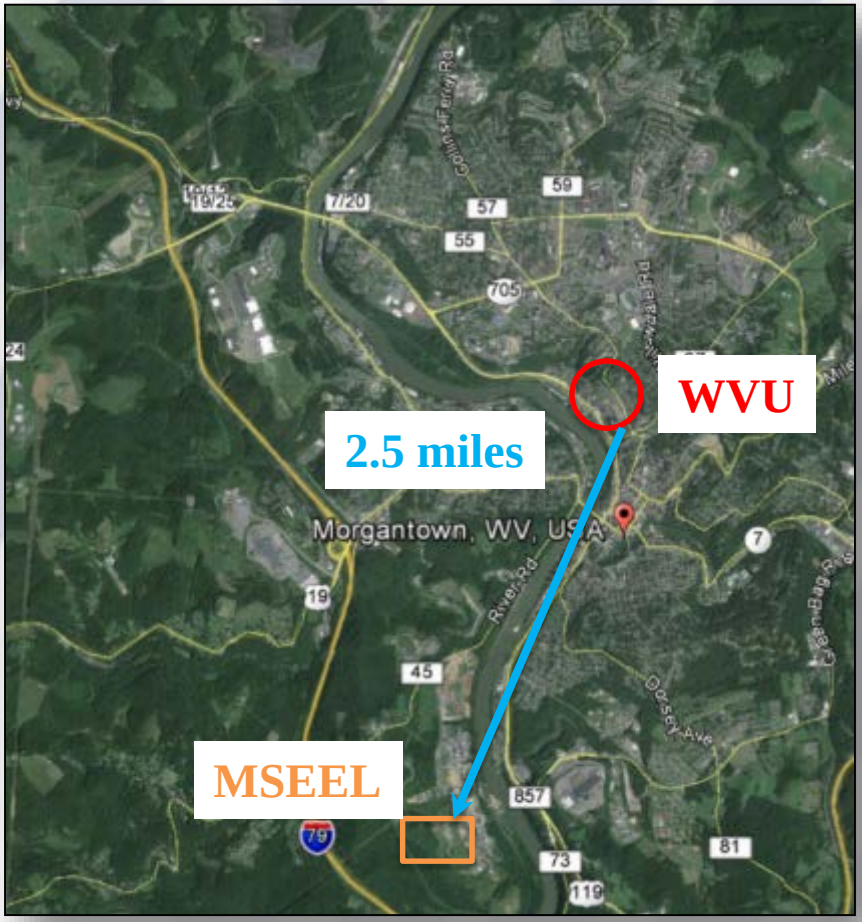


MSEEL Site

- The understudy well is located in Morgantown Industrial Park (MIP) site in the state of West Virginia (USA).
- It is a part of the **Marcellus Shale Energy and Environment Laboratory** (MSEEL) research.

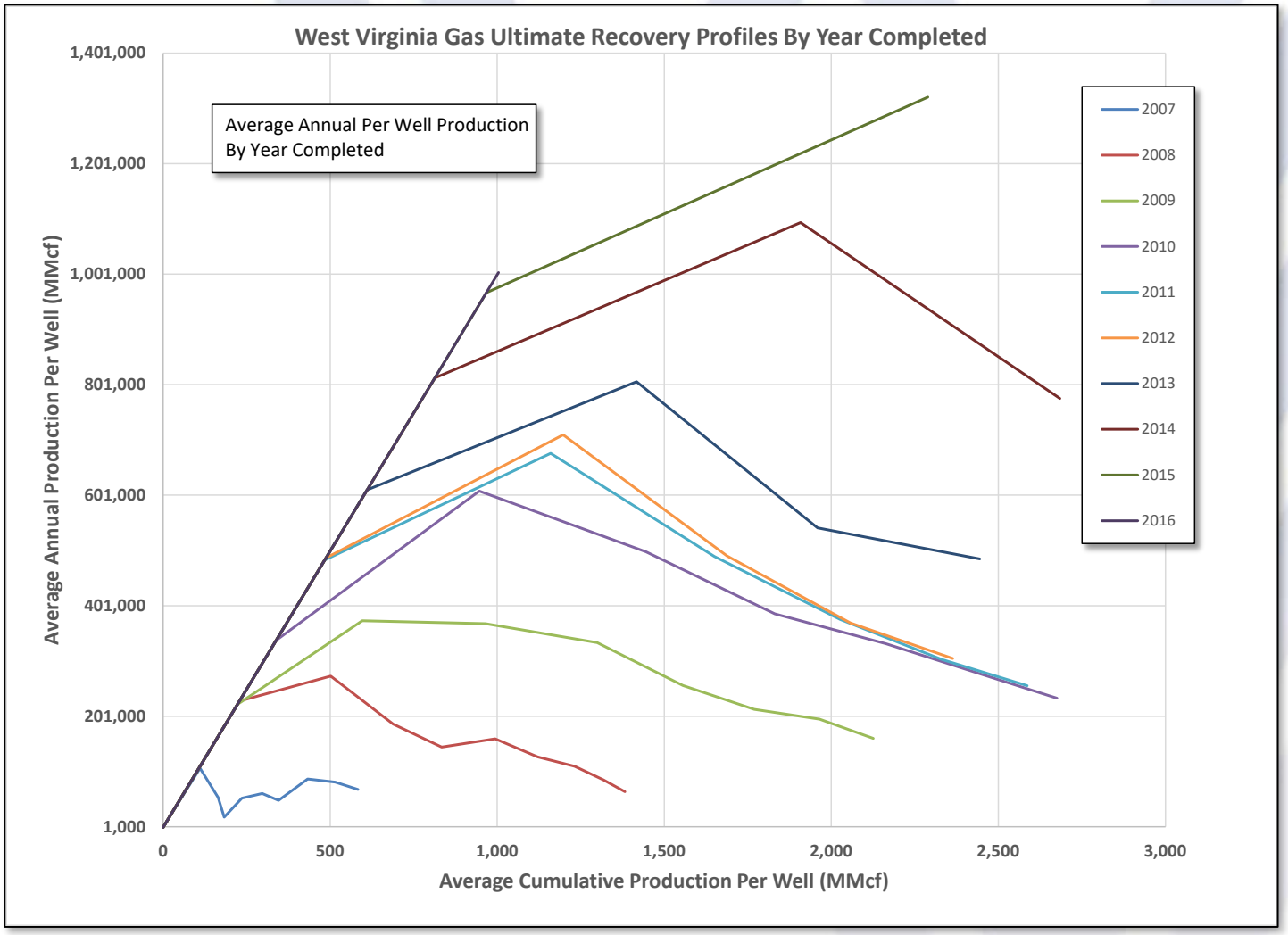
MSEEL Site


MIP-5H
MIP-3H
MIP-5W
MIP-6H
MIP-4H
0.6 km
0.4 mi

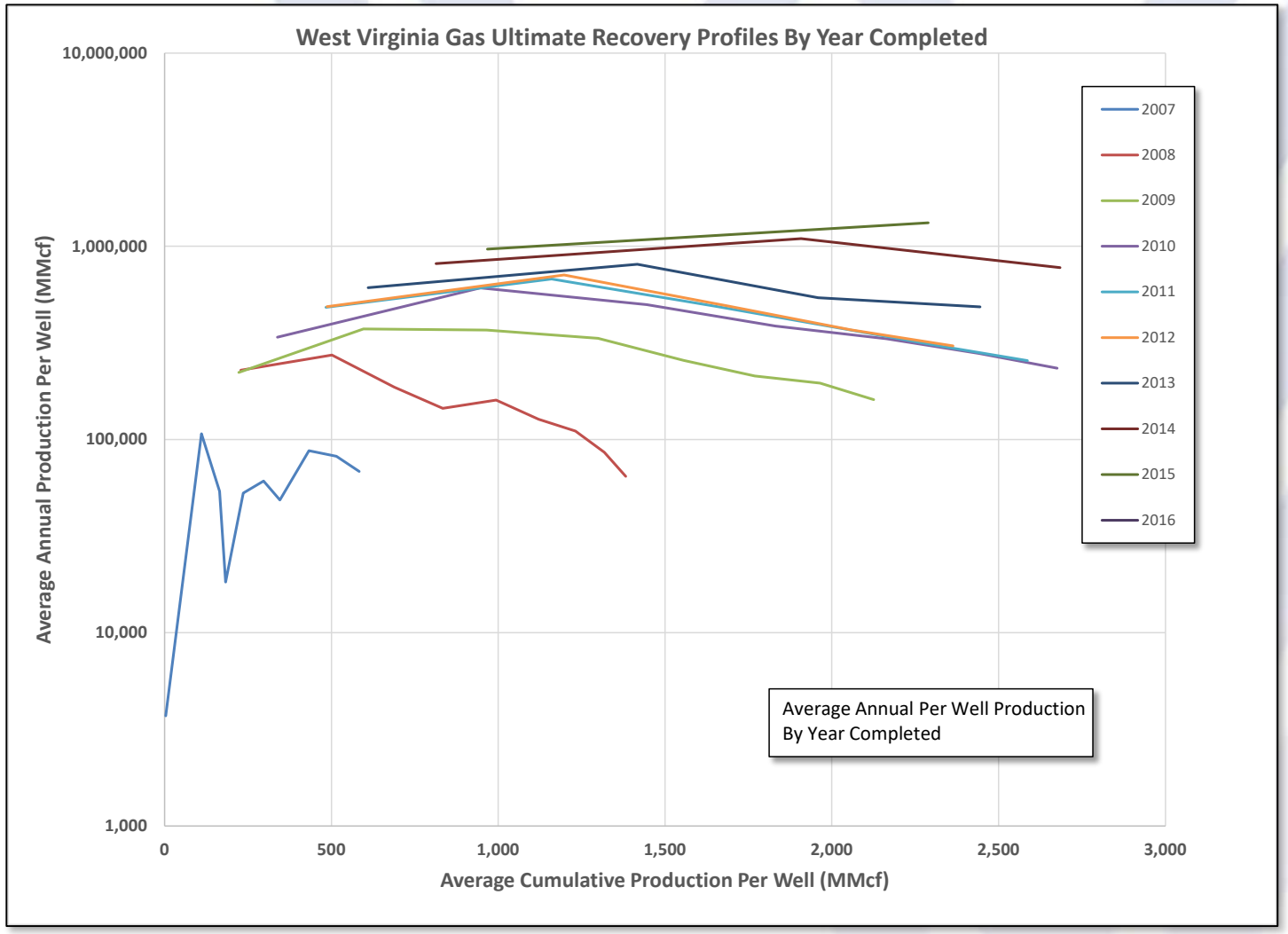

WVU
2.5 miles
Morgantown, WV, USA
MSEEL
79
857
73
119
81
45
19
7

MSEEL
Drilling MIPU 3H and 5H

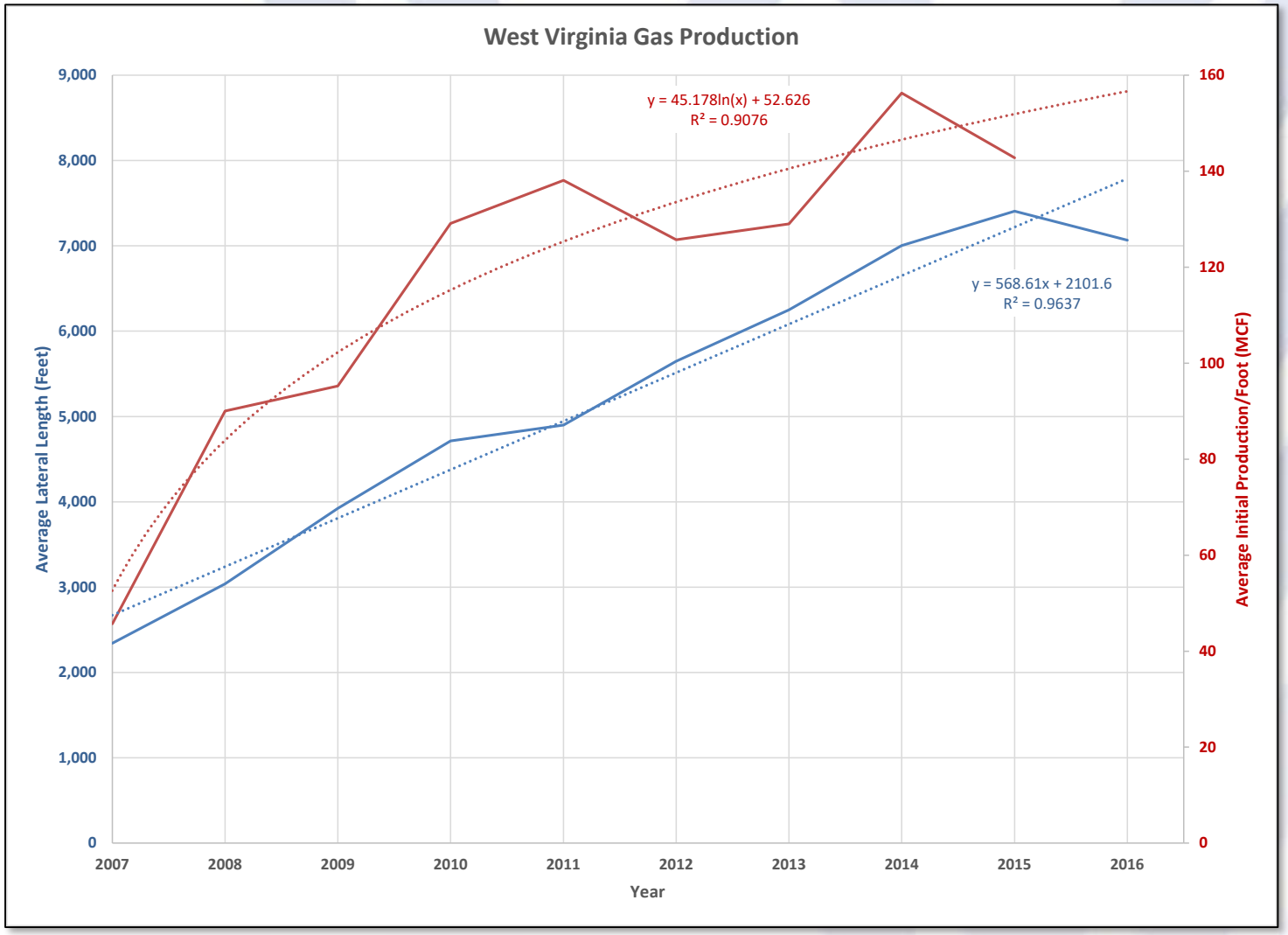
Estimated Ultimate Recovery



Estimated Ultimate Recovery

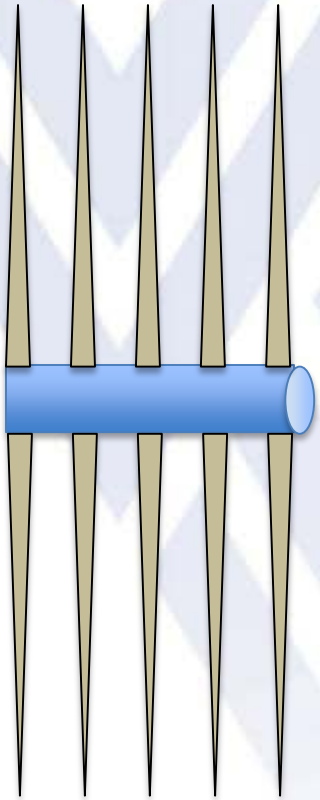


Drilling Efficiency



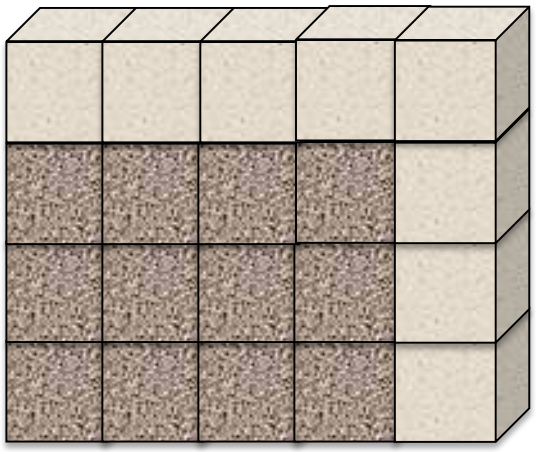
Increased Productivity Per Well

Proppant 1,157 to 1,342 lbs/ft.
12 cubic feet of sand per foot

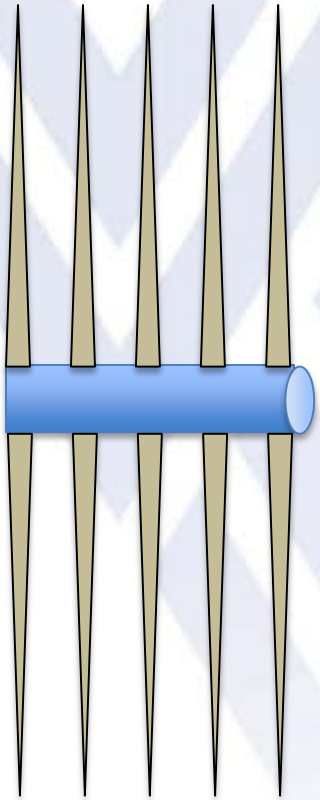


2011 ~30 days drilling
Total Completed Horizontal
MIP-4H – 3,782 Feet
MIP-6H – 2,342 Feet

Increased Productivity Per Well



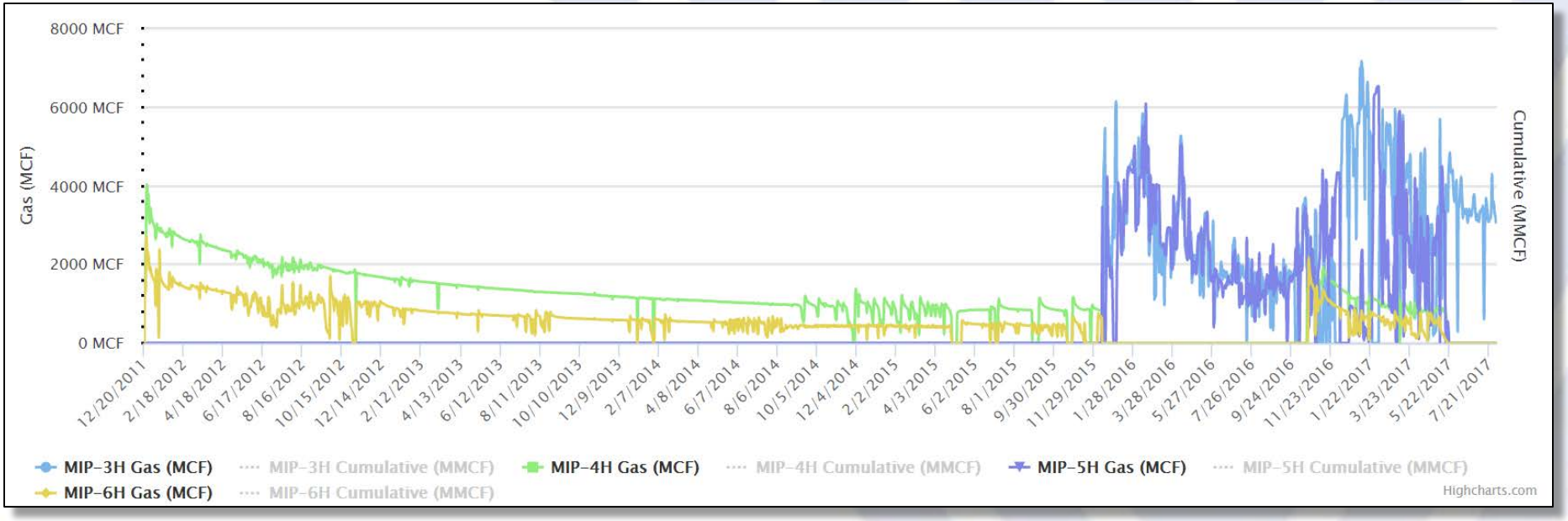
Proppant 1,858 to 1,917 lbs/ft.
20 cubic feet of sand per foot



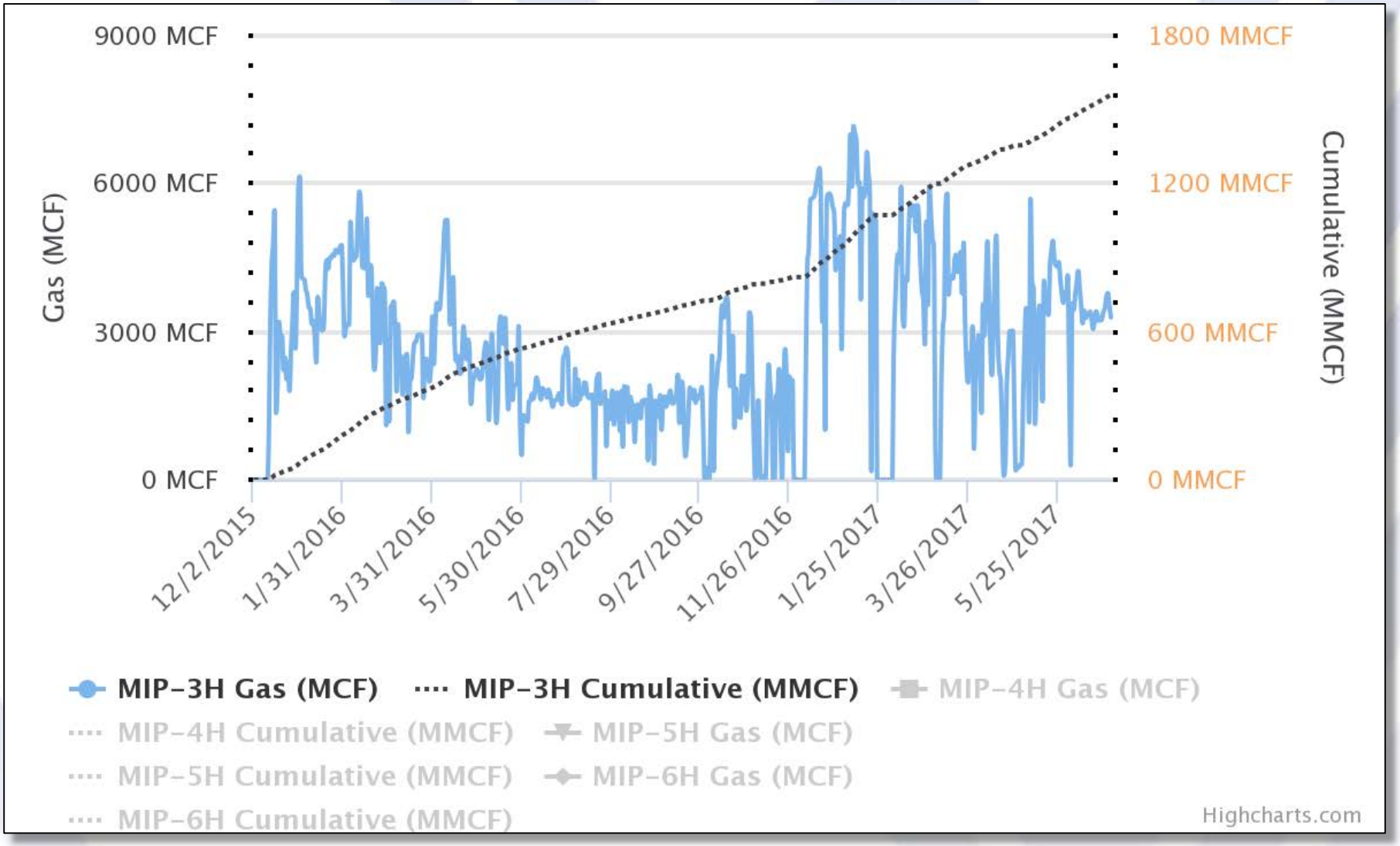
2011 ~30 days drilling
Total Completed Horizontal
MIP-4H – 3,782 Feet
MIP-6H – 2,342 Feet
Proppant 1,157 to 1,342 lbs/ft.
12 cubic feet of sand per foot

2015 ~7 days drilling
Total Completed Horizontal
MIP-3H – 6,058 Feet
MIP-5H – 5,784 Feet

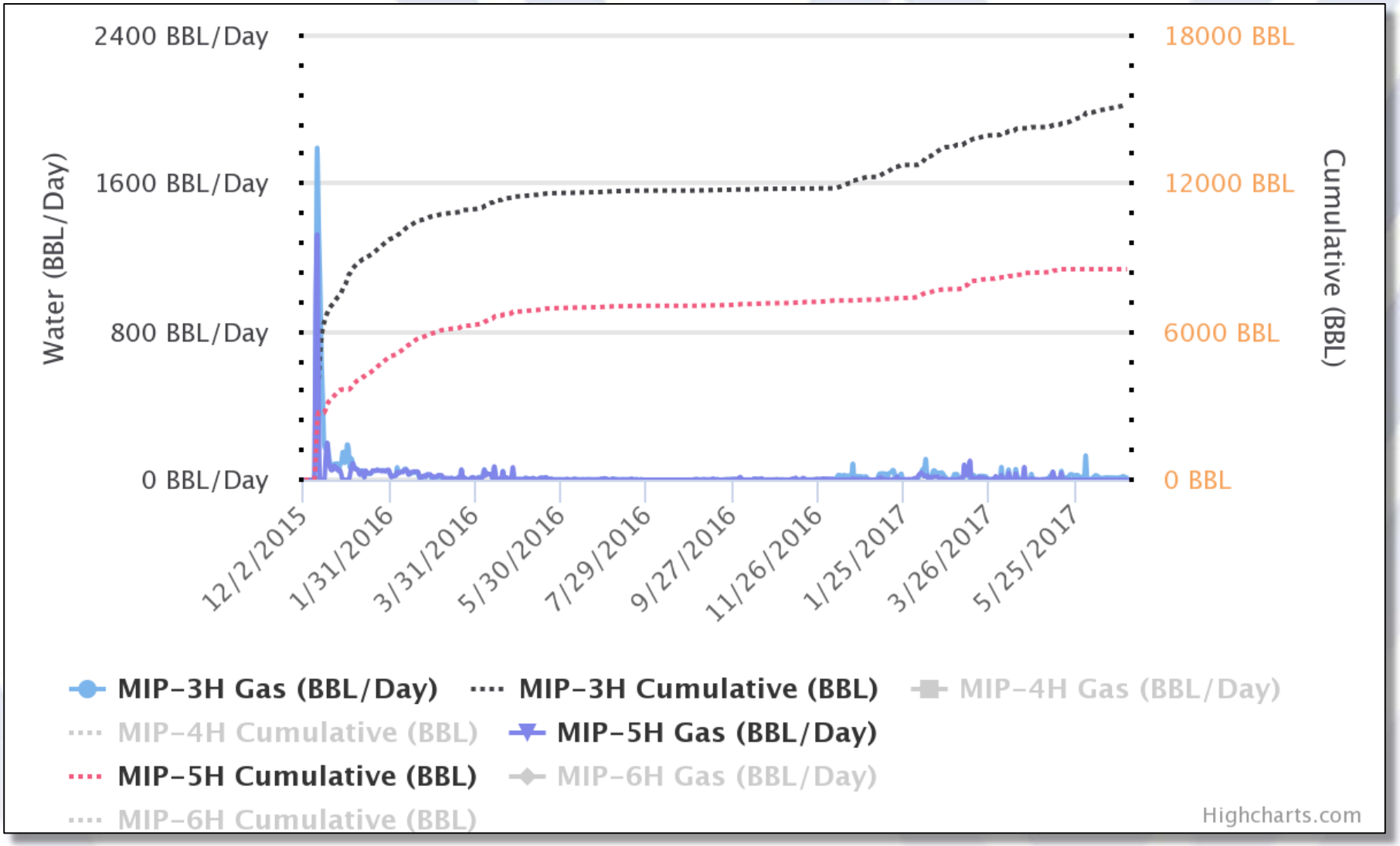
Production Volumes: MIP 3H, 5H, 4H, 6H



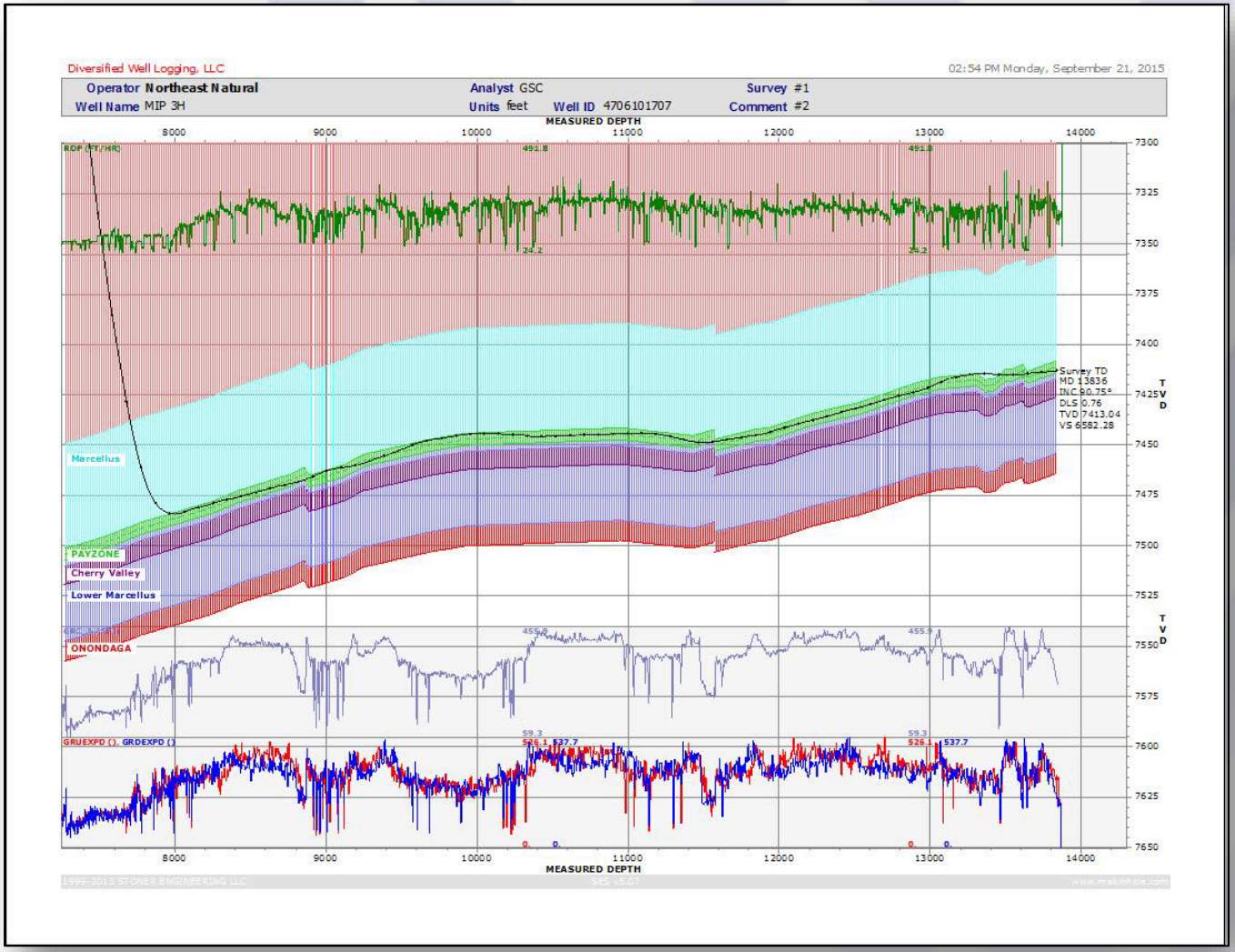
Production Volumes: MIP 3H



Flowback Volumes: MIP 3H & 5H

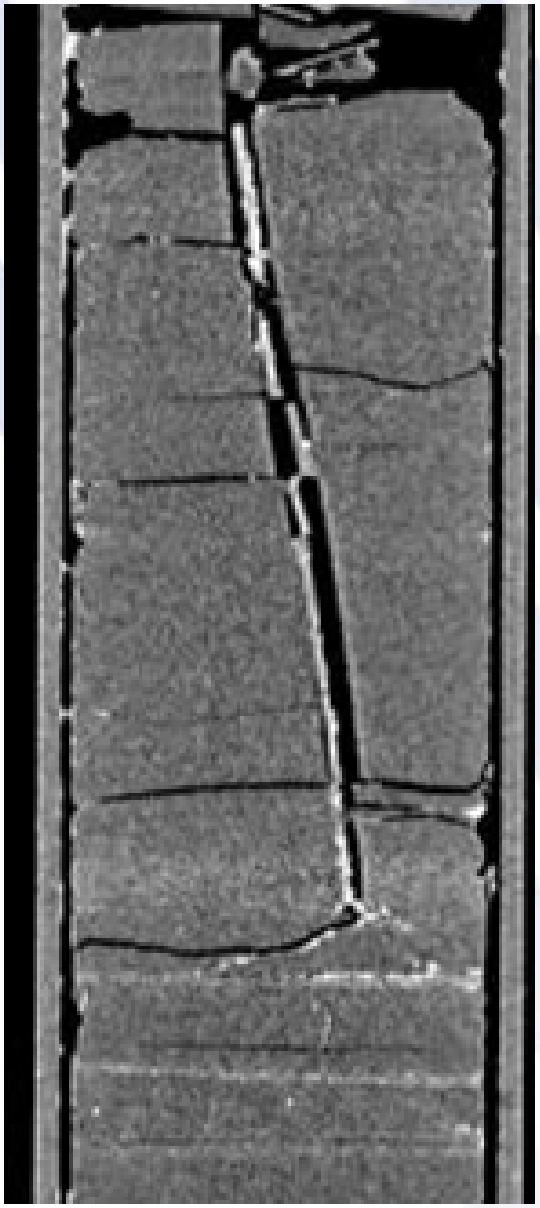


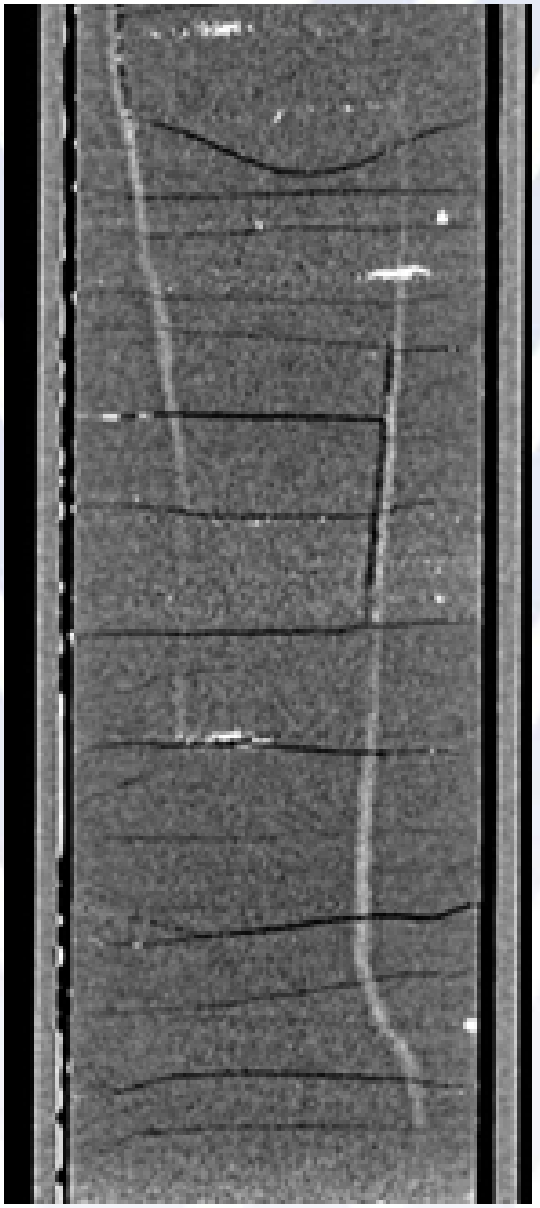
Geosteering MIP-3H



MSEEL
Completion MIPU 3H and 5H

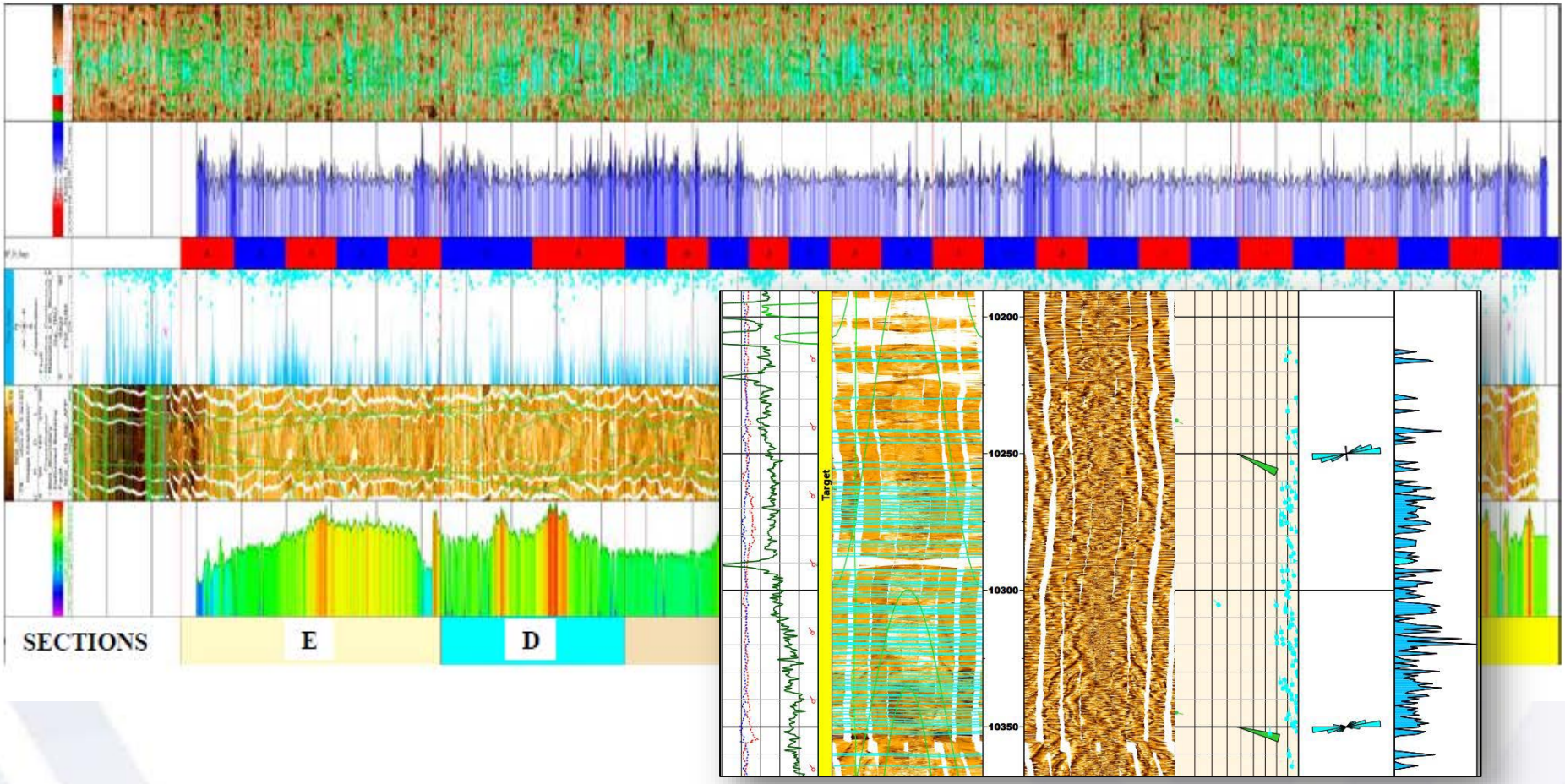
High Resolution CT Scanning – Fractures





MSEEL - LOGGING LATERAL

High Definition open hole logs in lateral with synthetic mud



MSEEL - LOGGING LATERAL

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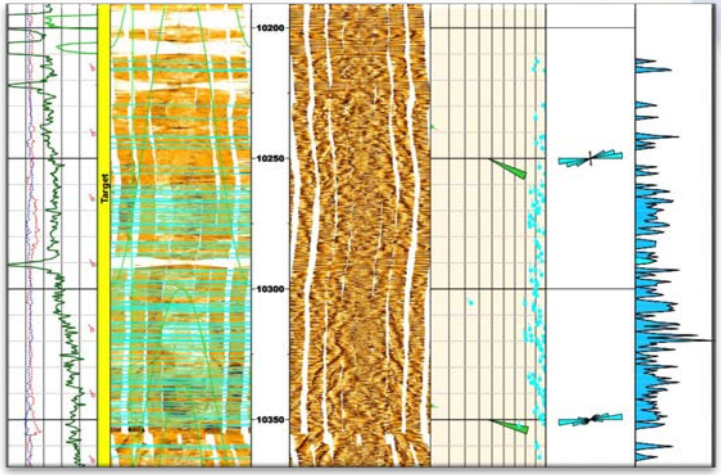
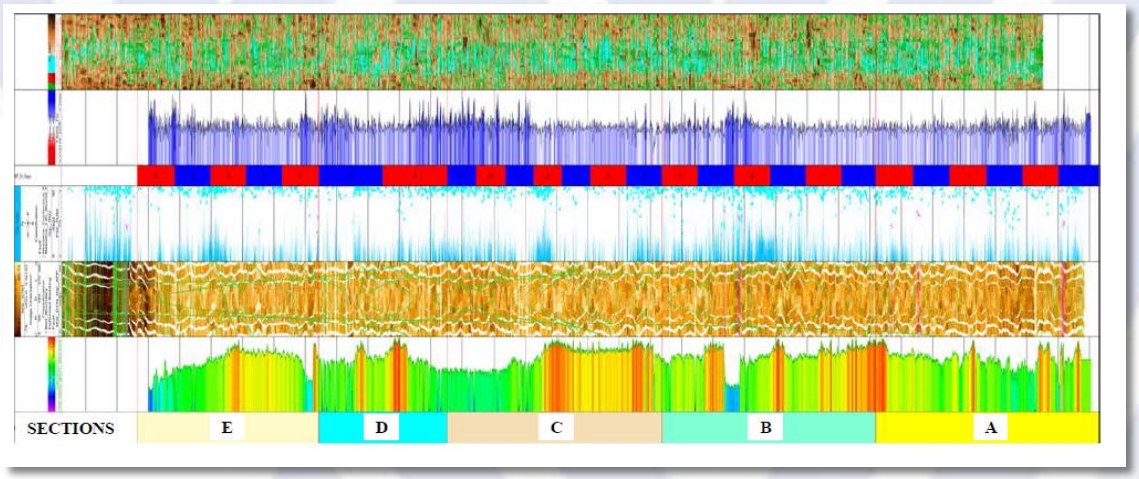
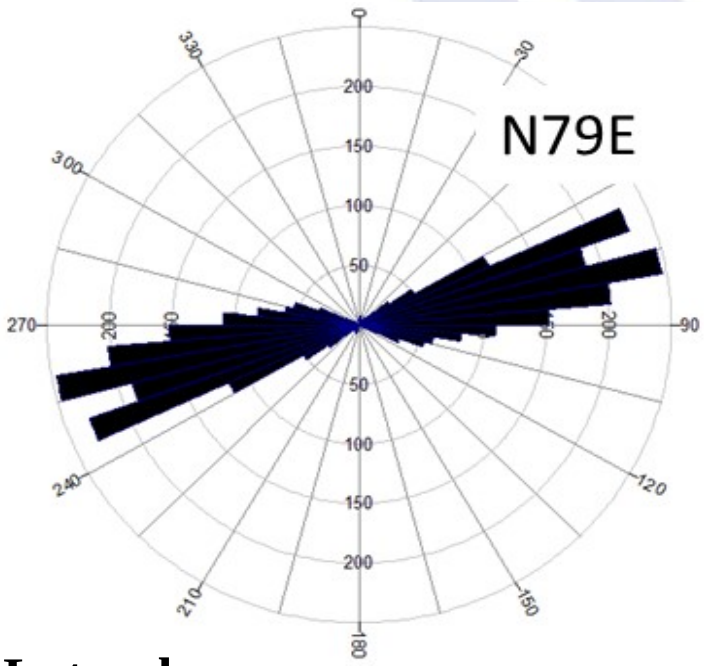




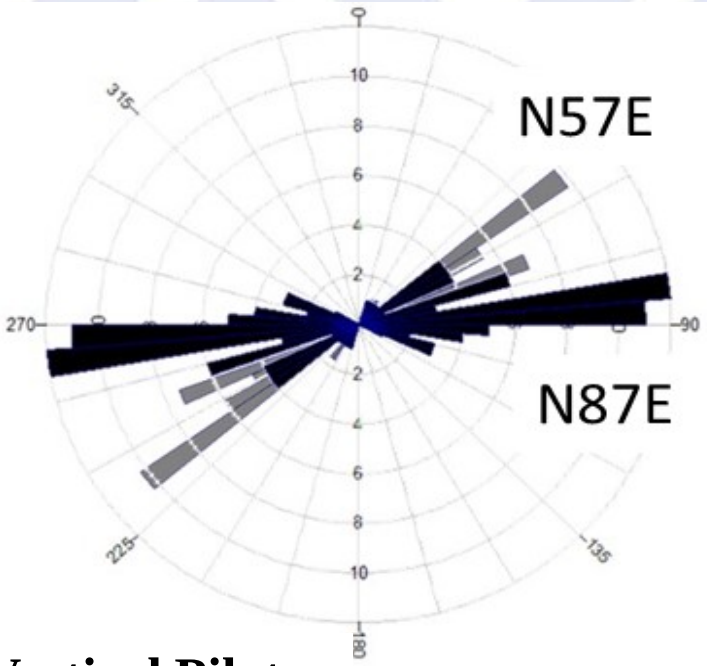
Fault/Fracture \ Stage	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
No of Faults	3				2	1				2	1																	
No of Fractures	41	25	48	29	15	69	47	51	97	160	86	65	72	17	14	90	25	56	68	71	37	46	21	41	42	89	66	28

Schlumberger

Natural Fractures MIP-3H

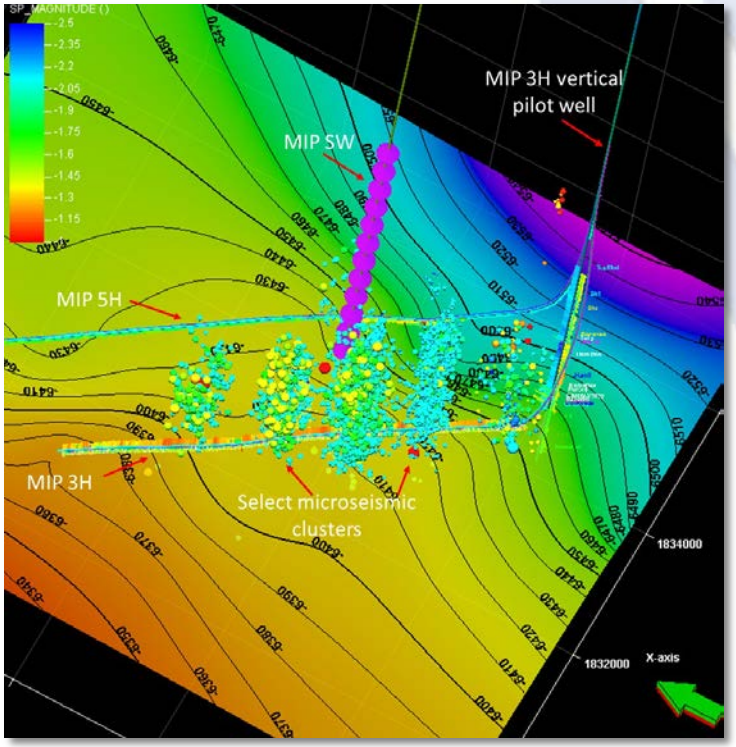


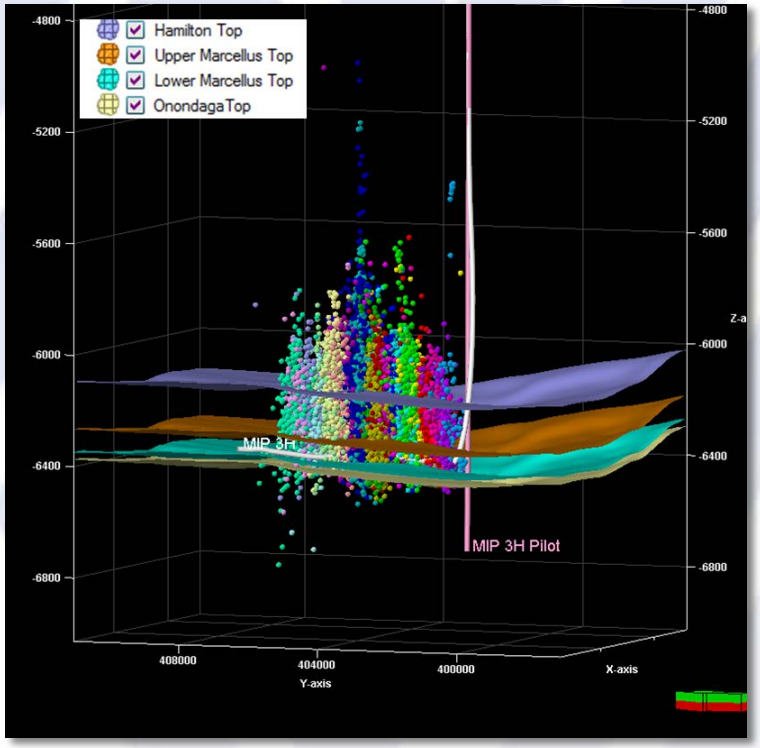
Lateral



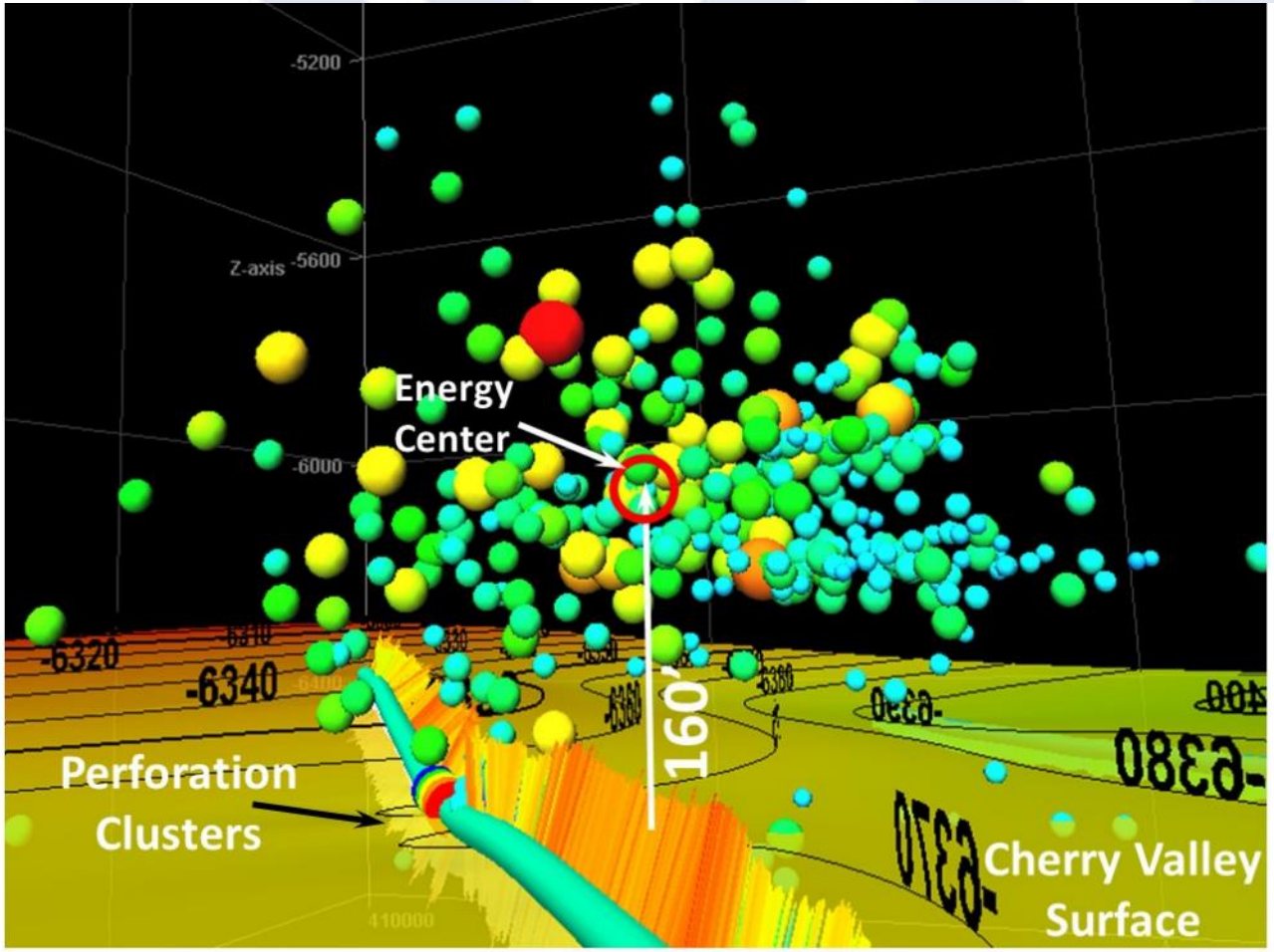
Vertical Pilot

Microseismic

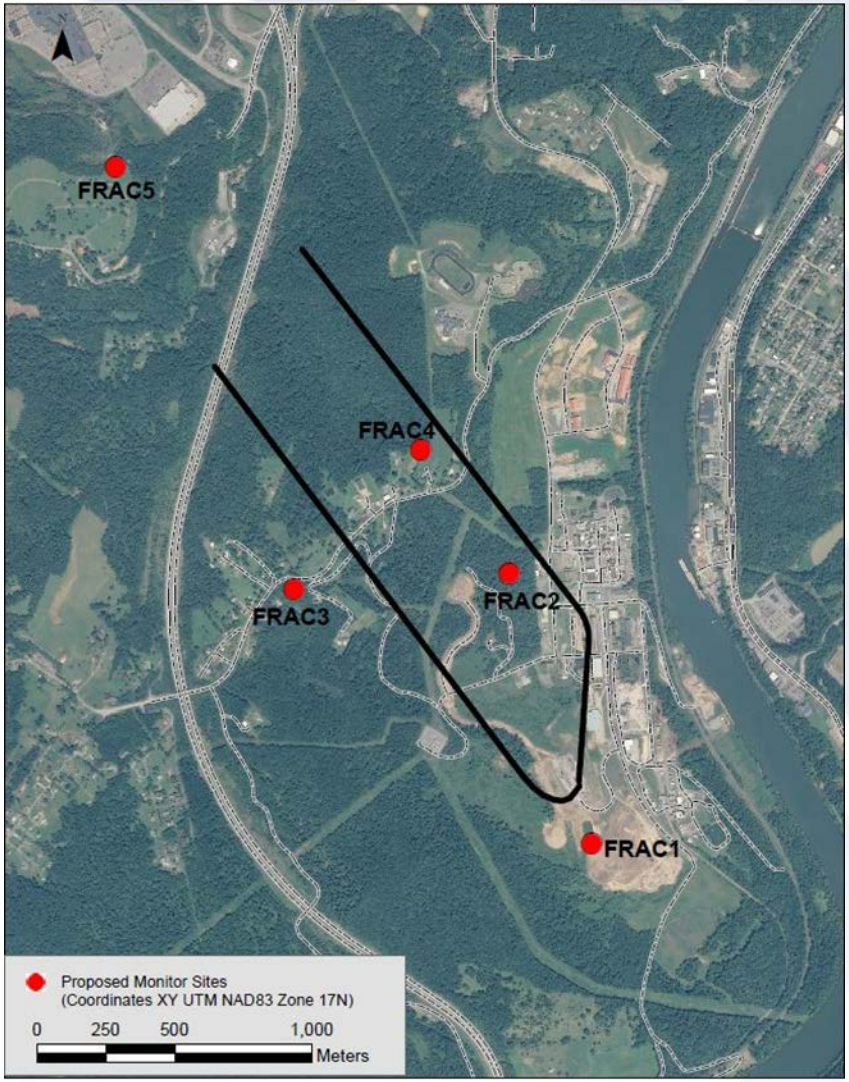




MSEEL - Microseismic



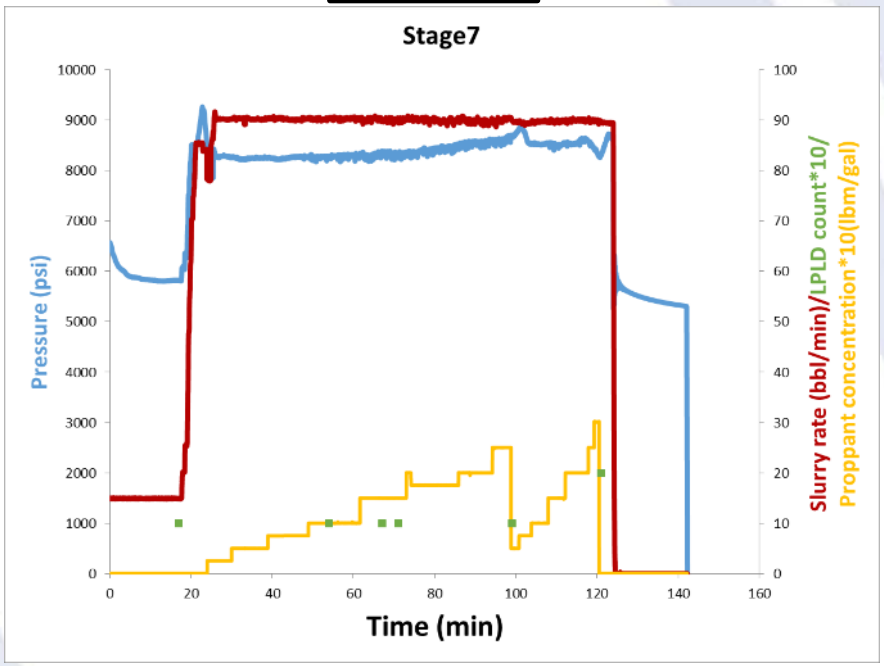
SURFACE MONITORING OF SLOW SLIP (LPLD)



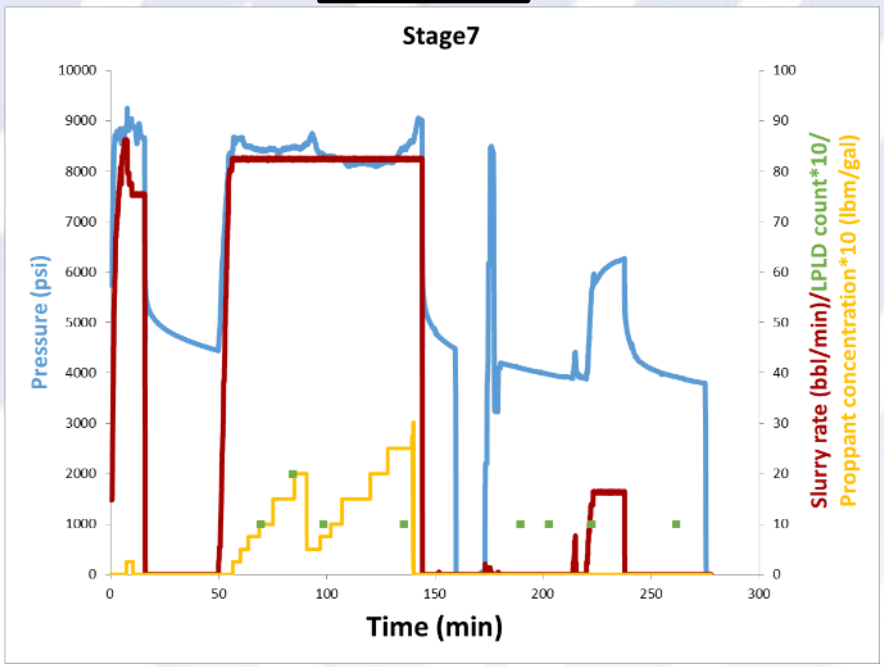
SURFACE MONITORING OF SLOW SLIP (LPLD)

LPLD and injection parameters

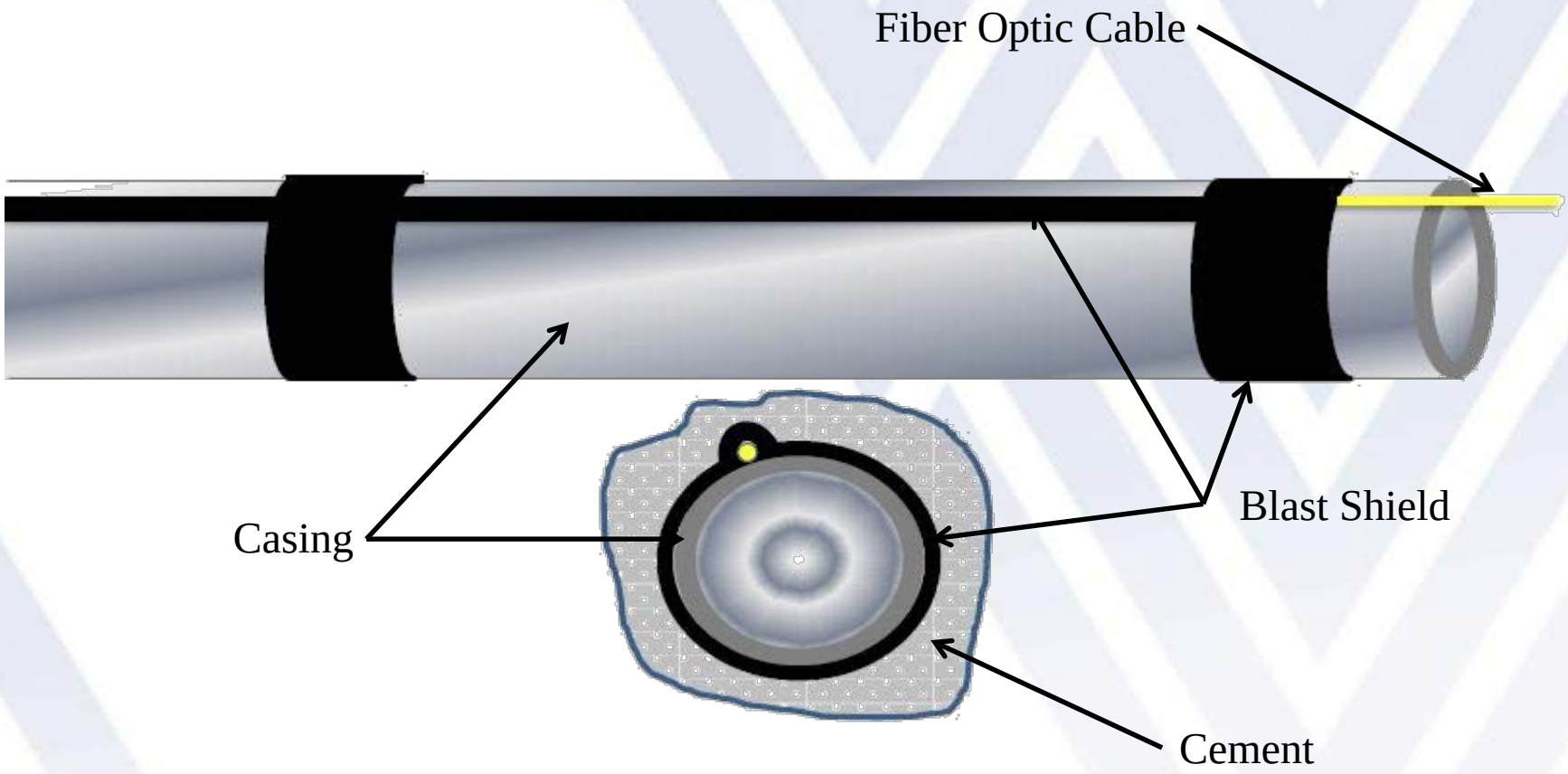
Well 3H



Well 5H



Fiber Optic Installation

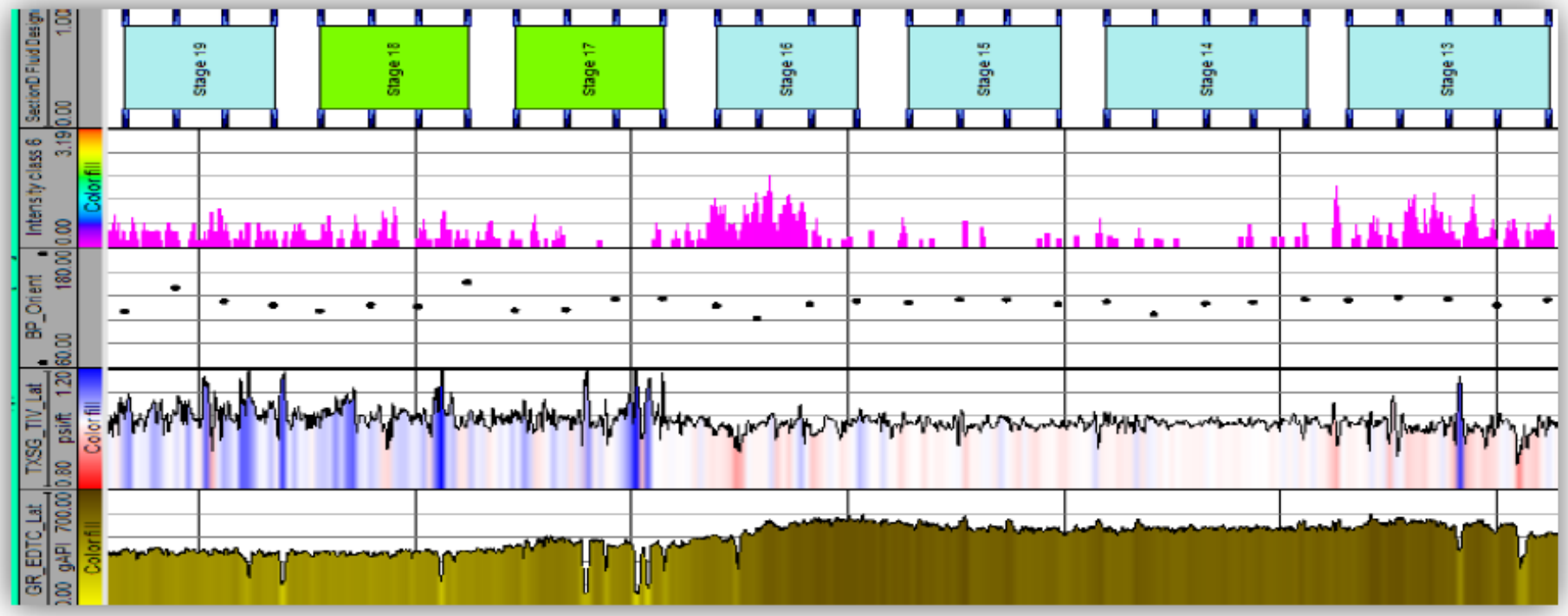


MIP 3H Completion Design

Section		Stage	Cluster Count	Total Shot Count	Shot Density (shot/ft)	Stage Length (ft)	Pump schedule
E	Best Practice Applied	28	4	40	6	191	A
		27	4	40	6	184	A
		26	5	40	6	225	A
		25	5	32	6	231	A
		24	5	30	6	222	A
		23	5	40	6	237	C
		22	5	40	6	220	C
D	Saphire VEF	21	5	40	5	218	D
		20	5	40	5	240	D
C	SLB Engineered Completion	19	4	32	6	180	C
		18	4	32	8	180	C
		17	4	32	6	181	C
		16	4	26	6	178	C
		15	4	26	6	186	C
		14	5	30	6	228	A
		13	5	30	6	230	A
B	NNE 75% 100-Mesh	12	5	50	5	231	B
		11	5	50	5	232	B
		10	5	50	5	227	B
		9	5	50	5	237	B
		8	5	50	5	222	B
		7	5	50	5	224	B
A	NNE Standard 35% 100-Mesh	6	5	50	5	245	A
		5	5	50	5	234	A
		4	5	50	5	230	A
		3	5	50	5	238	A
		2	5	50	5	223	A
		1	5	50	5	233	A

MSEEL - LOGGING LATERAL

High Definition open hole logs in lateral with synthetic mud

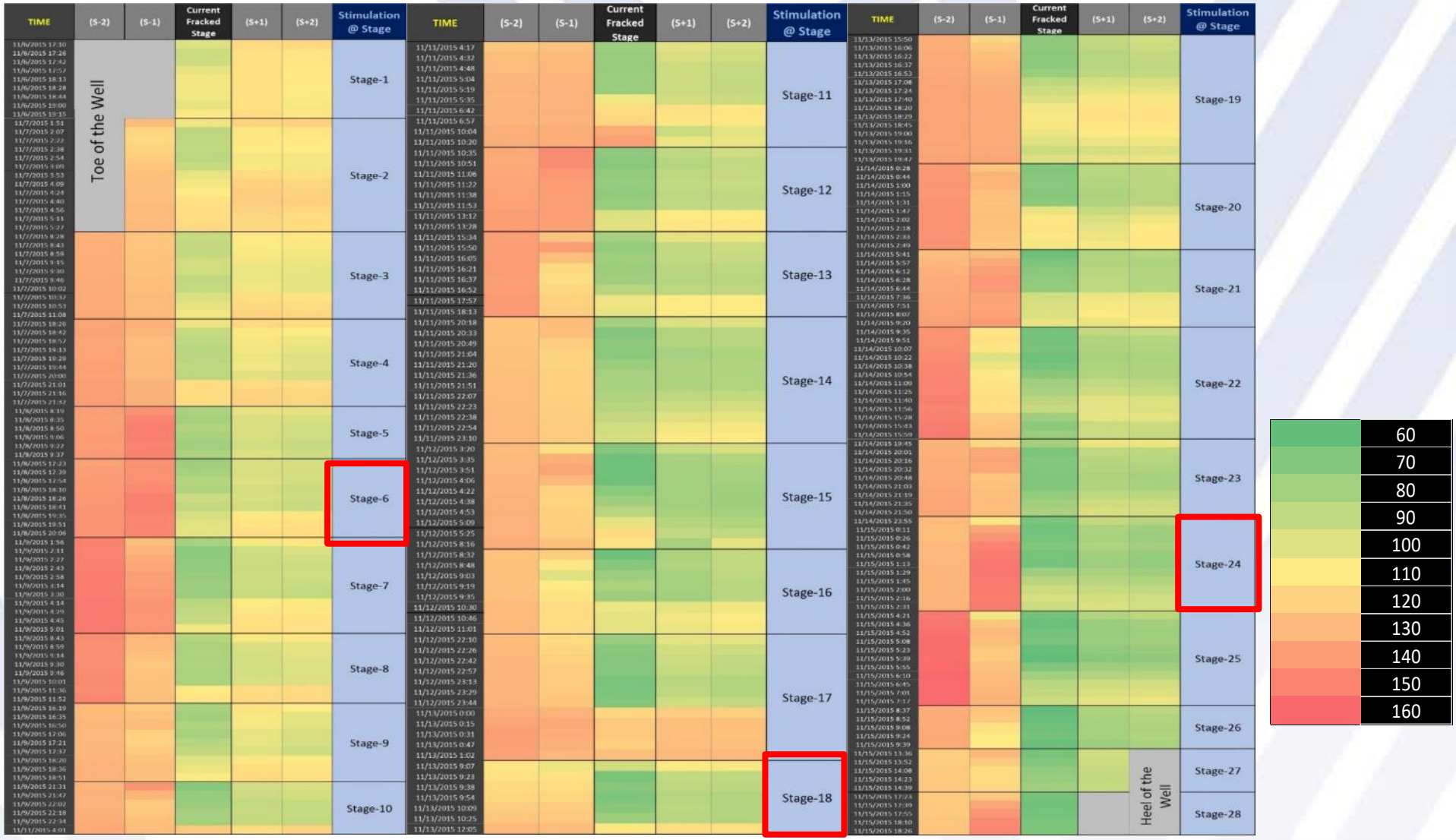


Mapped Faults & Fractures

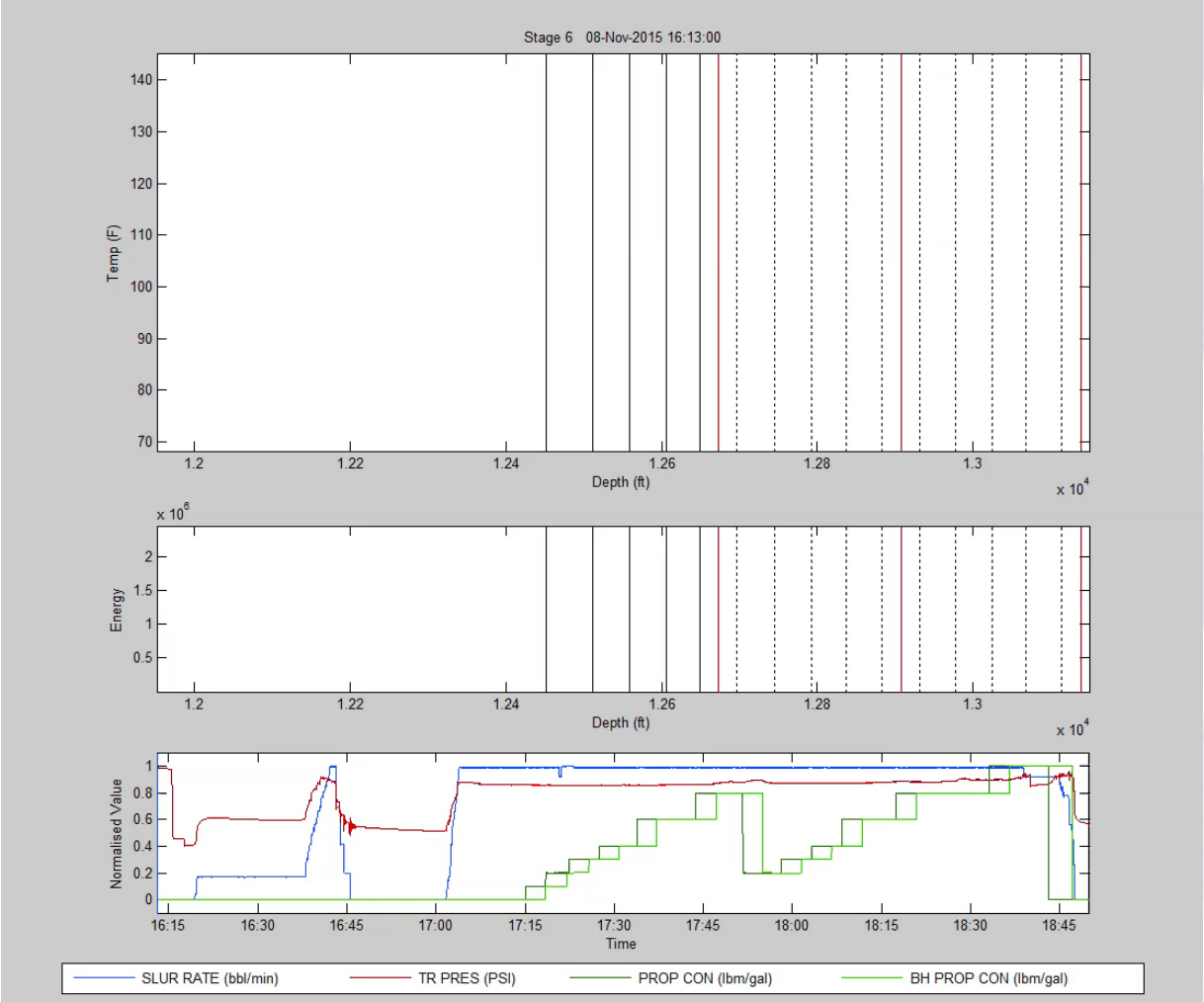
For MIP-3H the number of faults and fractures encountered at each stage is reported as:

Stage / Fault/Fracture	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
No of Faults	3				2	1				2	1																	
No of Fractures	41	25	48	29	15	69	47	51	97	160	86	65	72	17	14	90	25	56	68	71	37	46	21	41	42	89	66	28

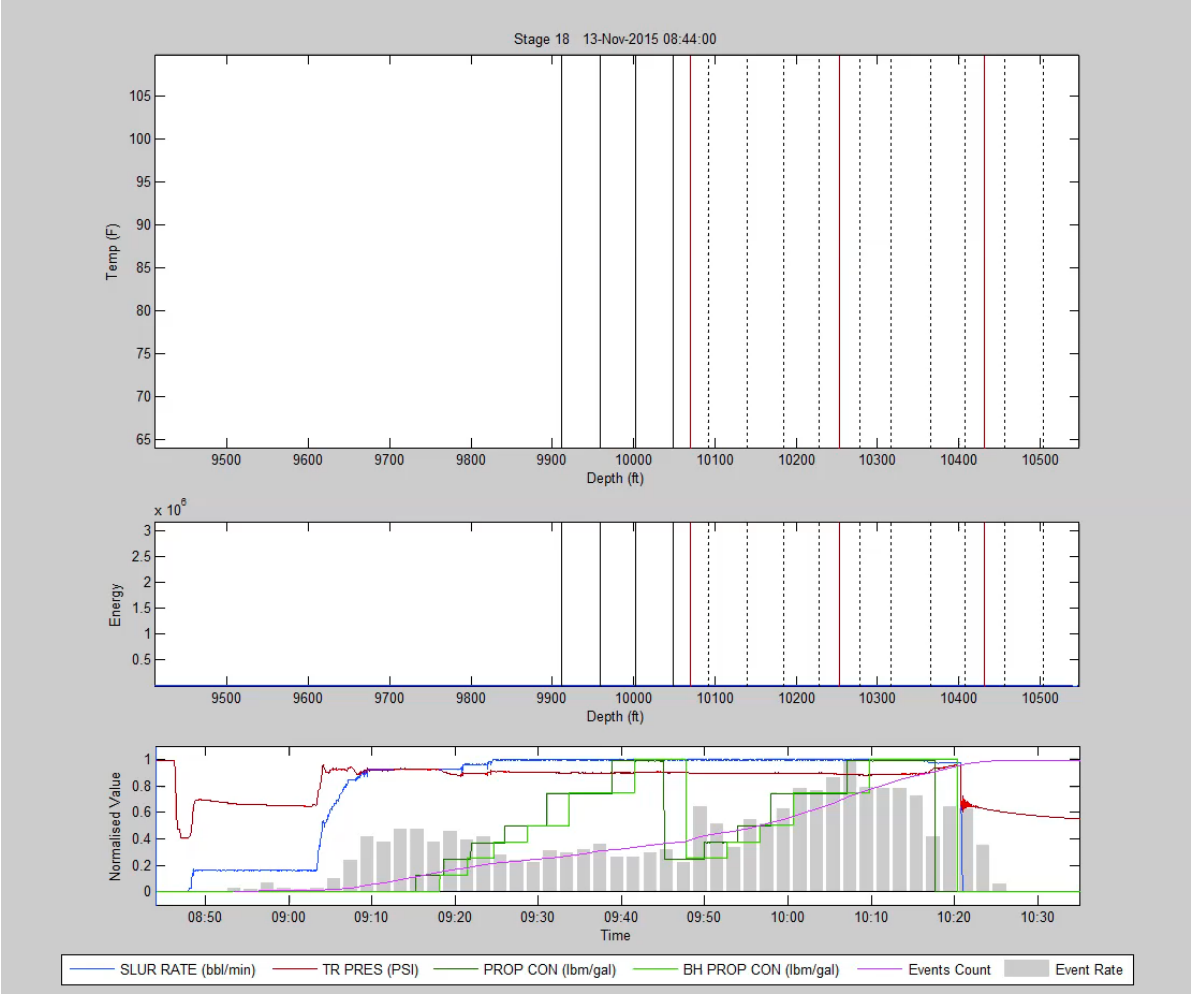
DTS Data


TIME
(S-2)
(S-1)
Current Fracked Stage
(S+1)
(S+2)
Stimulation @ Stage
Toe of the Well
Stage-1
Stage-2
Stage-3
Stage-4
Stage-5
Stage-6
Stage-7
Stage-8
Stage-9
Stage-10
Stage-11
Stage-12
Stage-13
Stage-14
Stage-15
Stage-16
Stage-17
Stage-18
Stage-19
Stage-20
Stage-21
Stage-22
Stage-23
Stage-24
Stage-25
Stage-26
Stage-27
Stage-28
Heel of the Well
60
70
80
90
100
110
120
130
140
150
160

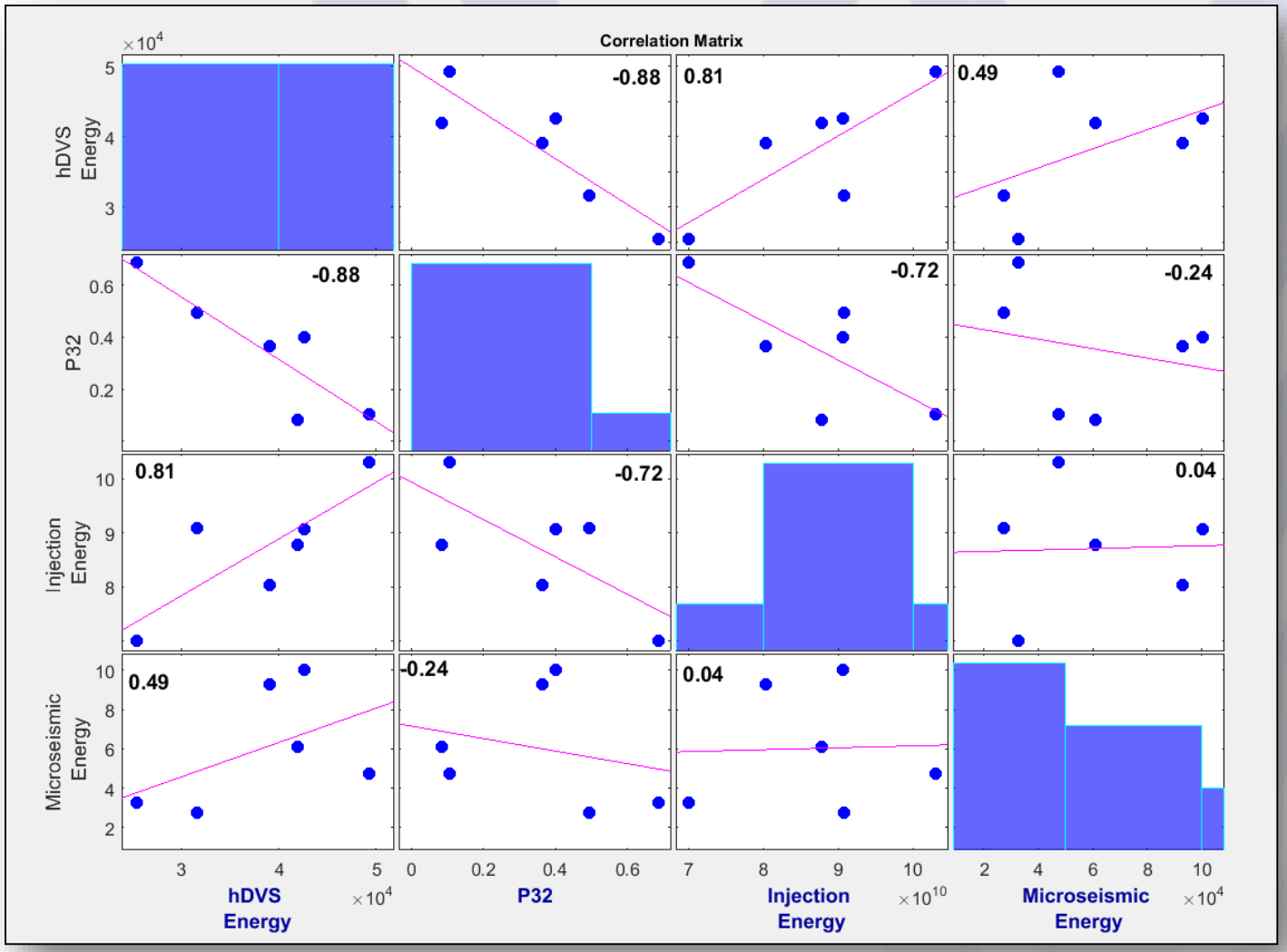
MIP3H - Stage 6: Geometric Completion Uneven Distribution



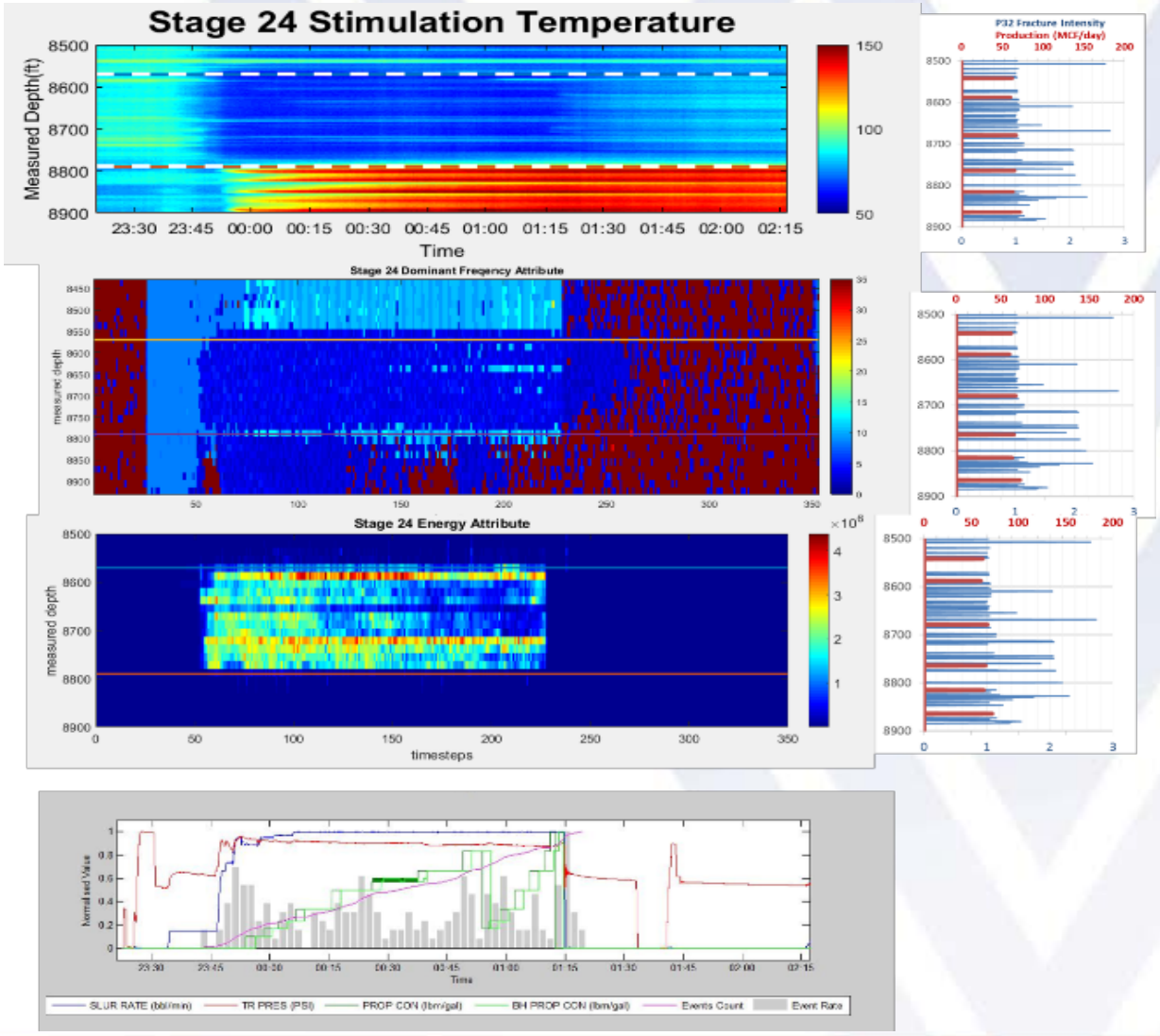
MIP 3H - Stage 18 Even Distribution



Microseismic, Injection Energy & Fractures



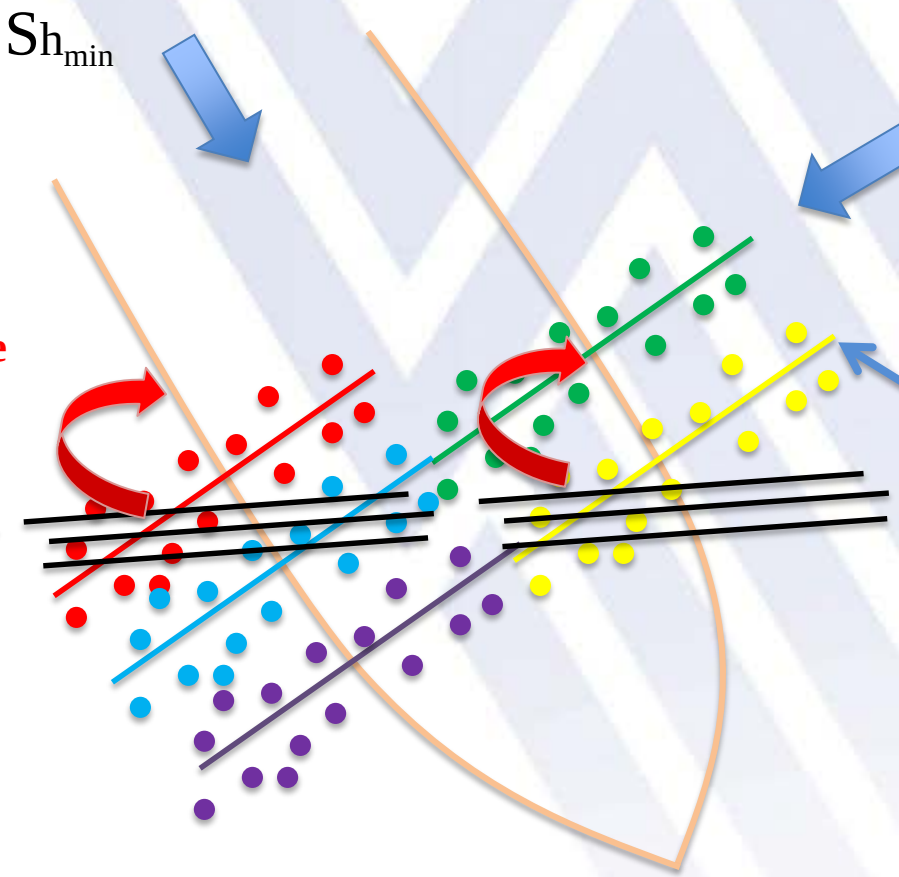
Dominant Frequency Imaging Using DAS Data



Payam Kavousi et al.

SURFACE MONITORING OF SLOW SLIP (LPLD)

Synopsis of slow-slip deformation



Temperature increase in previous stage(s)

Not critically oriented in stress field, results in "slow" slip with low frequency seismic expression typically missed during microseismic monitoring

Optimally, critically oriented in stress field, results in "fast" slip with high frequency microseismic expression

Adapted from Kumar et al. 2016 and Zoback et al., 2012

Conclusions

- The Marcellus Shale is a complex unconventional reservoir that does not respond in a straightforward manner during large scale hydraulic fracture stimulation.
- Completion efficiency along the lateral is affected by preexisting fractures oriented at an angle to existing principal stresses and strongly influence hydraulic fracture propagation. The results can be utilized as a guide to optimize the hydraulic fracturing design parameters for new wells.

Building Partnerships for Research, Education, and Outreach

This research was funded by a grant from Department of Energy's National Energy Technology Laboratory (DE- FE0024297).

West Virginia University
MSEEL
Marcellus Shale Energy & Environment Laboratory
Northeast Natural Energy