D2F Report

Company	**Northeast Natural Energy LLC**
Well	**Boggess 1H**
Formation	**Marcellus**
Location	**Monongalia, WV**

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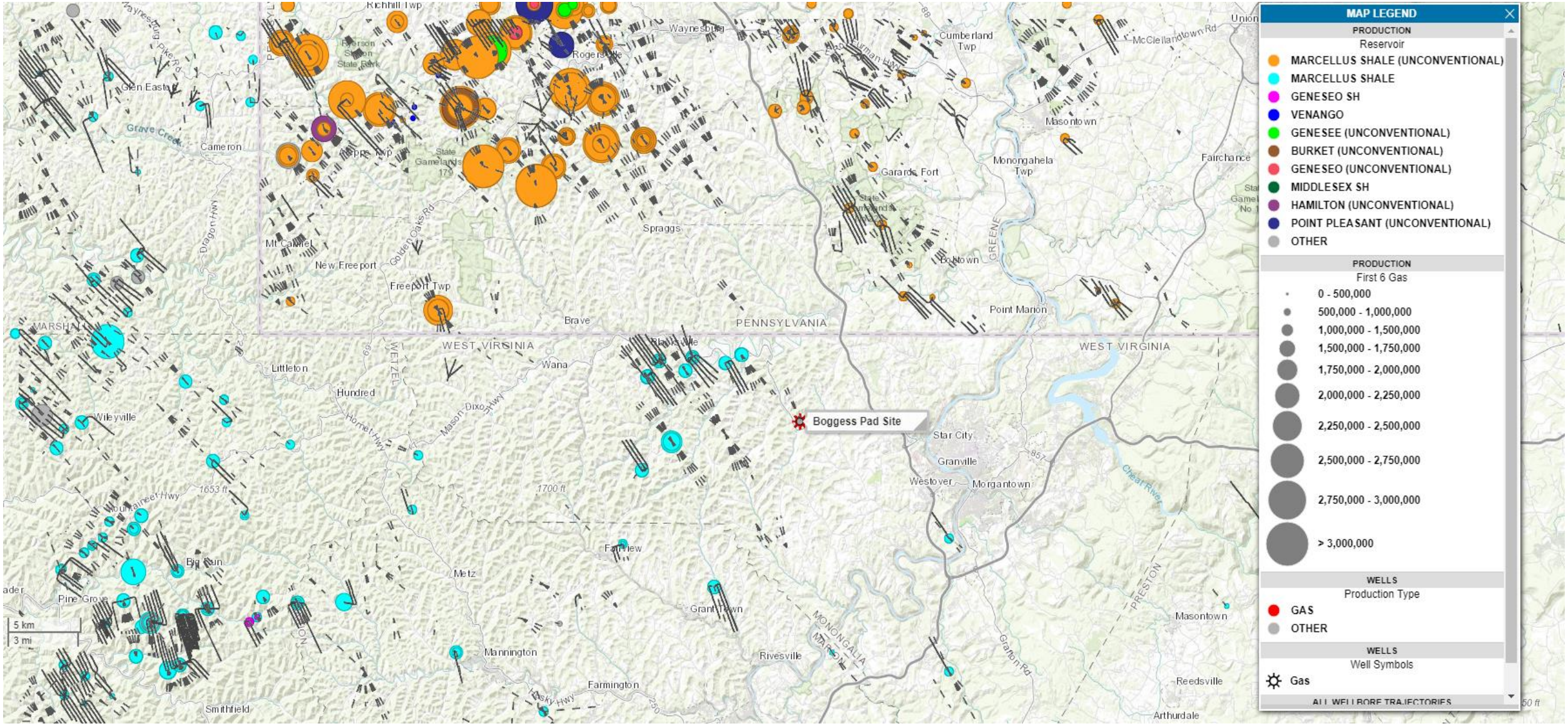
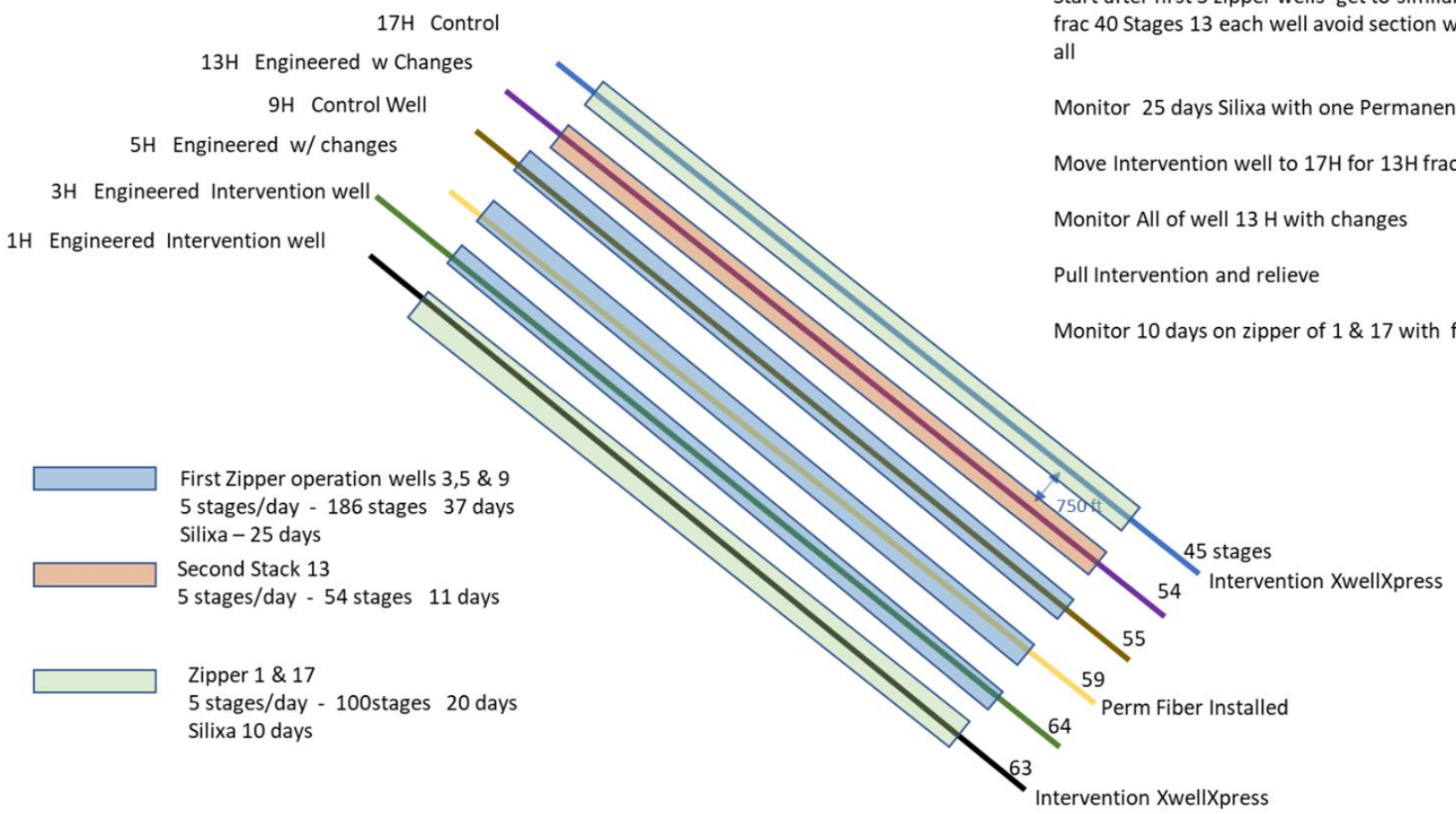
Area Map – First 6 months Gas by Reservoir



Detail Map with Frac Plan

Frac Plan for Northeast Energy



Silixa Plan
Start after first 3 zipper wells get to similar depth 8 days post start frac 40 Stages 13 each well avoid section where toe not visible on all

Monitor 25 days Silixa with one Permanent and one temp in 1H

Move Intervention well to 17H for 13H frac

Monitor All of well 13 H with changes

Pull Intervention and relieve

Monitor 10 days on zipper of 1 & 17 with from 5H only.

First Zipper operation wells 3,5 & 9
5 stages/day - 186 stages 37 days
Silixa – 25 days

Second Stack 13
5 stages/day - 54 stages 11 days

Zipper 1 & 17
5 stages/day - 100stages 20 days
Silixa 10 days

Input Data Provided

- Drilling data inclusive of standard parameters such as WOB, ROP, Torque, RPM etc.
- Directional data for well trajectory definition.
- Drilling report summary
- Mud Logs
- GR (drilling)
- Baseline Perf guidance
- Geosteering interpretation
- Natural fracture intensity channel from FracView interpretation

OmniLog Overview

Introduction

- Drilling data is used to generate a RockMSE profile.

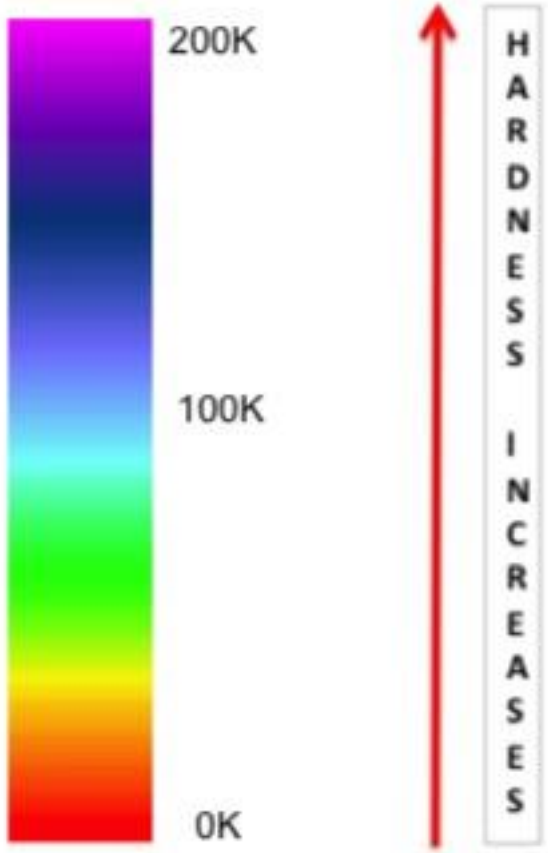
- Correction methodologies and algorithms (beyond the typical filtering, smoothing and de-spiking) are used to generate a RockMSE profile that more accurately represents the formation.

- The OmniLog comprises the final computed RockMSE along with any other available data (GR from the MWD, Mud Log Lithology, Gas shows from Mud Logs, Casing tally information etc.) and provides an insight to the geomechanical heterogeneity along the lateral.

- The OmniLog is presented on Driller's Depth.

OmniLog Color and Quality Reference

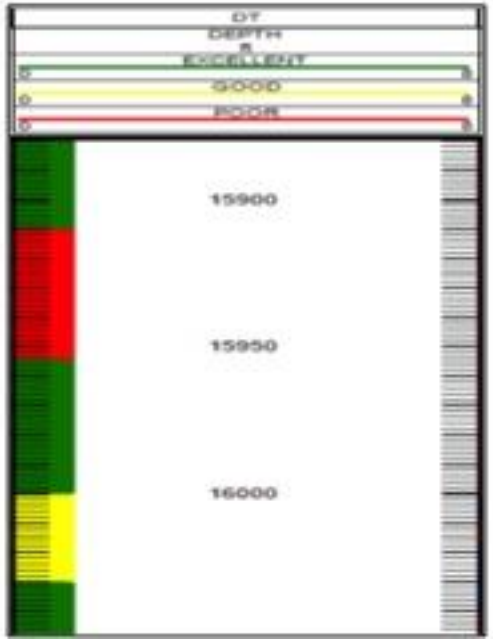
RockMSE Color Reference Index



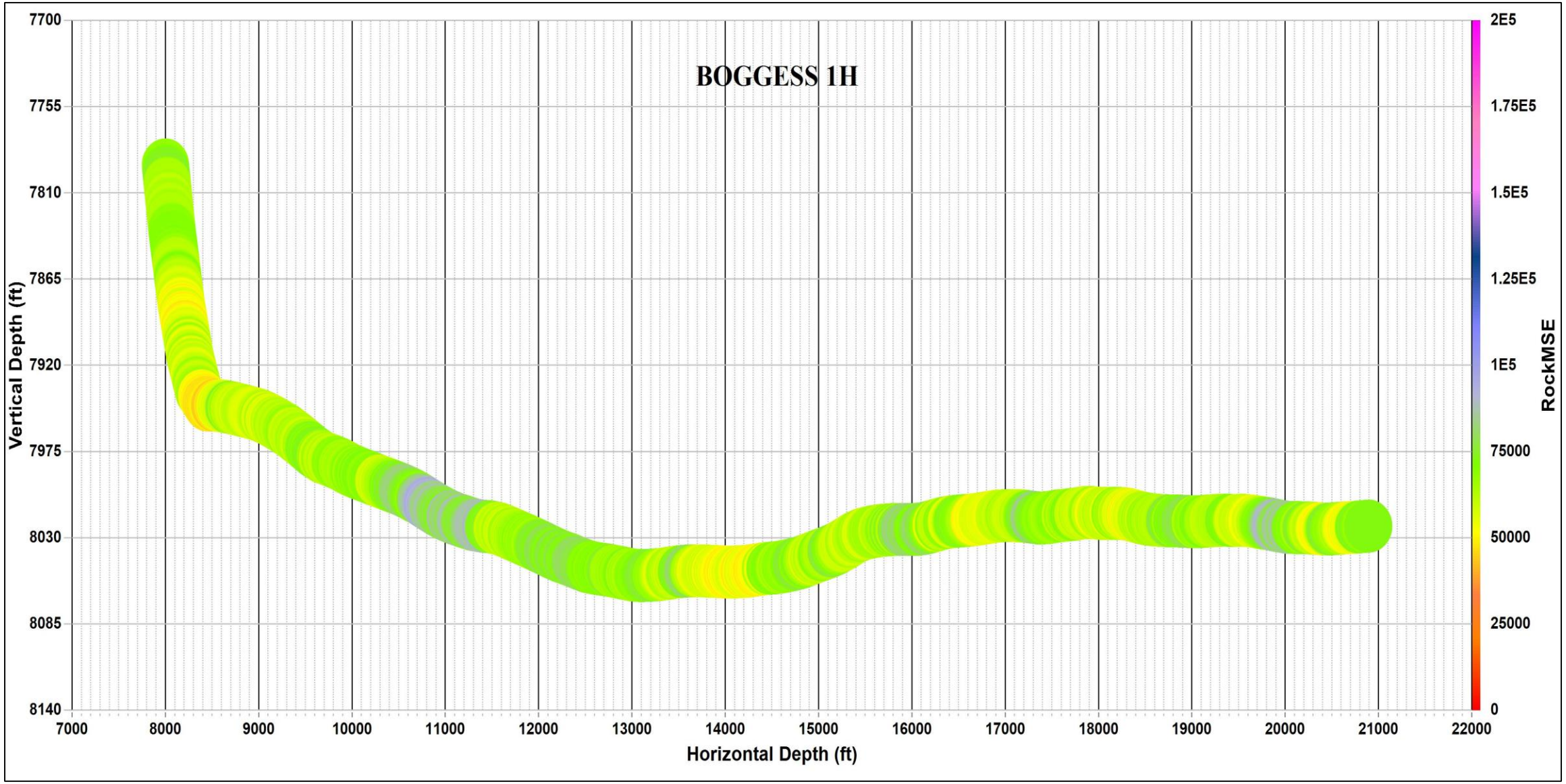
Quality Reference Table

Color Code	Quality Reference	Description
	Excellent	No Data Editing Required; High Level of Confidence in RockMSE Results
	Good	Some level of Data Editing Required; Good level of Confidence in RockMSE Results
	Poor	Quality of data is poor across large sections; Significant data editing required; Low confidence of results in RockMSE; Use with caution

Example Quality Reference Track



Trajectory Plot – Boggess 1H

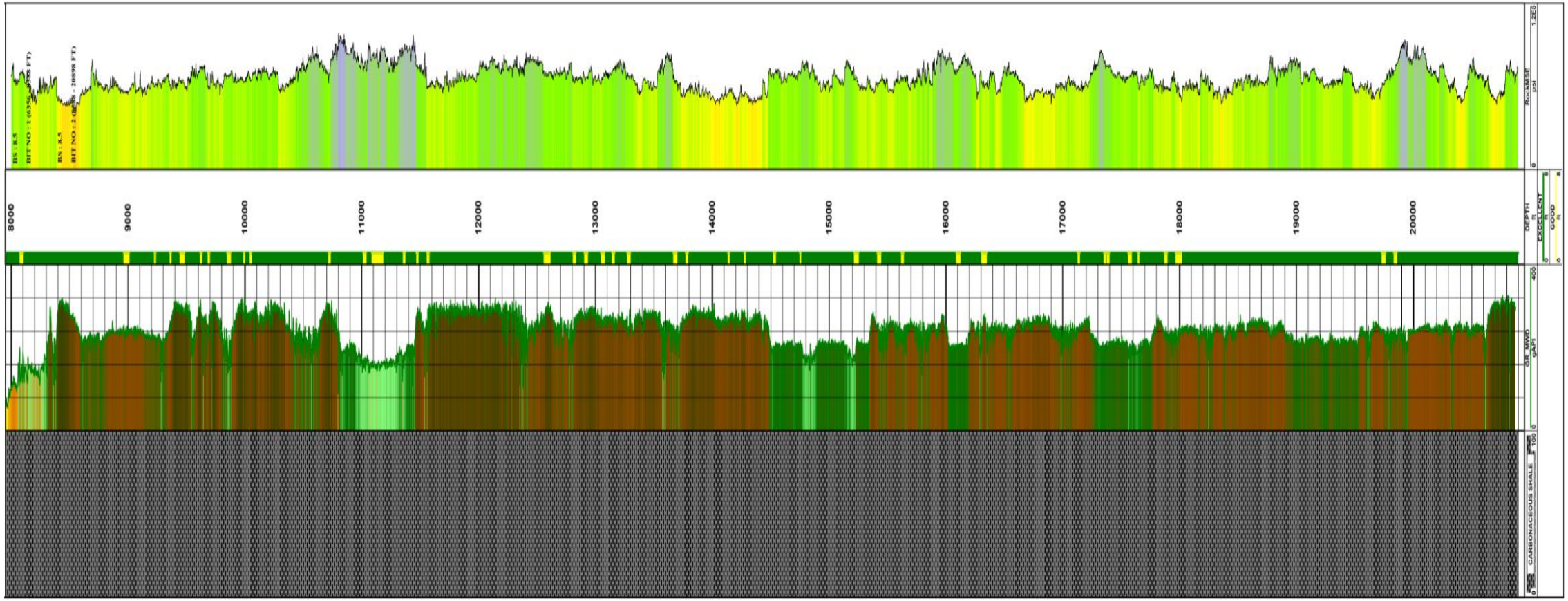


Well Overview – OmniLog/GR – Boggess 1H

OmniLog Lateral Profile

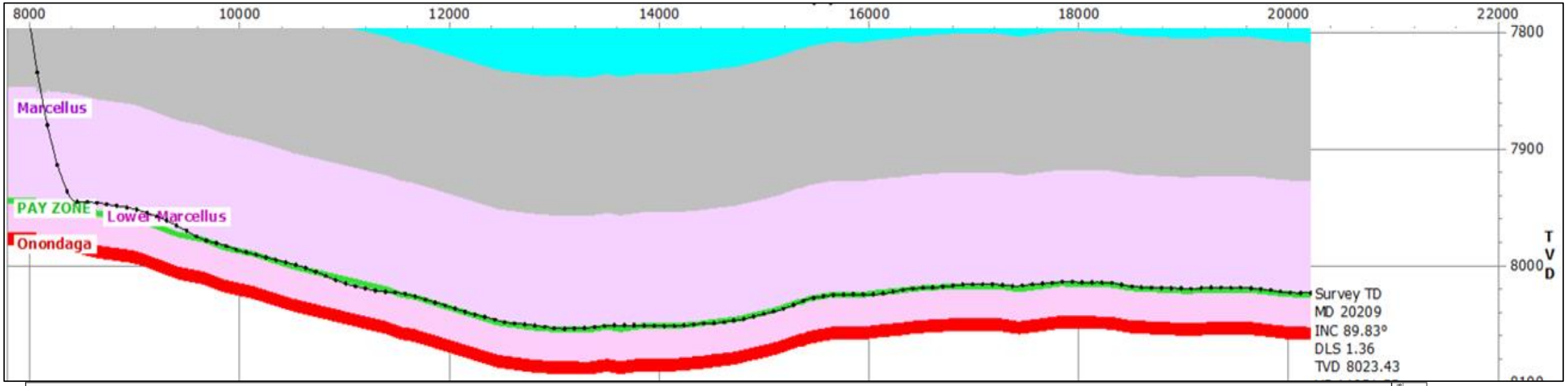
GR MWD

Mudlog Lithology



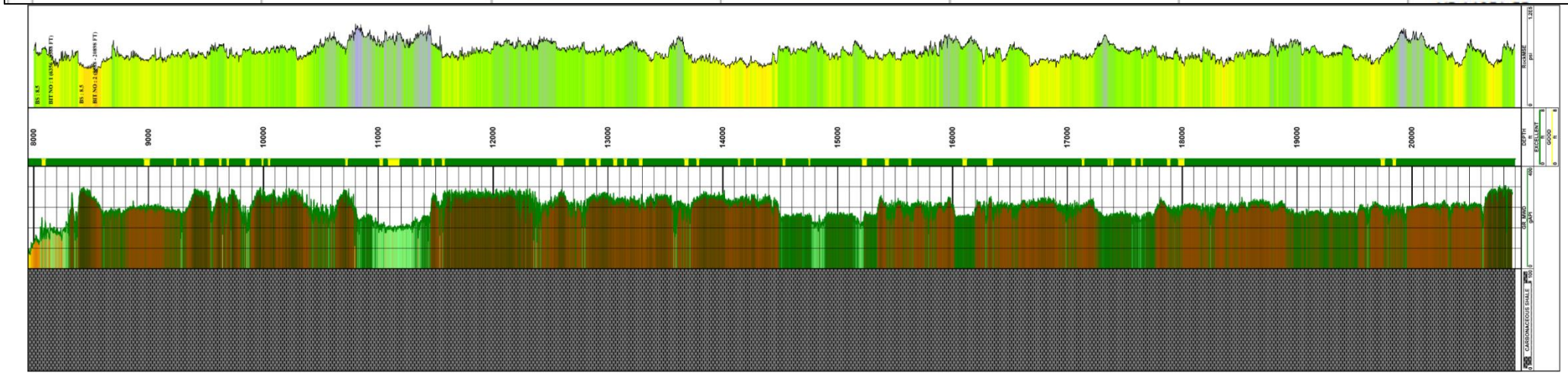
Geosteering Interpretation – Boggess 1H

Geosteering



RockMSE

GR MWD



OmniLog Observations & Summary

- Data was of reasonably good quality across the trajectory.
- As a result, we were able to generate a high quality OmniLog model for well Boggess 1H
- Hardness levels and Heterogeneity are consistent with other Marcellus wells.
- There is good correlation with GR across much of the lateral.

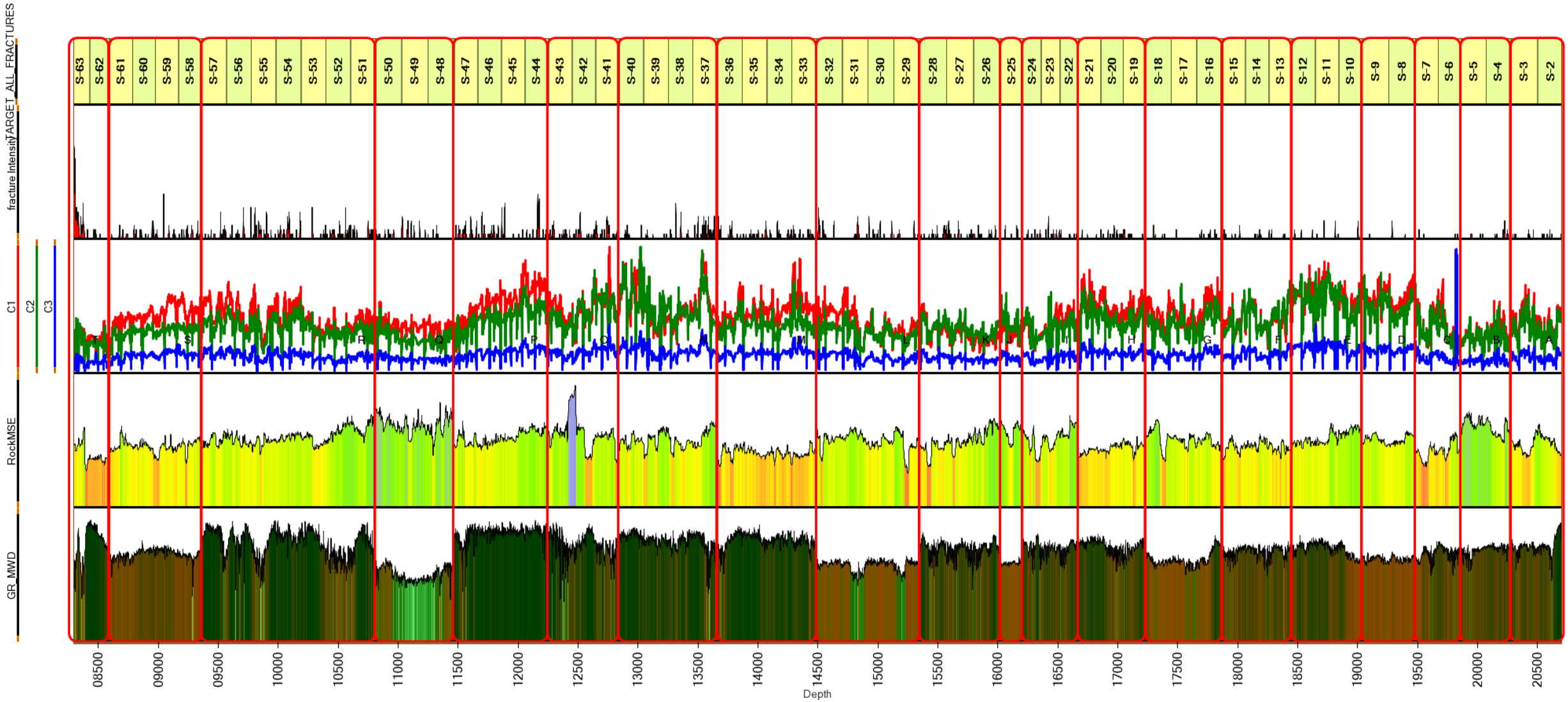
PerfAct Overview

PerfAct Summary

- PerfAct was run with the primary goals of:
  - Creating stage boundaries so each stage is in similar rock
  - Placing perforating clusters so that
    - Each cluster is in similar rock
    - Placement is biased to either avoid fractures or target fractures
  - Average stage length = 201’
  - 4-6 clusters/stage

PerfAct - Segmentation

Well Segmentation



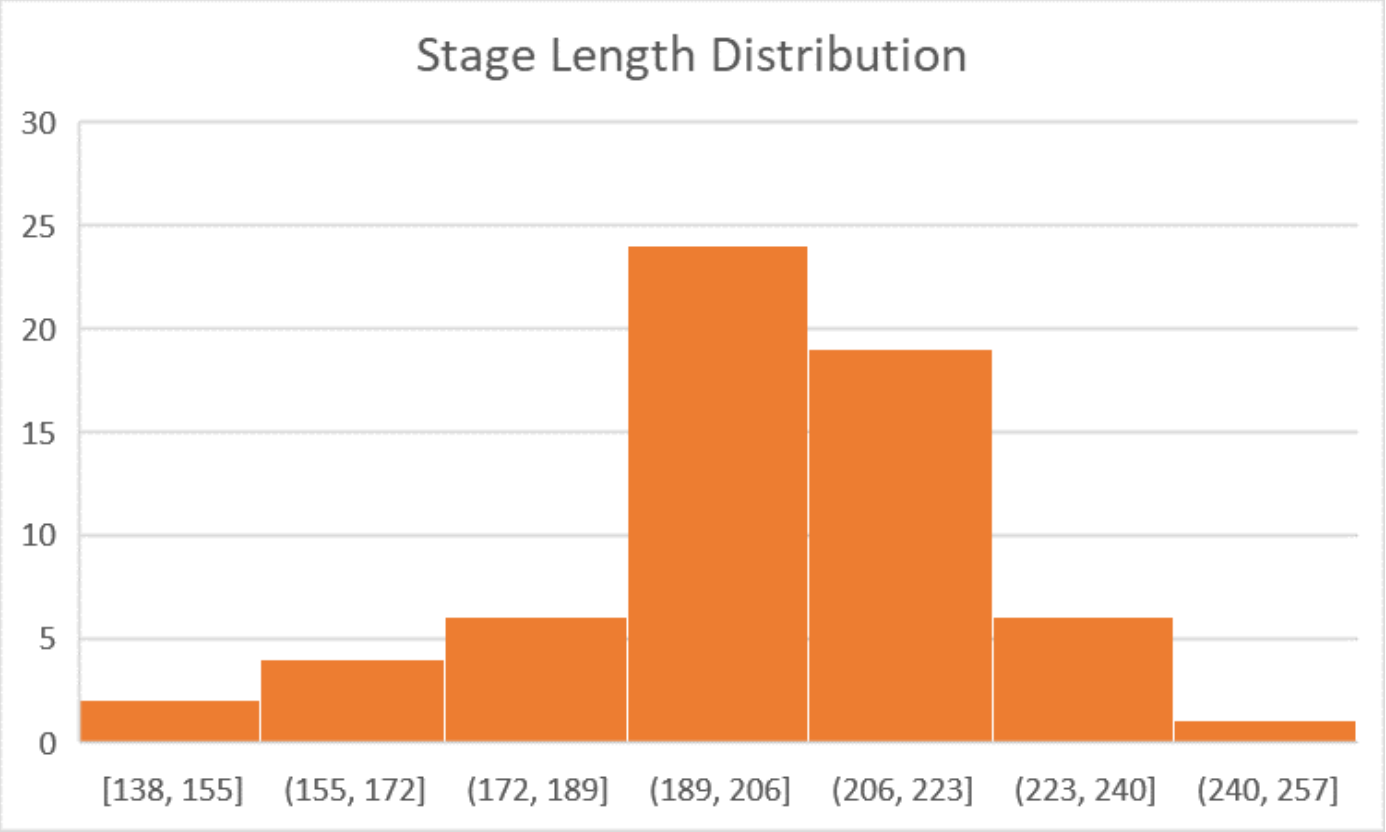
Segmentation Summary

Segment ID	Depth Start	Depth End	Segment L	No of Stag	Stages	GR_MWD	RockMSE	cture Inten	C1	C2	C3	TG
A	20275	20716	441	2	2,3	251	61203	0.270	64.1%	33.8%	2.1%	1874
B	19860	20275	415	2	4,5	240	78735	0.292	63.0%	34.9%	2.1%	1429
C	19480	19860	380	2	6,7	230	55351	0.192	62.7%	34.6%	2.6%	1699
D	19035	19480	445	2	8,9	217	66093	0.167	64.3%	33.6%	2.0%	2713
E	18450	19035	585	3	10,11,12	243	68129	0.279	62.3%	35.5%	2.1%	2820
F	17870	18450	580	3	13,14,15	236	58886	0.281	61.3%	36.5%	2.2%	2033
G	17230	17870	640	3	16,17,18	215	65977	0.240	65.8%	32.1%	2.1%	2118
H	16670	17230	560	3	19,20,21	249	57494	0.376	65.5%	32.4%	2.1%	2291
I	16205	16670	465	3	22,23,24	244	66681	0.508	63.0%	34.9%	2.2%	1715
J	16020	16205	185	1	25	207	73943	0.342	55.9%	41.9%	2.2%	1723
K	15345	16020	675	3	26,27,28	243	64730	0.522	58.8%	39.0%	2.2%	1555
L	14485	15345	860	4	29,30,31,32	200	65015	0.483	65.5%	32.3%	2.2%	1745
M	13660	14485	825	4	33,34,35,36	266	53143	0.536	66.9%	30.9%	2.2%	2193
N	12840	13660	820	4	37,38,39,40	265	65787	0.623	61.4%	36.4%	2.1%	2559
O	12250	12840	590	3	41,42,43	253	71970	0.782	62.8%	35.0%	2.1%	2401
P	11465	12250	785	4	44,45,46,47	284	68060	0.863	67.1%	30.9%	2.0%	2469
Q	10810	11465	655	3	48,49,50	177	80276	0.473	67.0%	30.9%	2.1%	1615
R	9360	10810	1450	7	2,53,54,55,5	260	68458	0.769	65.6%	32.3%	2.1%	1934
S	8590	9360	770	4	58,59,60,61	229	59479	0.589	68.6%	29.2%	2.2%	1996
T	8262	8590	328	2	62,63	248	52479	2.285	63.7%	34.1%	2.2%	1306

Top 1/5
Median
Bottom 1/5

Stage Length Distribution

- Stage lengths vary depending on well segmentation
- Average stage length = 201’

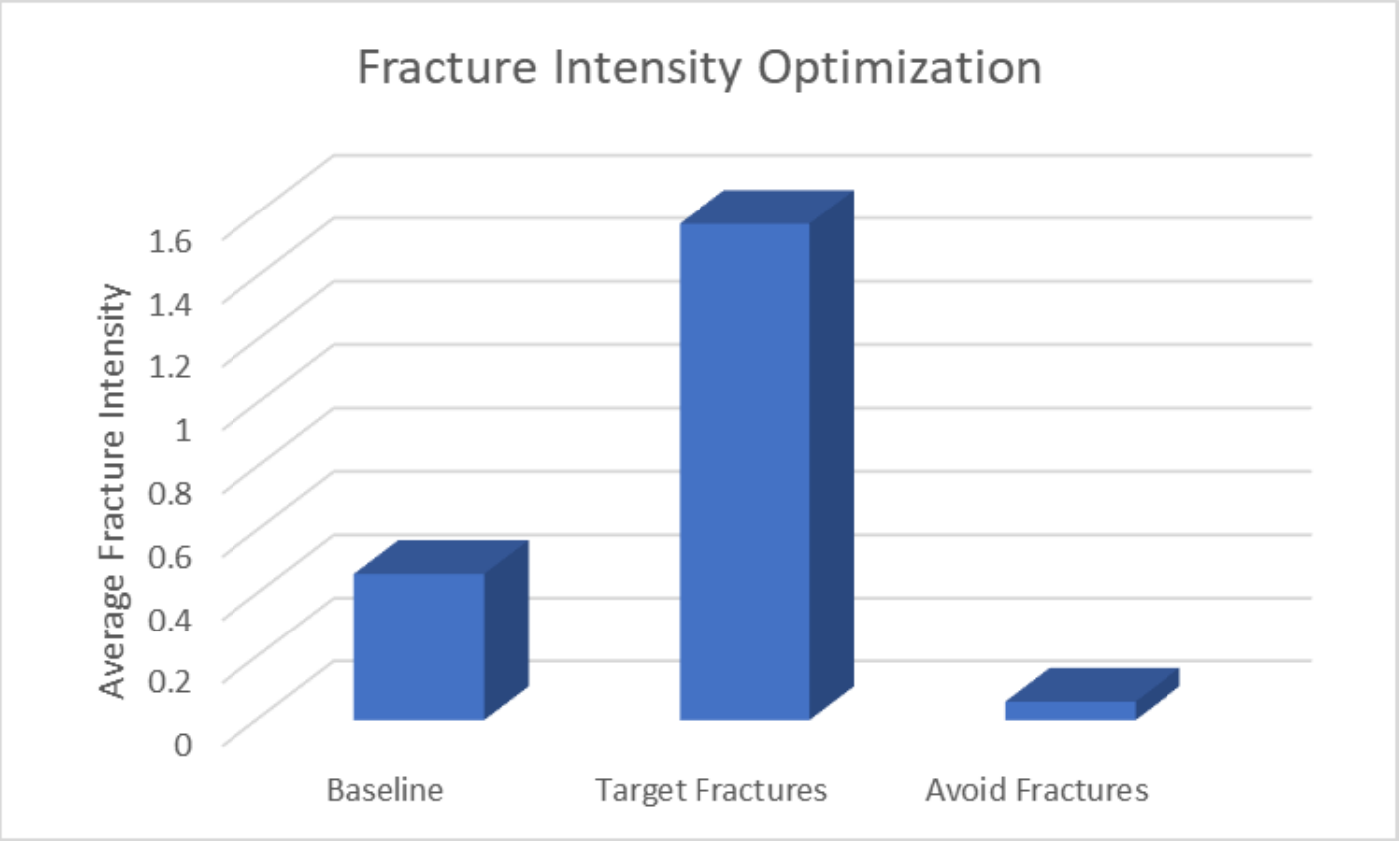


PerfAct – Optimization Parameters

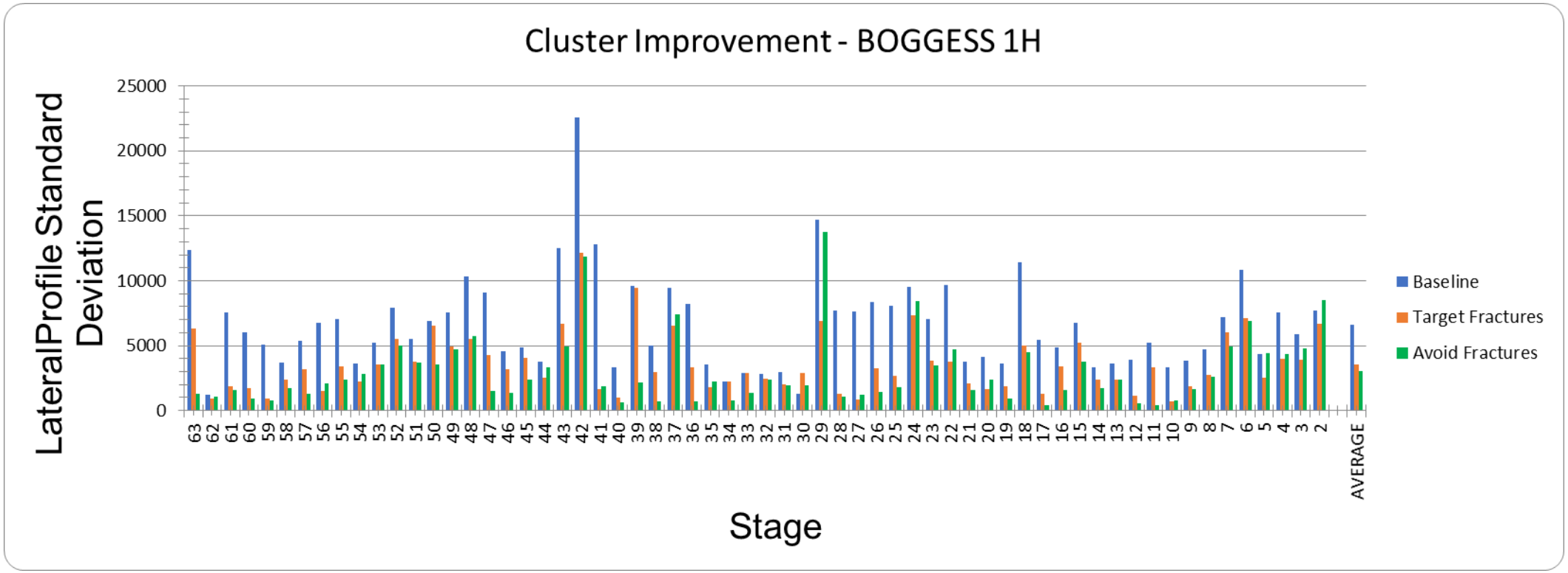
Optimization Parameters

Optimization was performed to put clusters in:

- Similar rock MSE (50%),
- Target or avoid fractures (35%)
- Avoid sudden changes (15%)



Reduction in RockMSE Standard Deviation



50% Reduction in Standard Deviation

Fluid Distribution

Fluid Distribution

Fluid distribution is estimated at each cluster based on OmniLog and the following completion parameters

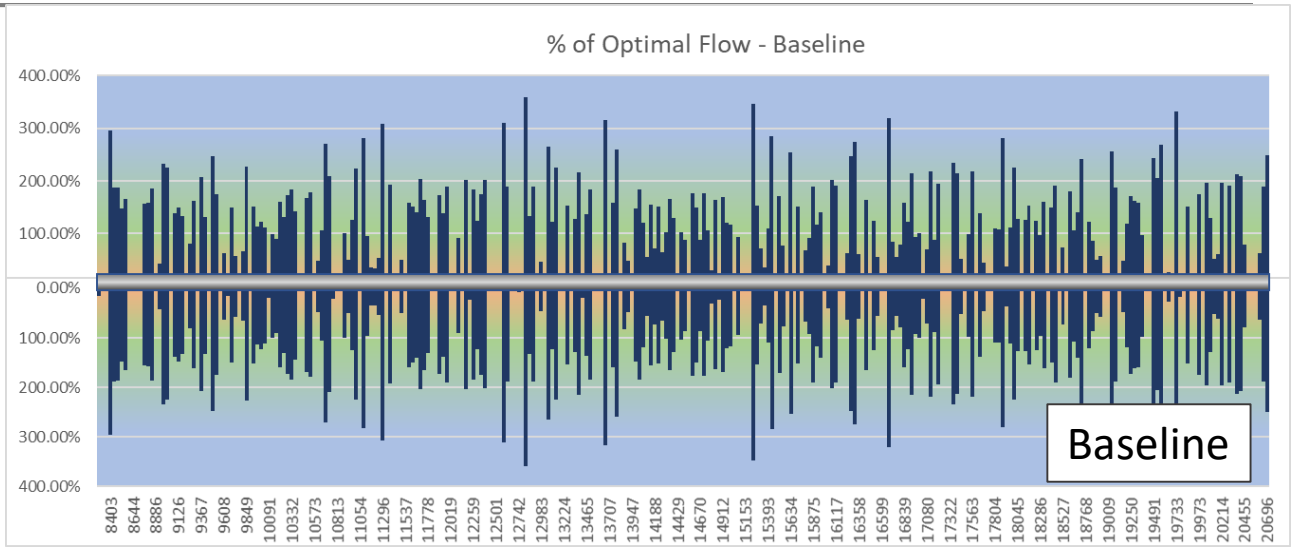
0.42” Entry hole diameter
0.7 Discharge coefficient
90 bpm pump rate

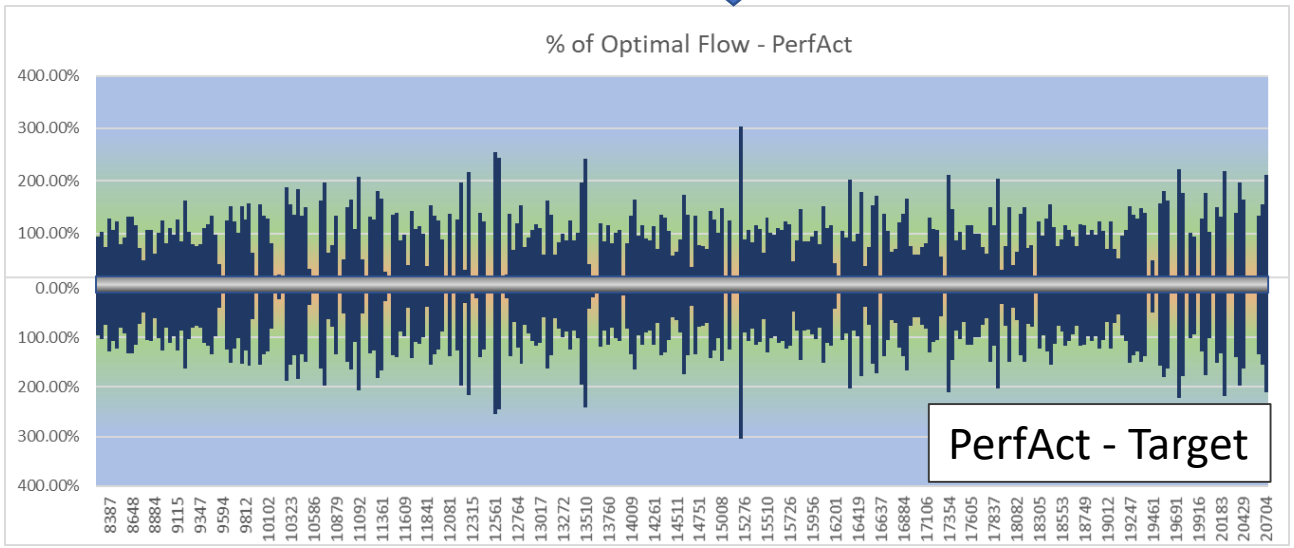
4/5 Clusters:

- 8 shots/cluster

6 Clusters:

- 6 shots/cluster

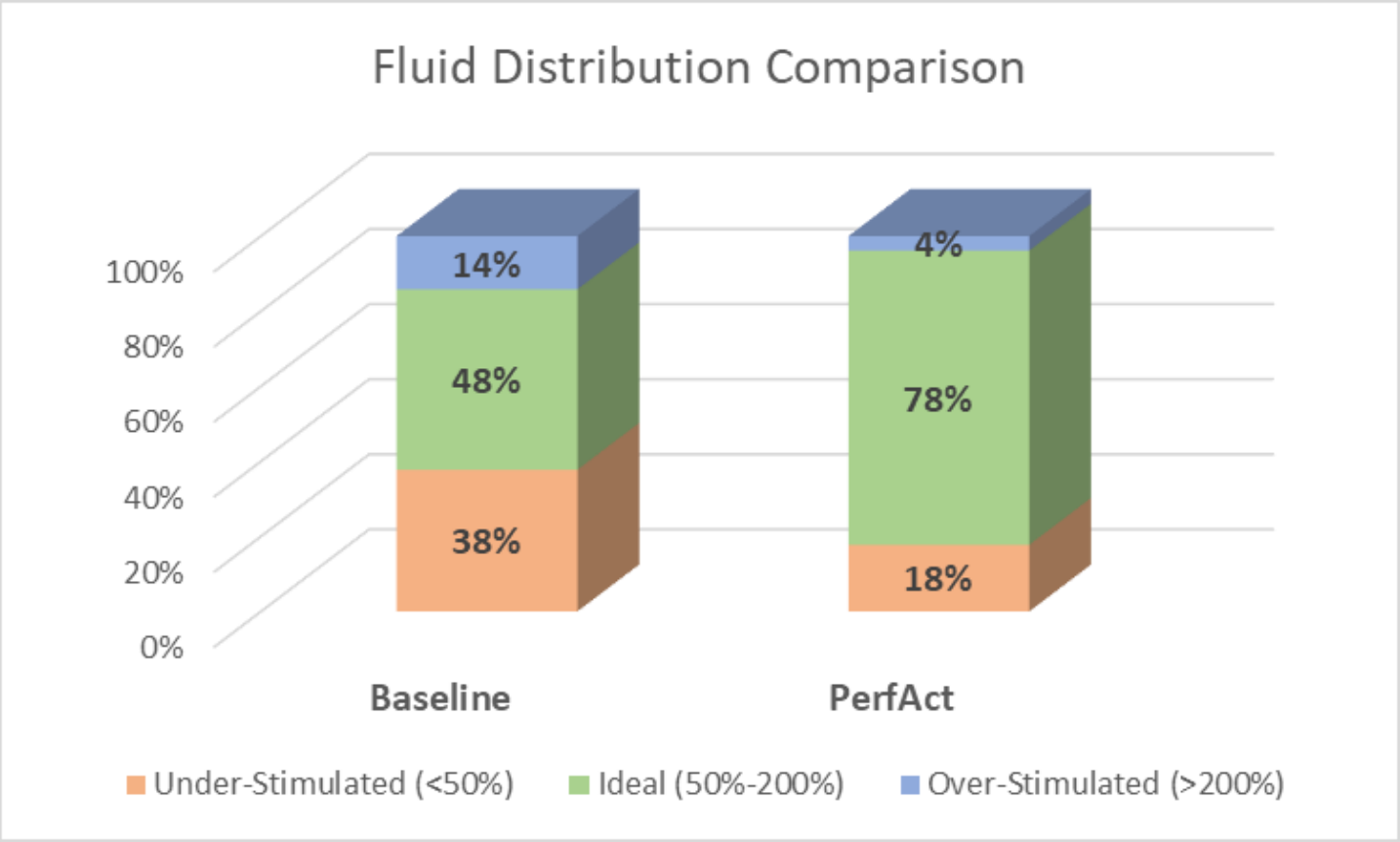




Fluid Distribution Summary

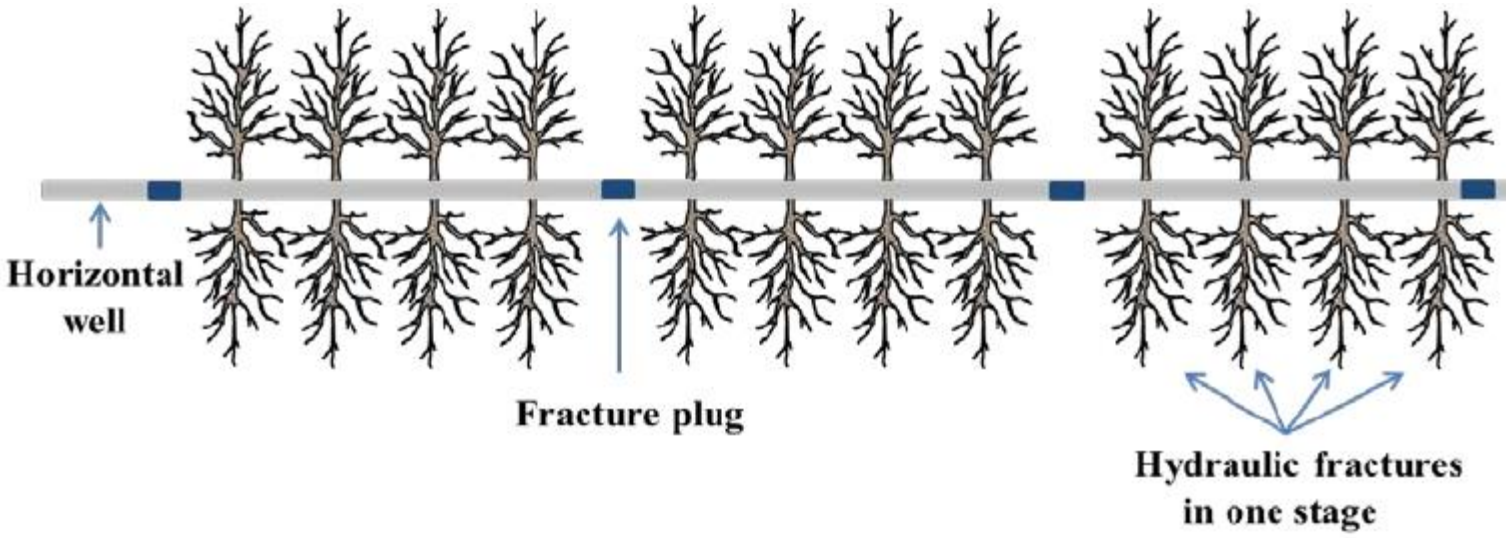
By placing perforations in like rock, we can achieve:

- 53% reduction in understimulated clusters
- 81% reduction in overstimulated clusters



Perforation Depth Control

Depth Control in Plug & Perf Completions



- Many completions designs based on geometric spacing
- Foot-by-foot data on formation characteristics not available or not utilized
- Precise placement of perforations is not critical in geometric design
- When actual rock measurements used to design completions, then accurate placement of perfs & plugs relative to those measurements is important
- The perforation design from PerfAct is provided on Driller's depth.

Casing String Design & Planning

- Use of toe sleeve impacts
  - Stage 1 initiation & space-out
  - Logistics & timing of wireline GR/CCL

- Use of adequate short “marker” casing joints recommended
  - Minimum 2-3 per lateral
  - More for longer laterals

- RA marker tags can optionally be used to aid correlation in low GR contrast

PDC Procedure – Shift Wireline to Driller's Depth

- Run wireline GR/CCL on first WL descent. Log from Toe to 200' above top perf or top marker joint & transmit LAS file to D2F ASAP. Maintain similar line speed and pump rate while logging.

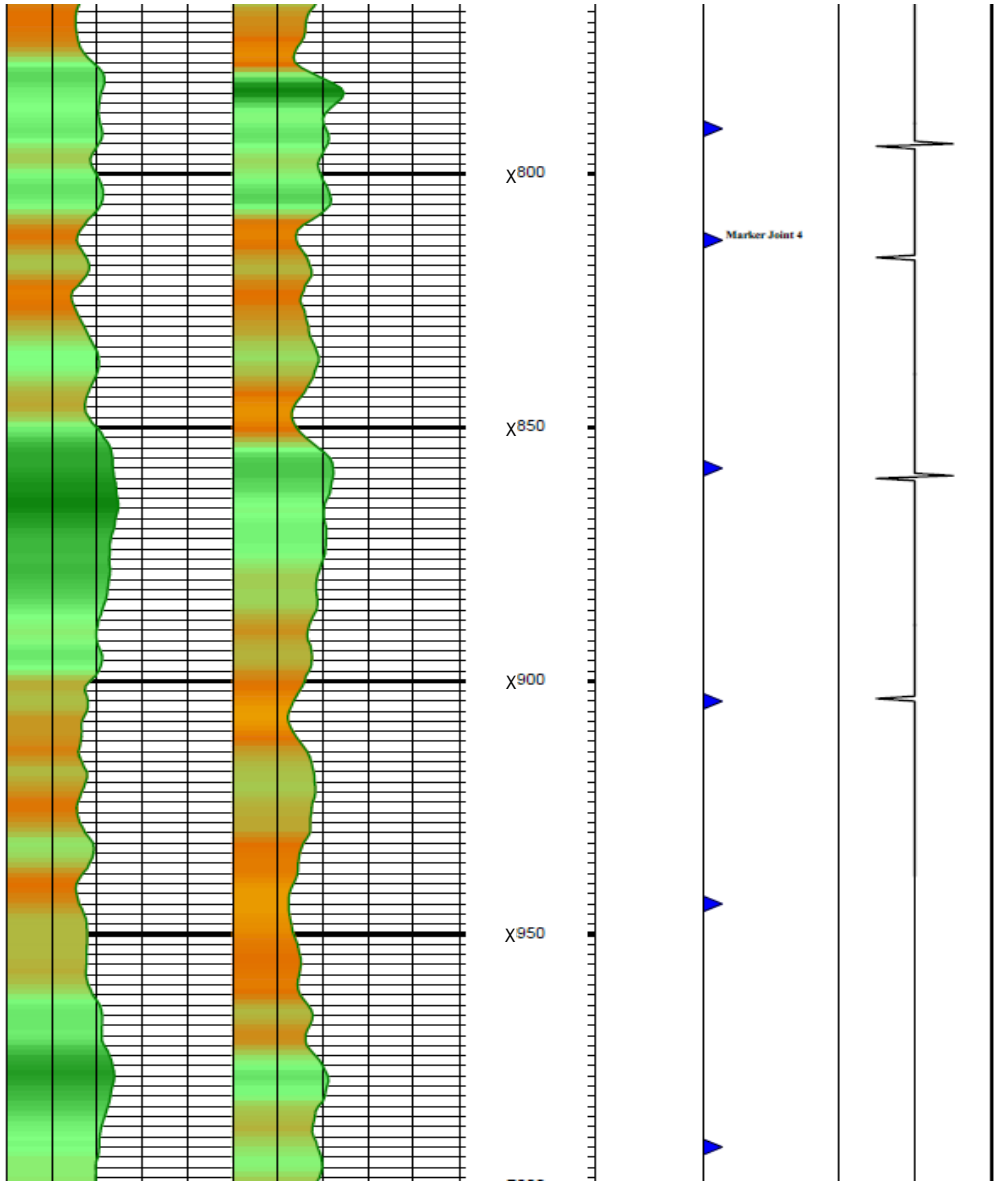
- D2F will depth match field GR/CCL to driller's depth using MWD GR and send corrected PDC log back to the field via operator.

- Perf depths and plug depths can then be used directly from this log or from perf schedule with no further adjustment.

- Procedure for subsequent descents is to tie in to adjusted PDC Log at the top marker joint, then again using 1 or 2 collars close to the perf interval for each stage.

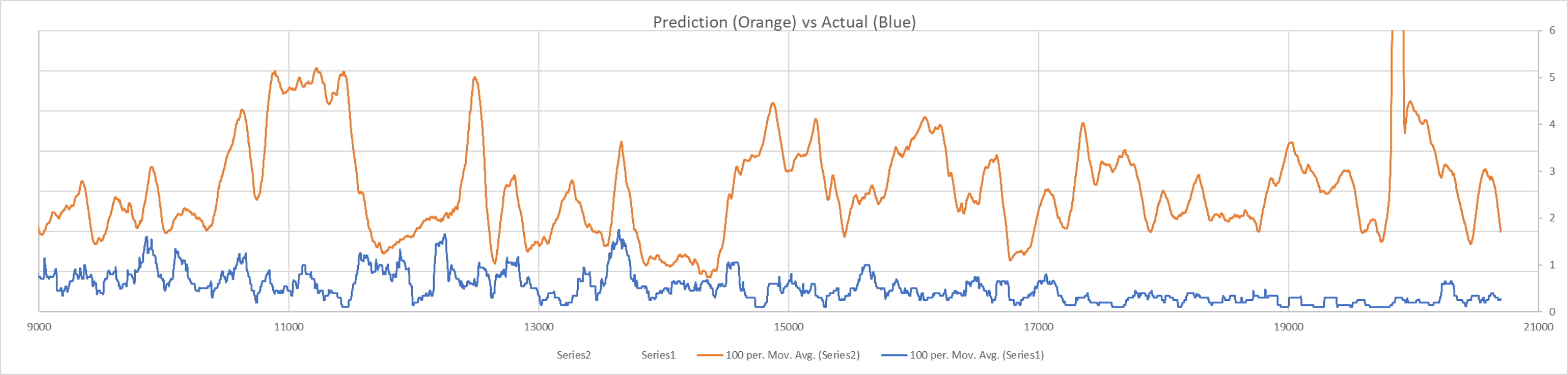
PDC Log Example 1

- Simple, fit for purpose log display for field use
- Marker joints & accessories annotated
- Low resolution LAS file may miss some collars



Fracture Prediction (Probability)

- New algorithm has recently been created that predicts fractures based on a number of factors (RockMSE, GR, Gas Shows)
- Still in early trials but results look promising



D2F Summary

- Data was of reasonably good quality across both wells, though there were several sections impacted by null values, missing data and spikes.
- Hardness levels and Heterogeneity are consistent with other Marcellus wells.
- Two designs were considered. One that targets fractures and one that avoids
- Reduction of standard deviation in RockMSE was 50% by using PerfAct.
- Stress variations amongst the perforations was significantly reduced across all stages by using PerfAct. This resulted in:
  - 32% more clusters stimulated
  - 81% fewer dominant fractures