Knowledge Integrity Service

# Case Study

## DeGolyer and MacNaughton Workflow for Well Performance Analysis, Fracture Modeling and Completion Design

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Dallas, Texas

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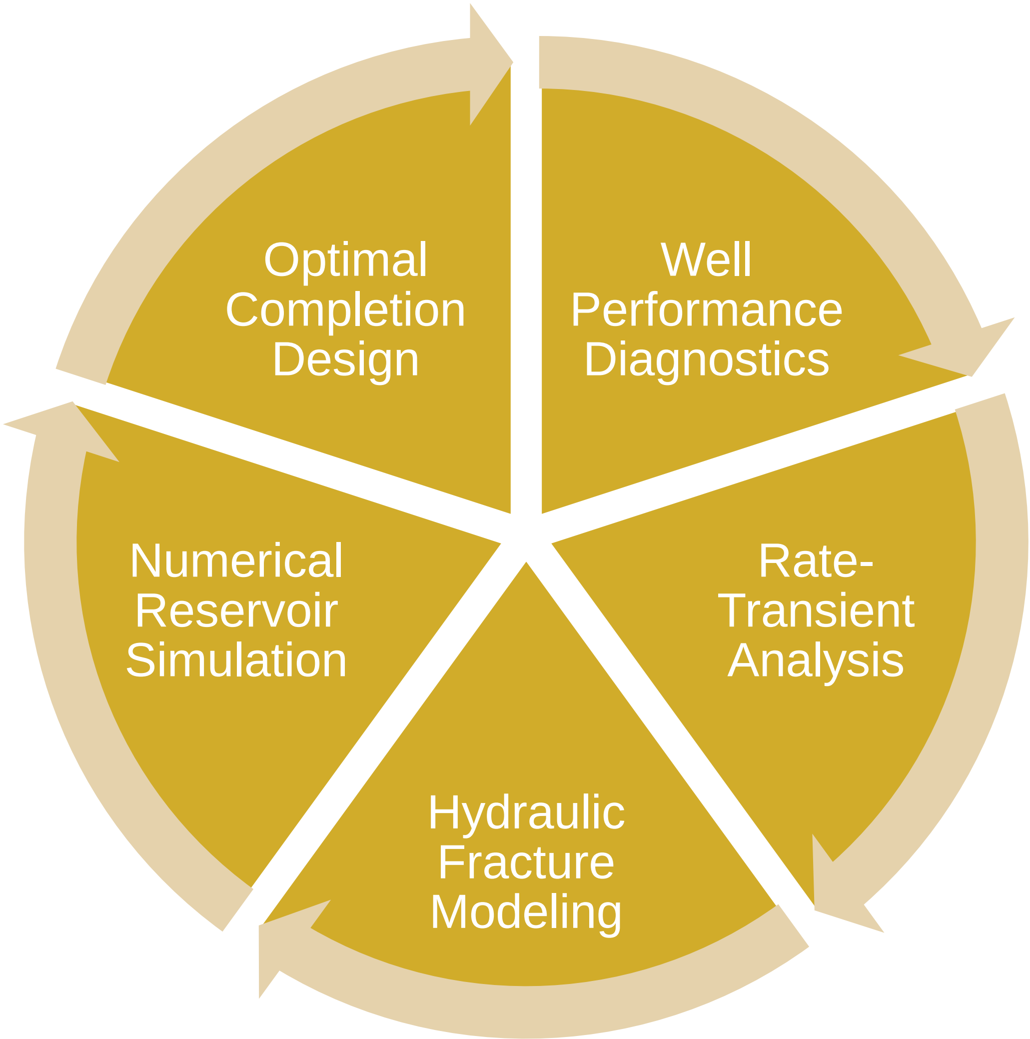
Worldwide Petroleum Consulting

# Workflow

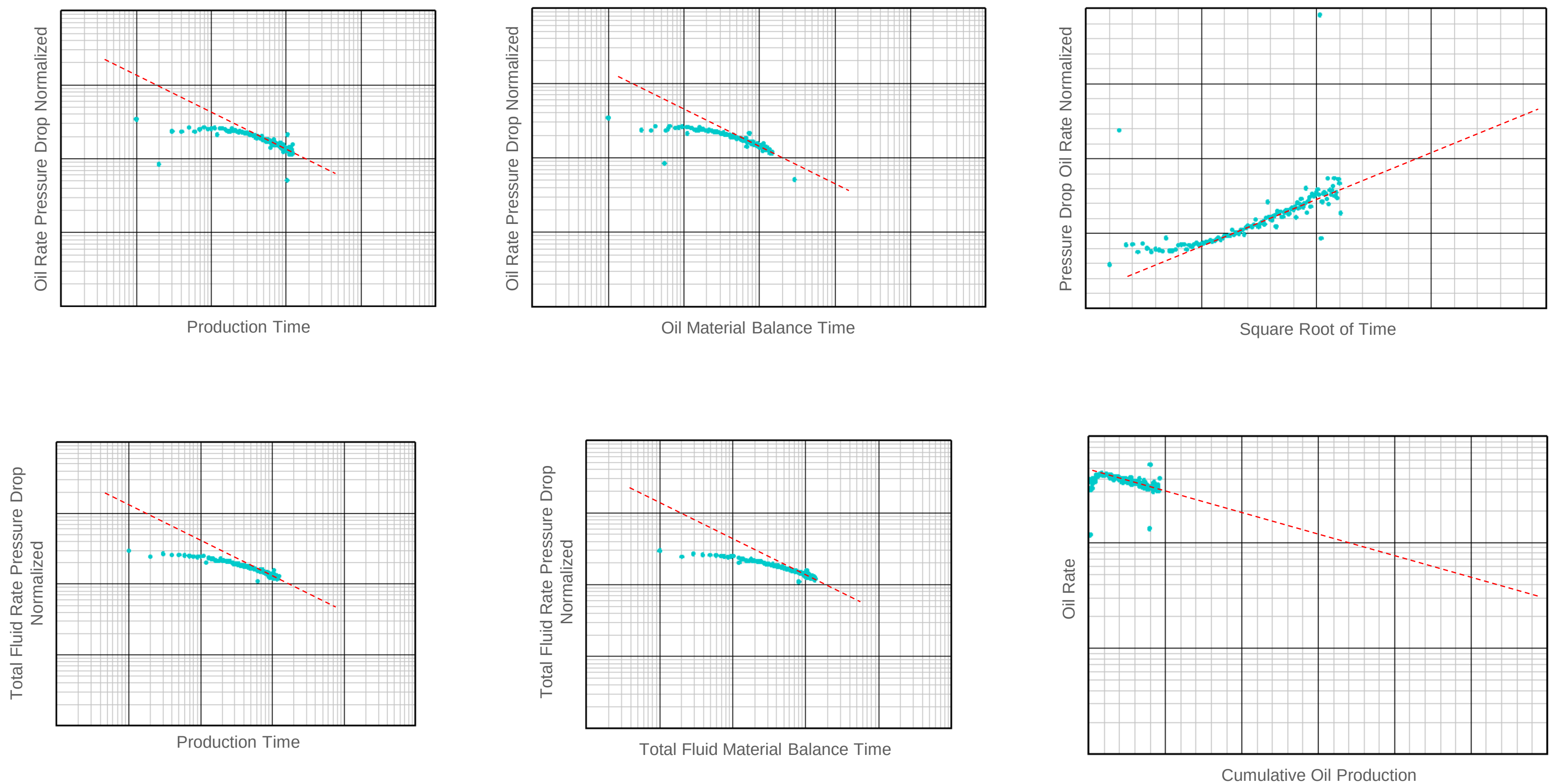
Multi-step process to assess well performance and completion design



# Production Diagnostics

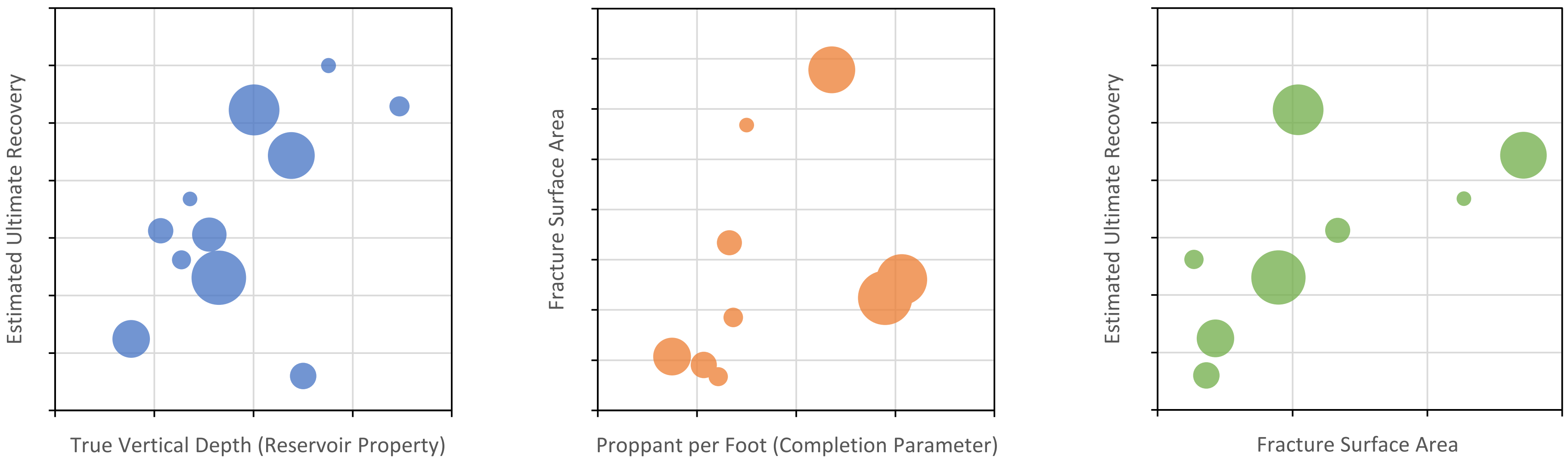
Deliverables of single well production diagnostics are metrics, flow regimes, etc.

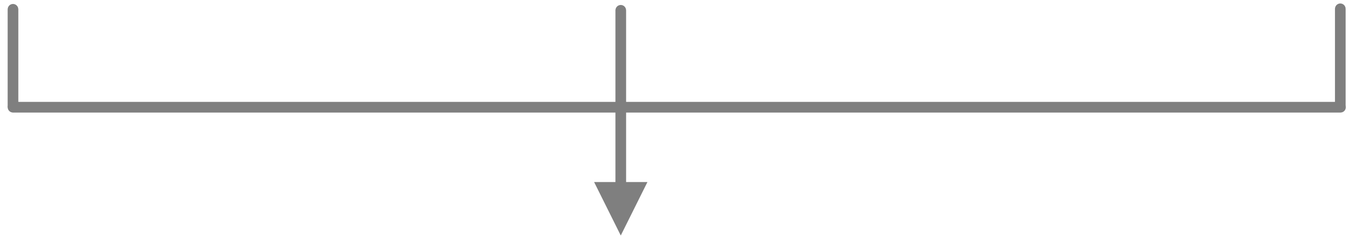
## Diagnostics Dashboard



# Production Diagnostics

## Correlation of metrics from diagnostics yields potential drivers of productivity

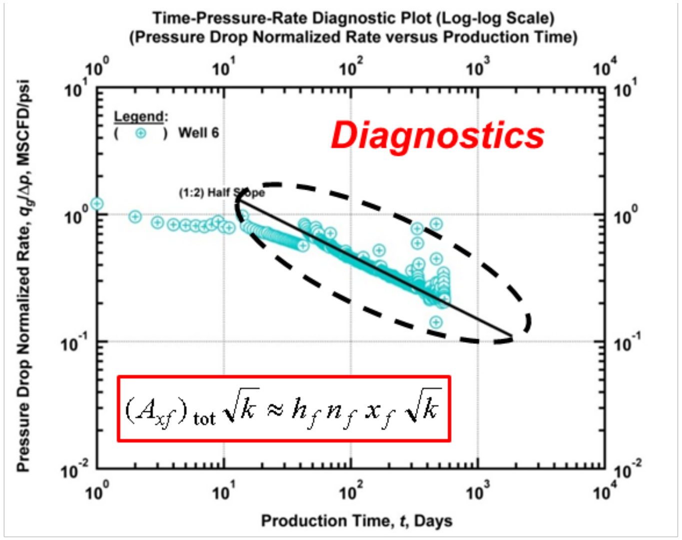


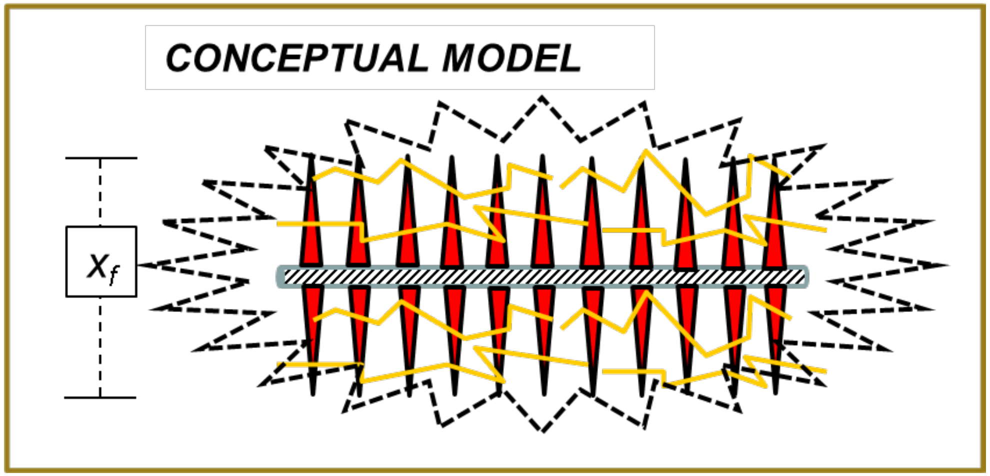



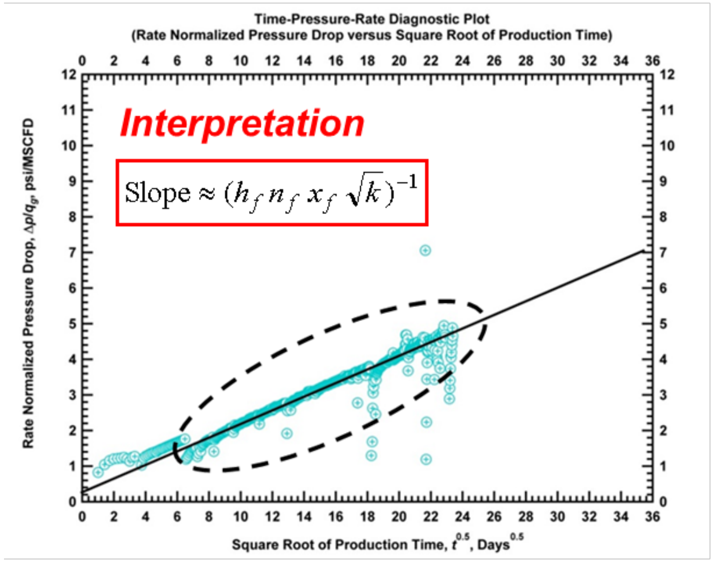
Metrics from well performance diagnostics, completion parameters, and reservoir properties are compared in search of potential drivers of productivity

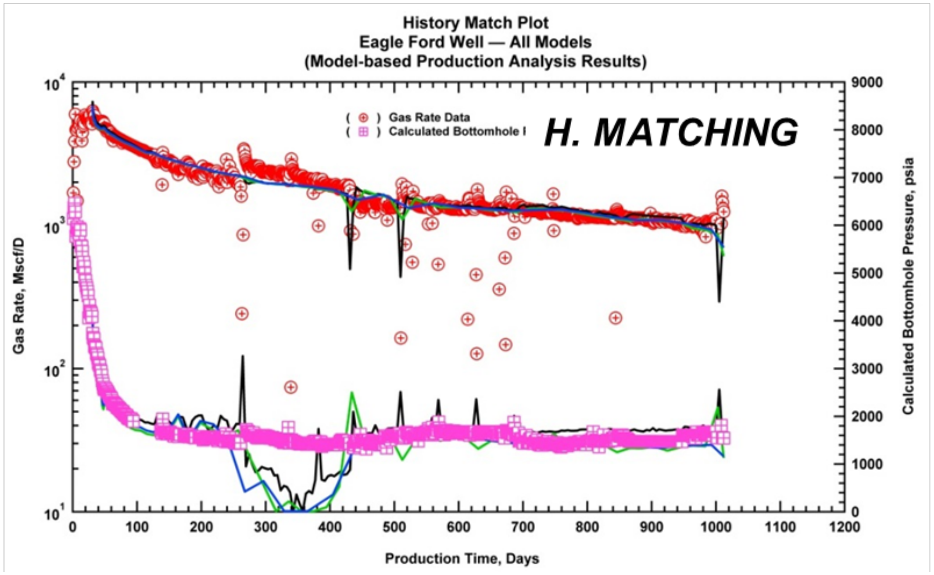
# Rate Transient Analysis

Production diagnostics provides insight into understanding flow regimes and relating to models



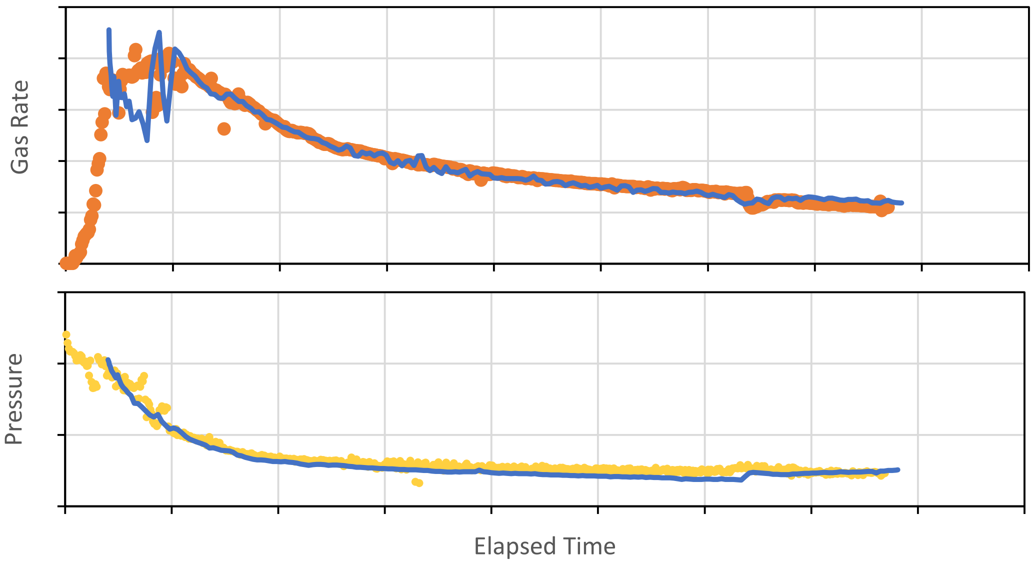



# Rate Transient Analysis

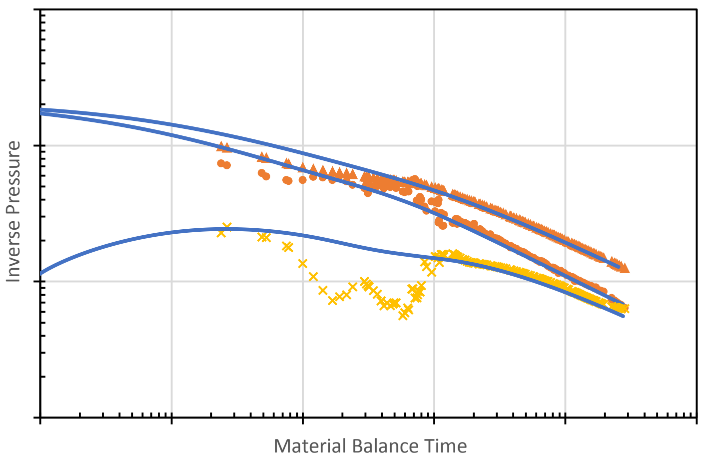
Results provide effective fracture surface area and permeability (to be used in reservoir simulation)

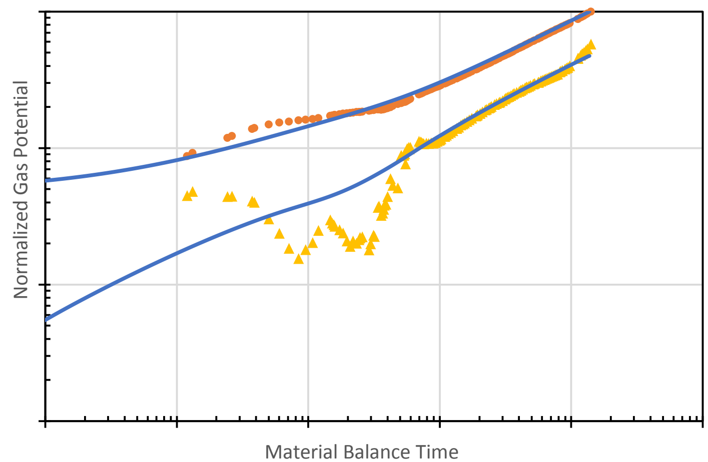
## History Match Plots




| Property | Value |
|---|---|
| Skin | 0.001 |
| Well length, ft | 5000 |
| Number of fractures | 100 |
| Fracture half length, ft | 75 |
| Fracture height, ft | 150 |
| Permeability, md | 5E-4 |

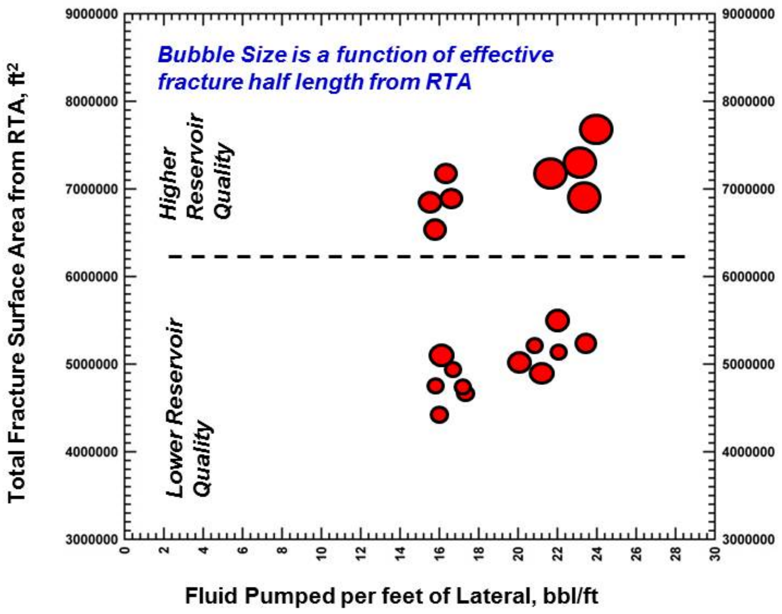
## Diagnostic Plots



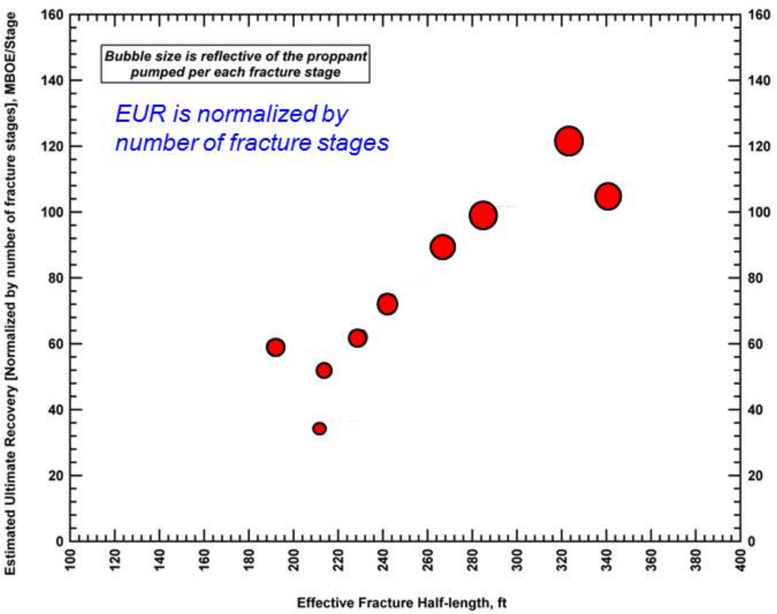



# Rate Transient Analysis

## Results are generally used to evaluate completion efficiency when multiple wells are analyzed




*Example 1 – Correlations of rate transient analysis results with completion design parameters*



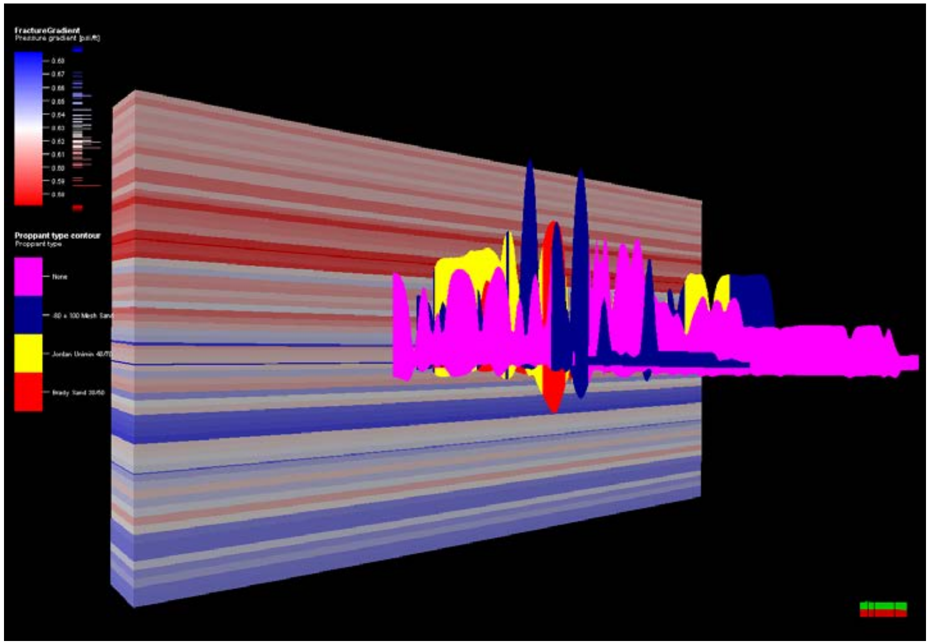

*Example 2 – Cross plot of effective fracture half-length values from rate transient analysis*

- Tie to Well Completion — Comparison of RTA Results vs. Completions Design
  - Example 1 illustrates a case study where increasing amount of fluid pumped (i.e., slick water jobs) yields higher total fracture surface area (through RTA).
  - Example 2 indicates that better completions (translated as higher effective fracture half-length in RTA) provide higher EUR values.

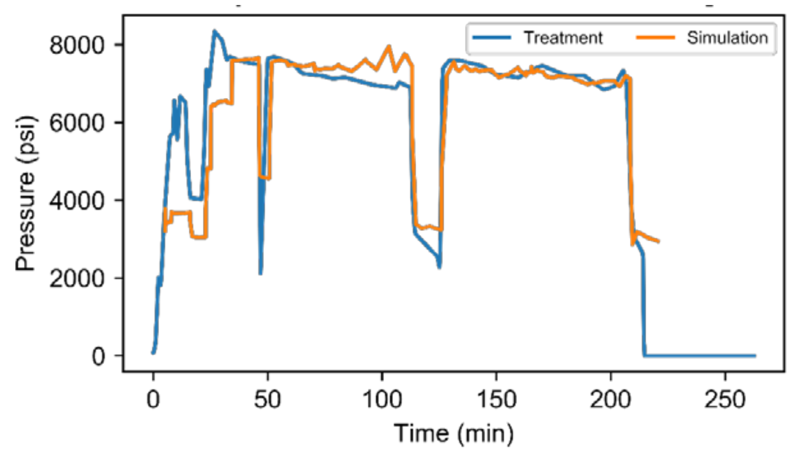
# Hydraulic Fracture Modeling

Fracture modeling provides fracture geometry through history matching treatment pressure data

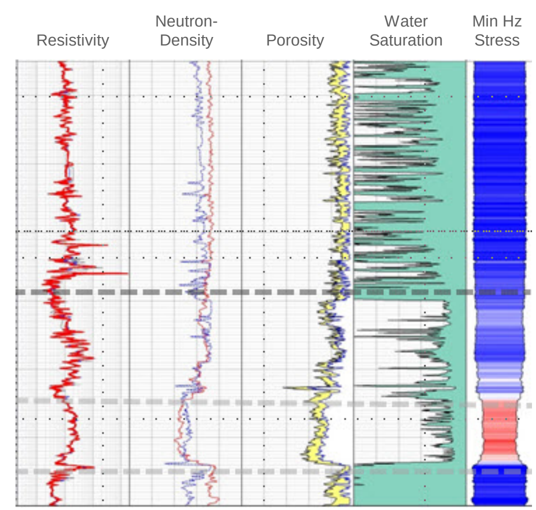
3-D View – Proppant type distribution along the fracture plane overlain the formation fracture gradient



Matching Actual Treatment Pressure Data



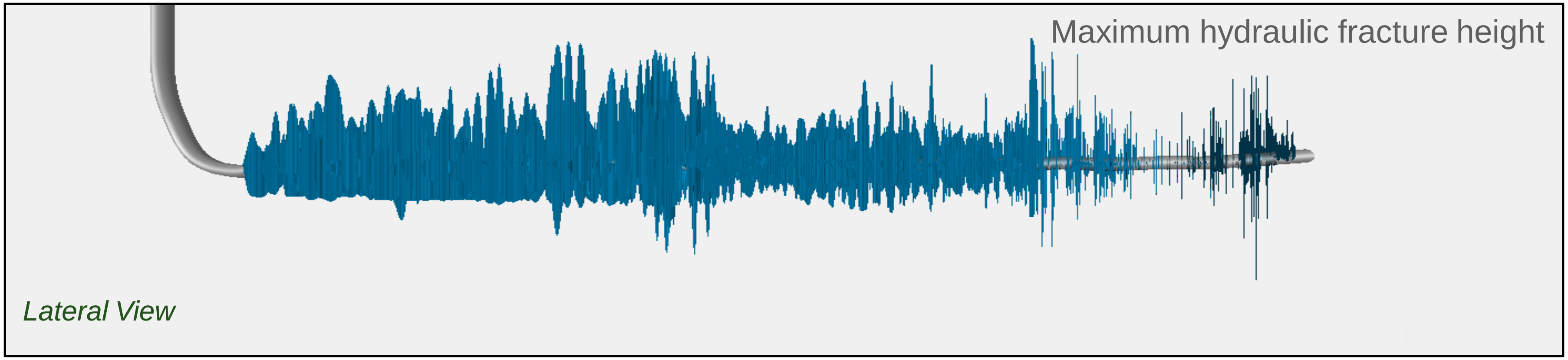

Petrophysical and Geomechanical Properties from Logs

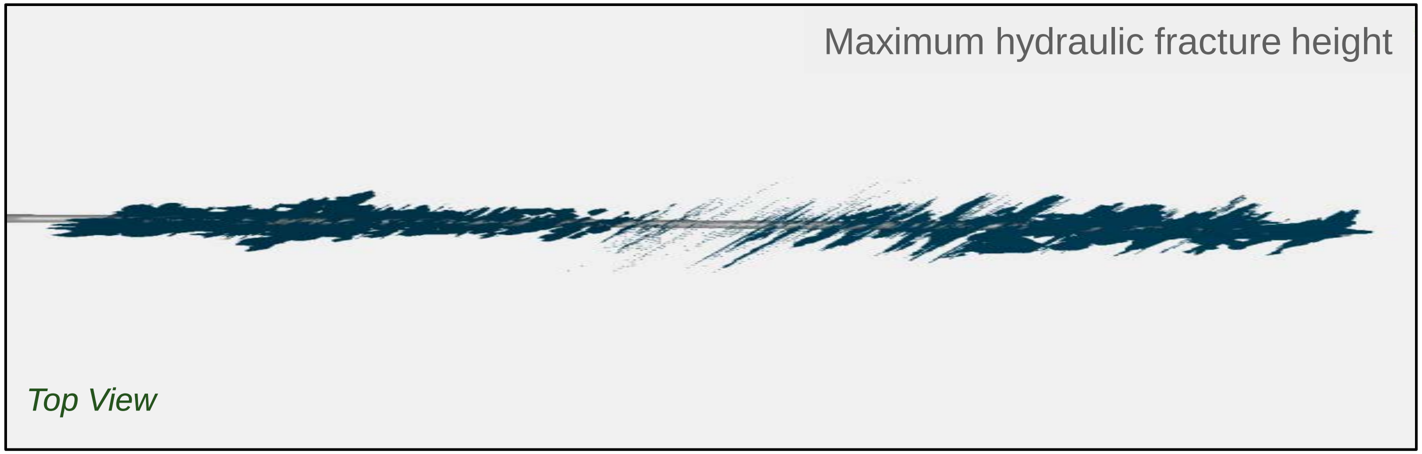



- Treatment pressures were calibrated to actual data.
- Fracture properties are the main output.

# Hydraulic Fracture Modeling

## Generated fracture geometry is incorporated into a reservoir model for modeling production

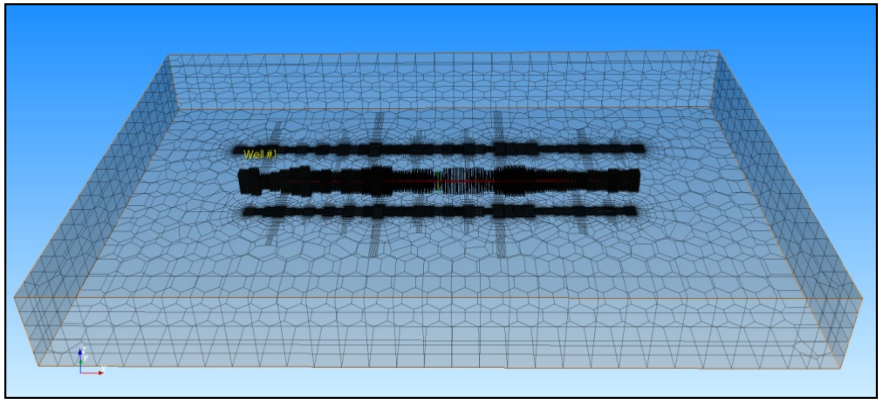


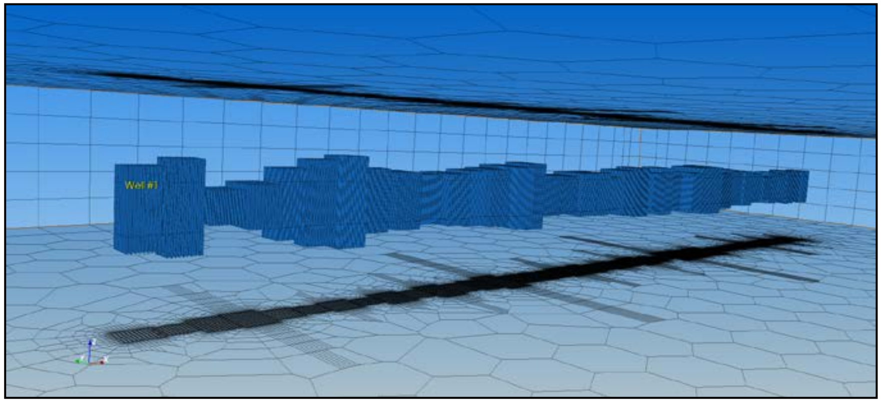



# Numerical Reservoir Simulation

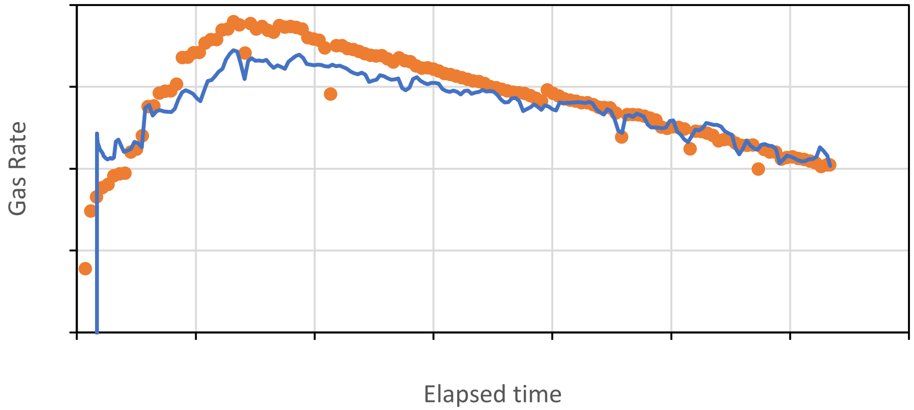
## Fracture geometry from modeling is simplified and then utilized in reservoir simulation

### Reservoir Simulation Grid Overview



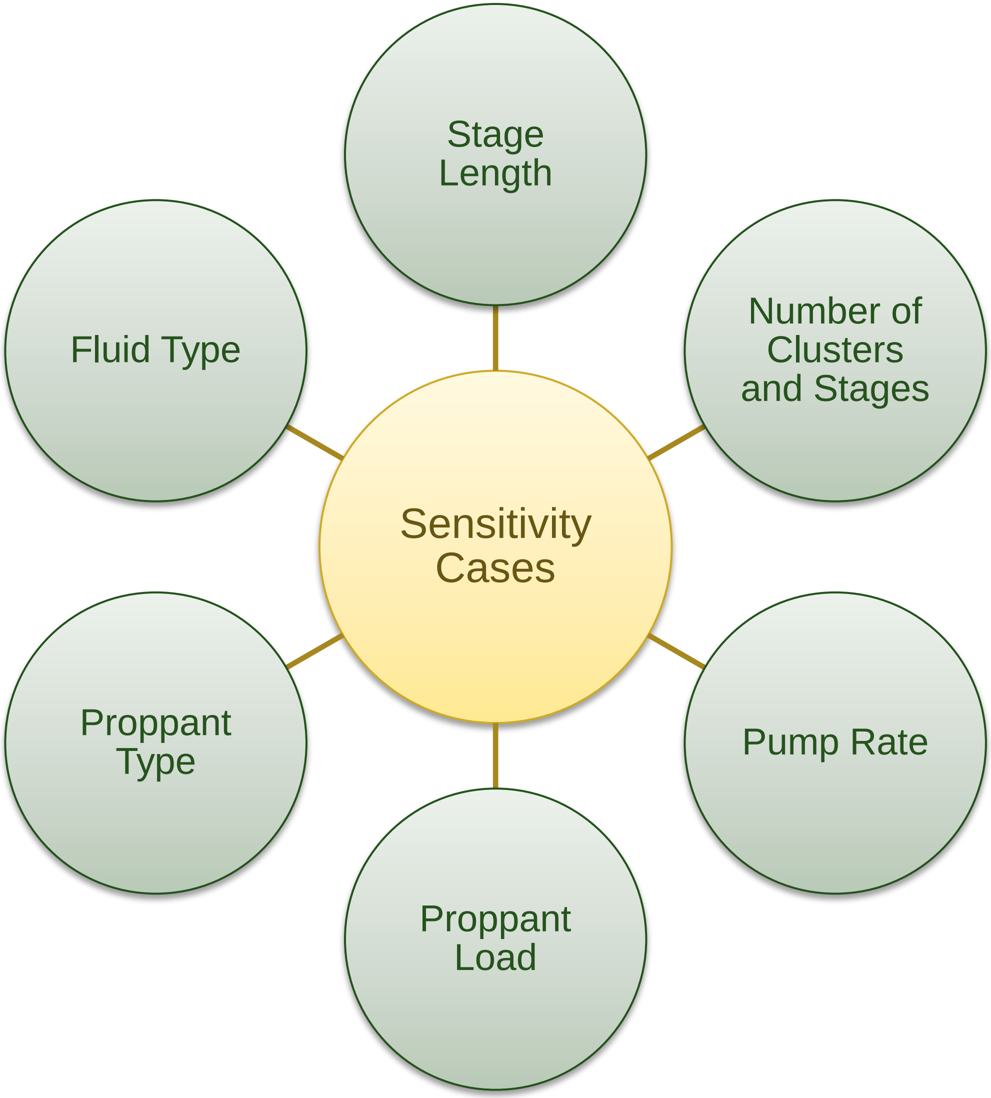




### History Match



# Completion Design Sensitivities

## Sensitivities are performed to investigate impact of key completion parameters




### Pump Rate: Base and -25%

- [ ] Horiz. stresses
- [ ] Young's modulus
- [ ] Stress contrast
- [x] Pump rate
- [ ] Fluid volume
- [x] Prop mass
- [x] Fluid type
- [ ] Prop type
- [ ] 2D DFN

| | PumpStep | BasePumpRate (bbl/min) | DesignPumpRate1(%) (bbl/min) |
|---|---|---|---|
| 1 | | - | -25.00 |
| 2 | Pad | 12.00 | 9.00 |
| 3 | (New stage | 14.00 | 10.50 |
| 4 | (New stage | 80.00 | 60.00 |
| 5 | 0.25 PPA | 80.00 | 60.00 |
| 6 | 0.5 PPA | 80.00 | 60.00 |
| 7 | 0.75 PPA | 80.00 | 60.00 |
| 8 | 1 PPA | 80.00 | 60.00 |
| 9 | 1.25 PPA | 80.00 | 60.00 |
| 10 | 1.5 PPA | 80.00 | 60.00 |
| 11 | 1.75 PPA | 80.00 | 60.00 |

### Proppant Mass: Base, -10% and -25%

- [ ] Horiz. stresses
- [ ] Young's modulus
- [ ] Stress contrast
- [x] Pump rate
- [ ] Fluid volume
- [x] Prop mass
- [x] Fluid type
- [ ] Prop type
- [ ] 2D DFN

| | PumpStep | BasePropMass (lb) | DesignPropMass1(%) (lb) | DesignPropMass2(%) (lb) |
|---|---|---|---|---|
| 1 | | - | -10.00 | -25.00 |
| 2 | Pad | 0.00 | 0.00 | 0.00 |
| 3 | (New stage | 0.00 | 0.00 | 0.00 |
| 4 | (New stage | 0.00 | 0.00 | 0.00 |
| 5 | 0.25 PPA | 1750.00 | 1575.00 | 1312.50 |
| 6 | 0.5 PPA | 8500.00 | 7650.00 | 6375.00 |
| 7 | 0.75 PPA | 27000.00 | 24300.00 | 20250.00 |
| 8 | 1 PPA | 36000.00 | 32400.00 | 27000.00 |
| 9 | 1.25 PPA | 45000.00 | 40499.99 | 33750.00 |
| 10 | 1.5 PPA | 54000.00 | 48600.00 | 40500.00 |
| 11 | 1.75 PPA | 63000.00 | 56700.00 | 47250.00 |

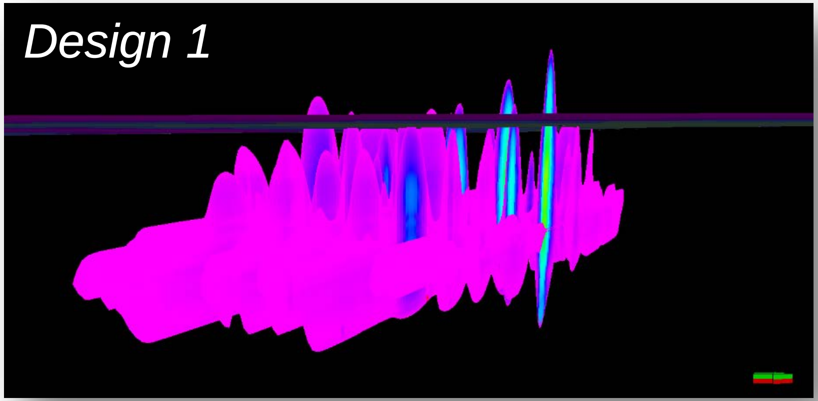
### Fluid Type: Base (slick water) and WF160 (60 lb/mgal linear gel)

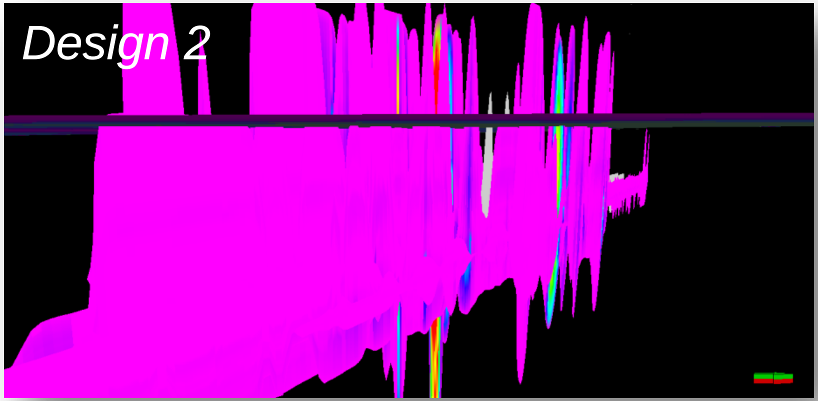
- [ ] Horiz. stresses
- [ ] Young's modulus
- [ ] Stress contrast
- [x] Pump rate
- [ ] Fluid volume
- [x] Prop mass
- [x] Fluid type
- [ ] Prop type
- [ ] 2D DFN

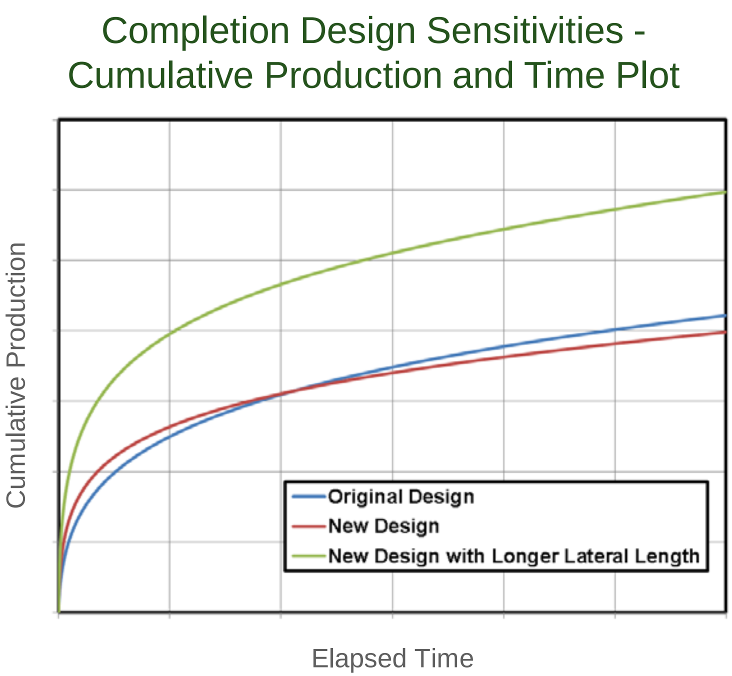
| | PumpStep | BaseFluidType | DesignFluidType1 |
|---|---|---|---|
| 1 | | - | WF160 |
| 2 | Pad | Base Fluid - B315(0.2 | WF160 |
| 3 | (New stage | HCl 15 | HCl 15 |
| 4 | (New stage | Base Fluid - B315(0.2 | WF160 |
| 5 | 0.25 PPA | Base Fluid - B315(0.2 | WF160 |
| 6 | 0.5 PPA | Base Fluid - B315(0.2 | WF160 |
| 7 | 0.75 PPA | Base Fluid - B315(0.2 | WF160 |
| 8 | 1 PPA | Base Fluid - B315(0.2 | WF160 |
| 9 | 1.25 PPA | Base Fluid - B315(0.2 | WF160 |
| 10 | 1.5 PPA | Base Fluid - B315(0.2 | WF160 |
| 11 | 1.75 PPA | Base Fluid - B315(0.2 | WF160 |

# Completion Design Sensitivities

Reservoir simulation is performed with fracture geometry based on design sensitivities



# Considerations for Evaluation and Development

Optimal evaluation and development involves an integrated approach

## Completion Design and Efficiency

- Fracturing fluids
- Proppant types and amounts
- Number of stages/clusters
- Flowback/choke management
- Fracture properties…

## Production Performance and Diagnostics

- Plots: Flowback evaluation
- Plots: Choke management
- Plots: Flow regime identification

## Reservoir Characterization

- In-place volume
- Thermal maturity (PVT)
- Natural fractures
- In-situ stresses
- Lateral landing point
- Fracture dimensions
- Mineralogy/brittleness
- Reservoir pressure

## Calibration, Analysis and Forecasting

- Rate-transient analysis
- Evaluation of parameters
- Correlation of results
- Numerical reservoir simulation
- Well interference