Distinguished Lecturer Program

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Distinguished Lecturer Program

Multiple Pay Tight Gas Sands

Can the Lessons Learned in the Rockies Help You?

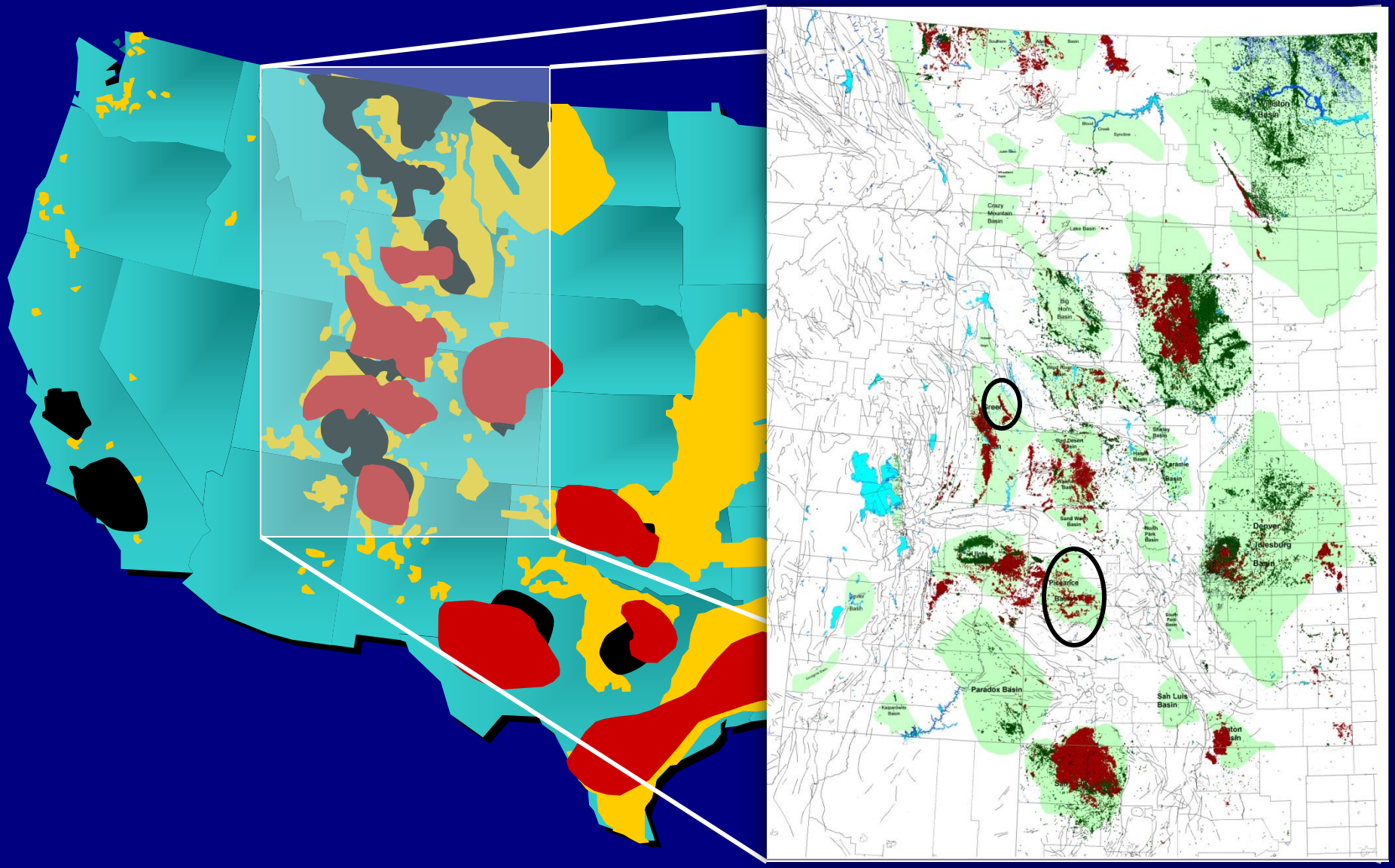
Mike Eberhard P.E.
Halliburton Energy Services

Society of Petroleum Engineers
Distinguished Lecturer Program
www.spe.org/dl

Agenda

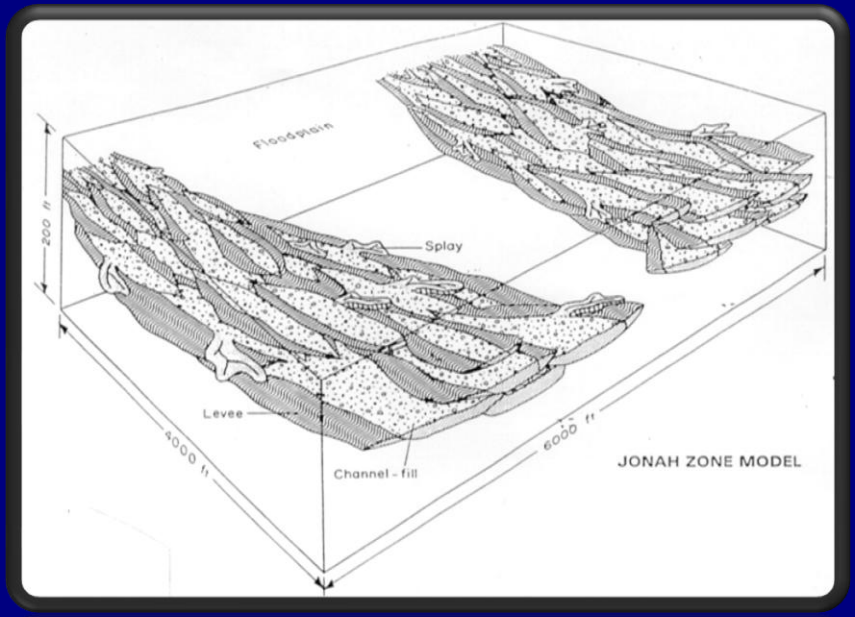
- Rocky Mountain Tight Gas
- “Factory” Completions for Efficiency
- Reservoir Considerations for Factory Completions
- Fracture Treatment Considerations
- Post Frac Evaluation
- Results
- Summary

Rocky Mountain Area - USA



Rockies Tight Gas Definition

- Lenticular sand formations dominate current completion programs
  - Sand shale sequences
- Resource plays
  - < 5 μd perm
- Hydraulic fracturing is required for economic production
- Over-pressured

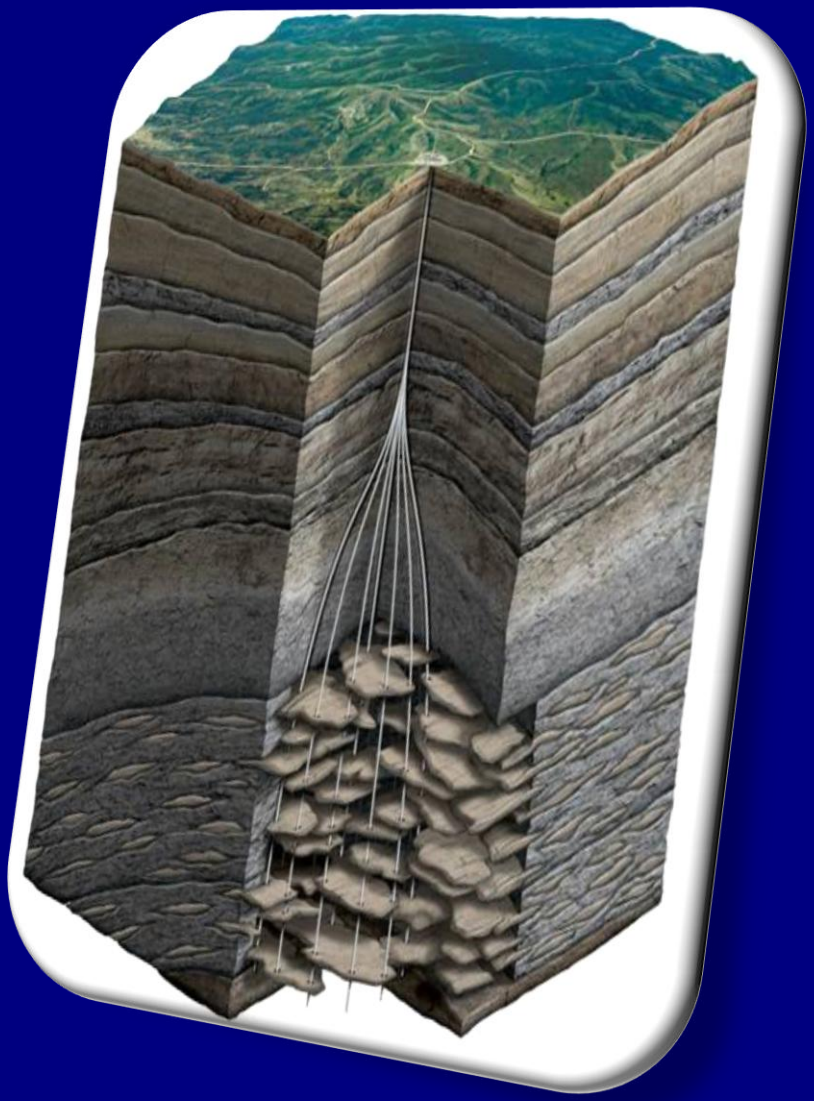


LiDAR-Orthophoto Composite Outcrop Photo – Piceance

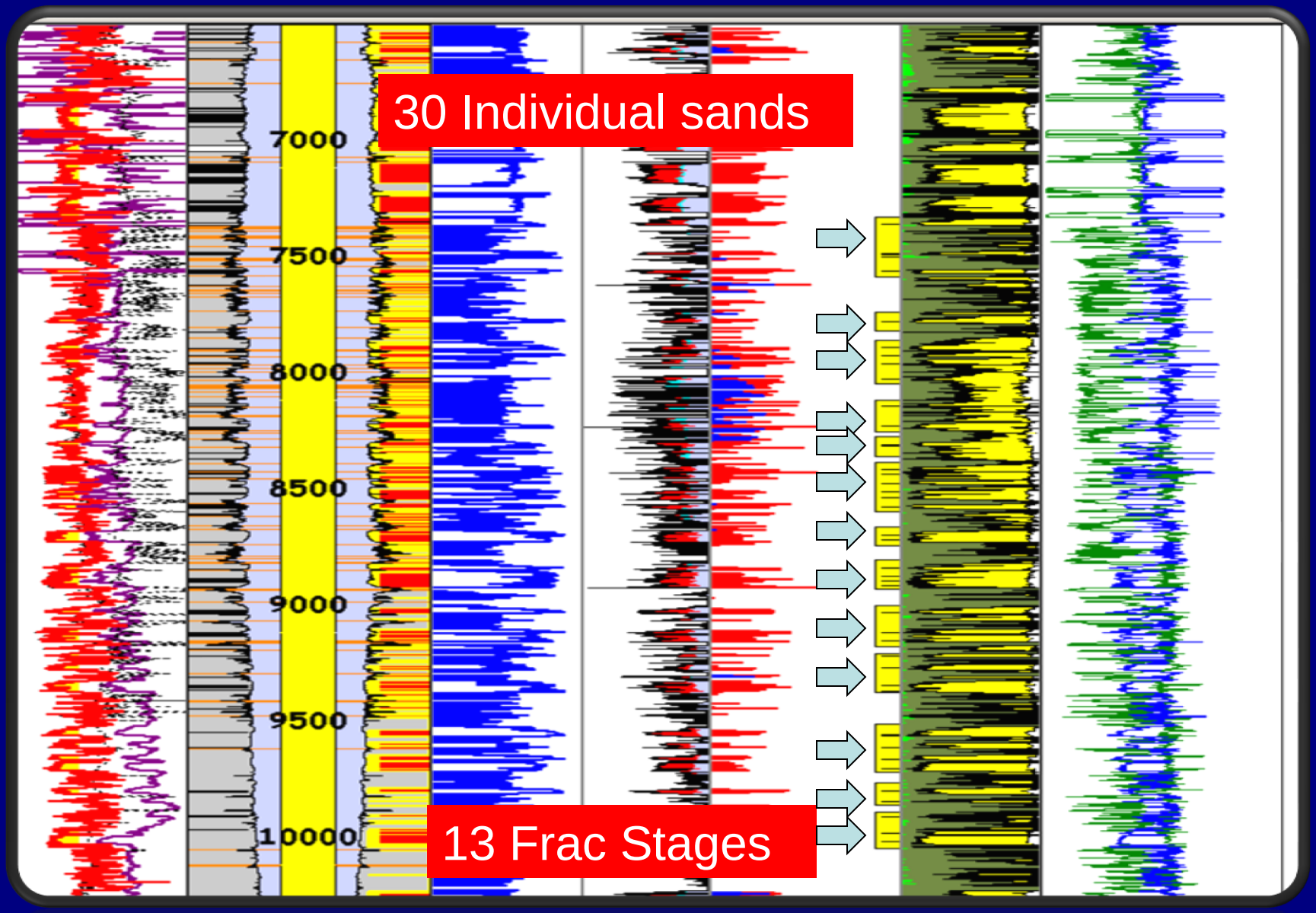
Figure provided by Matt Pranter (University of Colorado at Boulder) and Rex Cole (Mesa State College)

Pinedale/Jonah Area

- Up to 40 wellbores from a single pad
- 3,000 to 5,000 ft of gross interval
  - 30 to 60% net
  - TOOP 8 - 10,000’
- Up to 60 individual sands



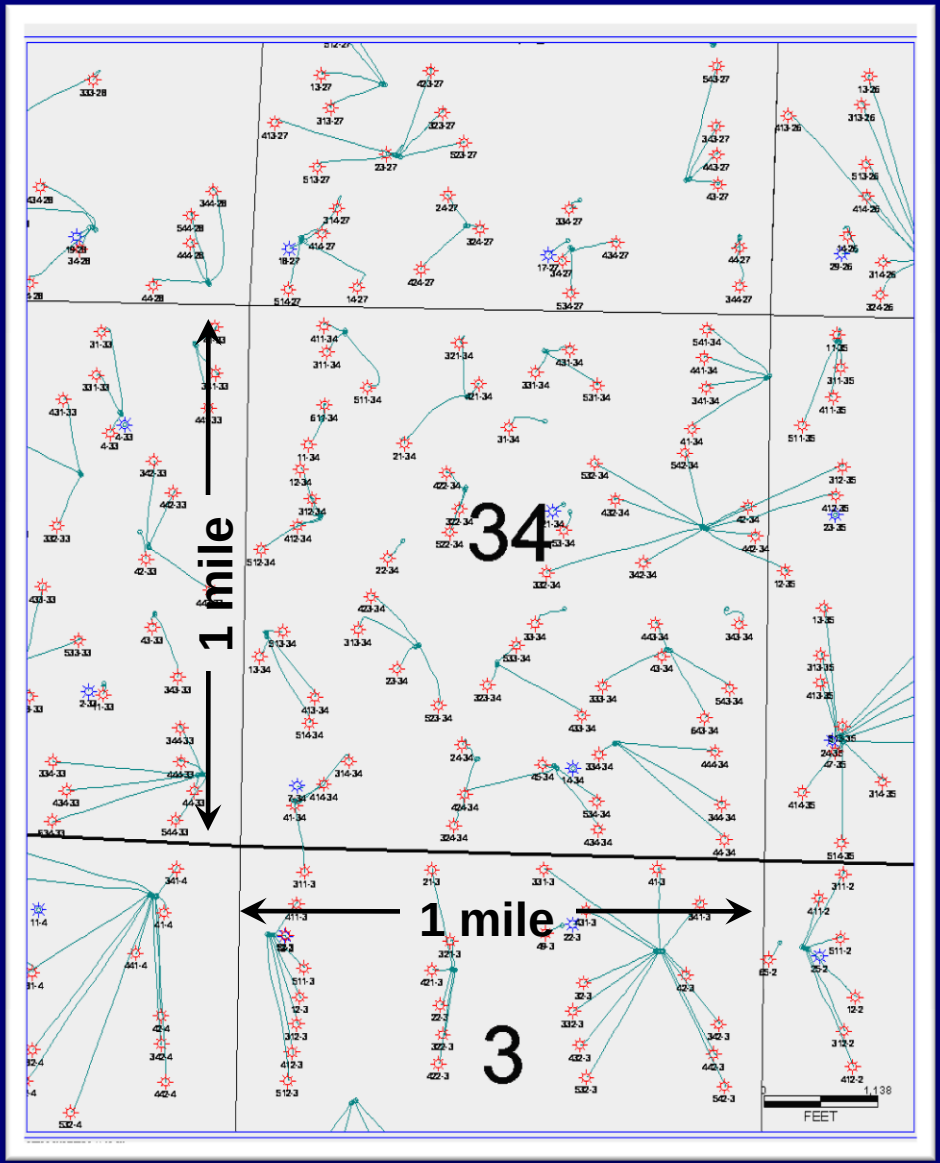
Stacked Pay Geology – Rockies



Tight Gas Sand Issues

- Marginal economics
  - High decline wells
  - Small drainage areas (reservoirs)
- A large number of wells required for economic programs
  - High density drilling programs
- Cost reduction by efficiencies
  - Factory “assembly line” approach

High Density Well Spacing - Piceance



High Efficiency Operations
"Frac Factories"

- Simultaneous operations
  - Drilling, perforating, fracing, completing, producing

High Efficiency Operations
"Frac Factories"

- Simultaneous operations
  - Drilling, perforating, fracing, completing, producing
- Multiple wells on a single surface pad
- Multiple wells treated from a single frac equipment location
- Goal - Multiple fracture treatments done per crew every day

Simultaneous Operations

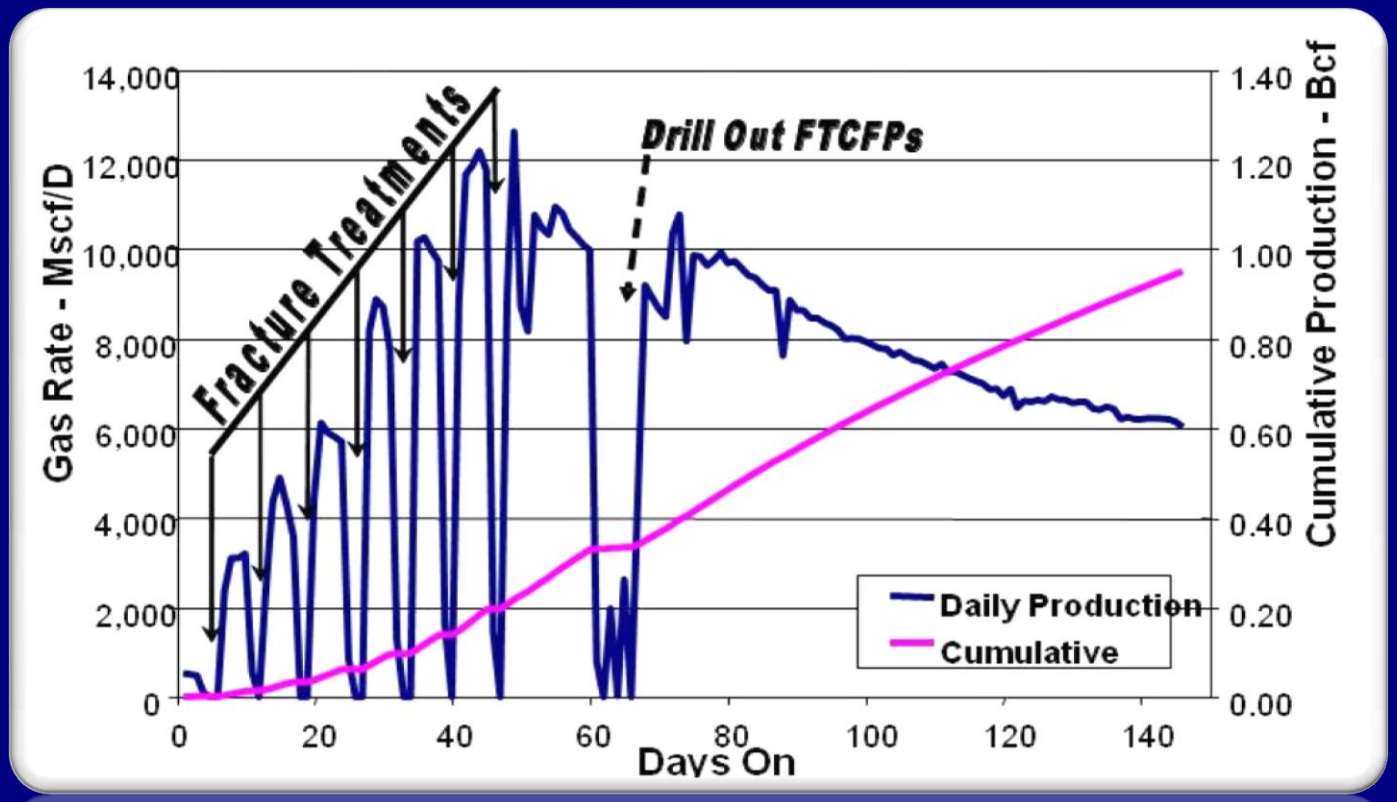
- Drilling and completion on same surface location

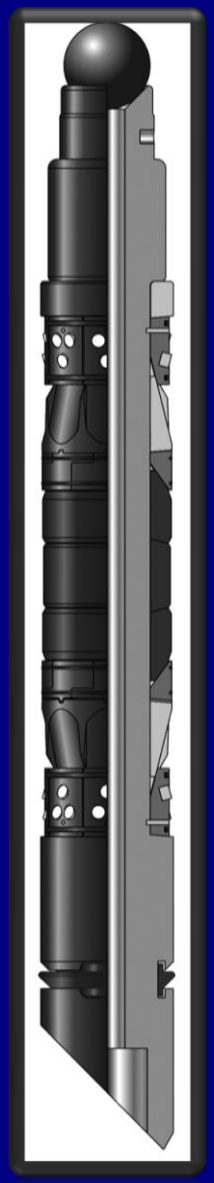
Simultaneous Operations

- Drilling and completion on same surface location
- New to US land operations
- Safety is primary concern
- Requires improved field coordination
- Better efficiency of existing equipment
  - 24/7 completion operations
- Reduces environmental impact

Multiple Stages per Day

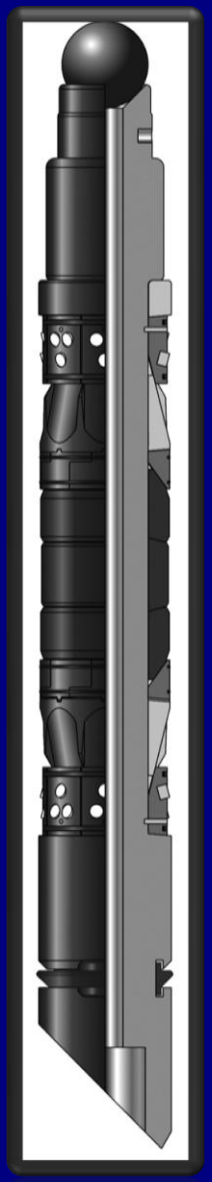
- Traditional perforate and plug
  - Use of composite flow through frac plugs



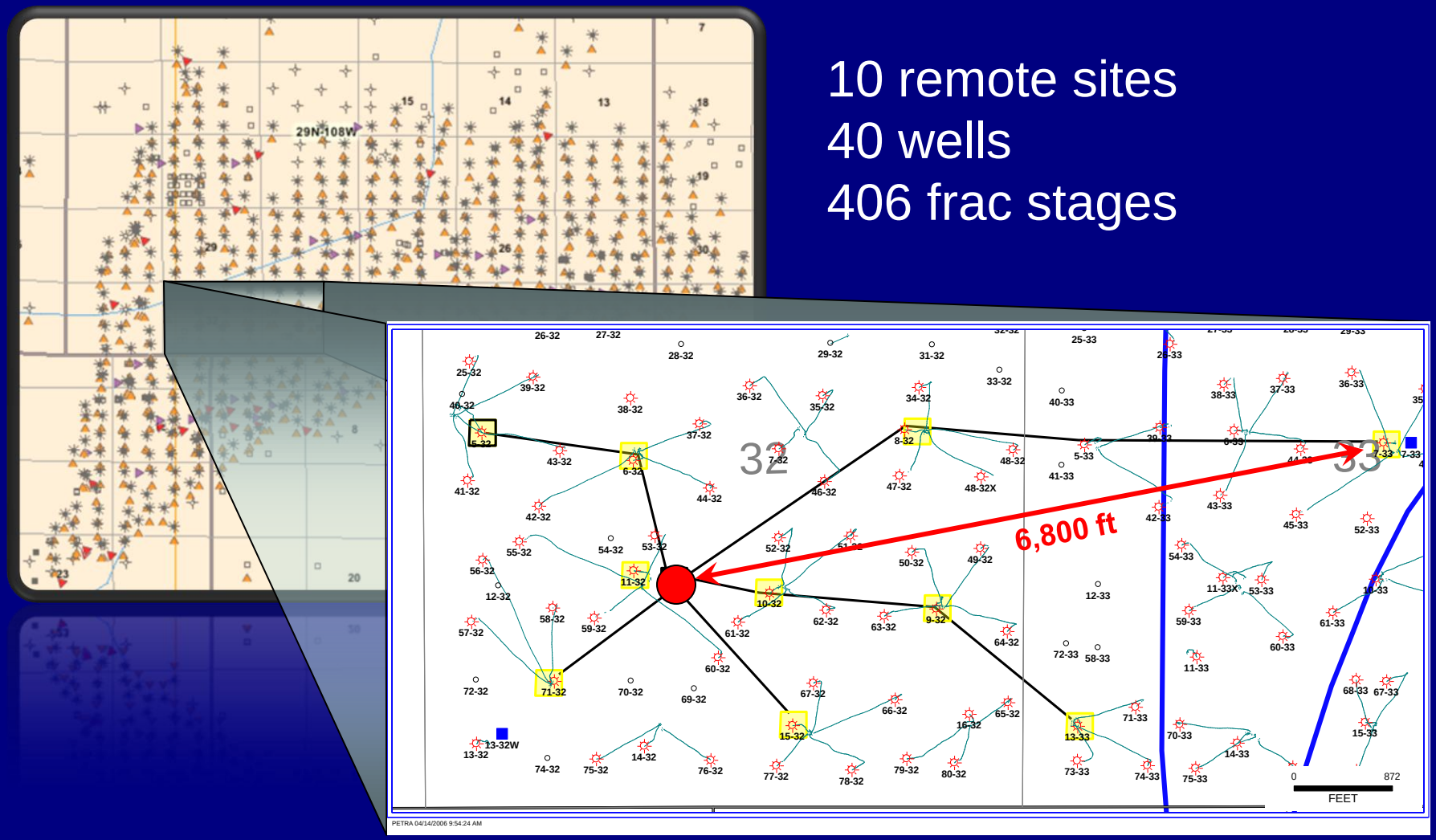


Multiple Stages per Day

- Traditional perforate and plug
  - Use of composite flow through frac plugs
- Coiled tubing deployed placement
- Continuous pumping operations



Multiple Pad Completions



10 remote sites
40 wells
406 frac stages

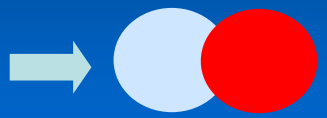
Map Courtesy of EnCana

Pitfalls with Factory Completions

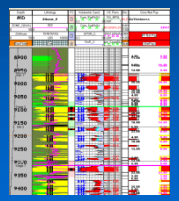
- Ignoring the reservoir
- “Cookbook” frac designs become standard
- Logistics start to mandate completions
- Well cost becomes main concern

Systematic Approach

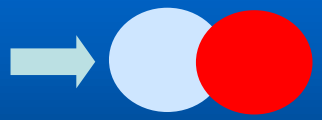
Petrophysical Model

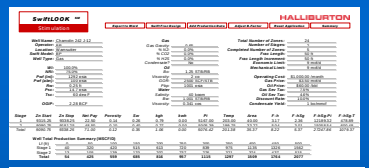


Reservoir Characterization Frac Design

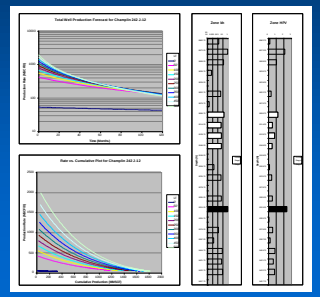


Stimulation Design

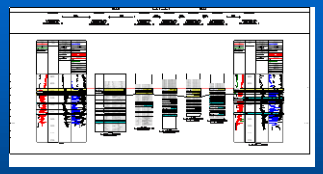




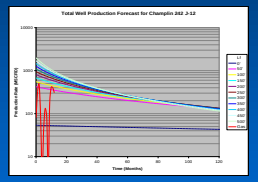
Predict Well Performance

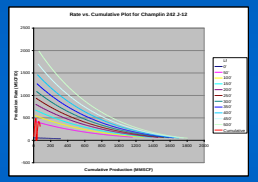


Offset Completions

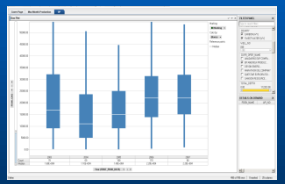


Surveillance of Results





Field Wide Surveillance



Model Review

Daily Work Flow Begins Here

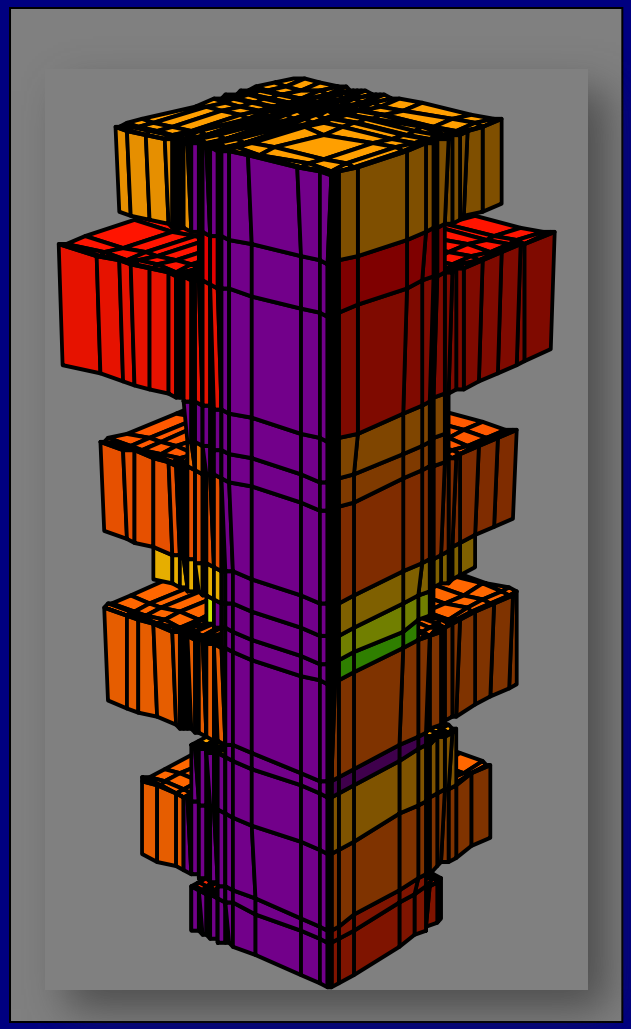
Validate Stimulation Model

A Petrophysical Model Will…

- Assist with determining completion intervals
  - “What-if” scenarios
- Incorporate reservoir potential into frac design considerations
  - Proppant type, job size, etc.
- Predict well performance based on completion program

Building a Petrophysical Model

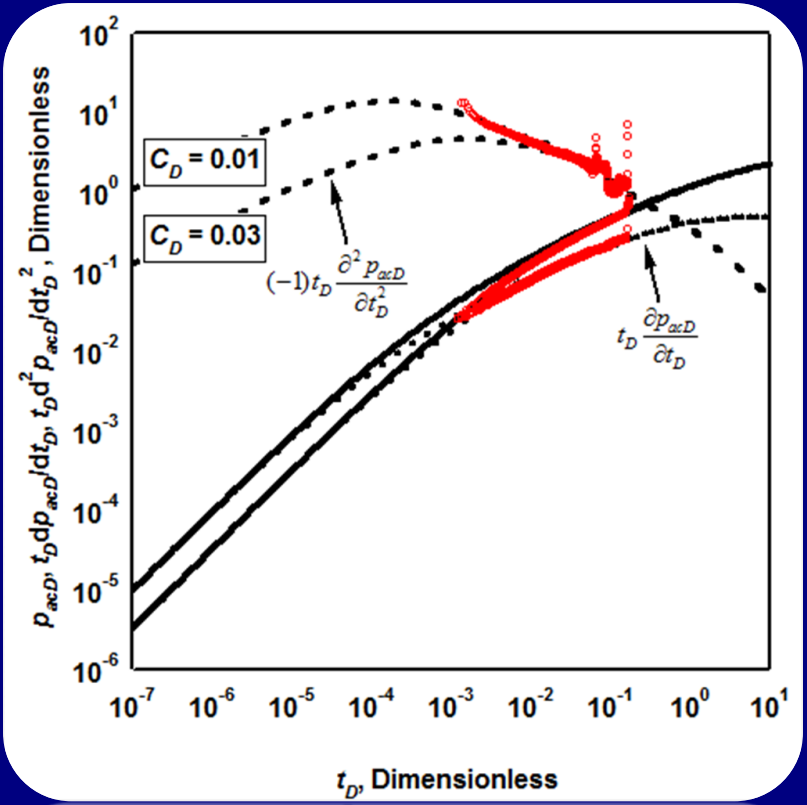
- Core analysis
  - Corrected for bottom hole conditions
- Diagnostic Fracture Injection Tests (DFIT)
  - Before and after closure
- Treating pressures
- Production results



Unconventional Pressure Transient Testing

Fracture-Injection/Falloff Tests

- Pre-frac or Refrac Evaluation
- Falloff Analysis
  - Reservoir Properties
  - Fracture Properties
- Multilayer models



Stimulation Issues

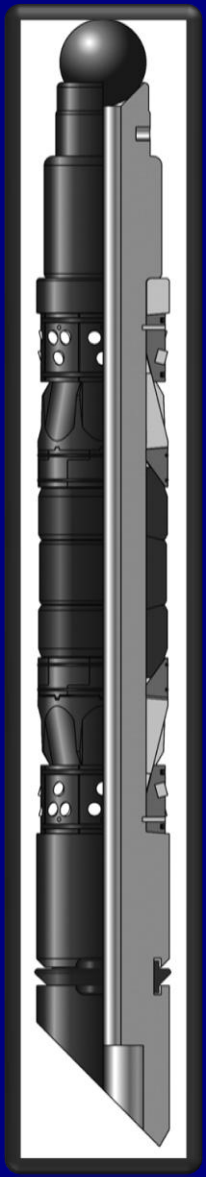
- Very long completion intervals
- Optimization of stimulation design
- Supply chain management
  - Water, proppant
- Consistent improvement in a large scale project

Design and Operations

- Traditional issues
  - Fluid systems
  - Proppant types
  - Additives
- Single or multiple well completion program
- When to flow back and for how long
- Reuse of frac and/or formation fluids

Single Well Completion

- Typically wireline plug and perf
  - Use flow thru composite bridge plugs (FTCBP)
- Limit number of intervals per frac stage
- Can be 24/7 operation
- Use a solid BP to isolate different pressure regimes
- Flow back well after completion



Multiple Well Completions

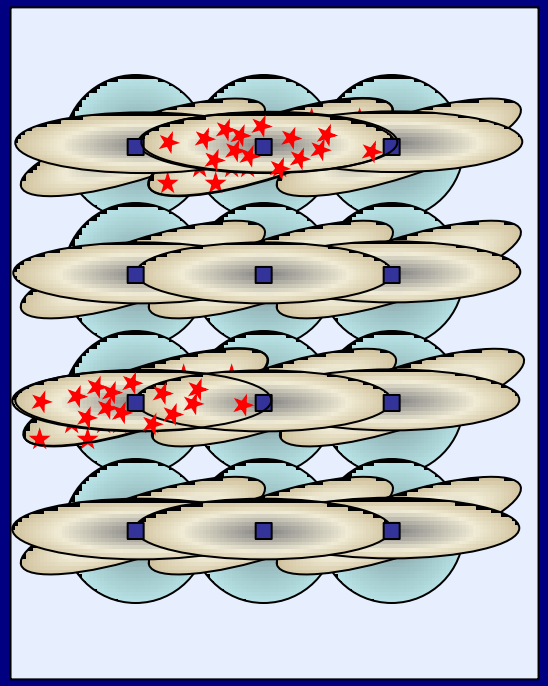
- Treat several wells from a single location
  - Requires close proximity
- Complete one or two stages then flow the well back
- Only move frac iron not equipment
- Use FTCBP for frac stage isolation

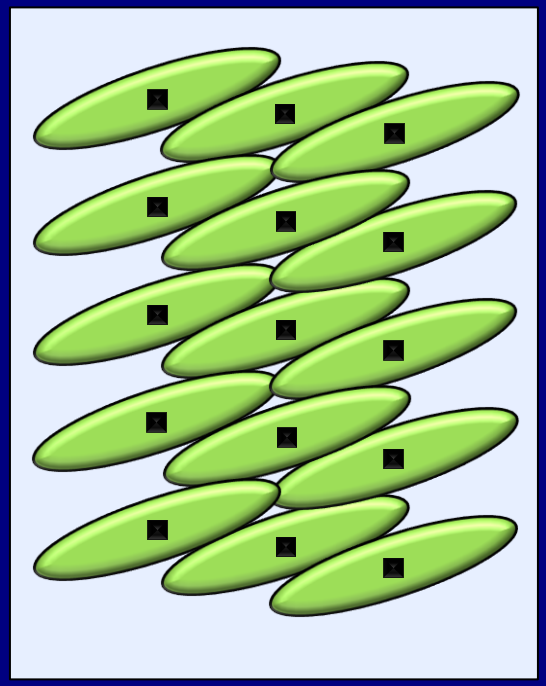
More Frac Factory Concerns

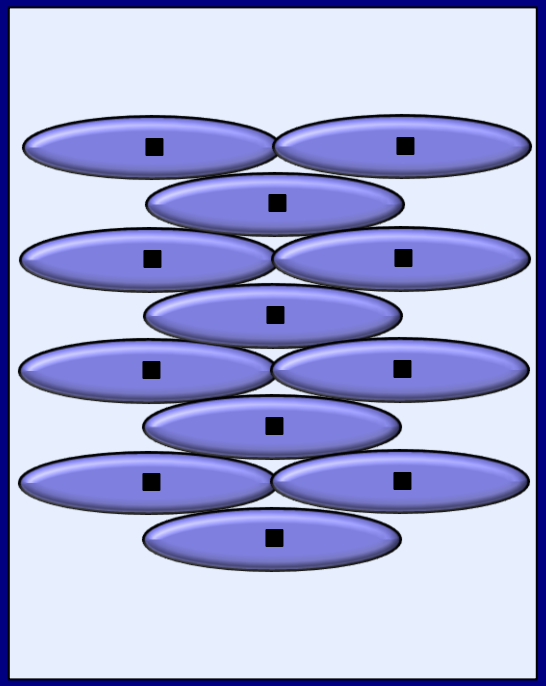
- No time to review results from changes
- Several wells completed before a problem is noticed
- Science is not done up front
  - High density drilling
- High change over of personnel

Diagnostics for Design

- Tiltmeters
- Microseismic monitoring





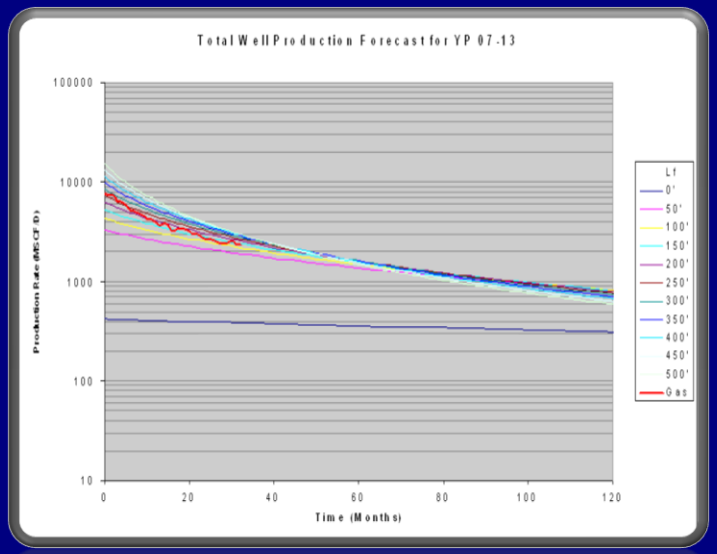


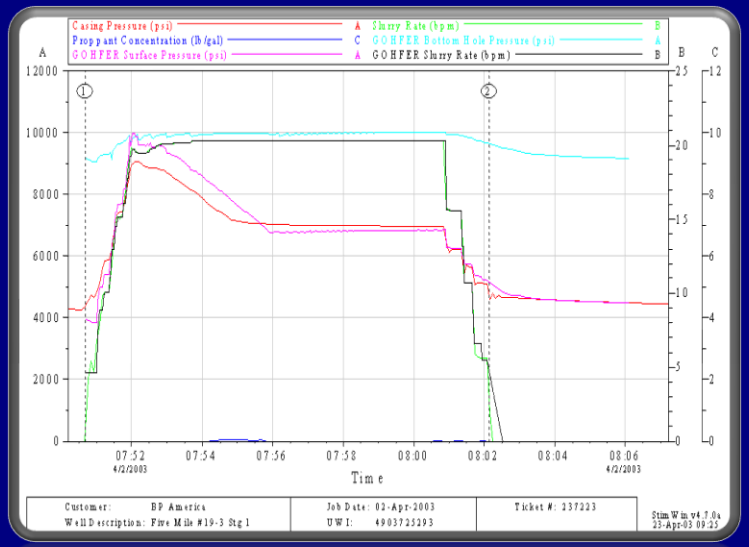
Diagnostics for Design

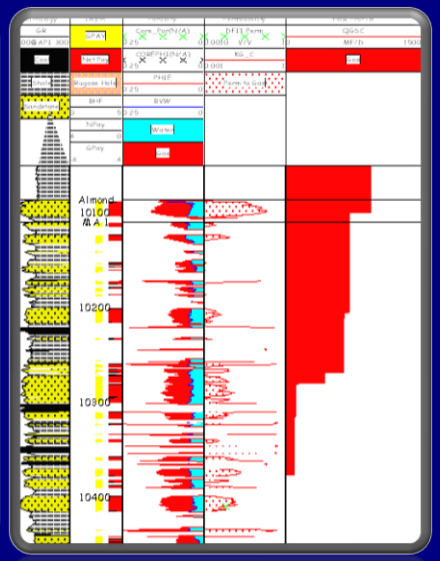
- Tiltmeters
- Microseismic monitoring
- Chemical/radioactive tracers
- Temperature distribution analysis
- Production Logs

Monitor and Adjust

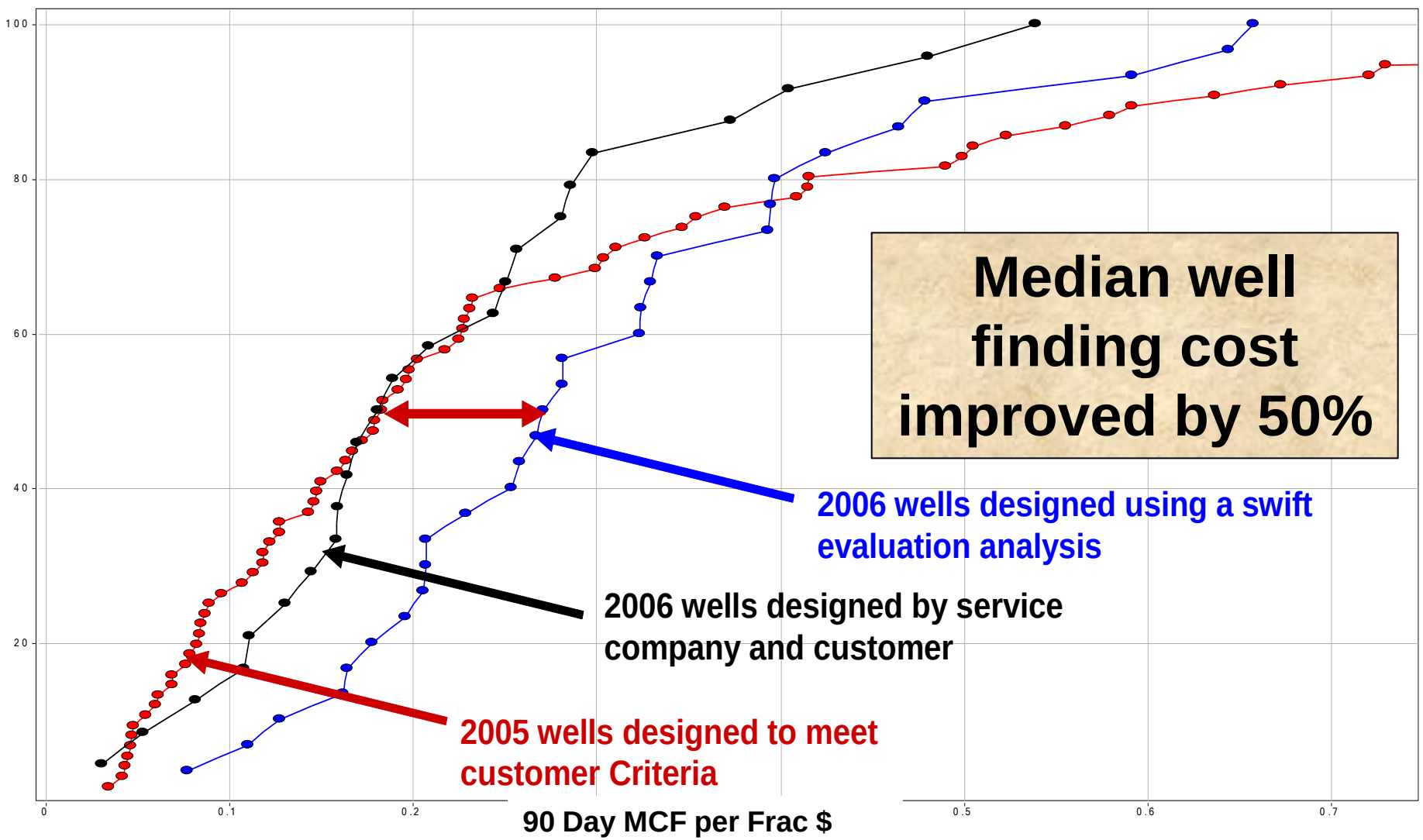
- Does the actual production match predicted?
- Does the stimulation treatment pressure history matches predicted?
- Does the production profile look reasonable?



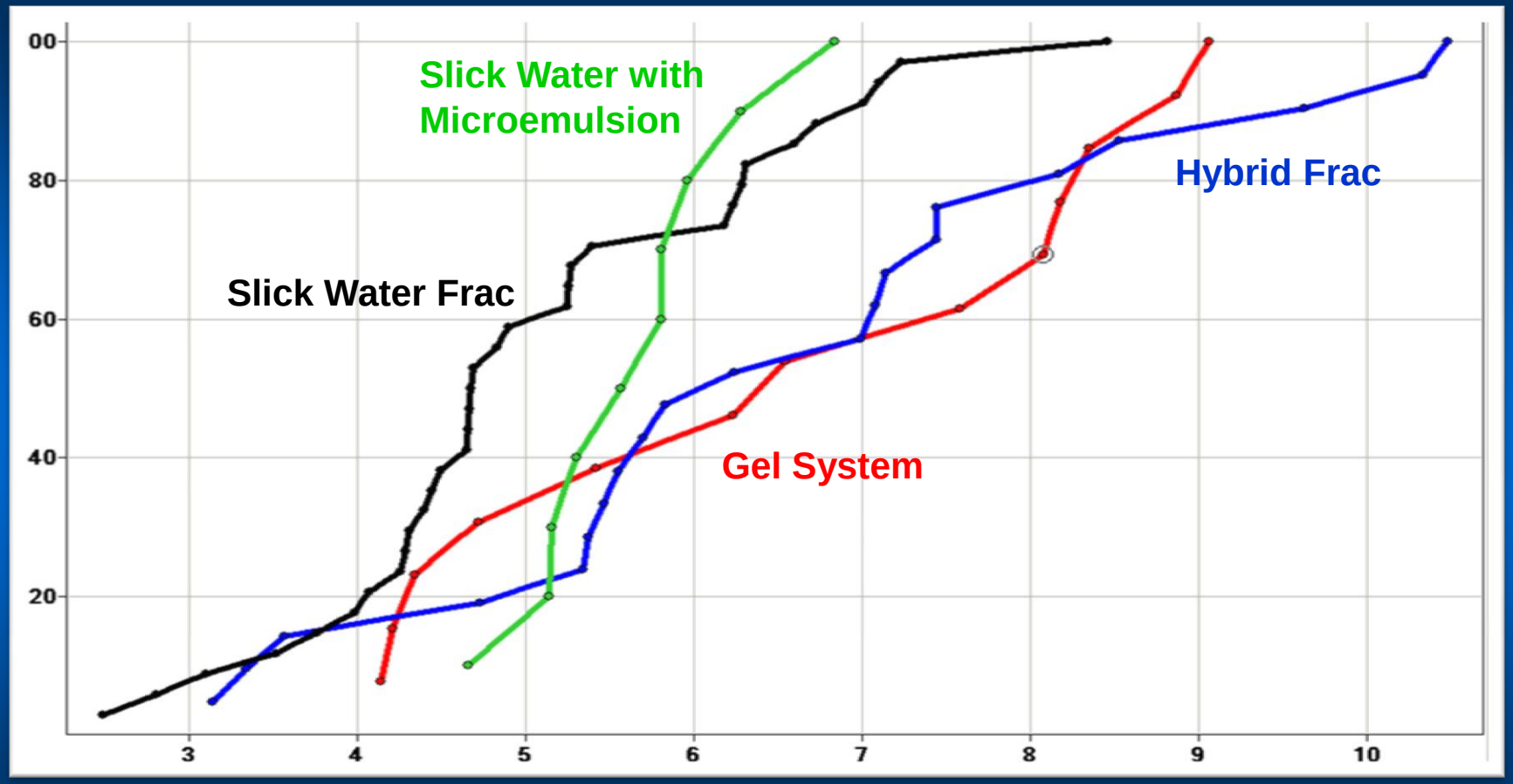




Production Improvement Using Reservoir Based Completion Designs



Benchmark Changes



Summary

- Efficient drilling/completion programs
- Effective stimulation of multiple intervals
- Watch out for pitfalls of factory mentality
- Calibrated petrophysical models
- Unconventional PTA used
- Consideration well completion strategy
- Use of diagnostic tools and lookback studies