

**The Society of Petroleum Evaluation Engineers  
SPEE Denver Chapter announces its October Luncheon Meeting.**

(Members and Guests are cordially invited to attend.)

**Friday, October 20, 2017 (corrected)**

**Mr. Creties Jenkins**

Partner with Rose and Associates, LLP



**Will be speaking on:**

**Appraising and Developing Your Unconventionals: How to Avoid  
Squandering Billions of Dollars Next Time**

**LUNCHEON STARTS AT 11:30 A.M.**

(A plate lunch will be served.)

**PRESENTATION BEGINS AT NOON**

**The Denver Athletic Club**

**3<sup>rd</sup> Floor, The New Petroleum Club Room  
1325 Glenarm Place (14<sup>th</sup> and Glenarm) Denver CO 80204  
Parking flat rate \$7.00 on space available basis**

**Cost: \$25.00 per Person**

Special pricing of \$25 continued into 2017. Normally \$35.

(Credit Card, Cash or Check made out to 'SPEE Denver Chapter')

**Please RSVP by Noon Wednesday, October 18, 2017**

**RSVP and simultaneously pay by credit card online at:**

<https://secure.spee.org/civicrm/event/info?reset=1&id=146>

If the above link does not work, alternatively go to [www.spee.org](http://www.spee.org) then select 'Local Chapters', then 'Denver', then 'Register Now'.

**Abstract:** Over the past three years, more than 100 oil and gas companies in North America with almost \$80B in debt have filed for bankruptcy. While these companies would like you to believe they were all victims of low commodity prices, many failed because of the way they approached appraising and developing opportunities. Two of the most common mistakes have been focusing on production attainment instead of value creation, and incorrectly thinking that enough was understood about a given reservoir to push ahead with development.

To mitigate these errors, unconventional reservoirs must be evaluated in a series of stages. In each stage, we need to (1) identify the key uncertainties and risks, (2) collect the data needed to quantify these, and (3) generate a probabilistic assessment of potential outcomes and their associated values. A key aspect in this evaluation is not only using rock and fluid data to identify the area with the greatest potential, but drilling enough wells to understand the production variance (irreducible uncertainty) and whether the average well will be economic. This includes quantifying the range of the average well and the confidence of achieving some minimum rate.

This process requires discipline, including maintaining consistent drilling and completion practices so variations in reservoir quality can be understood. To help ensure this process is followed, it is important to implement an assurance process consisting of 1) guidelines and workflows, 2) peer reviews and assists, and 3) periodic performance lookbacks. The time to do this is NOW, before prices rise again and we revert to our destructive habits.

**Speaker Bio.:** **Creties Jenkins** (P.E., P.G.) is a Partner with Rose and Associates where he specializes in the characterization of unconventional reservoirs. Creties has carried out integrated studies, peer reviews, training, and resource assessment work for more than 50 companies around the world. He has also conducted more than 100 industry courses and workshops over the past decade focused on tight oil and gas reservoirs. Creties has served as a technical editor, distinguished lecturer, and distinguished author for SPE and is a past president of the Energy Minerals Division of AAPG. He is also a co-author of SPEE Monograph 4: Estimating Ultimate Recovery of Developed Wells in Low-Permeability Reservoirs. Creties has previously worked for Tenneco, ARCO, and DeGolyer and MacNaughton in his 30-year career. He holds a BSc in Geological Engineering and an MSc in Geology from the South Dakota School of Mines.



**About SPEE:** <http://www.spee.org> SPEE was formed in 1962 as a professional, non-profit organization bringing together specialists in the evaluation of petroleum and natural gas properties. SPEE continues today to be strongly committed to providing educational and other services to its members and to the oil and gas industry, and to promoting the profession of petroleum evaluation engineering.

**For additional information, please contact:**

**Steve Gardner**

2017 Vice Chairman / Program Chairman SPEE Denver Chapter

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303-339-8119

**For event registration issues, please contact:**

**Mike White**

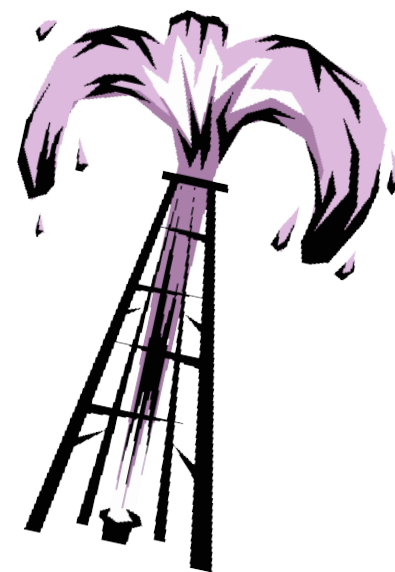
[mwhite@ResoluteEnergy.com](mailto:mwhite@ResoluteEnergy.com)

303-573-4886 Ext. 1450

# Appraising and Developing Your Unconventionals: How to Avoid Squandering Billions of Dollars Next Time

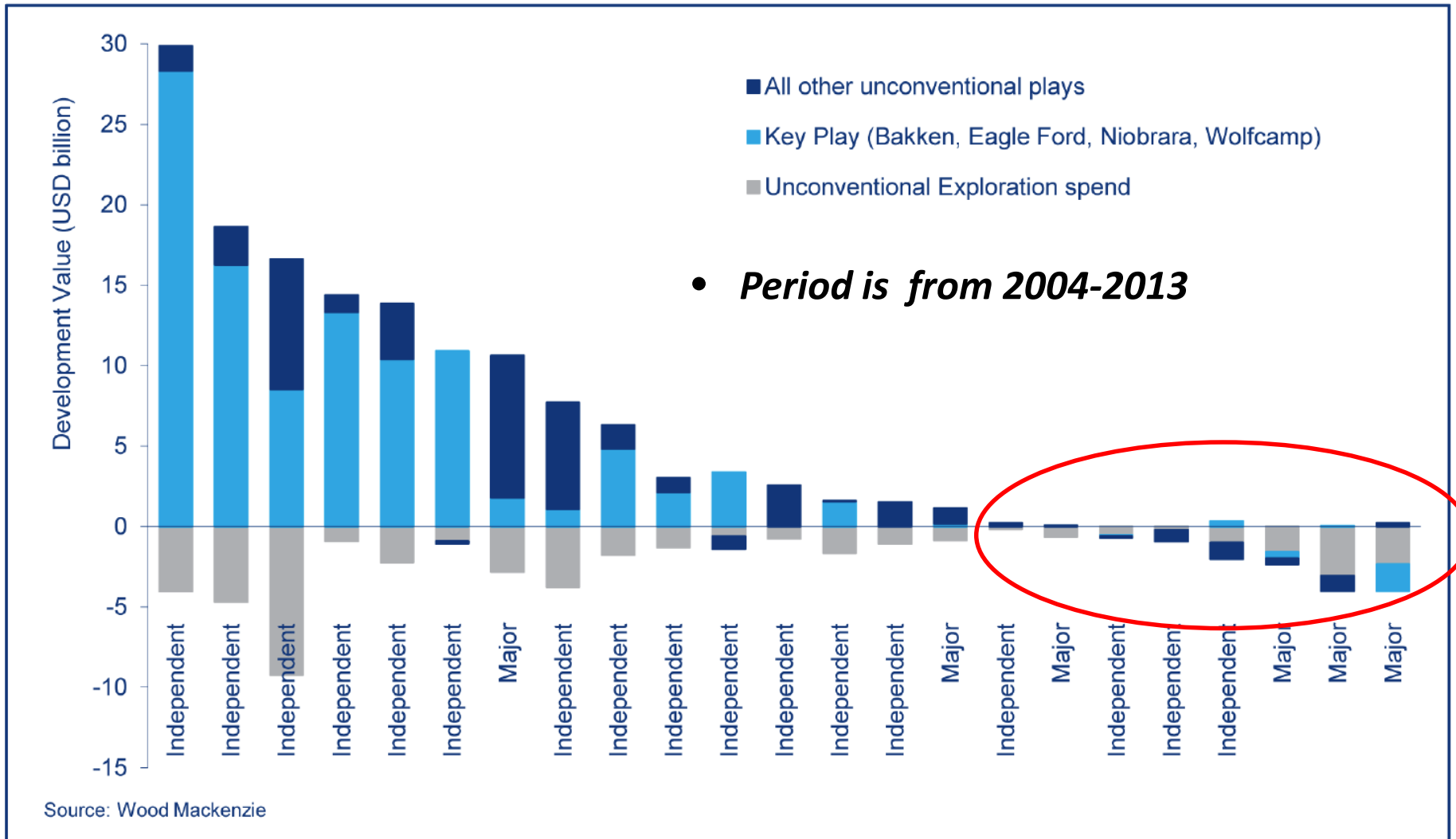


*Creties Jenkins & Mark McLane  
Rose and Associates*



Denver  
October, 2017

# Development Value in Unconventional Plays



- The 23 companies shown here acquired acreage in 30+ North American plays.
- 8 of these failed to deliver positive development value

# A Recent Company's Experience in Unconventionals

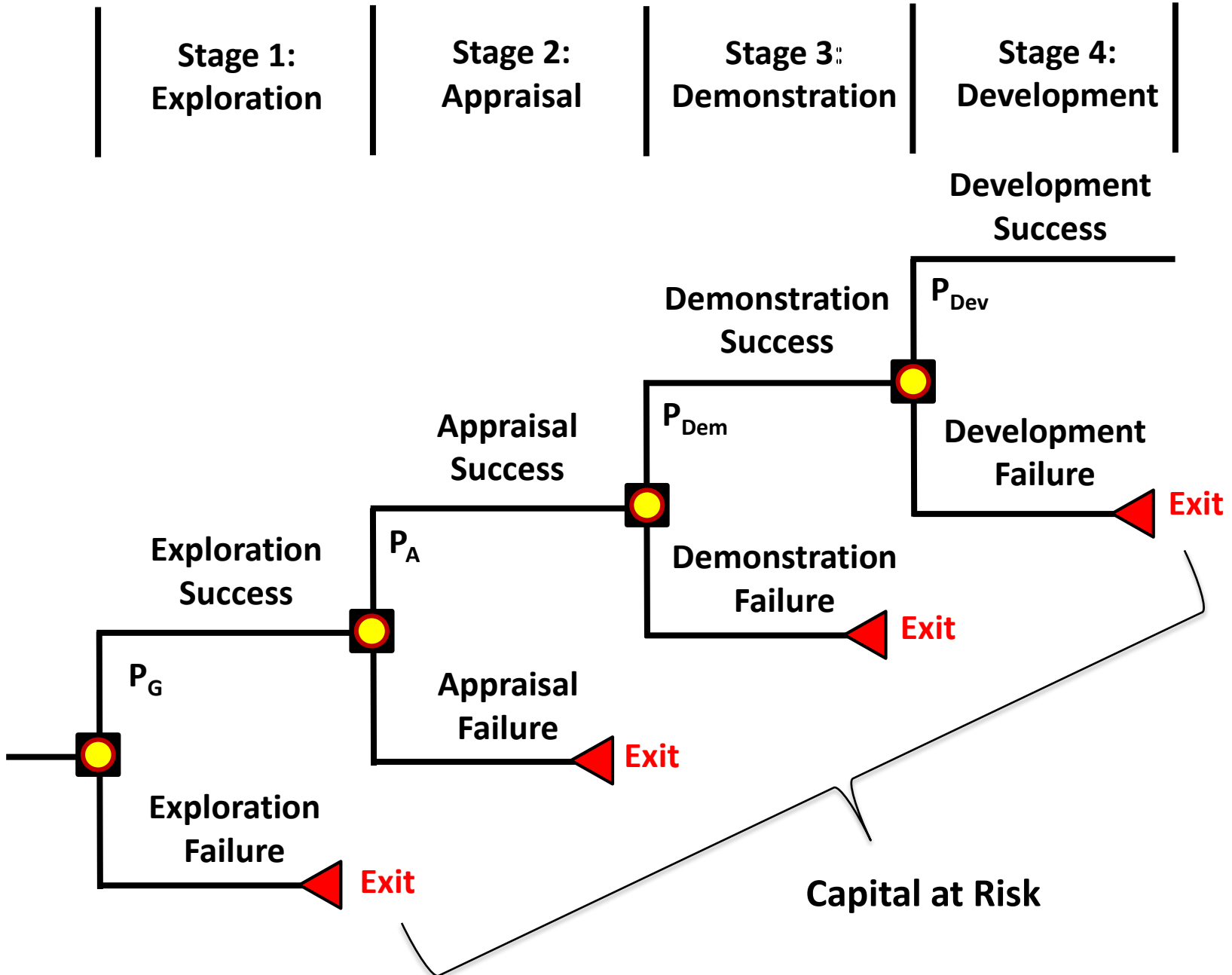
- Evaluated 16 different low permeability reservoirs
- Drilled 1000+ wells over a 1-year period
- Only ~200 of these had a rate-of-return of greater than 12%
- Each of the 16 projects was expected to have a rate-of-return of at least 40%
- By drilling all of these wells, the company attained their production goals
- They just squandered \$2-3 billion in the process
- In some of these projects, 80 or more wells were drilled with only one well being economic
- How does this happen and what can we do about it?

# U.S. Shale Plays

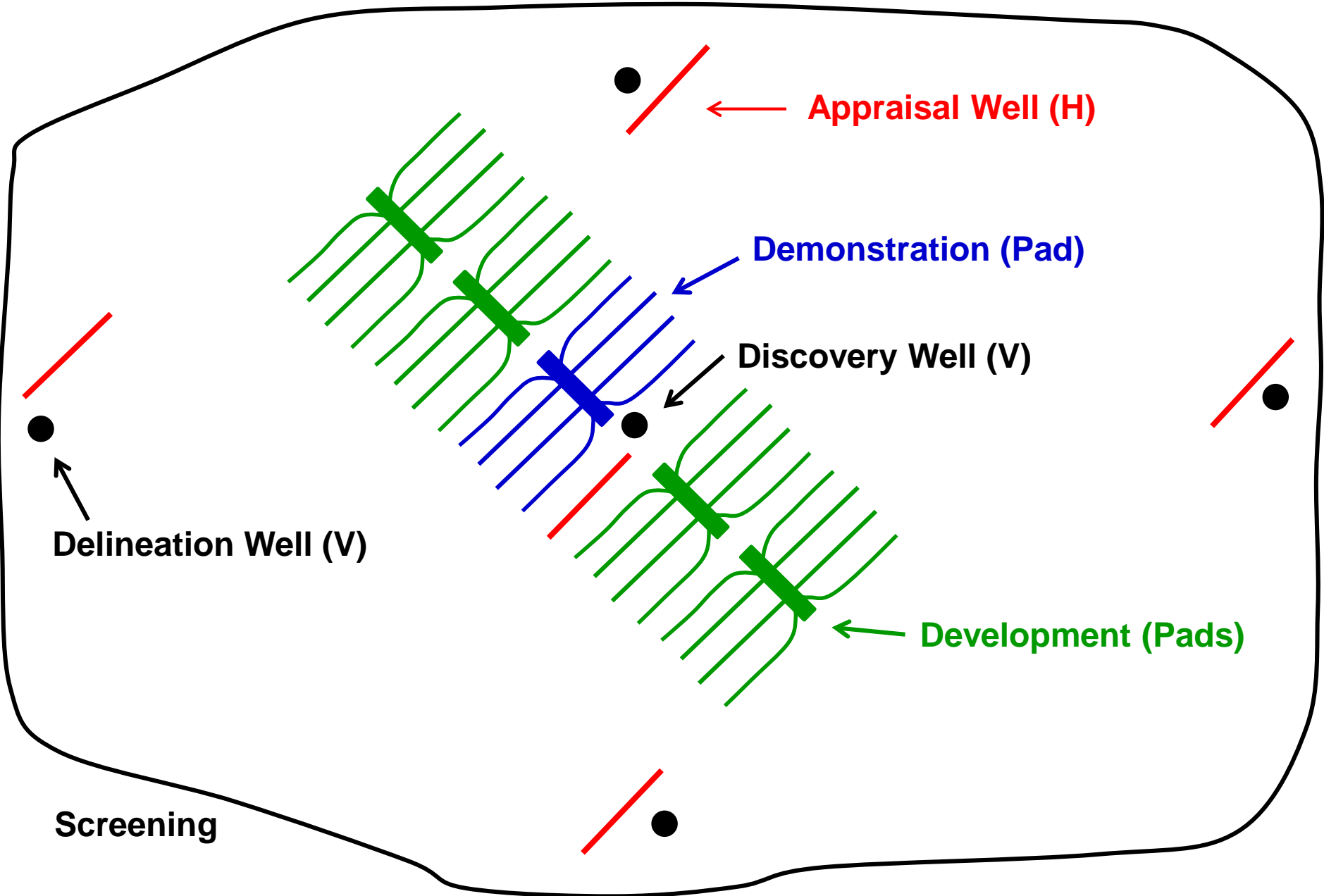


- What percentage of U.S. Shale Plays have been commercially developed?

# The Staged Approach



# Project Stages





# General Workflow



**Exploration**

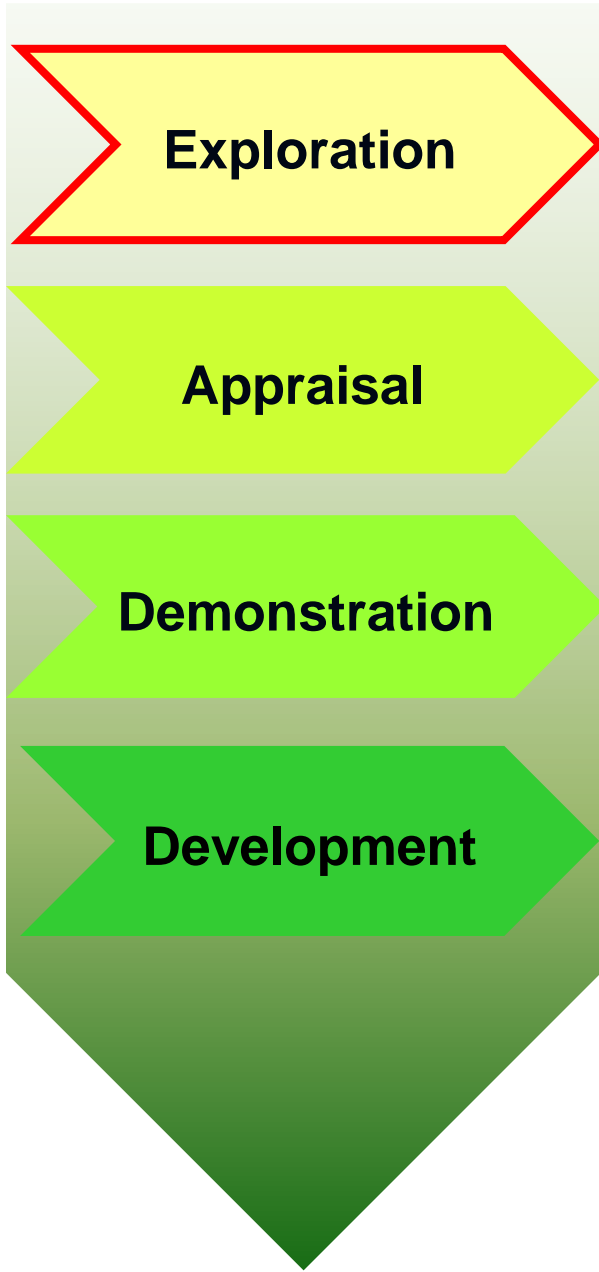
**Appraisal**

**Demonstration**

**Development**

- Identify the stage the project is in
- Assess the key uncertainties and risks in that stage
- Define the data and analyses required to make a good decision whether to proceed to the next stage or exit
- Design a work plan, timeline and budget to acquire this information

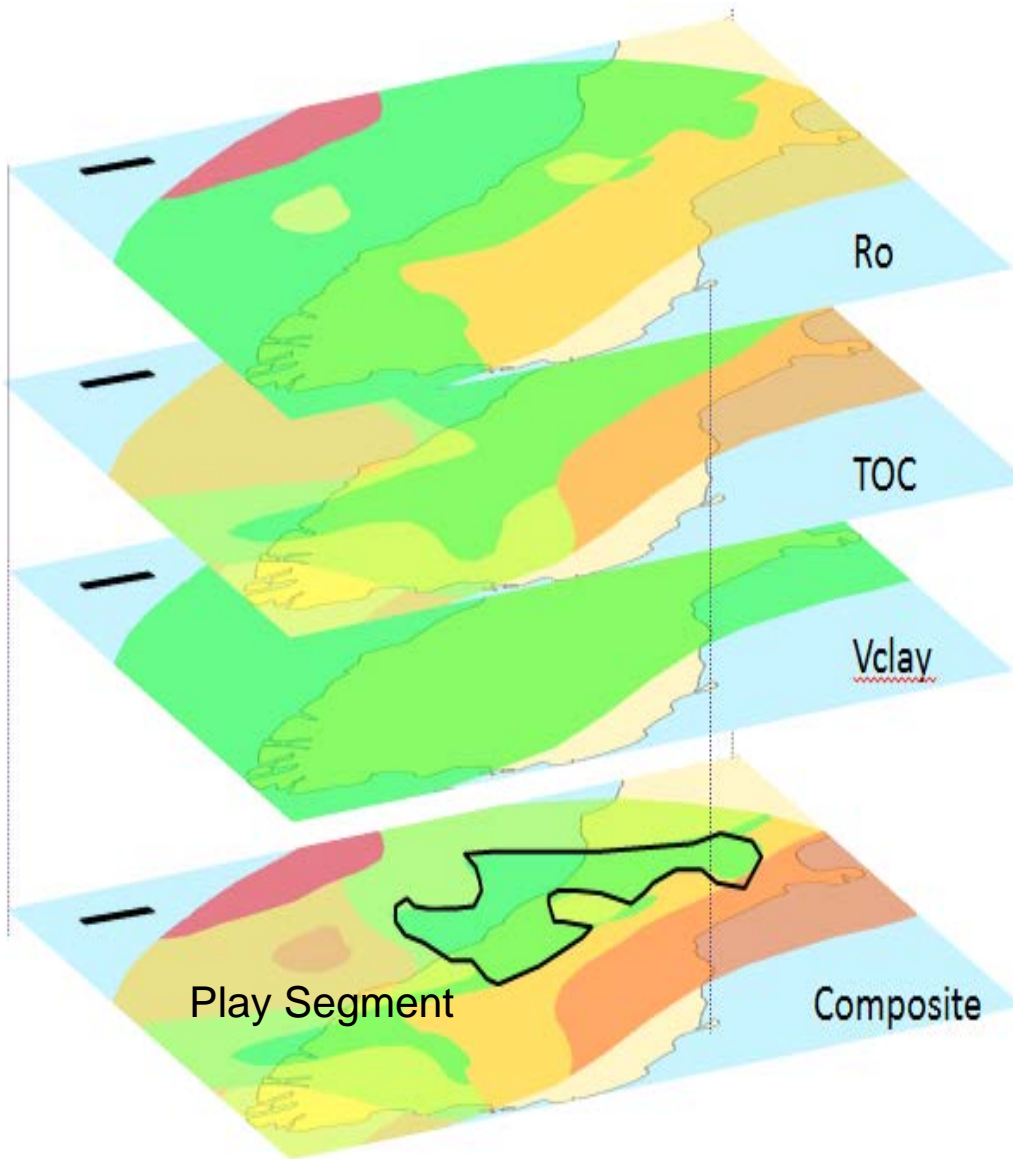
# Project Stage: Exploration



## Screening

- Target basins with prospectivity and rank opportunities
- Apply criteria for identifying sweetspots
- Collect all existing relevant information
  - Cast a wide net and be resourceful
  - Look for data to fill-in the gaps
  - Evaluate the entire stratigraphic column
- Build maps and spatially composite them
- Identify potential analogs
- Determine chance of geologic success (Pg) for defined play segments

# Spatial Compositing of Maps



- Organic richness (TOC)
- Thermal maturity (%Ro)
- Structure/tectonics
- Gross/net thickness
- Lithofacies/mineralogy
- Acoustic impedance
- Geomechanical properties
- Seeps/slicks
- Surface geochemistry
- Porosity/Permeability
- Fluid saturations (Sg, So, Sw)
- Evidence of overpressure
- Overburden thickness
- Seal thickness/rheology
- Reservoir temperature
- Paleogeography
- Key wells
- Acreage held/open
- Restricted/inaccessible areas
- Pipelines, other infrastructure

# Project Stage: Exploration



## Exploration

### Discovery

- Locate a significant quantity of producible hydrocarbons that has the potential for commercial development
- Drill multiple wells if failure is local and not regional
- Determine how many targets to investigate
- Decide what data to gather
- Integrate newly-acquired and existing data
- Acquire open acreage, build land position
- Determine failure criteria & what outcomes trigger an exit

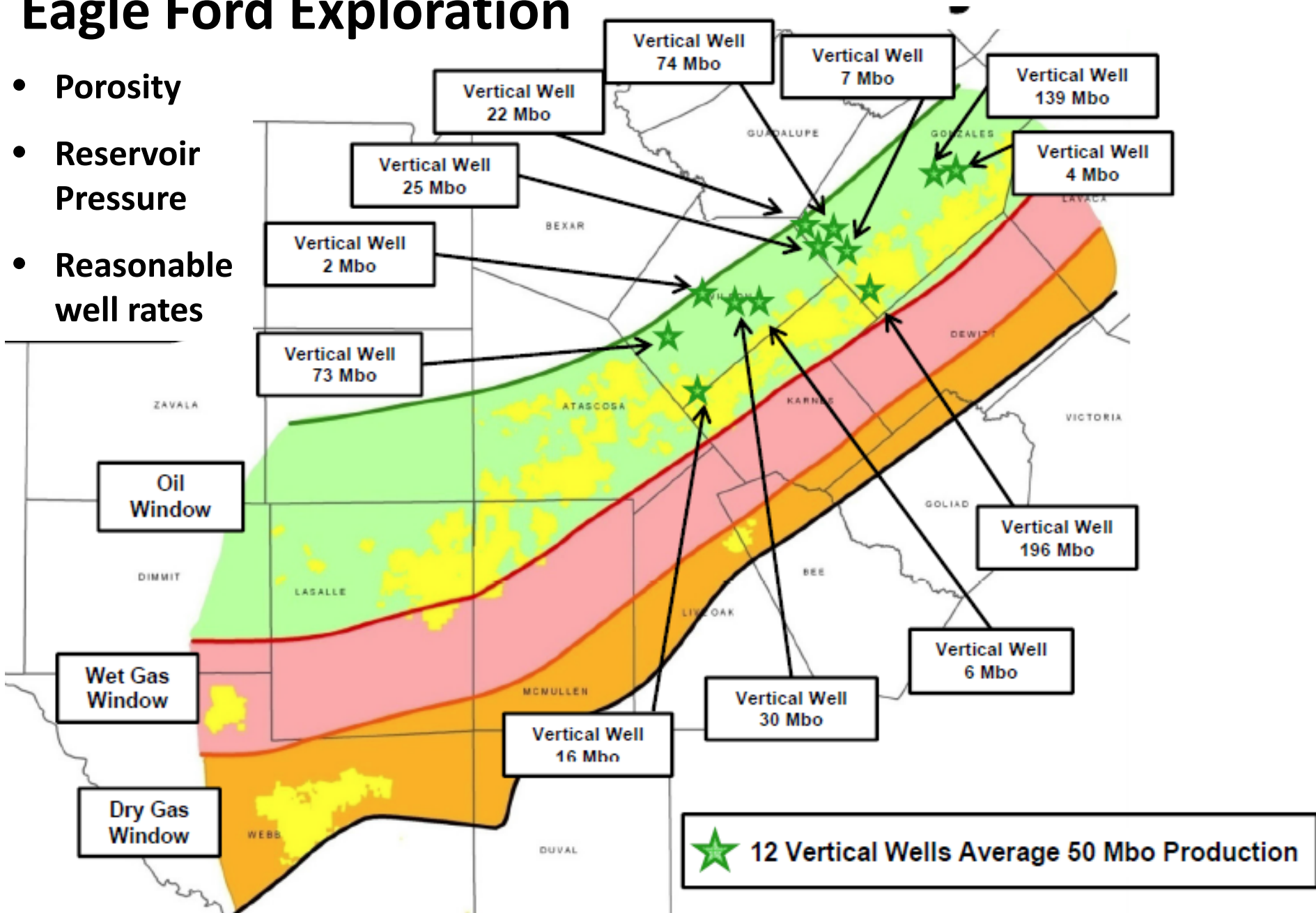
## Appraisal

## Demonstration

## Development

# Eagle Ford Exploration

- Porosity
- Reservoir Pressure
- Reasonable well rates



# Project Stage: Exploration



**Exploration**

**Appraisal**

**Demonstration**

**Development**

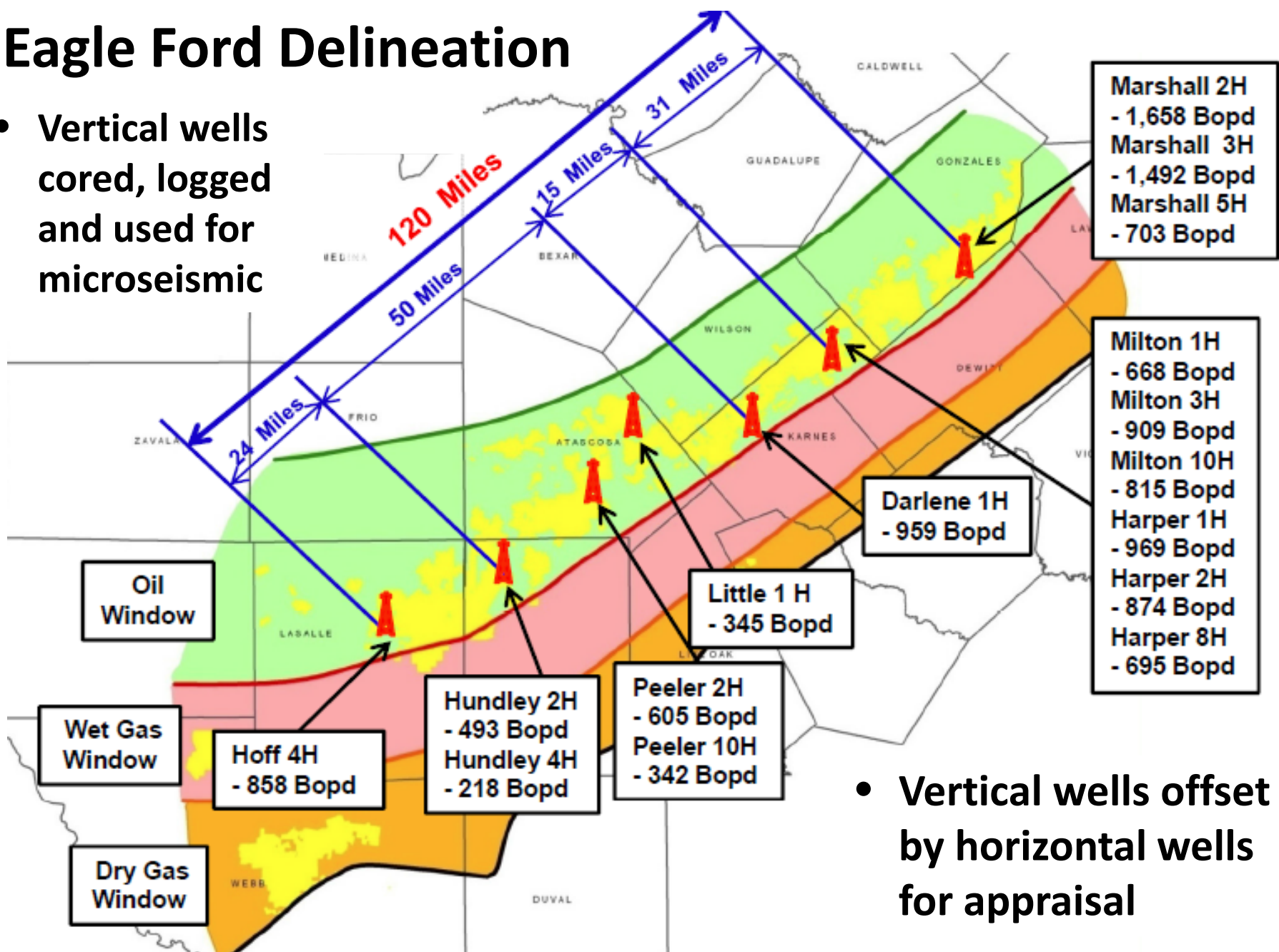
## Delineation

- Validate materiality—that the potential is sufficient to justify further investment
- Show that successive wells are as good or better than the discovery well.
- Confirm thickness, lateral continuity, and internal character with 2D seismic, well data
- Demonstrate that wells can be fraced and produce fluids with desirable characteristics
- Determine well count needed to meet a defined percent confidence of achieving some minimum average well rate
- Determine failure criteria & what outcomes trigger an exit



# Eagle Ford Delineation

- Vertical wells cored, logged and used for microseismic



- Vertical wells offset by horizontal wells for appraisal

# Project Stage: Appraisal



**Exploration**

**Appraisal**

**Demonstration**

**Development**

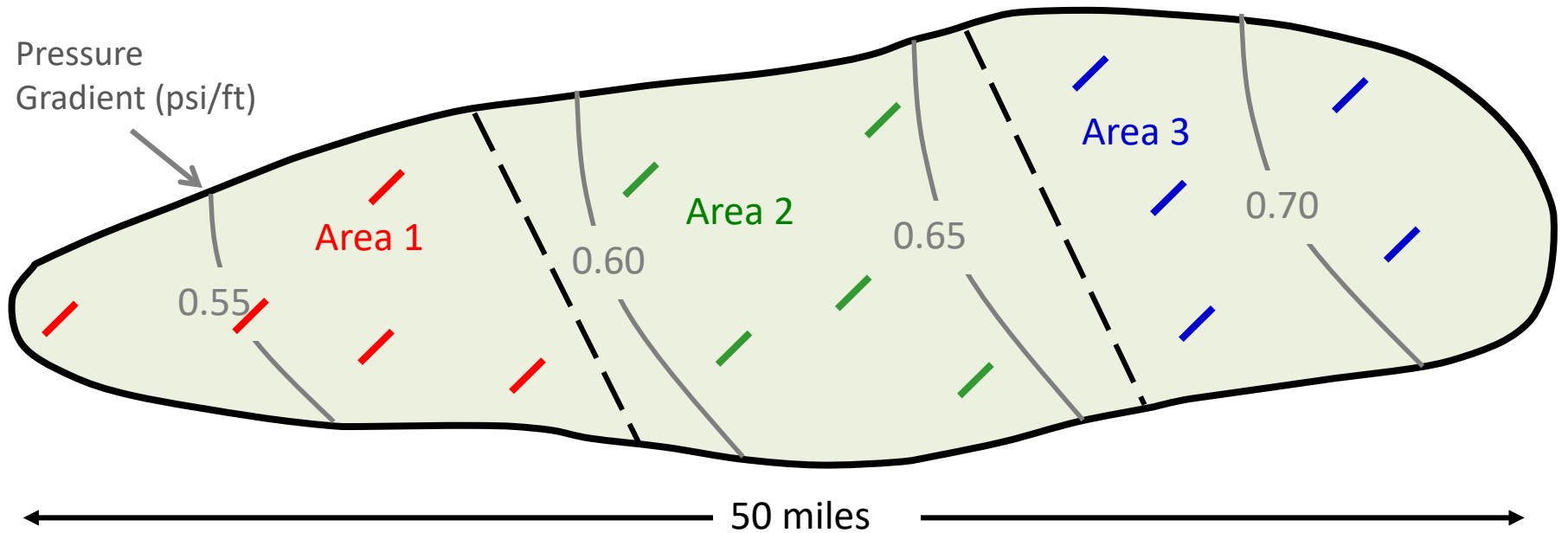
- Validate the ability to drill, complete, and produce hydrocarbons from individual horizontal wells at a rate/decline above some predetermined threshold
- Use consistent drilling/completion practices
- Identify areas of greatest productivity--will become the sites for demonstration projects
- Obtain key reservoir data (rates, pressures) to help quantify performance variability
- Determine well count needed to meet a defined percent confidence of achieving an average well rate that exceeds the threshold
- Determine failure criteria & what outcomes trigger an exit



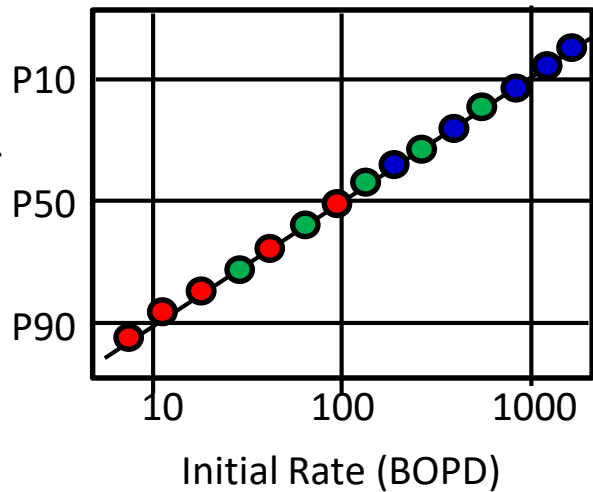
# Discussion at a Recent Conference....

- An engineer presented the results of a sand size trial in a shale reservoir where they pumped a 50-50 mix of 40/70 and 100 mesh to see how the wells compared to their traditional 40/70 sand completions.
- After the presentation he was asked what *confidence do you have in the results of this trial?* “I’m very confident”, he said, adding:
  - “The trial was done early when the shale was still *pristine*—we were just beginning to drill it up so there weren’t other variables interfering with you”
- Variables the engineer was likely thinking about: changes in stresses or depletion caused by earlier wells
- Variables the engineer was not thinking about : fractures, folds, pinch-outs, TOC, facies changes, porosity, perm, saturation, etc.

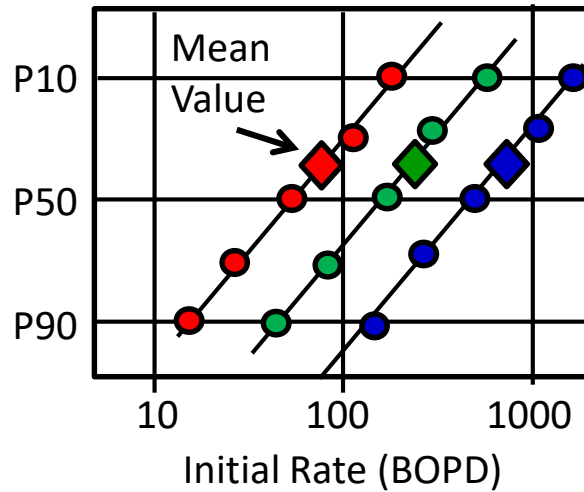
# High-Grading with Appraisal Wells



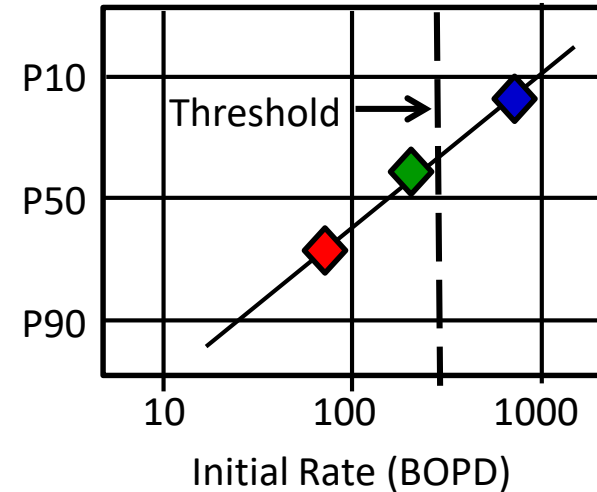
Rate Distribution



Rate Distribution by Area



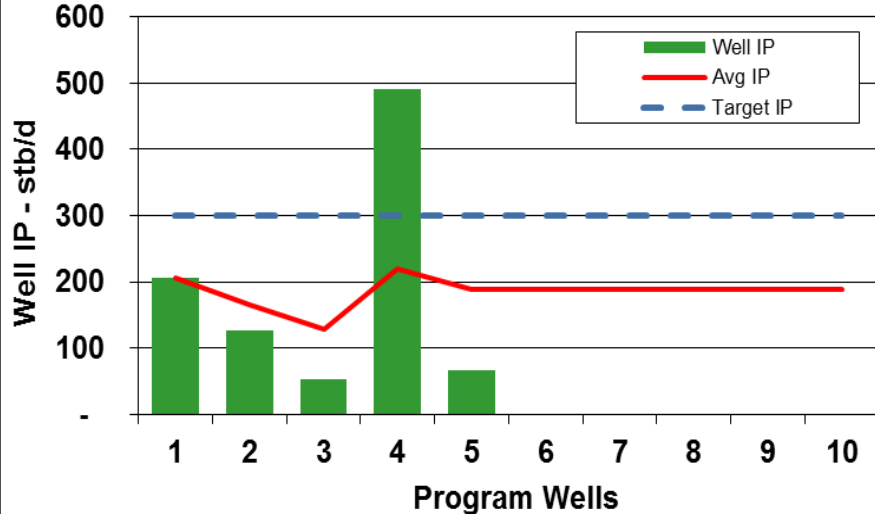
Mean Values by Area



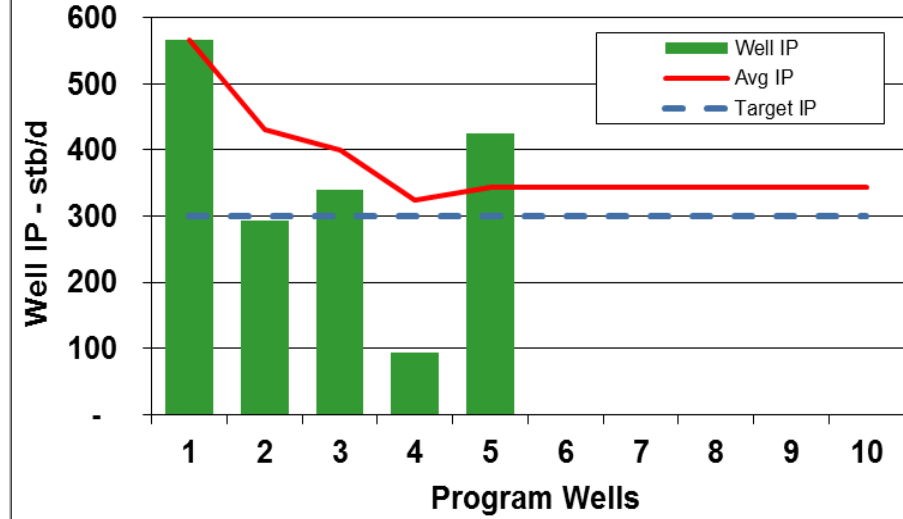
# Examples of 5-Well Drilling Programs

P90 = 75, P10 = 750, Pmean = 350, Threshold = 300

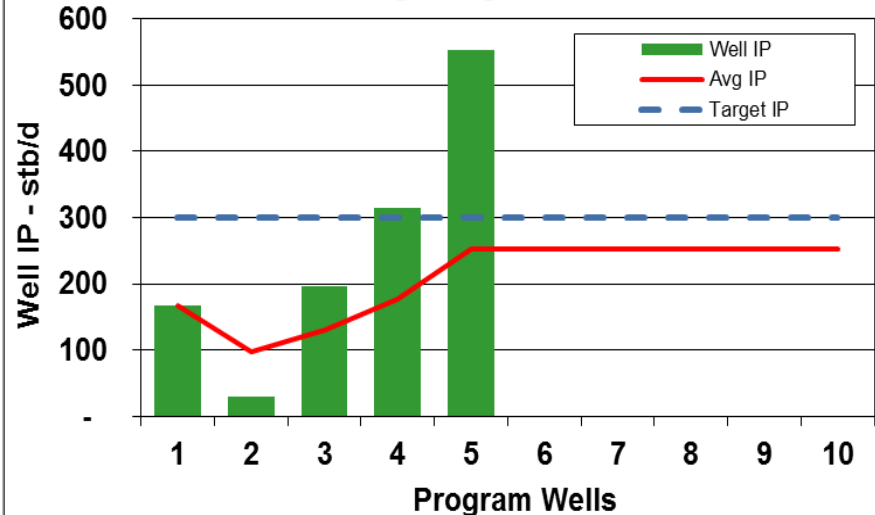
### Drilling Program Rate



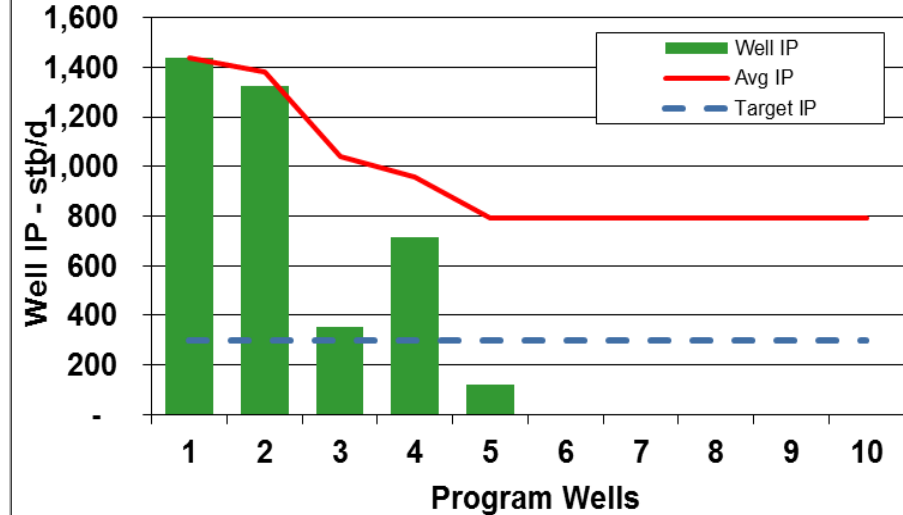
### Drilling Program Rate



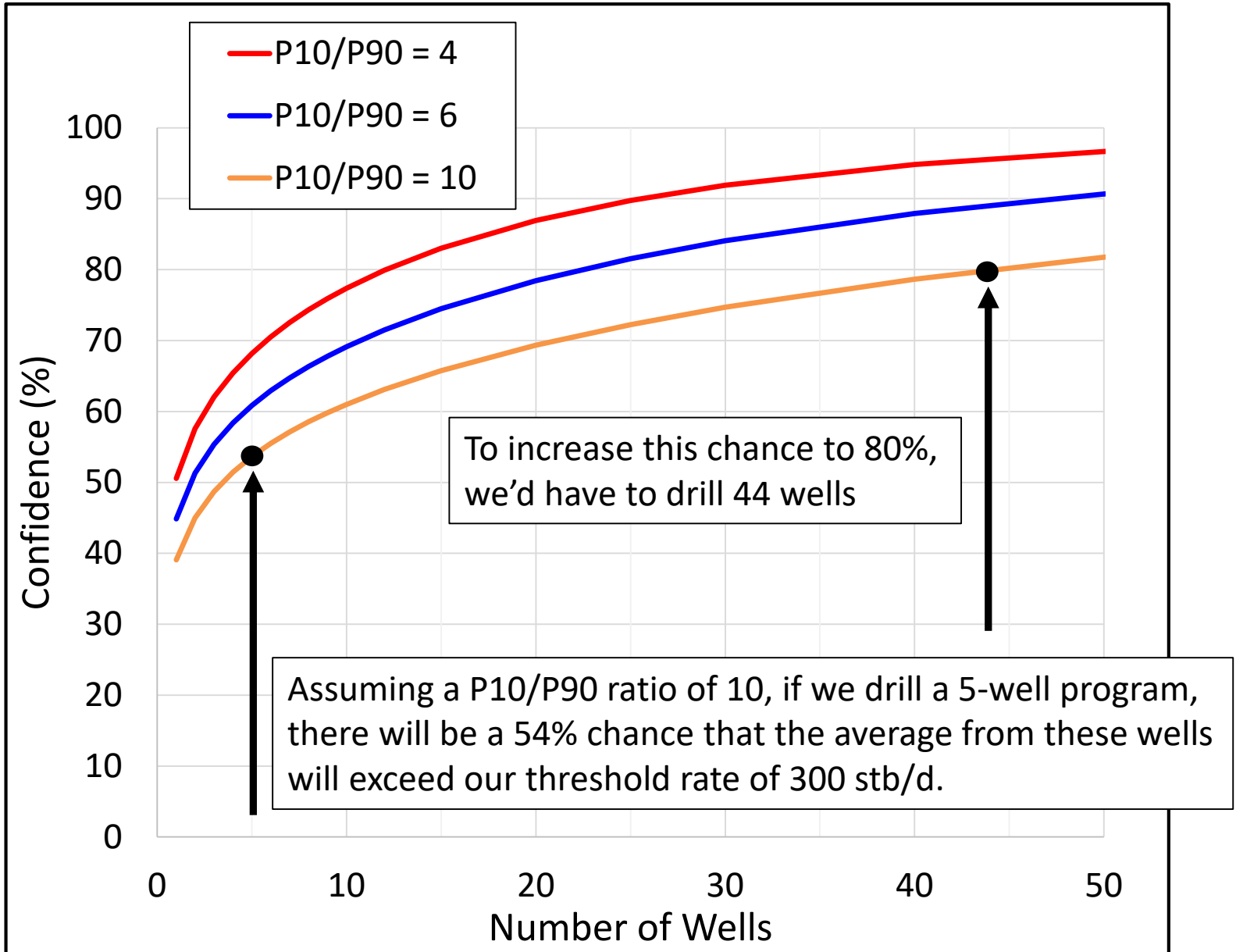
### Drilling Program Rate



### Drilling Program Rate



# Confidence Curves



# Project Stage: Demonstration



**Exploration**

**Appraisal**

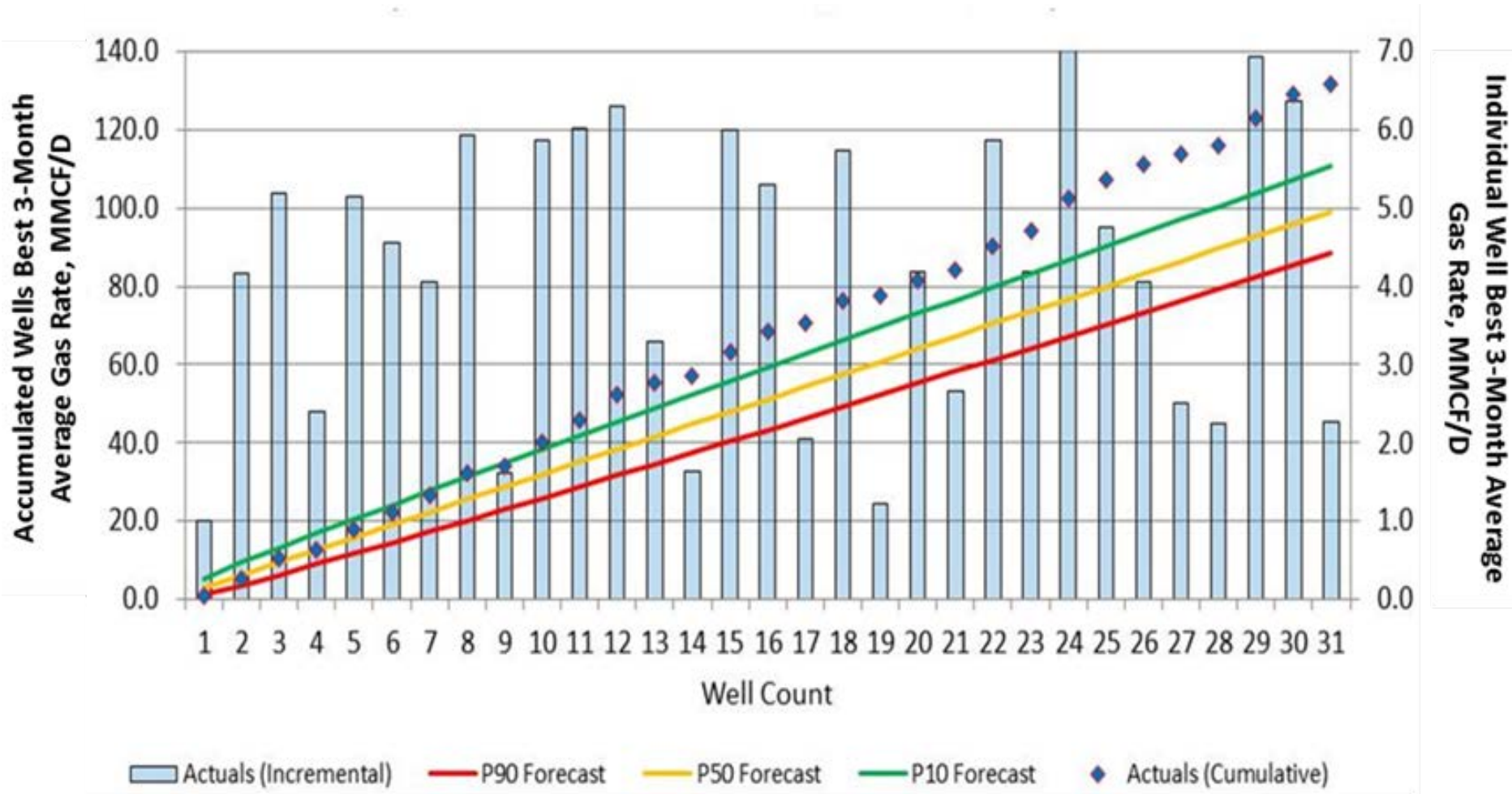
**Demonstration**

**Development**

- Validate that you have a commercially viable project above a prescribed confidence level
- May need multiple demonstration projects
- Determine the well count required to meet the prescribed confidence level
- Confirm type curve(s) and ensure that expected cost improvements are achievable
- Determine the well spacing that maximizes project value
- Use sequential aggregation plots to track performance vs forecast for major elements
- Determine failure criteria & what outcomes trigger an exit

# Sequential Aggregation Plot

Showing Best 3 Month Average Gas Rate for 31 Wells Compared to Forecasts



# Project Stage: Development



**Exploration**

**Appraisal**

**Demonstration**

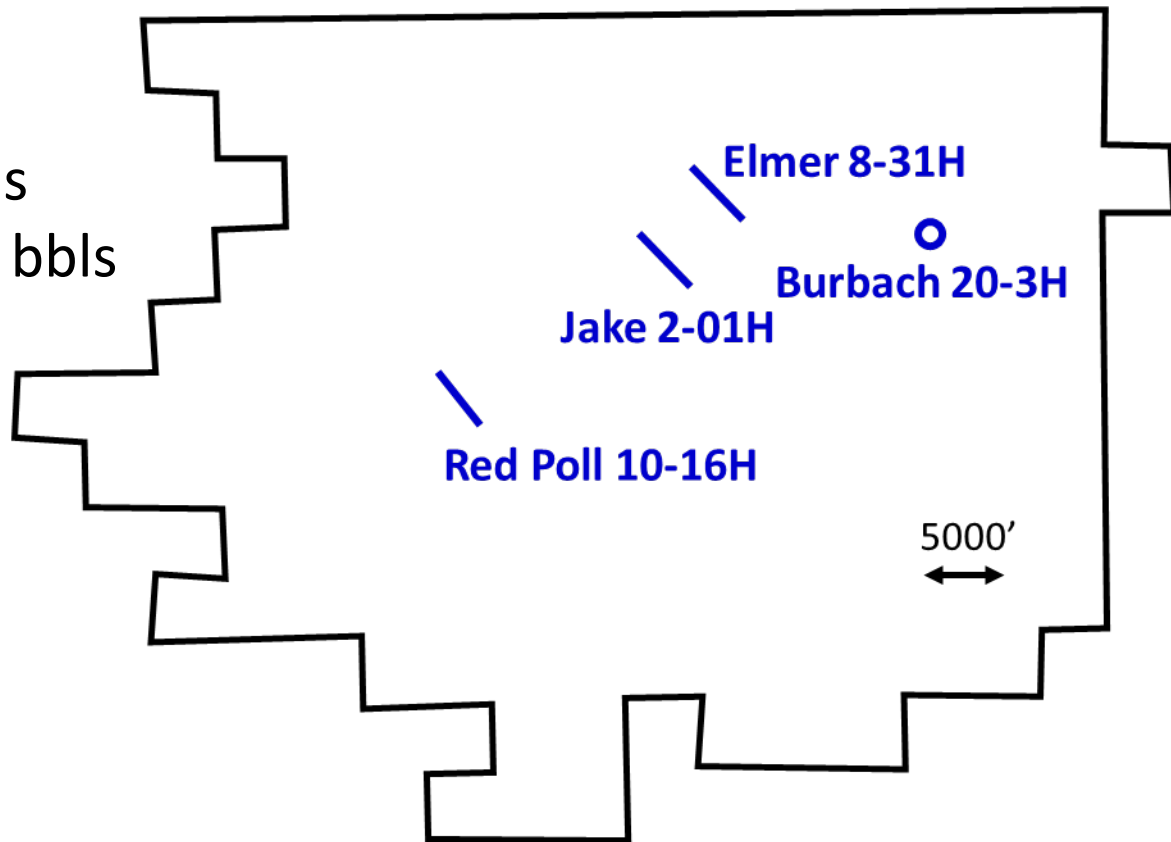
**Development**

- Proceed if the expected results are competitive with other opportunities in your company's portfolio
- As development drilling expands, ensure that results from new wells continue to meet expectations
- Use continuous learning and KPIs to reduce costs, optimize well spacing and maximize production & reserves
- Synchronize pad construction, well drilling, completion, fluid gathering and processing to maximize profitability

# Hereford Field Example (Niobrara Fm)

## 1 Year Cumulative Production for 3 Early Wells

Jake 2-01H = 70,410 bbls  
Elmer 8-31H = 53,413 bbls  
Red Poll 10-16H = 88,157 bbls

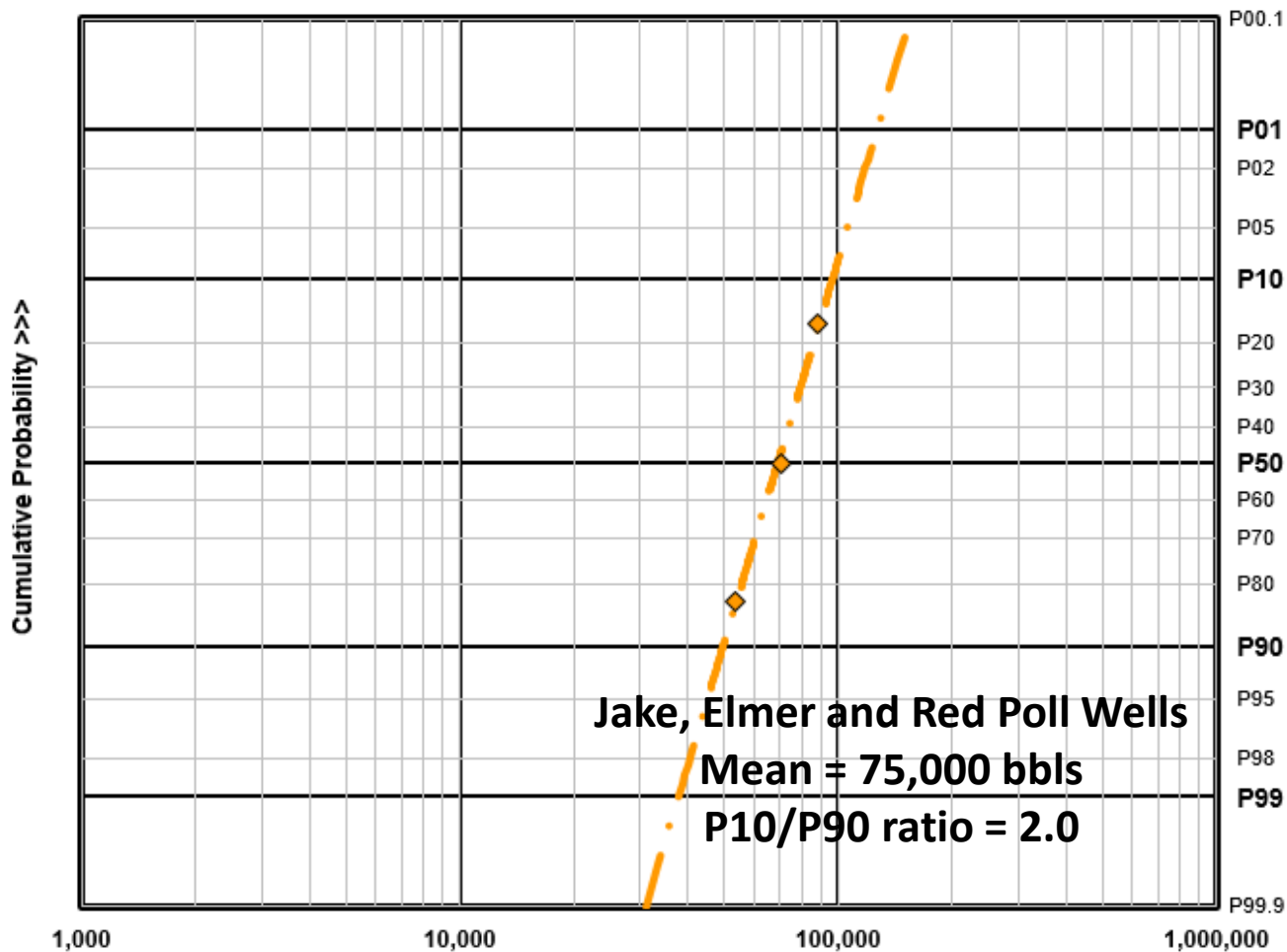


From "A Short History of the "Jake" Niobrara Horizontal Oil Discovery...", Mountain Geologist, July 2015  
Production data from the Colorado Oil and Gas Conservation Commission



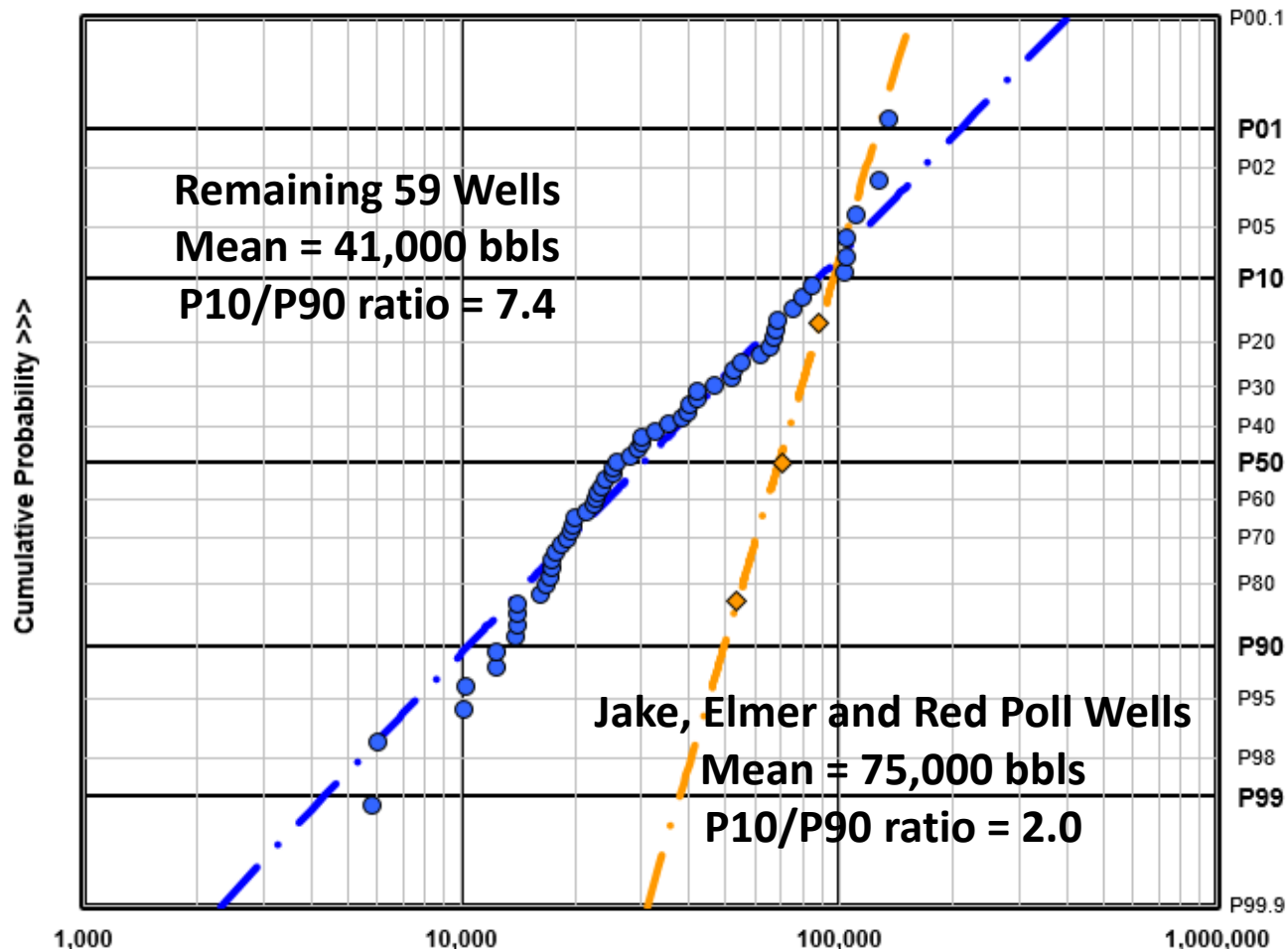
# Hereford Field Example (Niobrara Fm)

## 1 Year Cumulative Production for 3 Early Wells



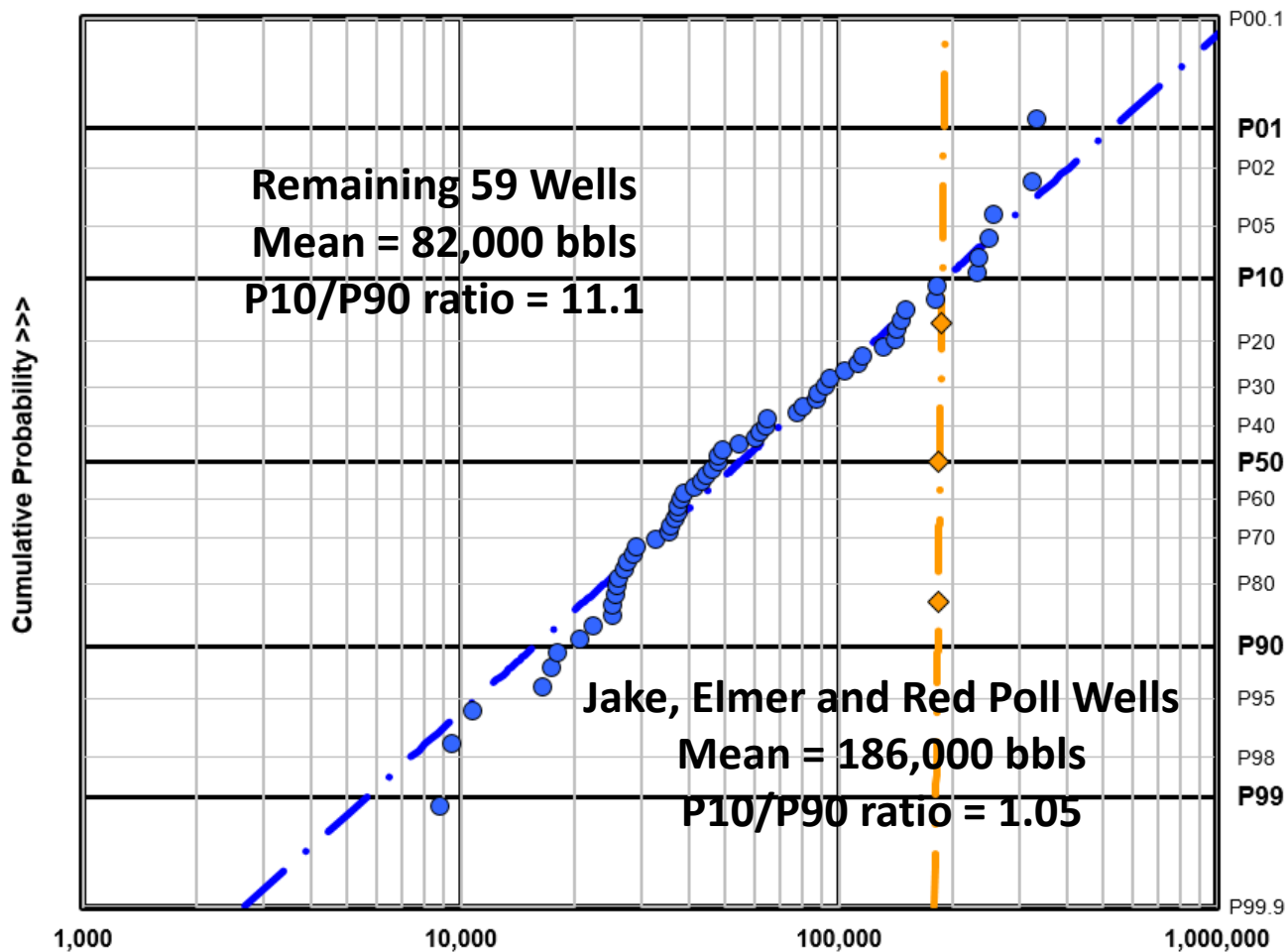
# Hereford Field Example (Niobrara Fm)

## 1 Year Cum. Production for 3 Early Wells + 59 Later Wells



# Hereford Field Example (Niobrara Fm)

## Cumulative Production Through 2016



# Hereford Field Example (Niobrara Fm)

## Cumulative Production Comparison

### Cumulative Production for 3 Early Wells

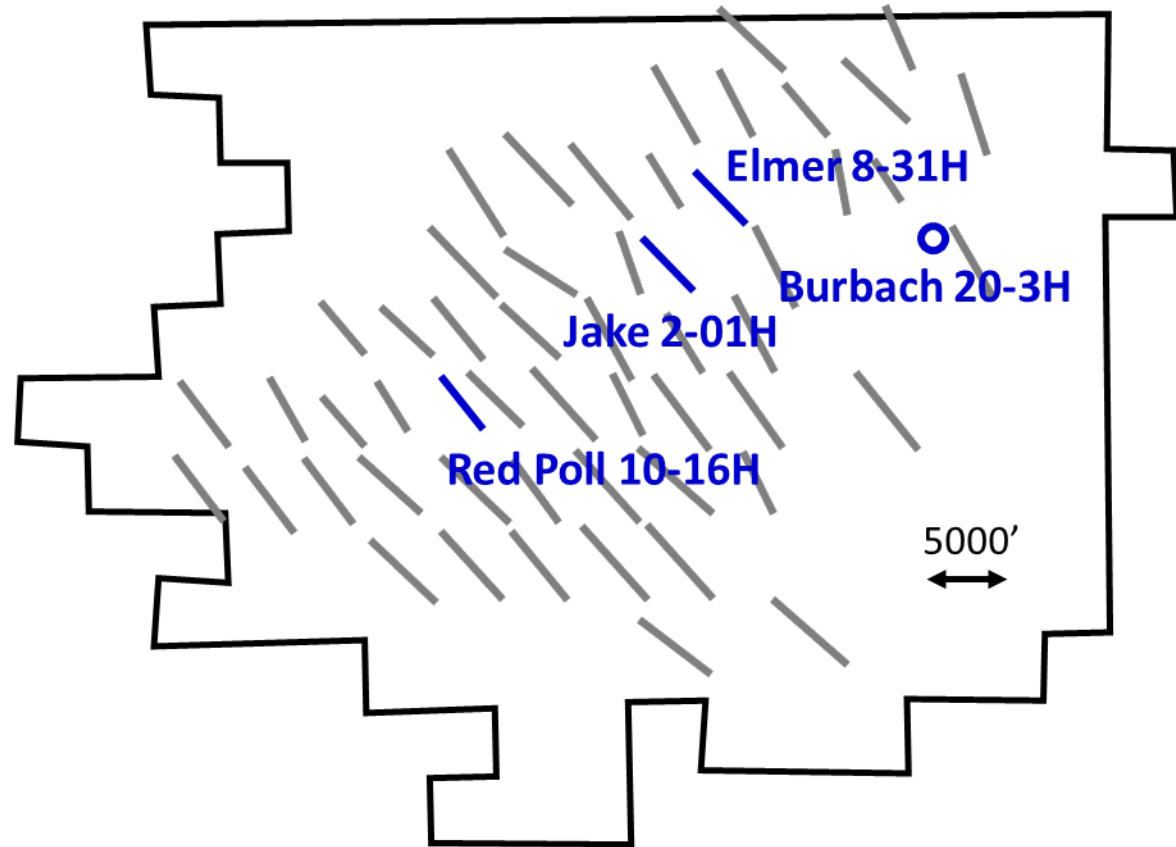
Jake 2-01H = 187 M bbls

Elmer 8-31H = 188 M bbls

Red Poll 10-16H = 182 M bbls

### Cumulative Production for 59 Later Wells

- 2 wells: > 300 M bbls
- 4 wells: 200-300 M bbls
- 10 wells: 100-200 M bbls
- 11 wells: 50-100 M bbls
- 32 wells < 50 M bbls
- P10/P90 ~ 11



Mean Cumulative Oil Per Well ~ 87 M bbls

At \$80 oil, need 42.5 M bbls to cover a well cost of \$3.4 MM

# The Staged Approach

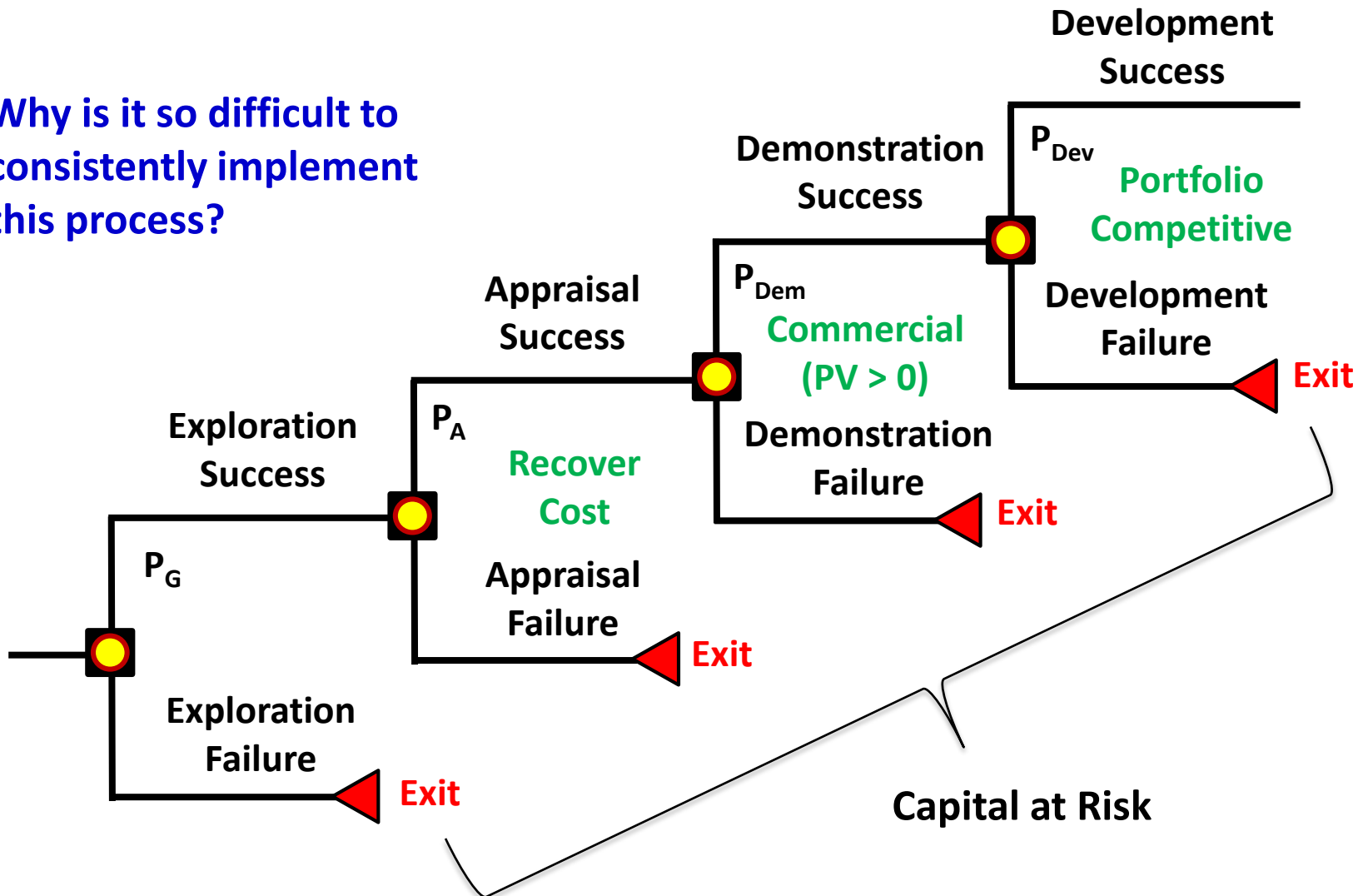
Stage 1:  
Exploration

Stage 2:  
Appraisal

Stage 3:  
Demonstration

Stage 4:  
Development

Why is it so difficult to consistently implement this process?



# The Assurance Process

- **Standards** such as minimum economic metrics and project size
- **Guidelines** including use of the staged approach
- **Workflows** that are discipline specific and tied to the staged decision tree, sets of deliverables, and KPIs
- **Peer assists** conducted with an independent external prospective to help ensure projects are properly focused
- **Documentation** to create a record of what was planned, predicted, and actually achieved
- **Lookbacks** to calibrate the outcomes and make changes that result in closer correspondence between what's promised and delivered in the future



# Key Questions for Decision Makers to Ask

- What is the source of the numbers that justify the recommendation?
- Does the recommendation assume that an approach that is successful in one area will be just as successful in another?
- Is there an over-attachment to a history of past decisions or to a rare but memorable success?
- Is the base case too optimistic? Too pessimistic?
- Were there dissenting opinions leading up to the recommendation? How was this resolved?
- If we delay a decision on this project for one year, what data would you gather in the interim and what impact could this have?



# A Concluding Thought



“If I had one wish, it is to see organizations dedicating some effort to study their own decision processes and their own mistakes, and keep track so as to learn from those mistakes.”

Daniel Kahneman – “Thought Leader” by Michael Scrage

# Appraising and Developing Your Unconventionals: How to Avoid Squandering Billions of Dollars Next Time

Thank You! Questions?



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