Monograph 5: A Practical Guide to Type Well Profiles

Society of Petroleum Evaluation Engineers

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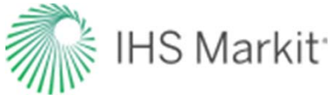

Committee Members

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SPEE Monograph 5 Committee

- In research stage. Opinions are not final!
- Begins Authoring phase Fall 2018
- Audience
  - Consumers (Investors, Banks)
  - Producers (Consultants, E&P)
  - Software Vendors
- Reaches Final Publication in 2020
- Needs more non-public Data!!

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Definition

Type Well **Profiles (TWP)**

method for constructing either (1) the "average well" performance or (2) the "average monthly" performance in a developmental program over time

Results can be directly applied to Cash Flow Analysis

Not

Type Well Curves

such as methods for analyzing pressure drawdown (flow) and buildup tests, diffusivity equation

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Why Type Well Profiles?

Solving Industry CRITICAL Tasks!

- Forecasts of New Wells with Limited History
- Forecasts of Undrilled Wells
- Development Planning
- Unconventional and Conventional

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What is the Committee trying to Accomplish?

Establish **Practical** Industry Guidance

- Adherence to Fluid Flow Principles
- Methods of Construction
  - Public Data vs Proprietary Data
  - Fit for Purpose
  - Analogous Bin Selection
  - Survivor Bias
  - Scaling
- Validation of Results
- Communication of Uncertainty

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Committee Methodology

- Create a **practical**, working outline
- Pick different areas and apply
- See what works and record observations, any changes to outline methodology
- Feedback and suggestions from industry peers along the way
- Coordinate with other industry groups

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Focus Area 1 Permian Basin *(Howard Co)*

- **Analogous Data Sets** are difficult to find
  - Multiple Benches (Wolfcamp A)
  - Completion differences
  - Small data sets
- **Multiphase, primarily oil**
- **Flow Regime Information** is limited
  - Not enough history to establish BDF (Boundary Dominated Flow)
  - Limited Pressure Data
  - Limited Daily Data
  - Very short linear flow period
  - Most of the data exists in BIF (Boundary Influenced Flow)
- **Validation of Results**
  - Not enough history to hindcast

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Focus Area 2 Barnet Shale (Johnson Co)

- **Dry Gas Window** (Lower Barnett)
  - Large Data Set
  - Single Phase
- **Historical Data**
  - Publicly available Monthly data, no daily
  - Assumed Constant Pressure
  - Oldest wells drilled in 2007
- **Established Diagnostic Techniques**
  - Long period of linear flow
  - Short Transient period
  - Boundary Dominated Flow, maybe
- **Straightforward Validation**
  - Enough history to validate results with hindcasting

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TWP Construction Outline - Step 1

- Determine Purpose (developmental drilling program)
- Choose Focus Area (and initial bins)
  - Formation
  - Well Type
  - Vintage
  - Fluid Type
  - Minimum number of producing months
- Forecast Individual Wells
  - Traditional Decline Curve Analysis
  - Based on Fluid Principles
  - Eliminate Survivor Bias
- Examine P10/P90 ratios, EUR Distribution
  - Inclusion/exclusion of data or wells

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TWP Construction Outline - Step 2

- Examine Well Selection (Re-bin as necessary)
  - Operator
  - Spatial Analysis (map)
  - Shape of Curve (flow regime)
  - Geologic Characteristics
  - Completion methods
- Determine Binning vs Scaling
  - Which variables
  - Multi-variate
  - Re-evaluate bins
  - Normalize to increase sample size
- Examine P10/P90 ratios, EUR Distribution
  - Inclusion/exclusion of data or wells

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TWP Construction Outline - Step 3

- Create P10, P50, P90 Forecasts
- Average Production or Average Forecasts
  - Monthly rate equals mean of underlying well monthly rates
  - TWP EUR equals average of underlying well EUR
- Fitness Metrics
  - Discounted Volume
  - EUR Distribution
- Evaluate Uncertainty

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Type Well Profiles - Fluid Flow Principles

Flow Regime Theory

from Monograph 4, describing multi-fractured horz wells

Transient Linear Flow

(until fracture interference, b=2)

Boundary Influenced Flow

(BDF of Stimulated Reservoir Volume b < 1, Linear beyond SRV b=2)

Boundary Dominated Flow (b < 1)

Goals:

Establish Start of Boundary Influenced Flow

Establish Decline rate and B

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Flow Regime Identification

Diagnostic Methods

- Pressure normalized Log(q) versus Log(MBT) sometimes effective
  - Absence of Daily Data makes it difficult to pick unique half-slope and unity slope solutions
  - Absence of Pressure data for rate normalization can make for misleading interpretation

- Log(q) versus Log(t) Plots
  - assumes constant pressure, single phase
  - Workable with monthly data

- GOR change method in multi-phase environment (based on some observations):
  - During Linear flow, if Flowing pressure is constant, GOR is constant
  - GOR starts to increase under Boundary Influenced Flow

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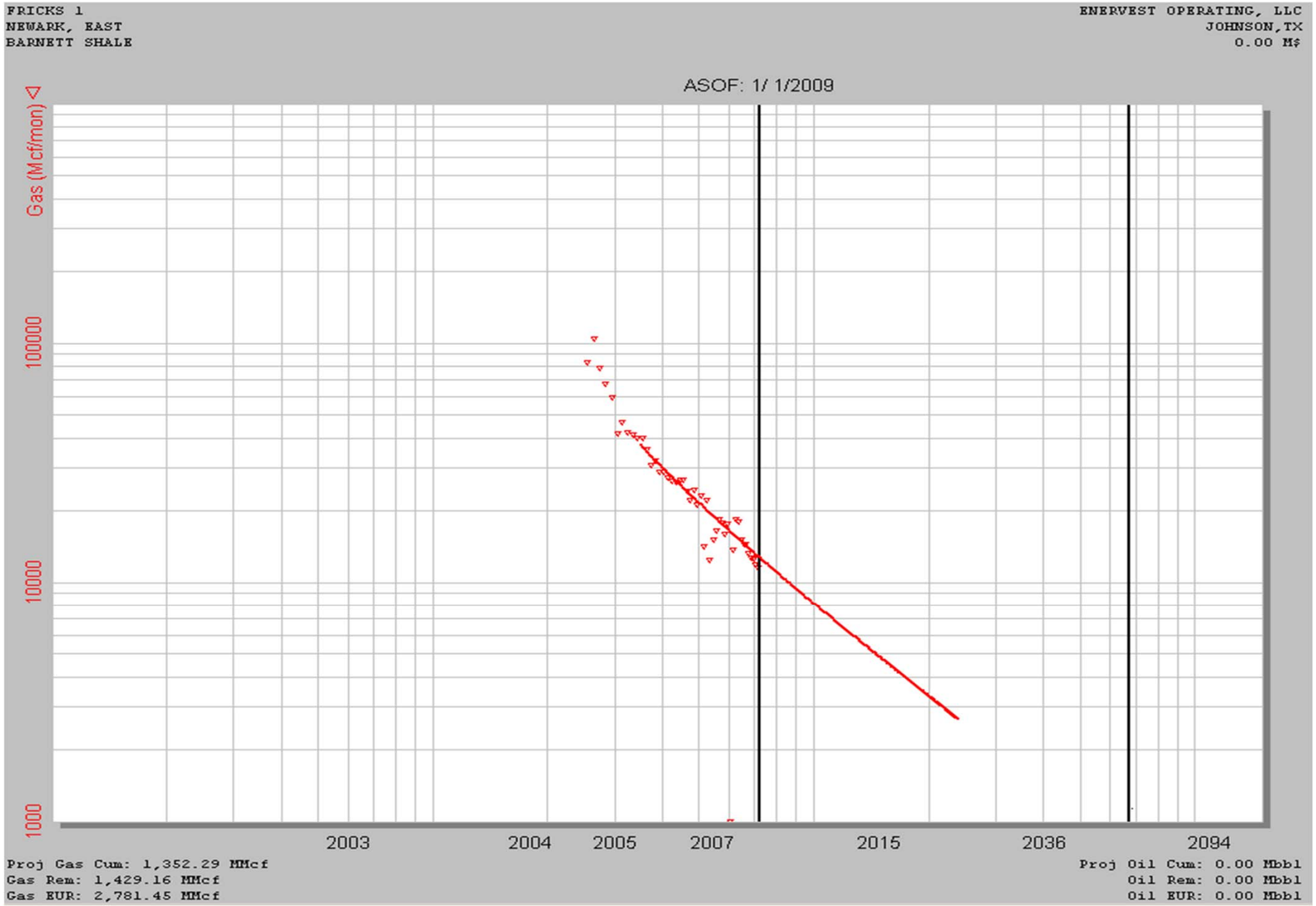
Flow Regime Identification

Log(q) versus Log(t)



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Practical Decline Models

- Single Segment Arps – *intended for BDF only, difficult or impossible to fit multiple flow regimes and usually overstates reserves*

- Two Segment Arps – *Linear & BIF , or BIF and BDF flow regimes*
    - Two different B Factors
    - Need to determine end of Linear Flow

- Three Segment Arps – *Linear, BIF, and BDF flow*
    - Three different B Factors
    - Determination of the end of Linear flow
    - Determination of the end of Boundary Influenced flow

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Survivor Bias

Tendency to bias towards the longest surviving wells when averaging production

- Forecast all wells individually first
- Separate TWPs by Vintage if you see a performance trend
- Divide by a constant well count (even as wells go off-line)

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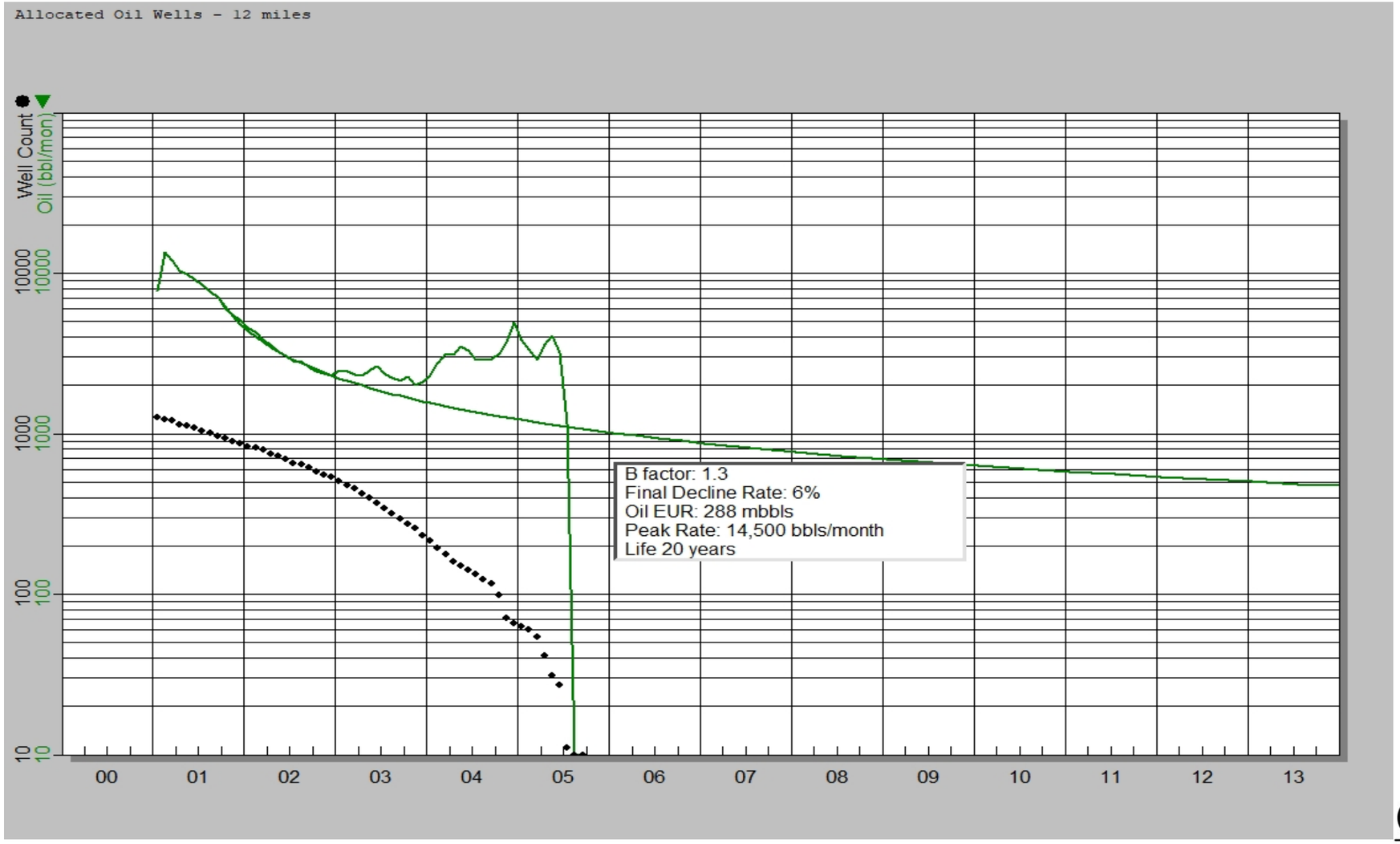
Survivor Bias - *declining well count, no individual forecast*



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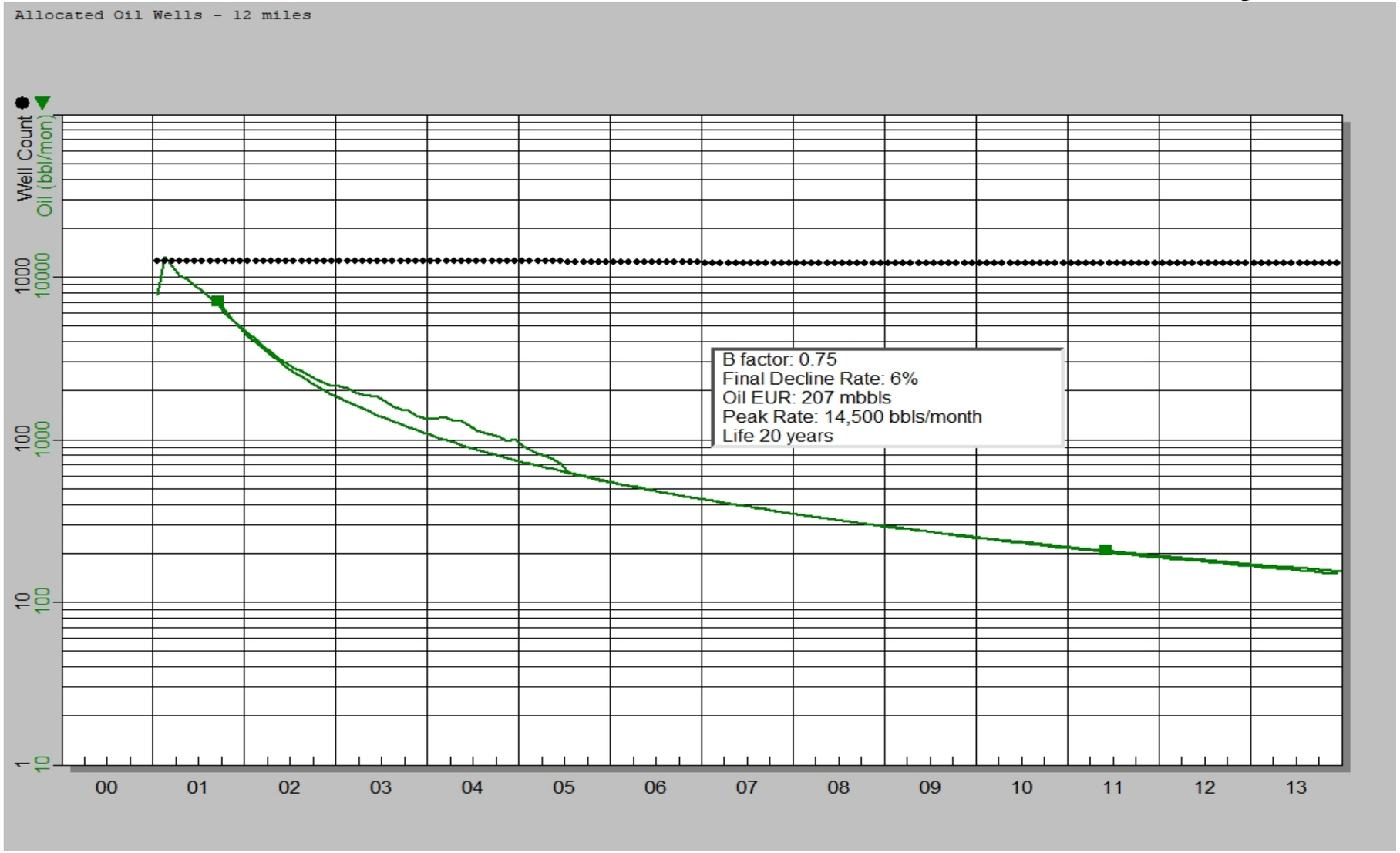
Survivor Bias - *constant well count, individual forecasts*



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Binning

Grouping wells into analogous categories so that a TWP is meaningful and predictive, while keeping the number of samples per bin statistically meaningful

- Multi-variate
  - Separate into regions of significant differences
- Correlate
  - Variables which show definite influence on performance results
- Anomalies may shed most light on differentiators

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Binning – Completion Differences

- Well Type (H vs V)
- Lateral Length
- Vintage
- Number of Frac Stages
- Clusters per Stage
- Pounds of Proppant
- Volume of Frac fluid
- Type of Frac Fluid
- Mesh Size
- Pump Type
- Pump Size
- Choke Size
- Choke management
- Proppant type
- Artificial Lift

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Binning – Geologic Differences

- Porosity
- Structure Thickness
- Organic Content
- phi*h
- Permeability
- Vshale
- Vcarbonate
- Vlime
- Fracture length
- Vdolomite
- Formation
- Vquartz
- Matrix density
- Fracture Orientation
- Dual porosity

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Binning – Reservoir Differences

- Thermal Maturity
- Initial Water Saturation
- Initial Reservoir Pressure
- GOR
- Performance
- Initial Potential
- B factor
- Flow Regime

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Scaling – Tradeoff versus Bin Size

Scaling

Establish Correlations

IP versus Lateral Length

EUR versus Lateral Length

Note Decline rate and Qi are both changing

Note that EUR per foot decreases with increasing length

Possible new techniques on scaling to curve shape using permeability and calculated fracture half-length

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Uncertainty

Sources of Uncertainty

- Uncertainty of the Individual Forecasts
  - clean data
  - sufficient history
- Is Sample set “truly” analogous
- Is Sample set large enough for high statistical confidence
- Clarity of Purpose
  - Analogy of input area wells to intended use area
  - For single well or developmental program

- The level of Uncertainty does not preclude the use of a TWP or not, what is important is that the Level of Uncertainty is adequately communicated from the producer to the consumer.

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Closing

Monograph 5 is a work in progress. If you would like to contribute comments, suggestions, ideas, or data, please contact me at

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Thank you!

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