Status of SPEE Monograph 4—Estimating Developed Reserves in Unconventional Reservoirs

John Seidle

MHA Petroleum Consultants

SPEE Annual Conference

Coeur d'Alene, ID

11 June 2013

SPEE Monograph 4 Purpose

- **Assess current methods to forecast performance of wells in unconventional reservoirs given different reservoir types, different completions, and different well maturities.**

SPEE Monograph 4 Committee Members

Chris Clarkson (Univ of Calgary) – invited

Jim Erdle (CMG)

Creties Jenkins (Rose & Associates)

John Lee (SPEE, Univ of Houston)

Casey O'Shea (IHS/Fekete)

John Ritter (SPEE, Occidental Petroleum)

John Seidle (SPEE, MHA Petroleum Consultants)

Darla-Jean Weatherford (TextRight, technical editor)

Scott Wilson (SPEE, Ryder Scott)

SPEE Monograph 4 Outline

1. Definition of unconventional reservoirs (UCR)
2. Exploration, Reconnaissance, and Geologial Aspects of UCR
3. Drilling , Completions, and Operations in UCR
4. Overview of Early Reserves Estimation and Production Forecasting
5. Classical Decline Curve analysis (DCA)
6. Modern Performance Analysis
7. Analytical Models
8. Numerical models
9. Probabilistic Methods and Uncertainty in Forecasts and Estimated Ultimate Recovery
10. Summary of Current Technology and Expected Future Trends

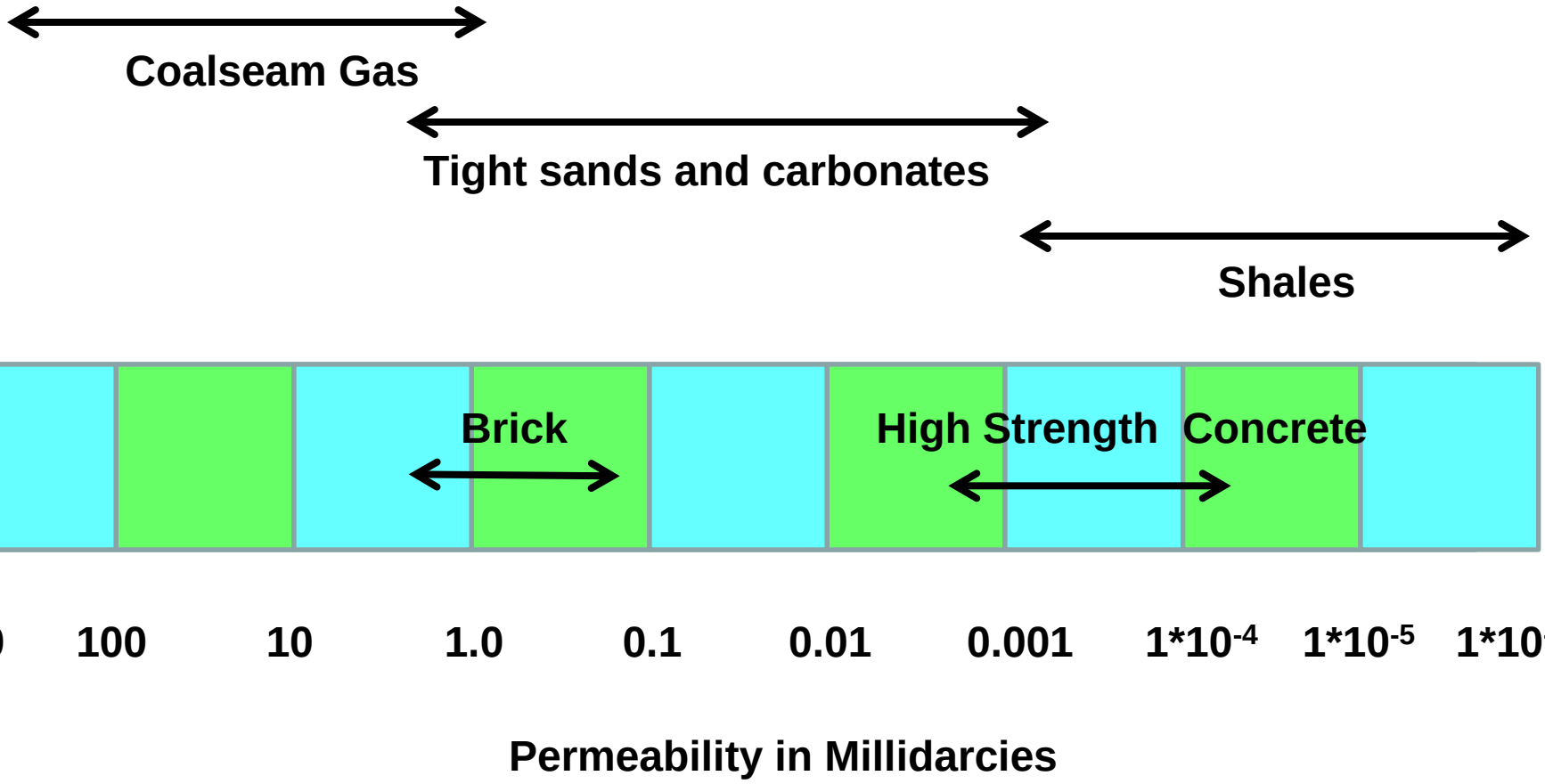
SPEE Monograph 4 – Characteristics of UCR's

1. Wells exhibit a repeatable statistical distribution of Estimated Ultimate Recoveries (EURs).
2. Offset well performance is not a reliable predictor of undeveloped location performance.
3. A continuous hydrocarbon system that is regional in extent.
4. Free hydrocarbons (non-sorbed) are not held in place by hydrodynamics.
5. Requires extensive stimulation to produce at economic rates. (Development and application of technologies not commonly deployed for the exploitation of conventional resources, such as extensive stimulation and micro-seismic.)
6. Produces little in-situ water (except for Coalbed Methane and Tight Oil Reservoirs).
7. Does not exhibit an obvious seal or trap.
8. Low permeability (< 0.1 md).
9. May exist outside of a conventional trap
10. May be characterize by discrete "fields" that merge into a regional accumulation
11. Do not have a well-defined hydrocarbon-water contact
12. Hydrocarbons may be held in place by water (CBM), but not by hydrodynamics
13. Commonly are abnormally pressured (higher or lower than hydrostatic)
14. Have large in-place resources, but low recovery factors compared to conventionals
15. Have geologic "sweet spots" or "fairways" of production
16. Economic production may depend on locating natural fractures or higher permeability facies types (raisins in the pudding)
17. Reservoirs may be self-sourcing, or are in close proximity to source rocks
18. May have water located updip from gas (basin-centered accumulations)
19. Contain few truly dry holes—nearly all wells are capable of producing some hydrocarbons, i. e. – little to no inherent exploration risk.
20. Per well EURs are generally lower than EURs from conventional gas accumulations
21. Potential large-scale development footprint.

SPEE Monograph 4 – Unconventional Reservoirs

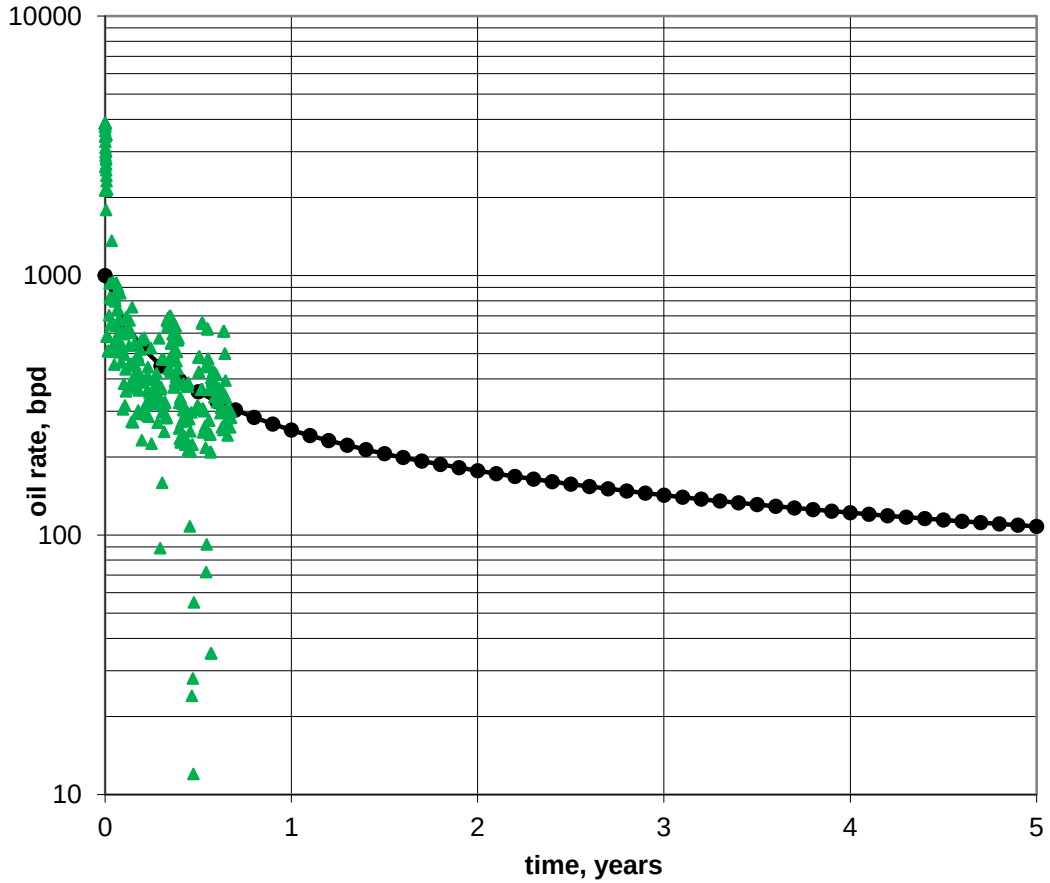
1. **Shales**
2. **Tight sands and carbonates**
3. **Coals**

Permeabilities of Unconventional Reservoirs



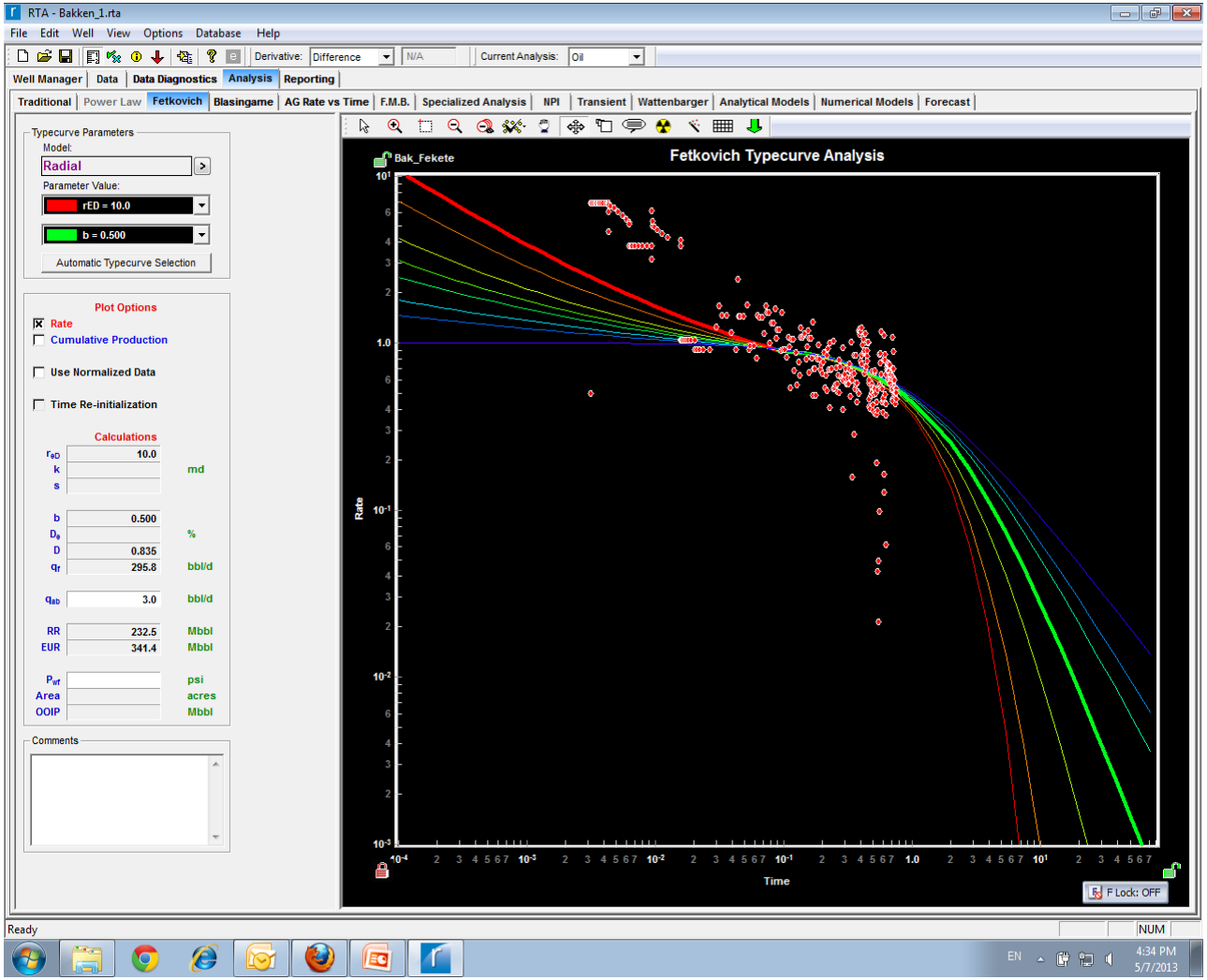
Example problem - Bakken oil well - data

Example problem - Bakken oil well – decline curve analysis



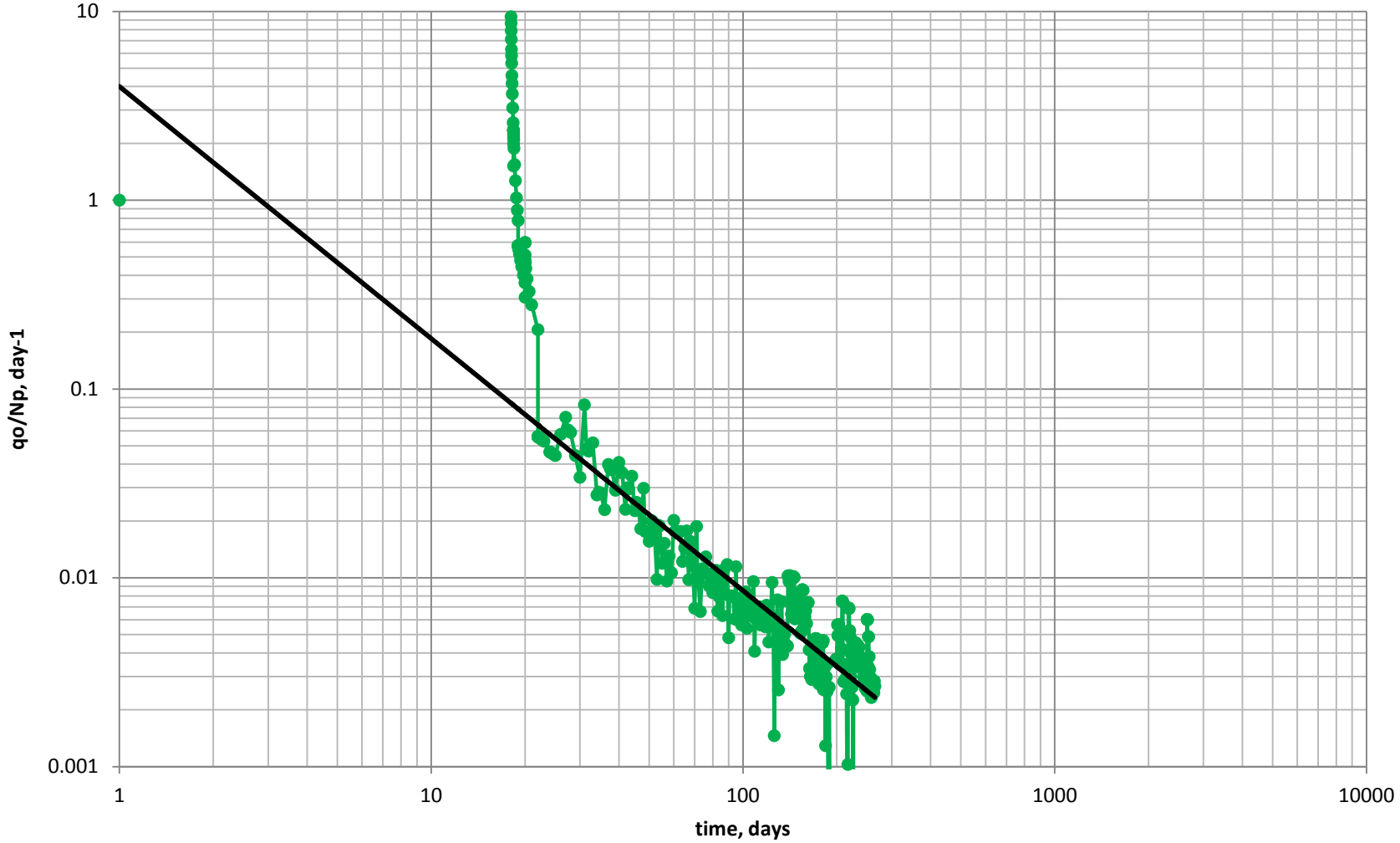
- **Decline parameters**
  - **Qi = 1,000 bpd**
  - **De = 74.62%/yr**
  - **b = 1.8**
  - **Dmin = 5 %/yr**
- **30 yr cum = 918 mbo**

Example problem - Bakken oil well – Fetkovich/Arps match

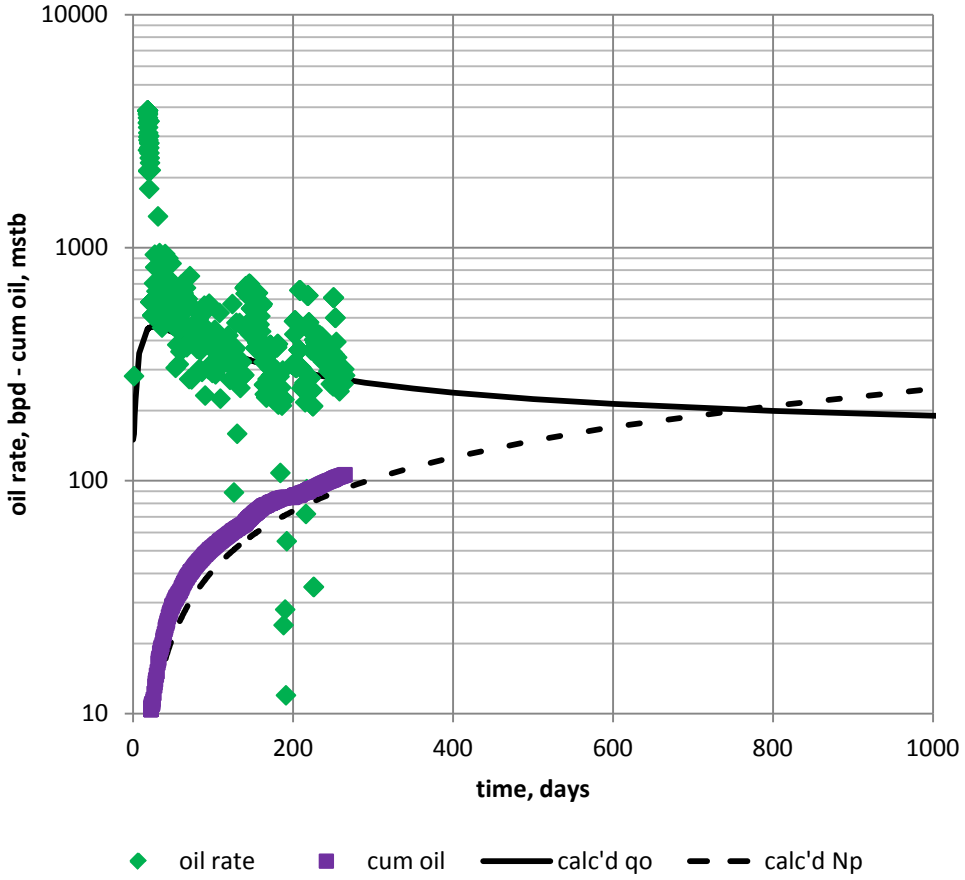


EUR = 341 mbo?

Example problem - Bakken oil well – Duong plot



Example problem - Bakken oil well – Duong results

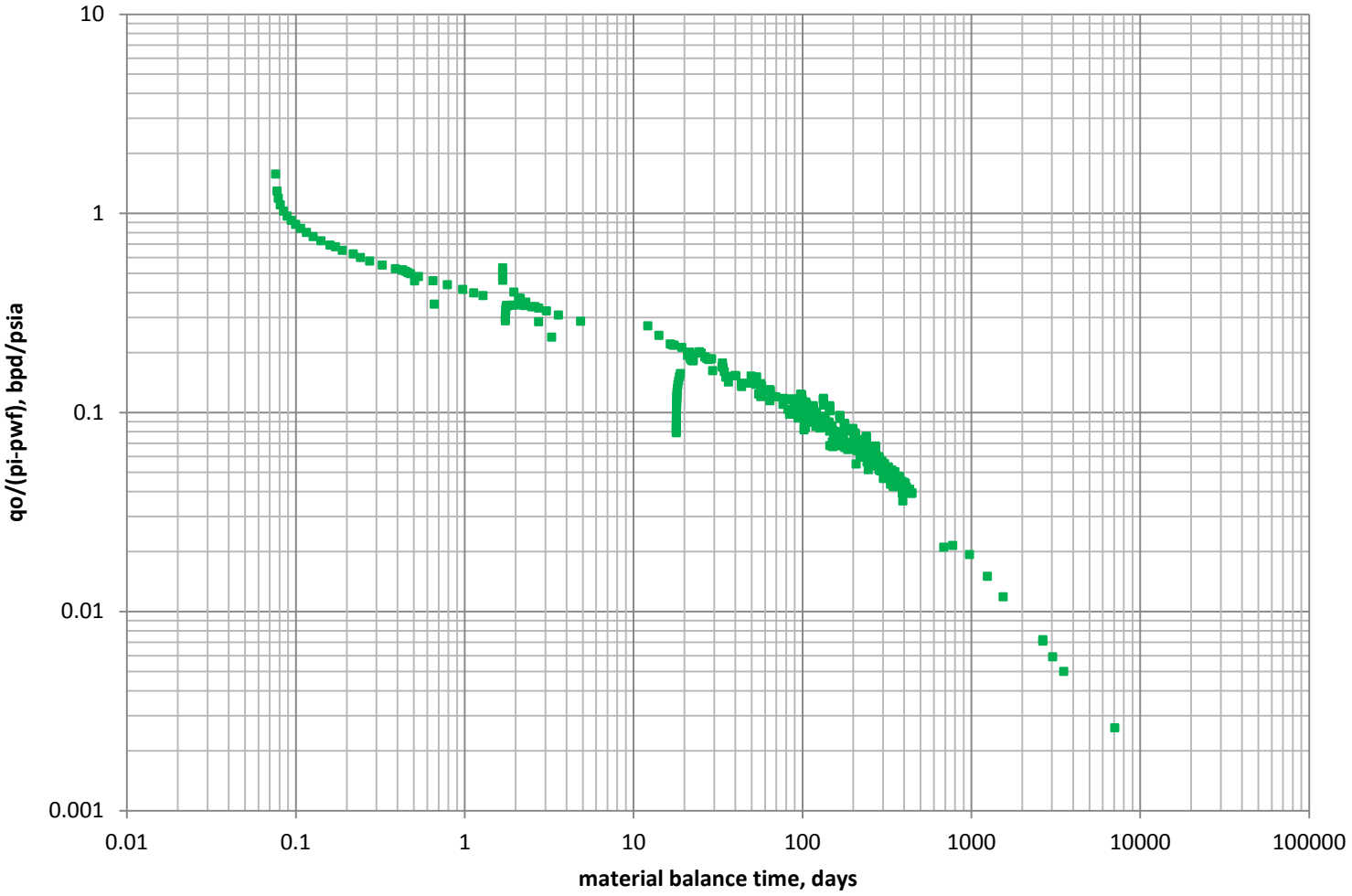


- **30 year forecast**
  - **oil rate = 153 bpd**
  - **cum = 1,829 mbo**

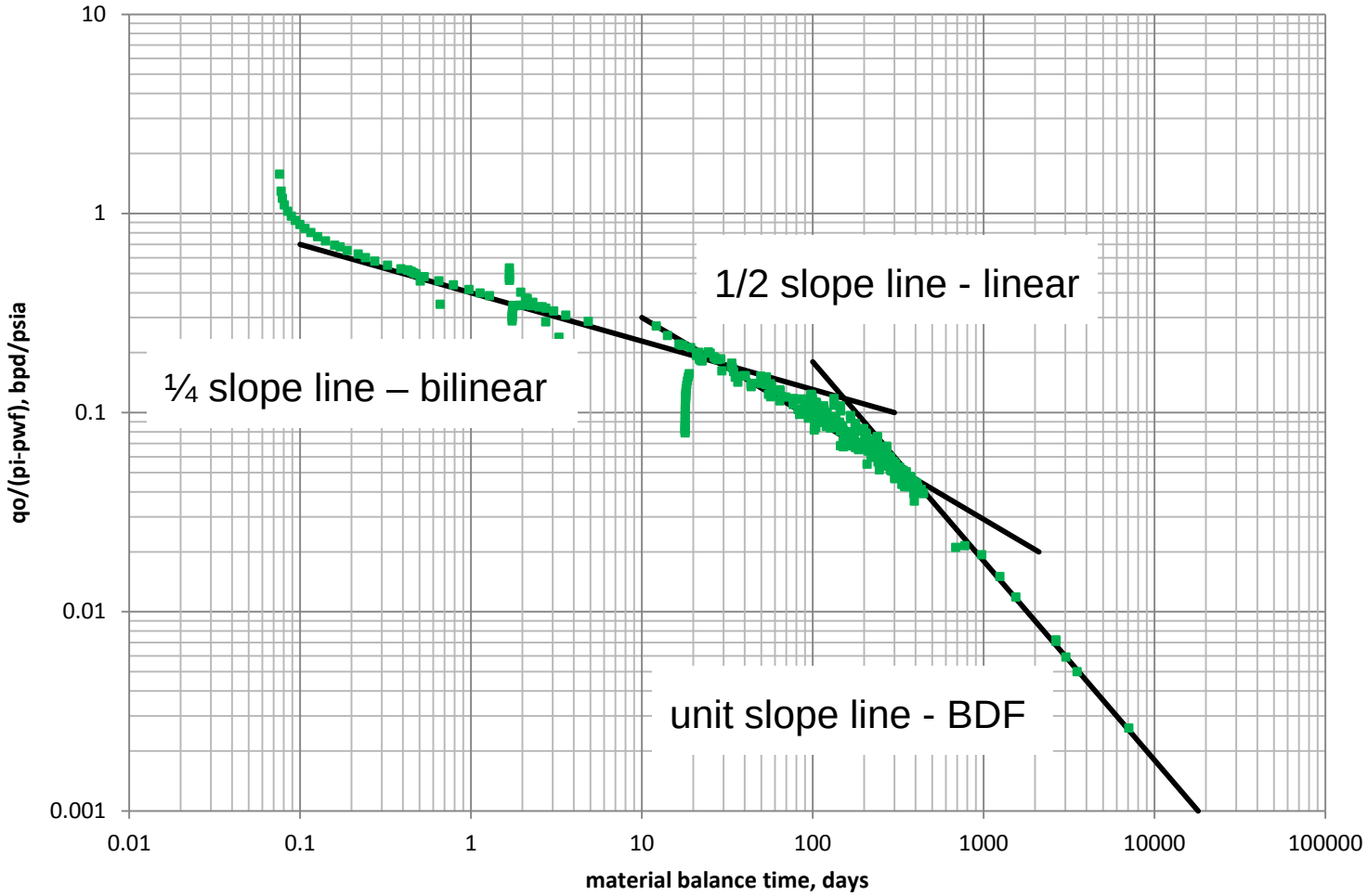
Example problem - Bakken oil well – results - 1

1. **Decline curve analysis – 30 yr cum = 918 mbo**
2. **Fetkovich/Arps – EUR = 341 mbo?**
3. **Duong – 30 yr cum = 1,829 mbo**

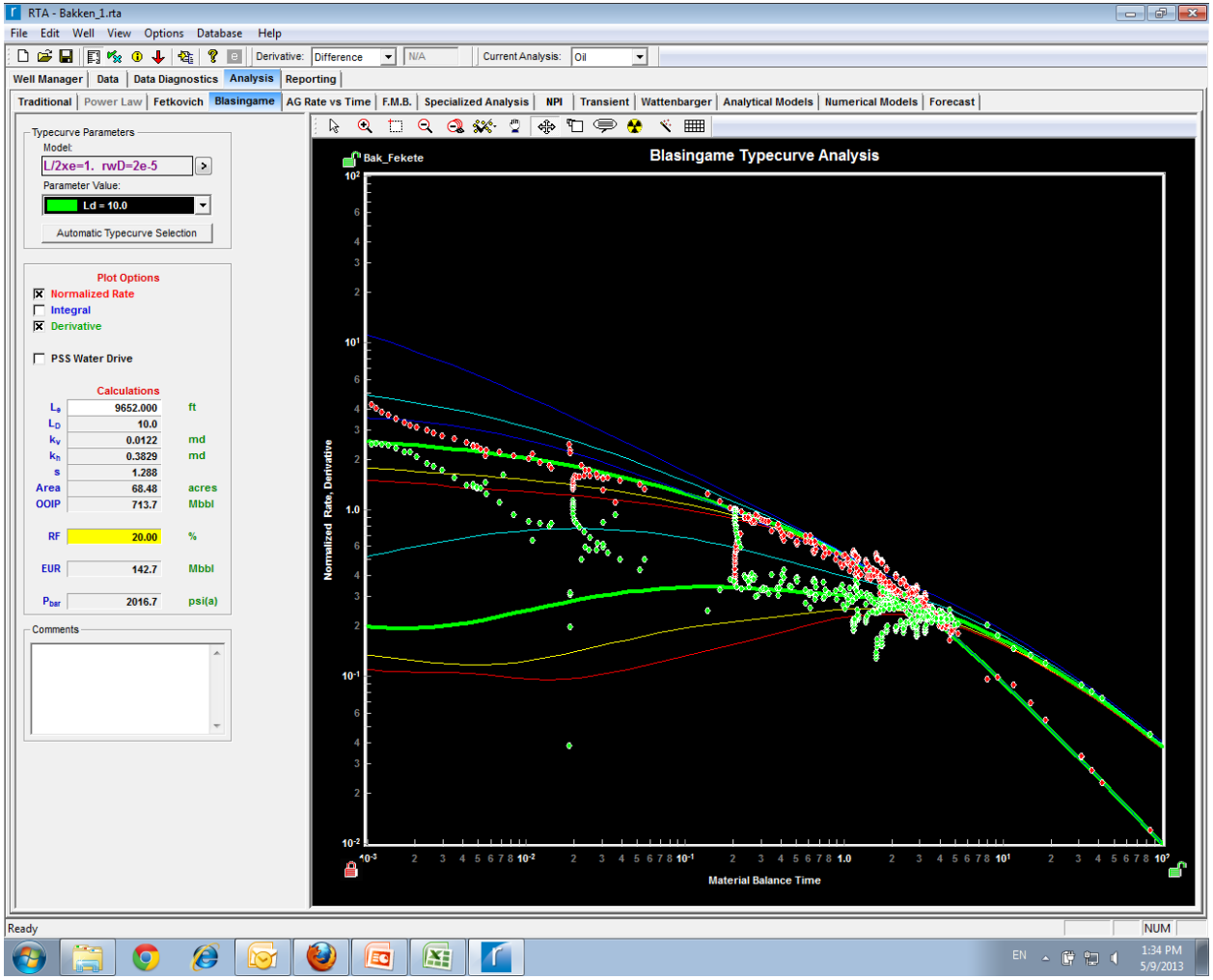
Example problem - Bakken oil well – The Most Important Plot – normalized rate vs material balance time



Example problem - Bakken oil well – The Most Important Plot – normalized rate vs material balance time



Example problem - Bakken oil well – Blasingame match

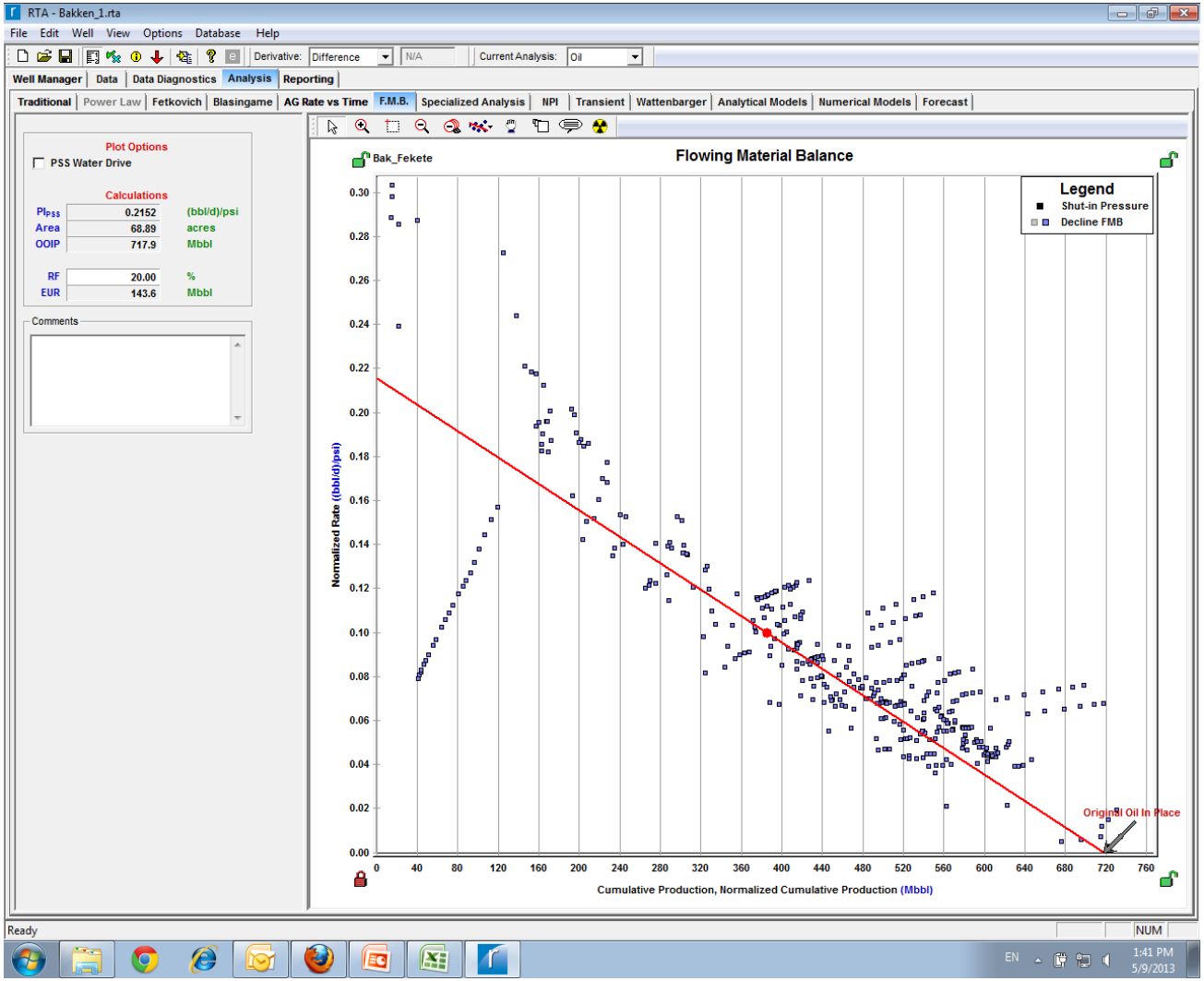


OOIP = 714 mbo

EUR = 143 mbo

assuming 20% recovery factor

Example problem - Bakken oil well – flowing material balance

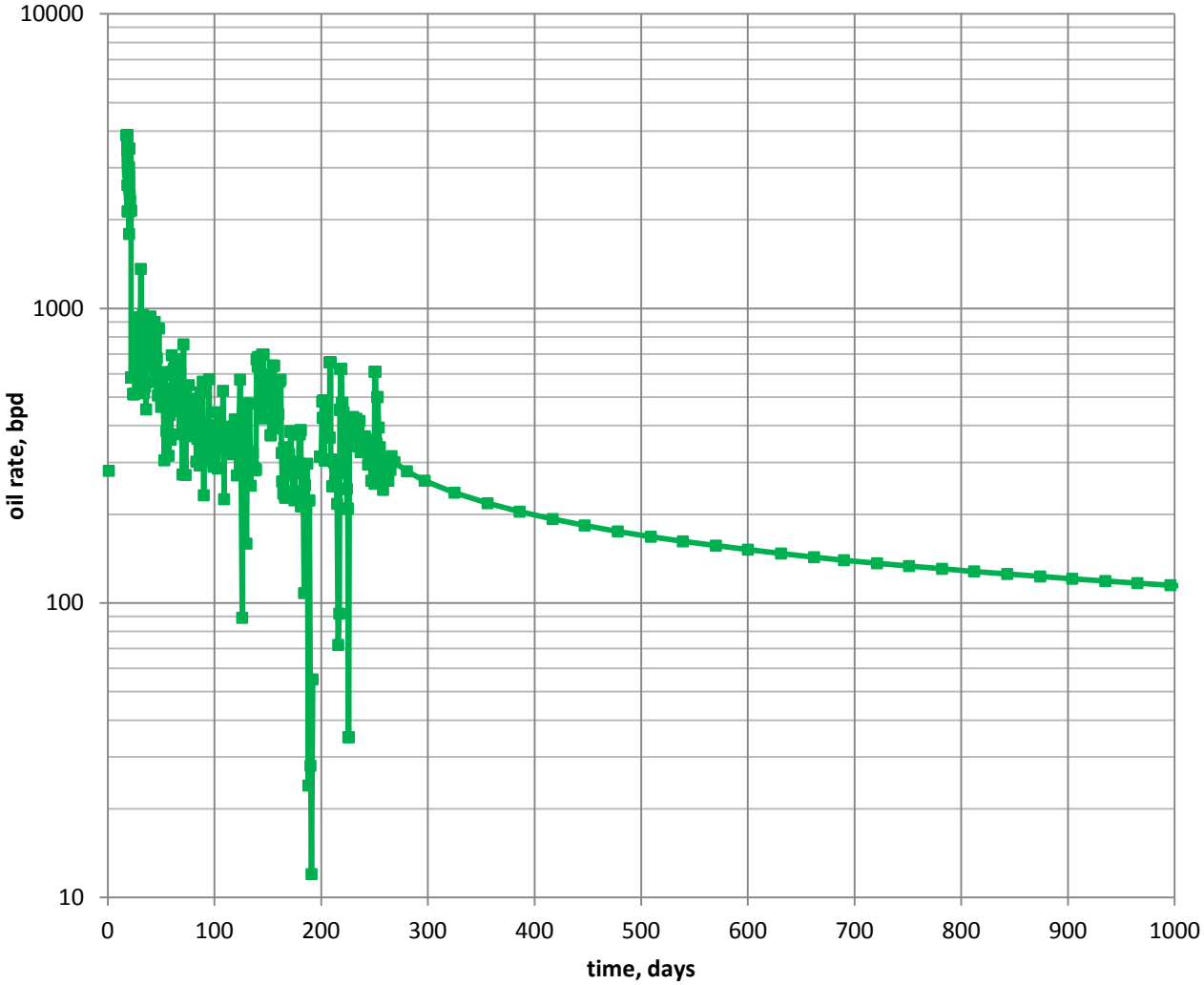


OOIP = 718 mbo

EUR = 144 mbo

assuming 20% recovery factor

Example problem - Bakken oil well – simulation



OOIP = 689 mbo (SRV)

30 yr cum = 763 mbo

111% recovery factor?

Flow from outside SRV?

Example problem - Bakken oil well – results - 2

1. Decline curve analysis – 30 yr cum = 918 mbo
2. Fetkovich/Arps – EUR = 341 mbo?
3. Duong – 30 yr cum = 1,829 mbo
4. Blasingame – OOIP = 713.7 mbo / EUR = 143 mbo?
5. Flowing Matl Balance - OOIP = 717.9 mbo / EUR = 143 mbo?
6. Simulation – OOIP = 689 mbo / EUR = 763 mbo

Example problem - Bakken oil well – results - 3

1. Decline curve analysis – 30 yr cum = 918 mbo
2. Fetkovich/Arps – EUR = 341 mbo?
3. Duong – 30 yr cum = 1,829 mbo
4. Blasingame – OOIP = 713.7 mbo / EUR = 143 mbo?
5. Flowing Matl Balance - OOIP = 717.9 mbo / EUR = 143 mbo?
6. Simulation – OOIP = 689 mbo / EUR = 763 mbo
7. Actual = ??? mbo

SPEE Monograph 4 -- Proposed Timeline

- 31 August - Revised chapter drafts
- 1 October – Draft manuscript back to committee
- 15 October – Committee comments to Chair & Technical Editor
- 1 November – Draft manuscript to SPEE Executive Committee
- 1 January 2014 – Draft manuscript to sister societies
- 1 March – Comments back from SPEE Ex Comm & sister societies
- 1 April – Final manuscript to SPEE Ex Comm

SPEE Monograph 4 -- Summary

- **Methods to estimate developed reserves in conventional reservoirs often not reliable in UCR's.**
- **Current industry practice of EUR determination from hyperbolic decline early + terminal exponential late may not be definitive.**
- **Construct the Most Important Plot to identify flow regimes and appropriate models.**

SPEE Monograph 4 – Summary (con't)

- **Accurate determination of EUR's in UCR's requires rich data set**
  1. **Production data**
  2. **Initial reservoir pressure & bottomhole flowing pressures**
  3. **Geology & geophysics**
  4. **Completion & stimulations**
- **Confidence in analysis increased by using more than one method**
- **How to handle routine reserves job with several hundred wells in a few weeks?**

SPEE Monograph 4 Committee – Interested in your comments & questions

jseidle@mhausa.com