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# Artificial Lift Applications in Unconventional & Tight Reservoirs

**Rajan N. Chokshi, Ph.D.**

Accutant Solutions
Accurate Accountable Acumen

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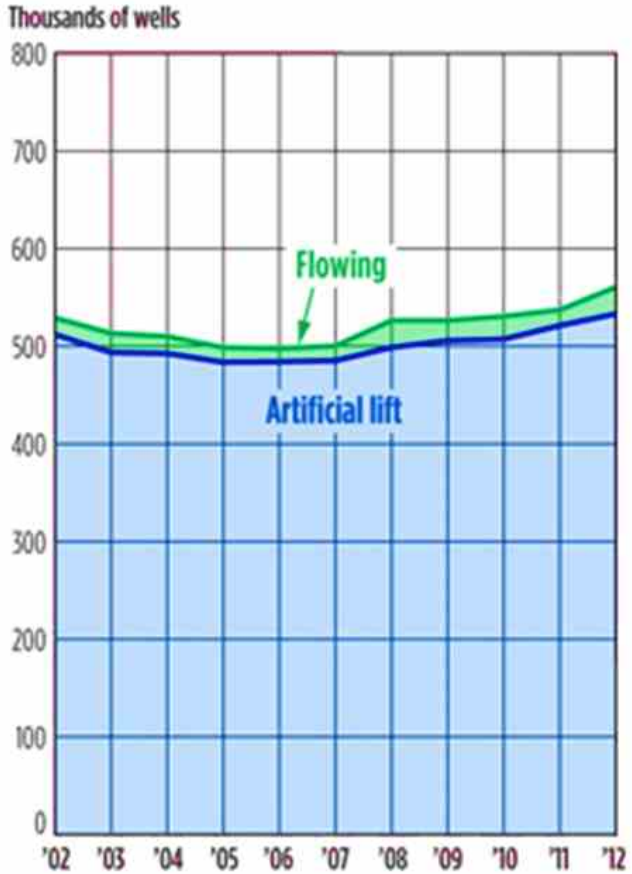
# Presentation Outline

- How Lift applications differ for Unconventional & Tight wells
  - Well geometries
  - Flow behavior
- What works
  - Field Practices & Couple of Examples
- Importance of
  - Lift Life Cycle Planning
  - Lift Optimization, Monitoring & Surveillance
- Conclusions

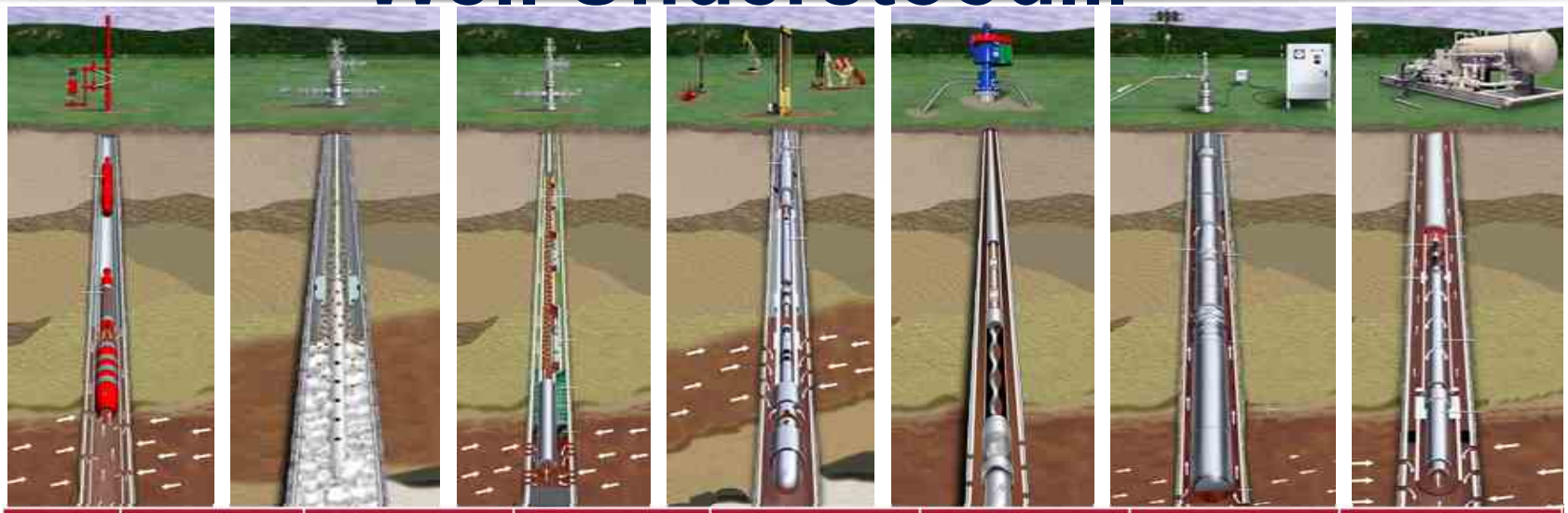
# Artificial Lift Applications are Well Understood...




**Source: World Oil, Feb 2014, 2015:**
"the percentage of U.S. oil wells produced by artificial lift is staying steady at about 95%. .." for over ten years now.

**2013**: Wells on ALS: 550,757.. Total Oil wells: 579,420
**2014**: Wells on ALS: 564,961... Total oil wells: 600,679

# Artificial Lift Applications are Well Understood...



| | Plunger Lift | Foam Lift | Gas Lift | Reciprocating Rod Lift | Progressing Cavity Pump | Electrical Submersible Pump | Hydraulic Jet Pump |
|---|---|---|---|---|---|---|---|
| Energy Source | Formation Pressure | Formation Pressure | Formation Pressure | Mechanical Assist | Mechanical Assist | Mechanical Assist | Mechanical Assist |
| Prod Rates | Low | Low | High | Med | Med | High | High |

Courtesy: Weatherford

# What's Different Now? Two Trends

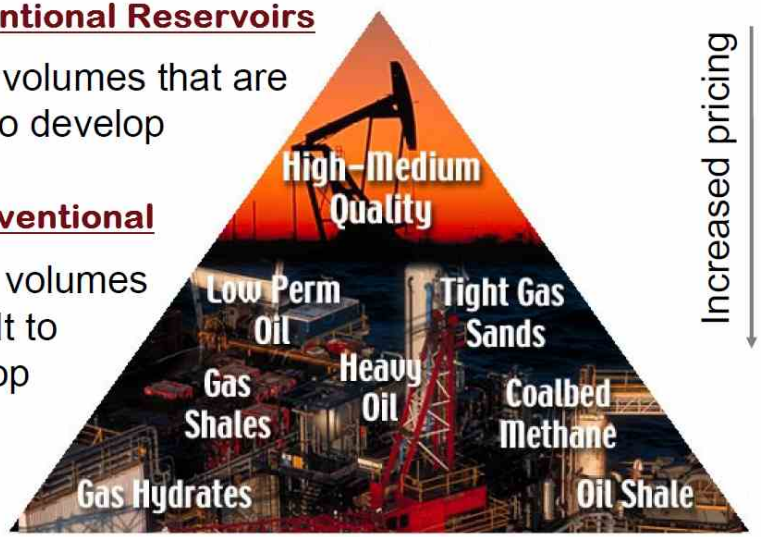
Unconventional & Tight Resources require improved technology & different approaches

**Conventional Reservoirs**

Small volumes that are easy to develop

**Unconventional**

Large volumes difficult to develop

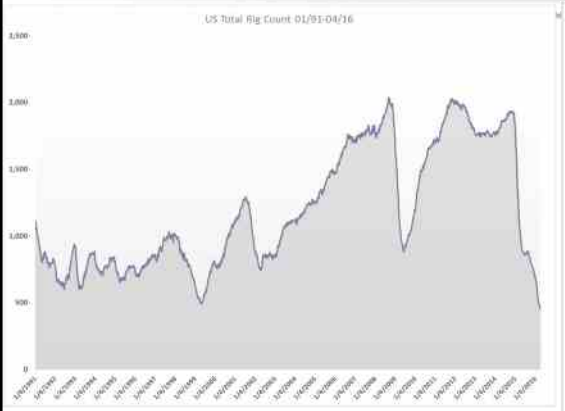


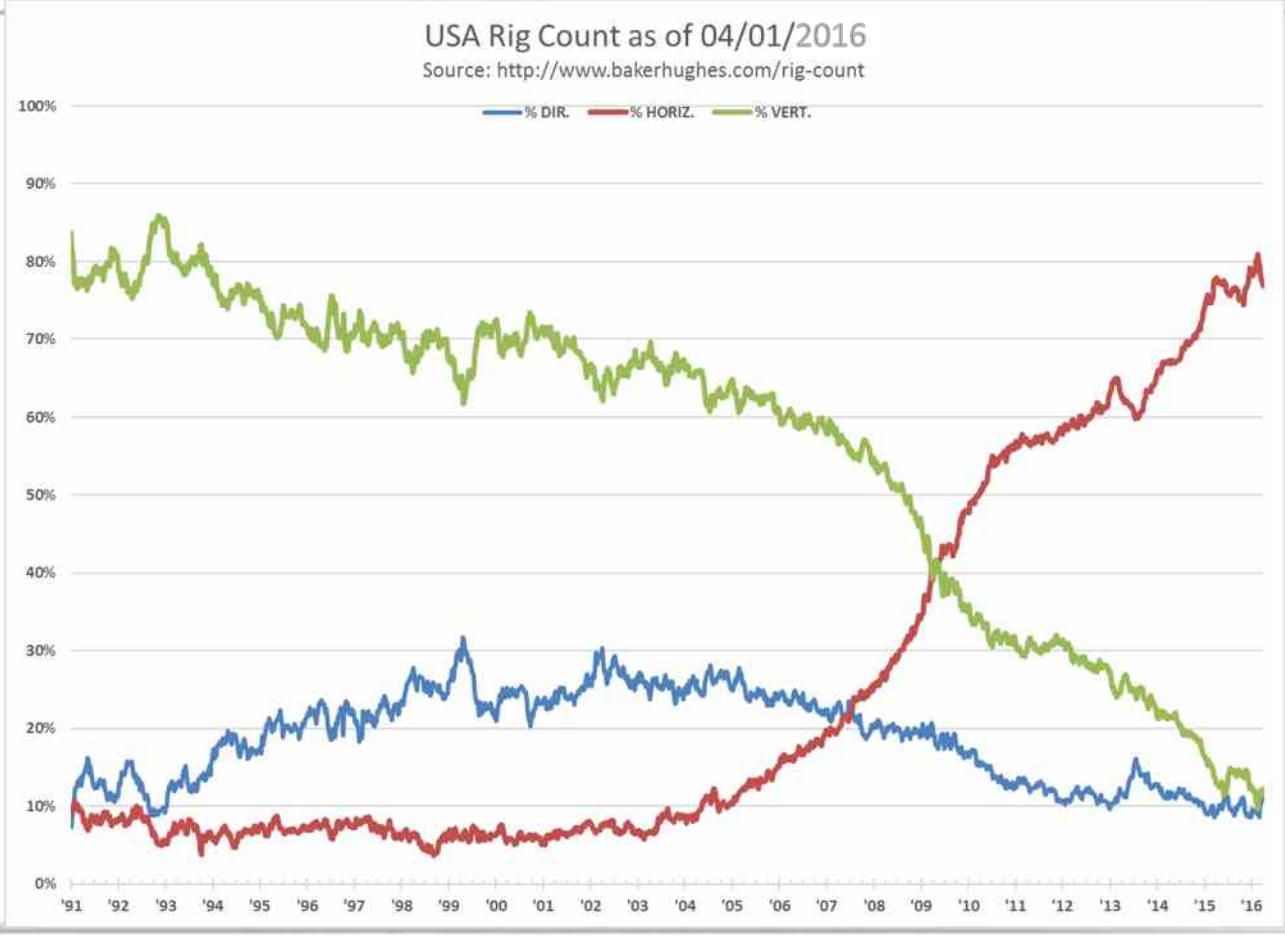

Increased pricing

Improved technology

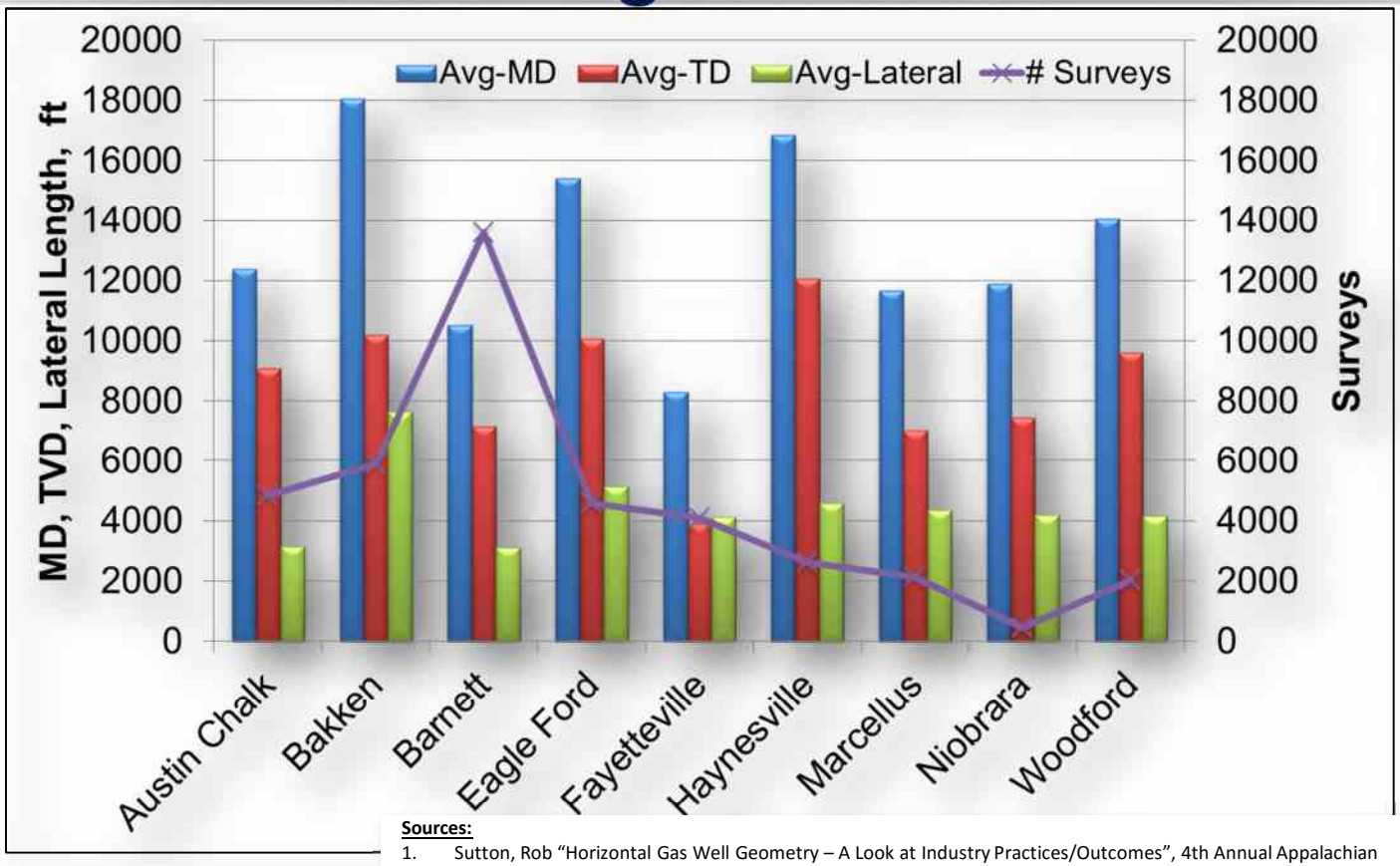
**Resource Triangle** Source: Holditch, S, "How Technology Transfer Will Expand Development of Unconventional Gas Worldwide," Nov 3 2009, IPEC, Tulsa

# What's Different Now? Two Trends



# Unconventional Wells – Long Laterals

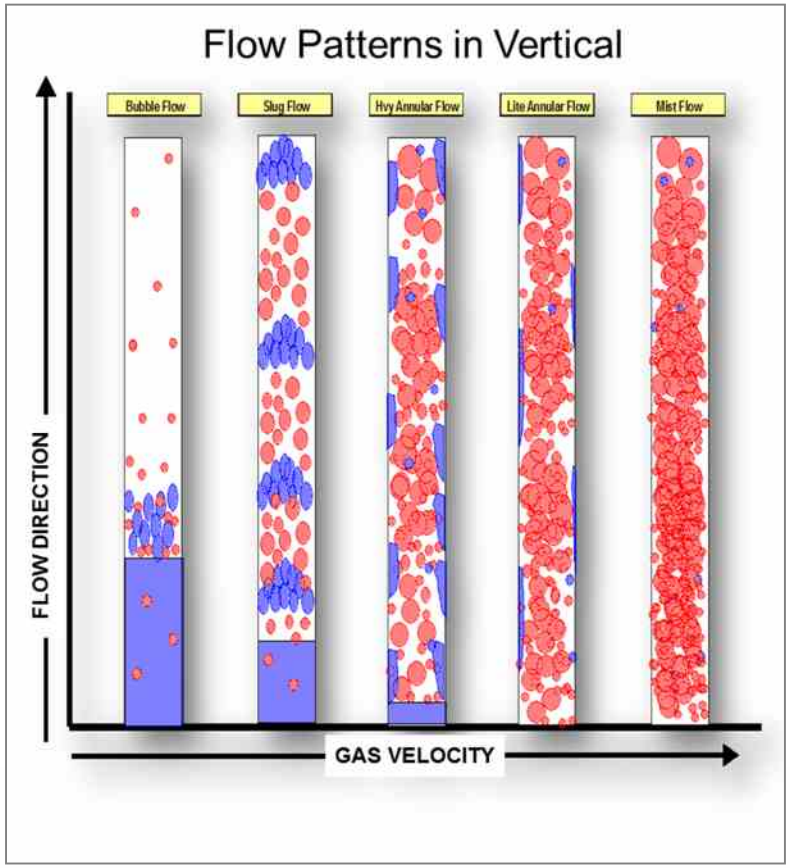


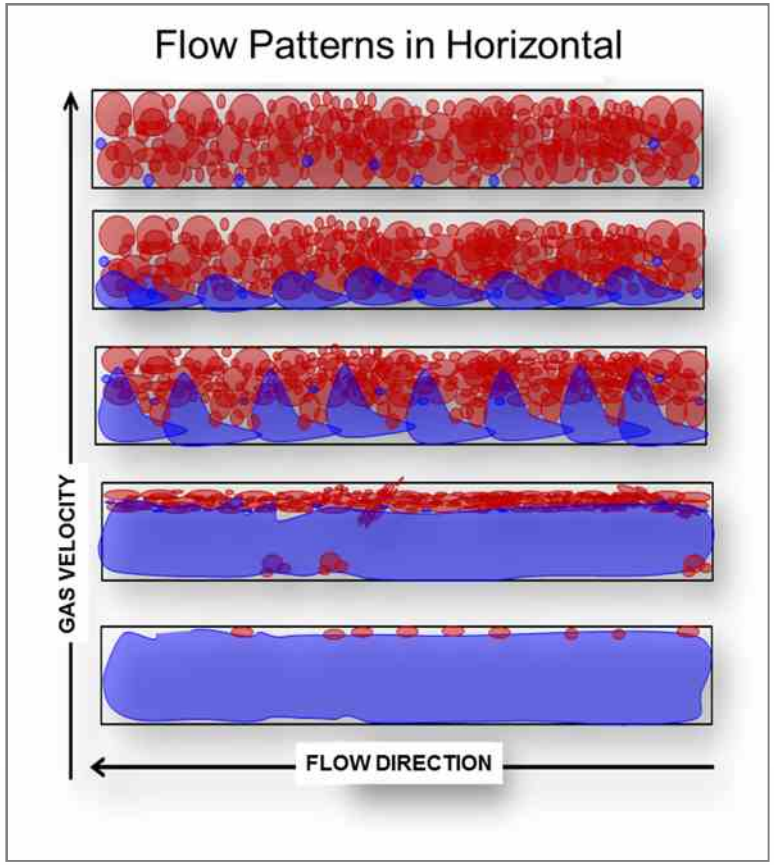


**Sources:**

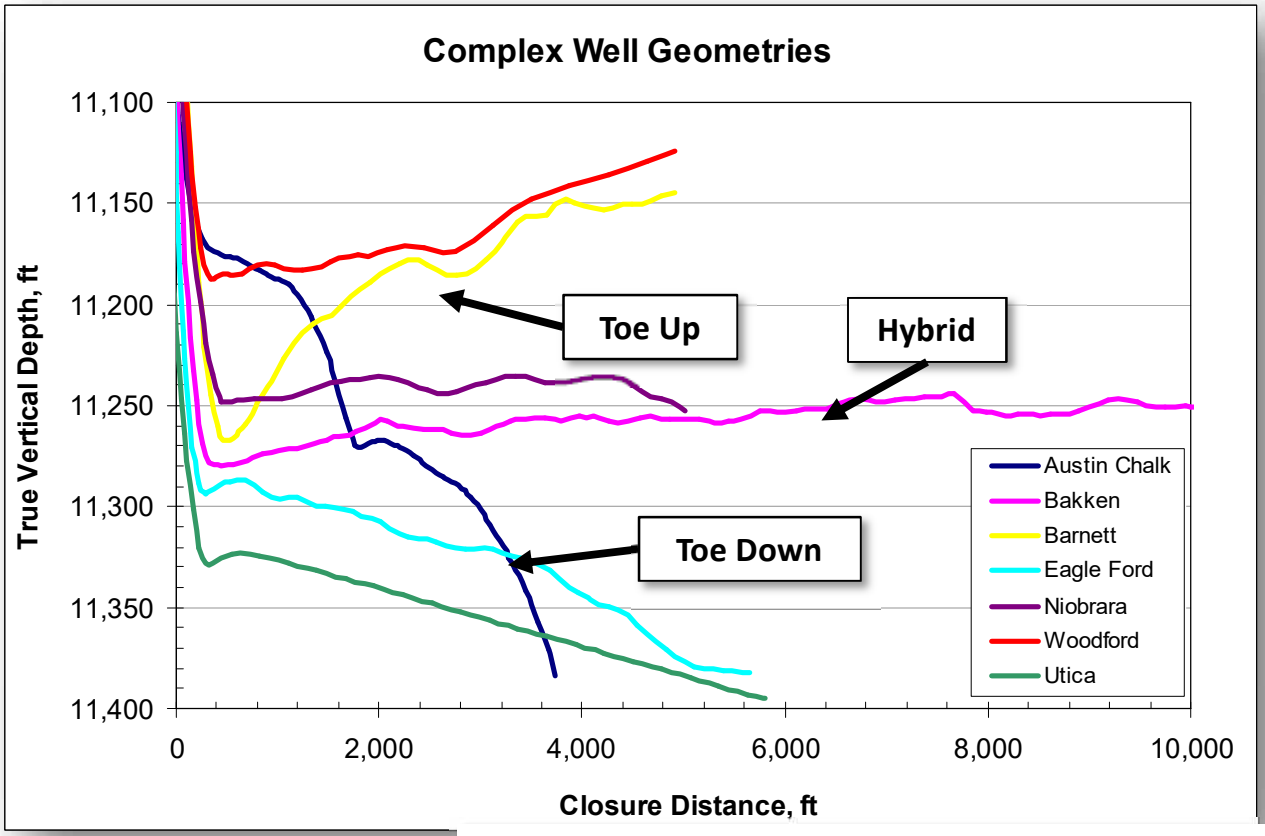
1. Sutton, Rob "Horizontal Gas Well Geometry – A Look at Industry Practices/Outcomes", 4th Annual Appalachian Basin Gas Well Deliquification Workshop, Jun 2013 **[26,270 Surveys]**
2. Sutton, Rob "Wellbore Geometry Effects on Well Production Performance", Presentation in SPE Conference "Liquids Rich Shale… Do You Believe in Peak Oil?," Rancho Palos Verdes, CA (May 2013) **[13, 925 Surveys]**

# Different Flow Behaviors in Wellbore



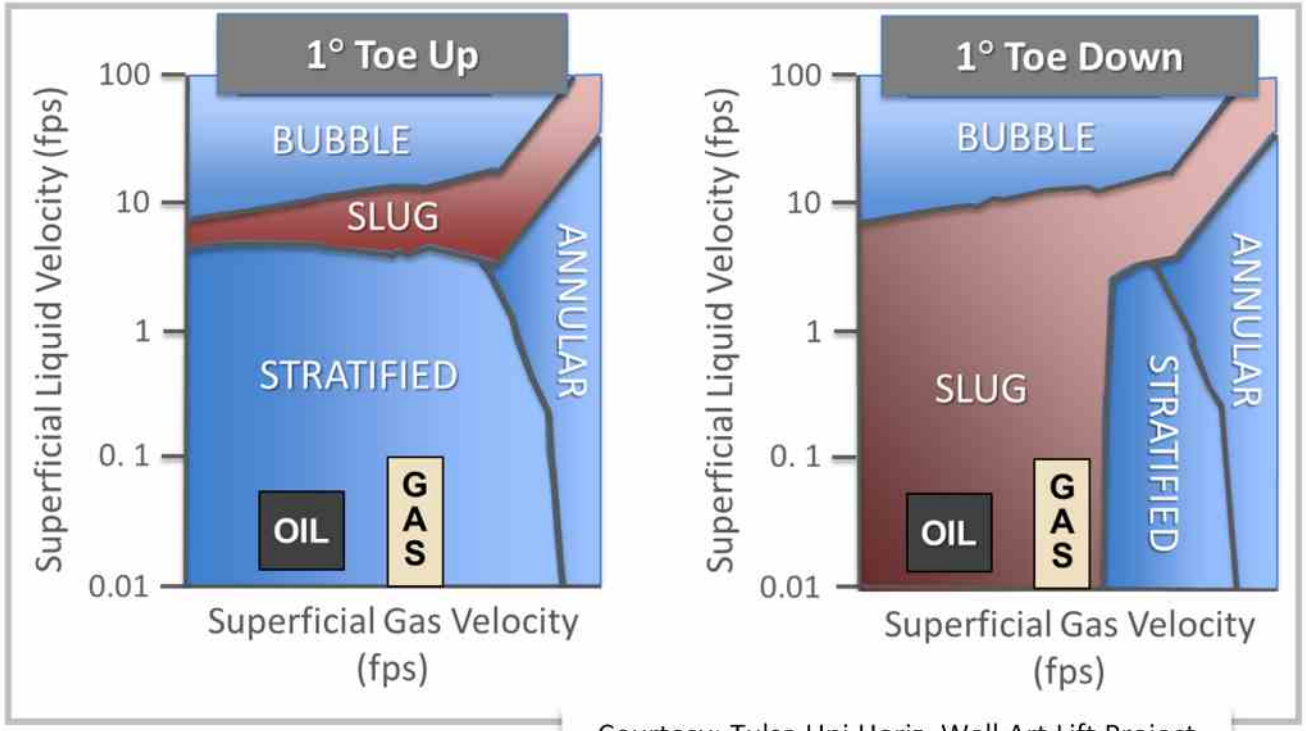



# Are Laterals Really Horizontal?



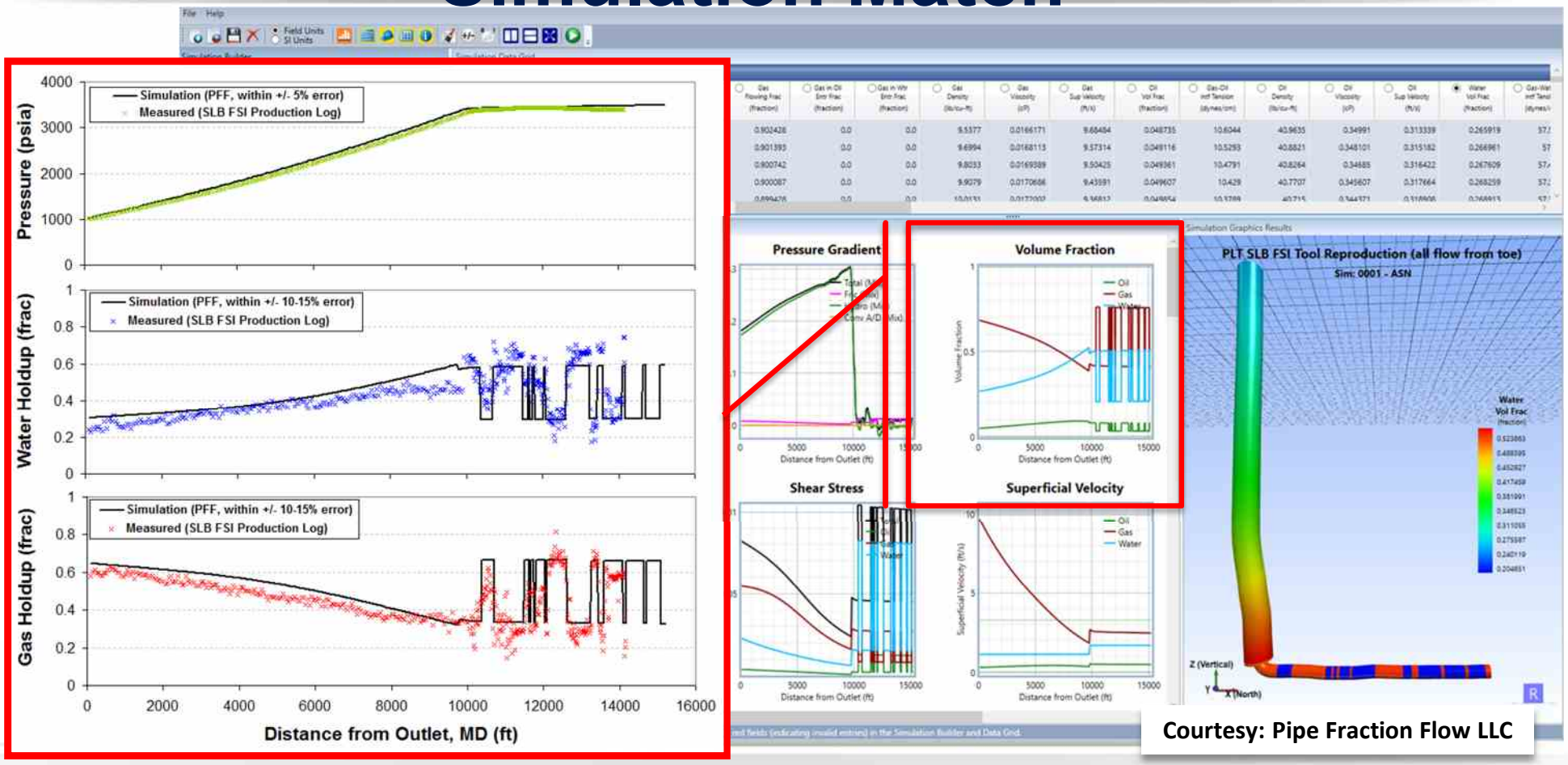

Source: Sutton, R.: "Wellbore Geometry Effects on Well Production Performance," SPE Liquids Rich Shale Conference, Rancho Palos Verdes, CA (May 2013).

# Flow in Lateral - Trajectories



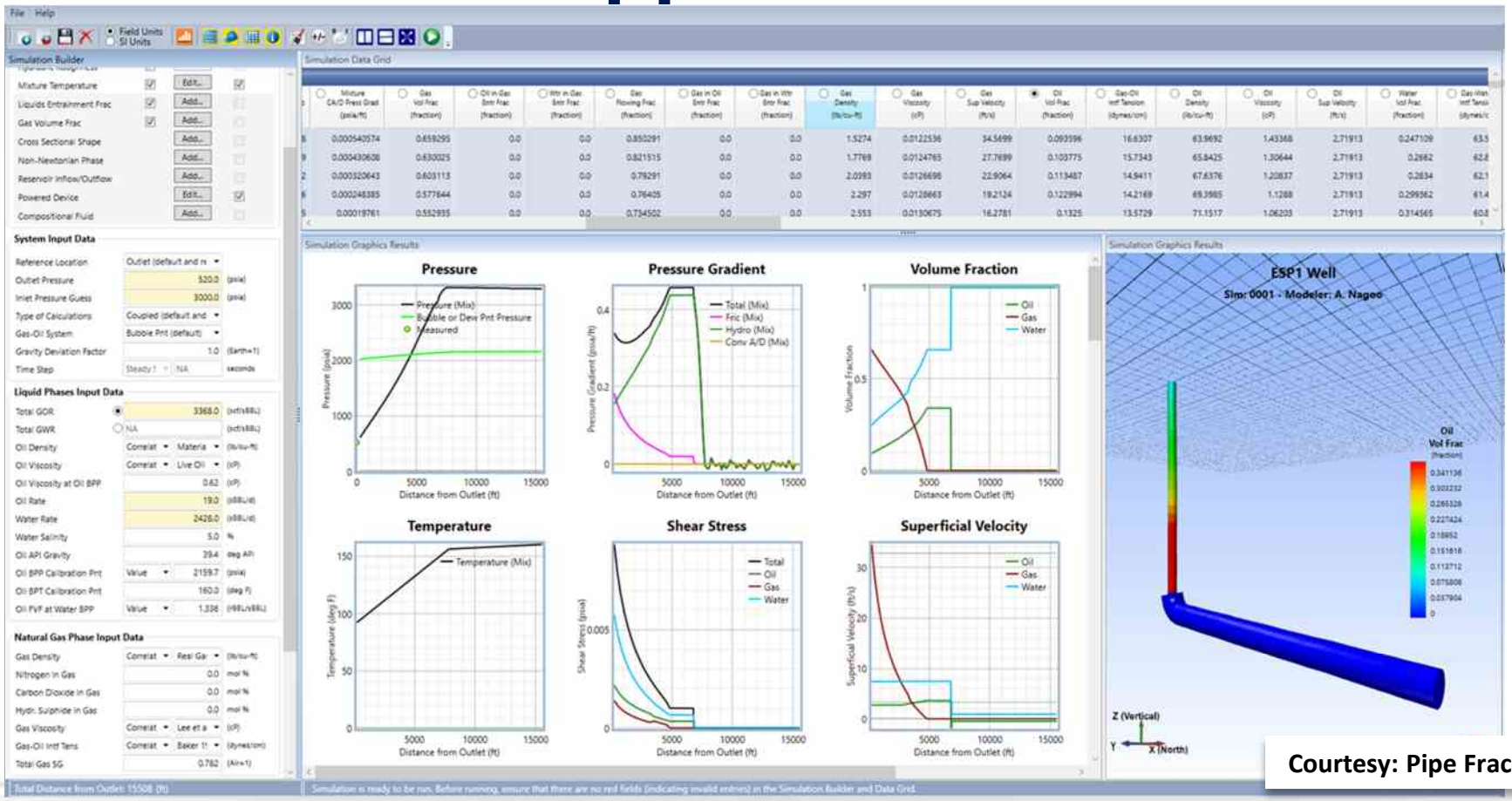

Courtesy: Tulsa Uni Horiz Well Art Lift Project Simulations

# Permian Gas Horizontal Well : Flow Simulation Match




Courtesy: Pipe Fraction Flow LLC

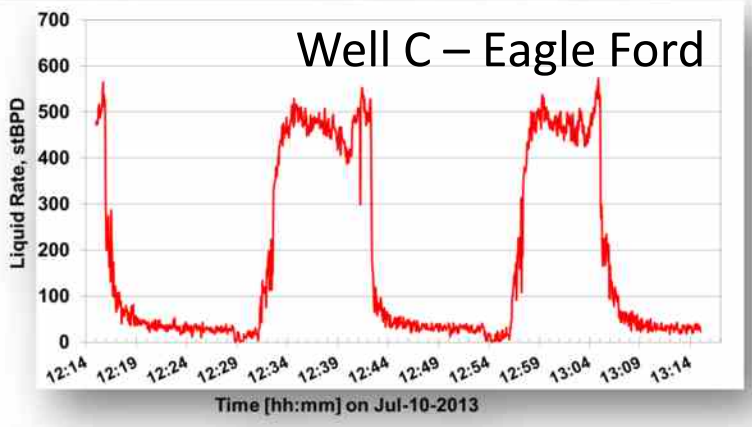
# Midland Wolfcamp Horiz. Oil Well – ESP Application

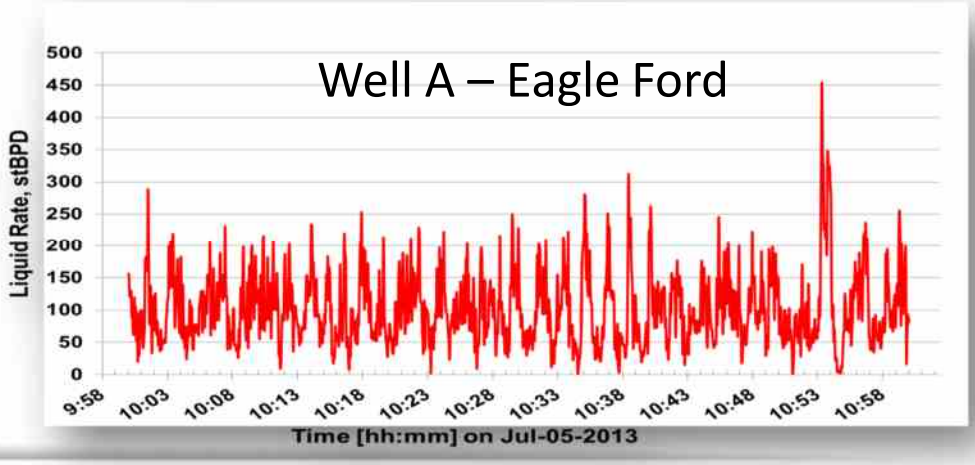



Courtesy: Pipe Fraction Flow LLC

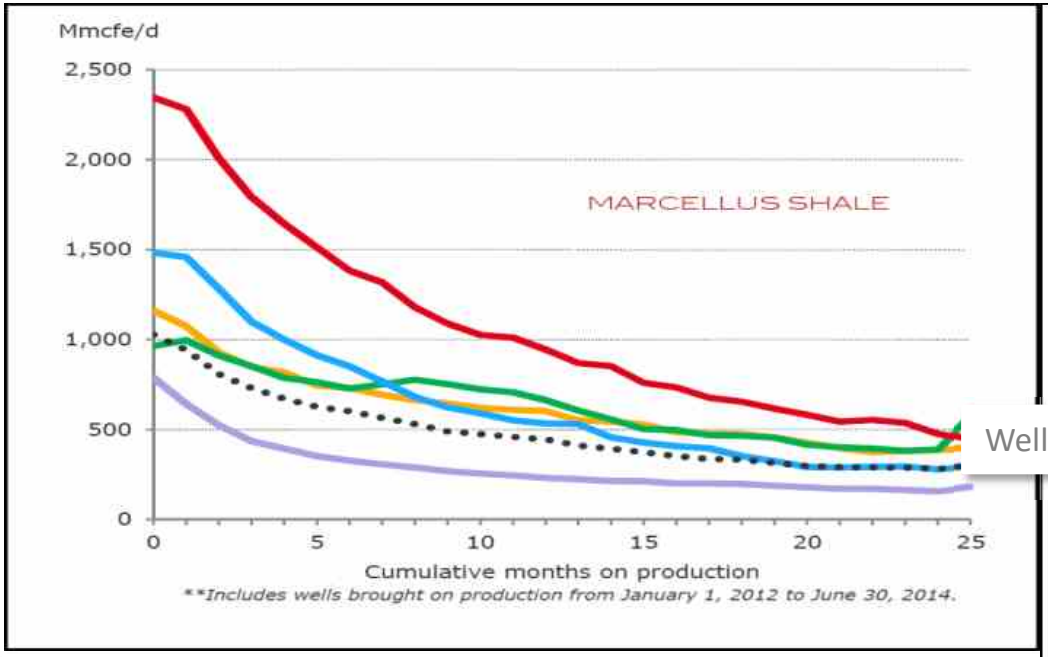
# Challenges of Turbulent Flow

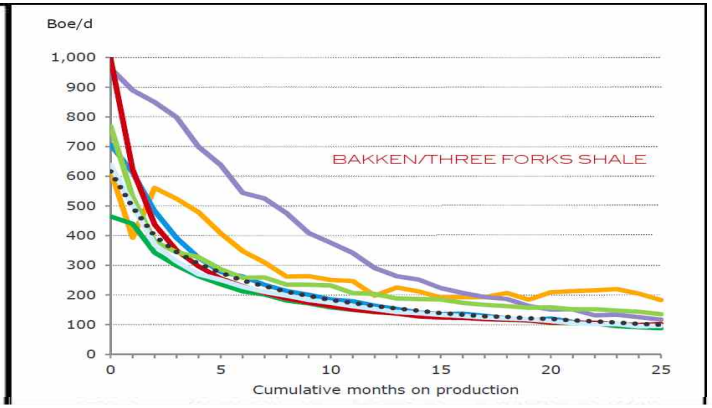
- Pumping
- Gas-liquid separation
- Monitoring
- Back pressure



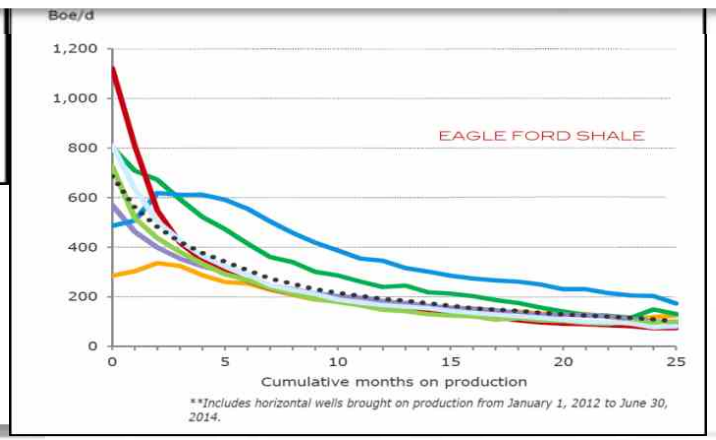



# Variable Production Rates




Well Rate Decline Curves for Shale Assets (After Rystad 2014)




"... ... the average decline curves for Bakken and Eagle Ford wells have not shown significant changes since 2010. The major improvement can be observed in the increased 24-hr initial production, but this rate rapidly declines."

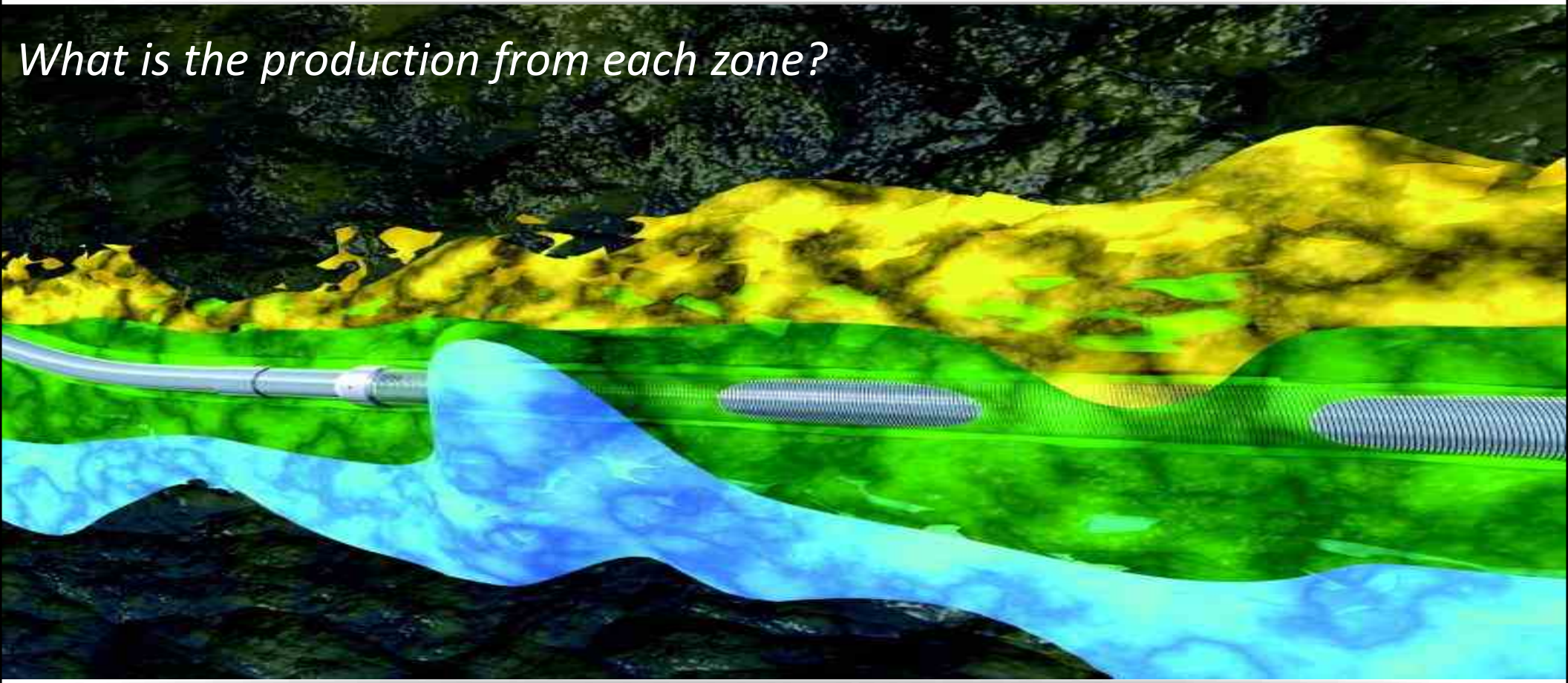
Source: Rystad Energy: US Shale Newsletter, Vol. 1 No. 3, Jul 2014

# Variable Production Rates

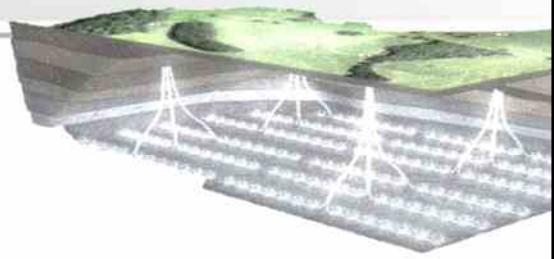
- Must plan for a wide range of production rates

| Shale Play | 1st Year Typ Decline Rate |
|---|---|
| Barnett | 65% |
| Eagle Ford | 60% |
| Haynesville | 81% |
| Marcellus | 74% |
| Woodford | 59% |
| Bakken | 69% |

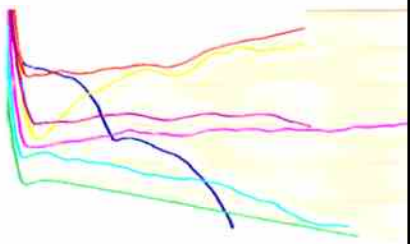
# Uncertain Inflow Phase Distribution



# Production Challenges in Horizontal Wells



1. Deep, long, slender well geometries
   - The impact of well geometry on EUR



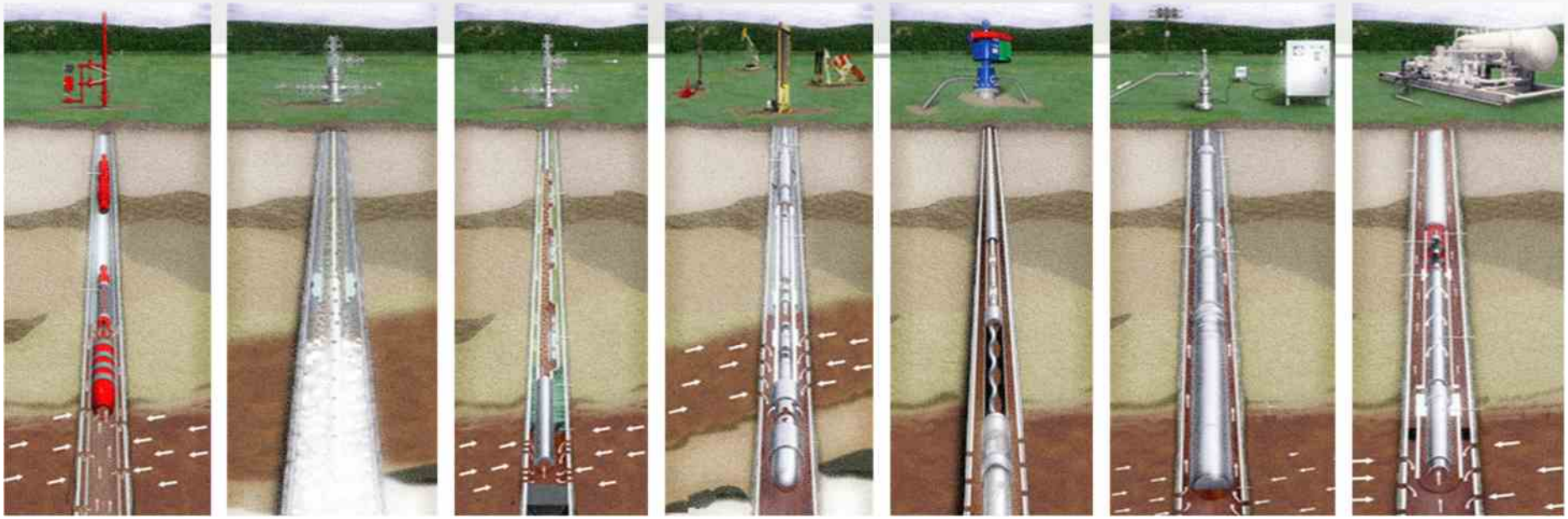
2. Sluggy and turbulent flow

3. Rapidly changing production rates

4. Uncertain inflow phase distribution

Trapped gas

Trapped liquid



# LESSONS LEARNED

# Some Lessons – Draining the Lateral

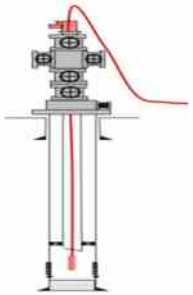
- Involve production/operations with well geometry decisions during the well design.
  - Toe up orientation if possible.
  - ‘Rat hole’ for better gas separation???
  - Control tortuosity of horizontal section of well - Minimize undulations/traps
  - Intentionally plan/control vertical transition to horizontal section
  - Will casing geometries permit sufficiently sized ALS technology in future?

# Some Lessons – Draining the Lateral

- *Early* Operations
  - Choke the production rate
    - Increases EUR
    - Increased FBHP delays gas breakout might reduce pooling in the lateral traps
  - Maintain adequate liquid levels
      - » 200 ft above liner top
      - » 75 to 100 ft above pump.

# Lift Toolbox for Unconventional & Tight Wells



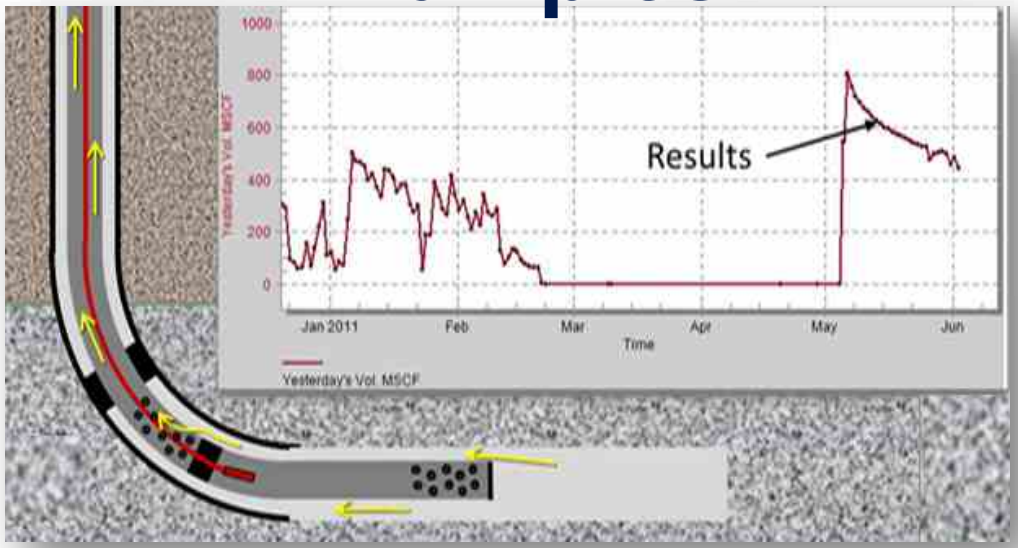
| | Gas Lift | Rod Lift | Plunger Lift | Capillary | Electrical Sub. Pump | Jet Pump |
|---|---|---|---|---|---|---|
| **Gas shales** | Preferred | Low BHP | High GLR | Foam lift, inhibition | - | Frac fluid flow-back, Initial unloading |
| **Oil shales** | Limited | Preferred | - | Inhibition | High perm or choked | |

**Source: Internal research US shale plays, © Weatherford, 2010 - 2013**

# Lessons – Deliquifying Laterals

- Mechanical pumps can pump from low spots but are not effective in “sweeping” liquids through laterals.
- Mechanical pumps can have gas interference issues.
  - Gas anchors are required in gassy wells.
- Where possible, land mechanical pumps:
  - In vertical section 50 to 100 ft above the liner top
  - In straight sections if within the deviated section
- Use continuous lift optimization (surveillance, analysis, prioritizing, adjustment)

# Hybrid Lift in Gas Deliquification Examples

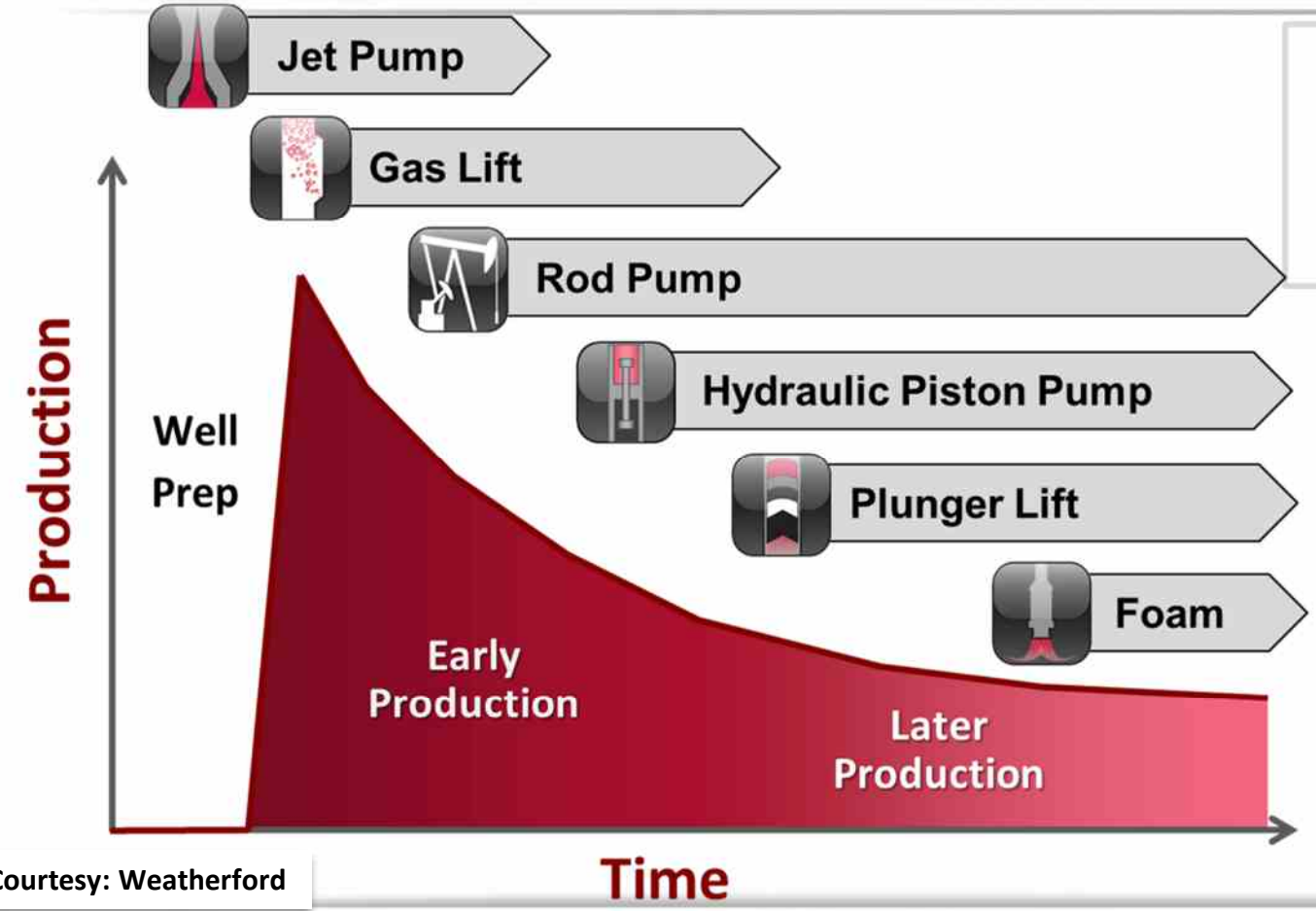



**Barnet Shale: Combination Lift Application**

- Gas-Lift + Area Reduction + Foam Injection
- Foam injection in the lateral: Surfactant delivered at the toe

Source: Bracken, J: "Capillary and CVR Test Horizontal Well Bore," presented at the 3rd Annual Appalachian Basin Gas Well Deliquification Seminar, Marietta, Ohio (Jun 2012).
Another application : Farina *et* al., "Artificial Lift Optimization with Foamer Technology in the Alliance Shale Gas Field," SPE 160282 presented at the Annual Technical Conference and Exhibition, San Antonio, TX, USA (Oct 2012).

# On Lift Life Cycle Planning



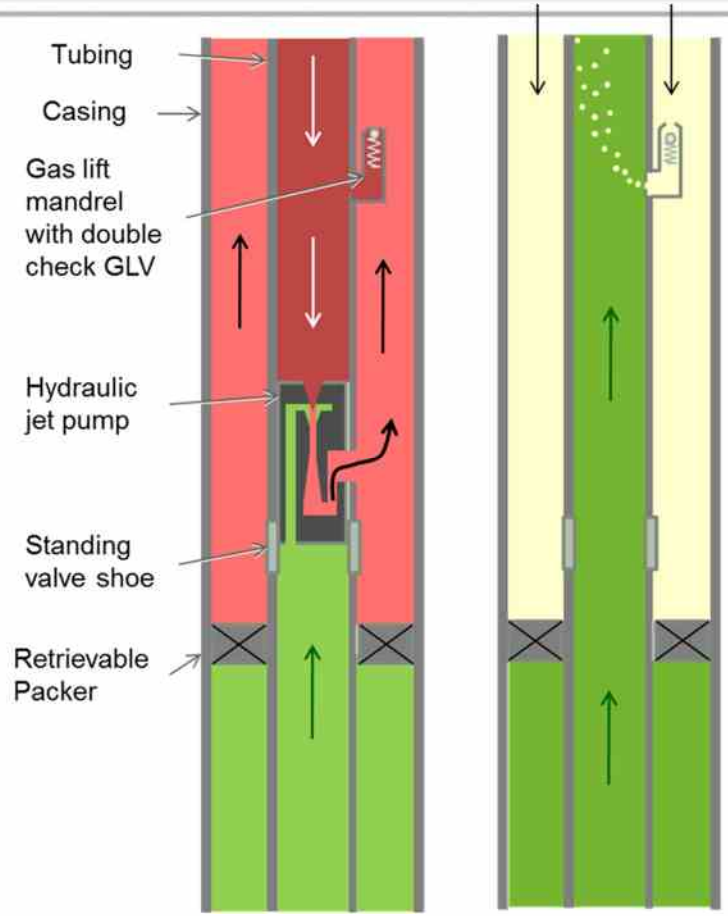

Completion Considerations

Change lift technologies without large workover rigs

∴ Less down-time

Courtesy: Weatherford

# Hybrid Completion: JP → GL



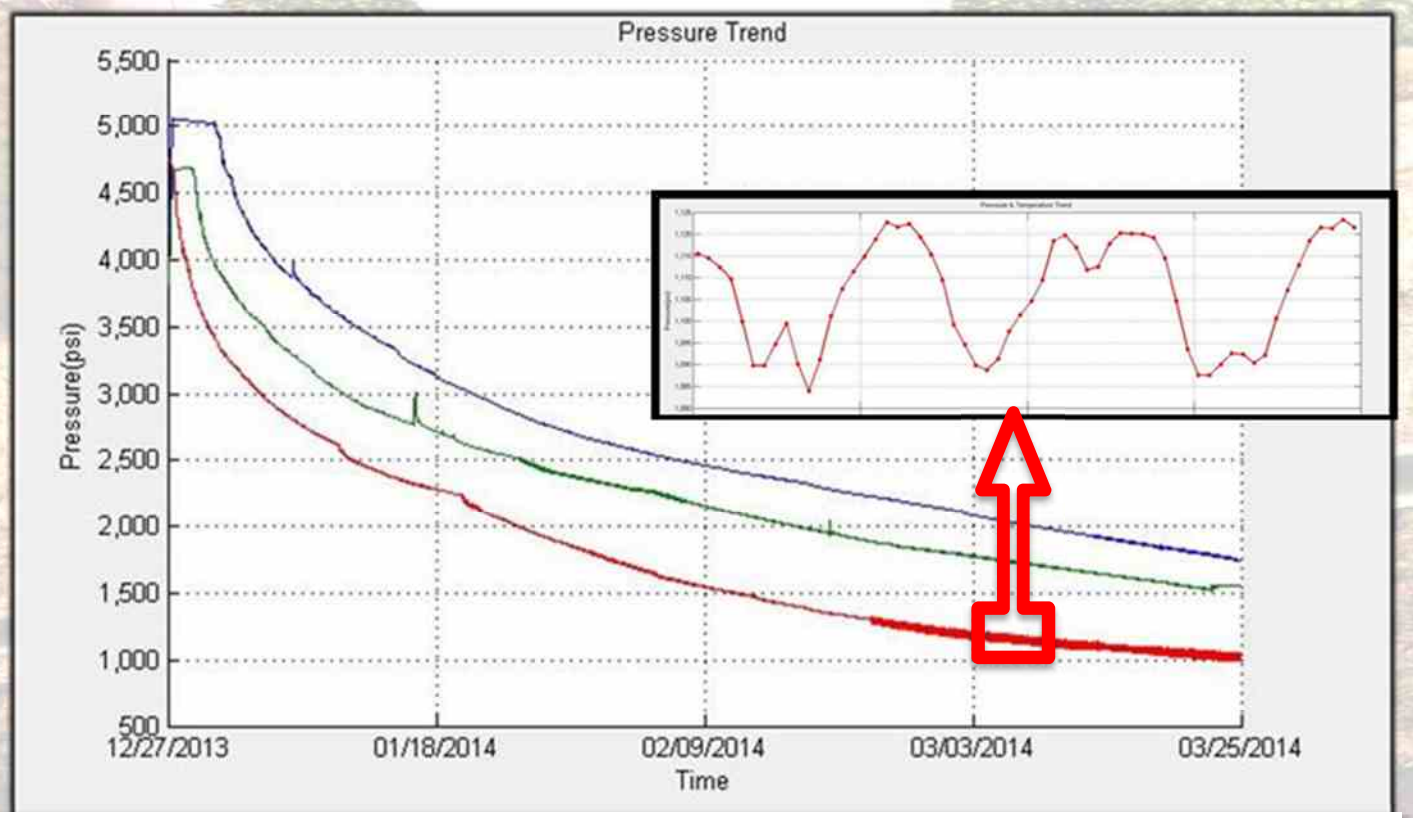

Courtesy: Weatherford

# Surveillance & Monitoring

- Accurate and timely monitoring is critical for production management and optimization.
  - Tracer chemicals for initial inflow
  - Production logging for snapshot of transients
    - Sporadic measurements are not adequate for managing dynamic production.
- Permanent downhole gage systems provide continuous real-time visibility of production conditions.
  - Artificial lift status
  - P, T, Q
  - Zonal contribution
- Data visualization and analysis software simplify production management and optimization.

# Case: Permanent Electronic Gauges – Shale Rod Pumping

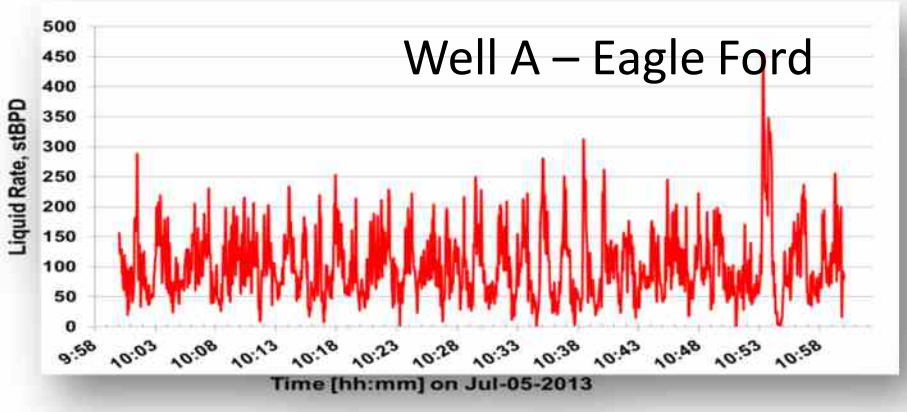
Continuous high granularity measurements revealed slugs

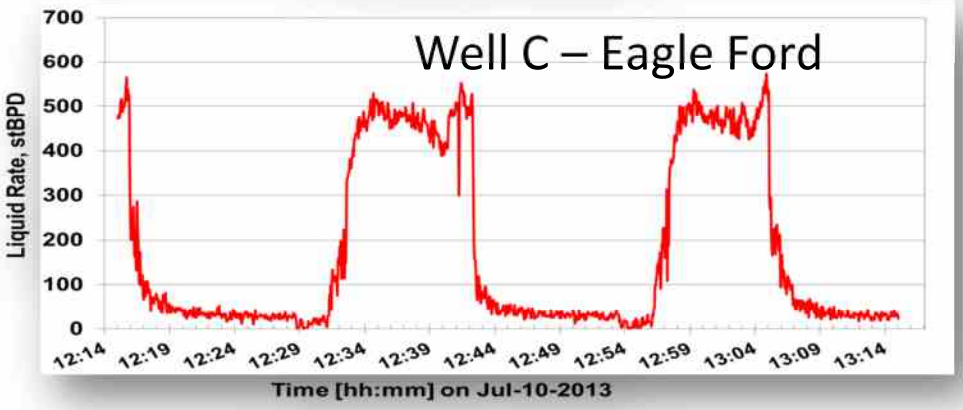



Source: Gonzalez, L. E., Chokshi, R. N., & Lane, W. C. (2015, October 20). Real-Time Surface and Downhole Measurements and Analysis for Optimizing Production. Society of Petroleum Engineers. doi:10.2118/176233-MS

# Case: Accurate Flow Measurements in Shale

Courtesy: Weatherford



# Conclusions

- How are artificial lift applications different for unconventional & tight wells?
  - Well geometries pose production challenges
  - Understanding of flow behavior is very important and still developing.

**Additional References**

1. Lane, W., & Chokshi, R. (2014, August 28). Considerations for Optimizing Artificial Lift in Unconventionals. SPE. doi:10.15530/urtec-2014-1921823.
2. Gonzalez, L. E., Chokshi, R. N., & Lane, W. (2015, August 4). Importance of Downhole Measurements, Visualization and Analysis in Producing Unconventional Wells. SPE. doi:10.15530/urtec-2015-2164102

# Conclusions

- What needs to be done?
  - Involve production & operations during well design
    - Toe Up.... Avoid Traps in Lateral
  - Select flexible lift systems
    - Stay current on what works where and why.
  - Think in terms of the lift life cycle
    - You will need to change to another lift – sooner or later...
  - Include Lift Monitoring & Surveillance from the beginning
    - Surface Flow and downhole P/T measurements add considerable value to the overall production optimization and recovery.

**Additional References**

1. Lane, W., & Chokshi, R. (2014, August 28). Considerations for Optimizing Artificial Lift in Unconventionals. SPE. doi:10.15530/urtec-2014-1921823.
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