What Limits Reach in Deep Water?

Brandon Foster
K&M Technology Group

SPE/AADE/NOGS

13th Annual Deep Water Symposium

August 27th – New Orleans, LA

K&M TECHNOLOGY GROUP

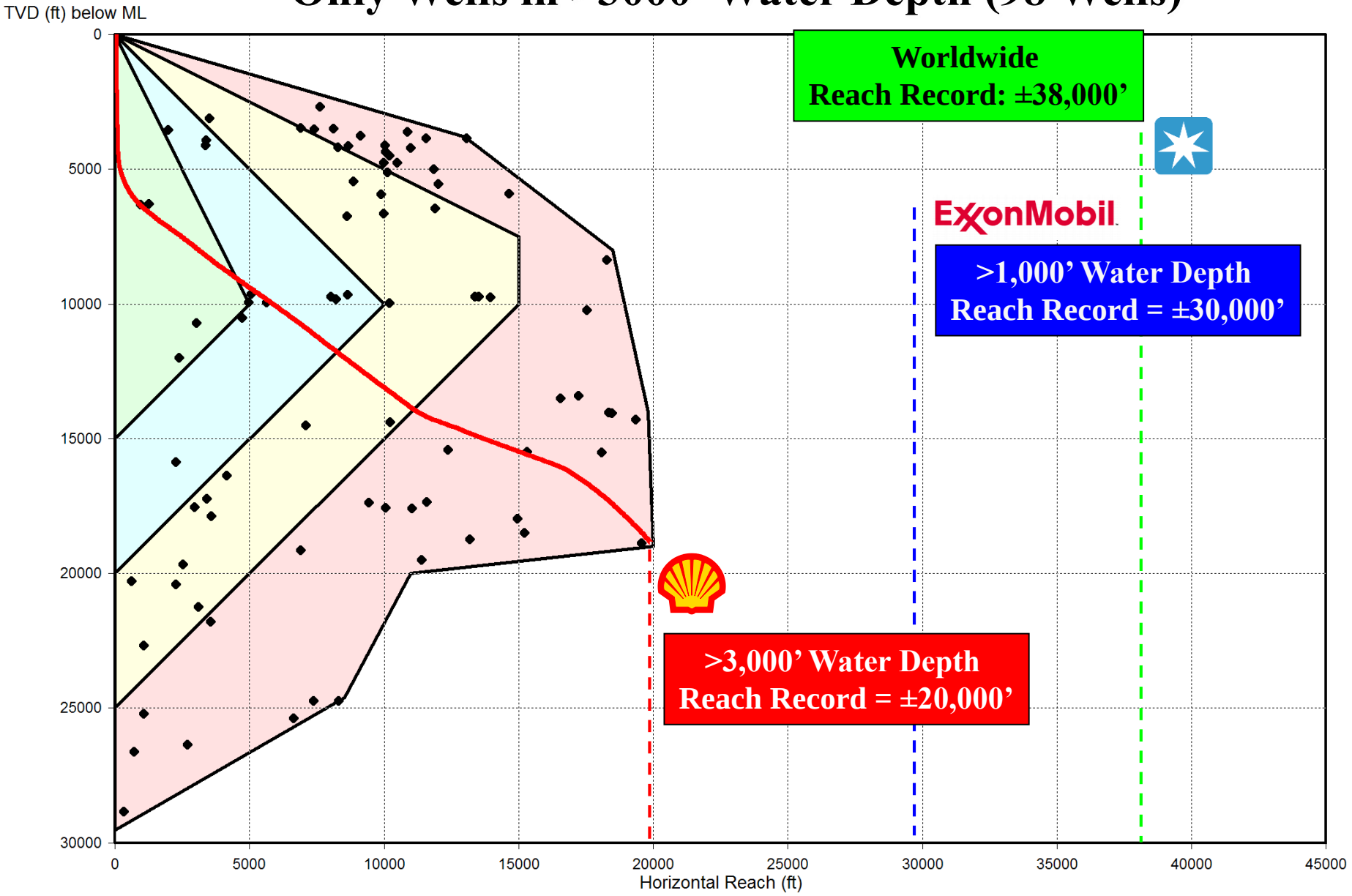
Introduction

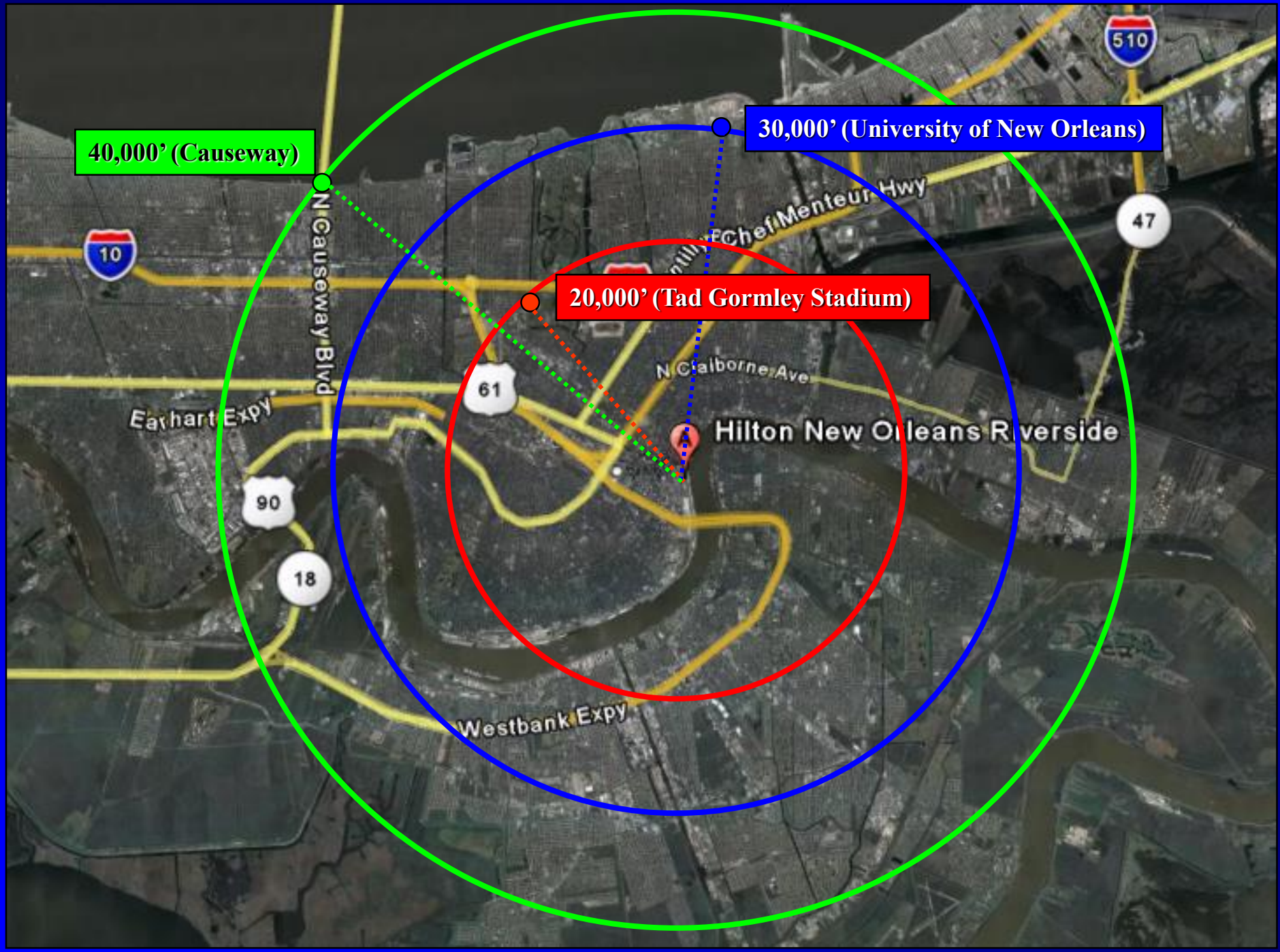
- **Upcoming projects exceed industry ER experience**
  - **Technical limitations can be solved with existing technology**
    - **Limitations are different for deep vs. shallow BML**
  - **Fear often trumps legitimate technical rationale**
    - **Due to bad experiences in the past with ER wells**
    - **Or perception that vertical is faster, cheaper, and easier**

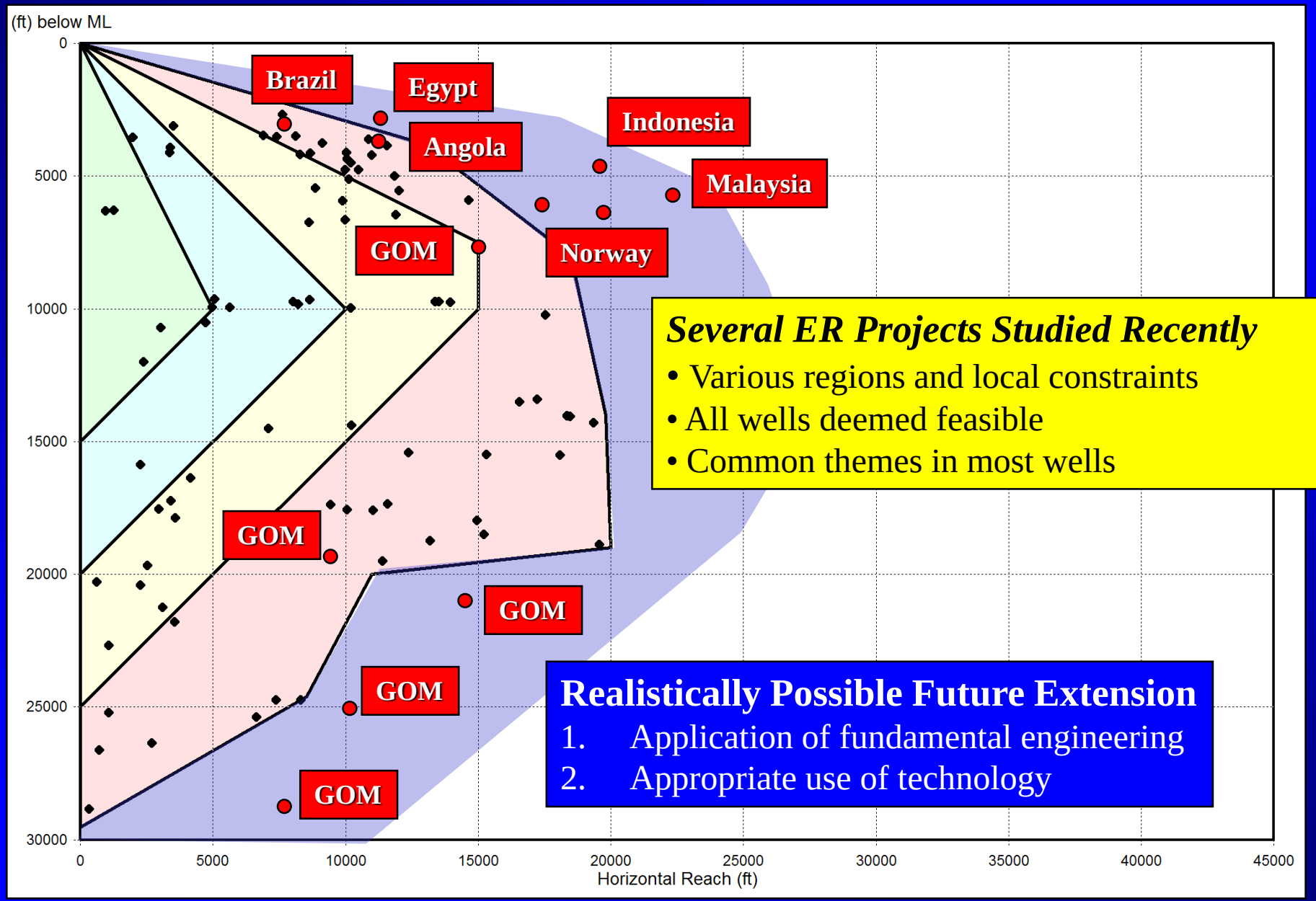
- **ERD Wells in Deep Water *are* more challenging**
  - **Compared to vertical deep water**
  - **Compared to shallow-water or land based ERD**

- **However, the challenges can be met**
  - **With fundamental engineering**
  - ***Then* application of appropriate technology**

Only Wells in >3000' Water Depth (98 Wells)




40,000' (Causeway)
30,000' (University of New Orleans)
20,000' (Tad Gormley Stadium)
Hilton New Orleans Riverside
N Causeway Blvd
N Claiborne Ave
Earhart Expy
Westbank Expy
10
61
90
18
510
47


(ft) below ML
0
5000
10000
15000
20000
25000
30000
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
Horizontal Reach (ft)
Brazil
Egypt
Angola
Indonesia
Malaysia
Norway
GOM
GOM
GOM
GOM
GOM
Several ER Projects Studied Recently
• Various regions and local constraints
• All wells deemed feasible
• Common themes in most wells
Realistically Possible Future Extension
1. Application of fundamental engineering
2. Appropriate use of technology

What Limits Deep Water Reach?

Depends on the "Type":

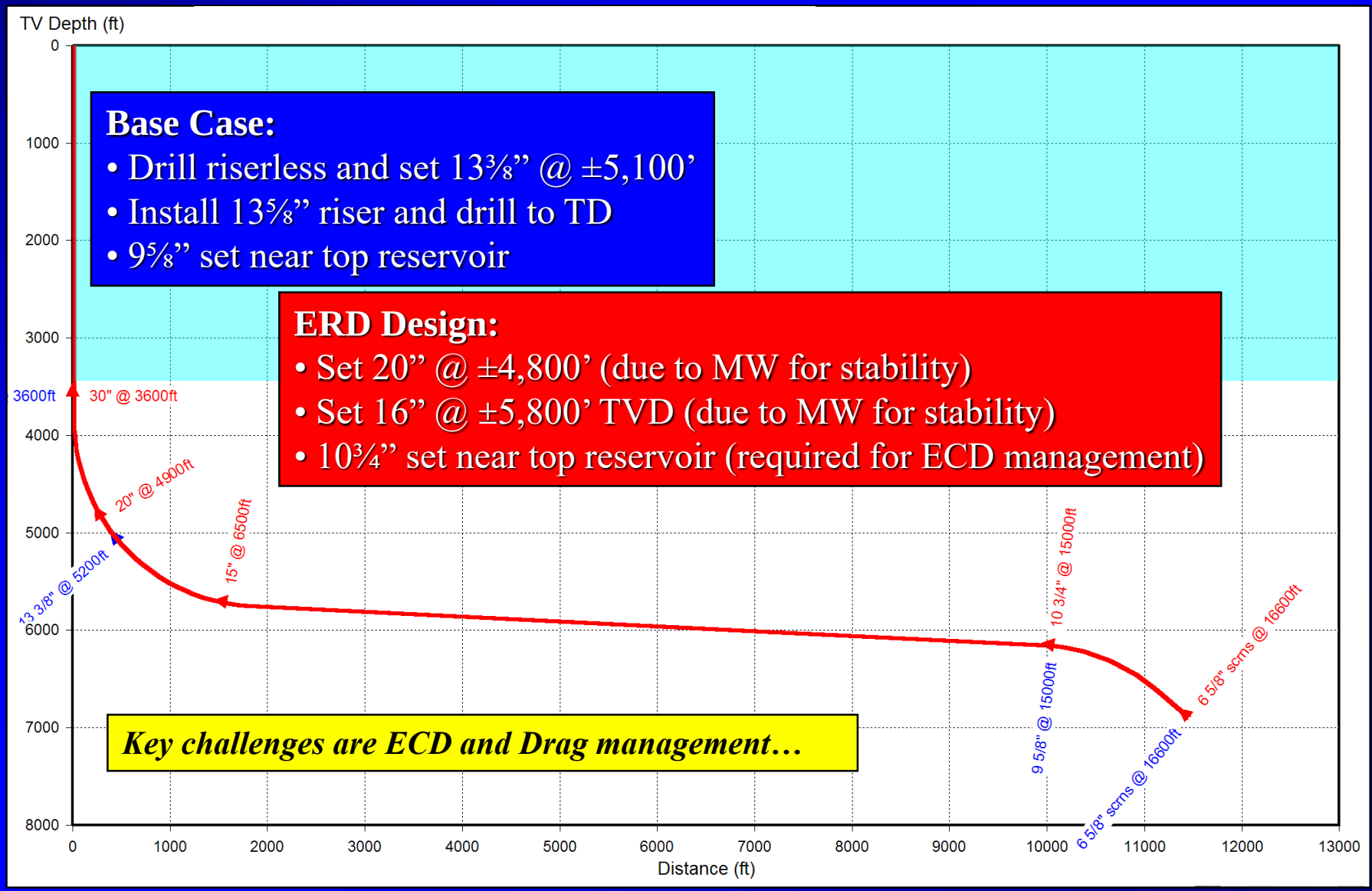
- **Shallow (<7,000') below Mudline**
  1. **ECD – Rapid growth relative to fracture gradient**
  2. **Drag / Buckling - Running casing and completions**

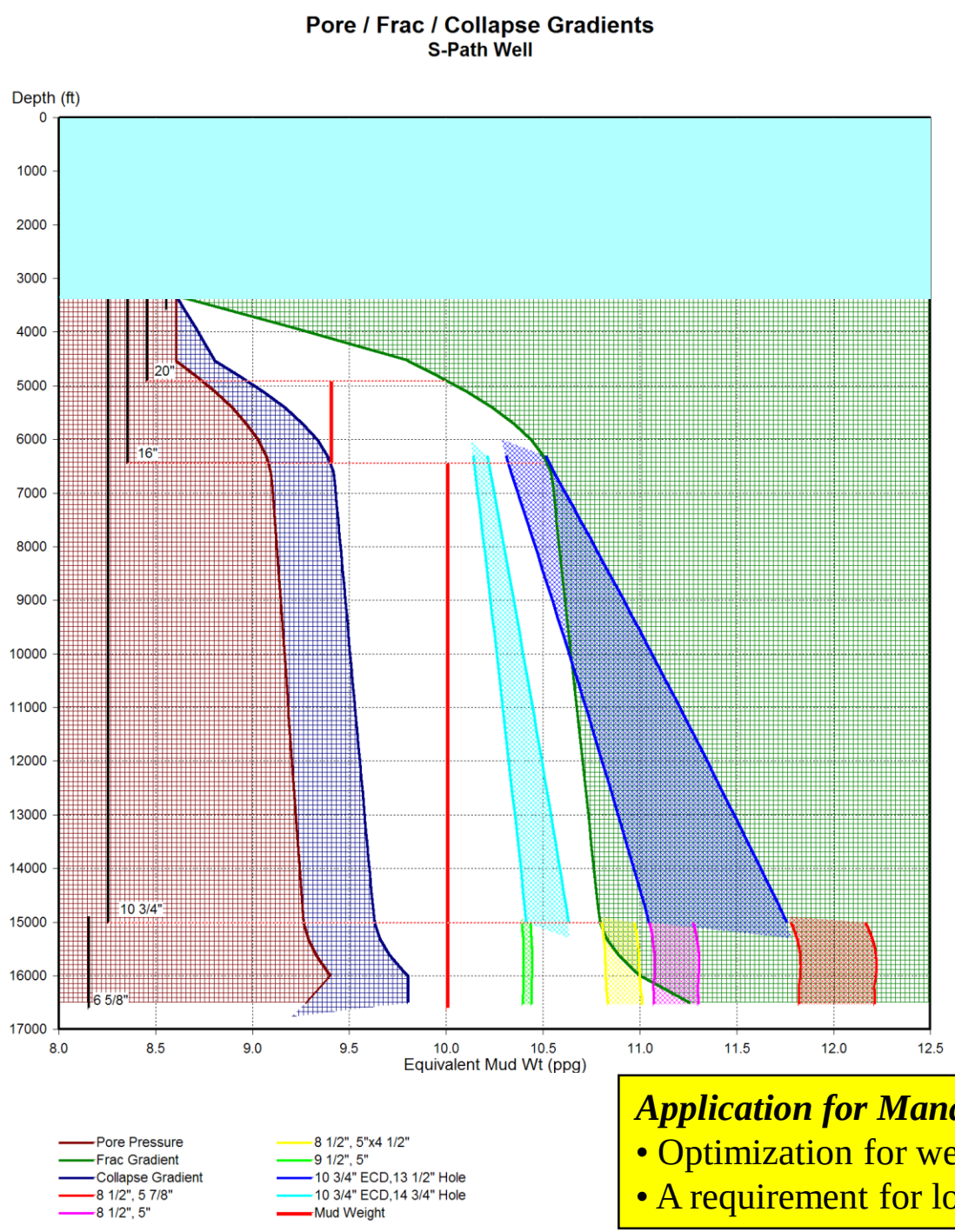
- **Deep (>15,000') below Mudline**
  1. **Tension – Drives exotic drillstring and hoisting equipment**
  2. **Side Forces – Generally quite high (depends on KOP and DLS)**
     - **Creates high torque**
     - **Elevates risk of casing & drillpipe wear**
  3. **Hydraulics - Deep "big hole" drives rig hydraulics package and drillstring (which then complicates tension and side force)**

"Shallow" BML Example

- Offshore Egypt
- TLP Based ERD Development Opportunity
- ±3,500' Water Depth, ±7,000' TVD (±3,500' BML)
- Up to 11,000' Departure Required
- Narrow Pore Pressure / Fracture Gradient Margin
  - Mud Weight Driven by Wellbore Stability
  - ±1.0 ppg EMW Window in reservoir
- Base Case uses vertical design from offsets
  - 13⅜", 9⅝", 6⅝" screens
  - "Standard" design to simplify logistics

"Shallow" BML Example





Pore / Frac / Collapse Gradients

- For S-Path Trajectory
- Mud Weights for Stability + Swab

8½" Drilling ECD with 5⅞" drillpipe through 9⅝" casing is unmanageable

5" drillpipe is unmanageable too

5"x4½" drillpipe is marginal

Drilling 9½" hole through 10¾" intermediate with 5" drillpipe provides adequate margin

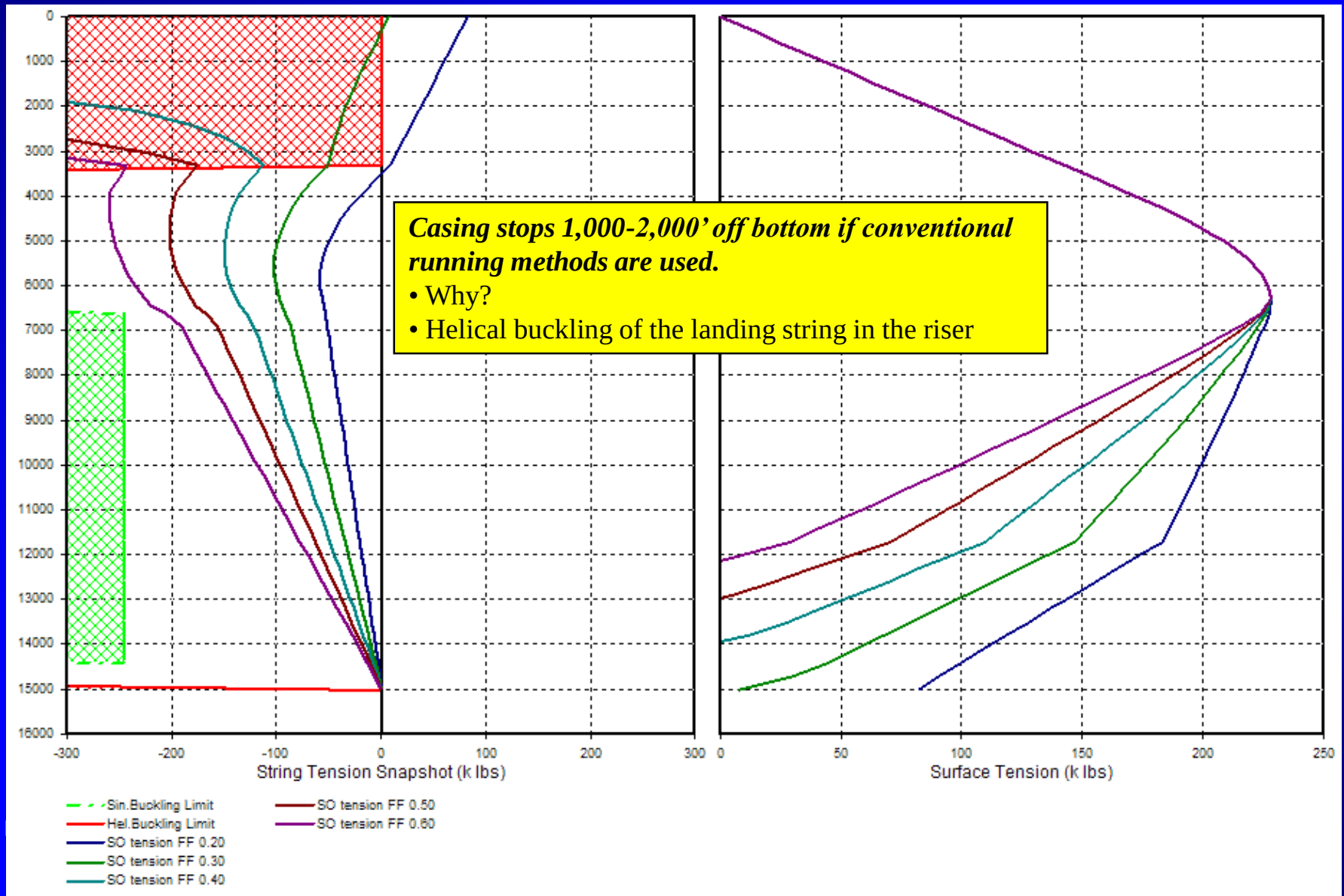
ECD when circulating 10¾" in 13½" hole exceeds FG – **unacceptable risk for cement job – High Rate Gas Well!**

Upsizing to 14¾" (through 16" casing / riser) reduced ECD to acceptable levels

Application for Managed Pressure Drilling (MPD)

- Optimization for wells of this departure
- A requirement for longer wells

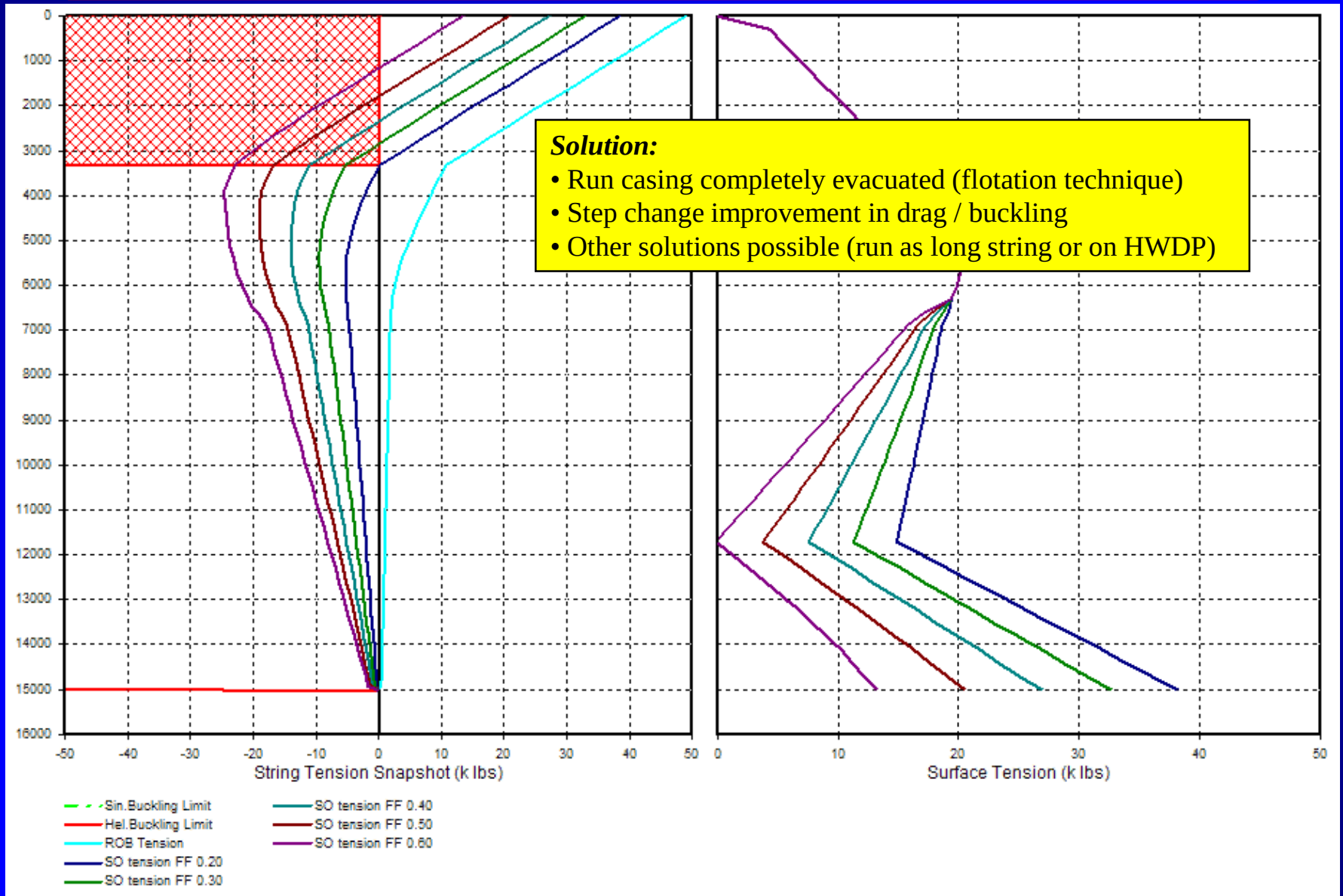
10¾” Conventional Casing Run



Casing stops 1,000-2,000’ off bottom if conventional running methods are used.

- Why?
- Helical buckling of the landing string in the riser

10¾” Floated Casing Run



Solution:

- Run casing completely evacuated (flotation technique)
- Step change improvement in drag / buckling
- Other solutions possible (run as long string or on HWDP)

“Shallow” BML Example

Conclusions

- ECD and Drag the key limitations
  - Solutions affect entire well design
  - Casing, Riser, Wellhead, and Drillstring
- Vertical well design logic would have lead to failure
- Logistical convenience would have lead to failure
  - 12-18 month lead time to procure appropriate materials

Summary

- **Solutions are available to exceed current industry ERD Envelope in Deep Water**

- **Pushing past perceived limits requires;**
  - **Fit-For-Purpose well design and equipment**
  - **Finesse to solve ECD and Drag (Shallow TVD BML wells)**
  - **Brute force rig equipment (Deep TVD BML wells)**

Where is the Future?

- Emerging Technology Opportunities
  - Managed Pressure Drilling
  - Lightweight material (Al, Ti, HSS, Composite)
  - Sag resistant low-rheology fluids
  - Expandable Casing/Liner
    - Planned (as opposed to contingency)
    - Set shallow (as opposed to deep)
  - Telemetry solutions

Questions

Contact Information:
Brandon M. Foster
K&M Technology Group
281-298-6900
brandon@kmtechnology.com