Well Completion Design for a Subsea Infill Oil Producer

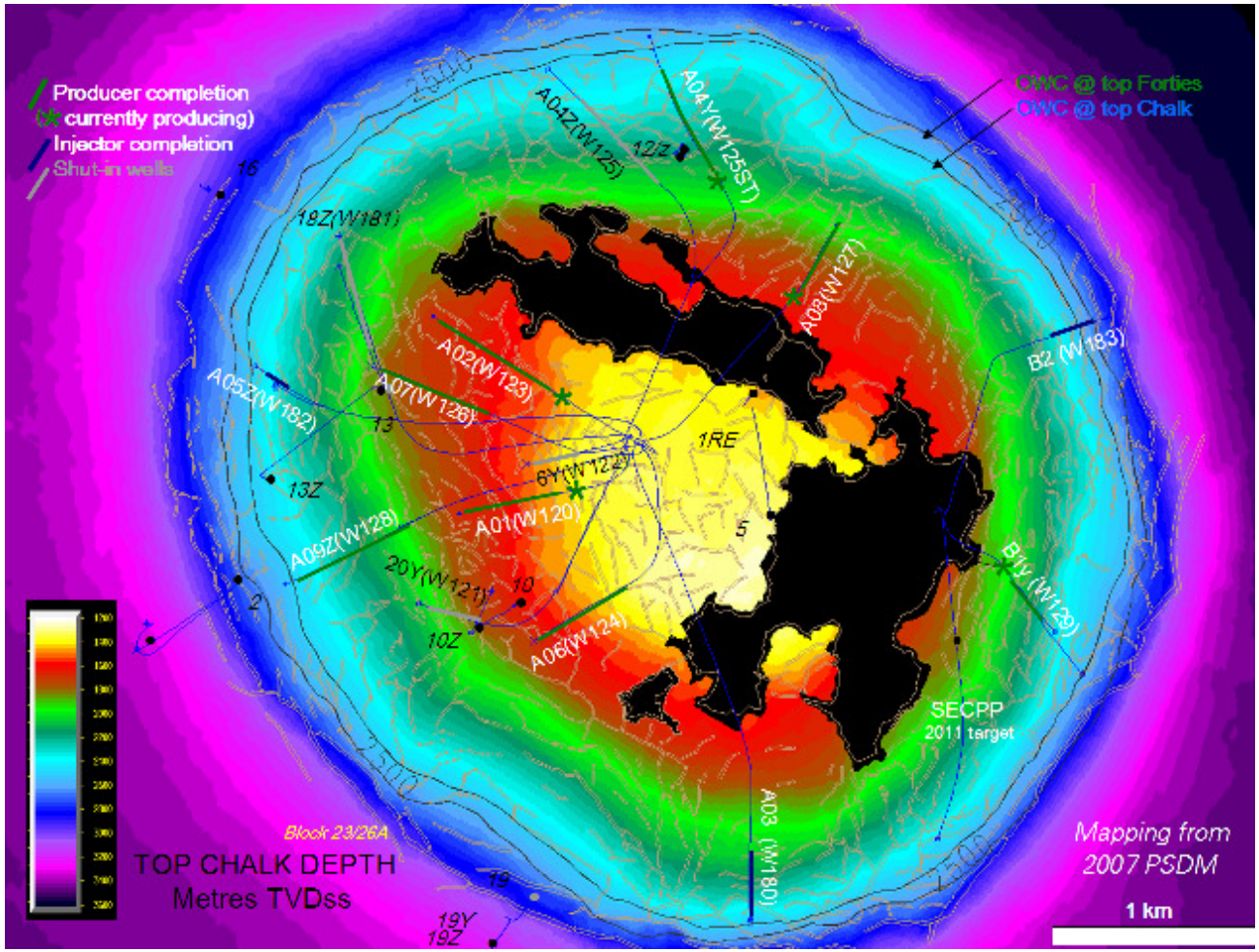
John Mason, November 2012

Presentation

- Field and Well Context
- Well Uncertainties
- Operational limitations
- Sandstone Perforating
- Chalk Perforating
- Managing well design uncertainty
- Conclusions

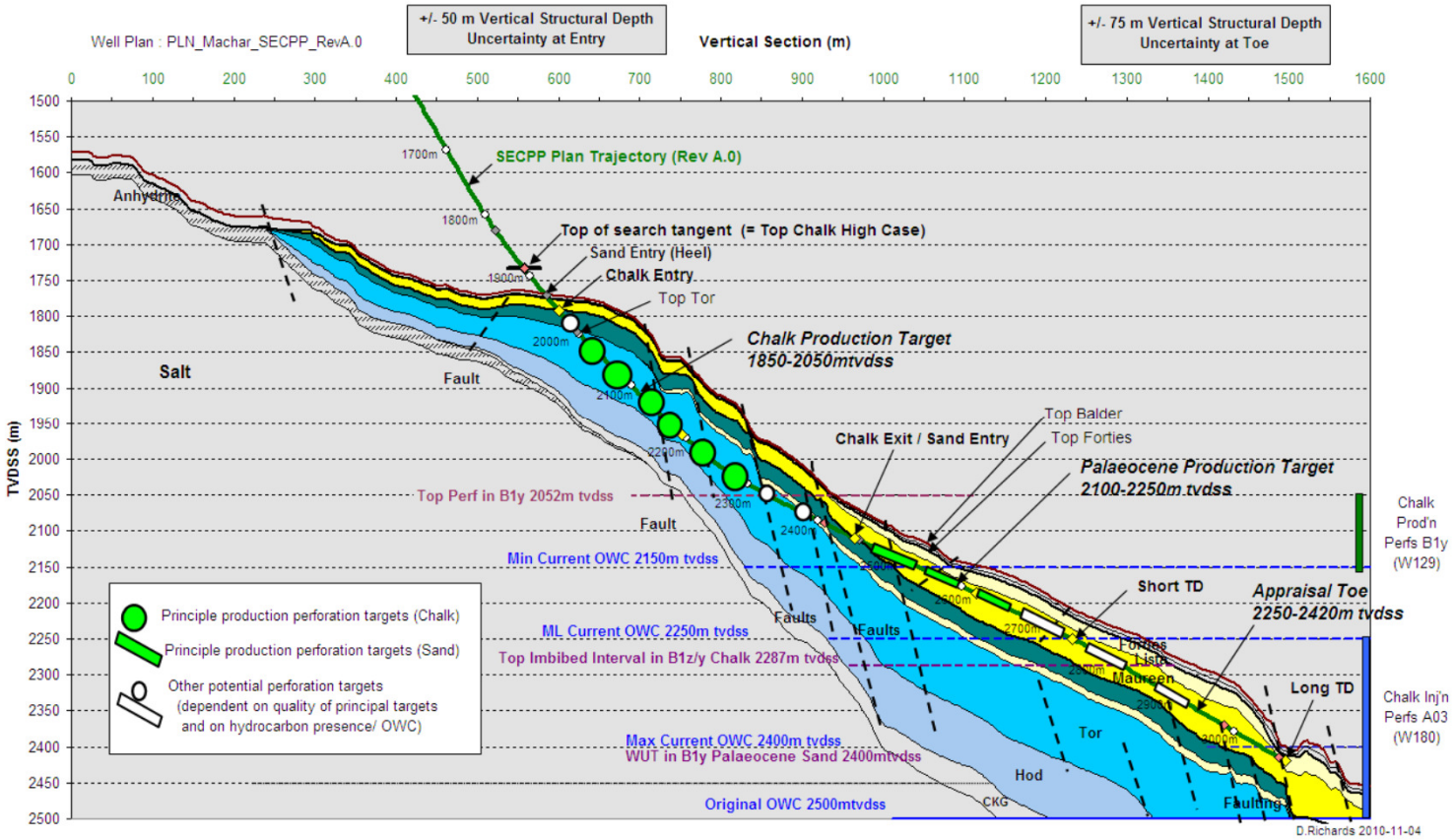
Field Context

- North Sea Mature Oil field...
- 85m water depth
- Normal P,T & PVT
- Subsea development
- Salt Diapir
- High dip angles
- Rotated Stress fields
- Chalk & sandstone
- Cemented liners
- Acid-fracced chalk
- Historical PI's of 5-150



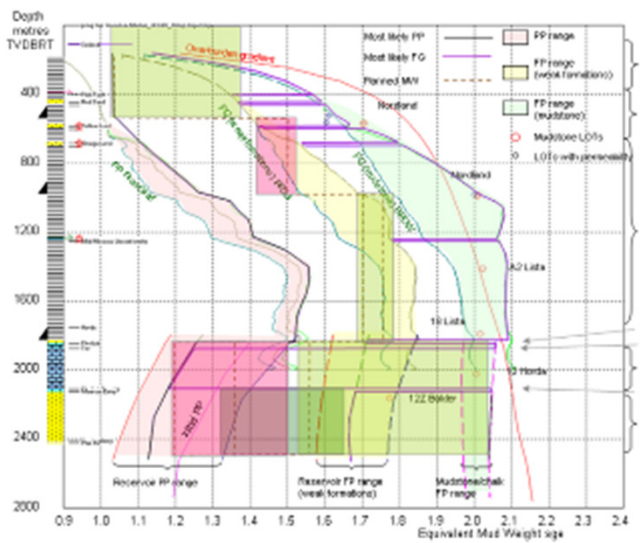
Well Context

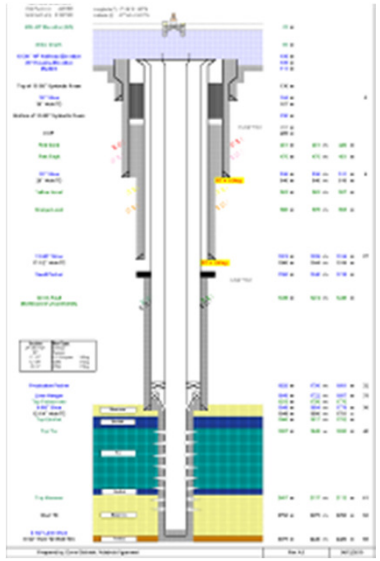
- Spud Nov 2012
- Small semi-submersible
- ~63°deviation
- 250m chalk
- 250m sand



Well Uncertainties

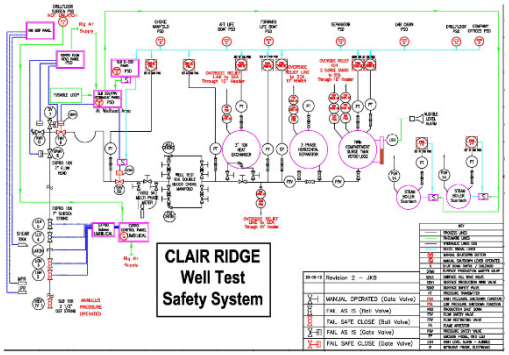
- Reservoir pressures 2680 – 4114psia at 2000mTVDss
  - **0.95 to 1.45** SG
  - Unknown *differential* depletion across the reservoir section
- Unknown Water saturations in the Palaeocene Sandstone
  - Perforating interval from 0m (if fully swept) to 250m (unswept)
- Weak rock strength in the Sandstone
  - sanding risks
- Natural fracturing in the chalk
  - minimal or moderate
- 5 ½" cemented liner
  - 4 ½" contingent liner

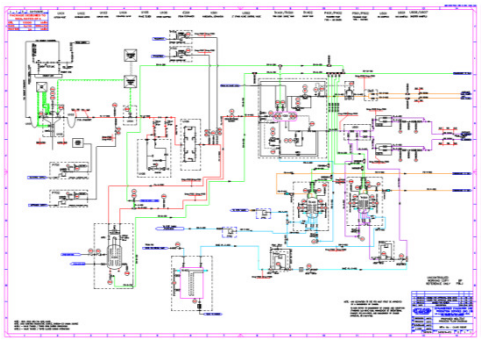




Operational Limitations

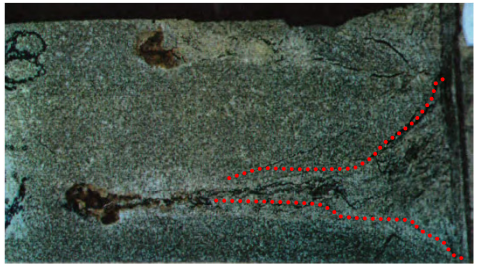
- Small 3rd generation semi-submersible rig
- November 2012 spud – winter completion operations
- Subsea flowline installation summer 2013
- Multiple completion scenarios for acid frac + sandstone perforating + flowback
- August 2012 – Internal Peer Review
  - Unable to operate well test spread + CT spread + acid fracturing
  - no rig well testing
  - acid frac only if flow-back through subsea facilities is acceptable

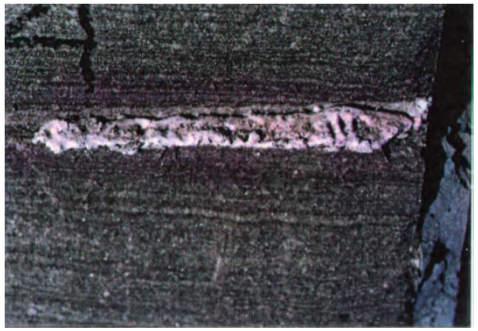




Sandstone Perforating

- Weak sand – sand production risks
  - Rotated Stress field negates the value of oriented perfs
  - Perforation phasing to maximise perforation spacing
  - Field evidence for benefits of increased perf spacing
- TCP for 150+ metres
  - Dynamic underbalance, static overbalance with clean brine
  - Sized carbonate pill vs. viscous pill to stem losses
  - liner plug above perfs being evaluated
- Wireline perforating for <150m
  - 70metres 2 7/8" guns 2-32 eline, addressable weak point
  - Unable to pull mechanical weak point – is this acceptable?
  - Run through flowhead means working at height
  - Selective perforating with addressable firing heads
- 3 3/8" vs. 2 7/8" guns - performance vs. operational flexibility
- Use the same service company for TCP and wireline?
- Slickline supplier also has double drum units with 2-23 eline





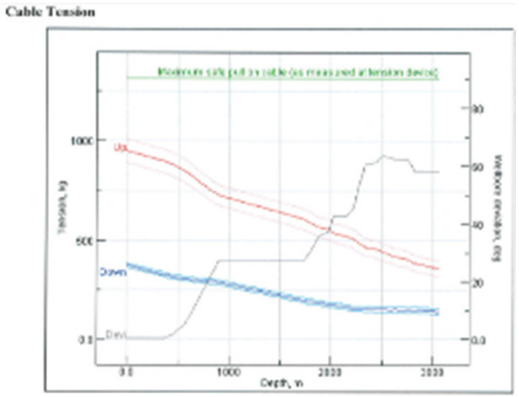
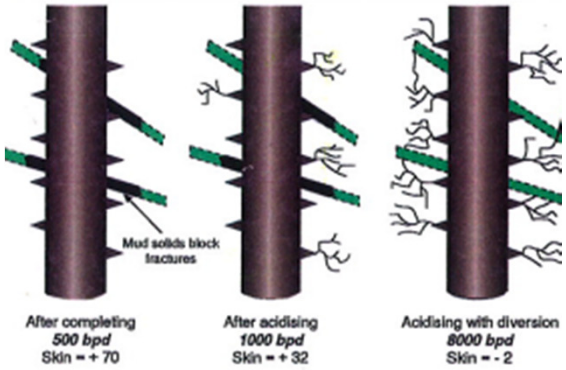
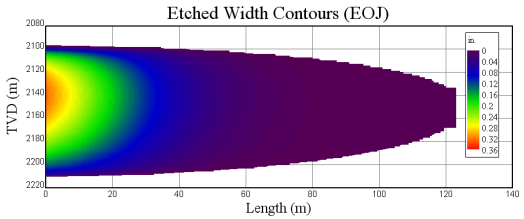


Fig.5 Normal tension along the cable with tool at 3050.5m (TD)

Chalk Perforating & Stimulation

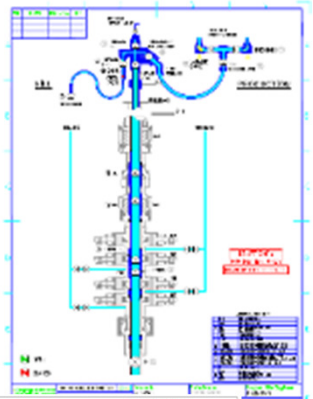
- Acid frac design for two scenarios
  - Numerous natural fractures – mud solids removal
  - Few natural fractures – viscous diverting acid
- Acid frac only if sandstone interval is water-swept
- Frac boat availability and planning for 'contingent frac'
- 5 ½" tubing string needed for frac through completion
- Limited entry wireline perforating, selective multiple intervals
- Engineered perforation EHD – shoot-out to assess parameters
- Biodegradable ball sealers depend on controlled EHD
- Gun centralisation for consistent EHD

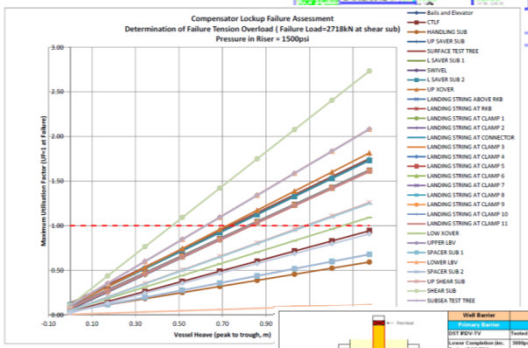


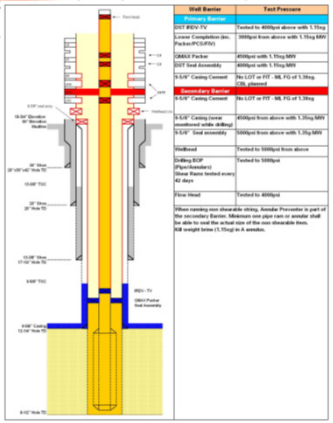


Managing Well Design Uncertainty

- Focus on 2 7/8” phased carrier guns
  - Dynamic underbalance
  - Eline tension modelling
  - Same guns for TCP or eline
- Prefer to work with one perforating service company
  - Reduced interfaces
  - Better control of work planning
- NaBr brine to cover wide range of formation pressures
  - PON-15b chemical use and discharge permitting
- Evaluate well barriers for marine riser disconnect
- Bleed-off package for eline perforating
- Rigorous risk assessment and mitigation planning
  - Compensator lock-up







Conclusions

- Small rig in winter increases operational risks such as riser disconnect
- Large reservoir uncertainty increases the possible well outcomes
- Key decisions are needed to frame the project around do-ability
- Reduce the variables for sandstone and acid frac perforating
- Decision on TCP, eline or acid frac according to well results
- Real-time supplier response to meet operational demands
- Small team with focus and continuity