Madden Deep Unit Madison Wells Fremont County Wyoming Challenges & Wish List

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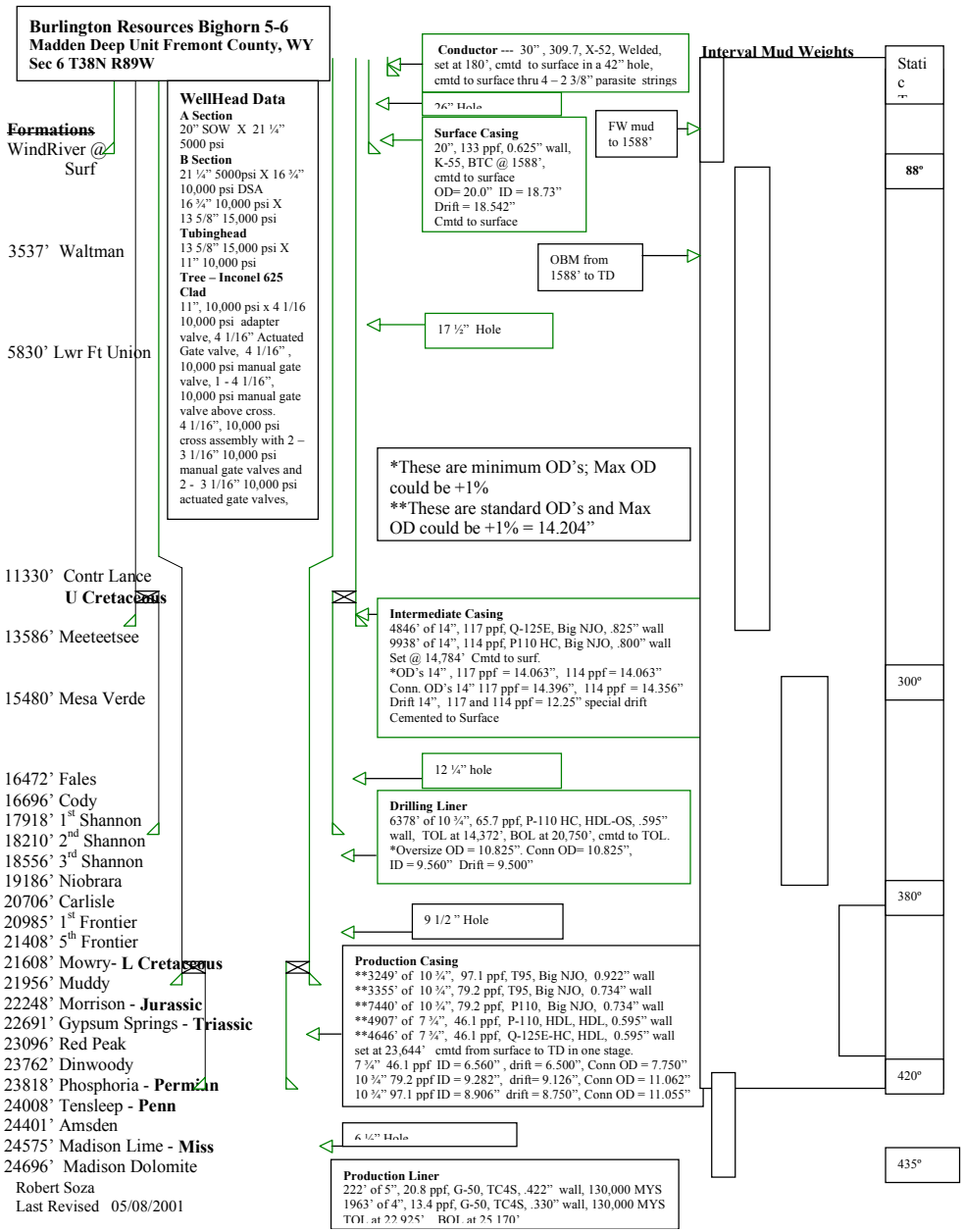
Challenges

- Deep -- +/- 25,000’ -- +/- one year to drill
- Large holes required for casing strings
- Crooked hole potential – shallow to +/-12,000’
- Hole stability issues with improper drilling fluids
- Fast drilling in large hole size requiring good hydraulics
- Slow hard drilling from 10,000’ to TD
- Tight hole clearances for casing strings
- Overpressured and depleted formations from 5,000’ to 24,000’
- Heavy casing strings – 2 strings over 1MM lbs
- Special rolling of most casing strings
- Hot -- +430^{o}F BHST
- Corrosive gases in the production stream -- +12% H_2S +20% CO_2

Wellbore Sketch



Where Do We Spend Our Time?

- 320 days thru running production liner
- 60 days on plateau – 19%
- 260 days drilling/tripping – 81%
  - 5143 drilling hours – 214.3 days = 82.4% of drilling days
    = 67% of total days
  - 1097 tripping hours – 45.7 days = 17.6% of drilling days
    = 14% of total days

Technology/Operations that Work on Madison Wells

- Downsized the hole vs. prior wells
- Diesel OBM
- Drilling large hole with bent motors
- Slow speed high torque motors
- PDC bits in 17 ½”, 16”, and 12 ¼” holes
- Long heavy casing strings with swaged connections
- Stabberless casing running
- Foam Cementing in one stage from 15,000’
- Diamond impregs and turbines
- Reverse circulation cementing on 24,000’ string of casing
- Monobore well design
- Use of CRA liner and tubing string
- Clad tubinghead and tree

Technology Wish List

- Whatever is done to improve technology for deep wells needs to be simple and have as few moving parts as possible – no moving components is excellent – i.e., we prefer fixed cutter bits to tricones due to less moving parts
- Large Diameter 17 ½”/16” Hole Section to 15,000’
  - More durable slow speed motors
    i.e., stator improvements
  - Tougher PDC bits – to drill sand/shale sequences
  - Cost effective straight hole drilling device
    We try to keep our holes under 1^{o} deviation from surface to 15,000’
- Intermediate Hole Section 12 ¼” to 21,000’
  - Durable slow speed high torque motors – stator improvements
  - Tougher tricones – metal to metal seals, gage protection, etc.
  - More aggressive diamond impregs
    Cutting structure and hydraulics
    Impregs designed to cut shale and sand sequences at higher penetration rates
  - More effective lost circulation/well control strategies

Technology Wish List *(cont)*

- Deep Hole Section 9 ½" and 6 ½" hole from 21,000 – 25,000'
  - Higher torque turbines – But transmissions mean more moving parts
  - More aggressive diamond impregs for sand/shale sequences
    Cutting structure and hydraulics
  - More durable diamond impregs for sand sections
  - Cementing techniques for long string
- Real time data manipulation between offset data, rock compressive strengths, PVT data, formation 6" ahead of the bit, etc.
  - Aggregation techniques vs. paper now
- Ways to slim deep holes
  - Reduce the casing to hole clearances – i.e., run 11 ¾" liner in 12 ½" hole or manufacture non standard casing sizes (14 1/8" OD with a 12 ¼" ID, 10 7/8" OD with a 9 ½" ID) to allow standard size bits to be used. Effective if hole stability is not an issue. If a casing string could be run that did not require cementing, i.e., the casing had a mesh, external coating that could be activated downhole and provide the annular seal – the above issues could be resolved and allow us to downsize holes – i.e., drill faster.