Optimizing Granite Wash Horizontal Drilling

Glenn Bone & Robbie Woodard
1/19/2011
1977 – 2003
10 Wells drilled
Stiles Ranch Area Today
Starting in 1977

**18,000' Morrow**

<table>
<thead>
<tr>
<th>MD</th>
<th>Casing Profile</th>
<th>Hole Size</th>
<th>Casing Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,000'</td>
<td></td>
<td>26''</td>
<td>28''</td>
</tr>
<tr>
<td>5,500'</td>
<td></td>
<td>17 1/2''</td>
<td>13 3/8''</td>
</tr>
<tr>
<td>13,000'</td>
<td></td>
<td>12 1/4''</td>
<td>9 5/8''</td>
</tr>
<tr>
<td>16,400'</td>
<td></td>
<td>8 1/2''</td>
<td>7 5/8''</td>
</tr>
<tr>
<td>18,000'</td>
<td></td>
<td>6 1/2''</td>
<td>4 1/2''</td>
</tr>
</tbody>
</table>

- Deep
- High Pressure (16-18 ppg mud)
- High volume
- Gas
- Minimal Completions
**GW Development 2004**

- Mid Range Depth
- Water Gradient
- Tight Rock
- Gas & Condensate
- Slick water Fracs

<table>
<thead>
<tr>
<th>MD</th>
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<th>Hole Size</th>
<th>Casing Details</th>
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<tbody>
<tr>
<td>400'</td>
<td></td>
<td>17 1/2</td>
<td>13 3/8&quot;</td>
</tr>
<tr>
<td>3400'</td>
<td></td>
<td>12 1/4</td>
<td>9 5/8&quot;</td>
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<tr>
<td>14,000'</td>
<td></td>
<td>7 7/8&quot;</td>
<td>4 1/2&quot;</td>
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Atoka Wash Development 2005

- Mid Range Depth
- Higher Pressures (TD with MW 11 ppg+/- 14.5 +/- ppg reservoir pressure)
- Tight
- Gas
- Slick water Fracs
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
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<tbody>
<tr>
<td>Thick zones</td>
<td>&gt; 1,500 ft</td>
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<tr>
<td>Porosity</td>
<td>6-12%</td>
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<tr>
<td>Low perm</td>
<td>0.01 md</td>
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<tr>
<td>Small DA’s</td>
<td>&lt; 40 ac</td>
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Initial Design

Directional Plan

Build @ 10-15 deg/100

Drill Well Due N/S
Goal to Test GW as a horizontal play
- Set pipe near vertical above wash
- Build 10-15 deg/100
- 4,000’ lateral
- 8.5 OBM in lateral
- LWD Logging
- 43 Days to TD
Negative Vertical Section Design

Directional Plan

Negative Vertical @ 3-7deg/100
Build to horizontal @ 10-15 deg/100

Drill Well Due N/S

GW Horizontals 2009
Goal: Improve GW economics by increasing lateral in zone

- Negative Build 3-7 Deg, back to lease line
- Build 10-15 deg/100
- 4,500’ lateral
- 8.5 OBM in lateral
- Shuttle logs
- 47 Days to TD
**Latch Collar Design**

**Directional Plan**

- Negative Vertical @ 3-deg/100
- Build to horizontal at 10-15 deg/100

**Drill Well Direction**

- 4 1/2" 13.5# P-110 Hydfil 521
- 6-1/4" HH8-13 15# TVD (4.5# VE) GW

- 8.4-8.6 GPM
Goal design wells for multiple laterals

- Negative Builds
- Latch collars in 7”
- Liner at TD
- 47 Days to TD for the first lateral
- 27 Days to TD for second lateral
Stacked Lateral Design

Directional Plan

- Negative Vertical @ 3-7 deg/100
- Build to horizontal at 10-15 deg/100

Drill Well Due N/S

- 8 3/4" cmt to 5,000' fill
- 12 1/4" cmt to surface
- 17 1/2" cmt to surface

- 12,700' 7" 29# P-110 LT&C
- 5,400' 9 5/8" 40# LT&C J-55 & HCK-55
- 300' 13 3/8" 48# ST&C H-40

Preset

- 20° Conductor @ 90°

8.4-8.6 OBM

4 1/2 13.5# P-110 Hydrid 521
6-1/8" Hole-13,150 TVD (4,500' VS) GW

Stacked Lateral Design
Stacked Lateral Design

- Goal Increase wells per section
  - Negative Builds
  - Latch collars in 7"
  - New horizontal wells stacked under or over current producers
  - 48 Days to TD due to more directional work required
Initial Well Changes

- Increased lateral length (improved economics)
- Added latch collars for future laterals
- Stacked lateral (increase number of wells per section)

Well Changes

- Improved Economics
- Increased days on well
- Increased cost of wells
- Wells much more complicated
Drilling Improvements

- Dropped MW to 8.0-8.2
- Soft land lateral

Well Changes

- Reduced OBM losses in lateral
- Improved ROP In lateral (20%)
- Reduced days on well to 46 (back to where we started)
Drill thru Design

Directional Plan

Negative Vertical @ 3.5 deg/100
Build to horizontal at 6.14 deg/100

Drill Well Due N/S

5 1/2 15.1# P-110 Hydrill 521 & BTC
6 3/4” Hole, 13,158’ TVD (4,300’ VSS) GW

7.8-8.2 OBM
Goal reduce well cost and time

- Water base thru loss zones
- 5 ½” casing at TD
- Stacked wells and Negative Build Vertical Section
- Days to TD 42
- Reduced well cost $750,000
- Improve pump pressures and complications for Completions
Drill Thru Results

Drill Thru’s

- Stiles 68 17-68 – AFE $3,808,002 Actual $2,588,593 / Took 34 days 17,465’ MD
- Stiles 68 20-68 – AFE $3,926,039 Actual $3,701,507 / Took 52 days MD 17,631’
- Stiles 16 10-16 – AFE $3,914,800 Actual $3,649,423 / Took 50 days MD 17,819’

Averages (Omit Stiles 68 19-68)

- AFE: $3,882,950
- Actual: $3,313,170
- Days: 45
Running 7 inch

- Cost average: $3,813,993 adjusted for rate increases
- Averaging 49 days

Savings: 4 days and $500,000

AFE’d without 7 inch

- Weatherly #3-1H – AFE $3,126,000 Actual 2,987,291
- Took 39 days MD 15,707
- Had major losses but ROP’s as high as 60 ft/hr
What are the parameters for running 7 inch or attempting a drill thru?

- Water sensitive shale’s & flow patterns
  - LSND vs. Dispersed

- When should you displace?

- Cost of losing OBM vs. running 7 inch
Future

- Improve PDC performance in Curve
- Reduce Slides
  - Adjustable Stabilizer
  - Change up BHA
- Attempt WBM if 7 inch is run
- Extended laterals in multiple sections