Horizontal Drilling in Kansas: A Case Study

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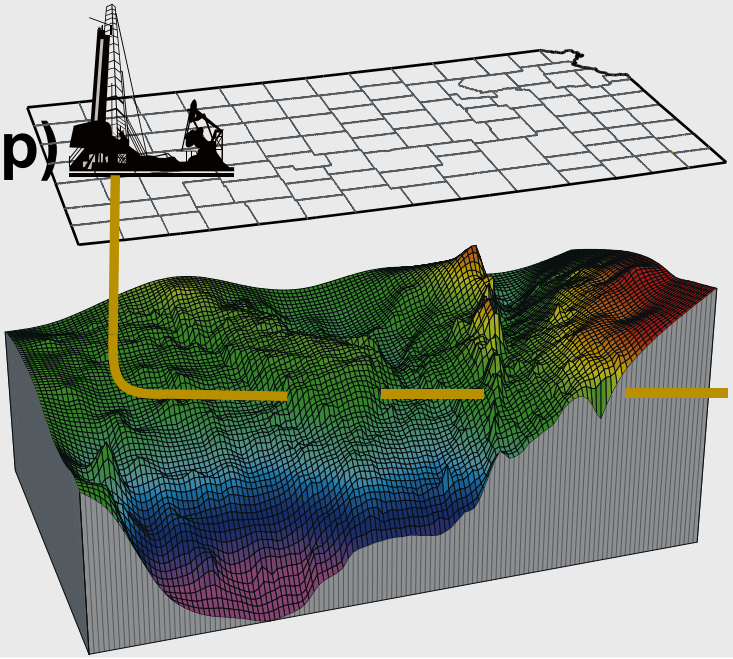
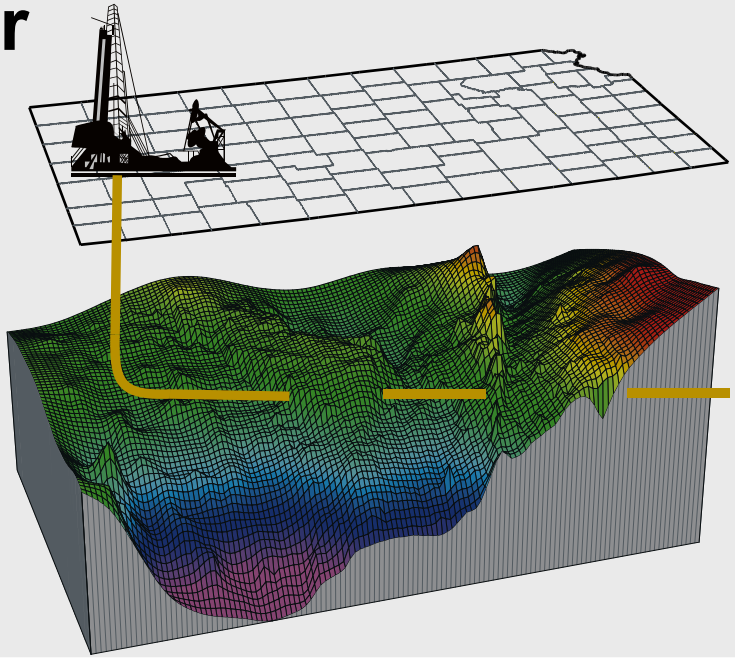
Acknowledgements

- US Department of Energy
- Mull Drilling Company Inc.
- Ritchie Exploration Inc.
- Sperry-Sun Drilling
- CMG
  (Computer Modeling Group)
- Security DBS
- Baroid
- Norseman
- Art Merrick Consulting
- Scientific Drilling

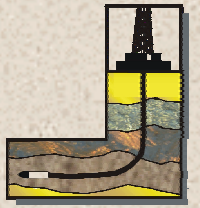


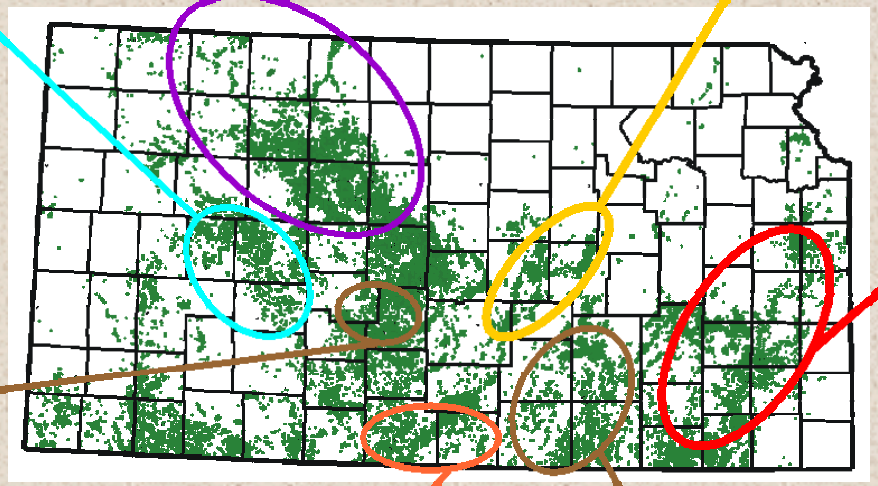
Additional Acknowledgements

- **Weatherford Tools**
- **Halliburton Coiled Tubing Services**
- **Tim Carr, Principle Investigator**
- **Paul Gerlach, Reservoir Characterization**
- **Saibal Bhattacharya, Reservoir Simulation**
- **Richard Pancake, Technology Transfer**



Potential Target

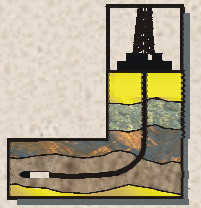


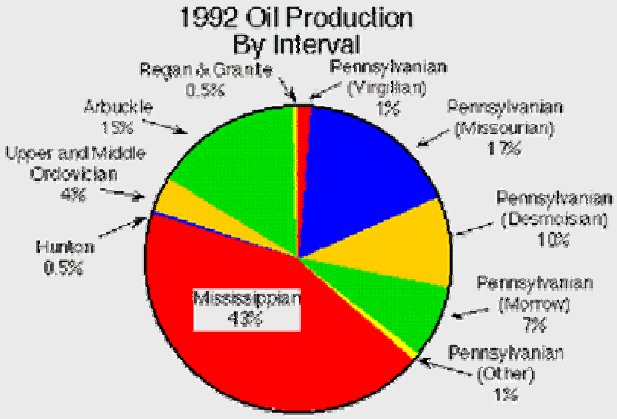


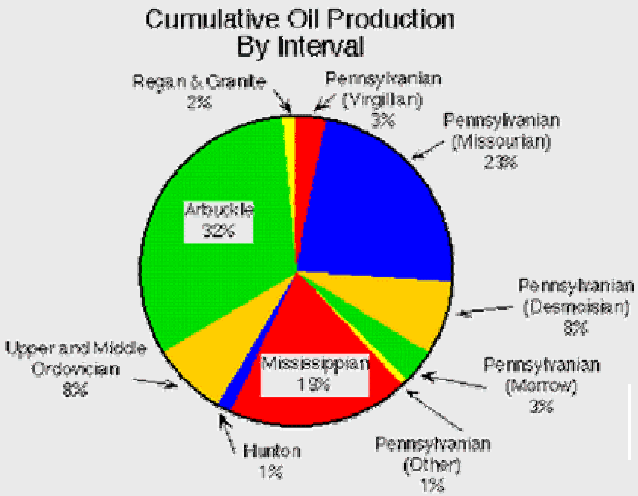
- **Numerous Targets**
  - **State Level**

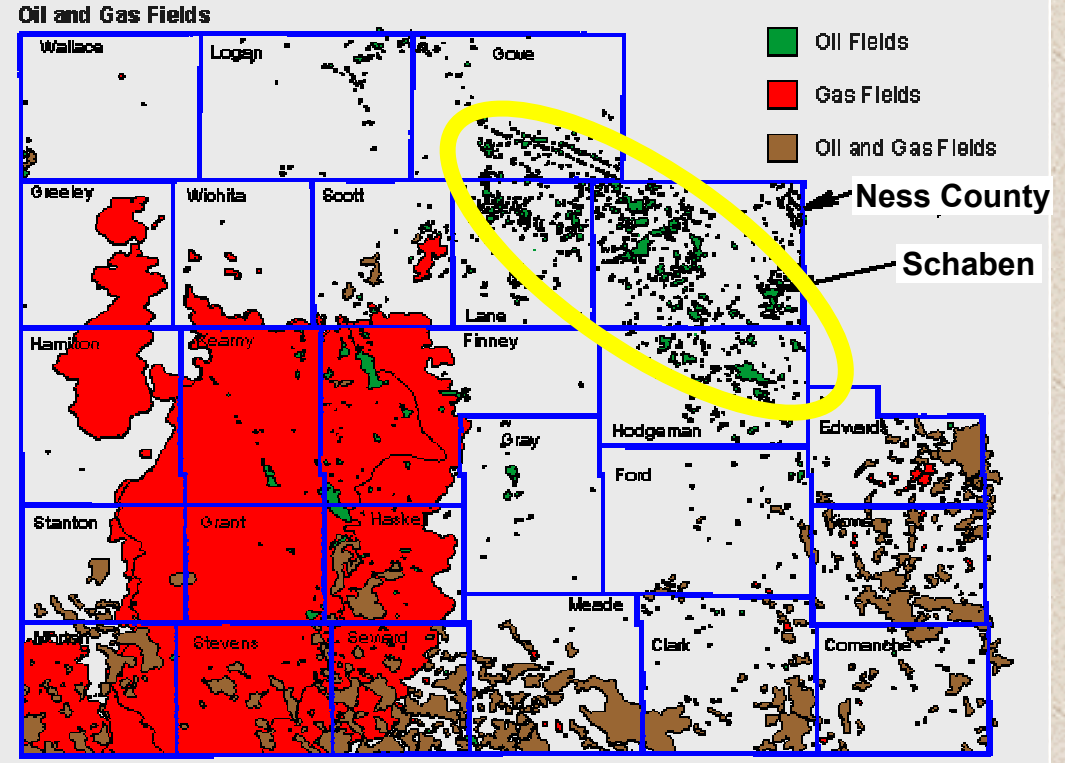
Modified from Paul Gerlach

Potential Target



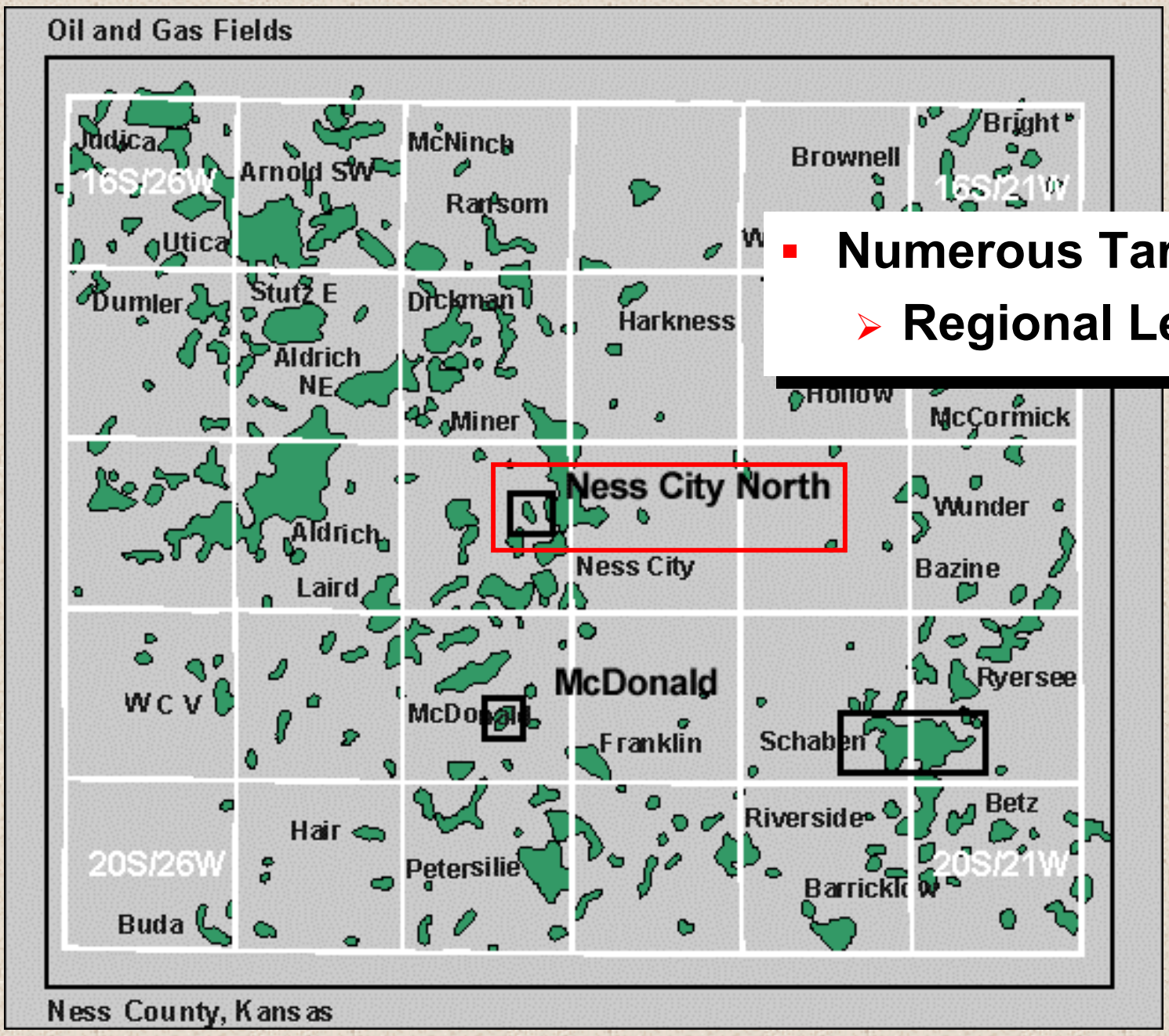


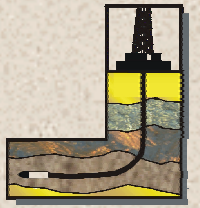




Southwestern Kansas

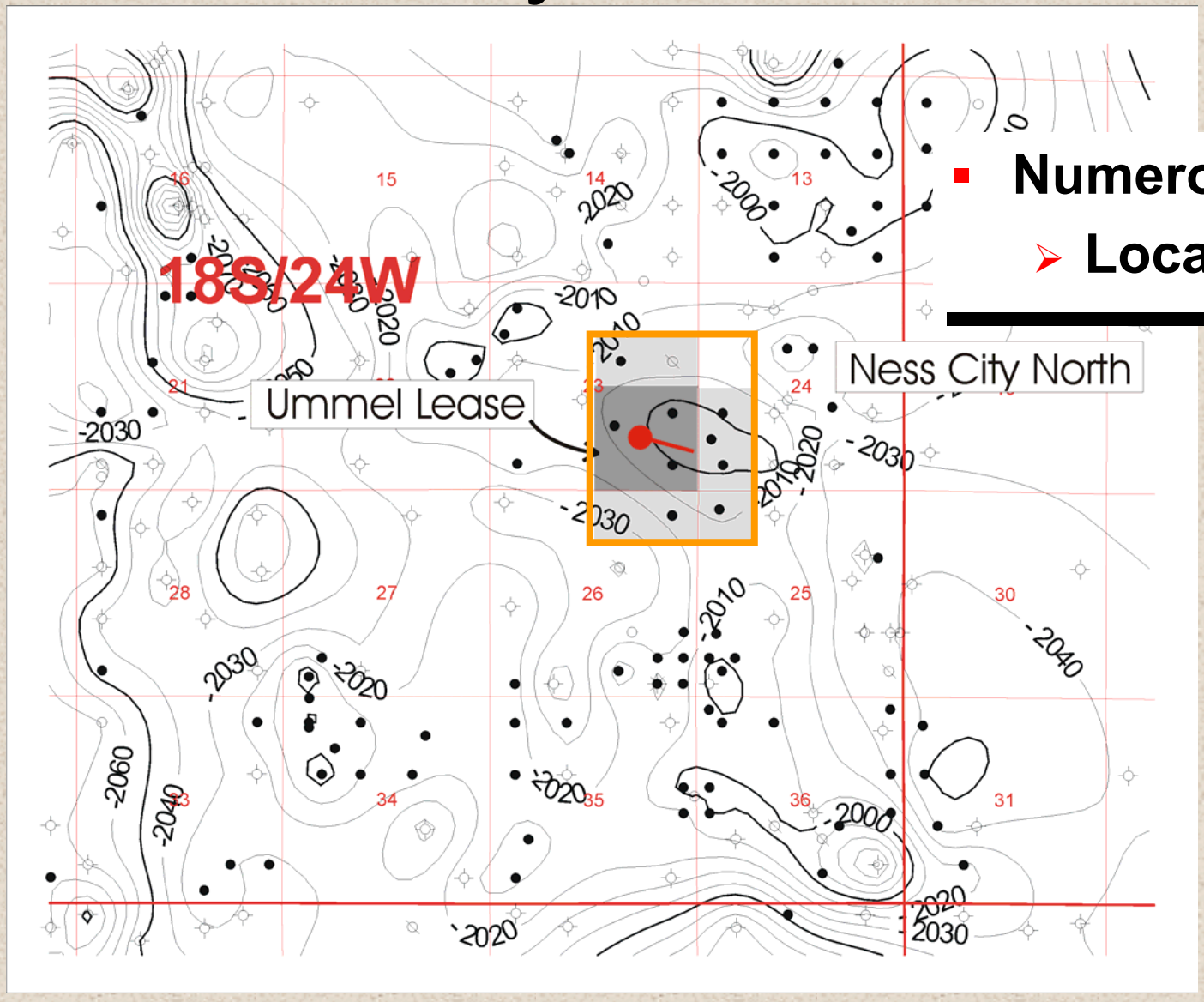
- **Numerous Targets**
  - **Mississippian**





- **Numerous Targets**
  - **Regional Level**

Ness City North Field



- **Numerous Targets**
  - **Local Level**

Doing Our Homework

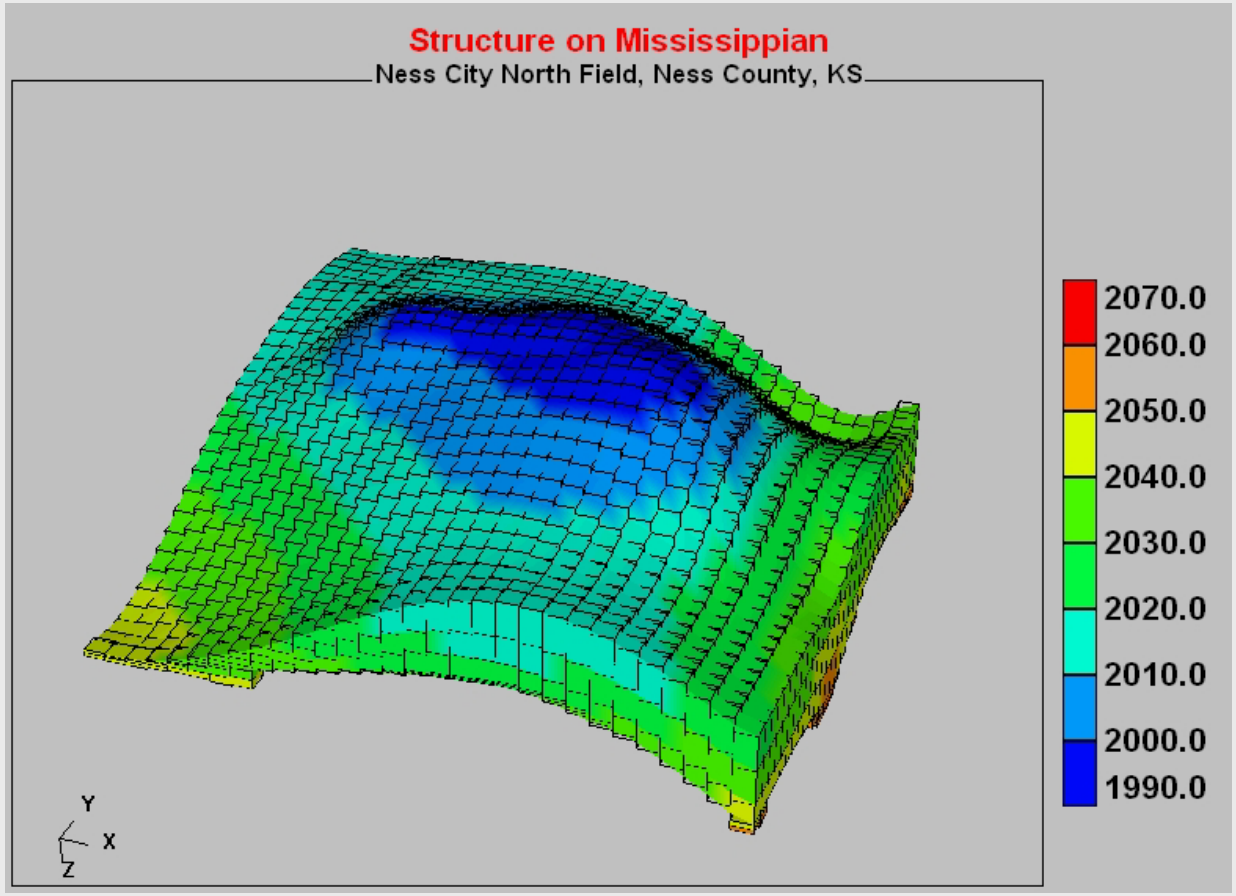
- **Reservoir characterization**
  - **Geologic & Petrophysical model**
- **Engineering analysis**
  - **Pressure & Production data**
  - **Reservoir Simulation**
    - **History Matching**
    - **Horizontal Infill Performance Prediction**

Reservoir Characterization

Geologic Model

Geologic model: log (GR, Res), core, production, DST data

Maps & cross-sections of Mississippian sub-units: 5 layered reservoir model



Reservoir Characterization

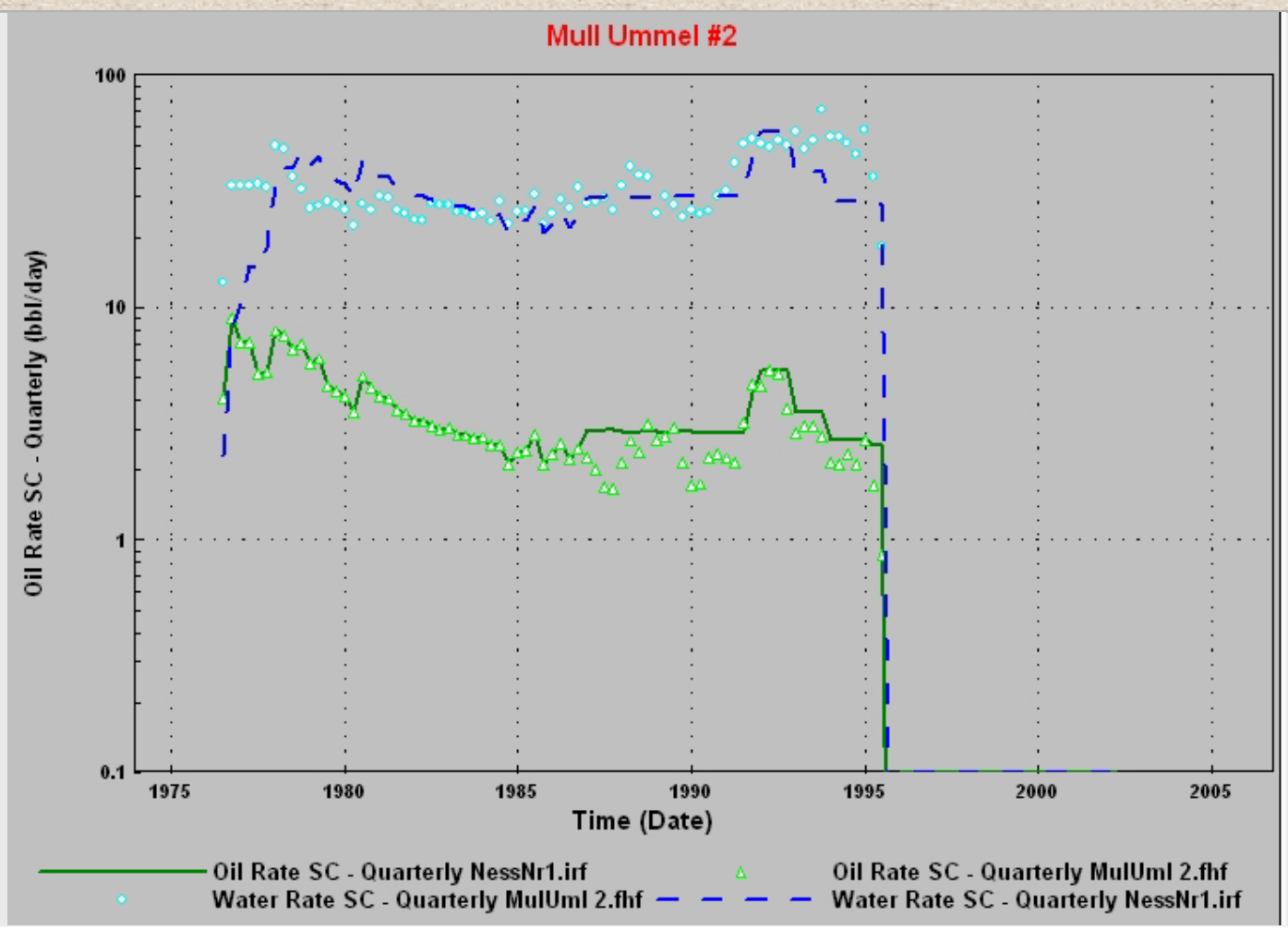
Initial Reservoir Model

- Identification of dominant lithofacies - core studies
  - LP1, LP2, LP3 - moldic pack-wackestone
  - HP1 & HP2 - moldic packstone
- Layer porosity - lower of
  - that calculated from phi-K correlation, and
  - the highest value measured on plugs with same dominant lithofacies

Sub unit	Phi, %	K, md
LP1	15	8
LP2	21.5	25
LP3	15	8
HP1	23.6	60
HP2	22.2	40

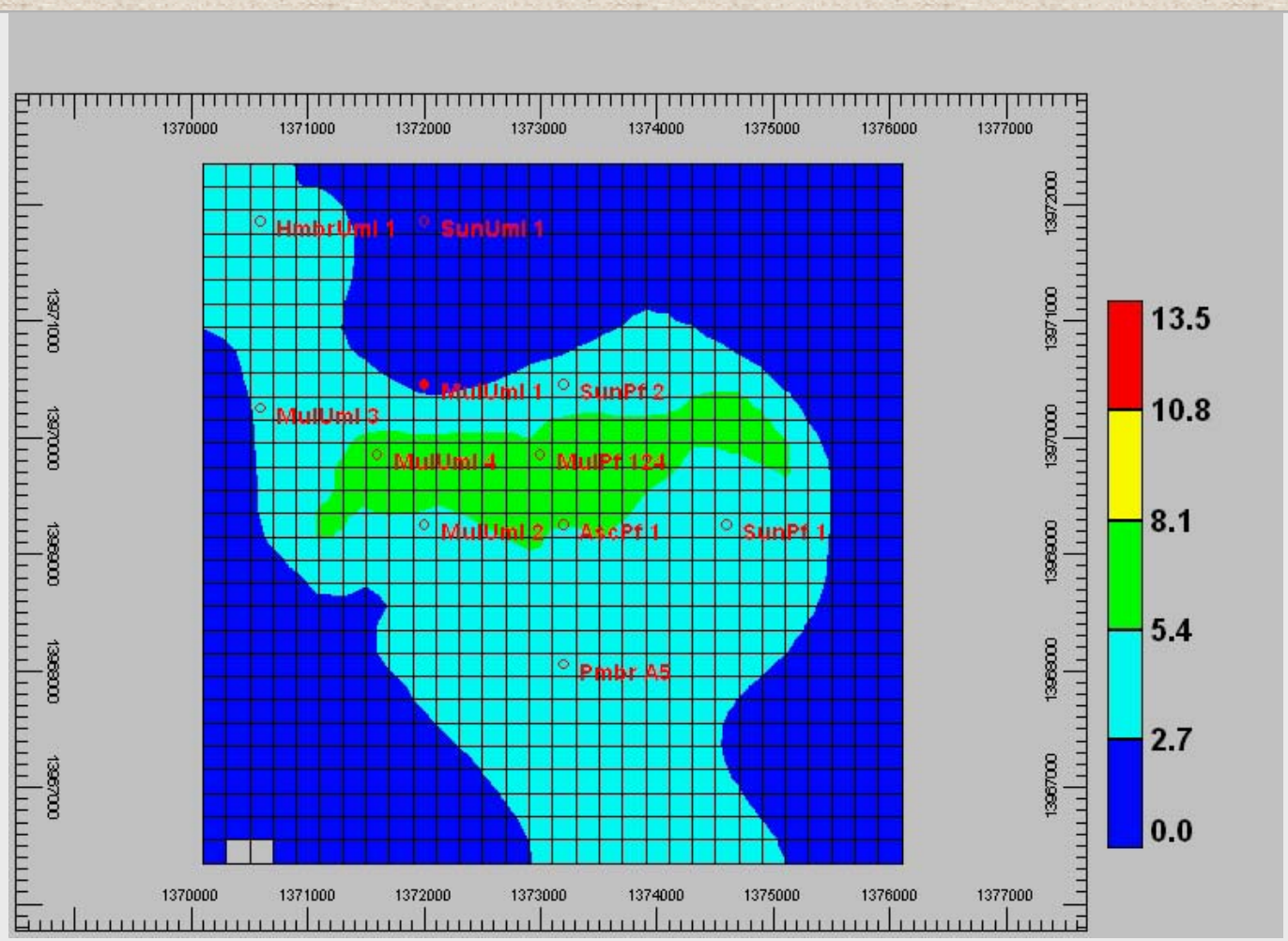
Engineering Analysis

Reservoir Simulation - History Match



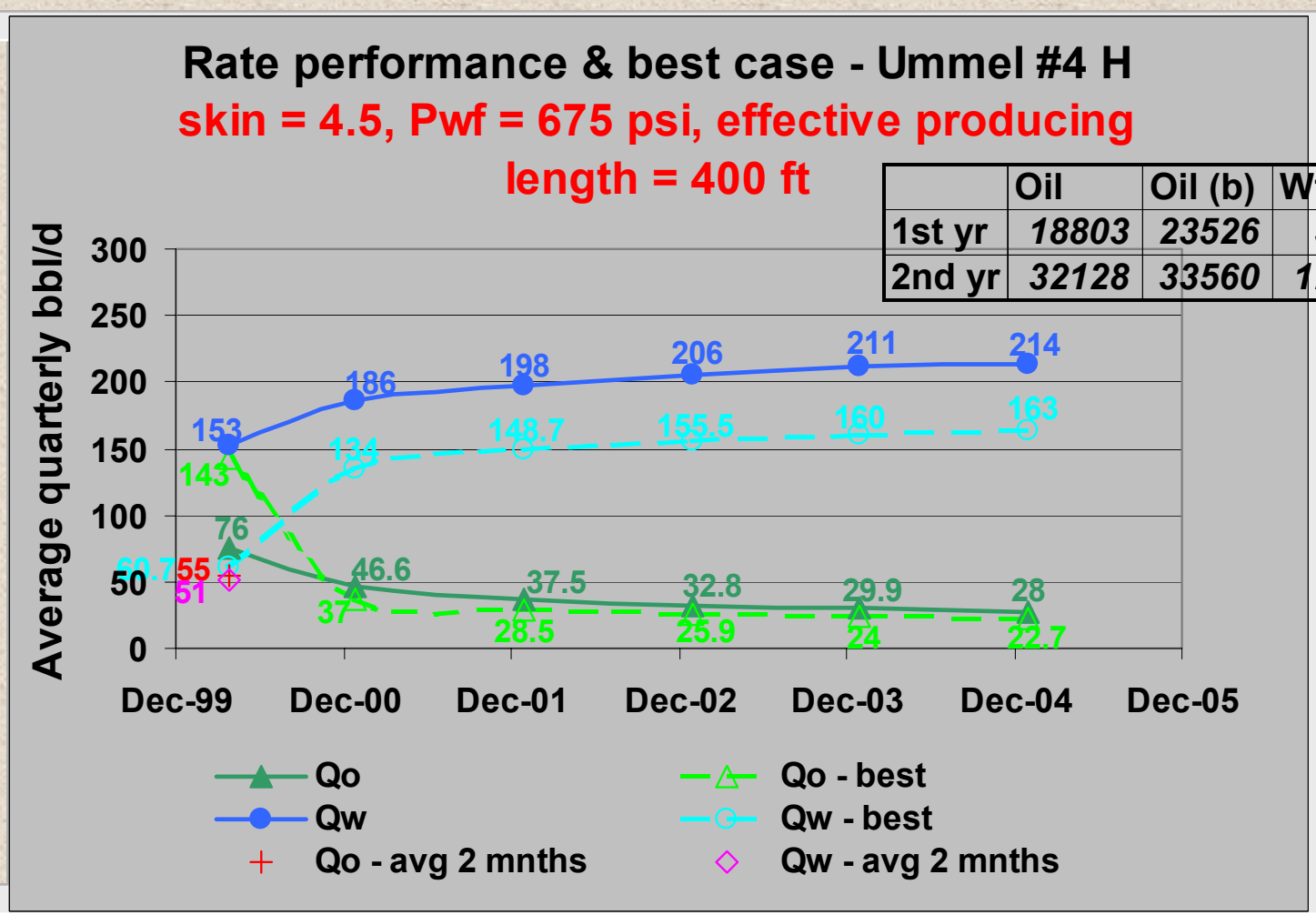
Reservoir Simulation

Residual Potential - So-ft, 2000



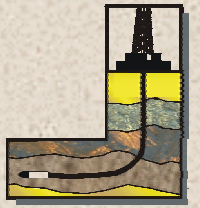
Performance Prediction

Performance Prediction - Infill



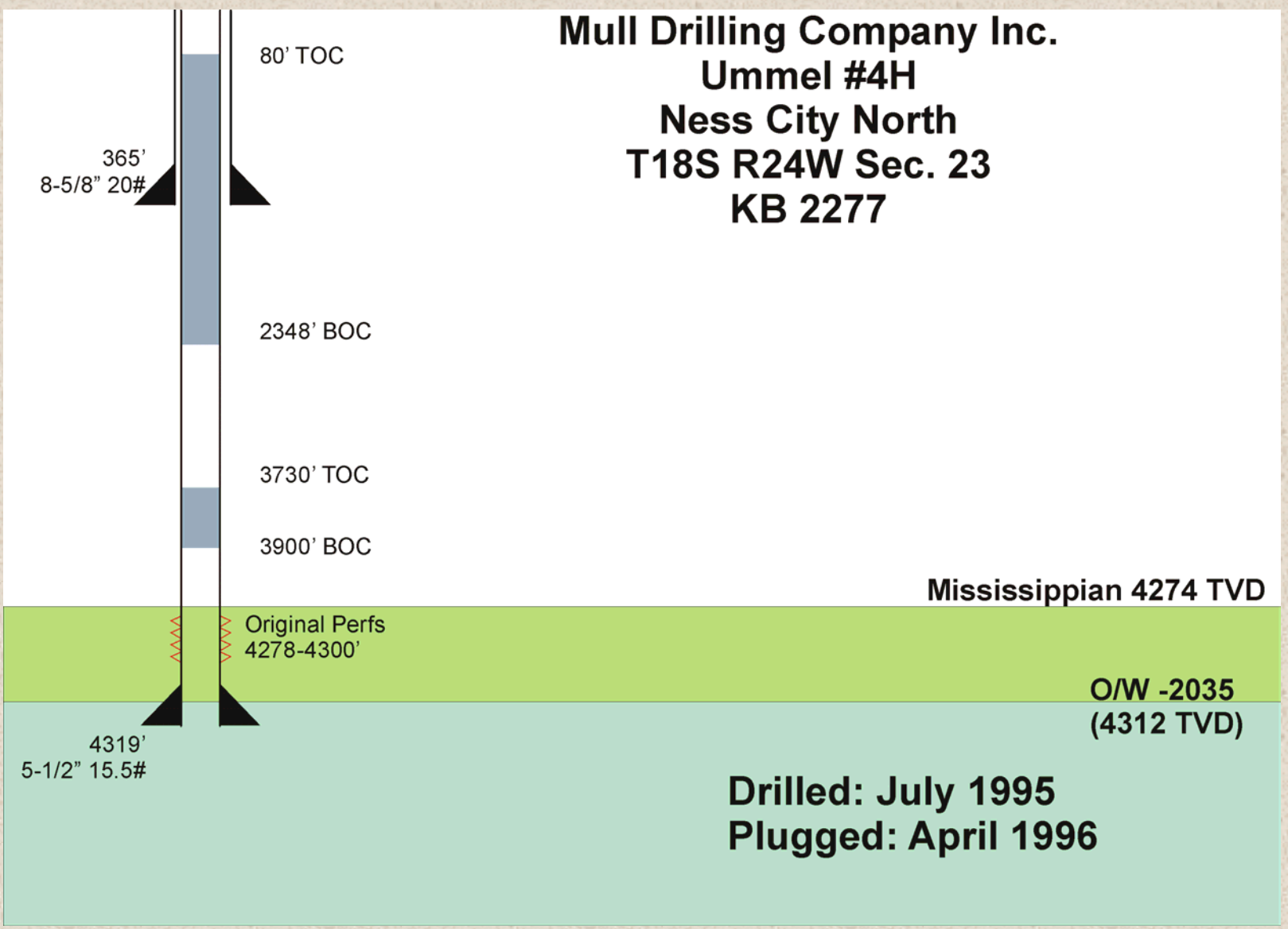
	Oil	Oil (b)	Wtr	Wtr (b)
1st yr	*18803*	*23526*	*59208*	*37232*
2nd yr	*32128*	*33560*	*126069*	*86816*

Details of Well Work

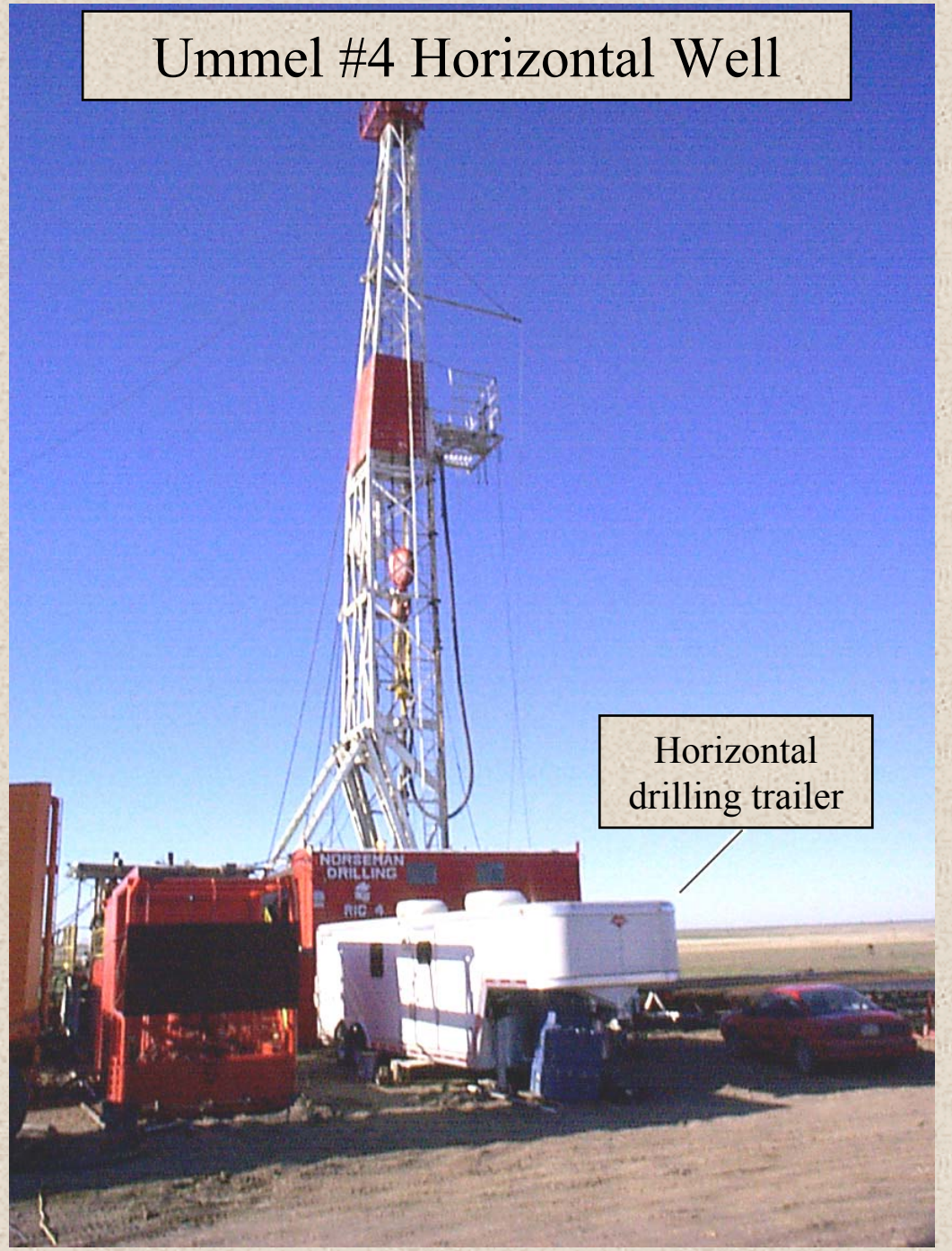


- **Original Plugged Wellbore**
- **Drill Out Cement Plugs & Set CIBP**
- **Set Whipstock & Mill Casing**
- **Drill Build Section**
- **Drill Lateral Section**
- **Set Liner**
- **Final Completion**
- **Coiled Tubing Workover**

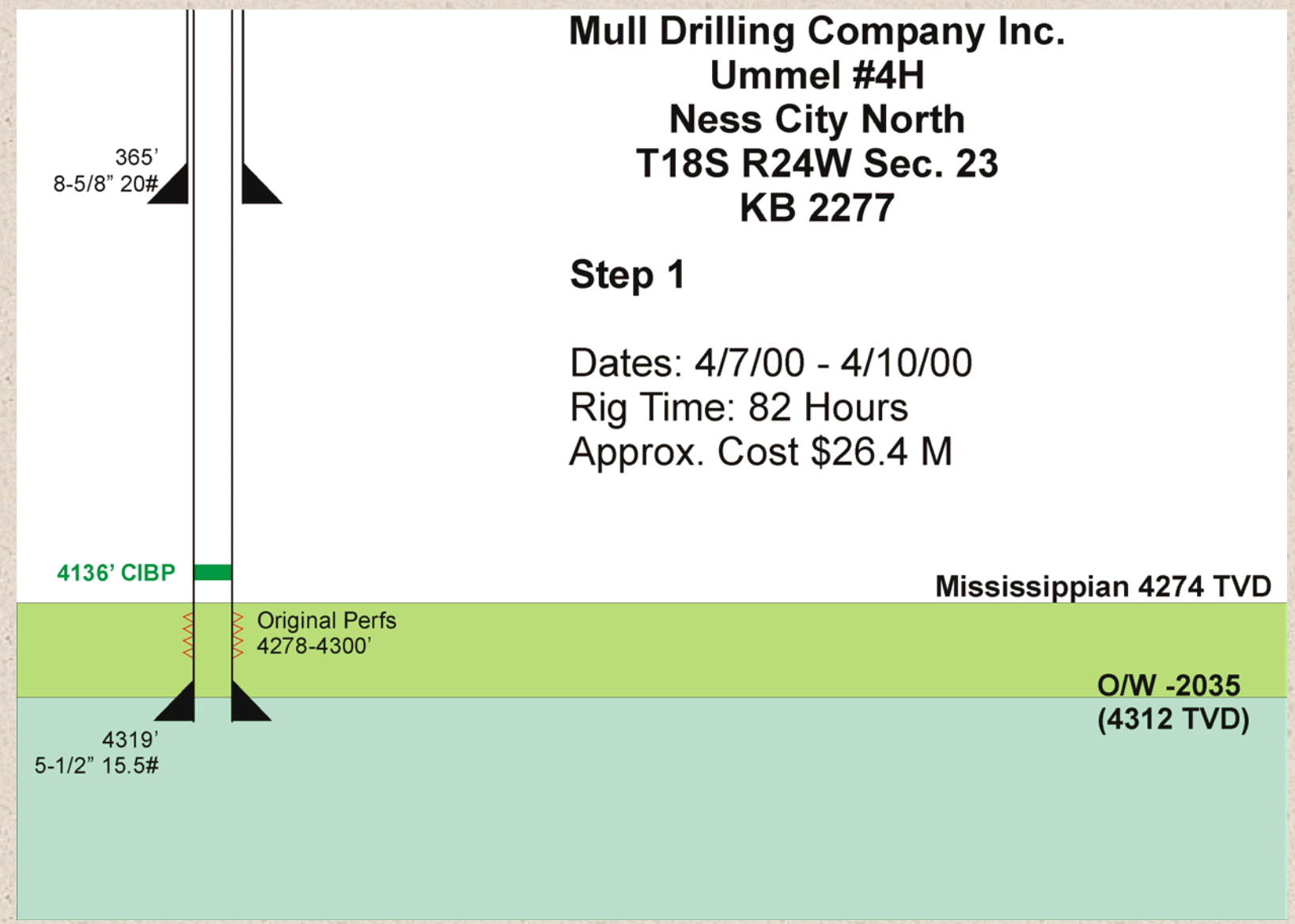
Original Plugged Well

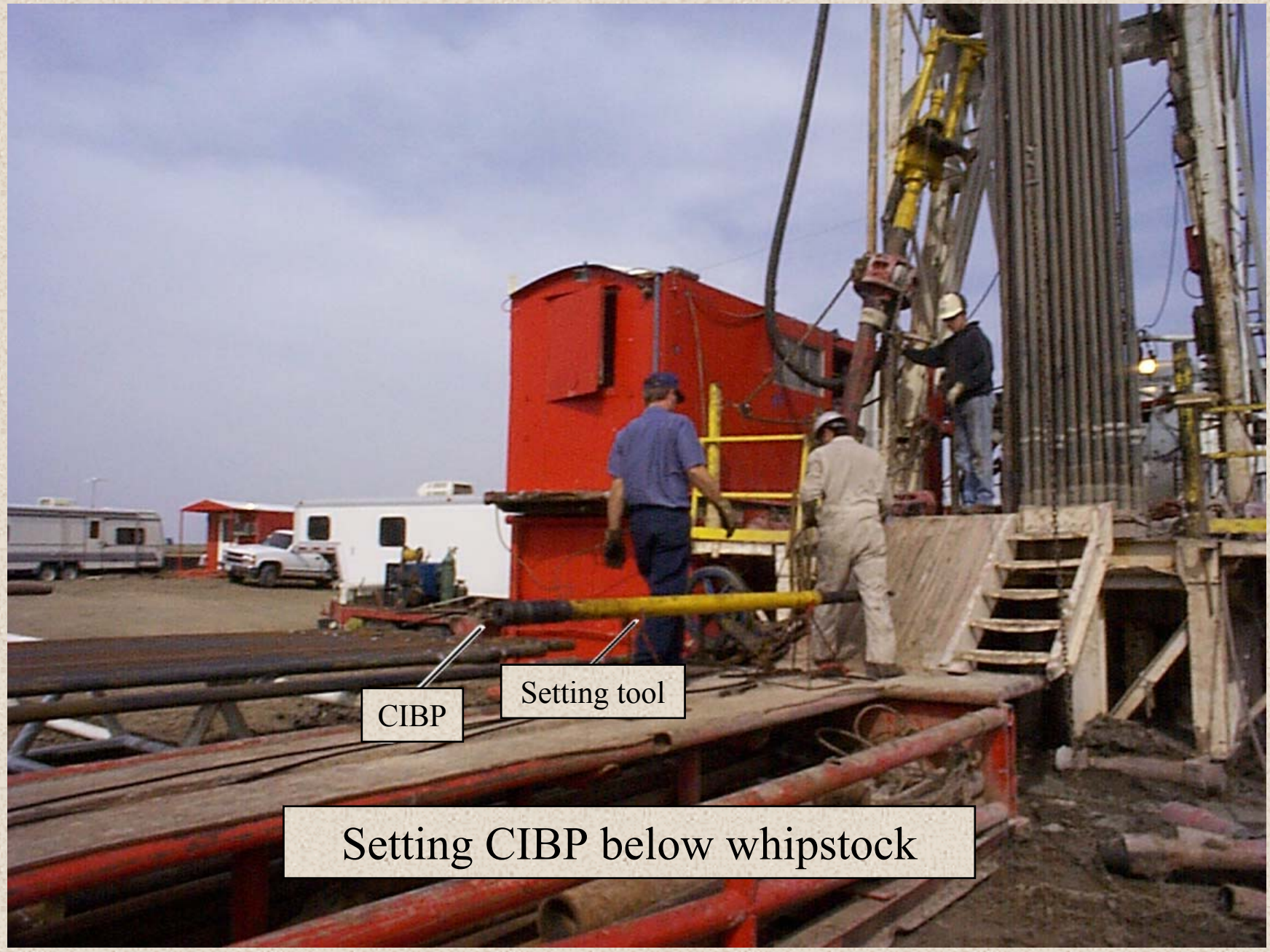


Ummel #4 Horizontal Well



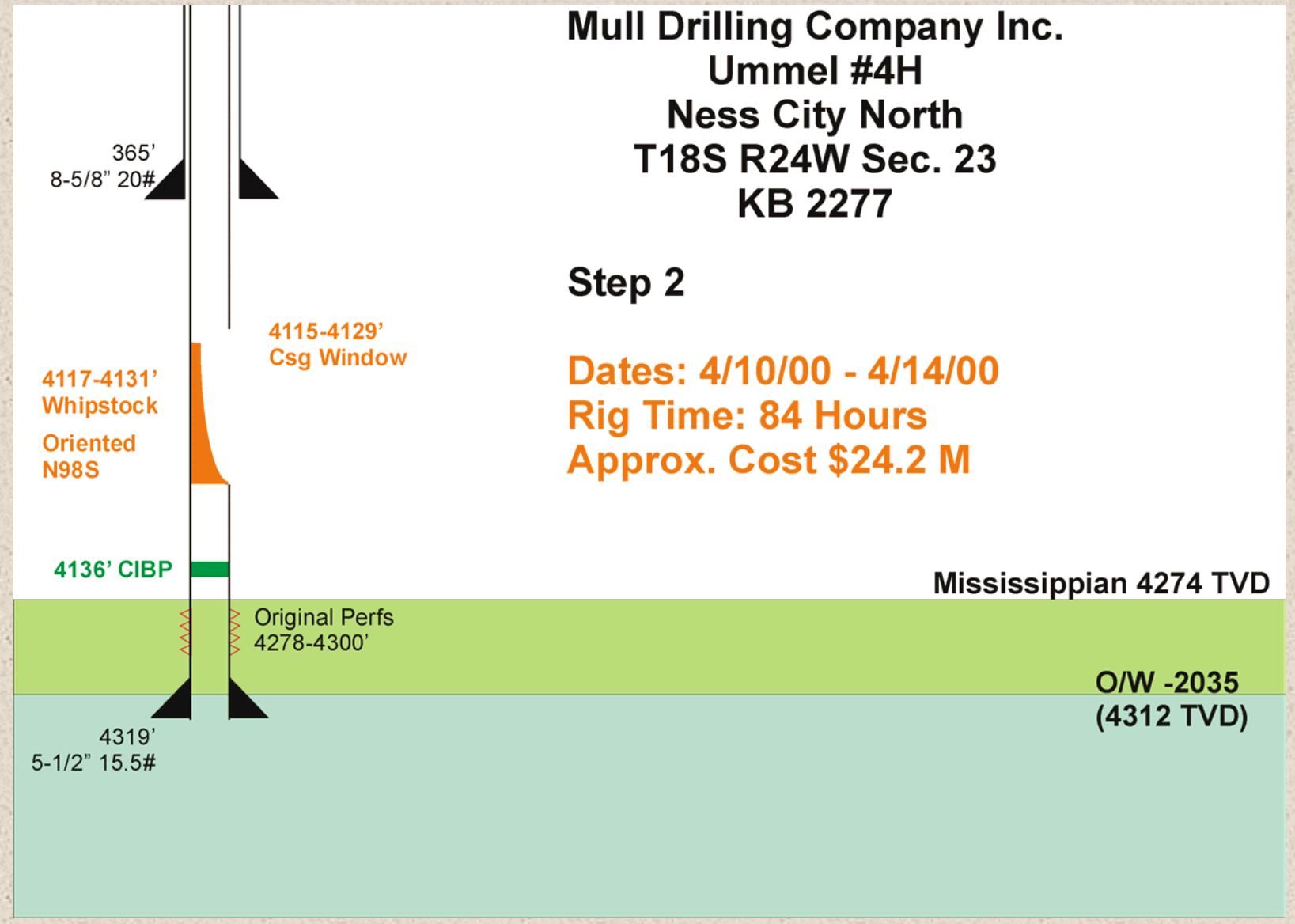
Drill Out Cement & Set CIBP

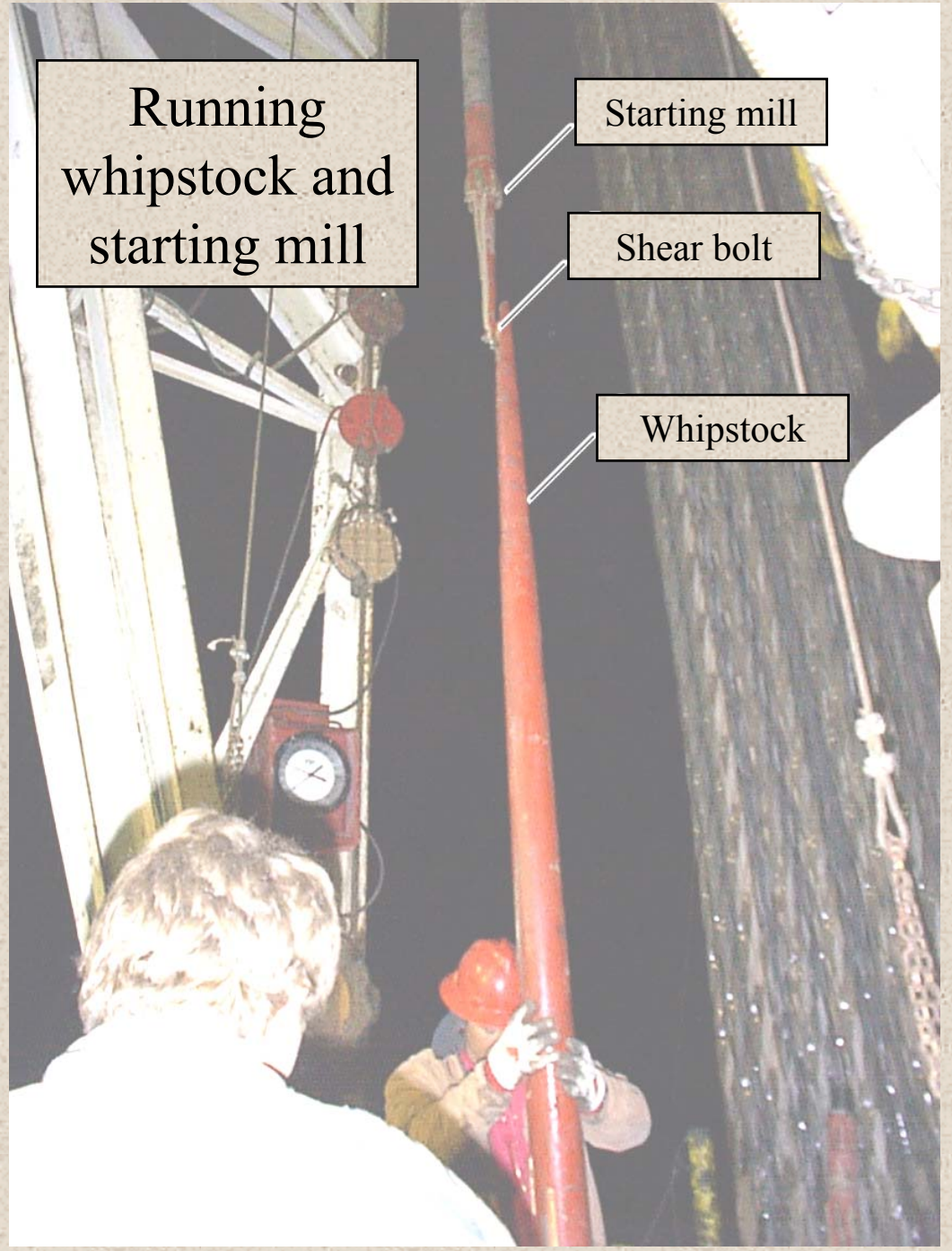




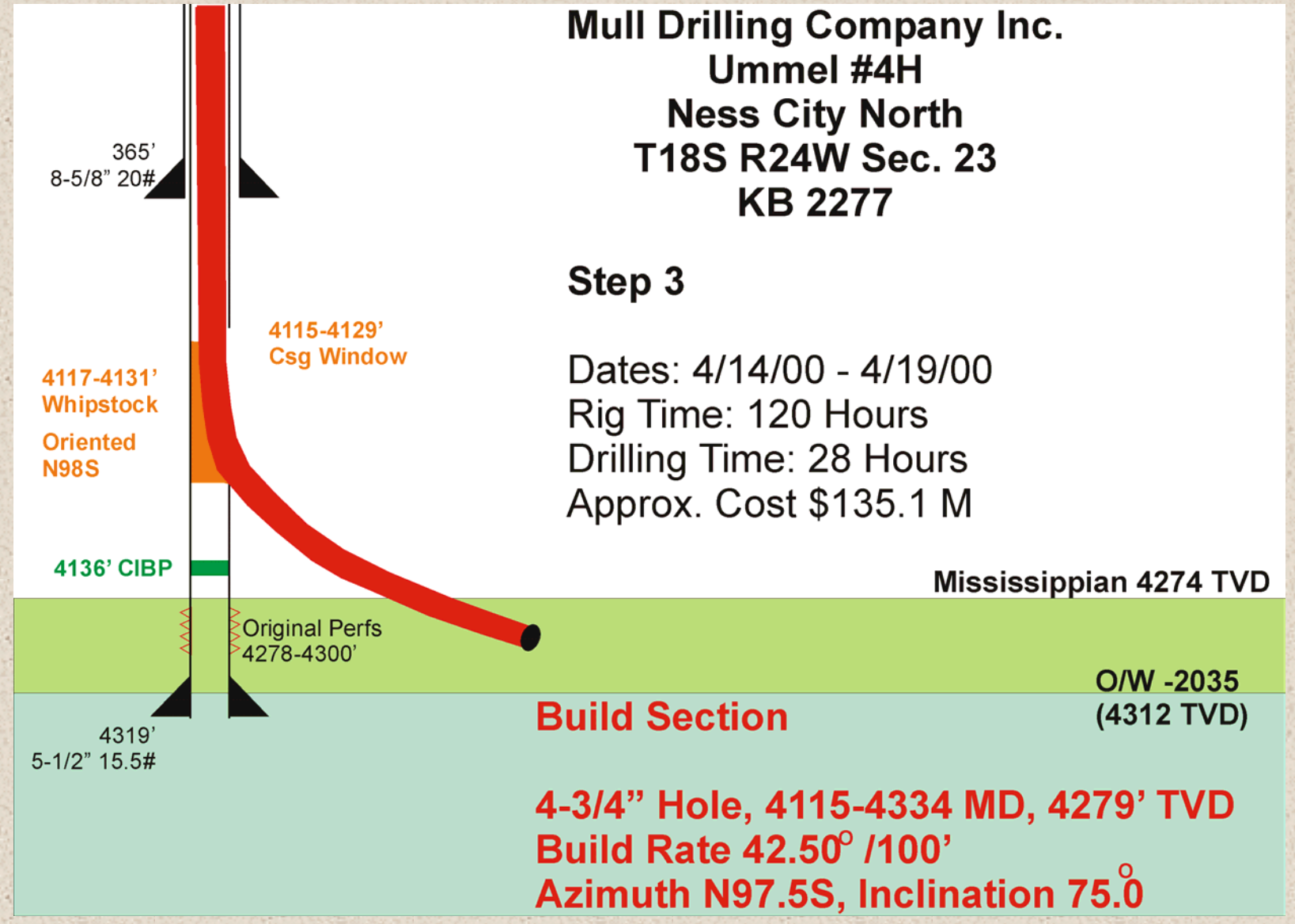
Setting CIBP below whipstock

Set Whipstock - Mill Casing

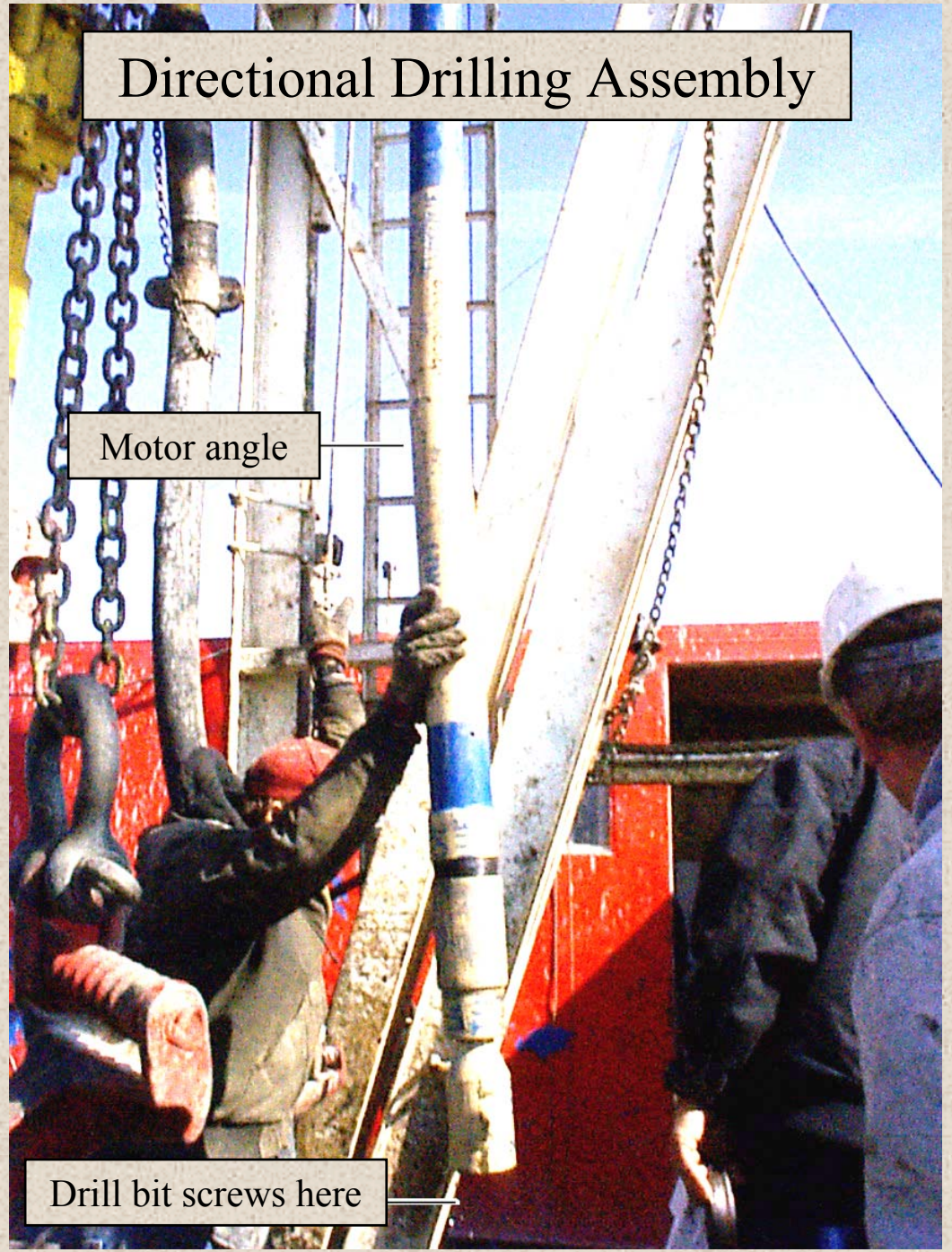



Running whipstock and starting mill
Starting mill
Shear bolt
Whipstock

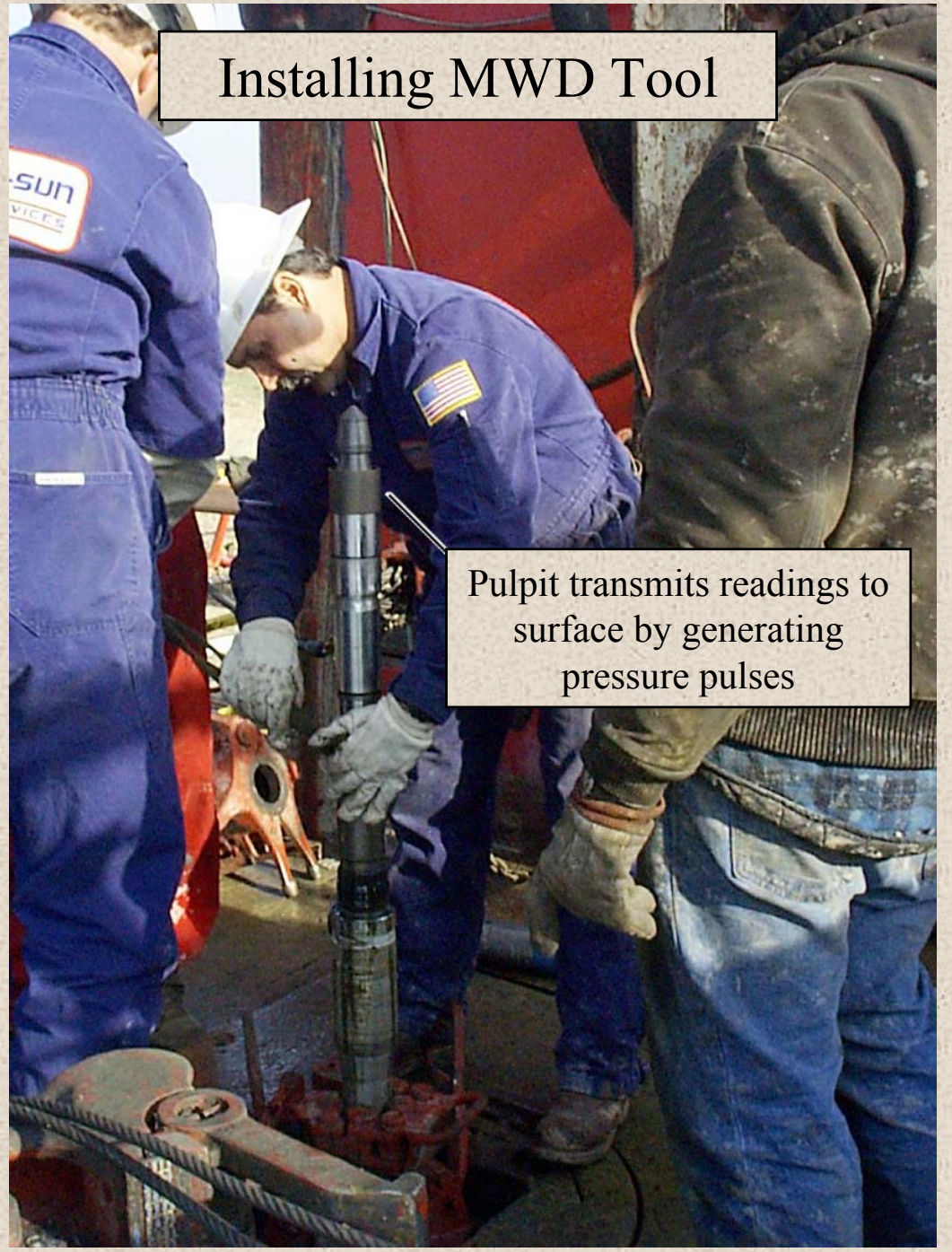
Drill Build Section



Directional Drilling Assembly

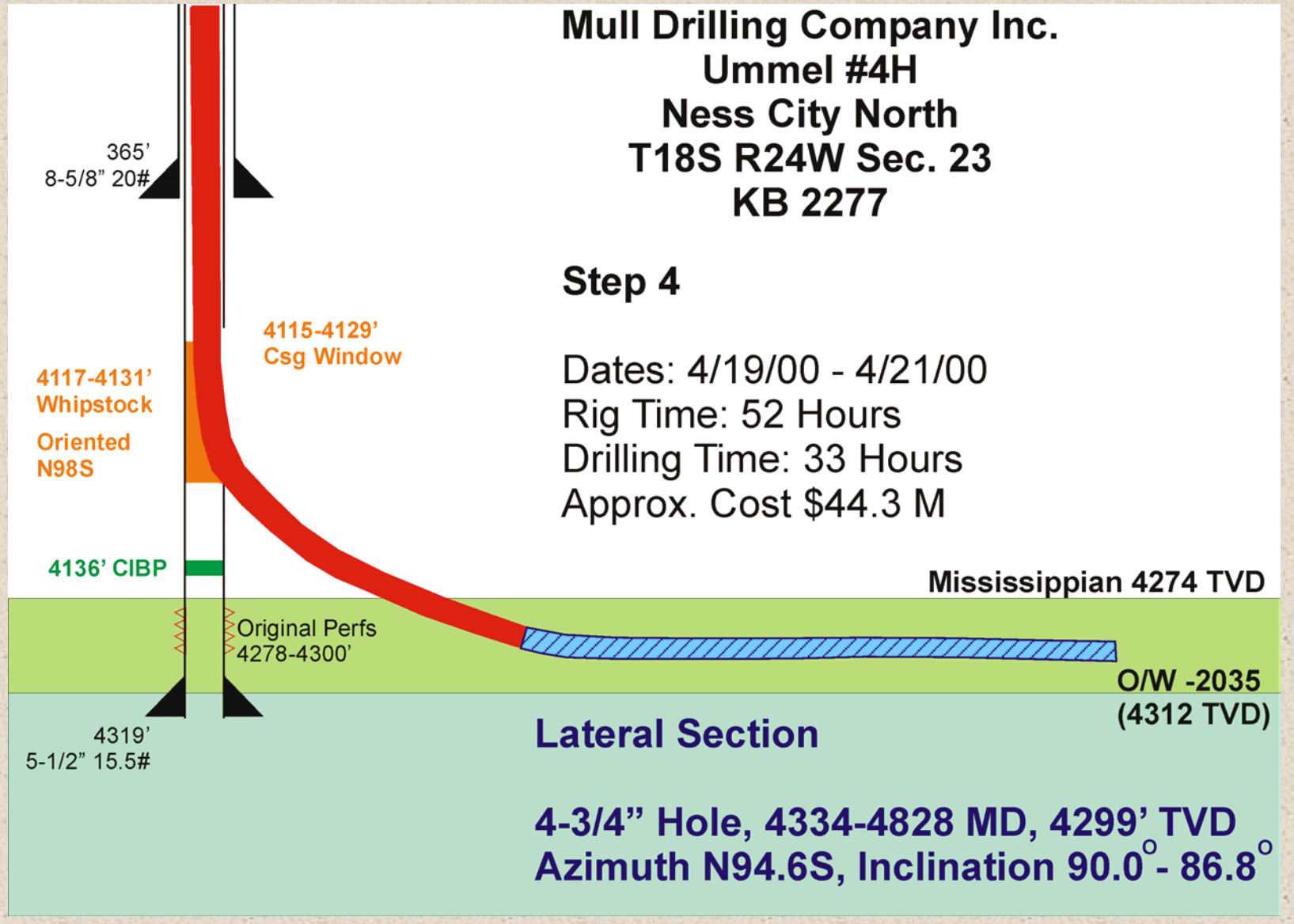


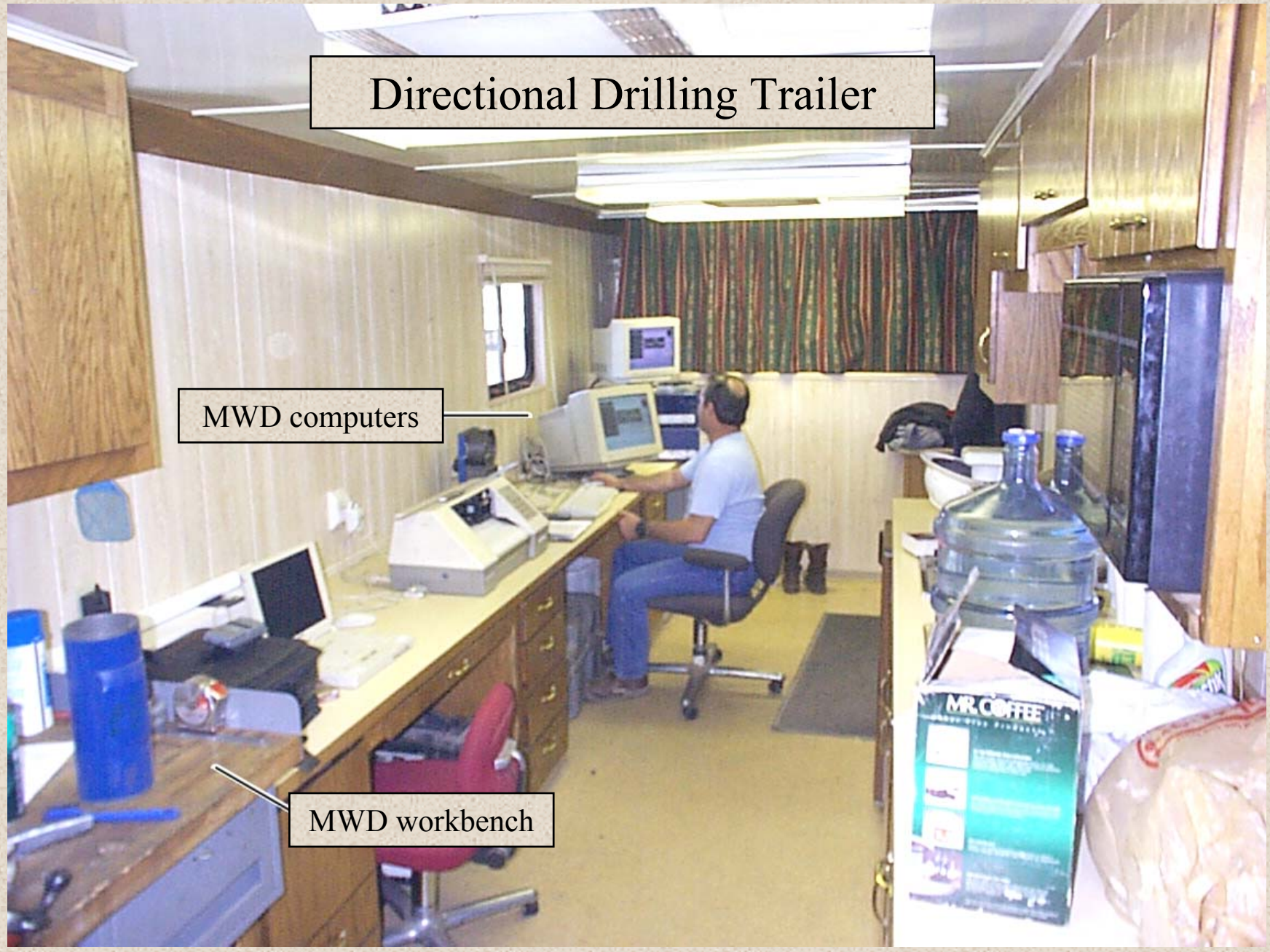
Installing MWD Tool



Pulpit transmits readings to surface by generating pressure pulses

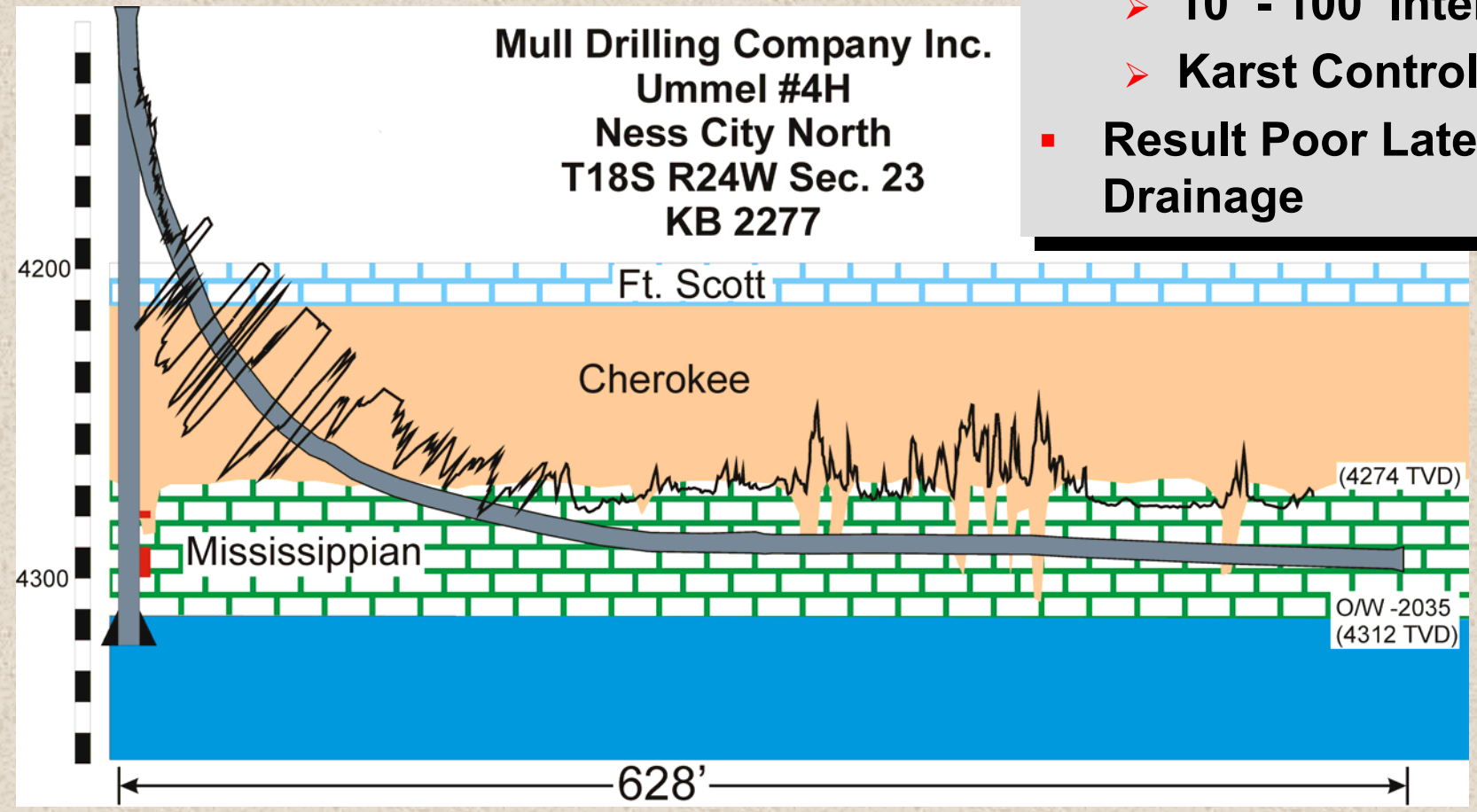
Drill Lateral Section



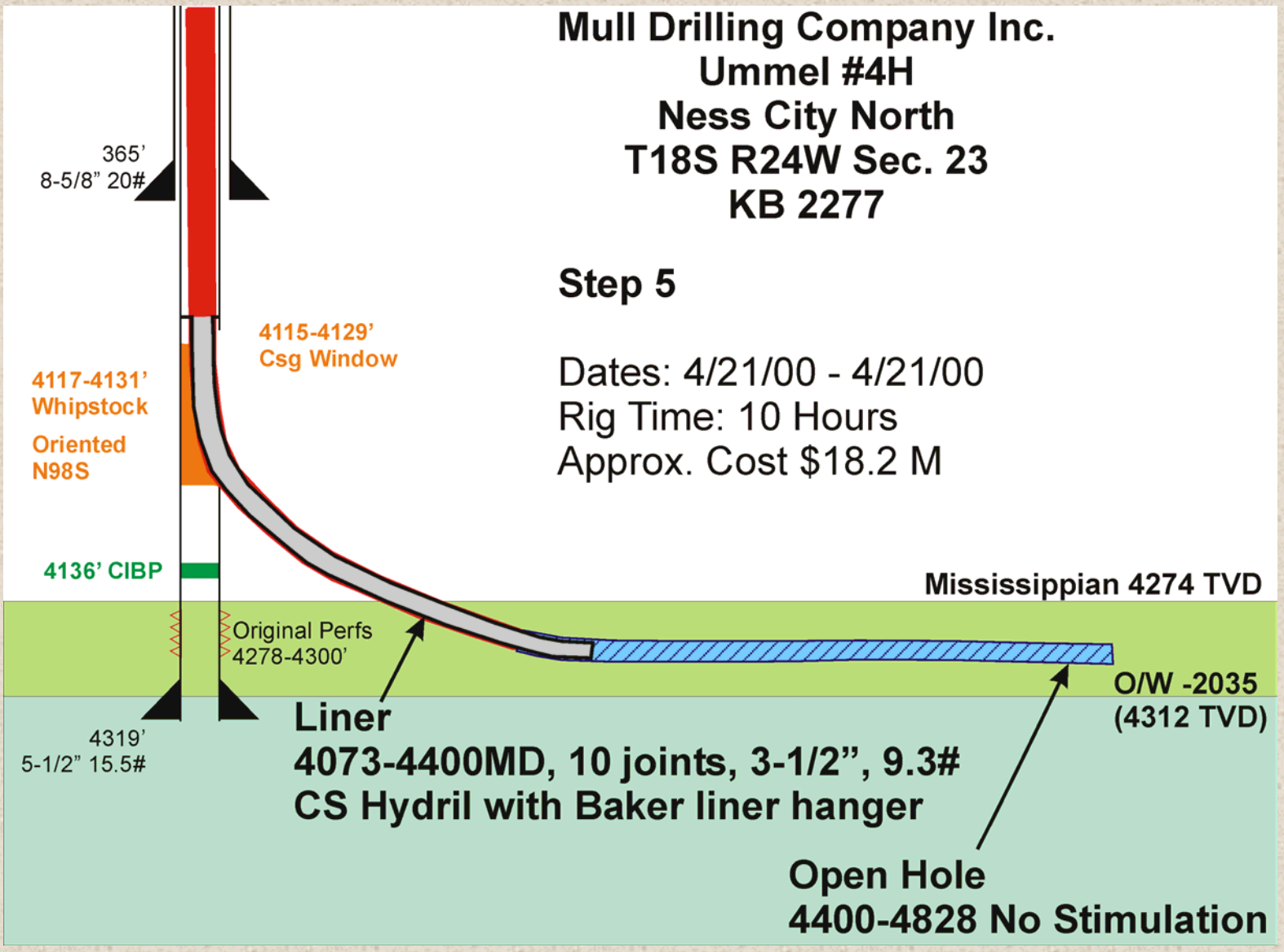

Directional Drilling Trailer
MWD computers
MWD workbench
MR. COFFEE

Reservoir Heterogeneity

- **Strong Horizontal Heterogeneity**
  - **10’ - 100’ Interval**
  - **Karst Controlled**
- **Result Poor Lateral Drainage**

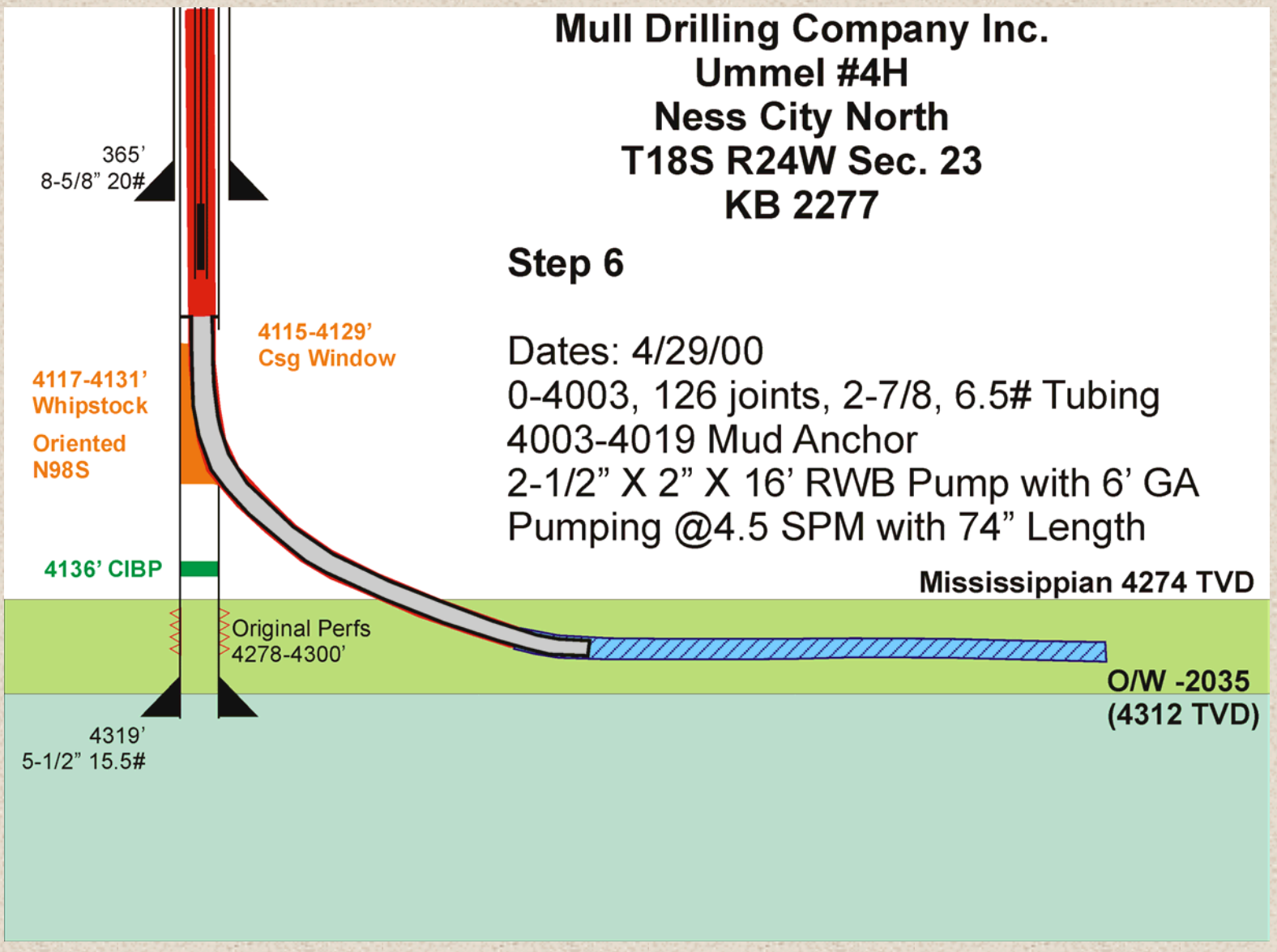


Set Liner

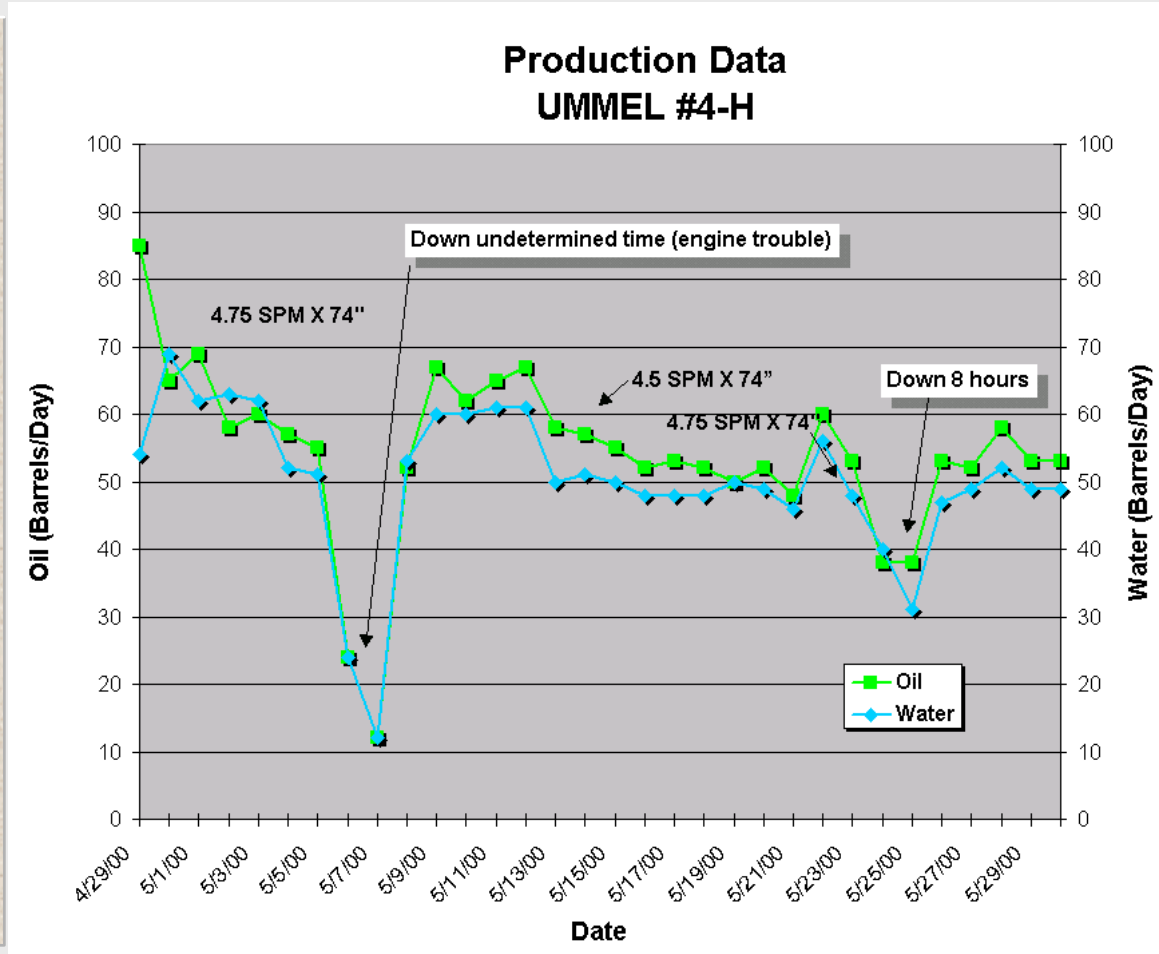

Mull Drilling Company Inc.
Ummel #4H
Ness City North
T18S R24W Sec. 23
KB 2277
Step 5
Dates: 4/21/00 - 4/21/00
Rig Time: 10 Hours
Approx. Cost $18.2 M
365'
8-5/8" 20#
4115-4129'
Csg Window
4117-4131'
Whipstock
Oriented
N98S
4136' CIBP
Mississippian 4274 TVD
Original Perfs
4278-4300'
O/W -2035
(4312 TVD)
4319'
5-1/2" 15.5#
Liner
4073-4400MD, 10 joints, 3-1/2", 9.3#
CS Hydril with Baker liner hanger
Open Hole
4400-4828 No Stimulation

Running 3-1/2” CS Hydril liner

Final Completion



Initial Production



IP: 85 BOPD & 54 BWPD (4/29/00)

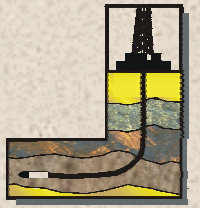
Daily Prod:

55 BO& 50 BW

for 2-1/2 months (May to mid-July)

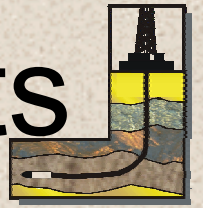
with 1000' of fluid over pump

Breakdown of Rig Time



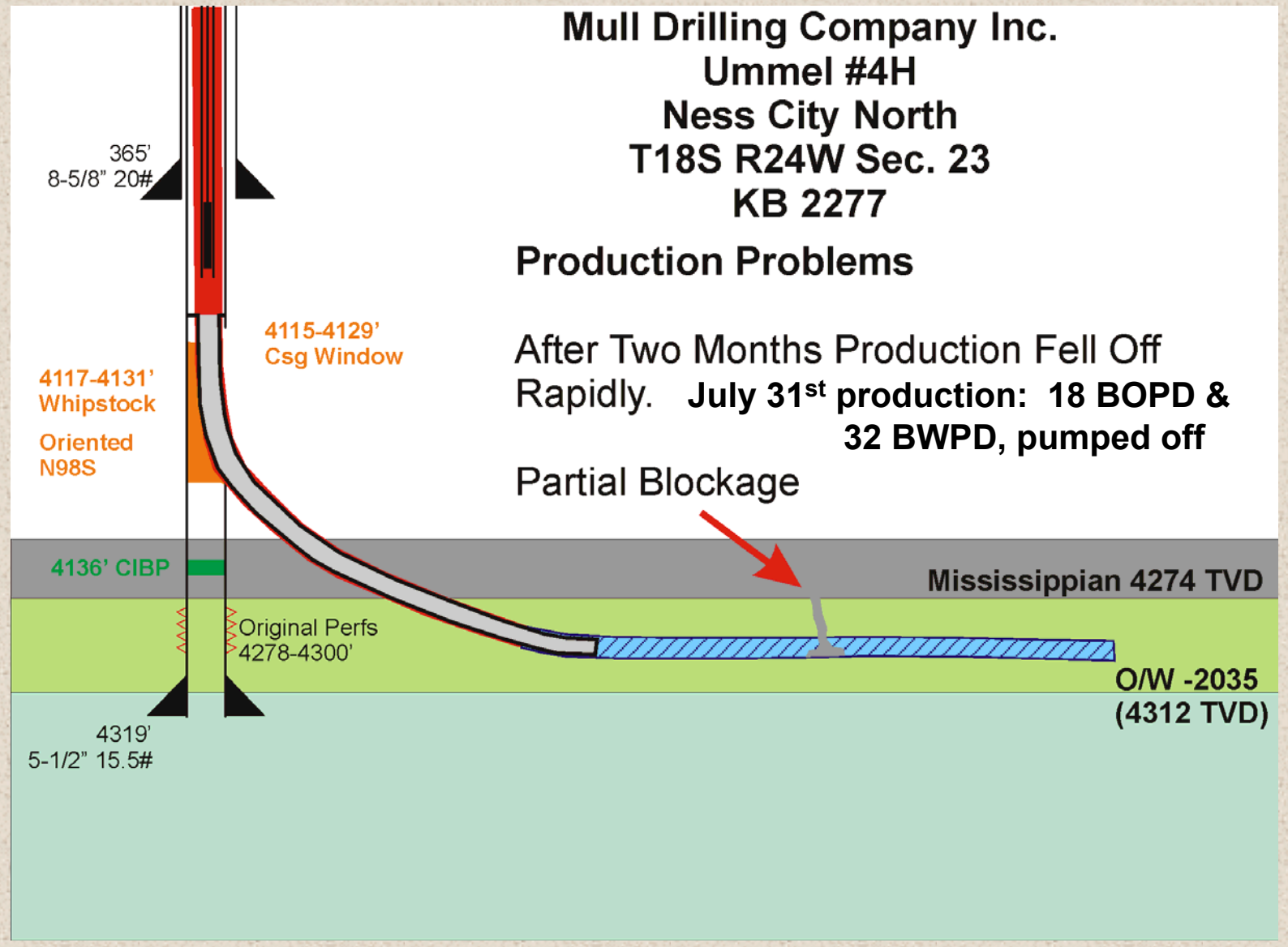
Work Performed	Approximate Rig Hours	% of Total
Drilling out cmt & setting CIBP	82.0	23.5
Setting whipstock & milling csg	84.5	24.2
Drilling build section	120.0	34.4
(actual drilling time)	*(27.8)*	*(8.0)*
Drilling lateral section	52.0	14.9
(actual drilling time)	*(32.8)*	*(9.4)*
Setting liner through the curve	10.0	2.9
Total	348.5	100

Drilling & Completion Costs

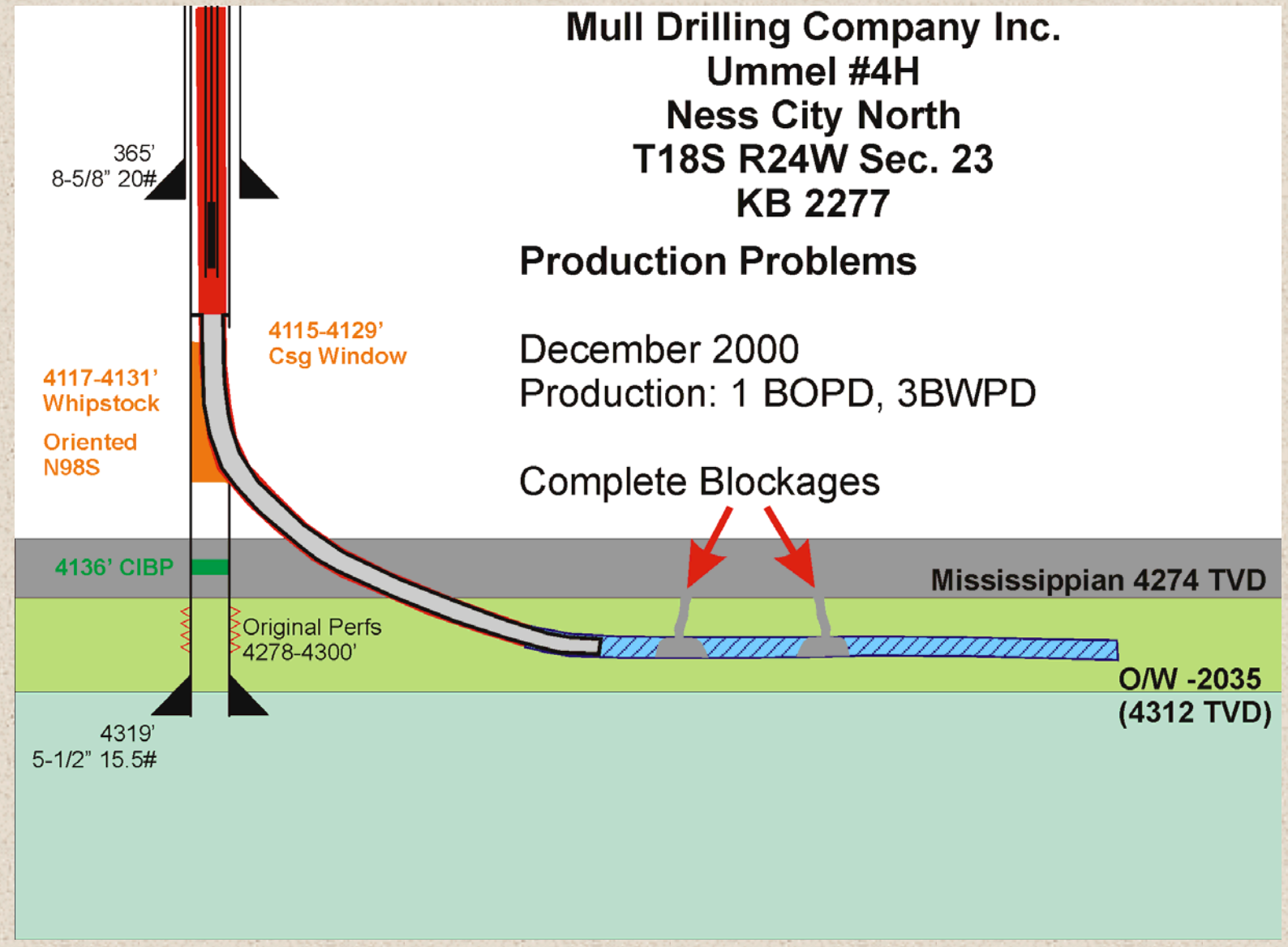


Intangible Drilling Costs	**$317,497**
Intangible Completion Costs	**$ 32,422**
Equipment	**$ 44,765**
Total	**$394,684**
DOE Reimbursement	**$116,776**
Net Cost to Mull Drilling Co.	**$277,908**

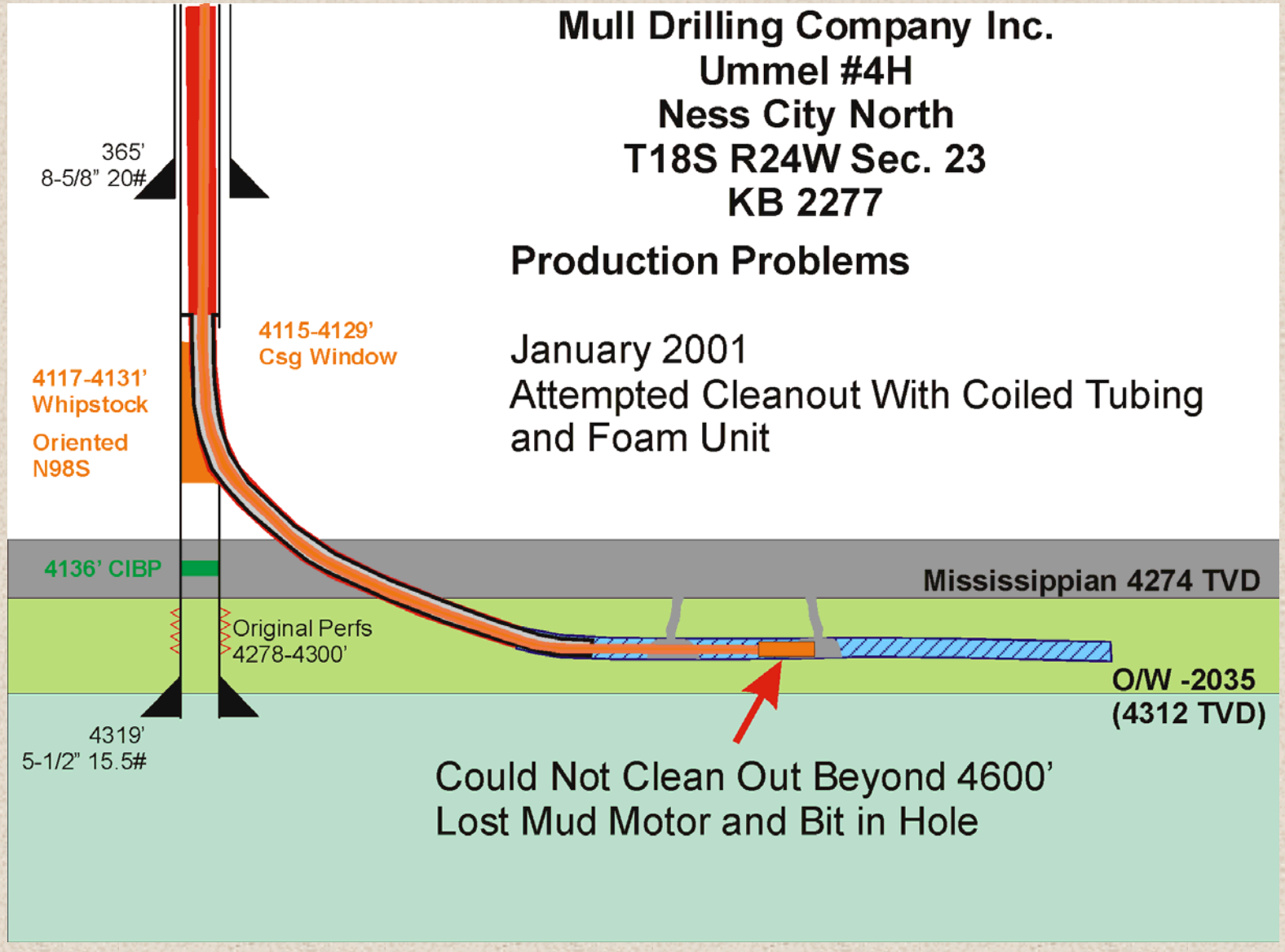
Initial Production Problems



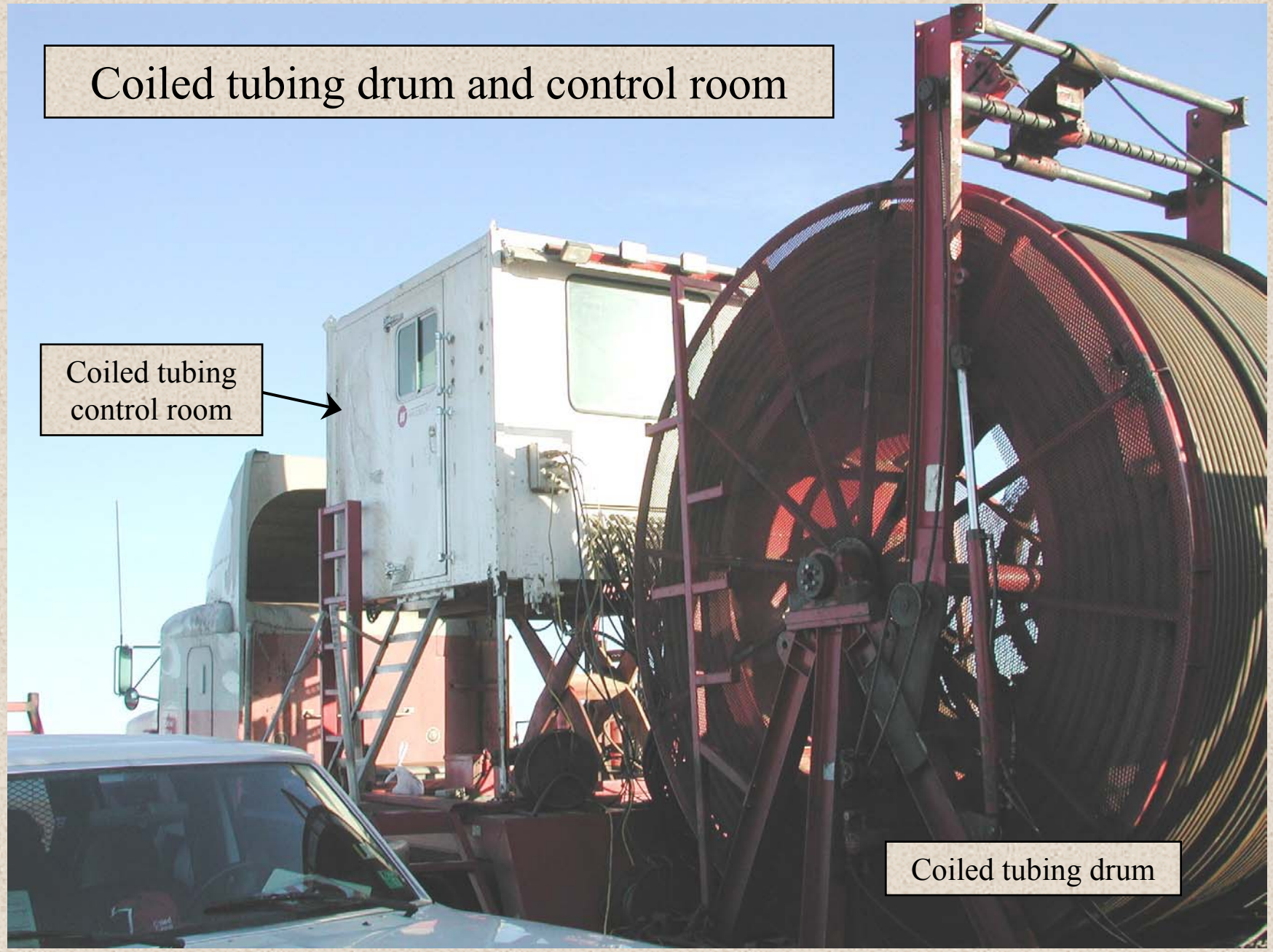
Complete Production Loss

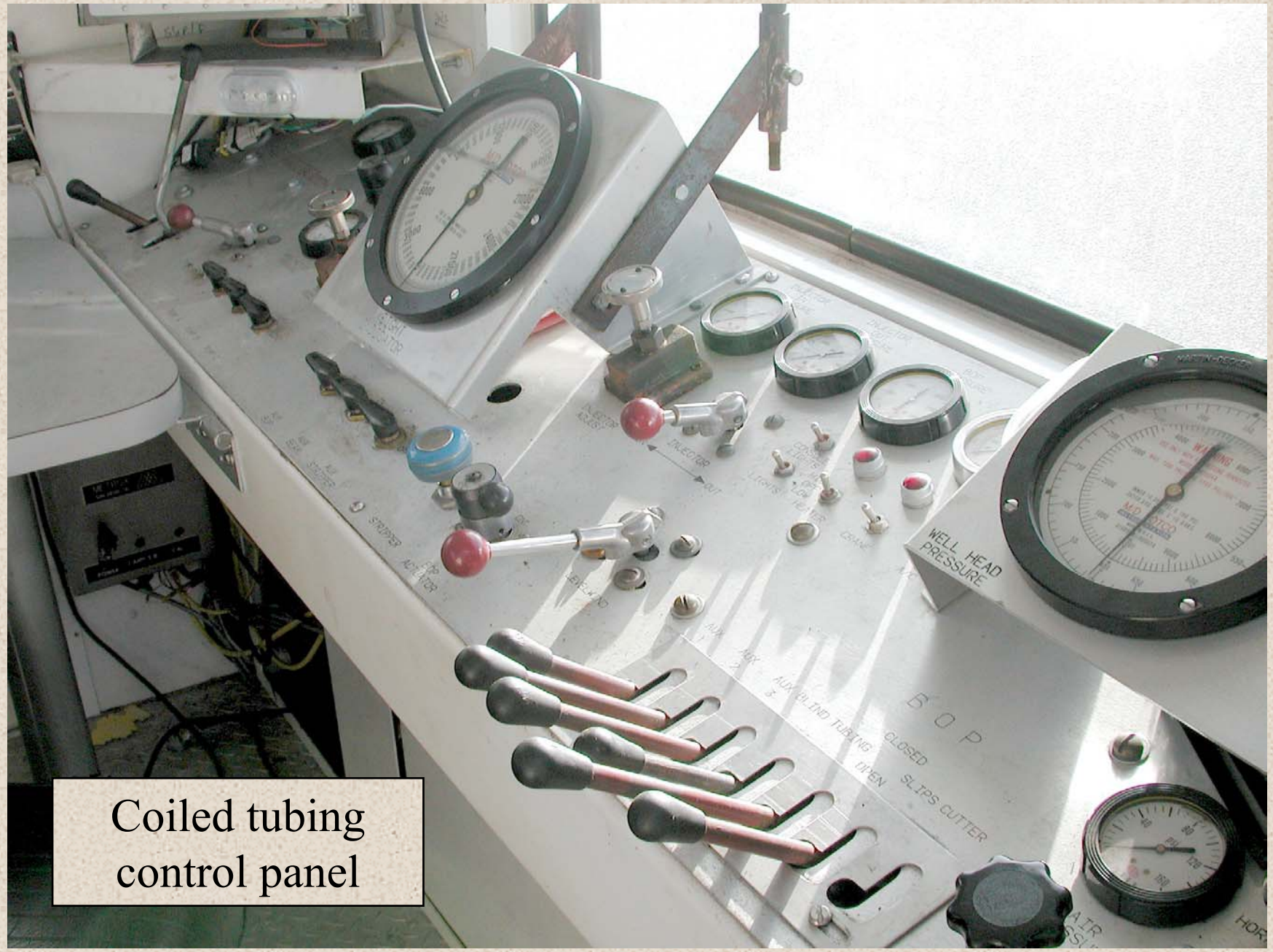


Workover Operations



Halliburton coiled tubing and nitrogen foam equipment

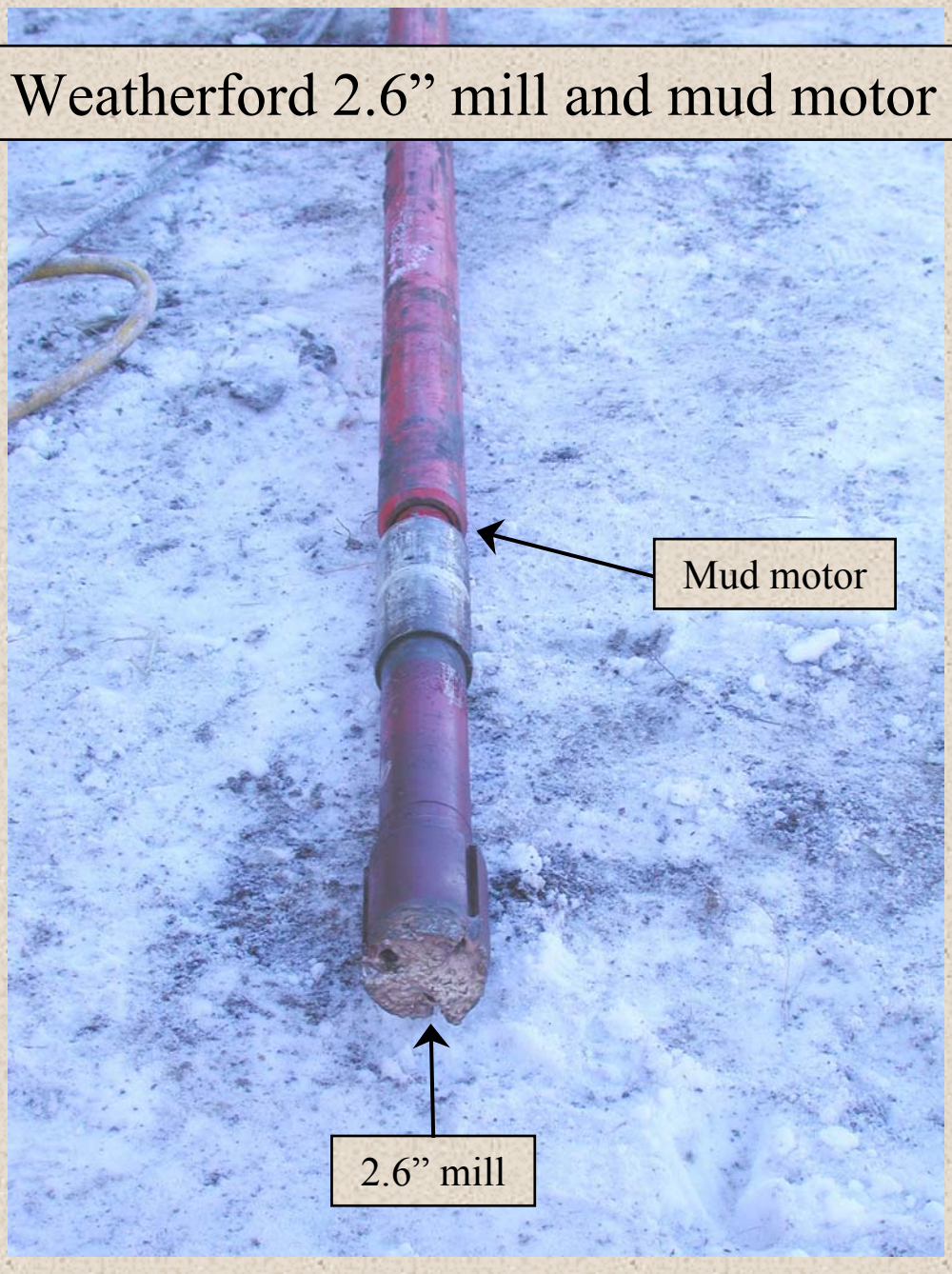

Coiled tubing drum and control room
Coiled tubing control room
Coiled tubing drum

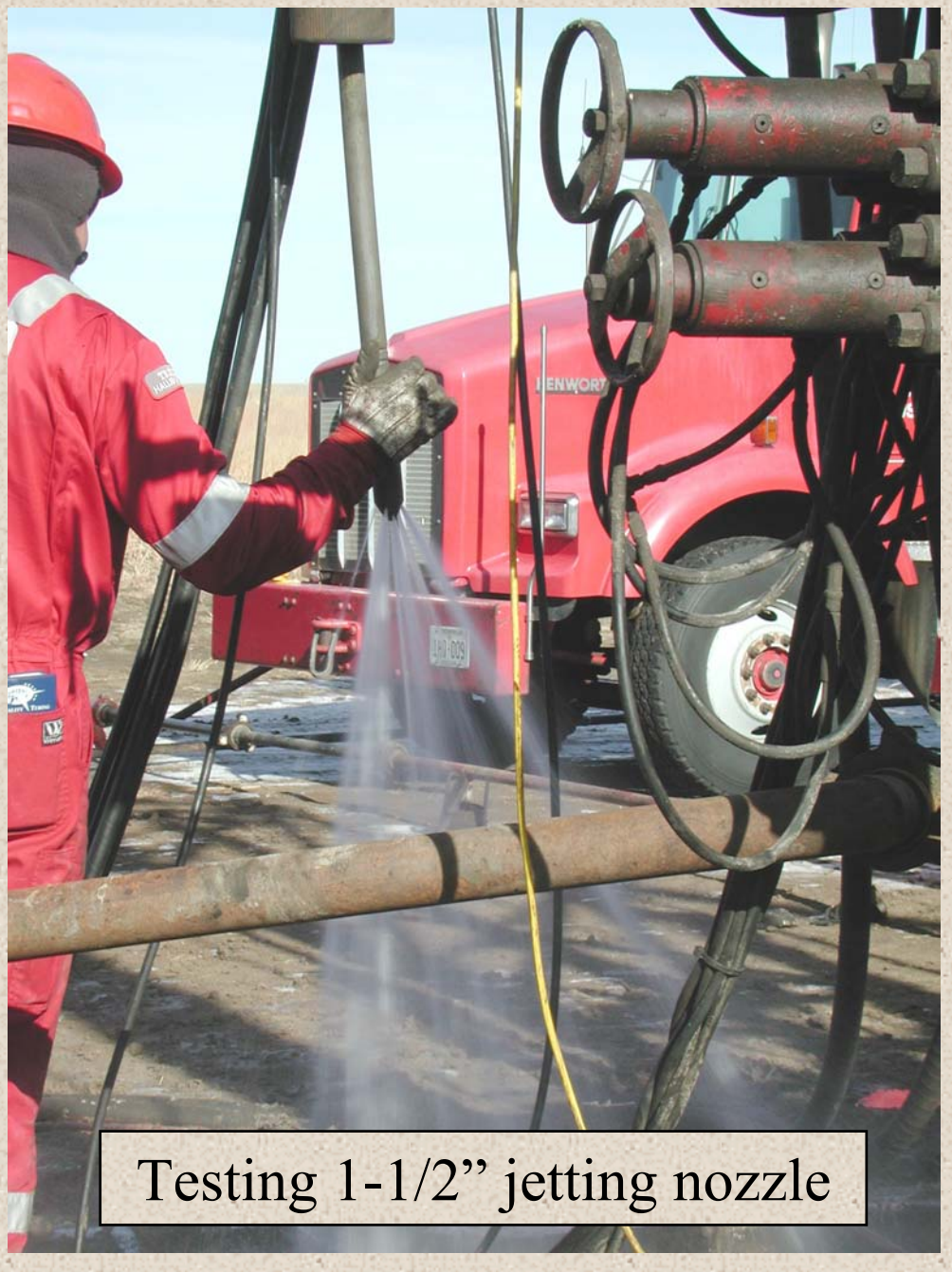


Coiled tubing control panel

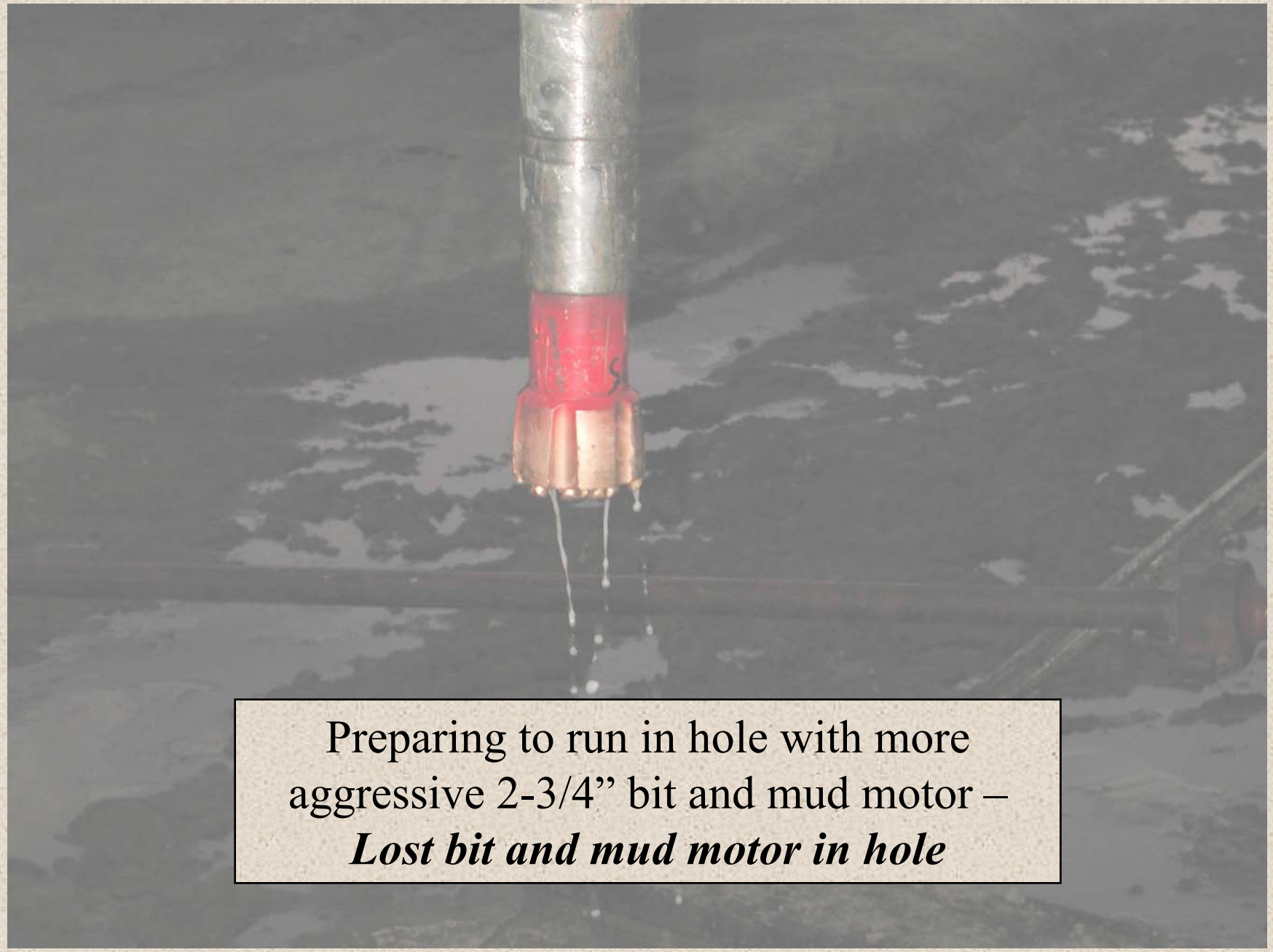
Halliburton nitrogen foam unit

Weatherford 2.6” mill and mud motor



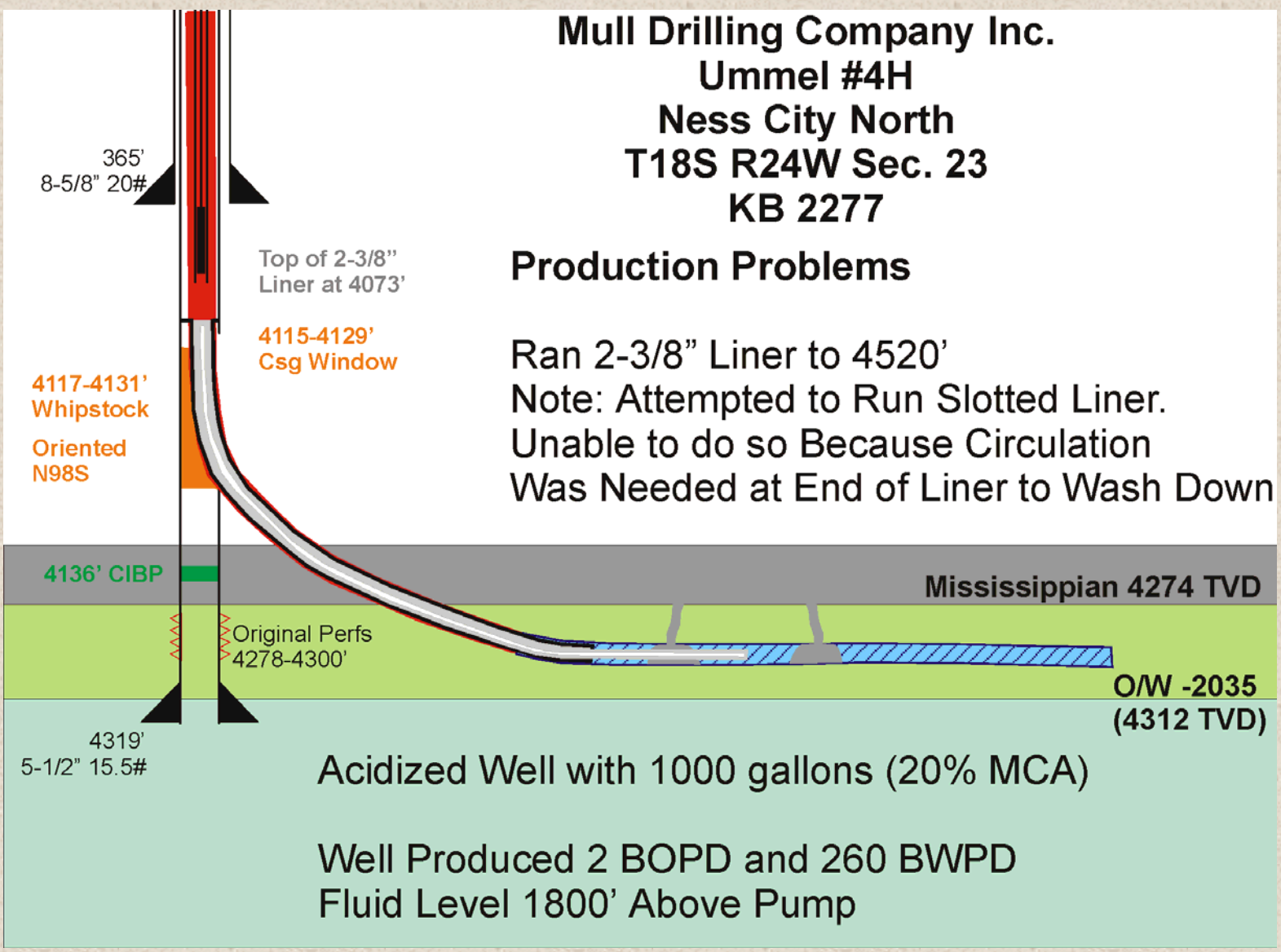


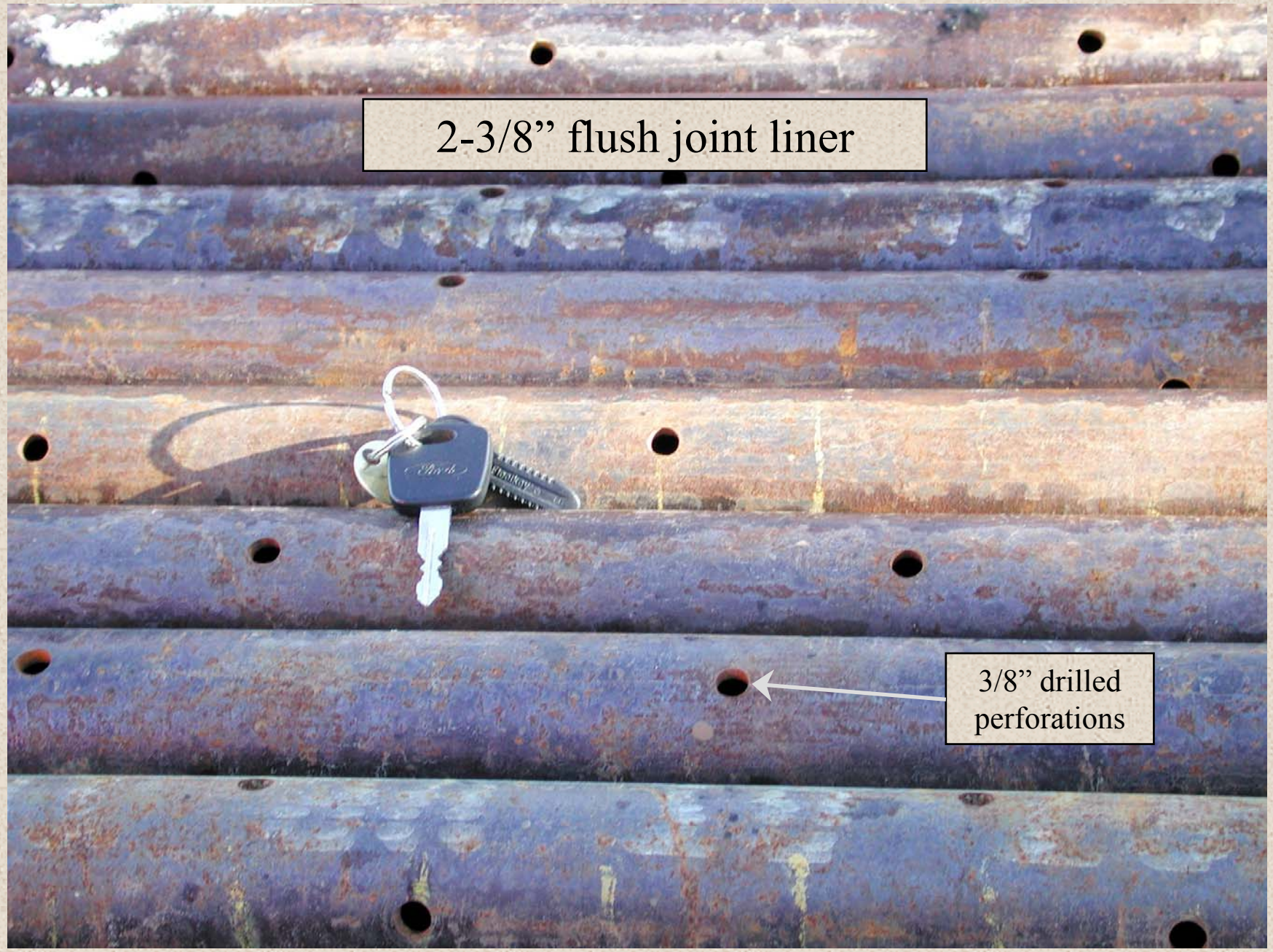
Testing 1-1/2” jetting nozzle



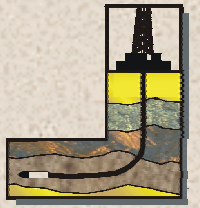
Preparing to run in hole with more aggressive 2-3/4” bit and mud motor – ***Lost bit and mud motor in hole***

Workover Operations



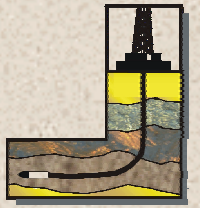

2-3/8” flush joint liner
3/8” drilled perforations

Lessons Learned for Horizontal Well



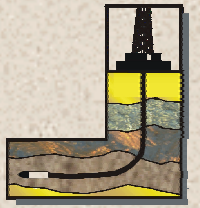
- **Operational Flexibility** **(Maintain Your Options)**
  - **New Well vs. Reentry**
  - **Hole Size**
  - **Drilling Fluids**
  - **Case off the Curve**
  - **Line the Lateral**
- **Good Planning**
- **Communication**
- **“The Lateral is a Piece of Cake”**
- **Horizontal Heterogeneity**

Applying What We Learned



- **Horizontal Well Supported Reservoir Characterization**
- **Mechanical Failure Made Horizontal Well Uneconomic**
- **Application of Reservoir Characterization Resulted in Extremely Successful Workover in the Field**

Pfannenstiel A #2-24 Workover



- **Well Originally Completed in LP1 Layer**
- **Added Perfs in LP2 Layer (structurally lower than original perfs)**
- **Increased Production –**

Before:	**2 BOPD**	**20 BWPD**	**(91% wtr)**
After:	**23 BOPD**	**125 BWPD**	**(84% wtr)**

Recompletion