Distinguished Lecturer Program

Primary funding is provided by

The SPE Foundation through member donations and a contribution from Offshore Europe

The Society is grateful to those companies that allow their professionals to serve as lecturers

Additional support provided by AIME

Distinguished Lecturer Program

SPE International

Recent Advances in Horizontal Well Water Shut-Off and Production Improvement

Keng Seng Chan
Petronas

Society of Petroleum Engineers
Distinguished Lecturer Program
www.spe.org/dl

PETRONAS

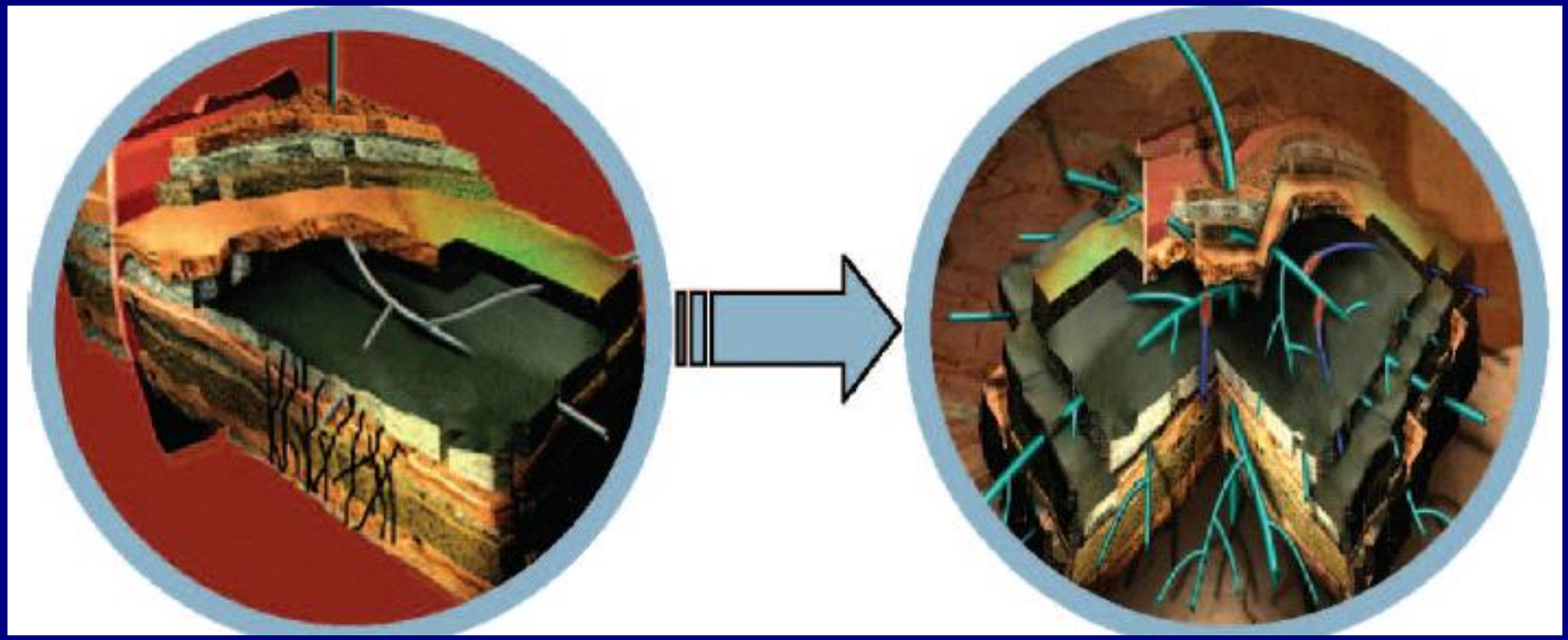
Outline

- Improved Oil Recovery
- Simple Solution and Successful Case Histories
- Integrated Solution for Well Production Enhancement
- Use of Inflow Control Devices to enhance well performance
- Balancing Water Movement in Reservoir
- Conclusions and Recommendation

Improved Oil Production Strategy

- Maximize Reservoir Contact (MRC)
  - Horizontal Wells with or without Hydraulic Fractures
  - Multi-Laterals
- Improve Reservoir Oil Flow
  - Reduce Oil Viscosity (Steam, CO_2)
  - Reduce Interfacial Tension (Surfactant)
- Optimize Sweep and Conformance
  - Delay Water Breakthrough
  - Shut Off High Permeability Channels
  - Shut Off Excessive Water
  - Stimulate and Perforate for Enhancing Oil Inflow

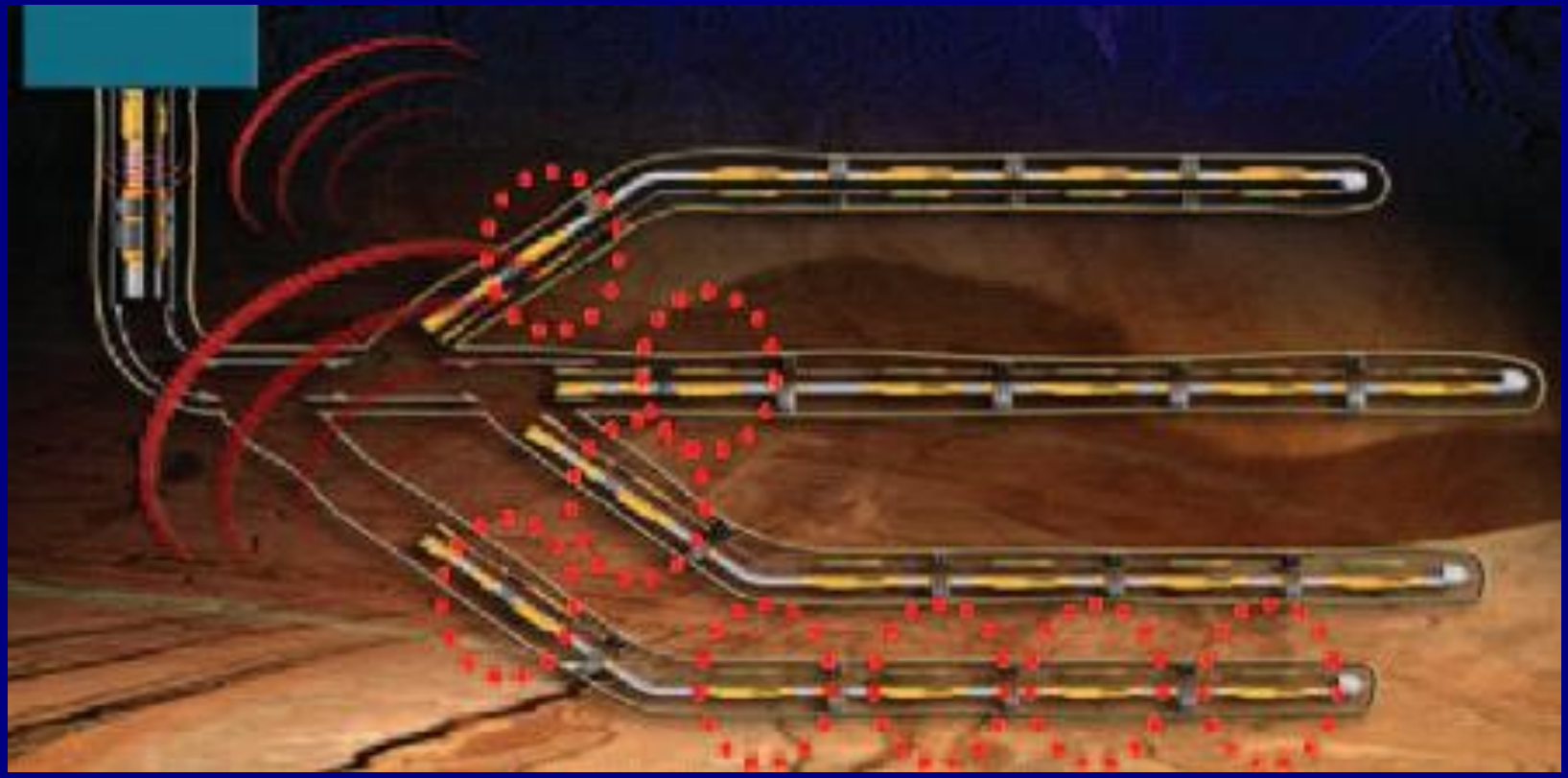
The Trend of Oil and Gas Production*



Maximum Reservoir Contact **Extreme Reservoir Contact**

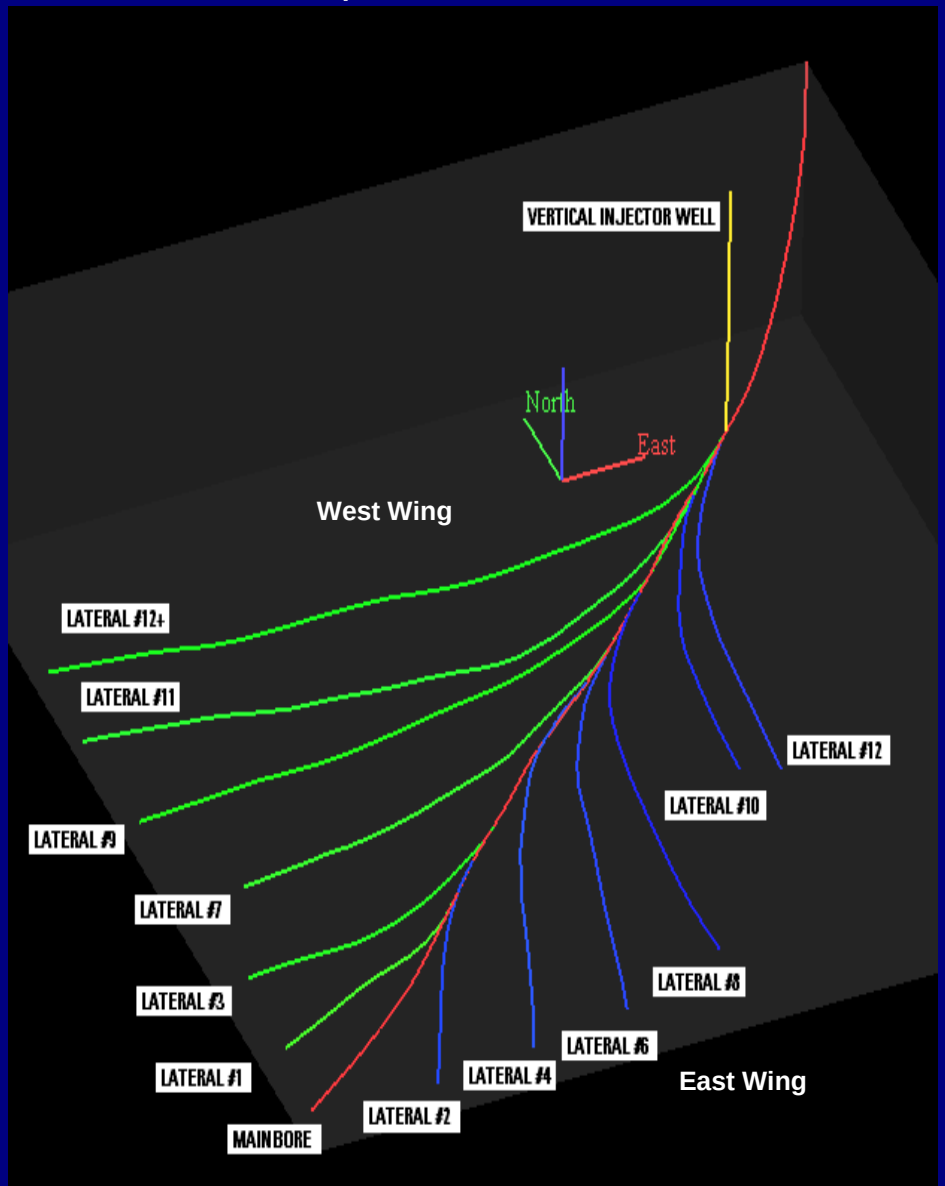
* Saggaf, M.M., “A Vision for Future Upstream Technologies”, JPT, March 2008

The Enormous Need for Isolation and Control



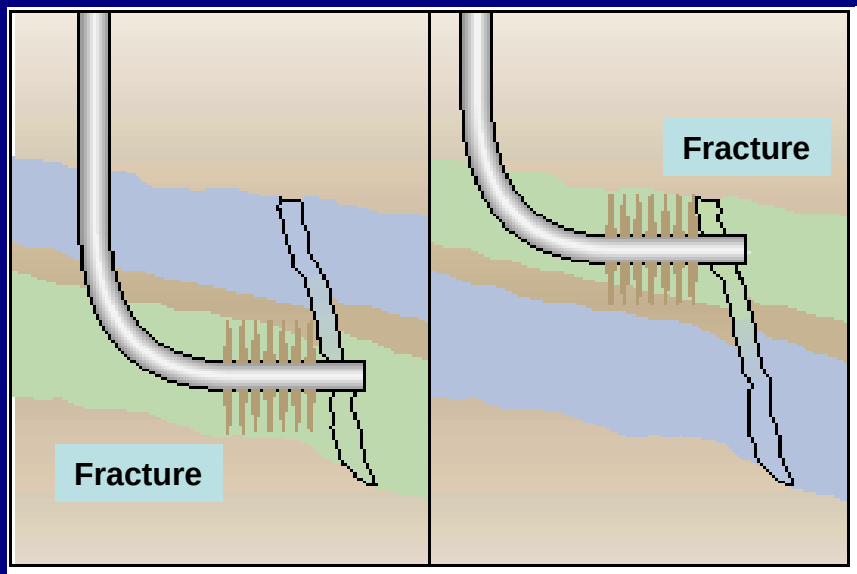
Unlimited Number of Smart Laterals
Unlimited Number of Valves per Lateral

The Art of Multi-Laterals
(Example of Maximizing Reserve Contact)

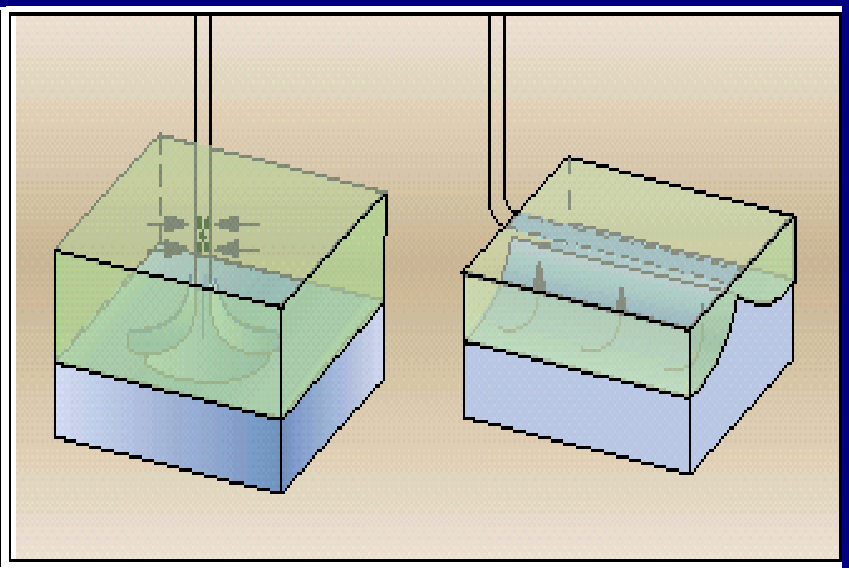


- Productivity = 49 conventional and hydraulically fractured wells
- What if water enters your laterals?

Where the water enters your wellbore?



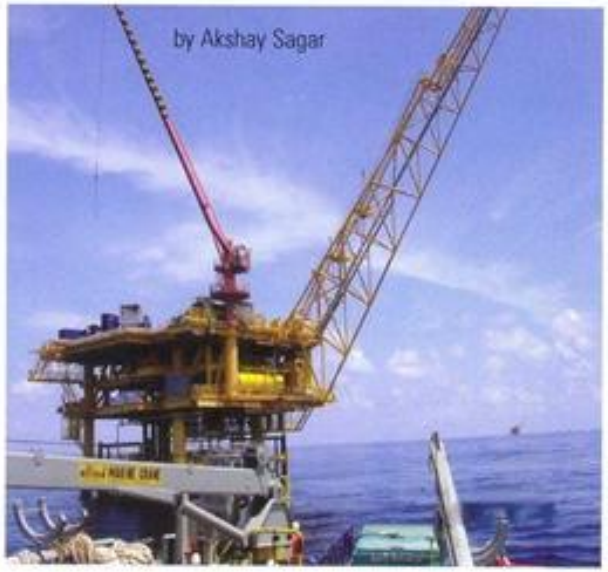
Fractures or Faults in a layer of water



Coning

- Where the water comes from ?
- How the water flows into your wells?
- Where the water enters your wellbore?

BRUNEI Bringing a Well Back to Life



by Akshay Sagar

A GROUND-BREAKING JOB enabled Total in Brunei to restore production on a dead well to 3,000 barrels of oil per day of natural production with only 1% water cut. The operation was completed safely via 10 tractor runs in a horizontal well without any downhole tool failures.

Two inflatable bridge plugs, the first ever to be set using MaxTRAC*, isolated a water producing zone, which was then successfully perforated. This intervention clearly demonstrated the value our combined technologies can bring to our clients. The new technologies deployed on this campaign were MaxTRAC, Wireline Perforation Shooting Tool (WPST*), Addressable Switch* and Secure Perforation*.

The success of the job was due to the professionalism of the Labuan team and the excellent job preparation. The detailed hazard analysis and job procedures demonstrated that we had good contingency plans in place to manage the risks, which gave the client confidence to proceed with the operation. The exceptional effort by the team to put together a specific maintenance container allowed the complete re-building of the tools in between the runs.

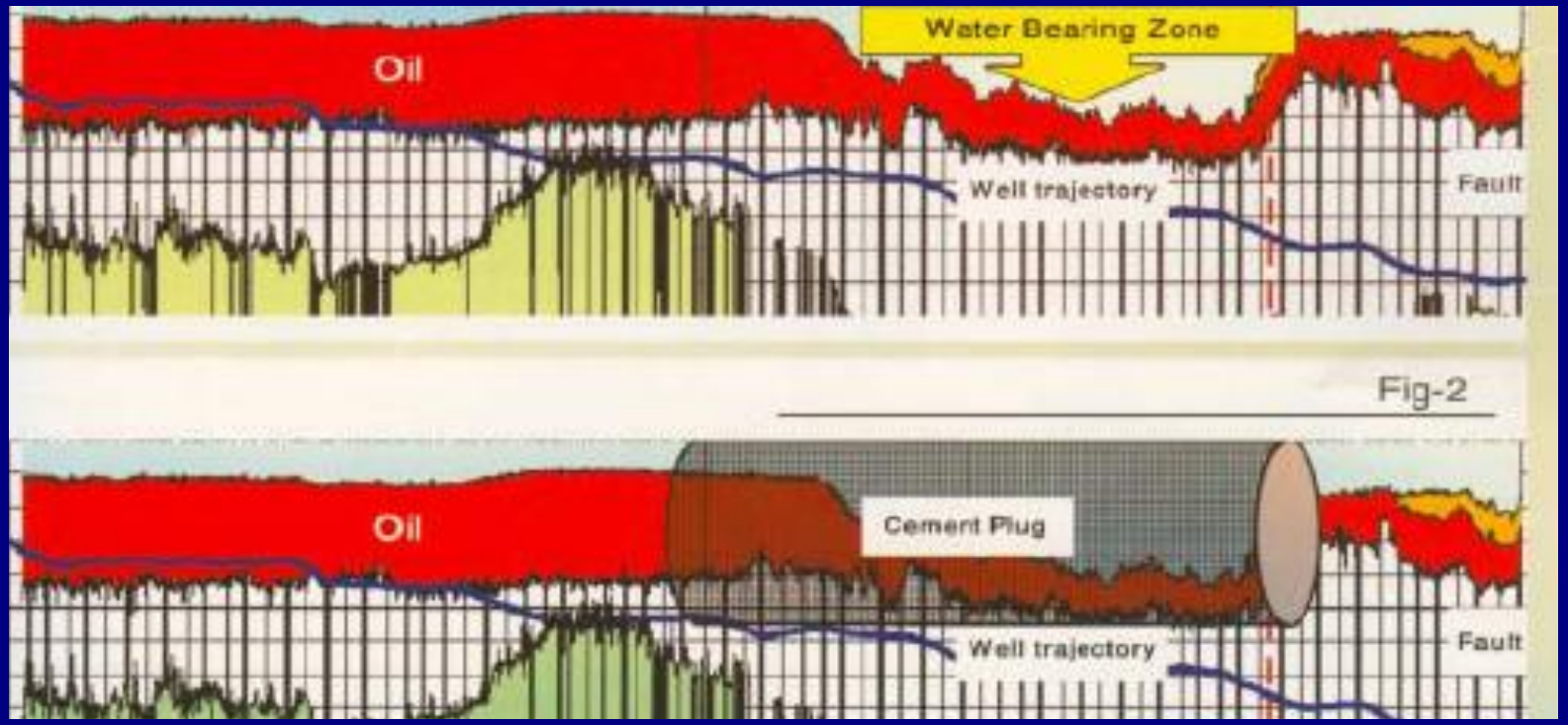
Thanks to all who contributed to this success, including: Scott MacPhee, Ling Kea Hing, Sani Aliamat, Shanmugham Sambatham, Arsad Ladolo, Raja Sundaram, Mohd Yusaran Johary, Zalani Hj Taha, Faizal bin Hj Ismail, Greg Moore, Jong Vui Chin, and Juan Tai Eng.

Horizontal Well
100% to 1% Water-Cut
3,000 BOPD Gain

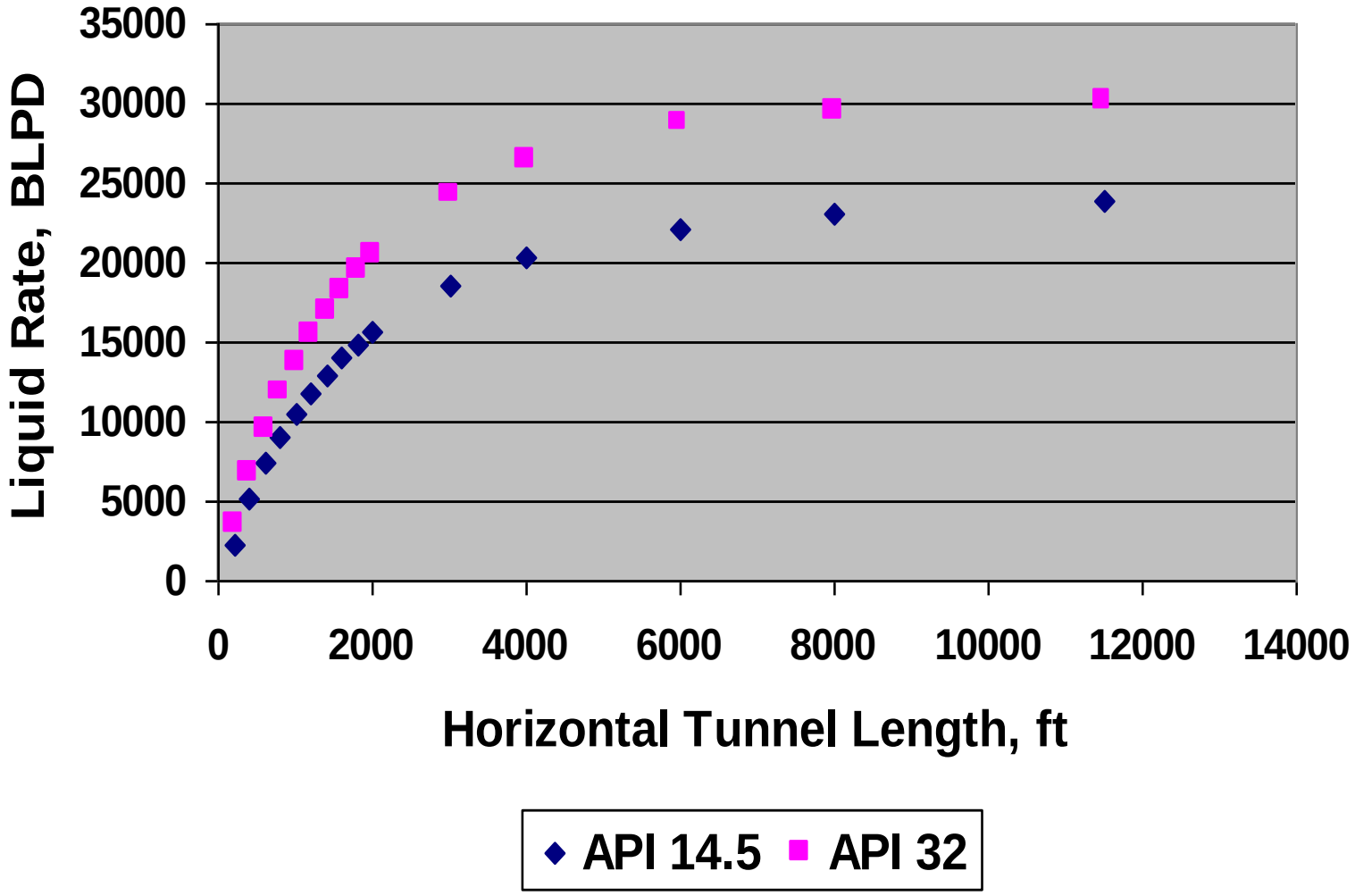
Simple Solution
(If water entering from toe)

- Coiled Tubing with Cement or Gel

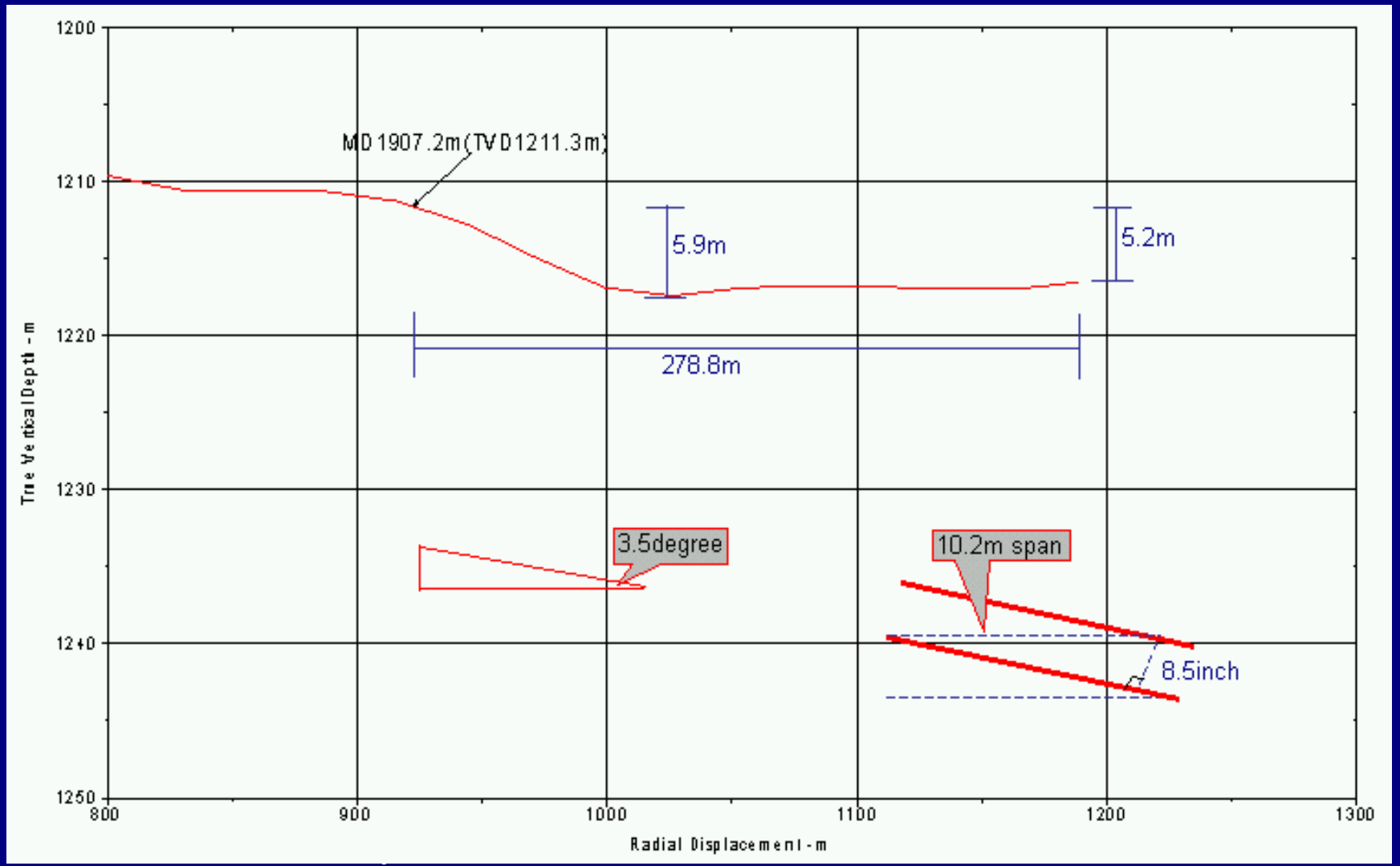
Horizontal Well
100% to 2% Water-Cut
2,500 BOPD Gain



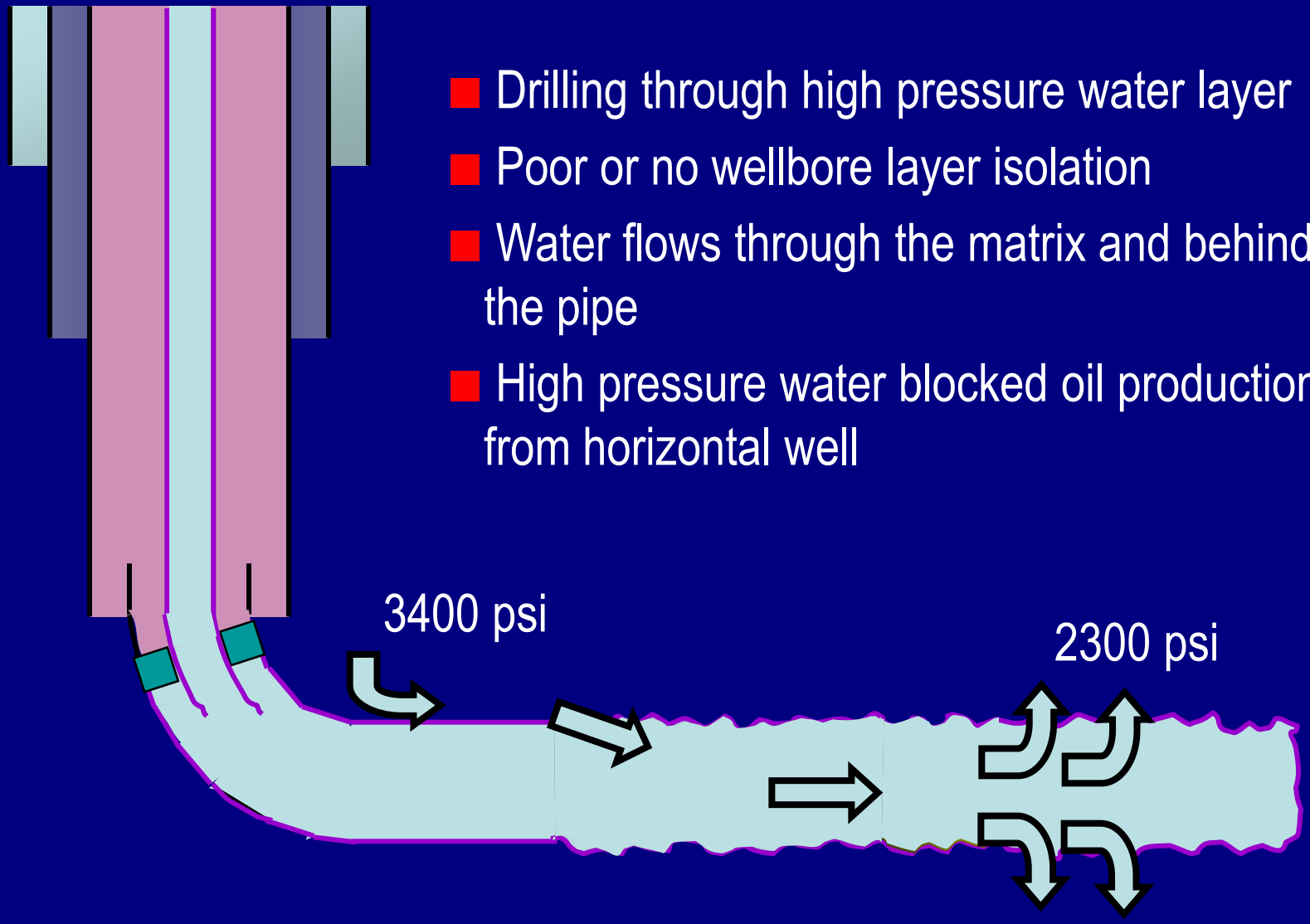
Effect of Tunnel Length



Fluid Slumping and Spreading in Horizontal Tunnel

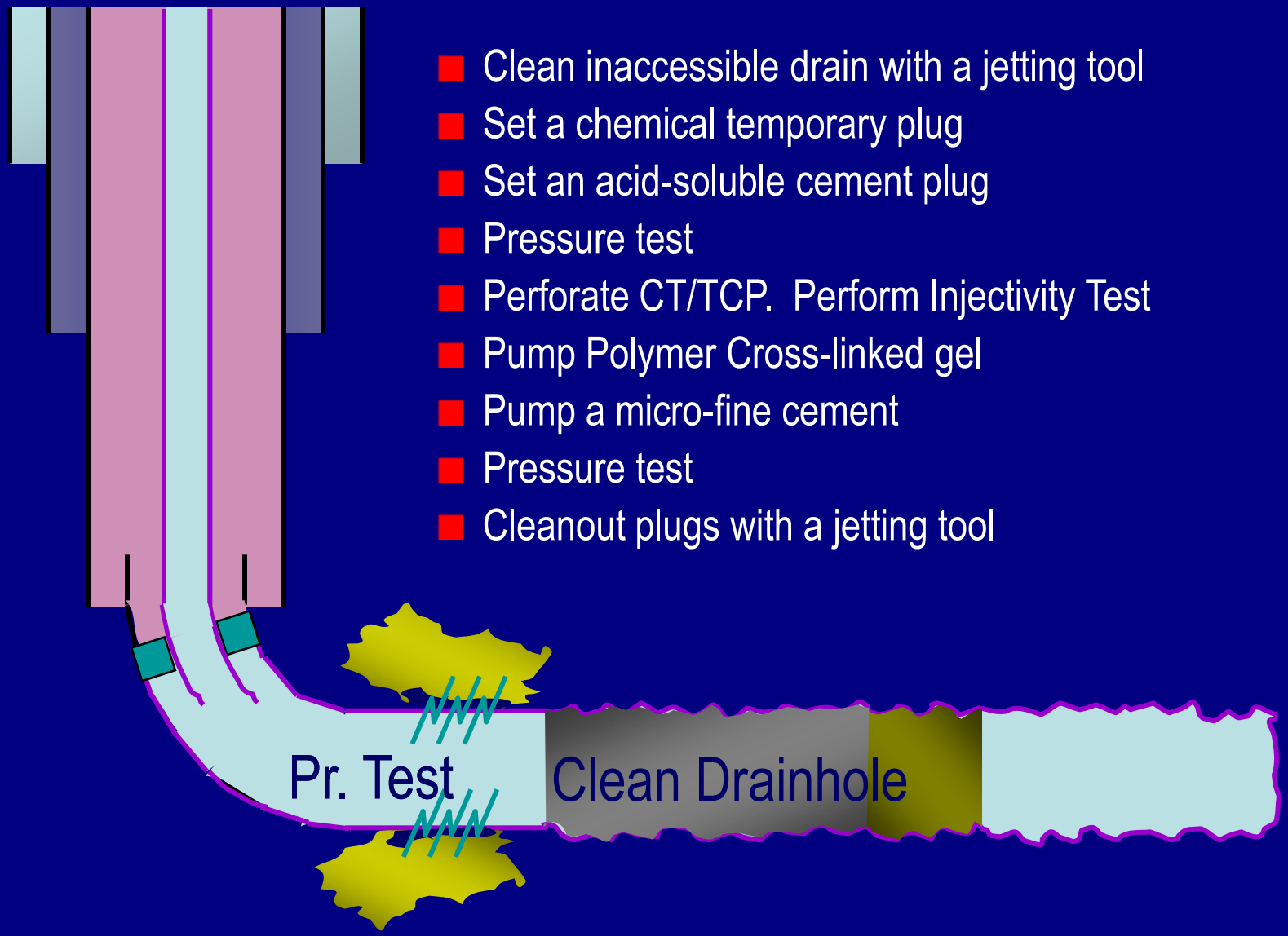


Case Example – Horizontal Well Drilling



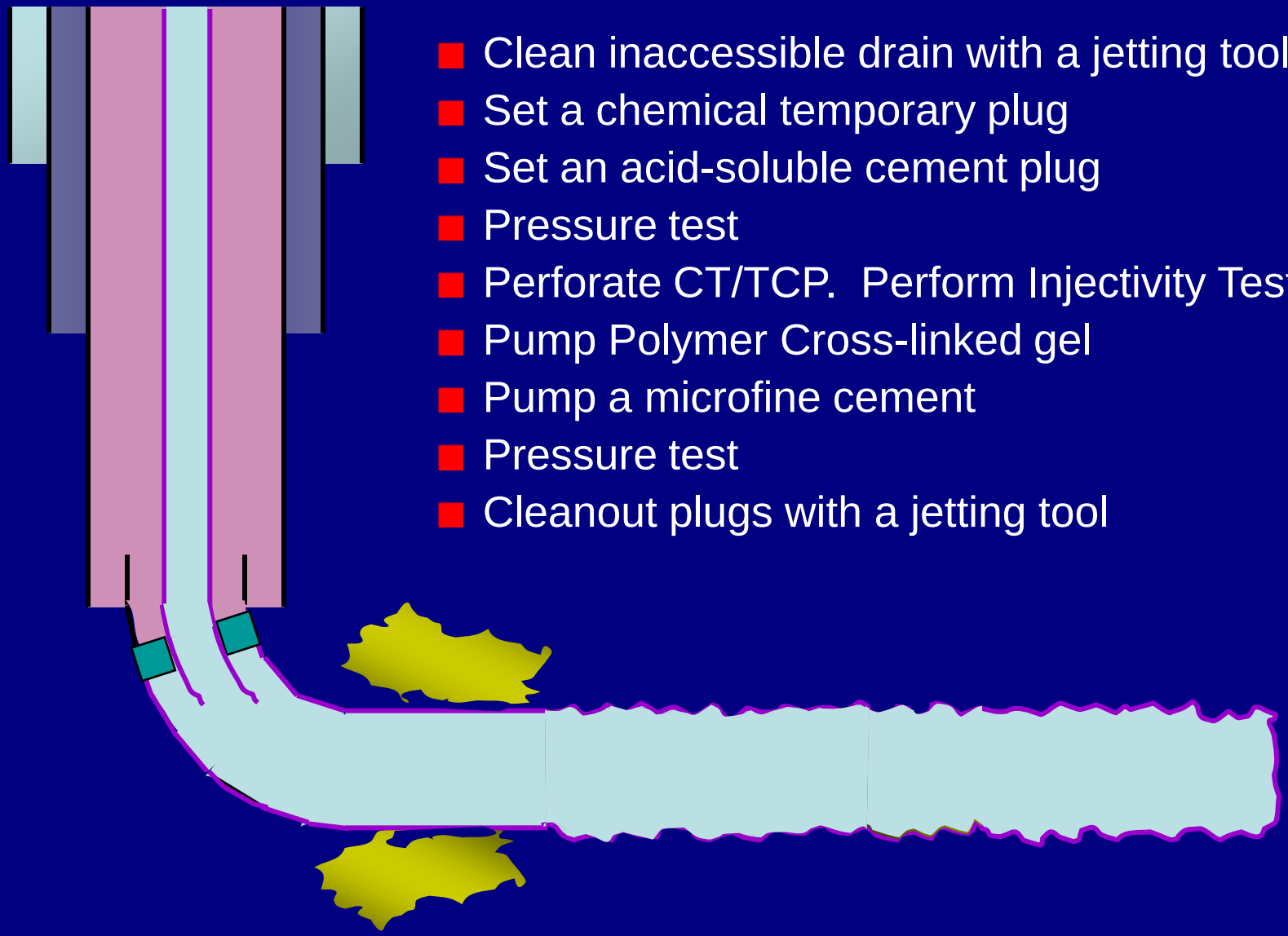
- Drilling through high pressure water layer
- Poor or no wellbore layer isolation
- Water flows through the matrix and behind the pipe
- High pressure water blocked oil production from horizontal well

Treatment Procedure



- Clean inaccessible drain with a jetting tool
- Set a chemical temporary plug
- Set an acid-soluble cement plug
- Pressure test
- Perforate CT/TCP. Perform Injectivity Test
- Pump Polymer Cross-linked gel
- Pump a micro-fine cement
- Pressure test
- Cleanout plugs with a jetting tool

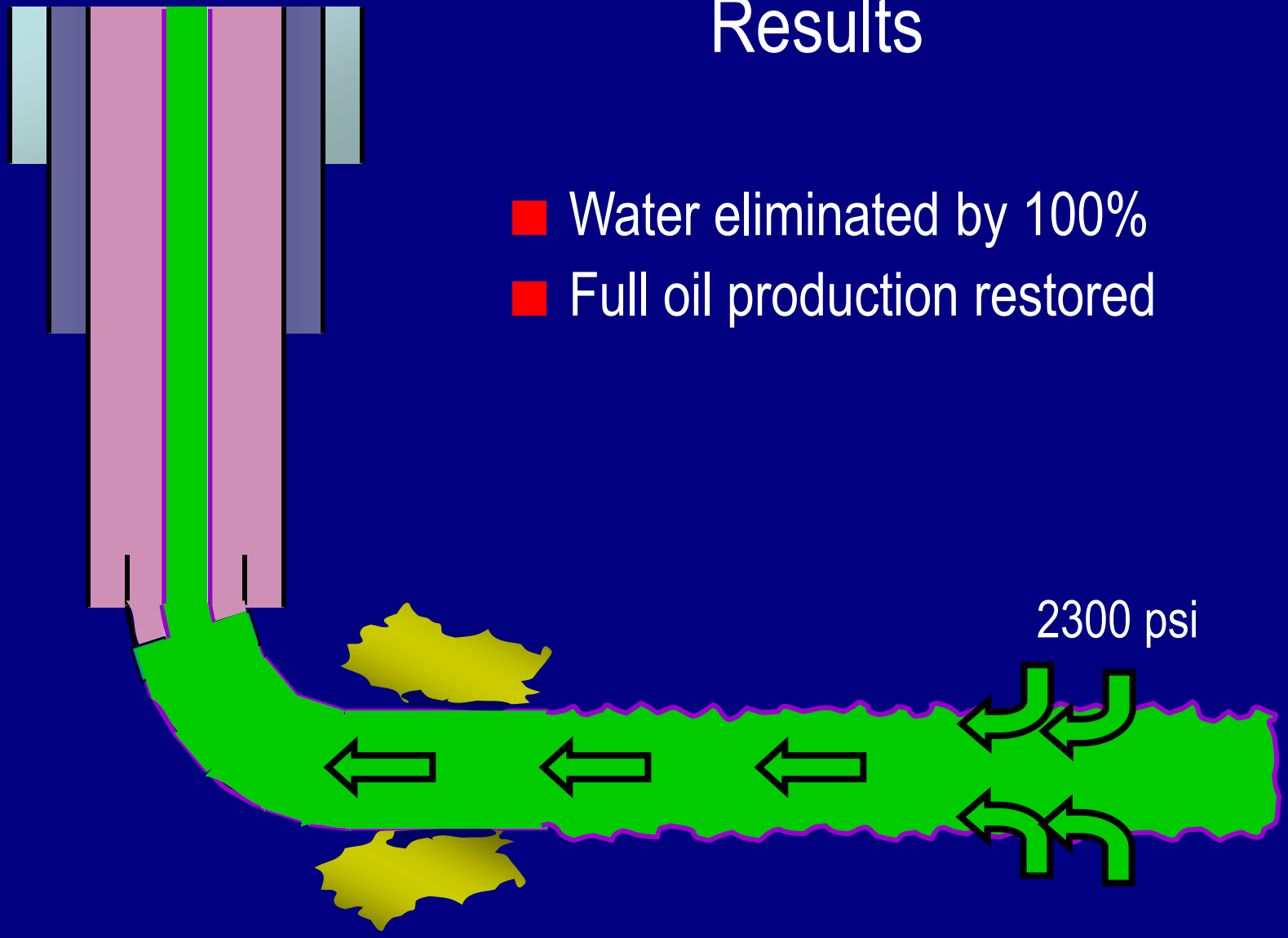
Treatment Procedure

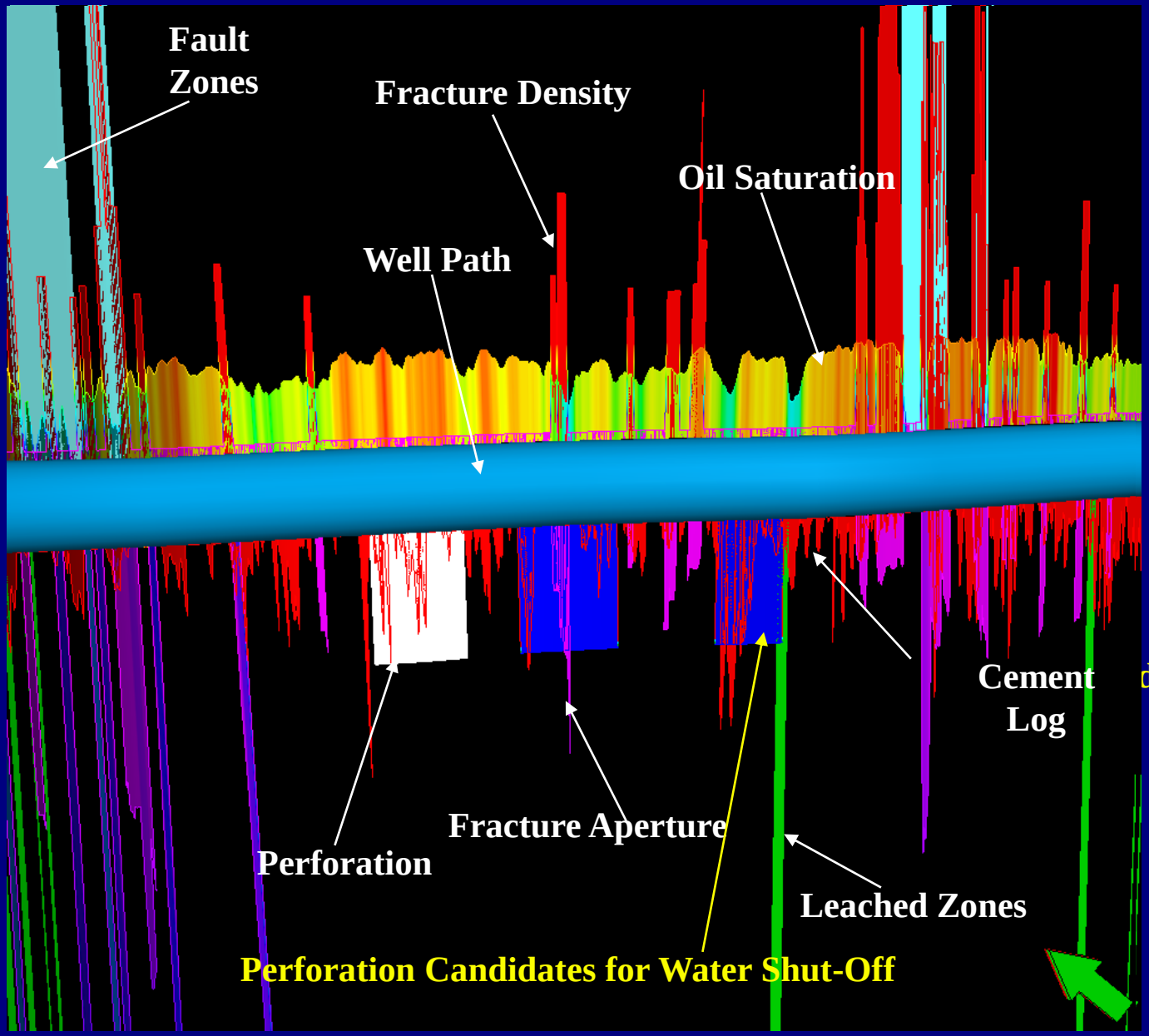


- Clean inaccessible drain with a jetting tool
- Set a chemical temporary plug
- Set an acid-soluble cement plug
- Pressure test
- Perforate CT/TCP. Perform Injectivity Test
- Pump Polymer Cross-linked gel
- Pump a microfine cement
- Pressure test
- Cleanout plugs with a jetting tool

Results

- Water eliminated by 100%
- Full oil production restored



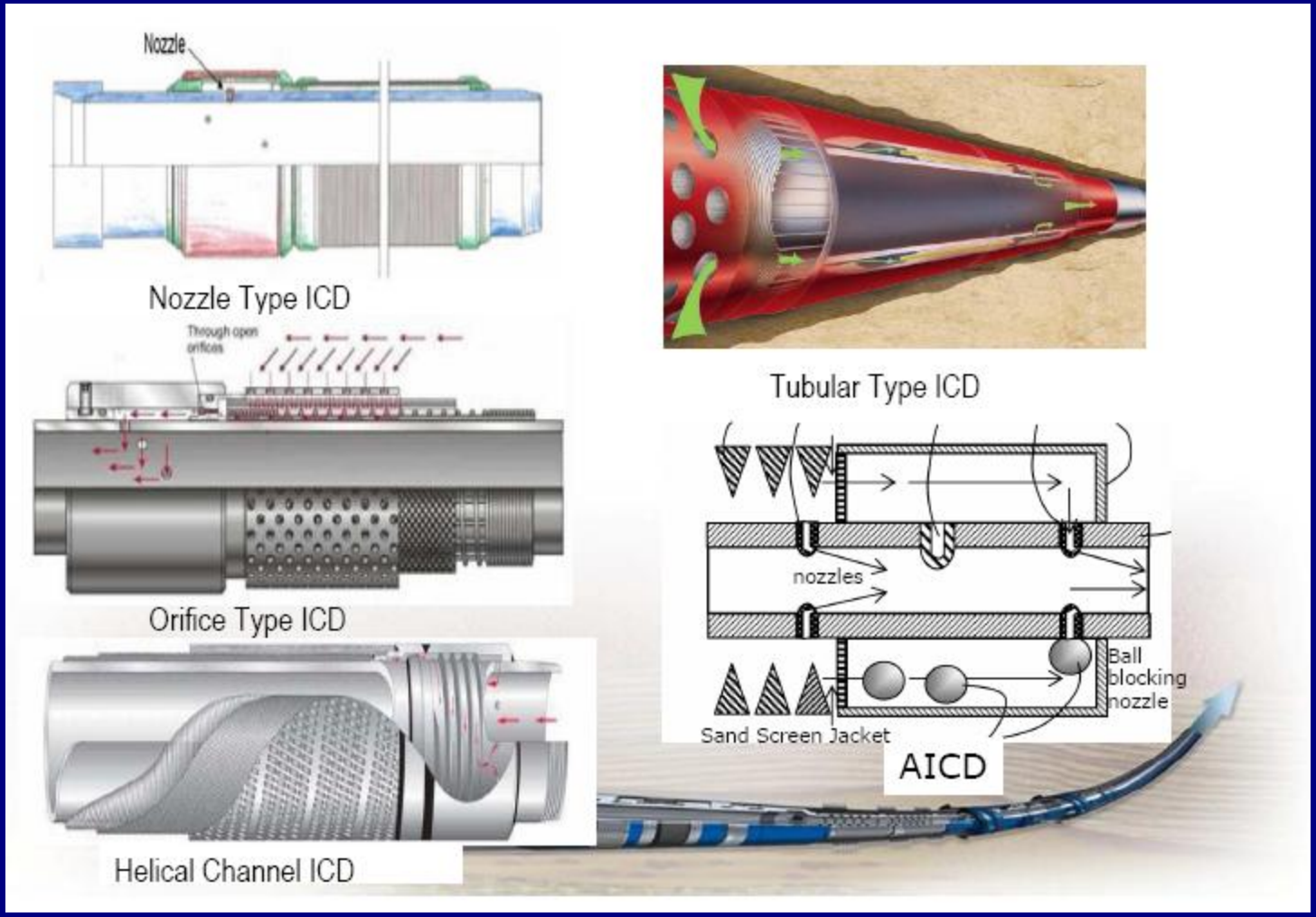


Integrated Solution for Horizontal Zonal Water Shut-Off

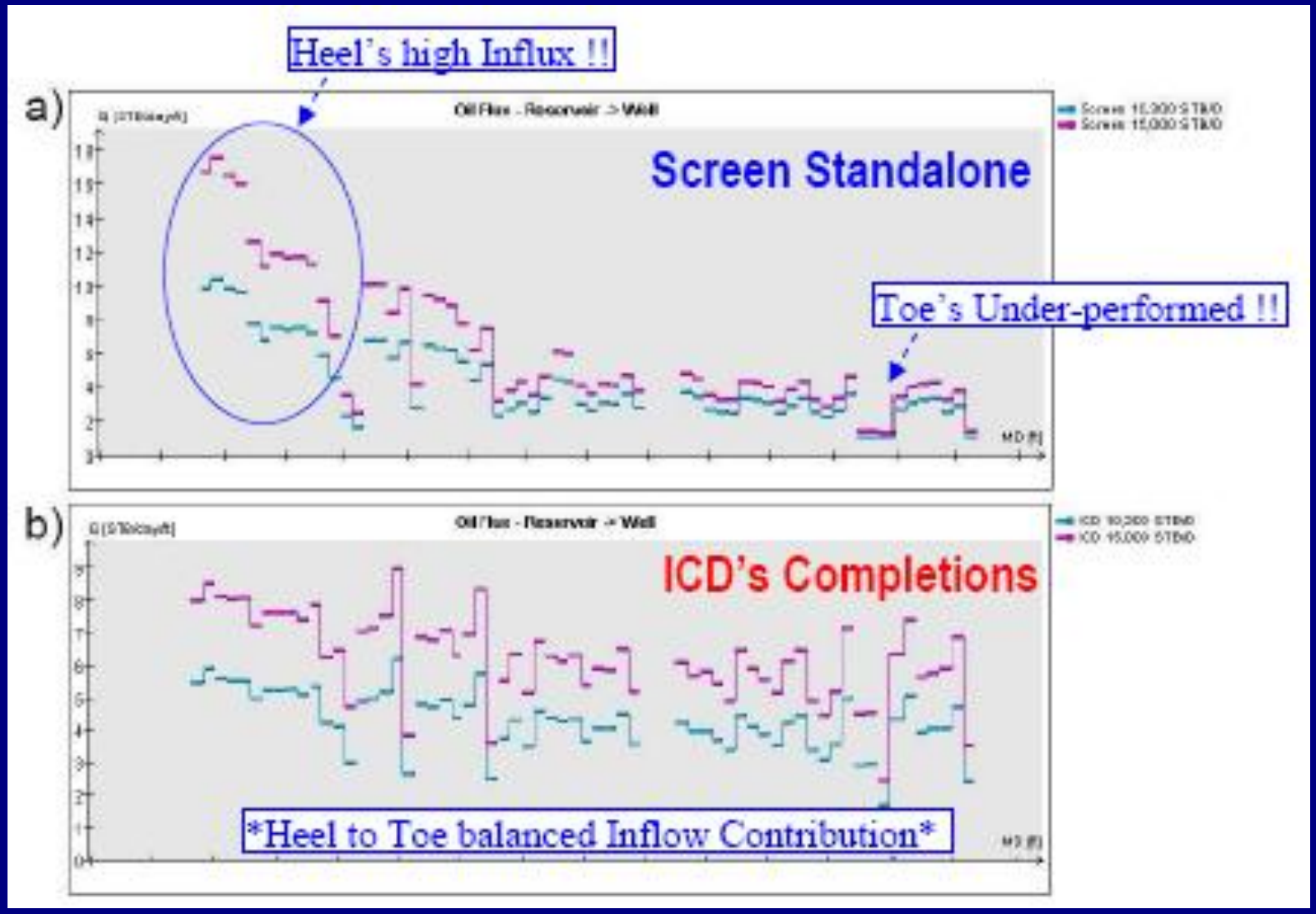
and

Production Optimization

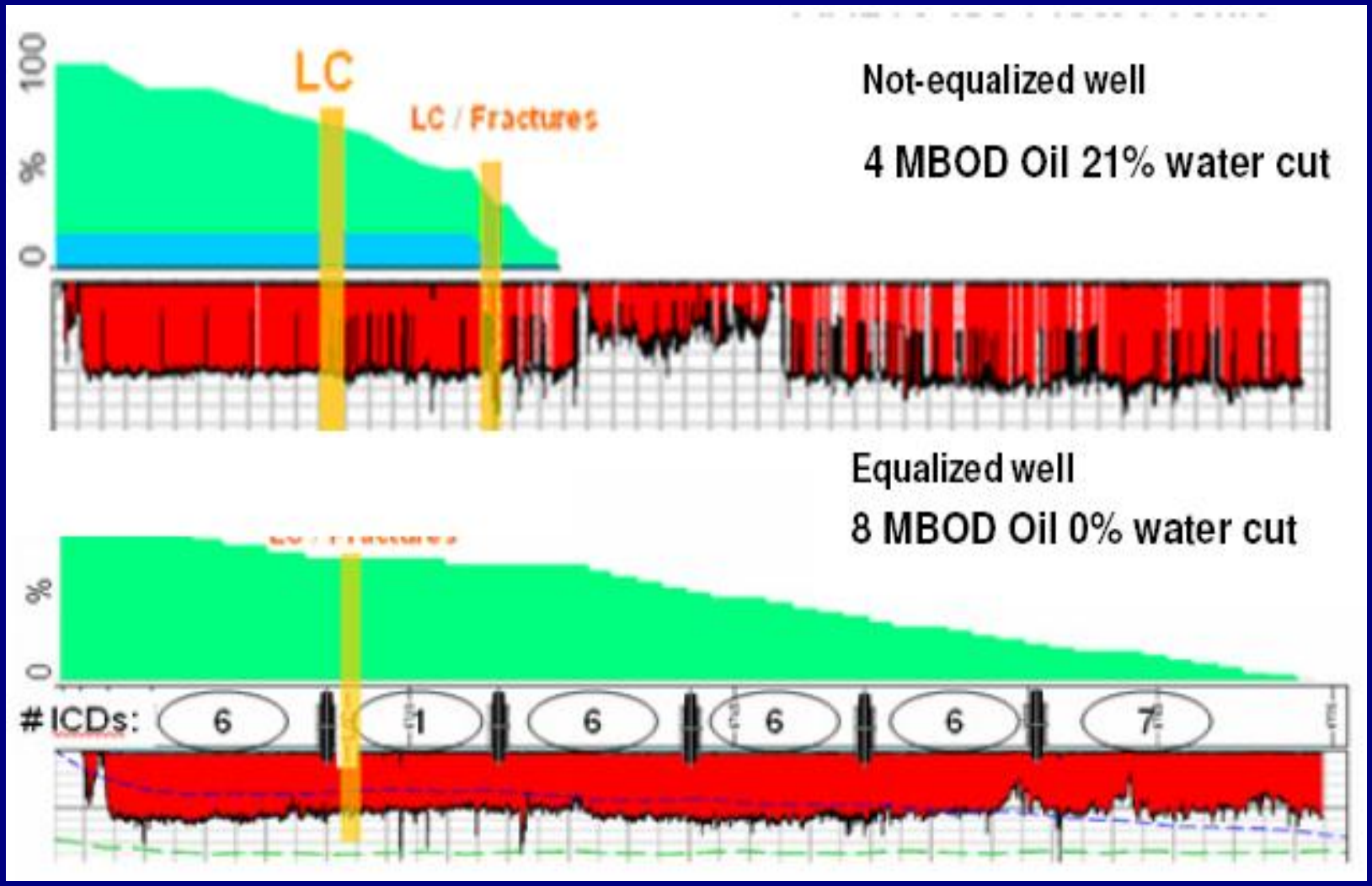
ICD Types


Nozzle
Nozzle Type ICD
Through open orifices
Orifice Type ICD
Helical Channel ICD
Tubular Type ICD
nozzles
Ball blocking nozzle
Sand Screen Jacket
AICD

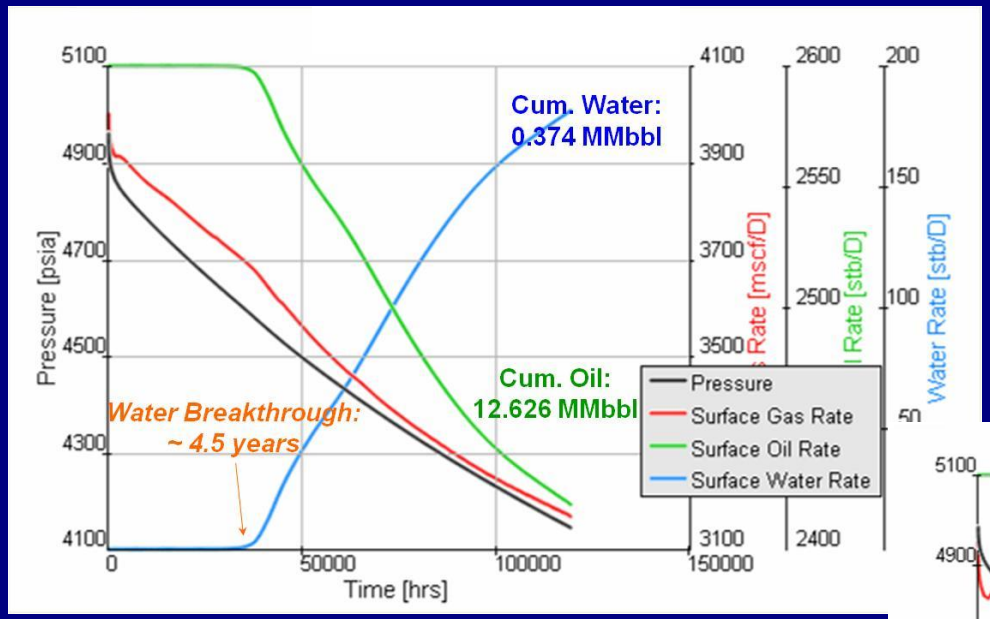
ICD Minimizes Toe-Heel Effect (OTC-19172)



ICD Improves Productivity (SPE 117213)

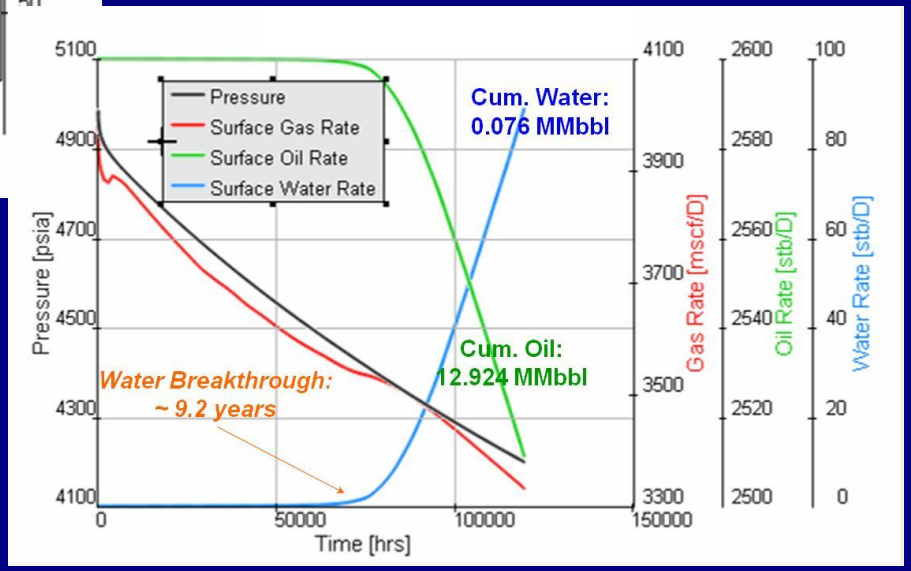


ICD Delays Water Breakthrough*



- Slotted Liner Completion
- **No ICD**
- Water Breakthrough **4.5 Years**

- Slotted Liner Completion
- **With ICD**
- Water Breakthrough **9.2 Years**

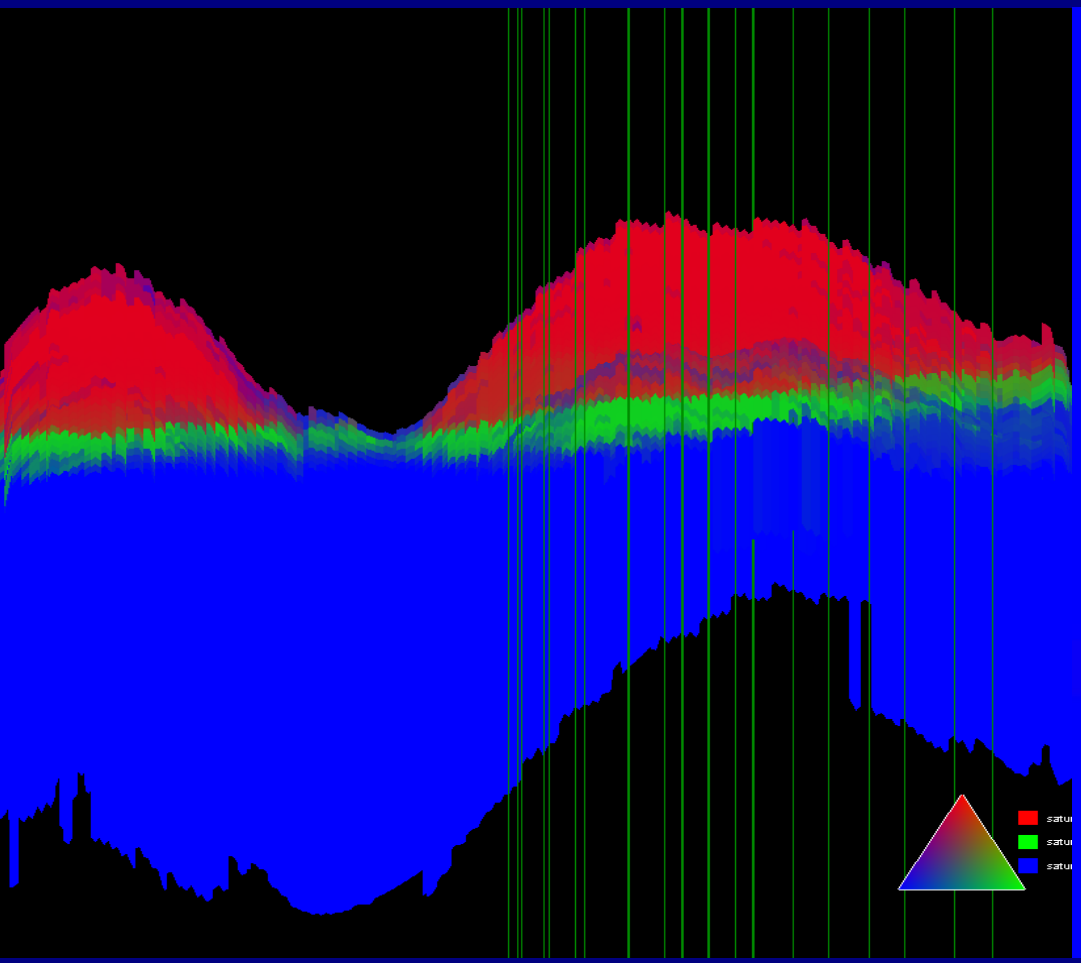


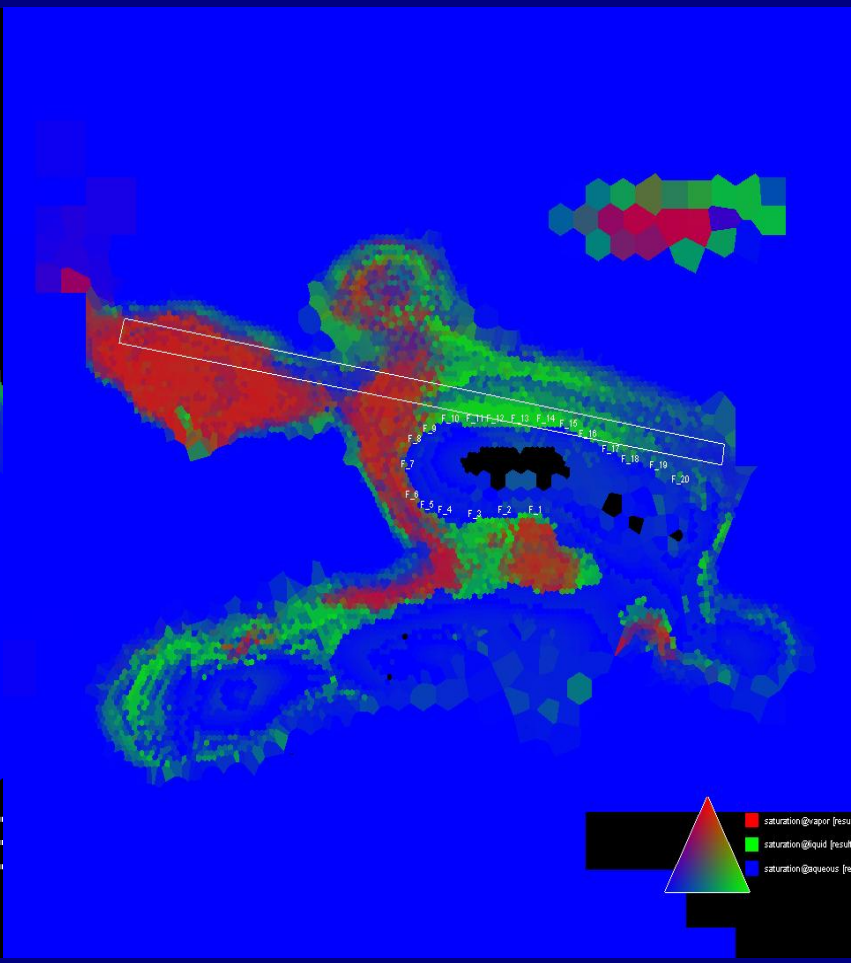
* ***Rhandy Regulacion***, *"'Evaluating the Benefit of Tube-Type ICD Using Coupled Well Modelling and Reservoir Simulation', presentation at Inflow Control Technology (ICT) Conference, 25-26 August 2009, Kuala Lumpur, Malaysia.",*

The Thin Oil Rim Reservoirs

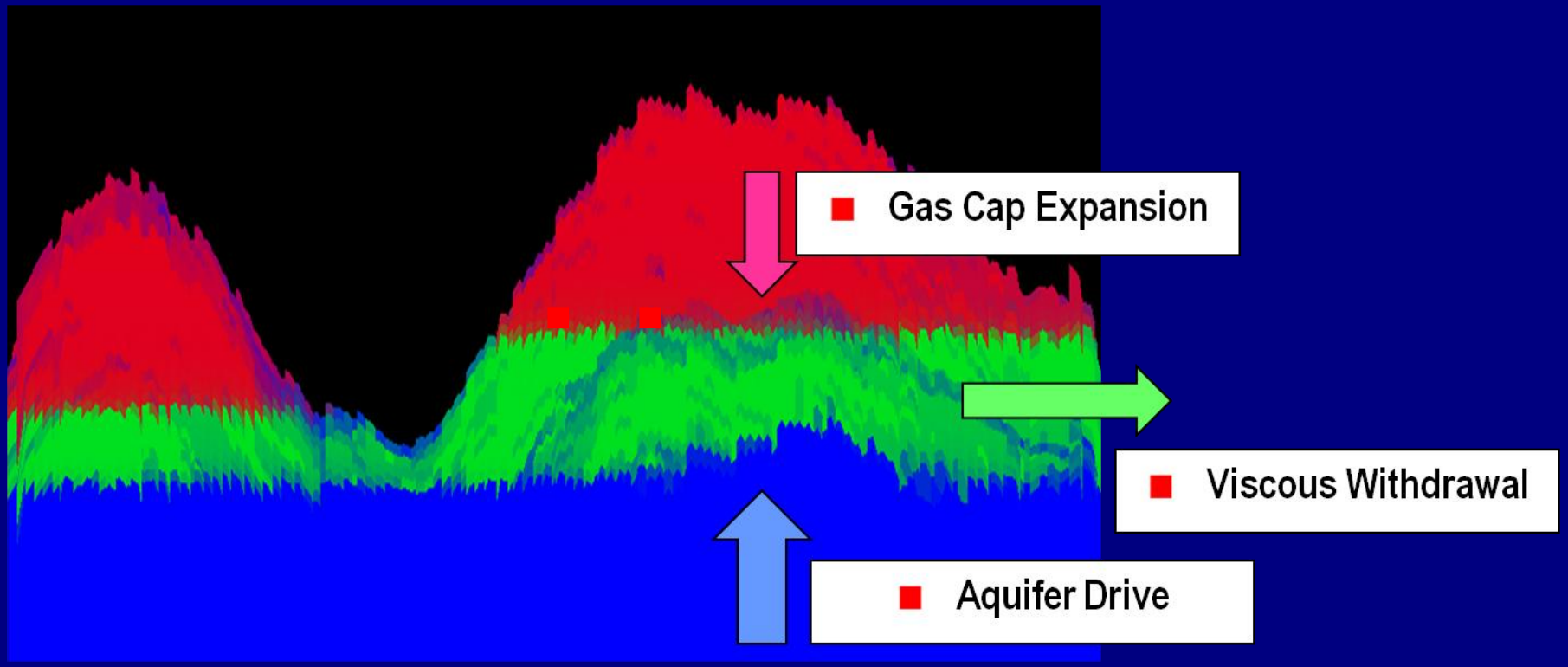
- Multiple Gas Caps
- Huge Regional Aquifer

Thin Oil Rim Reservoirs





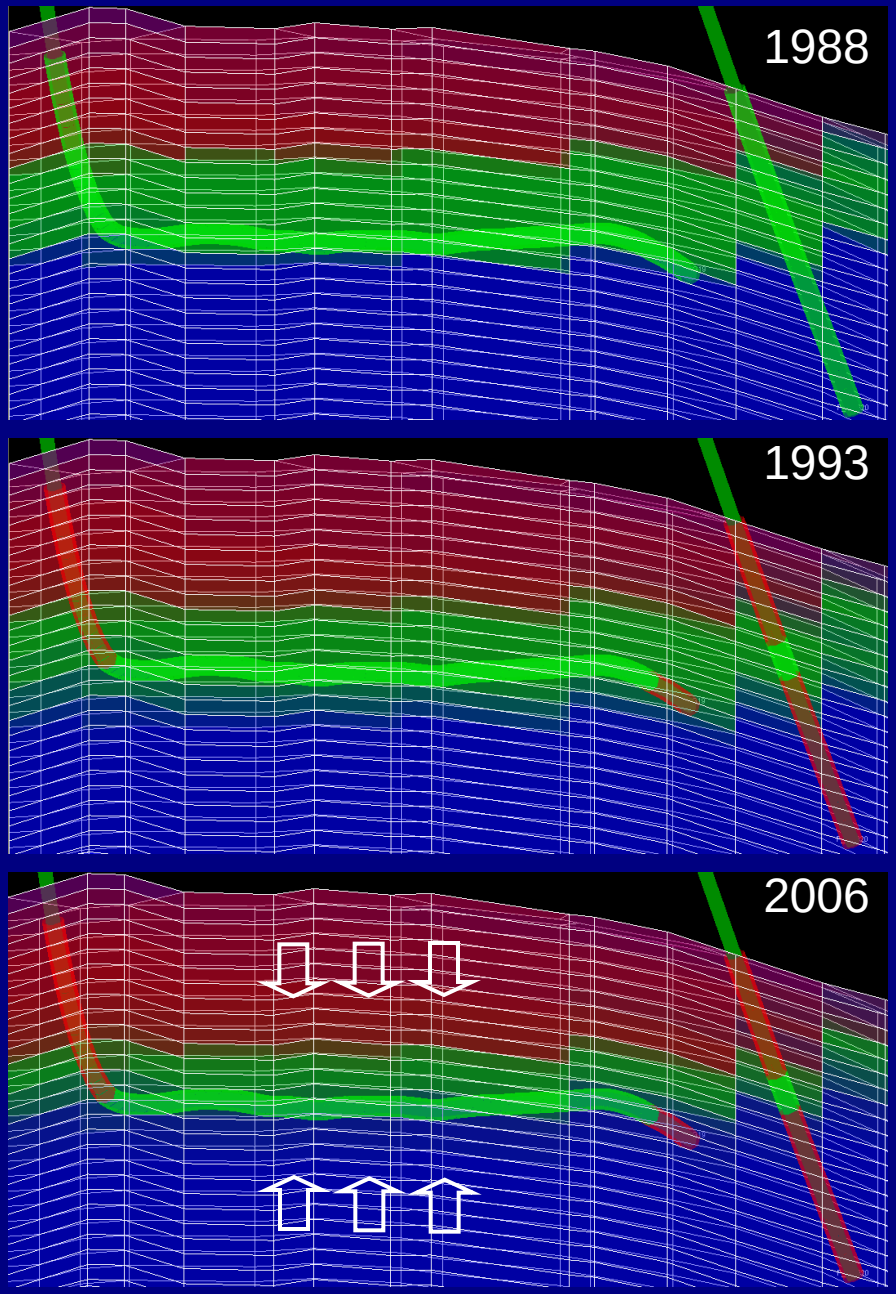
Force Balance to Control Bottom Water Movement



Produced Gas Injection
- Injection into Gas Cap
- Injection into Oil Rim
- GIGP Ratio

Water Injection
- Injection at GOC
- Injection at WOC
- Injection Rate

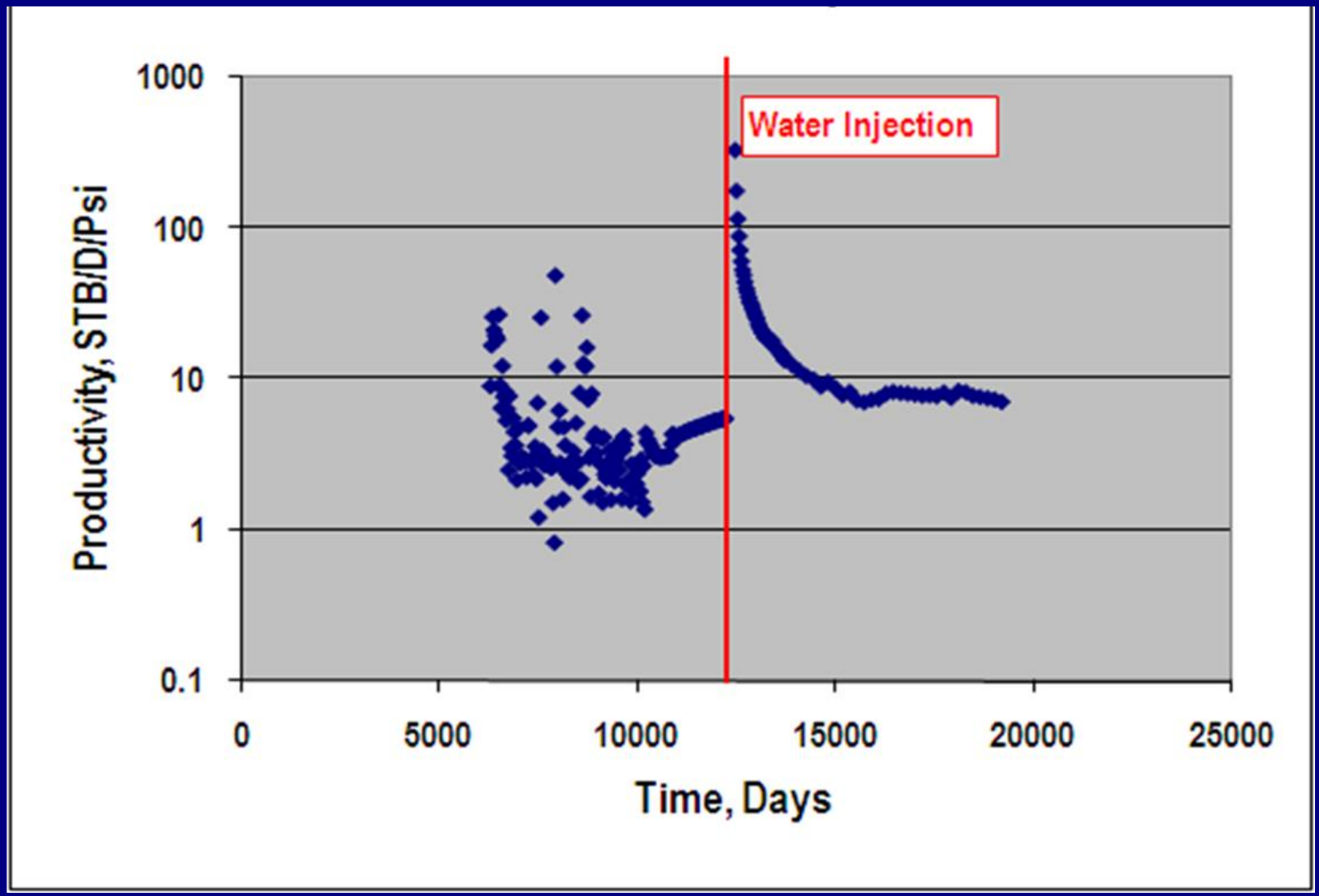
Water Production
- Selective Area
- Production under WOC
- Withdrawal Schedule



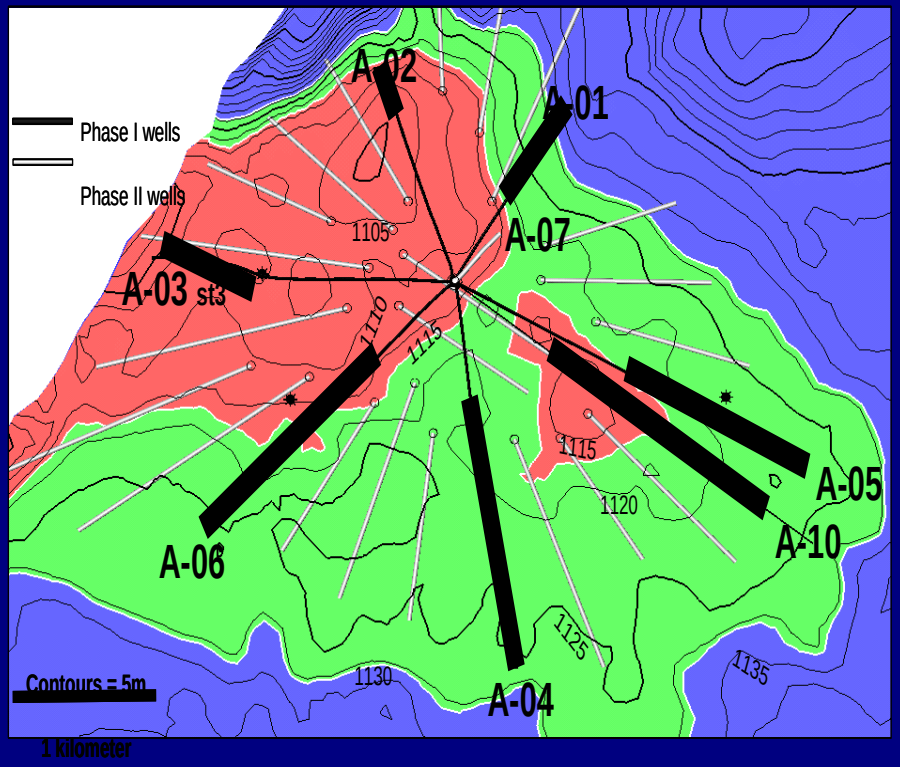
Force Balance in Oil Rim

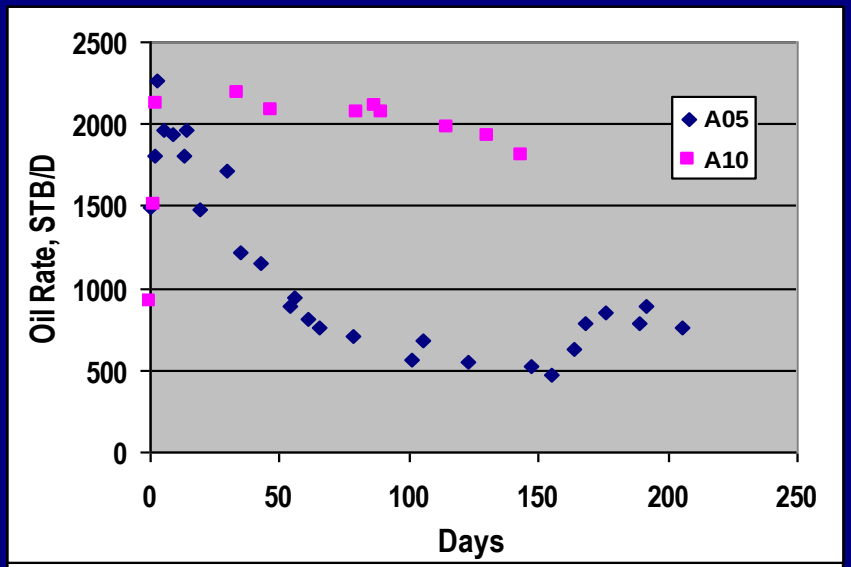
- Horizontal well very low draw-down (< 25 Psi)
- Vertical well with varying draw-down (up to 650 Psi)
- Significant Gas Cap Expansion and high bottom water upward movement
- Horizontal well currently under water
- Vertical well can still produce with adjusted perforation interval

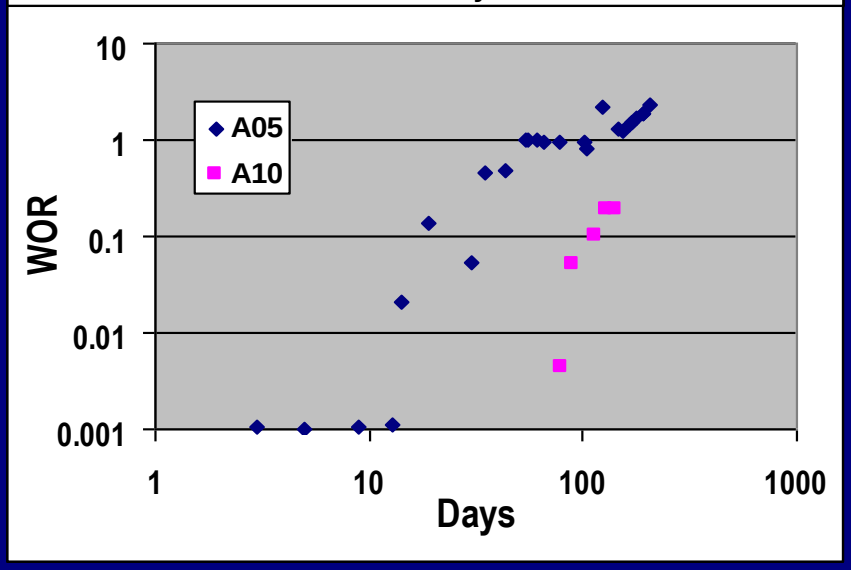
Well Oil Productivity Increase by Water Injection



A Tale of Two Wells

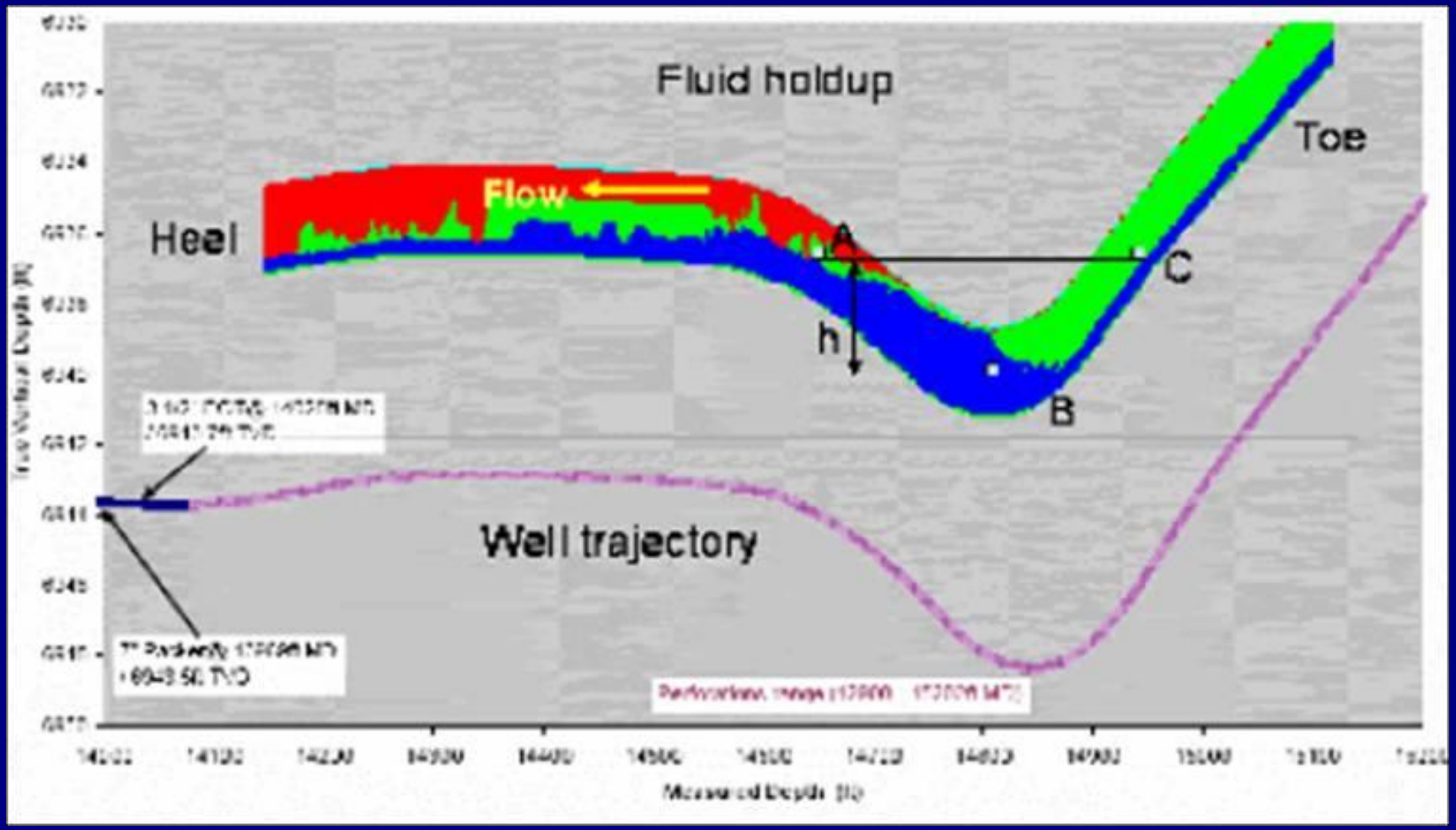






- 200 m lateral spacing for Well A05 & A10
- 5 m and 6 m above WOC respectively

Watch your Toes



SPE 122338, G. Kartoatmodjo et al, 2009 APOGCE

Horizontal Well Water Control

- Drill right. Watch your toe.
- Optimize the force balance in your reservoir, keep your wells in close contact with oil.
- Use of Inflow Control Devices to delay water breakthrough, minimize heel-toe effect, and improve productivity.
- Shut-Off excessive water entry


The Telegraph
M. PATOWARY
VIVEKANANDA LIBRARY
22, DR. MARKET, DULIAJAN
Anchor
A JOINT VENTURE OF EX-ITIANS
If you have a
water problem,
we have the solution
Pentair
Water solutions
AND ASSOCIATES


If you have a
water problem,
we have the solution
Pentair
Water solutions
AND ASSOCIATES

Distinguished Lecturer Program

Your Feedback is Important

Enter your section in the DL Evaluation Contest by completing the evaluation form for this presentation or go online at:

http://www.spe.org/events/dl/dl_evaluation_contest.php