RESMAN®
WIRELESS RESERVOIR SURVEILLANCE

ONS IOR Award, Norway

Improved Oil Recovery

The Importance of Technology

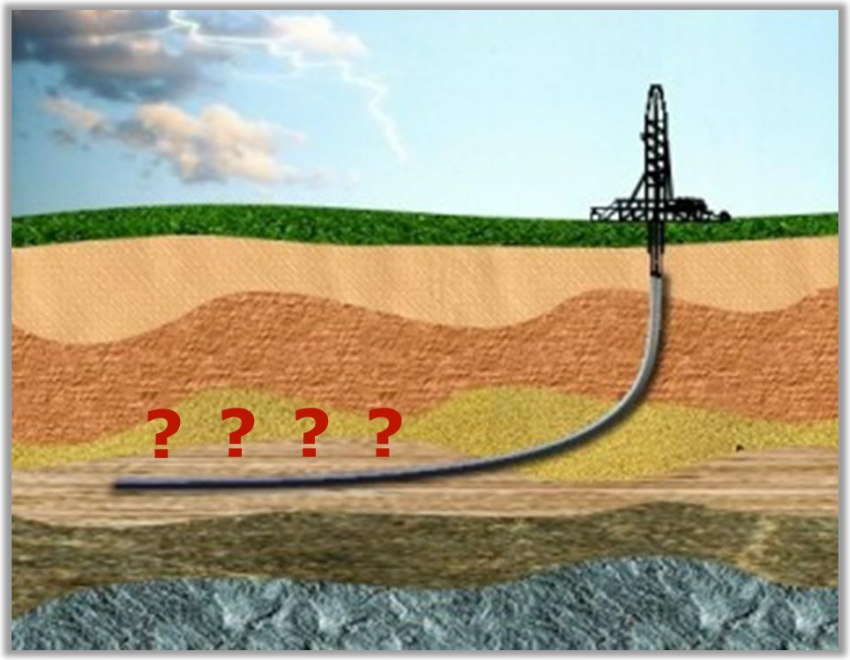
Gunnar Hviding
Chairman & CEO

Date: 28/08/2018

ABOUT RESMAN

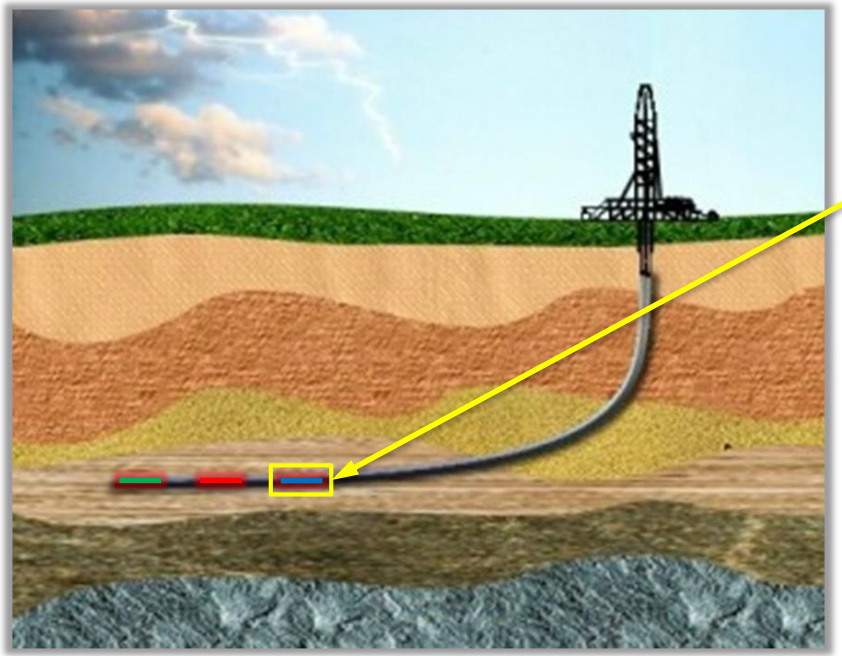
- Established 2005
- Headquarters in Trondheim, Norway
- 76 employees
- Global footprint
- R&D savvy. 15% of revenue
- Organic chemical tracers with 10 year lifetime
- Determining where in the well the production is coming from (zonal resolution of production)

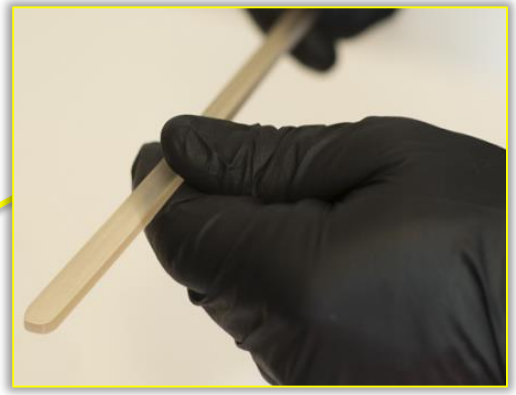
INDUSTRY CHALLENGE • REDUCE UNCERTAINTY



- How are my zones performing over time ?
- Where is water breakthrough occurring ?
- Is the toe producing ?
- What is optimal drawdown ?
- When did water break through ?
- How are zones developing over time ?

SOLUTION • RESMAN INTELLIGENT TRACER® TECHNOLOGY





- Production log
without the risk and cost
of well intervention

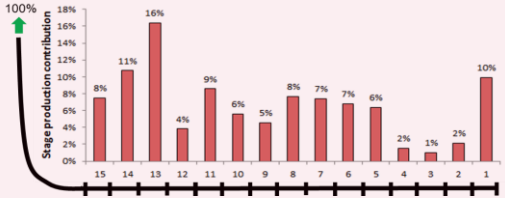
- **Continuous monitoring**

EXPANDING RESMAN MONITORING SERVICES TO OPERATOR MODELLING INTEGRATION

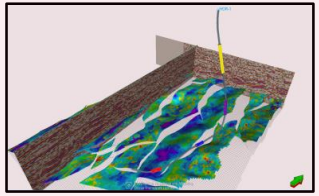
3 Sampling

4 Analysis
(parts per trillion)

5 Inflow Interpretation



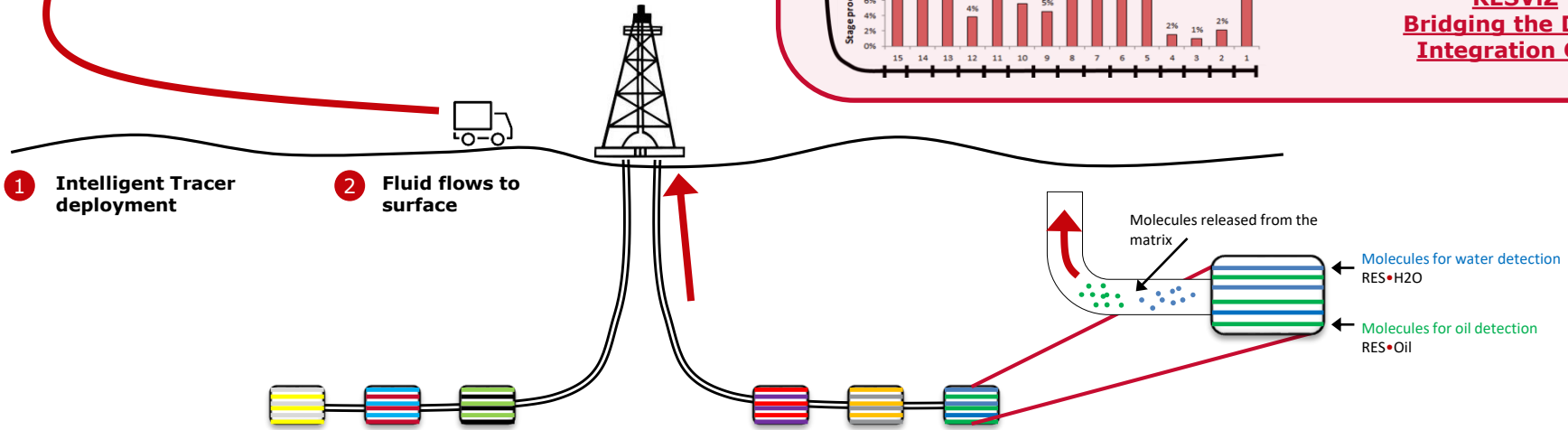
6 Inflow Tracer Data Integration



RESViZ
Bridging the DATA Integration GAP

1 Intelligent Tracer deployment

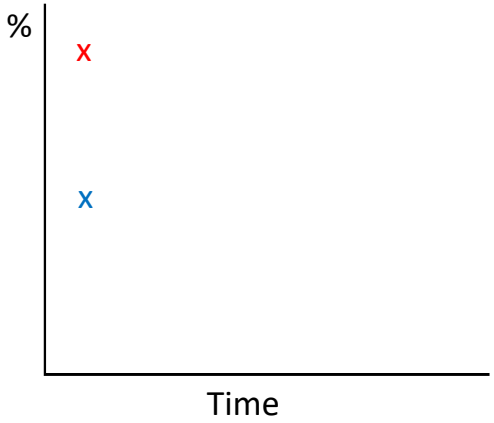
2 Fluid flows to surface



WORK FLOW: QUANTIFICATION vs. WELL MONITORING

1

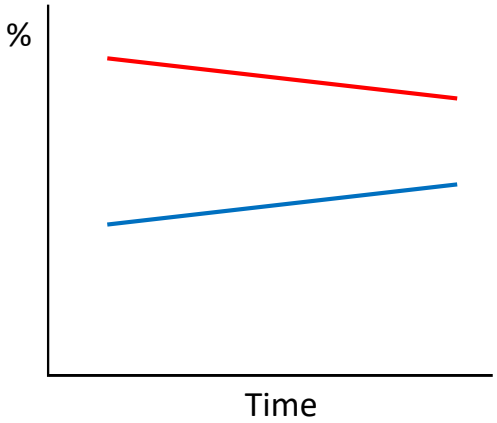
Transient analysis
Zonal production
Ip and production over time



Well clean-up verification
Initial rates (oil/water)
• QUANTITATIVE

2

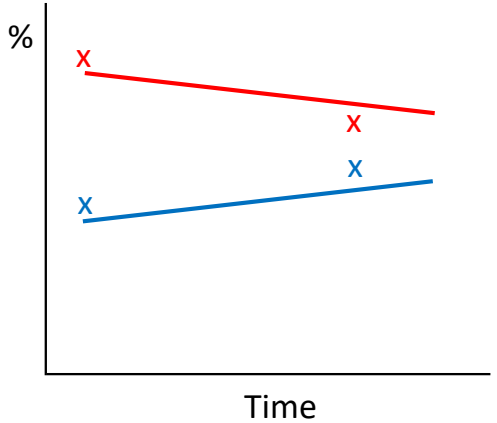
Continuous well monitoring
(production phase)



Zonal performance/ trending
Water breakthrough (event)
Optimal drawdown pressure
• QUALITATIVE Trend Analysis

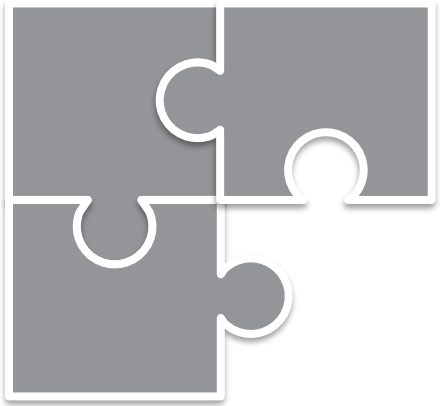
3

Re-start
(transient)

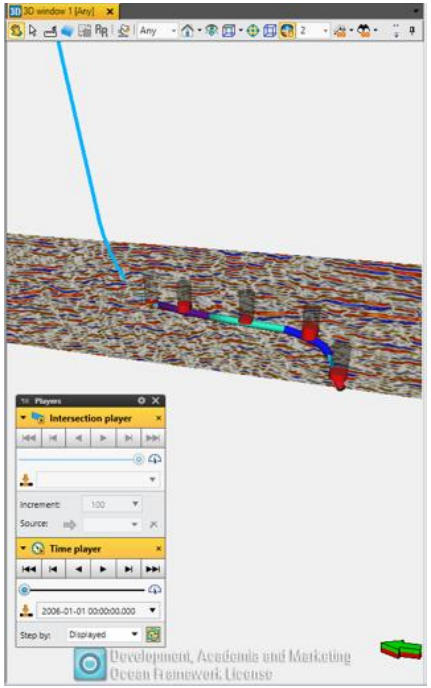


Quantification after restart
• QUANTITATIVE

WE ARE A PIECE OF YOUR PUZZLE



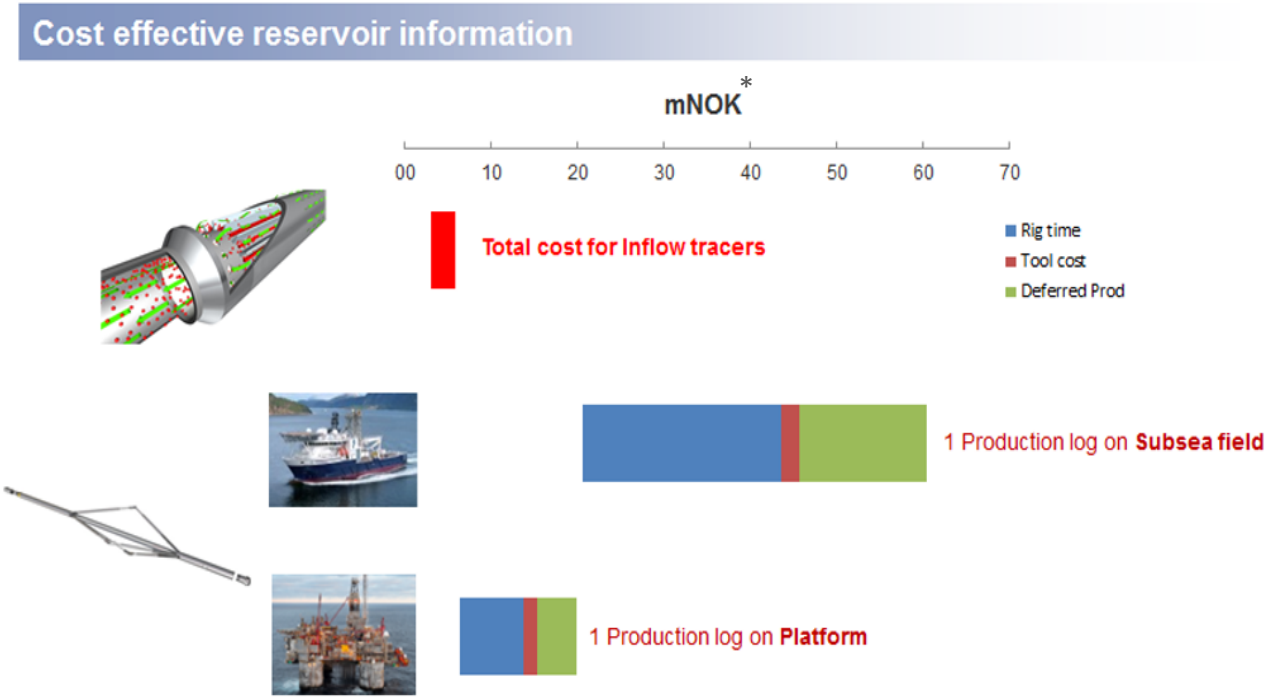
Seismic
Logs
Core data
Well path
Reservoir model and simulation
Multiphase meter
Downhole gauges
PLTs



- Zonal contribution
- Location and time of water breakthrough
- Optimal drawdown
- Zonal performance trend data

THE MOST COST EFFECTIVE WAY TO GET THE DATA

RESMAN Inflow Tracers vs. PLT's



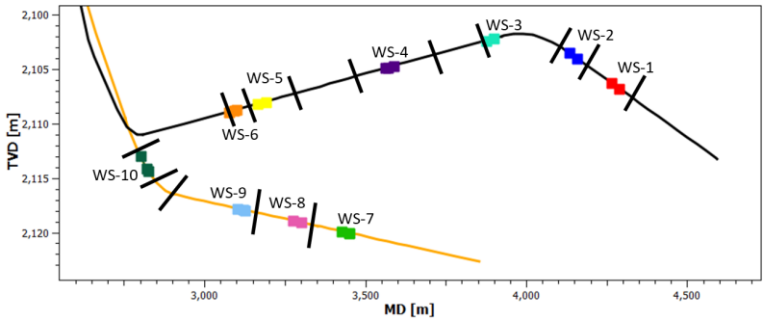
SPE paper 170619-MS
Presented by Statoil

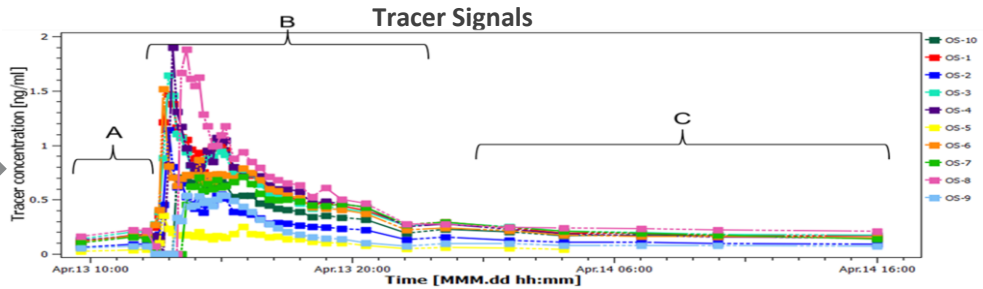
* Conversion Rate
$1 = 8 NOK
£1 = 10 NOK

IOR EXAMPLE 1

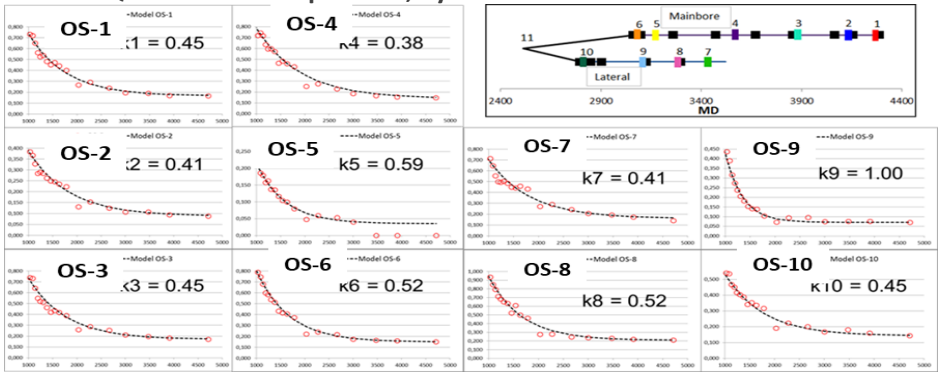
Zonal Inflow Contribution

CASE STUDY – QUANTIFICATION OF INFLOW (HORIZONTAL TWO-LATERAL WELL)

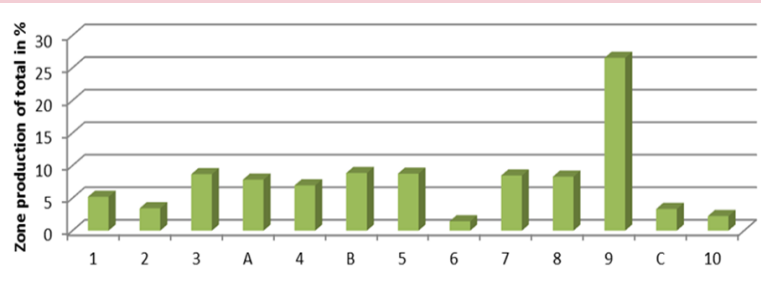




Inflow Quantification of period B, by Flush-Out model



Conclusions

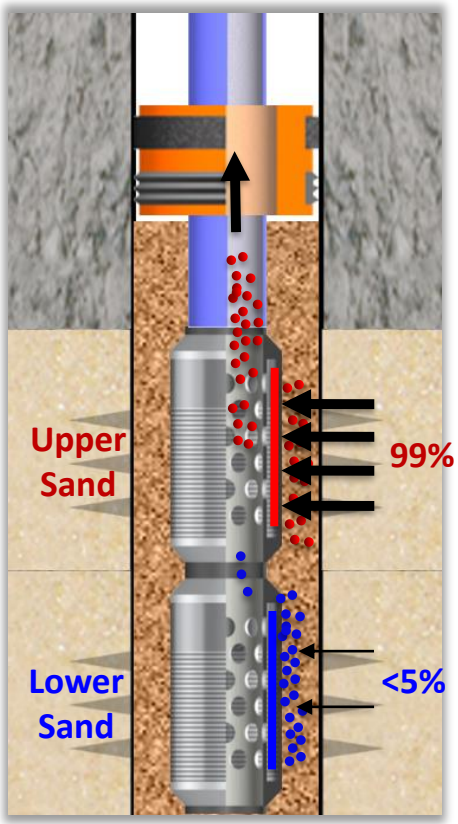


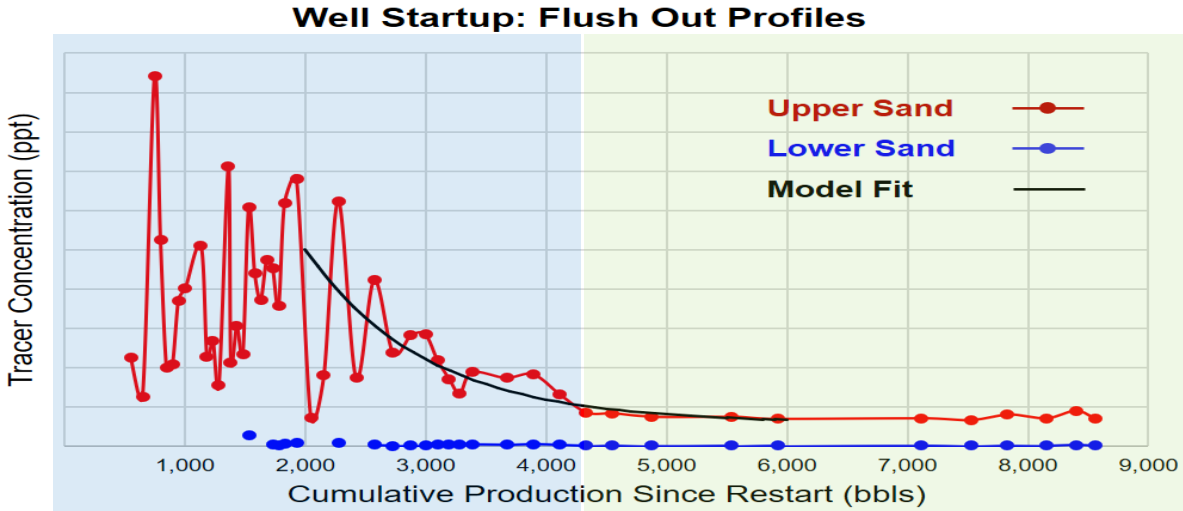
All zones producing similar, except **OS-9 that is producing twice** (per screen) as the other zones (per zone length) during the *transient* period

IOR EXAMPLE 2

Zonal Inflow Contribution

USING QUANTITATIVE AND QUALITATIVE DATA TO ARRIVE AT DECISION





Quantitative Analysis (startup)

- Upper sand major contributor
- Lower sand barely flowing

Qualitative Analysis (steady state)

- Upper sand still dominant
- Barely any response from lower sand

CONCLUSION: Lower sand is not economical

IOR EXAMPLE 3

Zonal Resolution to Global Water Production Data

WATER BT AND INFLOW LOCATION – ZONAL RESOLUTION TO PRODUCTION DATA

CHALLENGE

- Detect the location of water breakthrough

SOLUTION

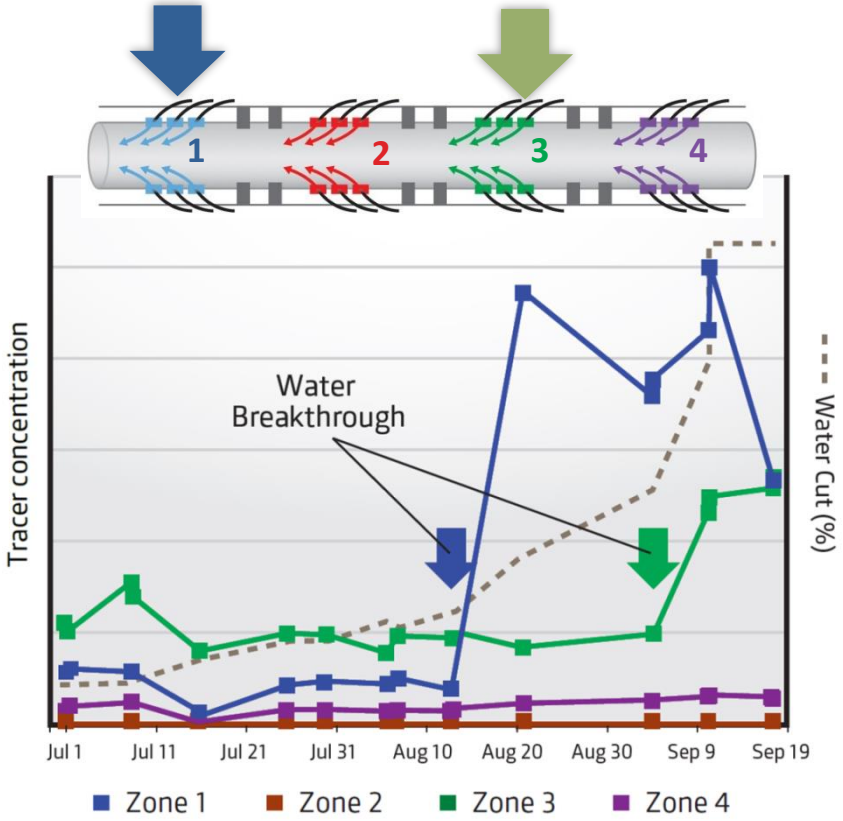
- Operator installed RES•H2O systems in four reservoir compartments

RESULTS

- Two independent water breakthrough events from one subsea well were detected:

  zone 1 and zone 3

- Operator adjusted the reservoir models and improved the management of the field-wide water flood program



IOR EXAMPLE 4

Operational Mode Analysis

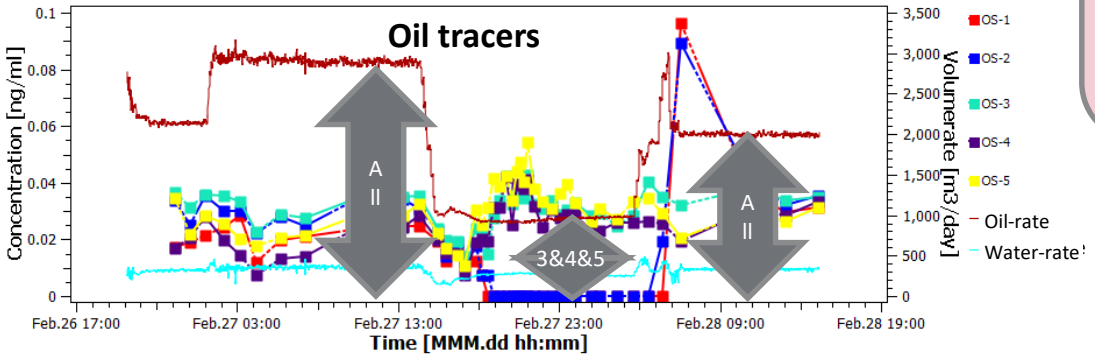
OPERATIONAL DECISION-MAKING USING MULTI-RATE TESTING

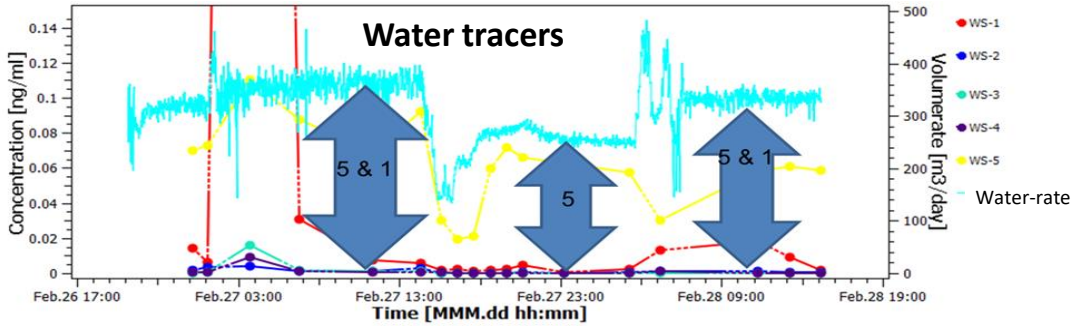
Critical well and reservoir information acquired based on inflow tracer data

- Sandstone reservoir - Horizontal well - 2000 meters of screens sections

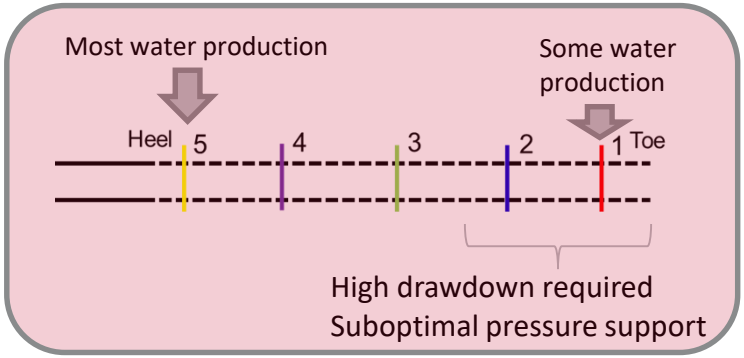
Conclusions:

- **Short-term:** Consequences of changing THP/BHP now known for the operation. Zone 1 and 2 requires highest drawdown
- **Mid-term**: Zone 5 as Water Shut-Off target
- **Long-term**: Targeted waterflooding. Water injector to sustain production from Zone 1 and 2
- Model Reservoir refinement





Conclusions



Zonal Production Heatmap

Zone	Drawdown Applied			
	Low		High	
	W	O	W	O
1				
2				
3				
4				
5				

IOR EXAMPLE 5

Advanced EOR Surveillance

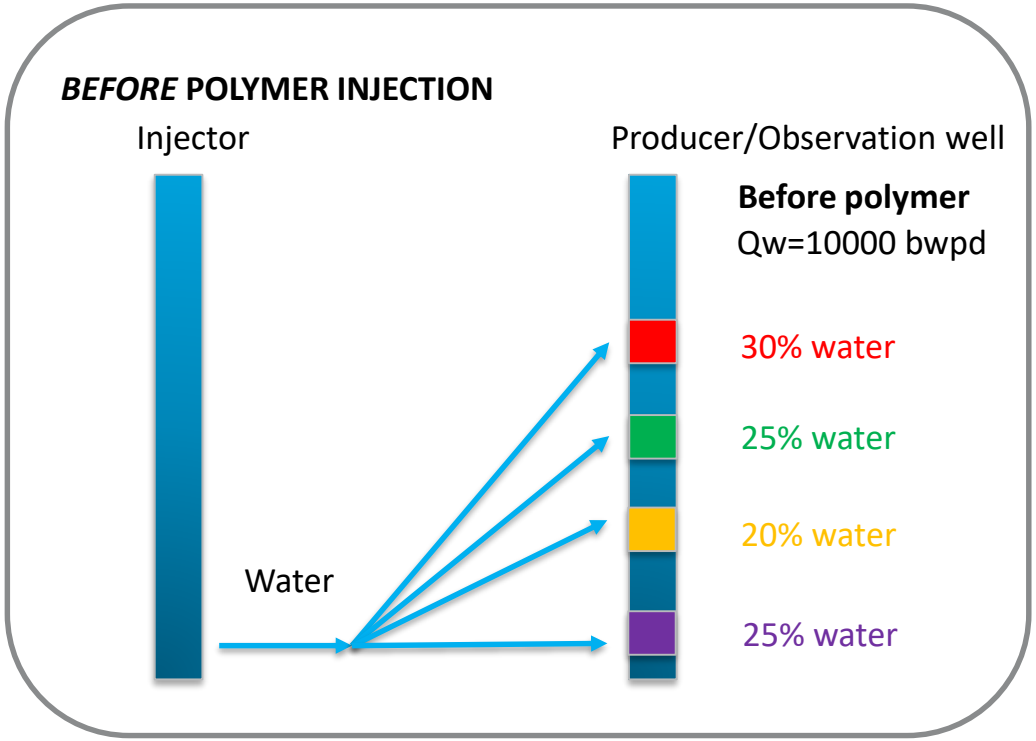
RESMAN TRACER TECHNOLOGY ENABLES DECISION-MAKING: ADVANCED EOR SURVEILLANCE

- **Advanced EOR Surveillance** for a variety of EOR methods to get quantitative zone-specific information

- **EOR** methods, e.g.
  - Macroscopic sweep: Foam, Gel, Polymer
  - Microscopic sweep: Surfactant, ASP, Low salinity

- 'Close-to-injector' Producer or Observation well to get 'fast response'
  - **STEP 1:** Zonal inflow before EOR treatment
  - **STEP 2:** Inject EOR chemical
  - **STEP 3:** Zonal inflow after EOR treatment

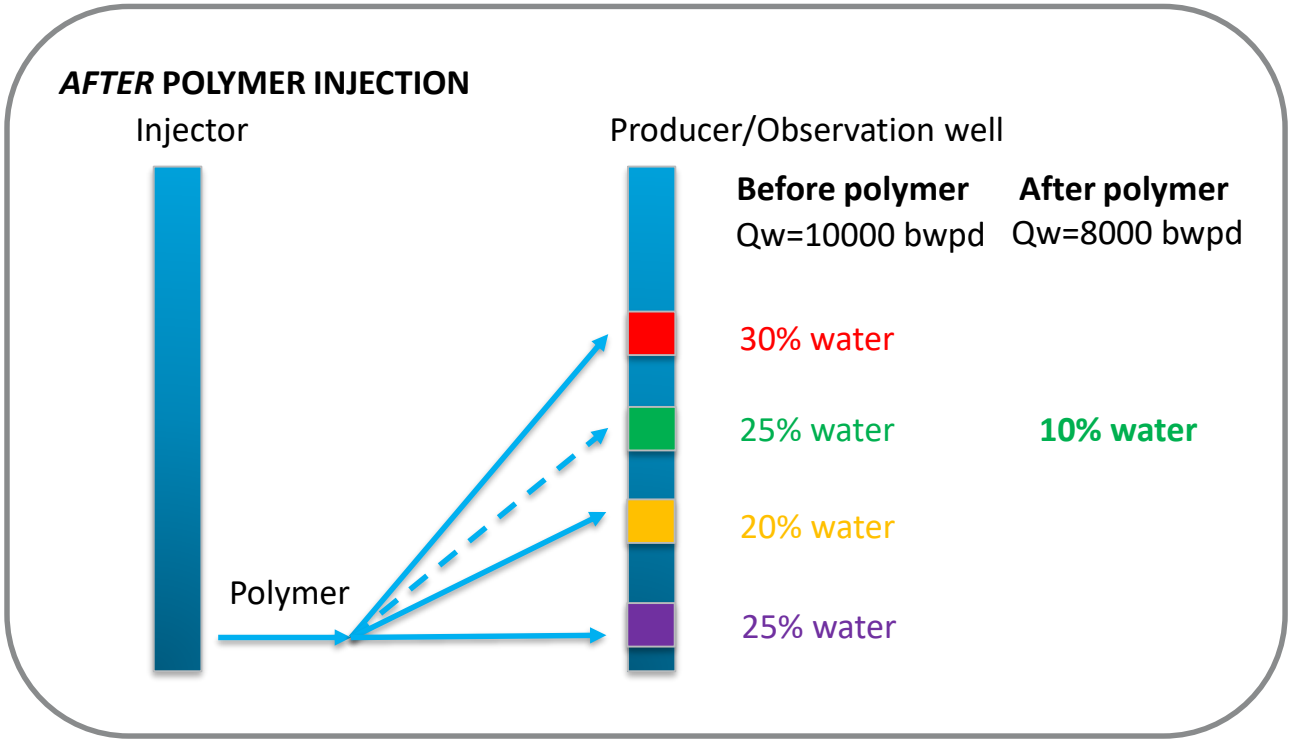
- Early indication of zone-specific EOR performance (e.g. reduced zonal water production)



RESMAN TRACER TECHNOLOGY ENABLES DECISION-MAKING: ADVANCED EOR SURVEILLANCE

Zone-specific EOR Surveillance information:

1. Polymer has improved macroscopic sweep between injector and green zone
2. Zone-specific EOR performance information.
3. Update of reservoir model with important detailed dynamic spatial information



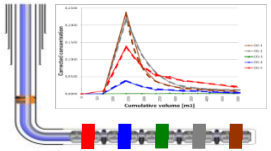
IOR SUMMARY

WORKFLOW

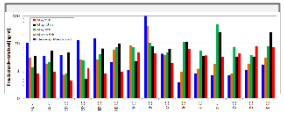
SUMMARY: WORKFLOW

Well start-up

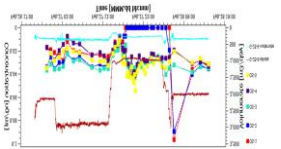
Zonal contribution



Continuous production monitoring



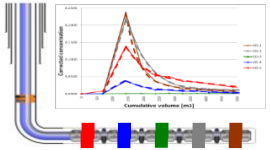
Multi rate test

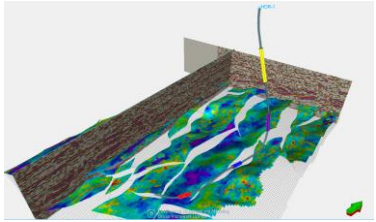


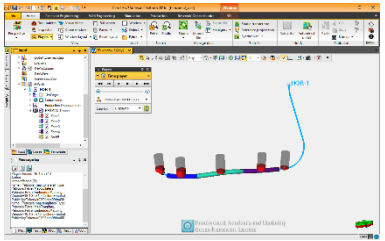
Re-start

Zonal contribution

Real time







Time – Monitoring Workflow

✓ **Actions**

Thank you for your attention

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