



# **RESMAN Reservoir Surveillance**

## **SPE Chapter Buenos Aires**

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## RESMAN TRACK RECORD SUMMARY

*Worldwide, June 2019*



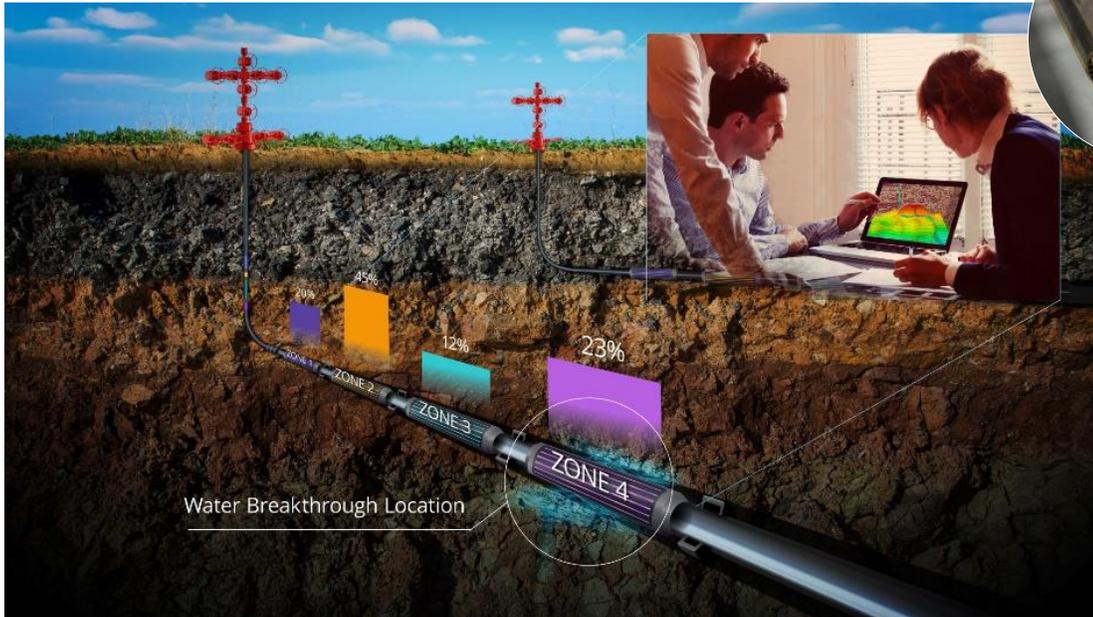
- RESMAN was formed in 2005 by Statoil Technology Invest
- 576 wells = 5173 Intelligent Tracer systems
- 61 clients in 40 countries
- Max commingled flow rate to date: 200,000 BFPD
- Max pressure to date: 30,000 psi
- Max temperature to date: 400°F (200°C)
- Acquired RESTRACK (inter-well tracers) in December 2018





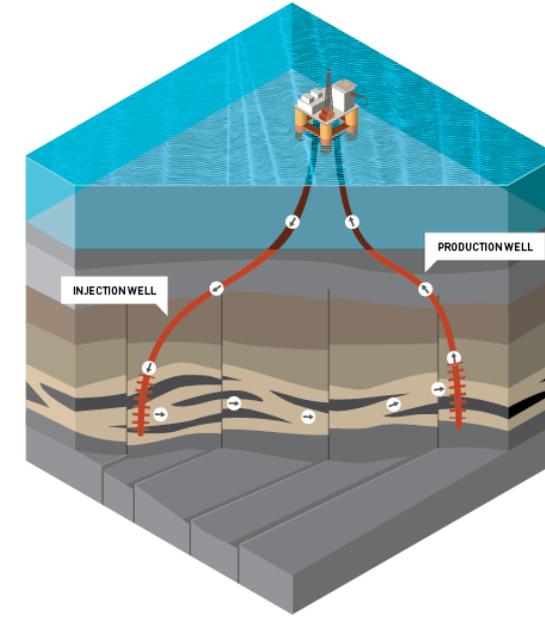
## DISTINCT TRACER APPLICATIONS: INFLOW + INTERWELL

### RESMAN Inflow tracers



- Quantify zonal inflow during startup
- Locate water breakthrough
- Correlate changes in PI to tracer trends
- Multiple years of monitoring life

### RESTRACK Interwell tracers

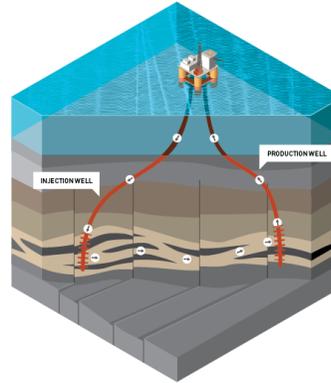


- Monitor reservoir communication and BT time between injectors and producers
- Assess sweep volume, efficiency, and heterogeneity



## Inter-well tracer test (IWTT)

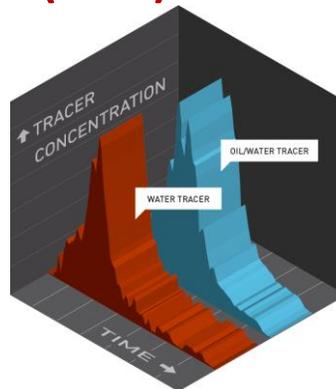
- Water injection
- Gas injection
- CO<sub>2</sub> injection
- WAG (Water Alternating Gas)
- EOR



- Breakthrough time
- Communication
- Allocation factor
- Sweep volume and efficiency
- Heterogeneity assessment
- Improve reservoir model

## Partitioning inter-well tracer test (PITT)

- Water injection
- EOR



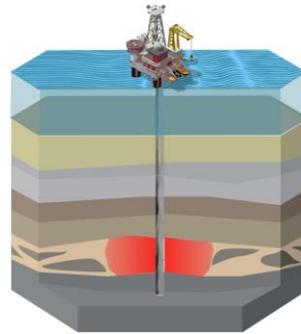
- Inter-well oil saturation
- Evaluate EOR potential
  - Larger evaluation area/volume than for SWCTT
  - Can be carried out under normal operations of wells



# RESTRACK – Single Well Product Offering

## Single-well chemical tracer test (SWCTT)

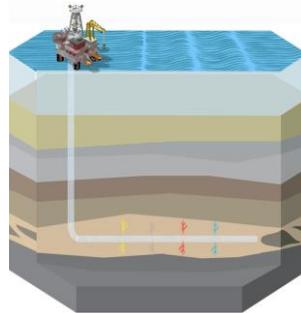
- Near well region flushed to residual oil saturation
- Tracer injected during water injection
- Onsite analysis



- Near well oil saturation measurement
- Evaluate EOR potential
  - Low salinity
  - Polymer
  - Surfactant
  - Etc.
- Connate water saturation

## Fracking/Stimulation Treatments

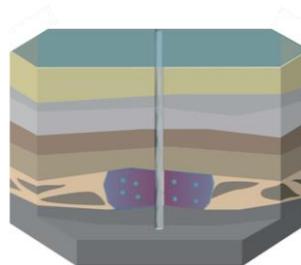
- Unique tracers used to track each stage
- Onsite or offsite analysis



- Confirm which zones are producing
- Calculated recovery during back flow
- Monitoring the back-production profile
- Assess inflow in each of the treated zones

## Push&Pull test

- Tracer for mass balance calculation
- Onsite or offsite analysis

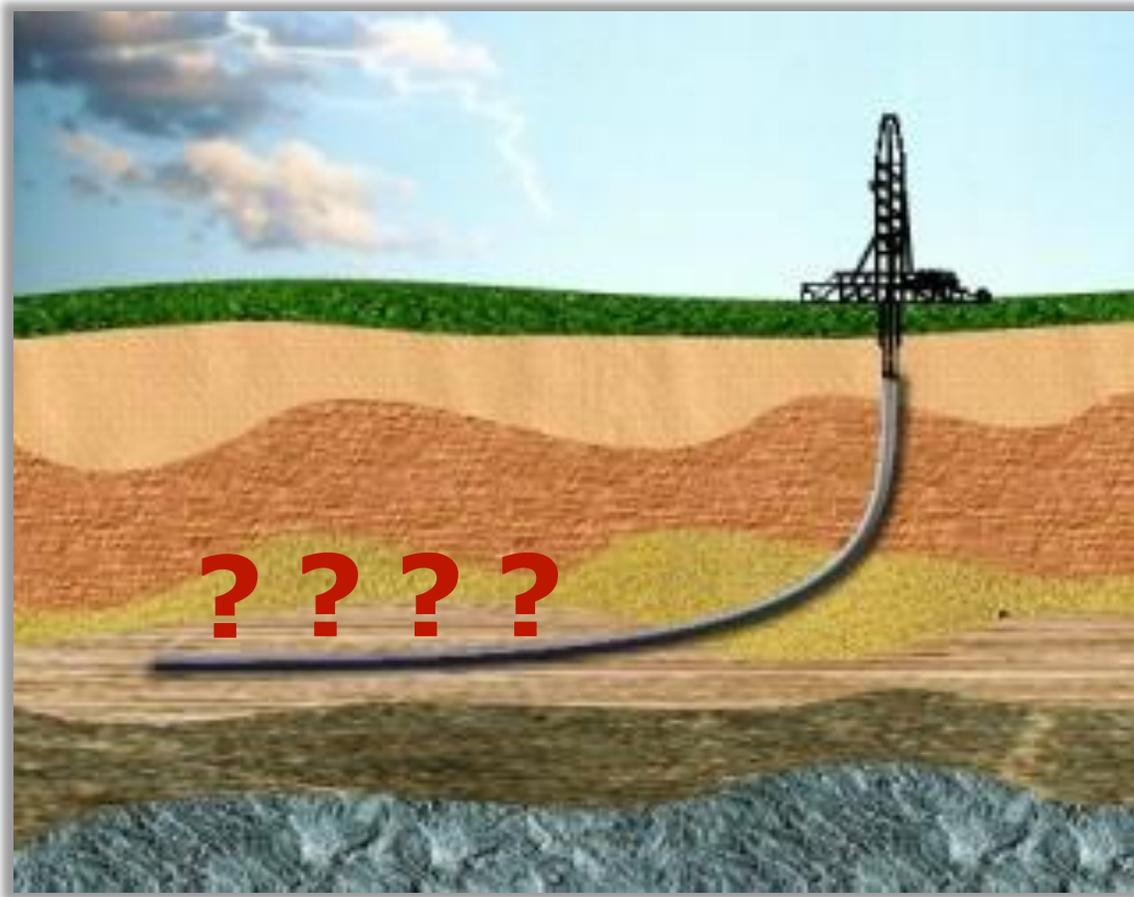


- Track mass balance of water
- Compare water behavior to that of well chemicals:
  - Polymer
  - Surfactant
  - Scale inhibitors etc.





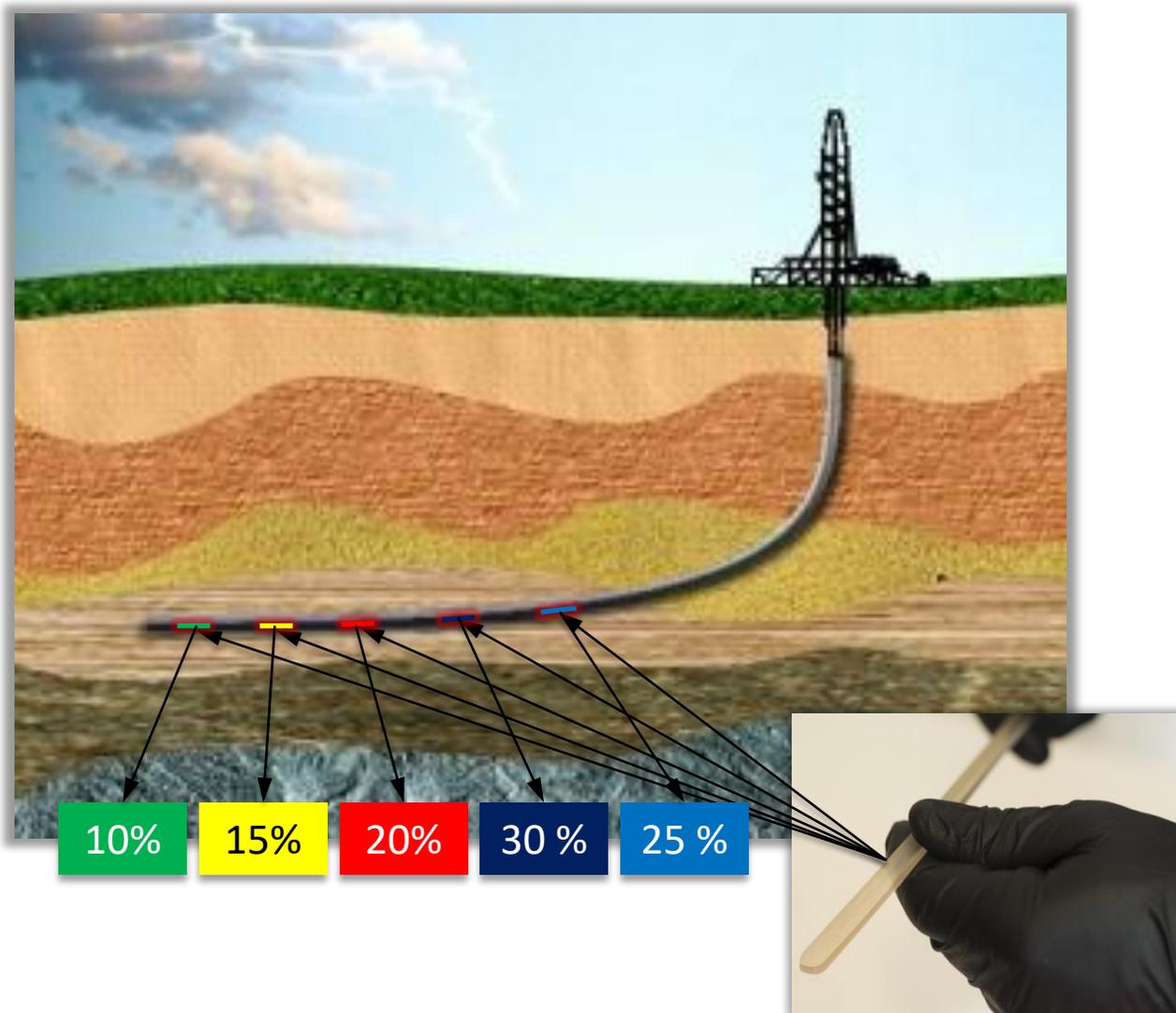
## INDUSTRY CHALLENGE: UNCERTAINTY



- How are my **zones performing** over time?
- Is my whole **lateral contributing**?
- Is my **lateral contribution** changing over time?
- Where is **water influx** occurring?



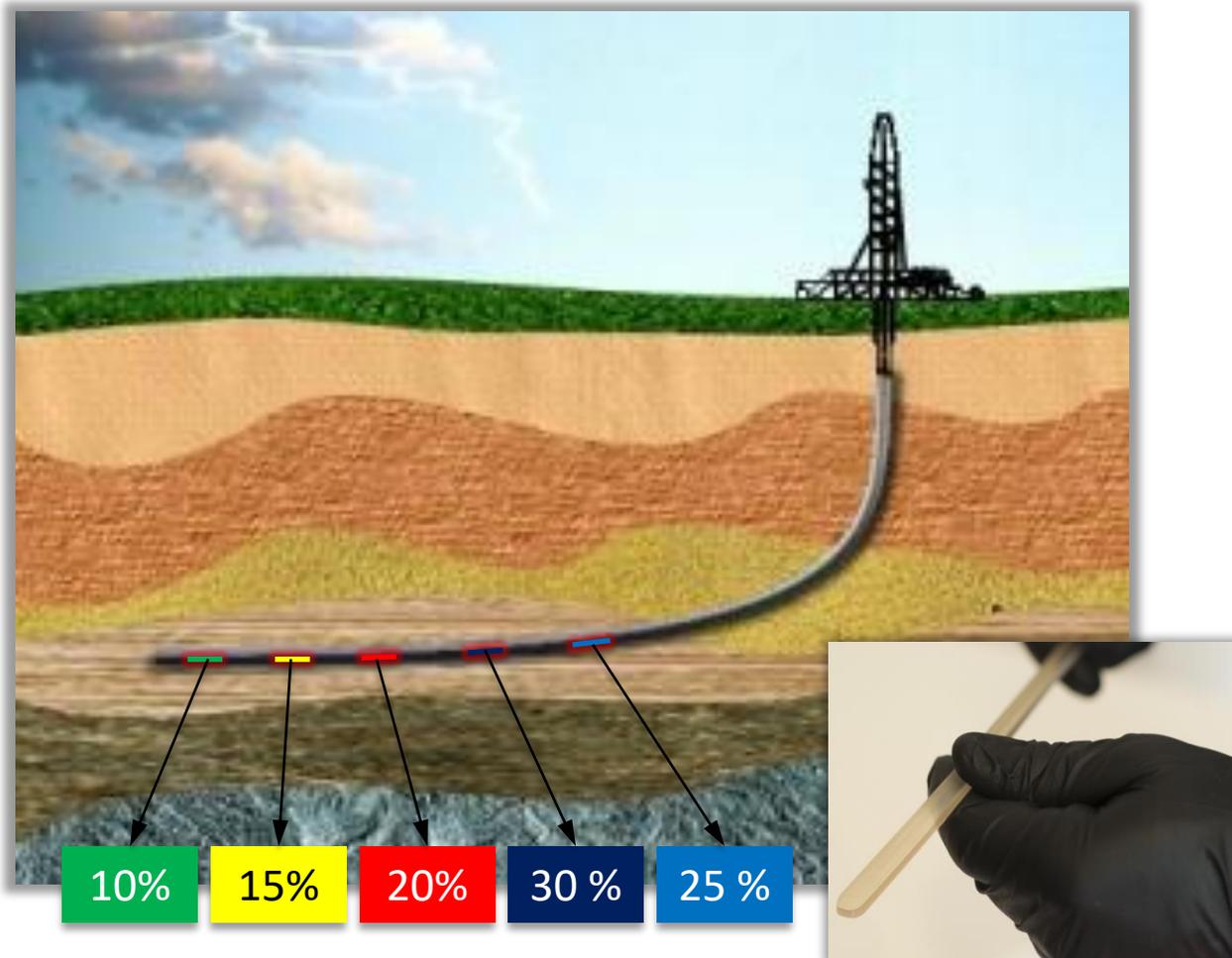
## SOLUTION: RESMAN INTELLIGENT TRACERS



- Inflow % and **zonal performance**
- Confirmation of **production**: early & long term
- Location of **water influx**



## SOLUTION: RESMAN INTELLIGENT TRACERS



- **Low-cost:** No added rig time. No expensive changes to completion. Repeated surveys with multi-year life.
- **Low-risk:** No intervention. No cables. PPT chemicals. No radiation.
- **Reliable:** Verified inflow models with 95% accuracy. Field proven in extreme conditions: 30k psi, 16 miles of tie back. 100 000 BFPD.



## APPLICABLE TRACER PATENTS FOR INFLOW MONITORING AND QUANTIFICATION

- **Reservoir Monitoring Patent:** Inflow monitoring using Intelligent Tracers  
- hydrocarbons and water ingress monitoring  
<https://www.google.com/patents/US8949029?cl=en>
- **Inflow Quantification Patent:** Zonal allocation of flow during start-ups using concentration decline functions and arrival time of tracer clouds  
<https://www.google.com/patents/US8949029?cl=en>

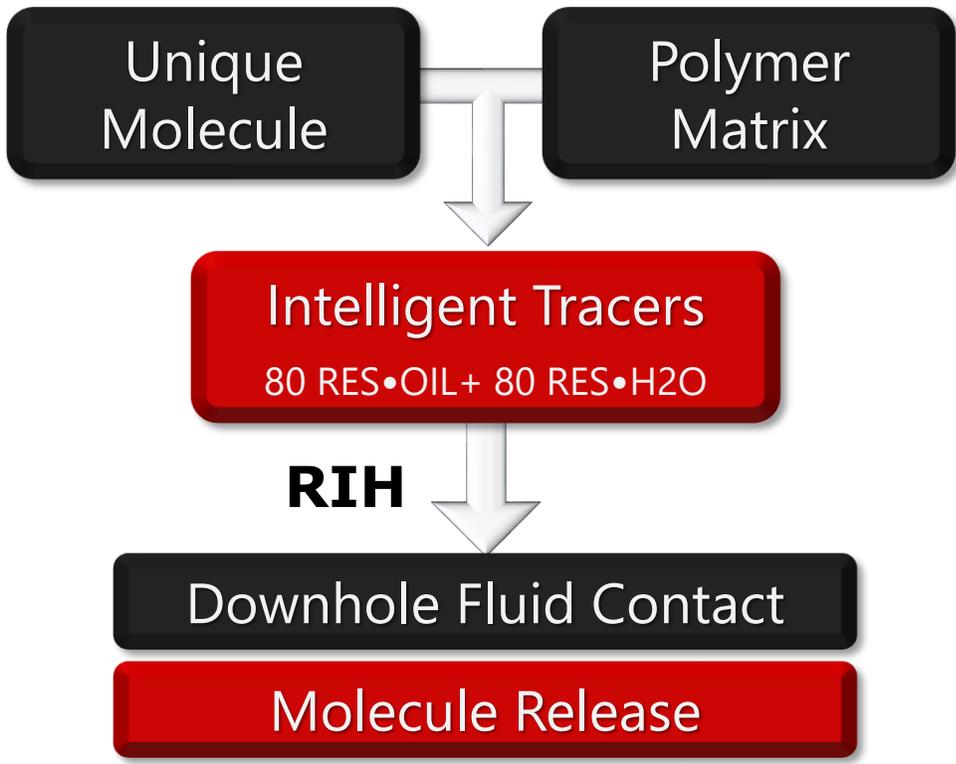


# How it Works

Technology Background

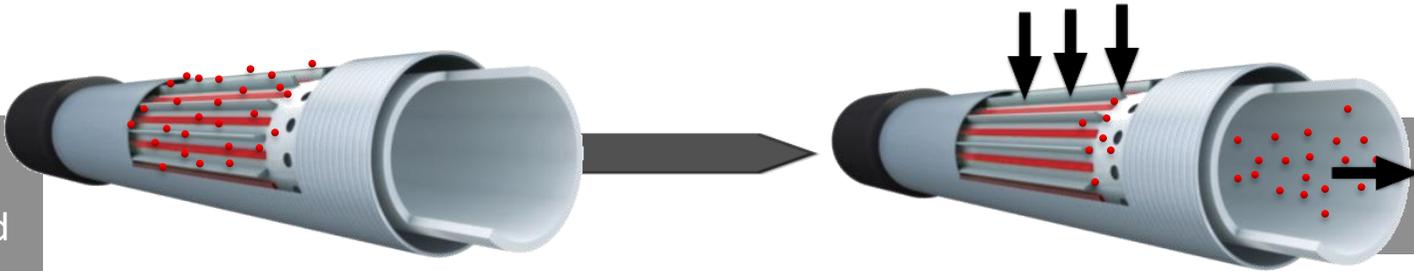


# HOW IT WORKS



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Molecules release in contact with target fluid and in static conditions



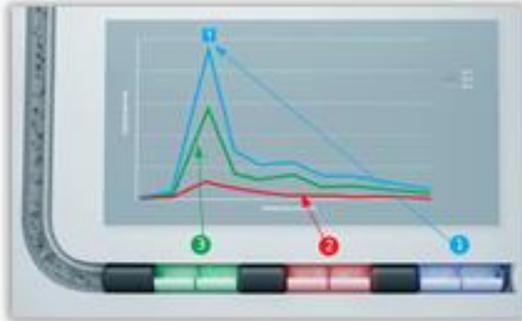
Well production carries molecules to surface



# FIELD DEVELOPMENT



On demand surveys, multi-year life



Up to  
**80 oil + 80 water**  
 unique signatures.  
 PPT detection.

No changes  
 to completion or  
 RIH procedure.  
 No extra rig time.

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# SAMPLING



# How it Works

Completion Integration with RESMAN

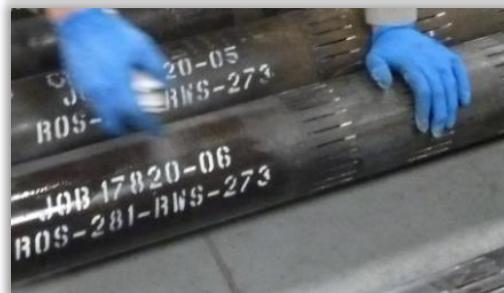
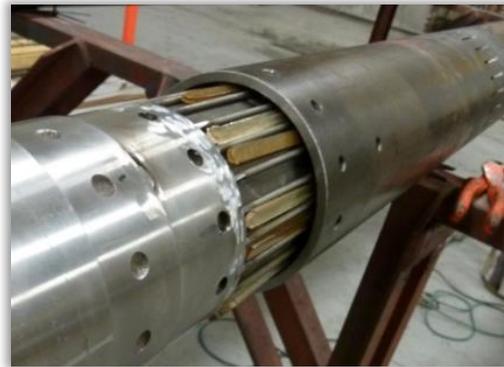


# COMPLETION INTEGRATION WITH RESMAN

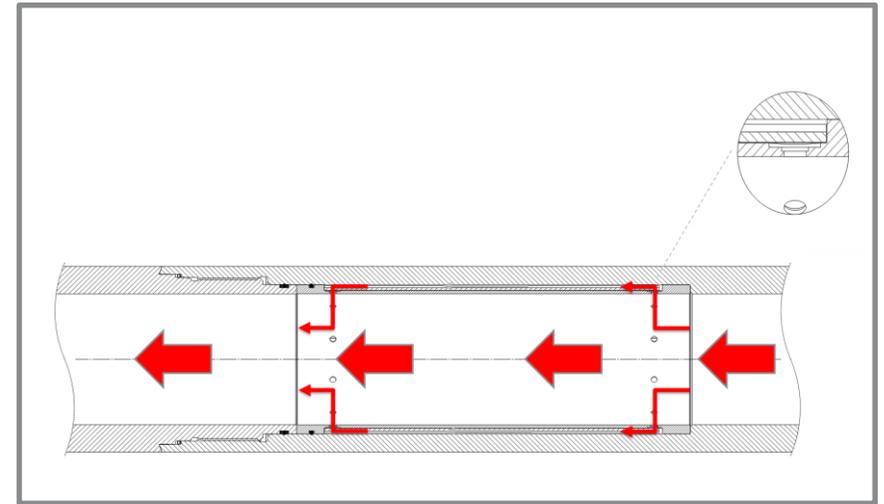
## Screens



## Pup joint carriers



## Plug and Perf - Unconventionals

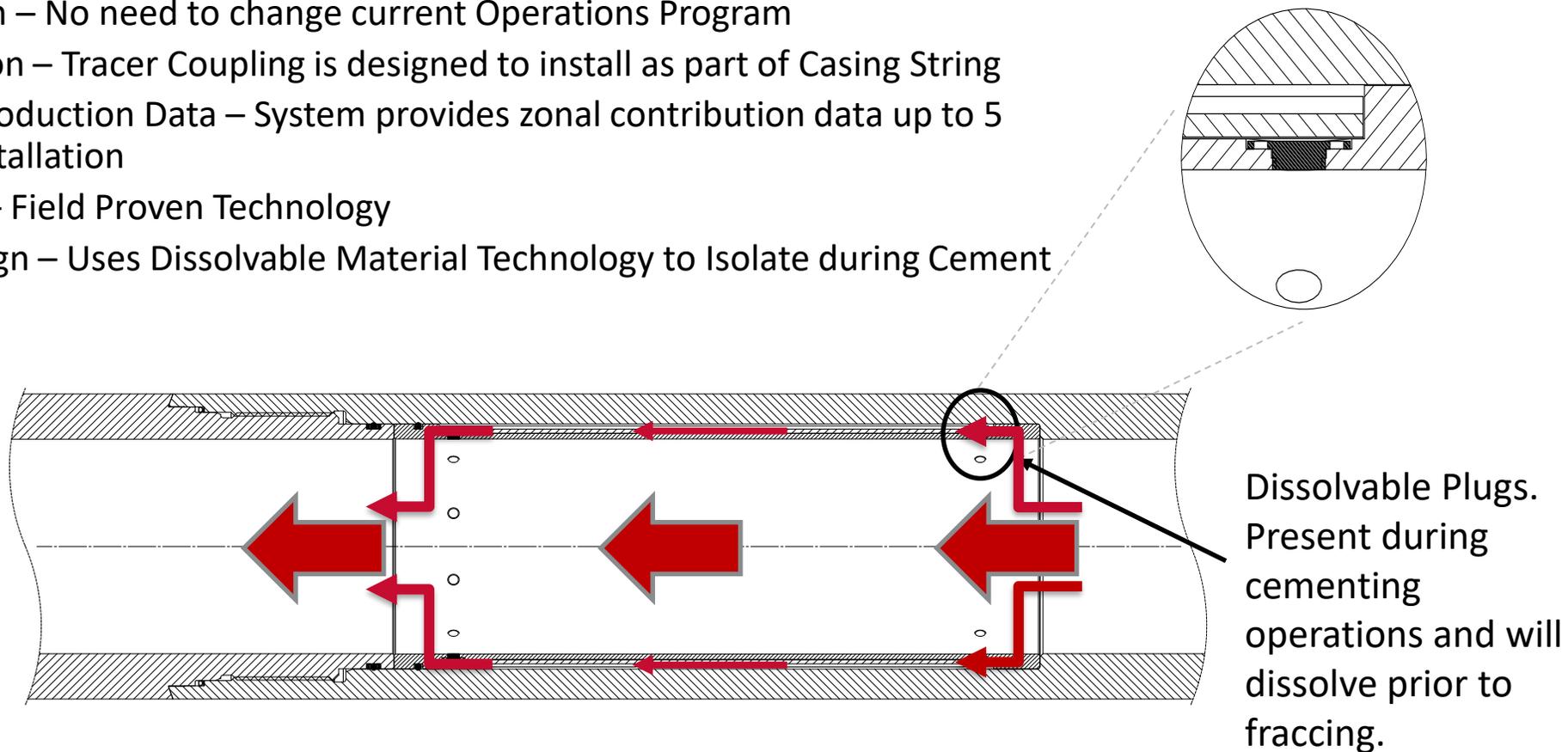


## Retrofit



# COMPLETION INTEGRATION WITH RESMAN – Plug and Perf

- Simple and Reliable: No moving parts!
- Passive System – No need to change current Operations Program
- Easy Integration – Tracer Coupling is designed to install as part of Casing String
- Continuous Production Data – System provides zonal contribution data up to 5 years after Installation
- Track Record – Field Proven Technology
- Patented Design – Uses Dissolvable Material Technology to Isolate during Cement Job

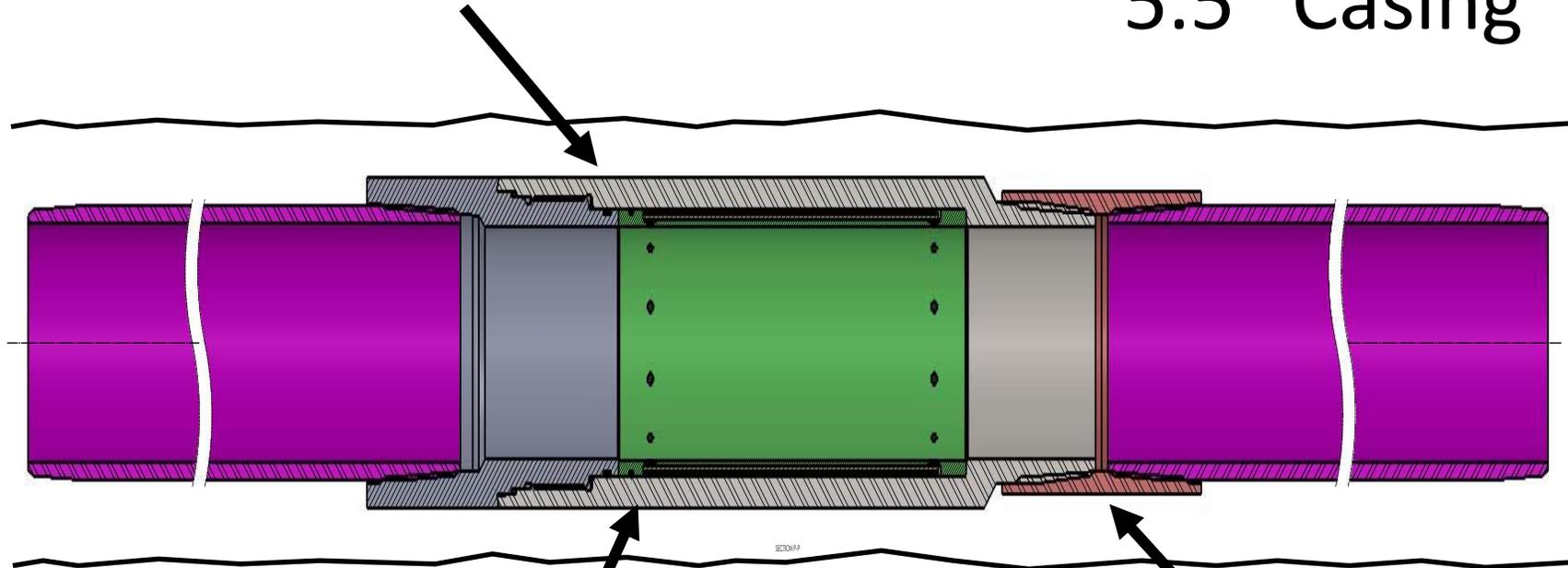




# COMPLETION INTEGRATION WITH RESMAN – Plug and Perf

## Tracer Coupling™

## 5.5" Casing

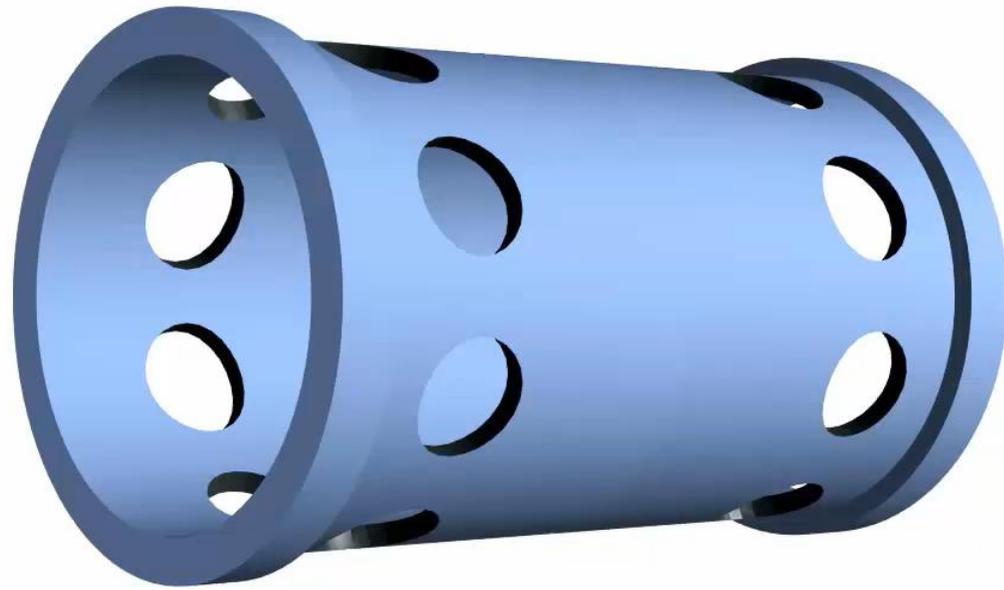


OD: 6.65"  
slightly larger than  
casing coupling

Casing  
Coupling  
OD Range : 6.30" – 6.05"



# TRACER COUPLING

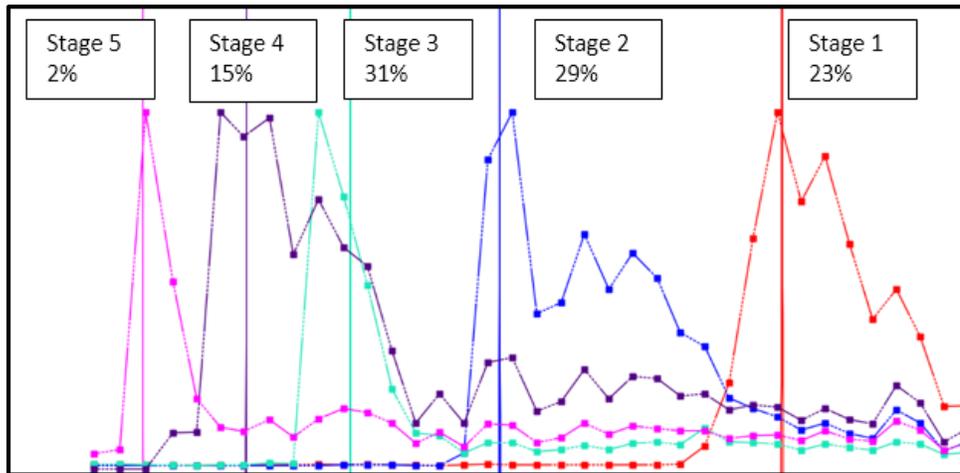




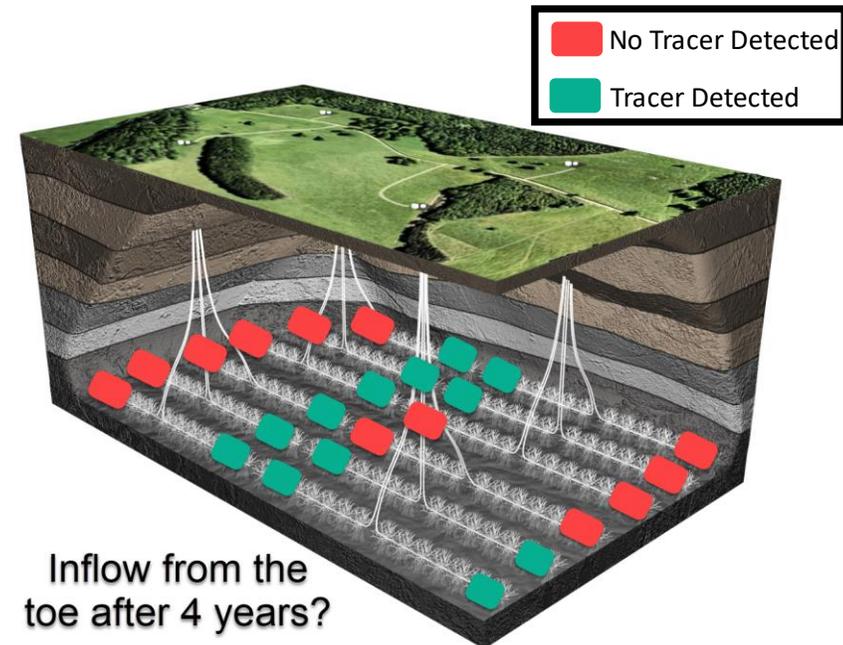
# Is the whole well flowing over time? (Flow Continuity Survey) How much is flowing from each segment? (Percent Inflow Distribution Survey)

Customizable to your data needs:

Percent Inflow Distribution from multiple segments of the lateral of a single well.



Verification of Flow Continuity via a single monitoring location across multiple wells.

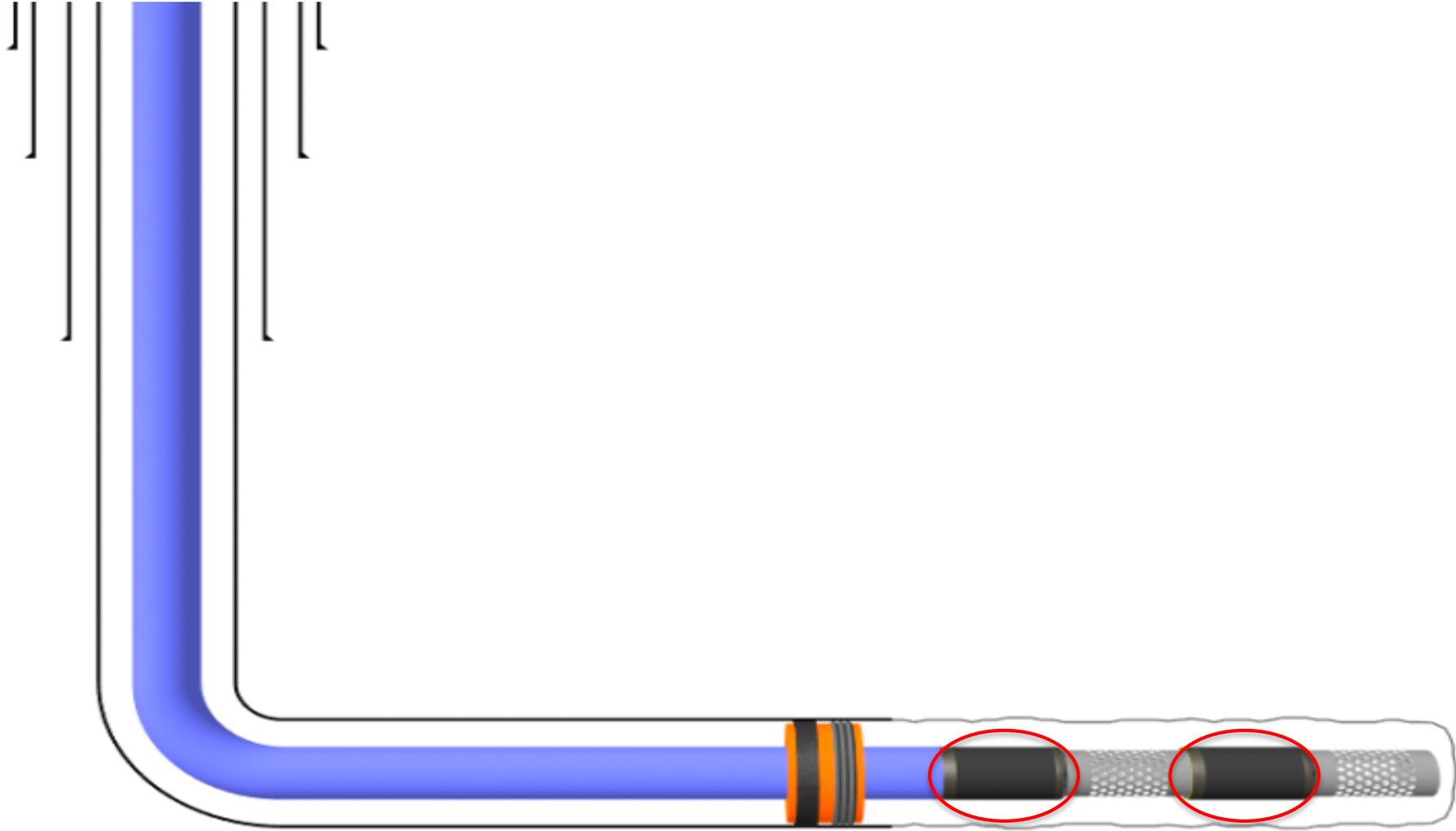


# How it Works

Percent Inflow Distribution – Tracer Arrival Method

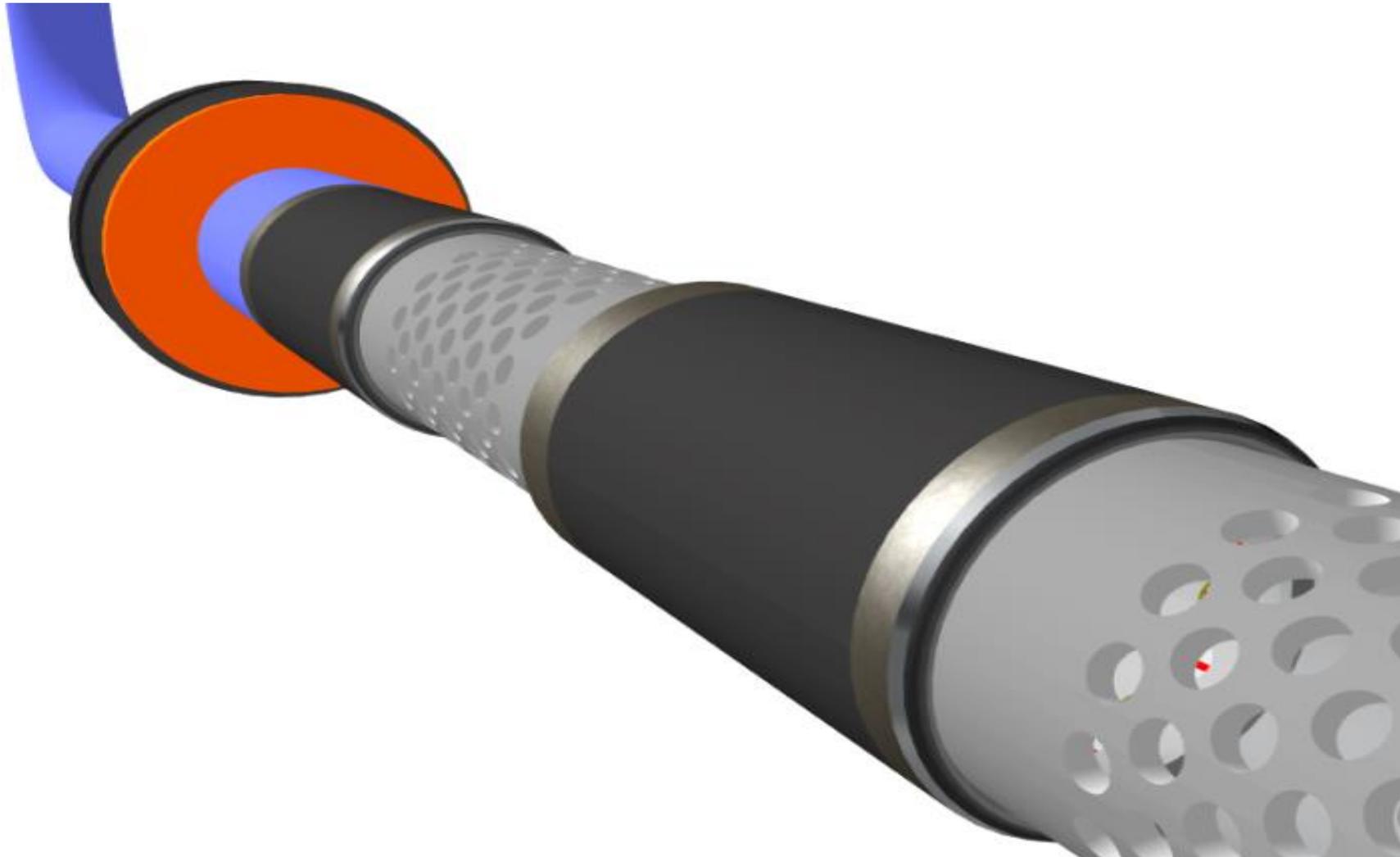


# TRACER ARRIVAL METHOD



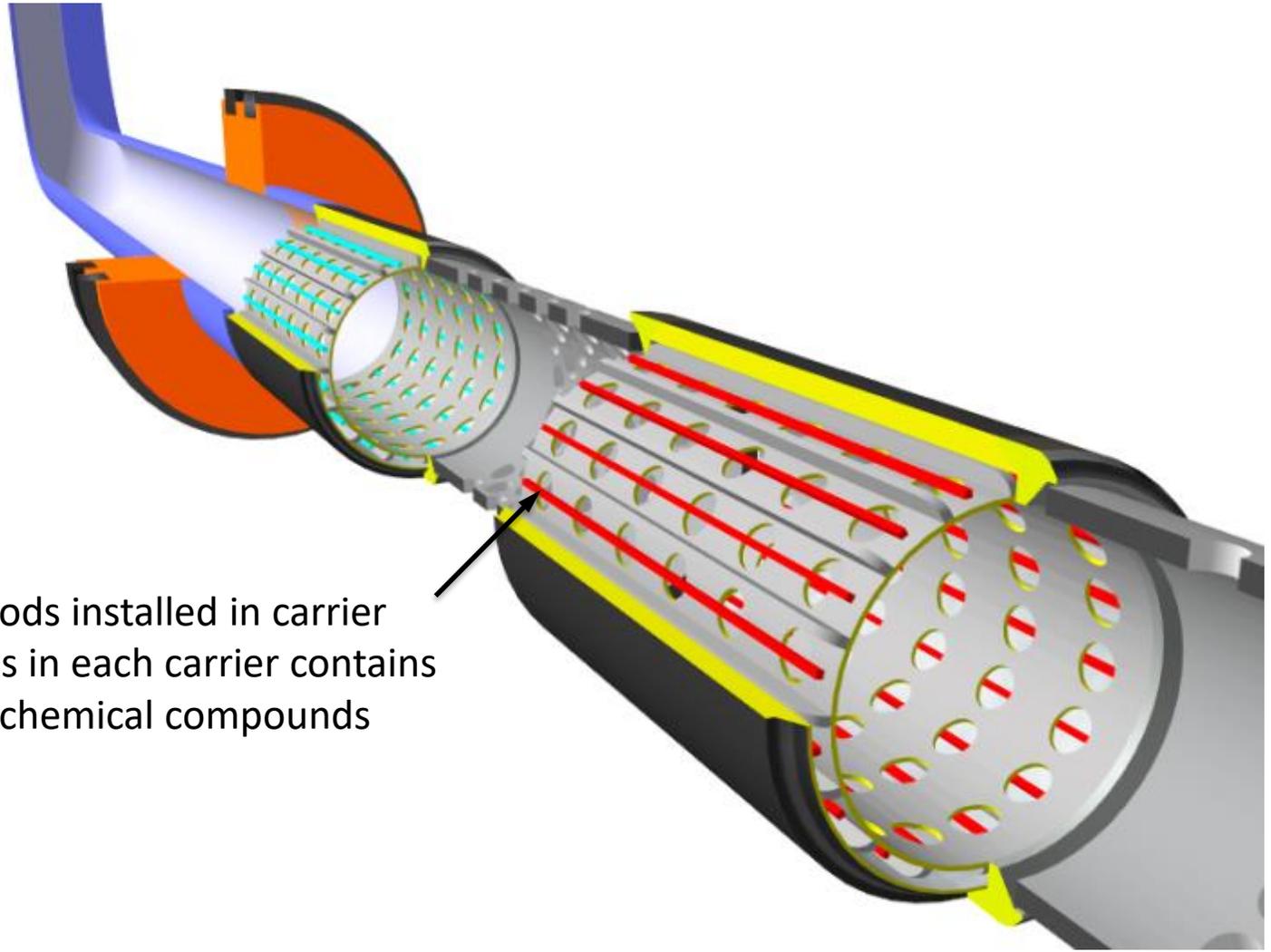


## TRACER ARRIVAL METHOD – DOWNHOLE PERSPECTIVE





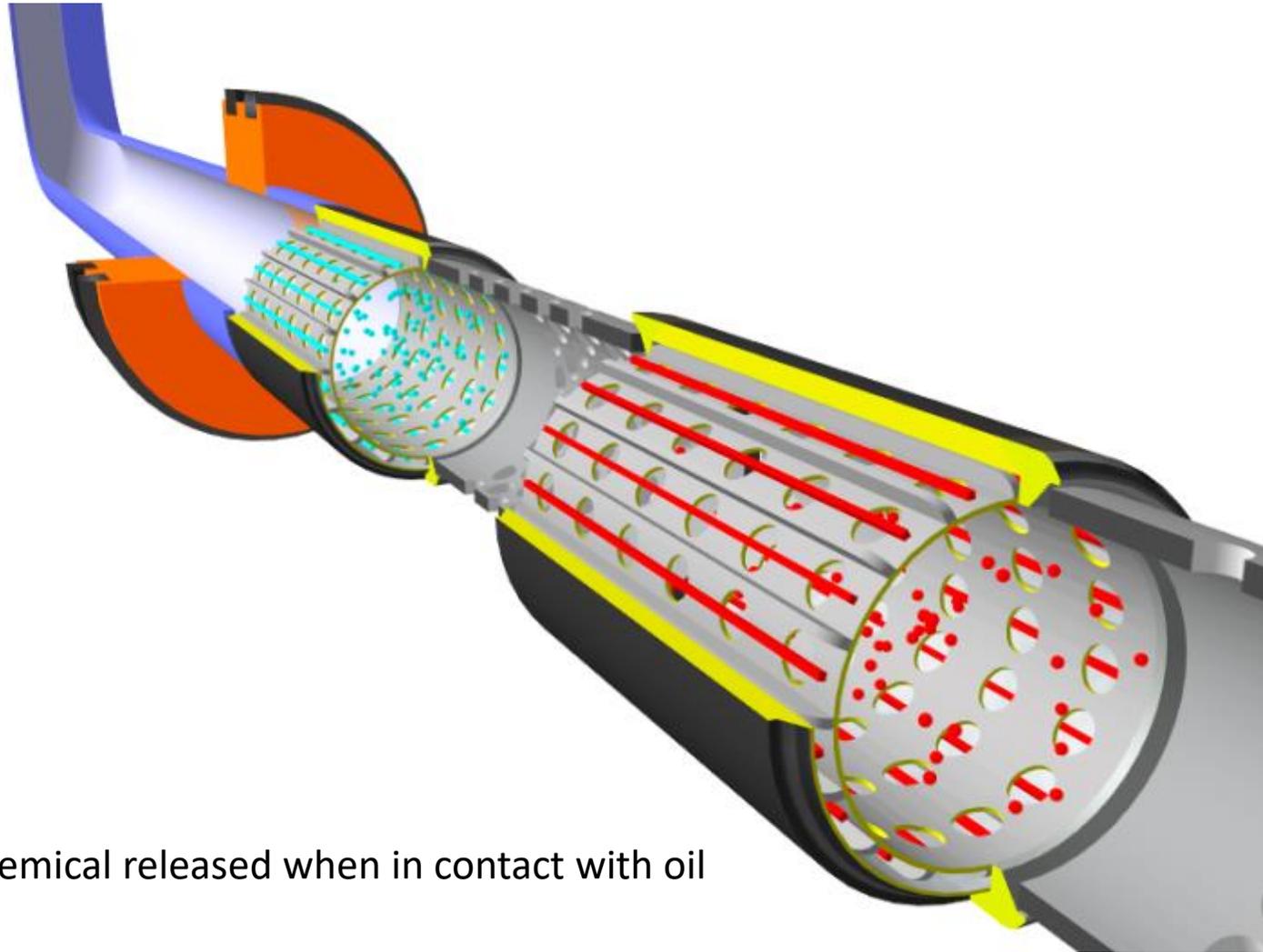
## TRACER ARRIVAL METHOD – CUT AWAY OF CARRIER



- Tracer rods installed in carrier
- The rods in each carrier contains unique chemical compounds



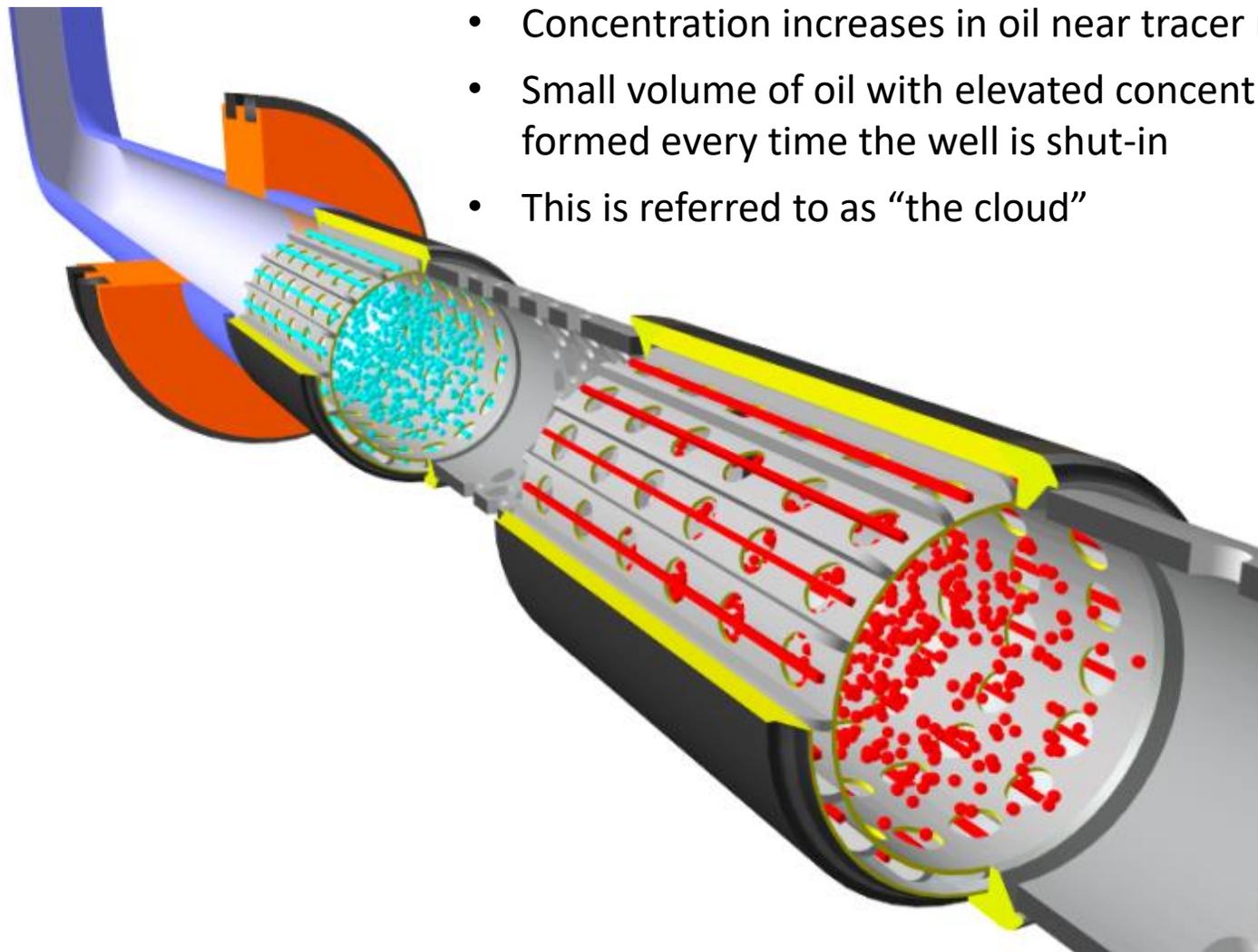
## TRACER ARRIVAL METHOD – STATIC CONDITIONS



- Tracer chemical released when in contact with oil



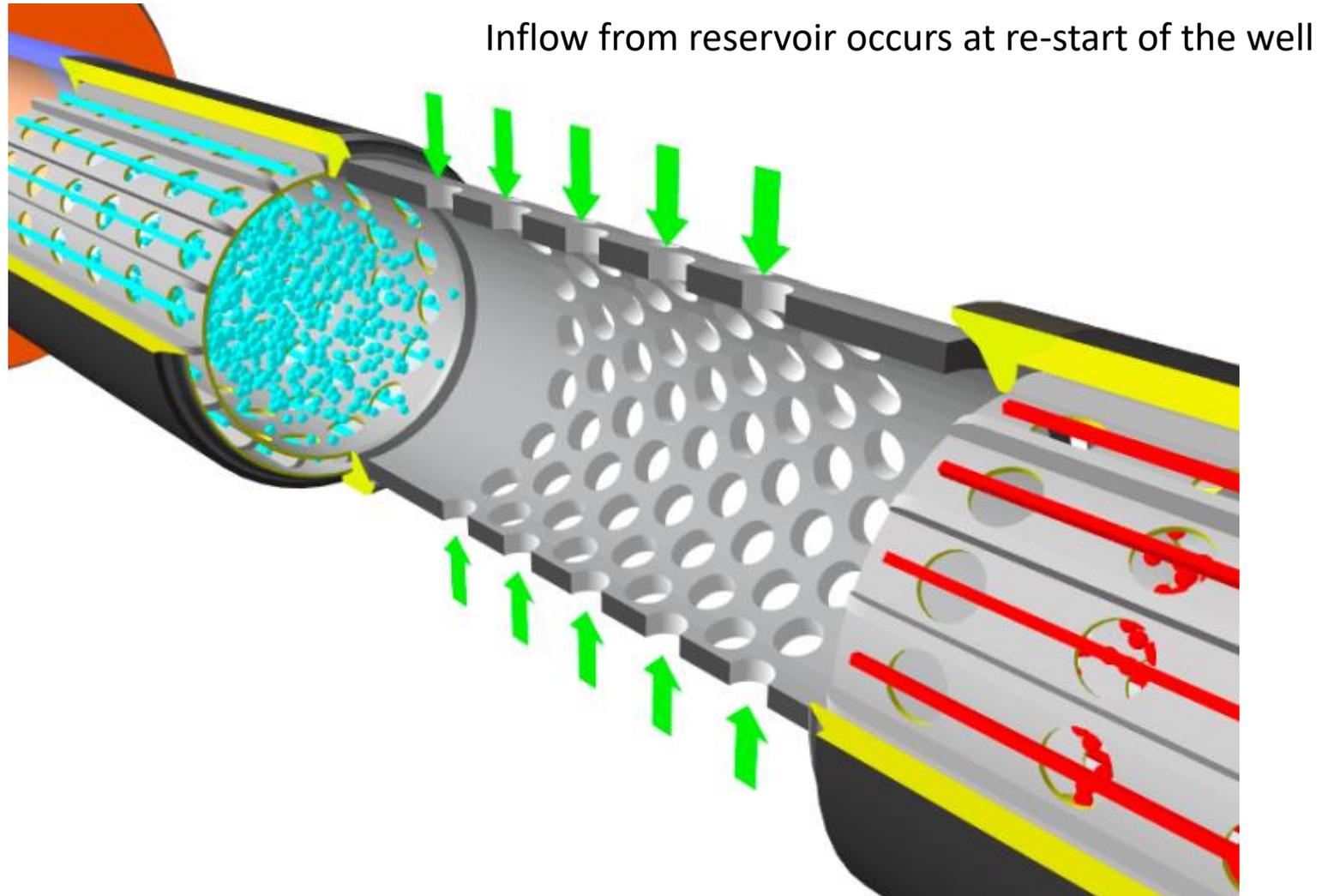
## TRACER ARRIVAL METHOD – CREATING THE CLOUD



- Concentration increases in oil near tracer rods
- Small volume of oil with elevated concentration is formed every time the well is shut-in
- This is referred to as “the cloud”

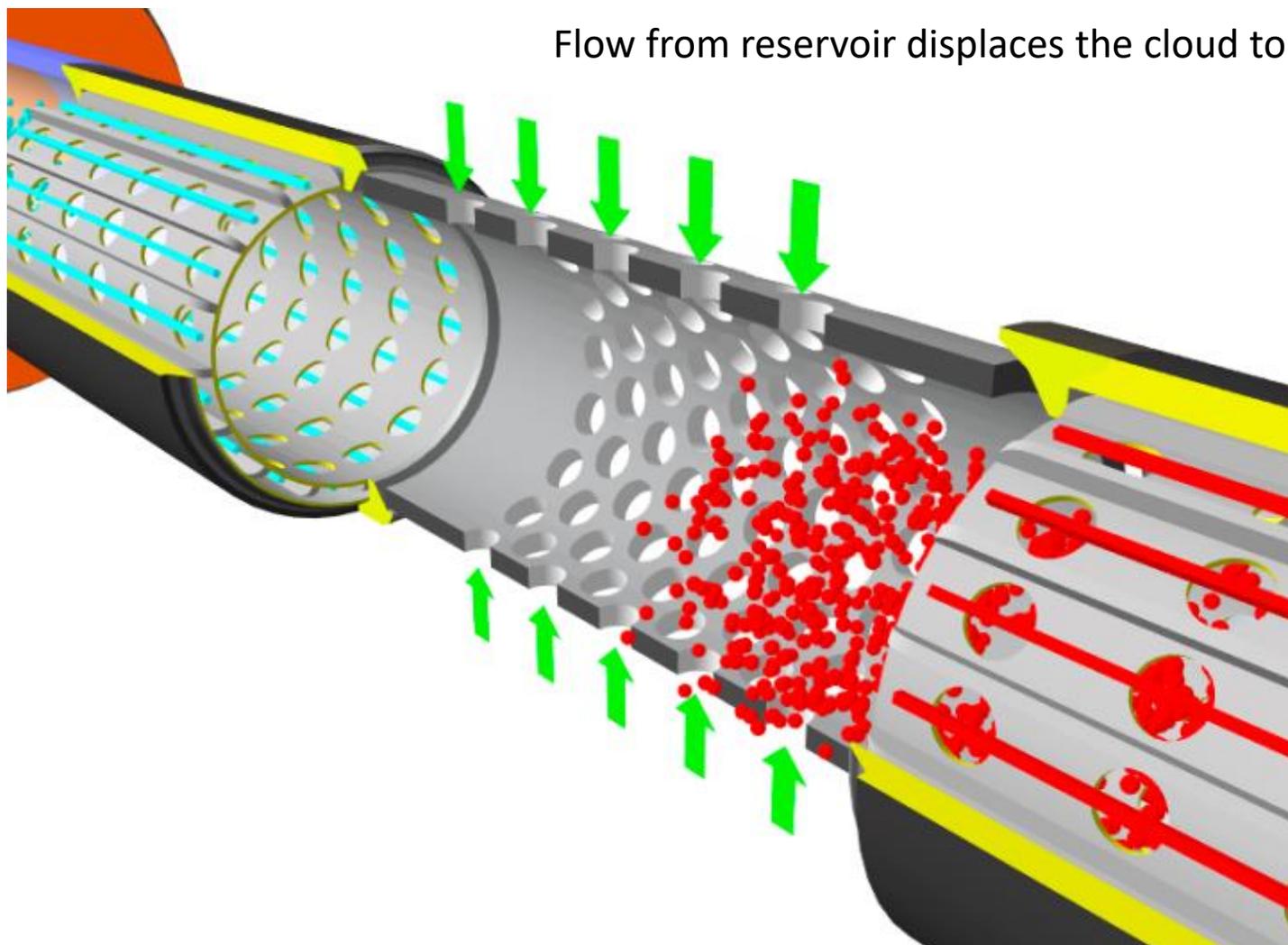


## TRACER ARRIVAL METHOD – INFLOW BEGINS



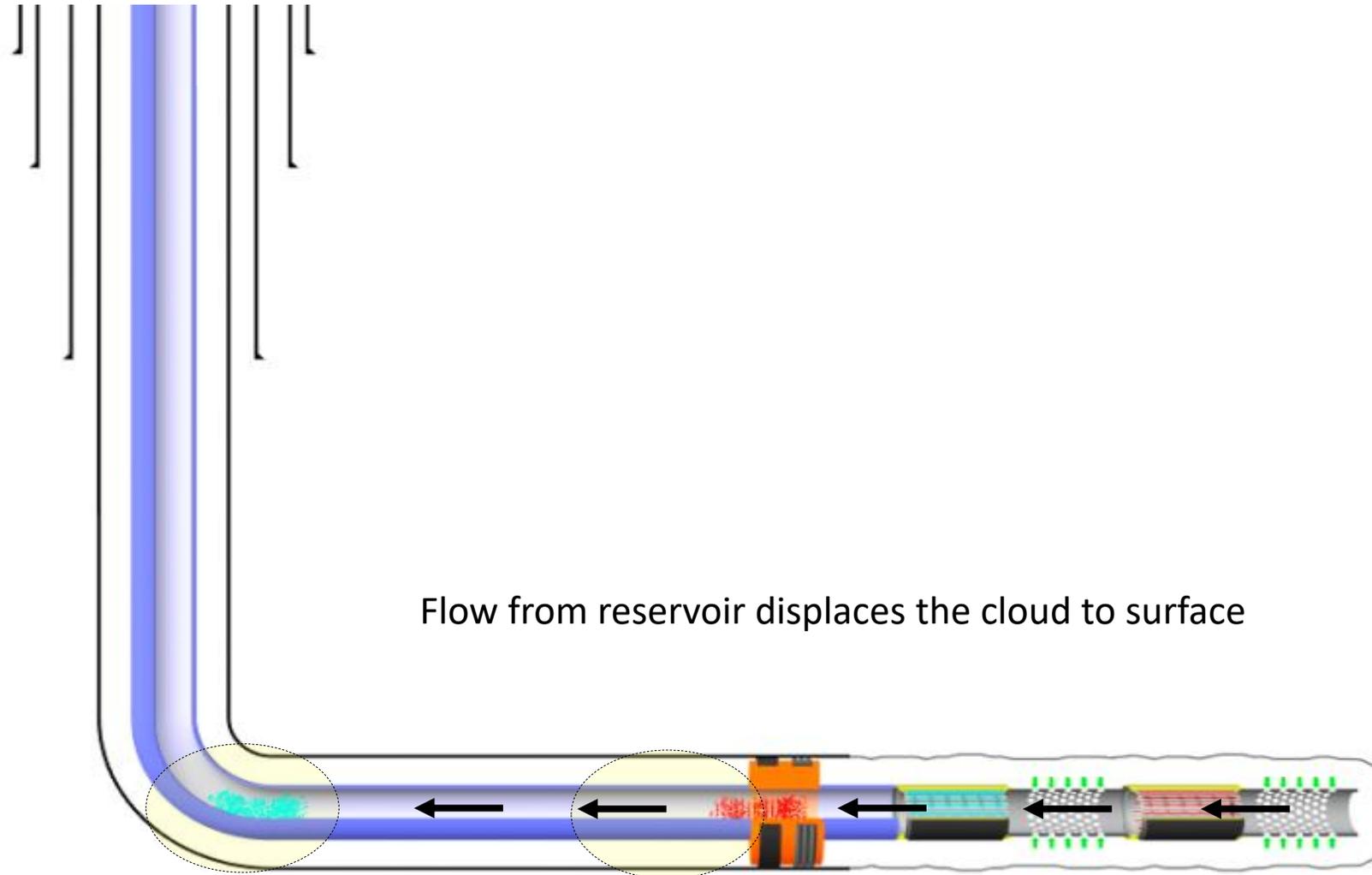


## TRACER ARRIVAL METHOD – DISPLACING THE CLOUD



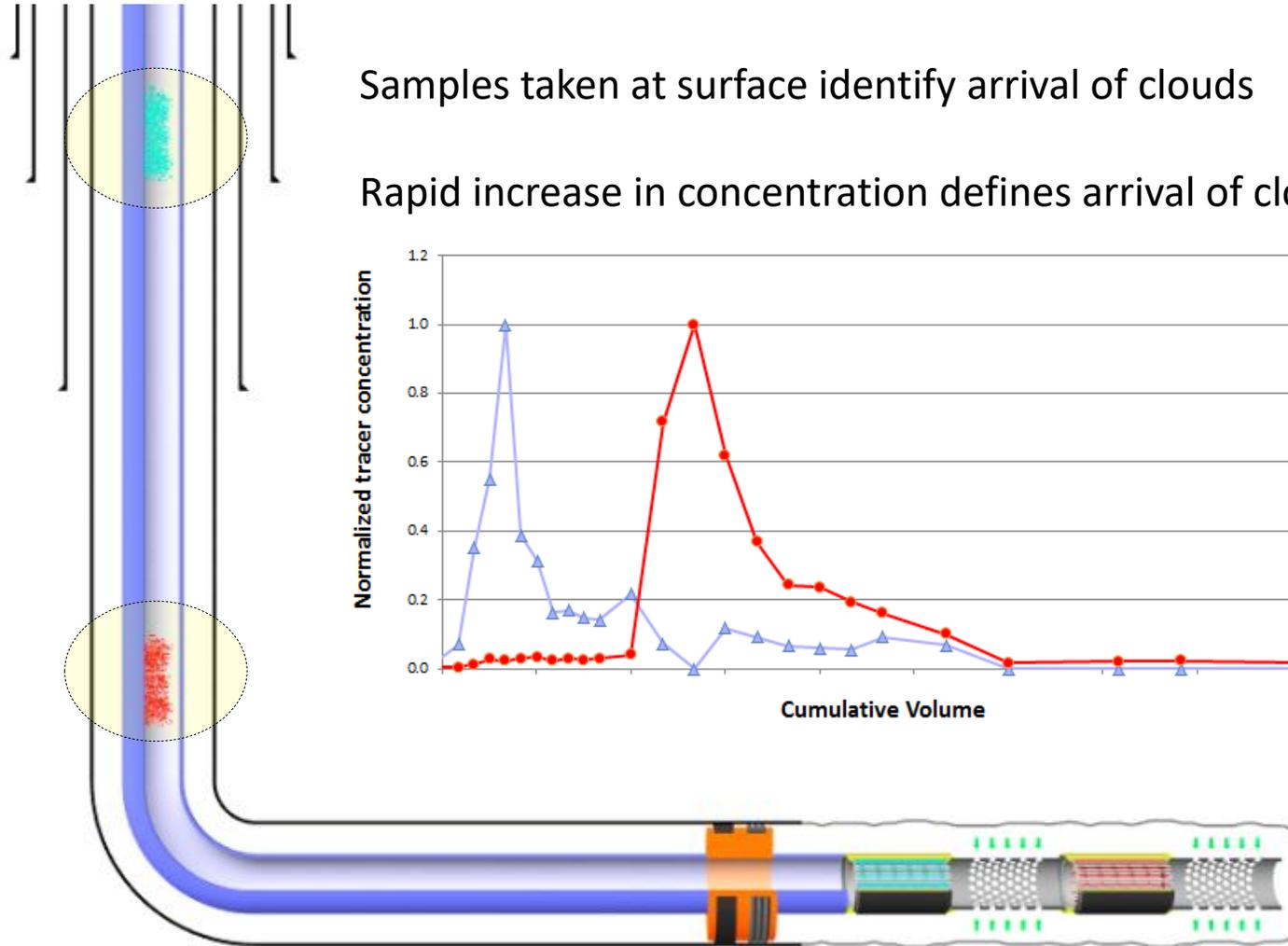


# TRACER ARRIVAL METHOD – DISPLACING THE CLOUD



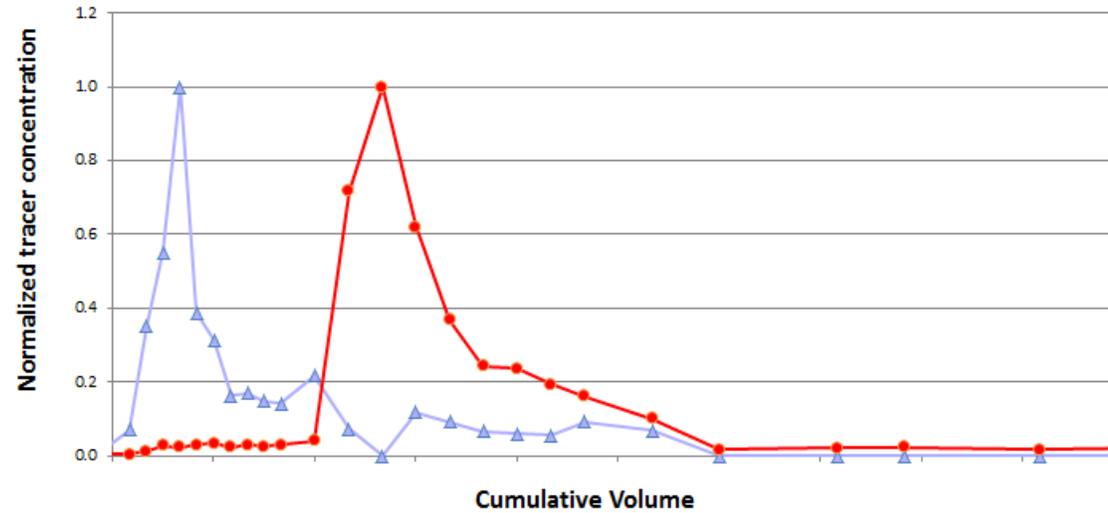


# TRACER ARRIVAL METHOD – SURFACE SAMPLING



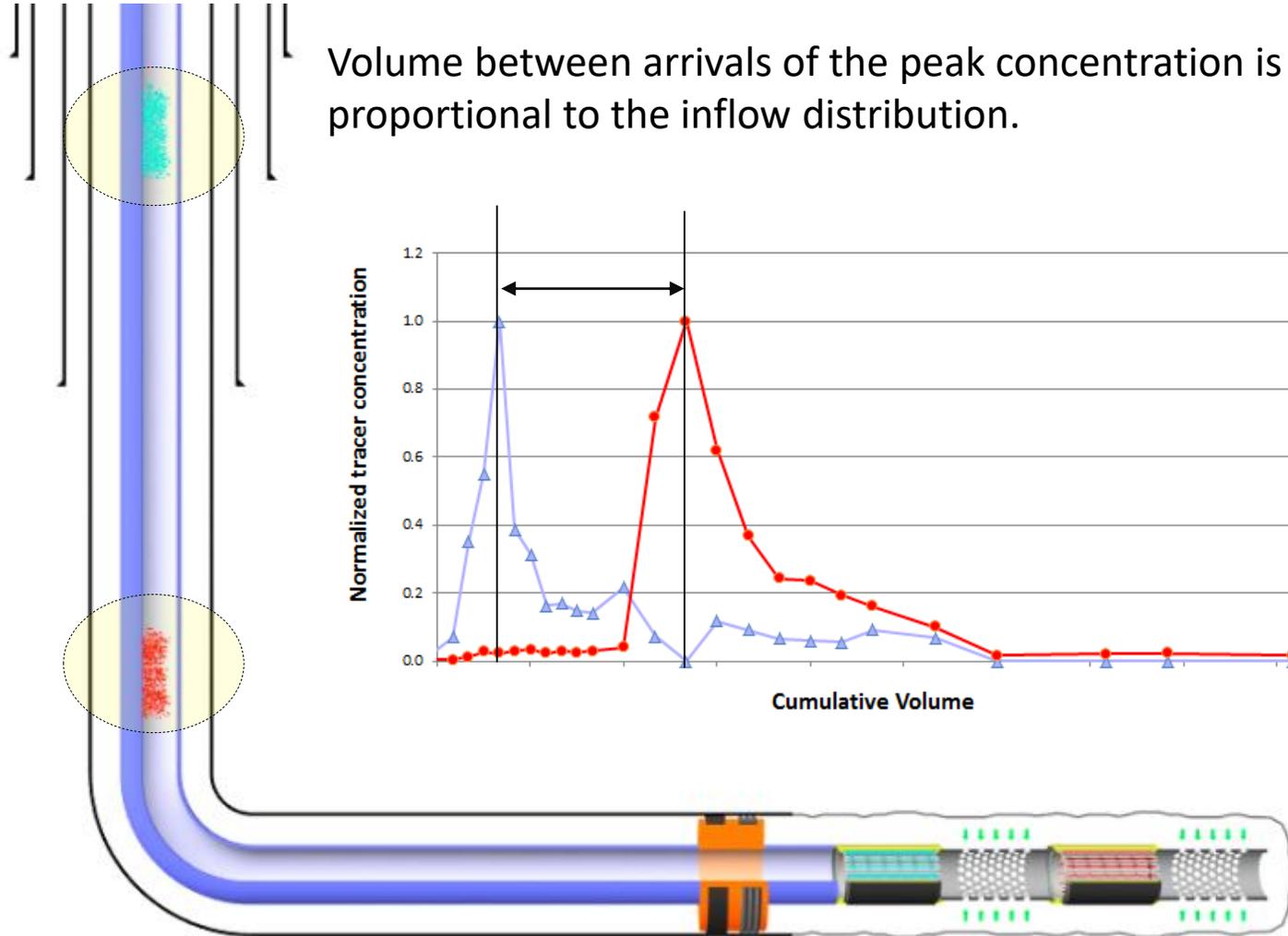
Samples taken at surface identify arrival of clouds

Rapid increase in concentration defines arrival of cloud





# TRACER ARRIVAL METHOD – INFLOW DISTRIBUTION



# Field Example

Eagle Ford Shale



# UNCONVENTIONAL APPLICATION: PLUG AND PERF

## Challenges

- Quantify inflow along horizontal
- Low-cost and repeatable solution
- No intervention

## Solution: RESMAN iTrace

- Five (5) iTrace carriers installed along the horizontal for inflow quantification
- Thus, each iTrace monitored production from 6 stages, **multi-year life**

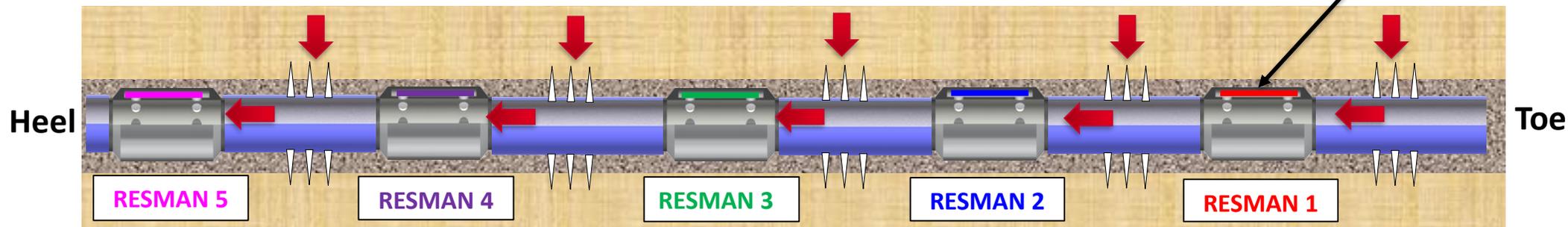
Plug & perf, 30 stages

TD = approx. 17,200 ft (5243m)

Lateral length = approx. 6,000 ft (1829m)

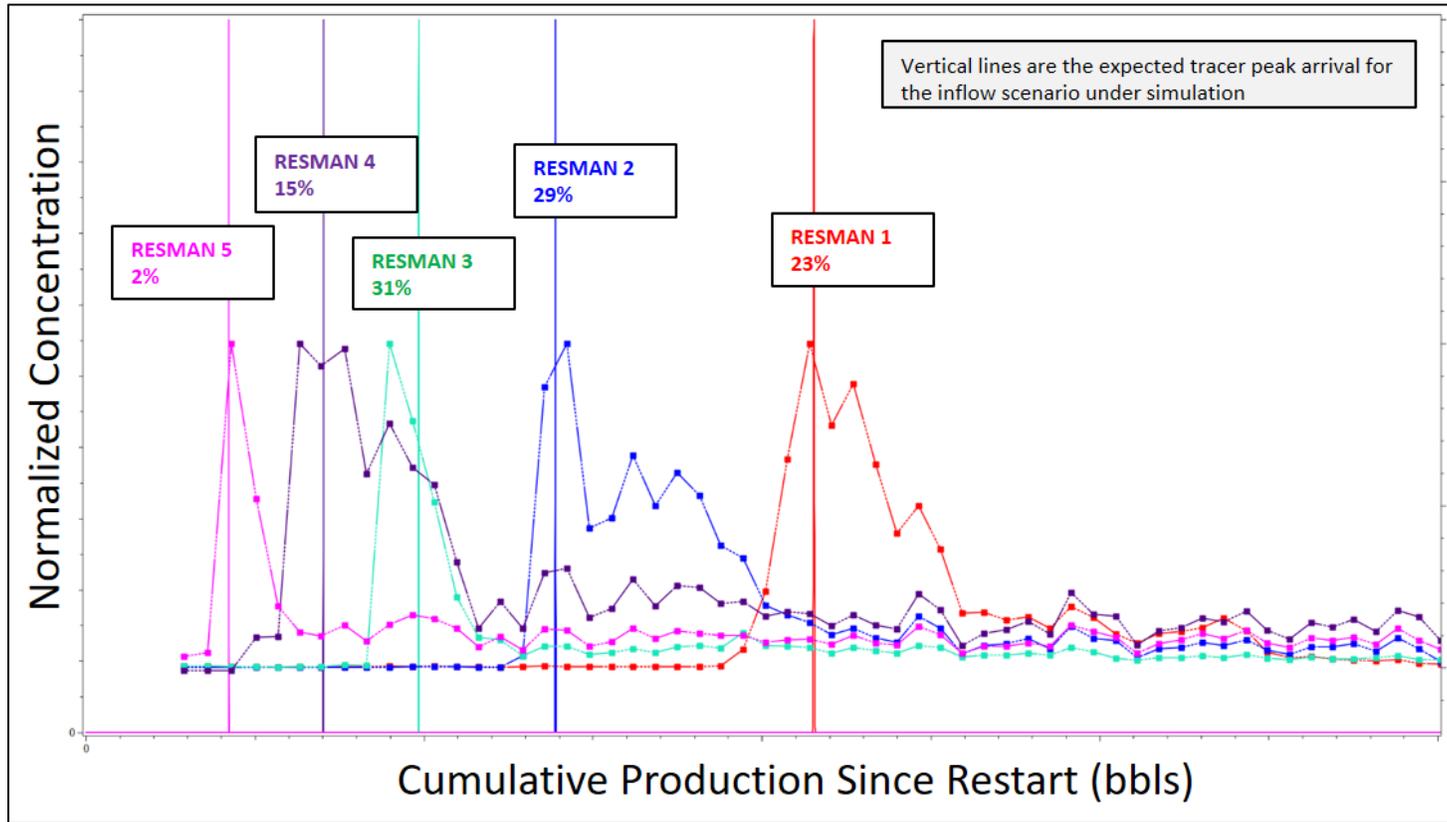


iTrace carriers

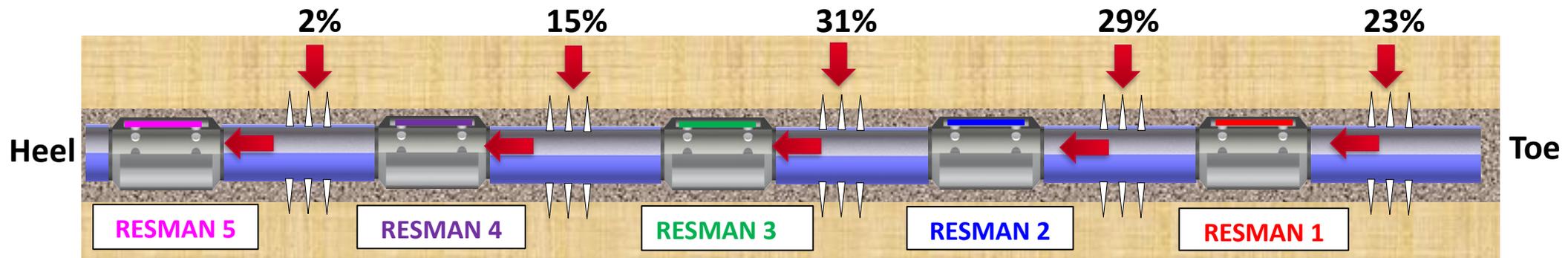




# UNCONVENTIONAL APPLICATION: PLUG AND PERF



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# How it Works

Flow Continuity



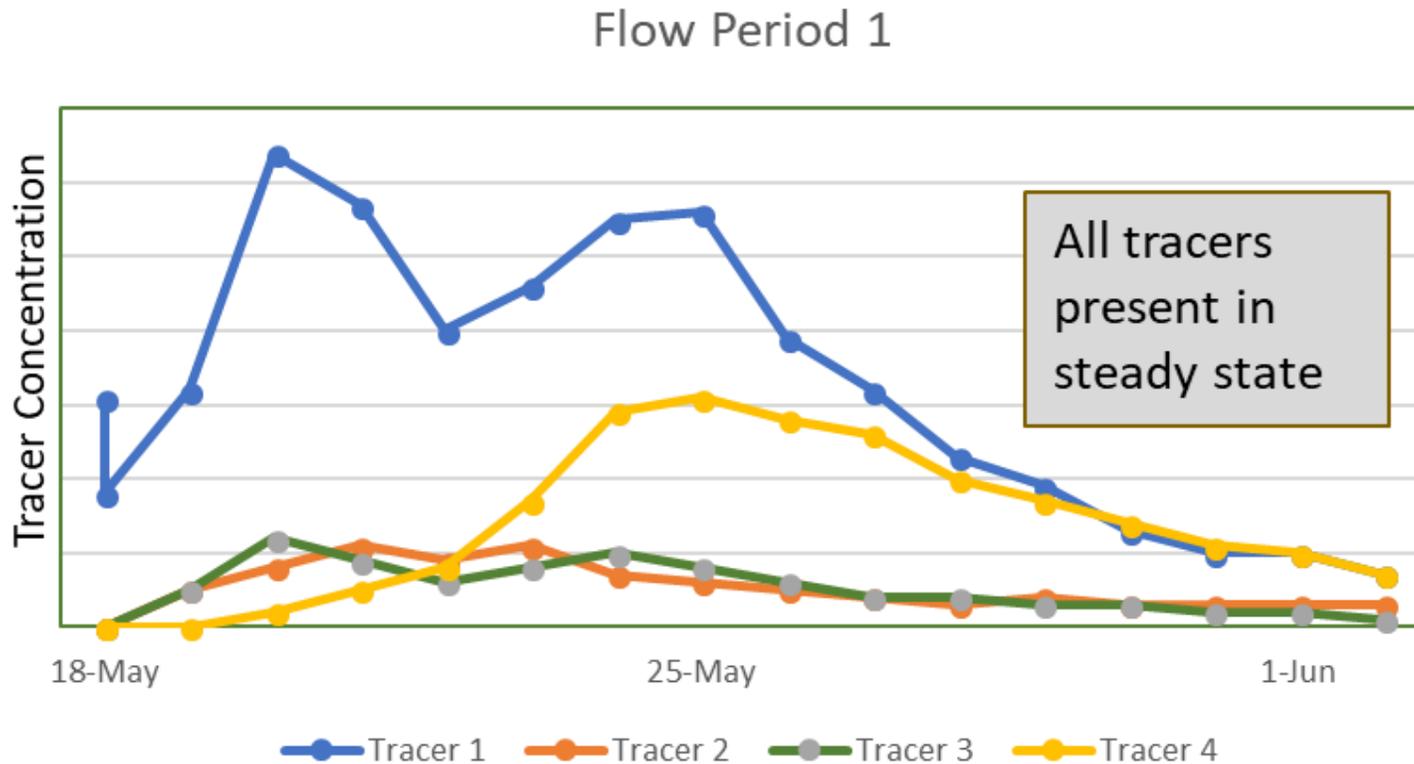
## STEADY STATE ANALYSIS

- During normal well production tracers can be used to verify flow from sections of the lateral.
- Changes in tracer signal can be correlated to changes in production to identify the location of the changes downhole.
- Steady state analysis is conducted with no intervention and no well shut-in required.



# CASE STUDY – STEADY STATE ANALYSIS

*Steady State Analysis – Wellbore Connectivity*

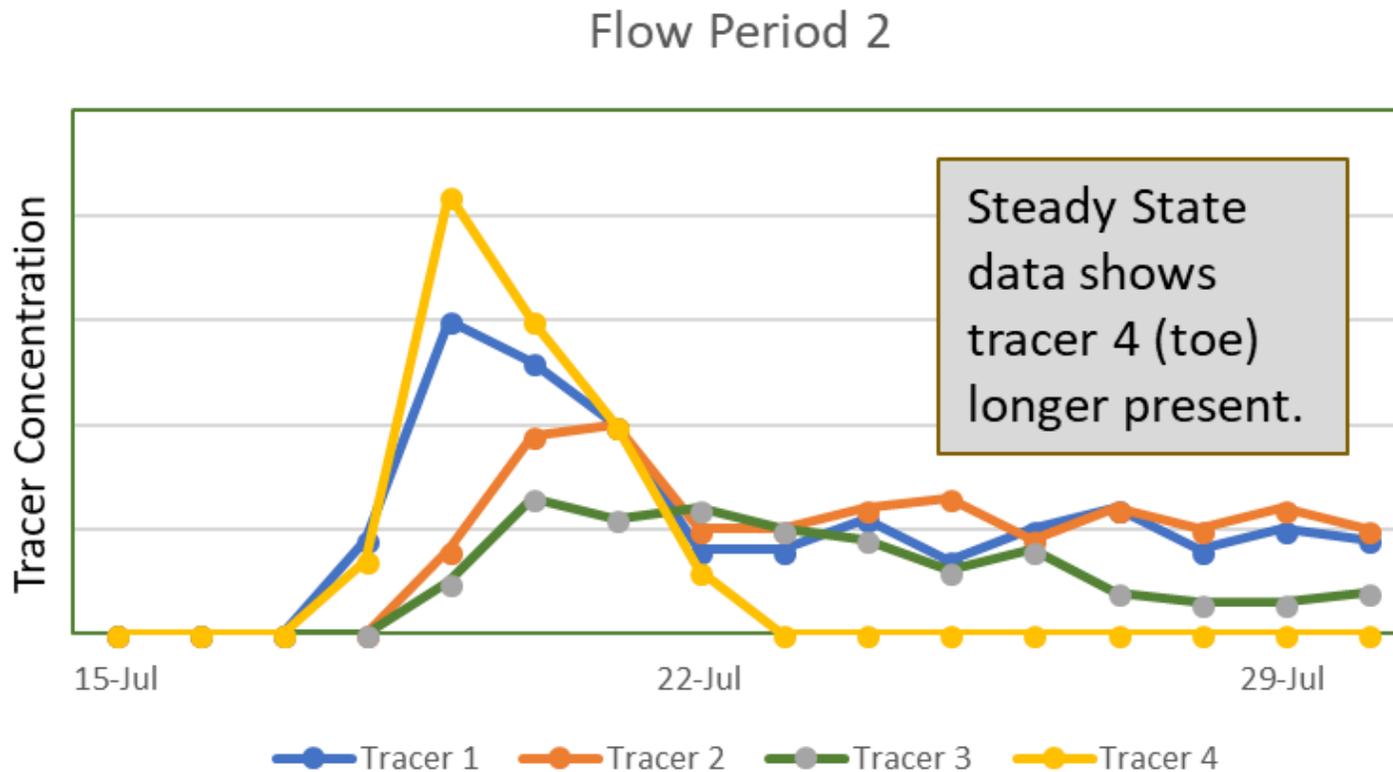


- Tracer Data from initial well production.
- Data shows oil production coming from all monitored zones.



## CASE STUDY – STEADY STATE ANALYSIS

*Steady State Analysis – Wellbore Connectivity*

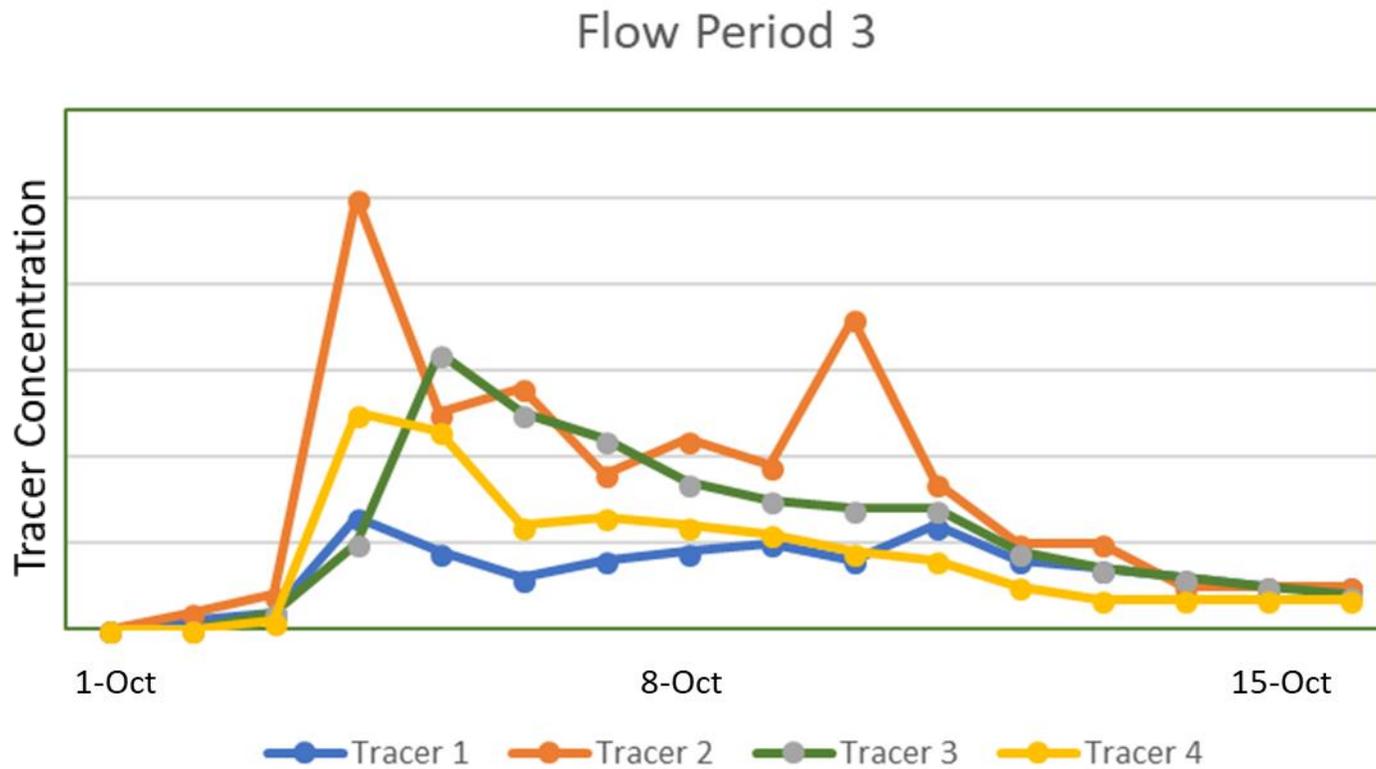


- Ongoing tracer analysis showed that oil was no longer flowing from the toe of the well (tracer 4).
- Tracer analysis supports intervention.



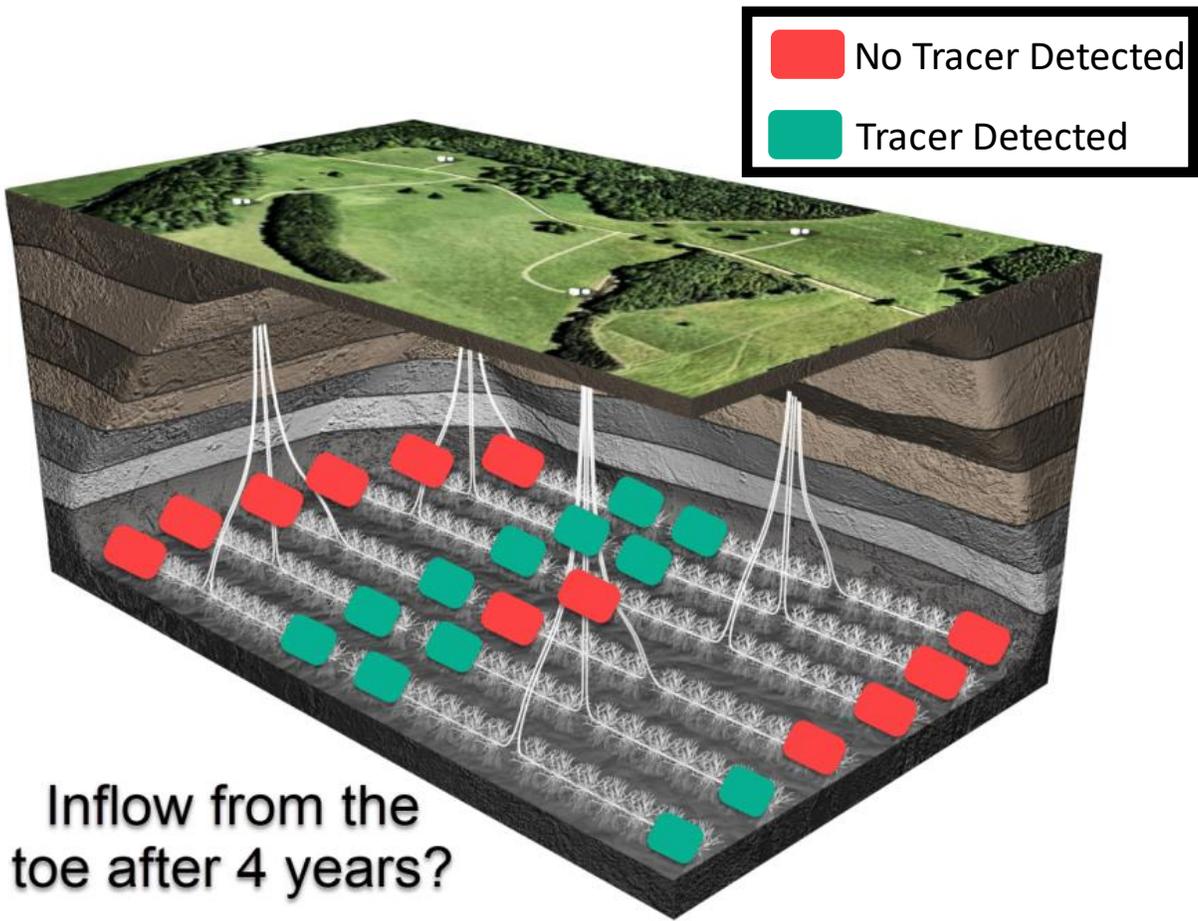
## CASE STUDY – STEADY STATE ANALYSIS

*Steady State Analysis – Wellbore Connectivity*



- Following intervention the tracer data is analyzed again.
- Analysis shows that all 4 oil tracers are present again.

# A TOE INFLOW VERIFICATION – FIELDWIDE FLOW ASSURANCE



Answers the question:  
“Is my whole lateral contributing?”

- Single tracer in the toe of each well.
- 2-3 samples per well a few times a year with no shut-in required.
- All wells analyzed as a single analysis run.

# Contact

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# Questions & Comments

