

sofoil

**MULTIWELL RETROSPECTIVE TESTING  
(MRT) –**

**RESERVOIR UNDERSTANDING WITHOUT  
PRODUCTION DEFERMENT**

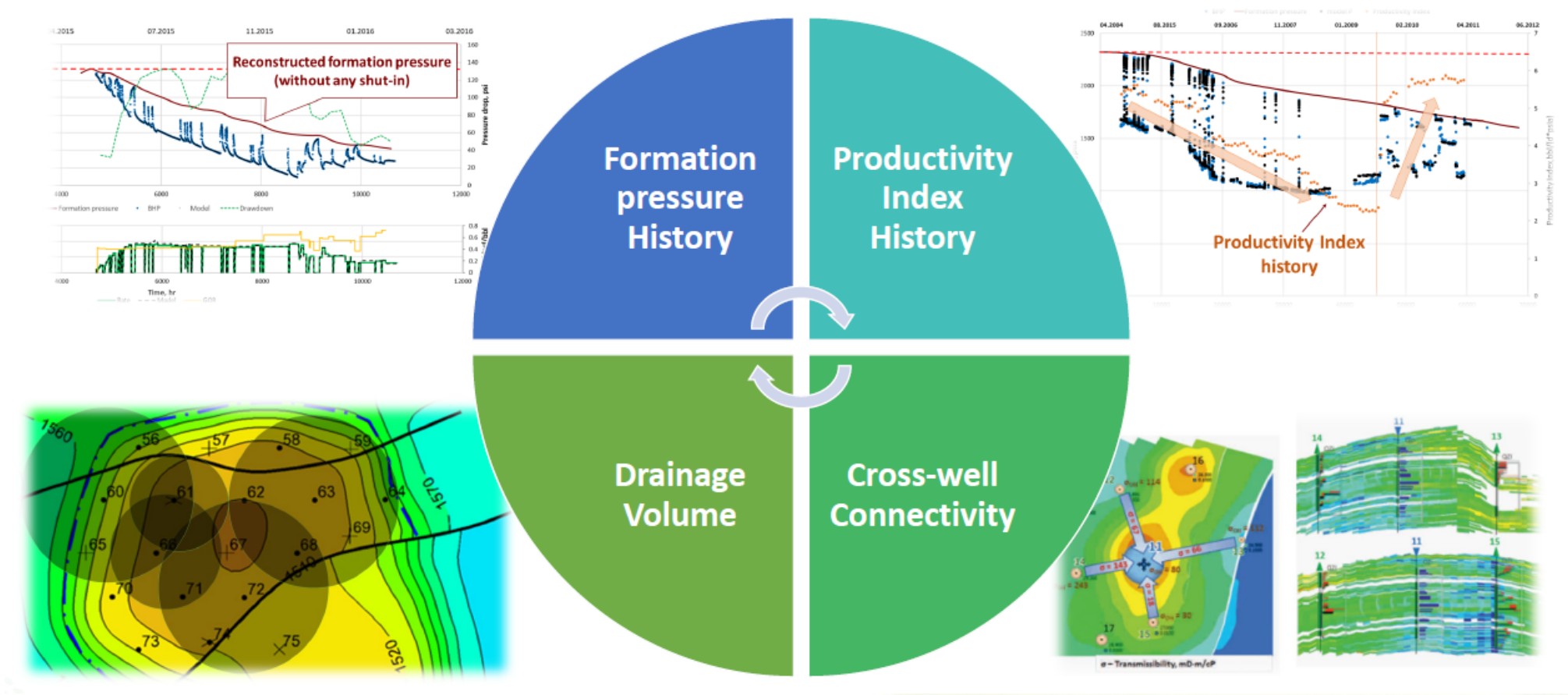


- **Liquid production decline**
- **Water cut increase**
- **Unclear response on waterflood implementation**
- **Unclear geology**

# MRT CONCEPT



**Multiwell Retrospective Test (MRT)** is a **service** that analyses rate and pressure historical data by the means of multiwell deconvolution – a mathematical algorithm that independently evaluates commutative pressure variations that come from each individual well



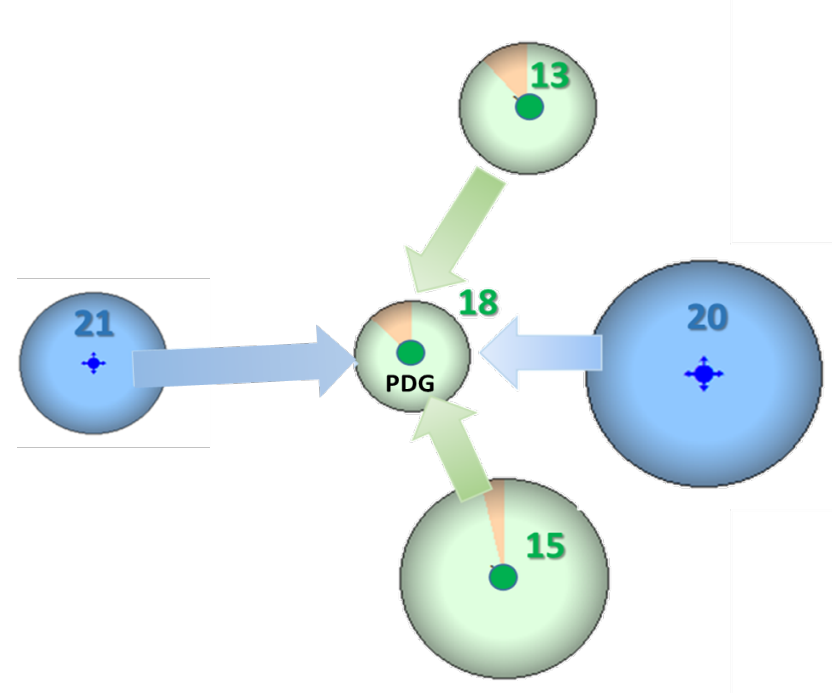
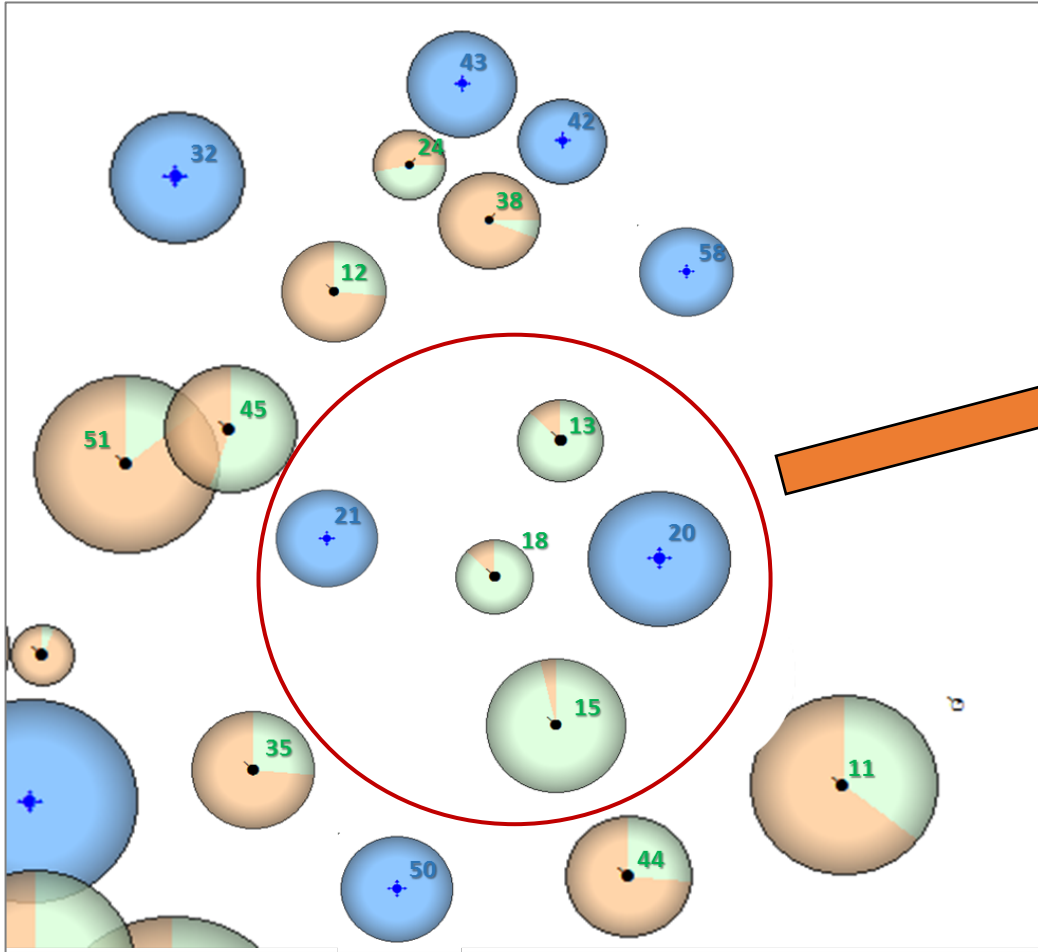


## Issues

- **Production decline**
- Water cut increase
- Formation pressure decrease despite a balanced pressure maintains system

## Concerns

- Cross-flows from the water saturated formation
- Injection water breakthrough
- Faults conductivity
- Possibility of injection water waste
- Possibility of well productivity index decrease



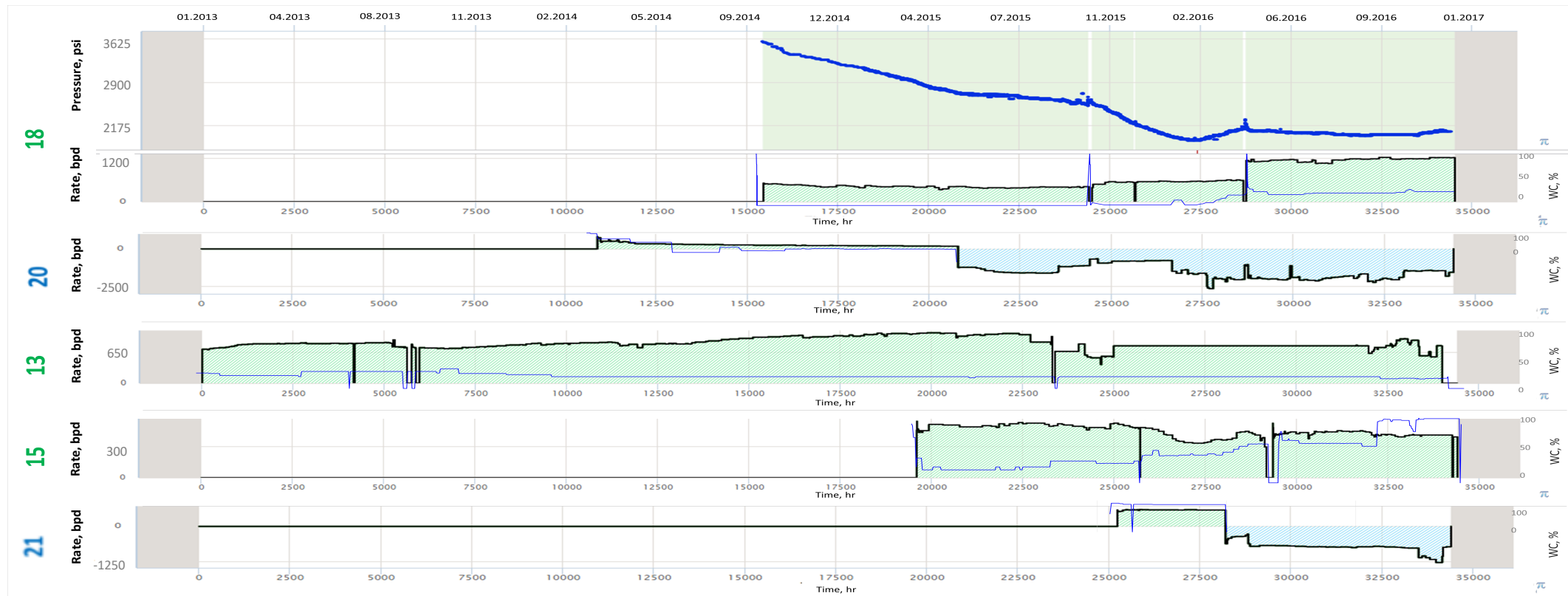
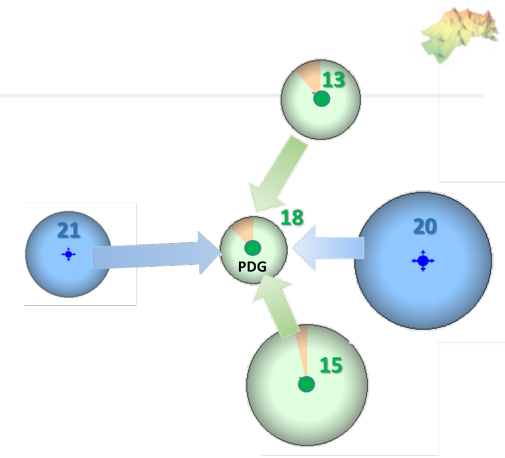
Consider the following group of wells.

There are 3 production wells #13, 18, 15 and 2 injection wells # 20 and 21.

The task is to identify the water source

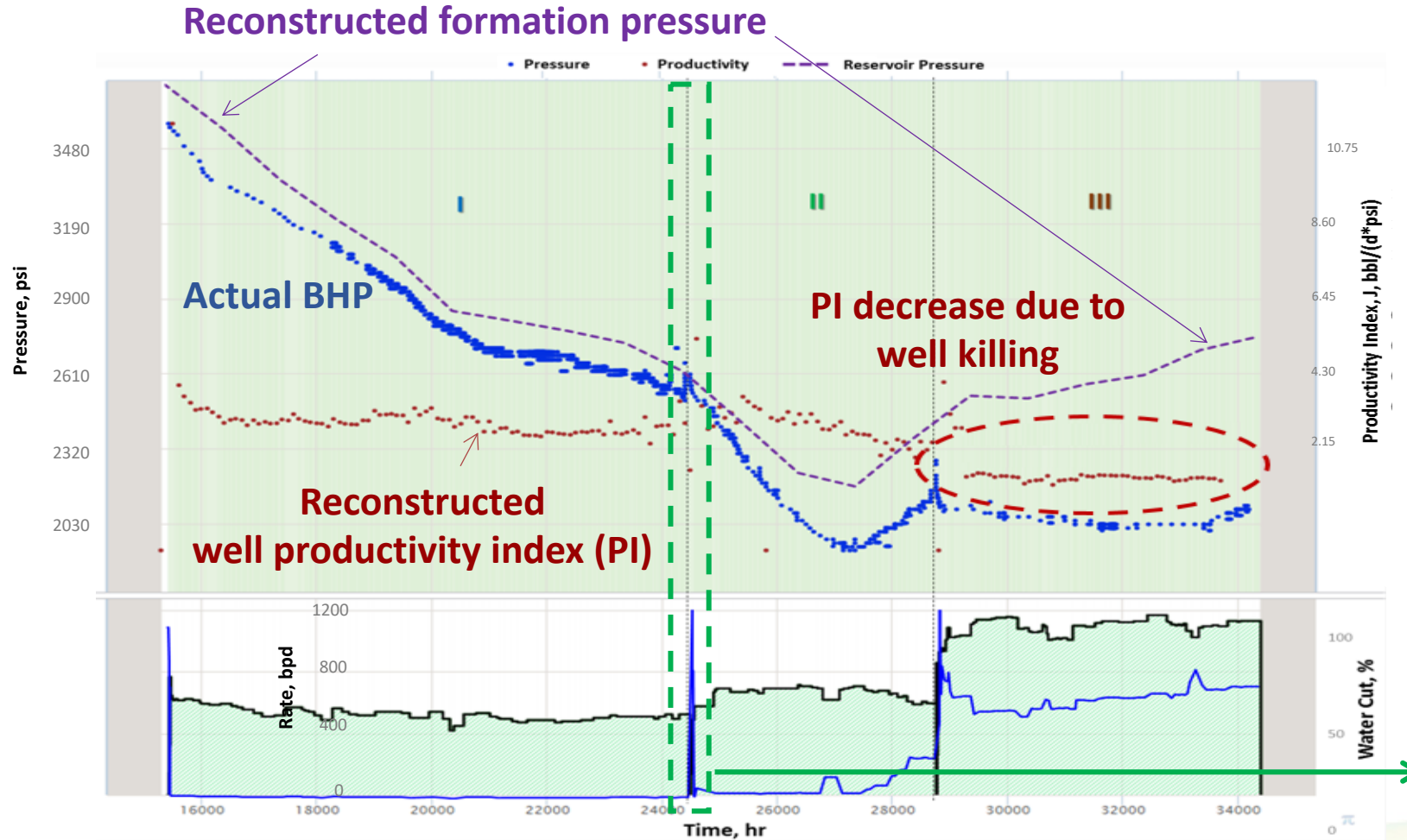
# MRT INPUT DATA

Historical rate-pressure record of the tested well **18** (with PDG).  
There are 4 rate history values of the offset wells **13**, **15**, **20** and **21**.

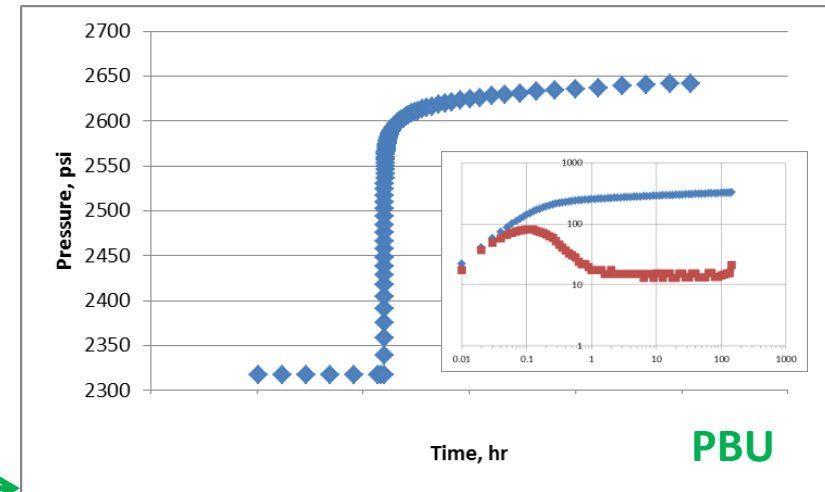
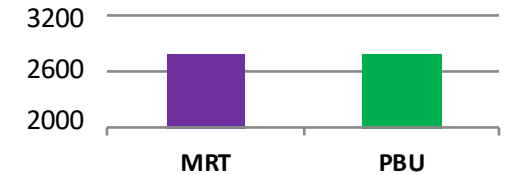


# MRT RESULTS. RECONSTRUCTION FRM PRESSURE HIST. AND PRODUCTIVITY IND.

Formation pressure is reconstructed without any shut-ins nor oil production deferments. Productivity index history gives information about skin-factor changes and urgent workover proposal in case there will be any issues with the well.



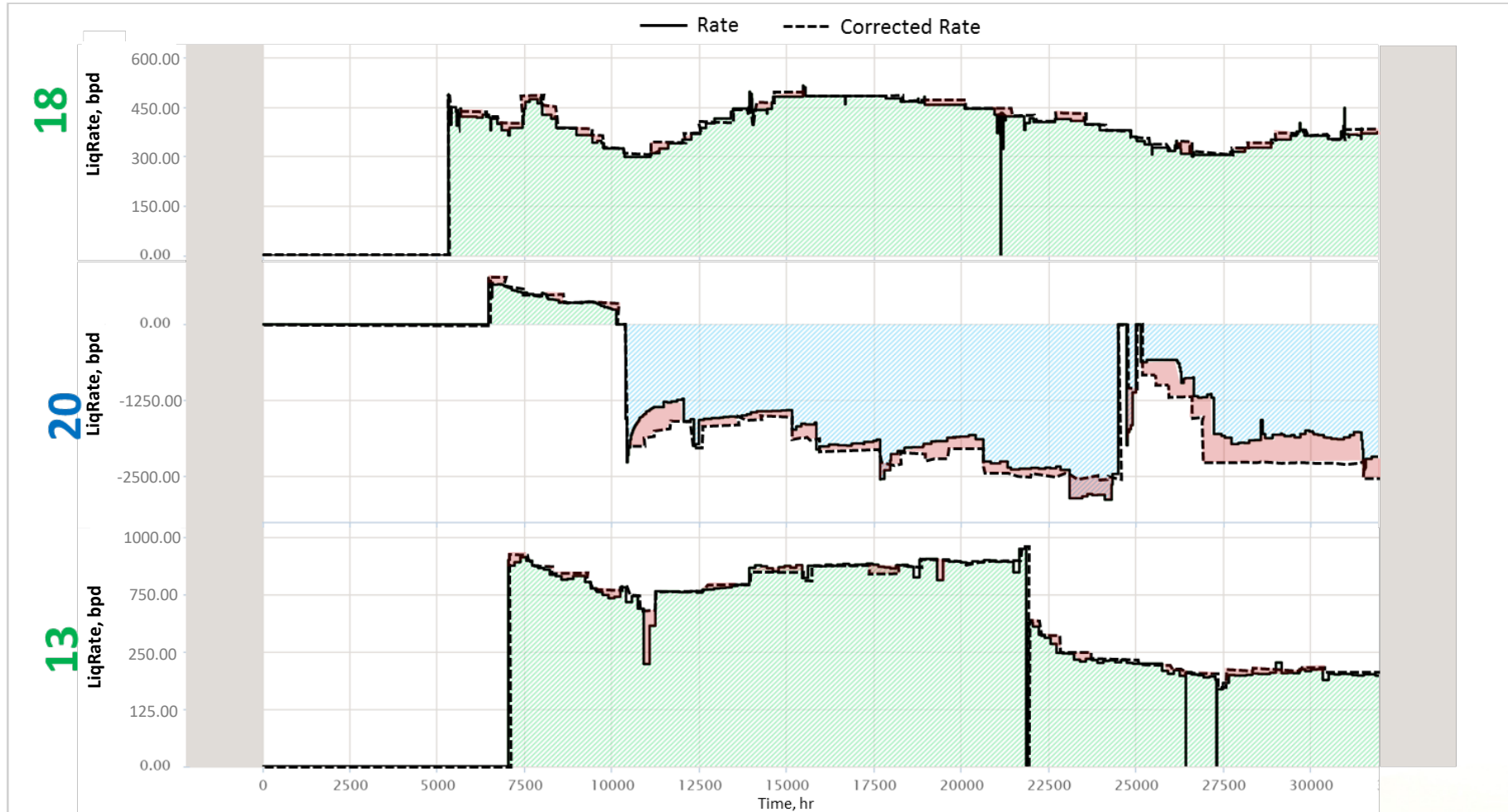
## Reconstructed formation pressure VS build-up formation pressure



# MRT RESULTS. RATE REALLOCATION



Technology reveals an unsystematic mistakes in well rate allocation and **provides a refined rate history**



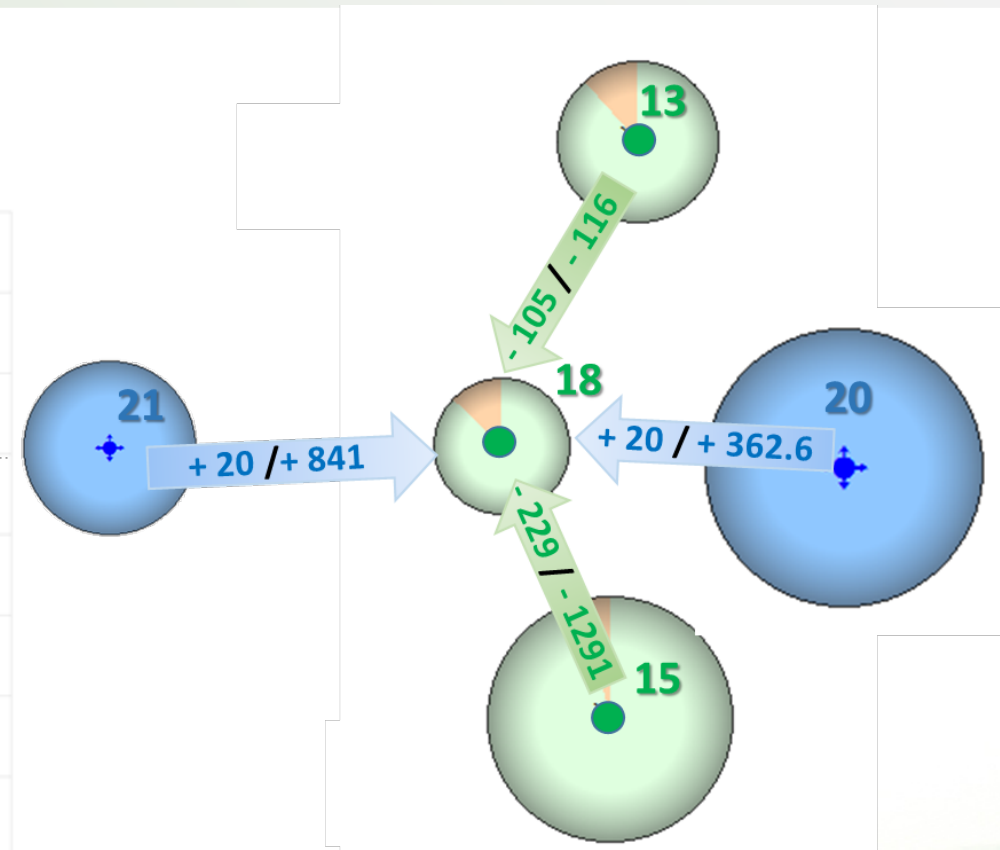
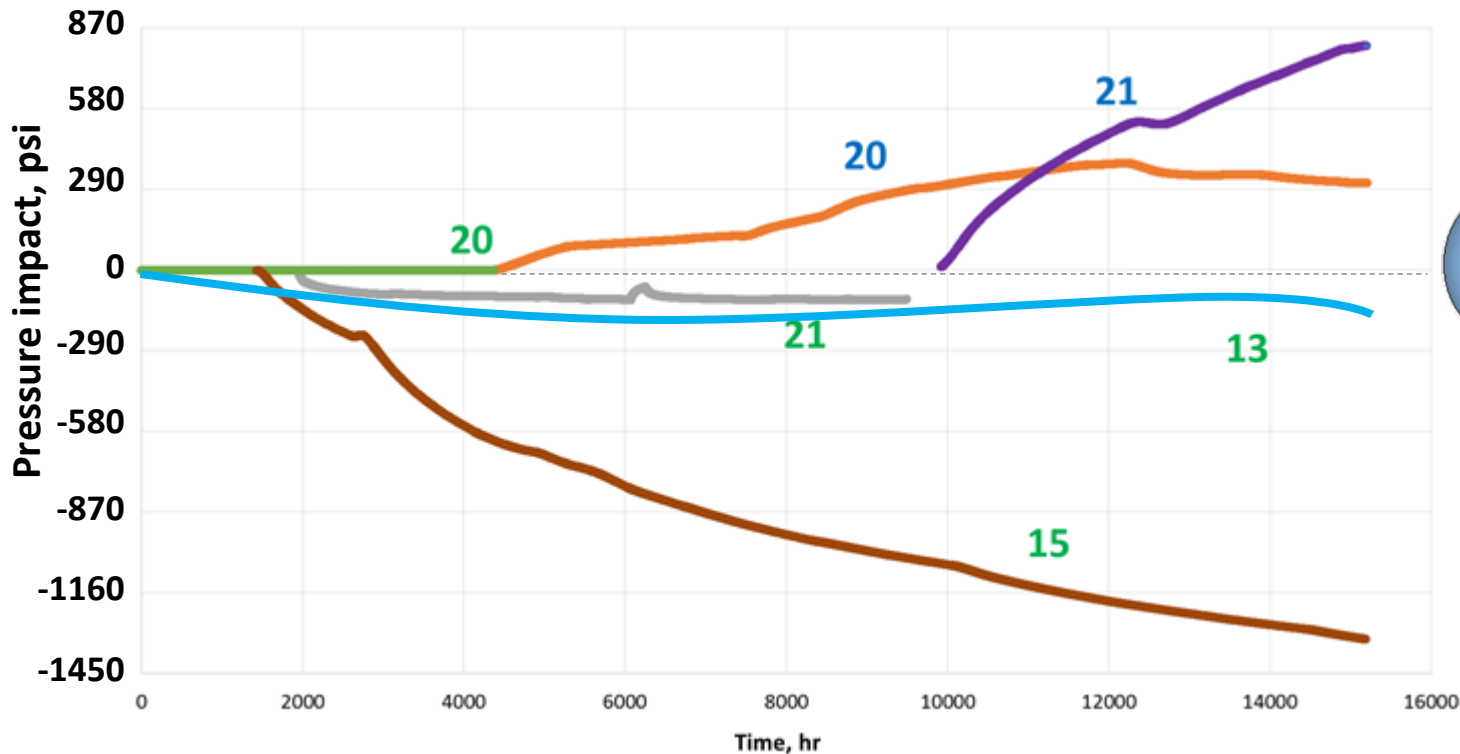


# MRT RESULTS. CURRENT / CUMULATIVE PRESSURE IMPACT



Restored transient responses and production / injection history provides a **quantitative well interference history**. It is used to prepare formation pressure maintenance system optimization recommendations.

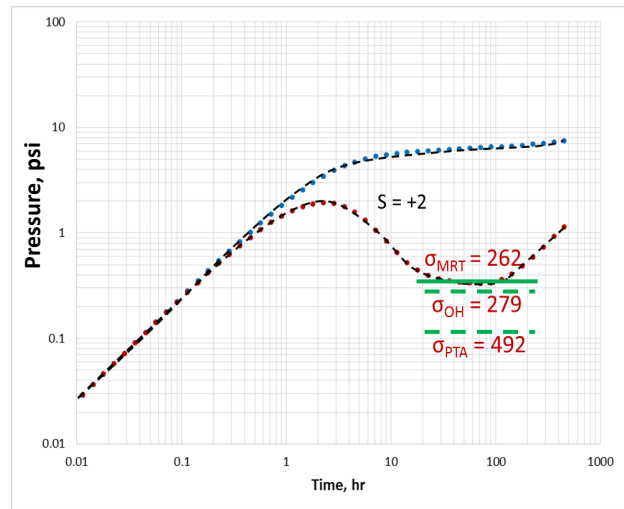
“Spider” plot



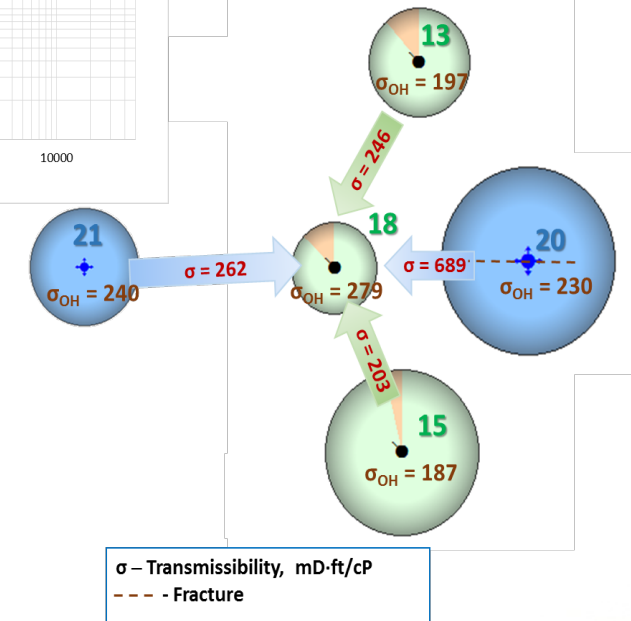
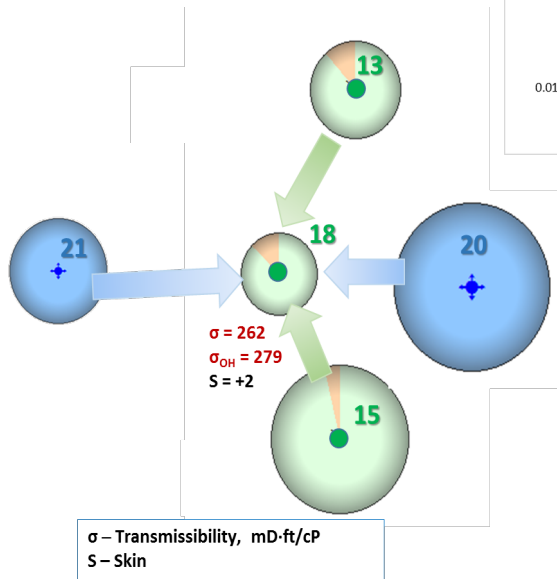
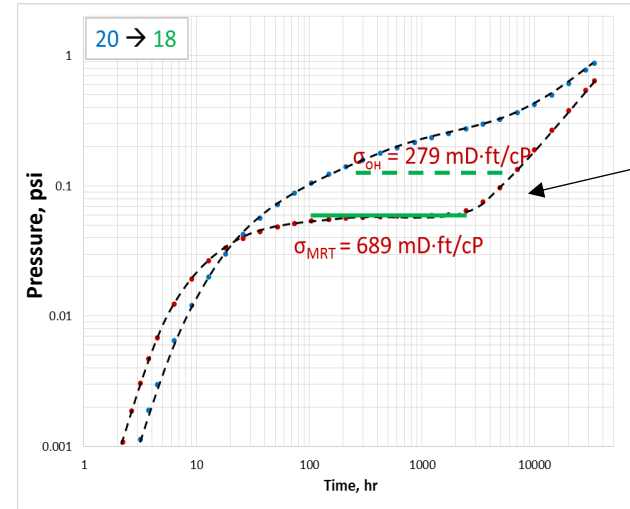
+ 20 / + 841  
 Current impact, psi/mnth / Cumulative impact, psi

# MRT RESULTS. CROSS-WELL TRANSMISSIBILITY BY FITTING CROSS-WELL RESPONSES

Well 18 transient response



Cross-well transient response

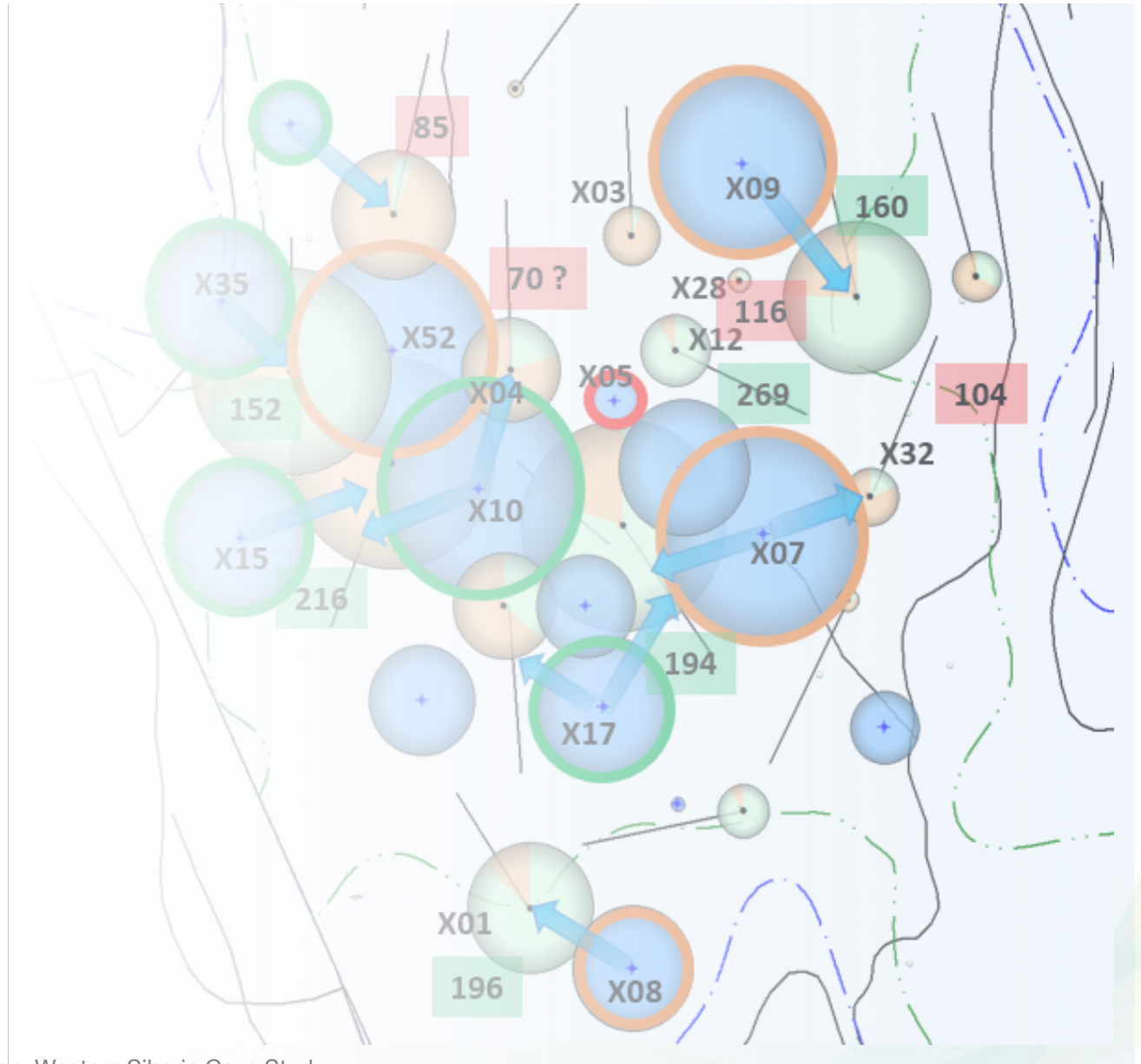


Cross-well transient responses fitting along with the diffusion model provides a unique information about transmissibility of the hydrodynamically connected part of the formation between the wells.

Additionally, wells with a suspected cross-flows are revealed.



# Waterflood fine tuning with MRT



# WATERFLOOD FINE TUNING WITH MRT

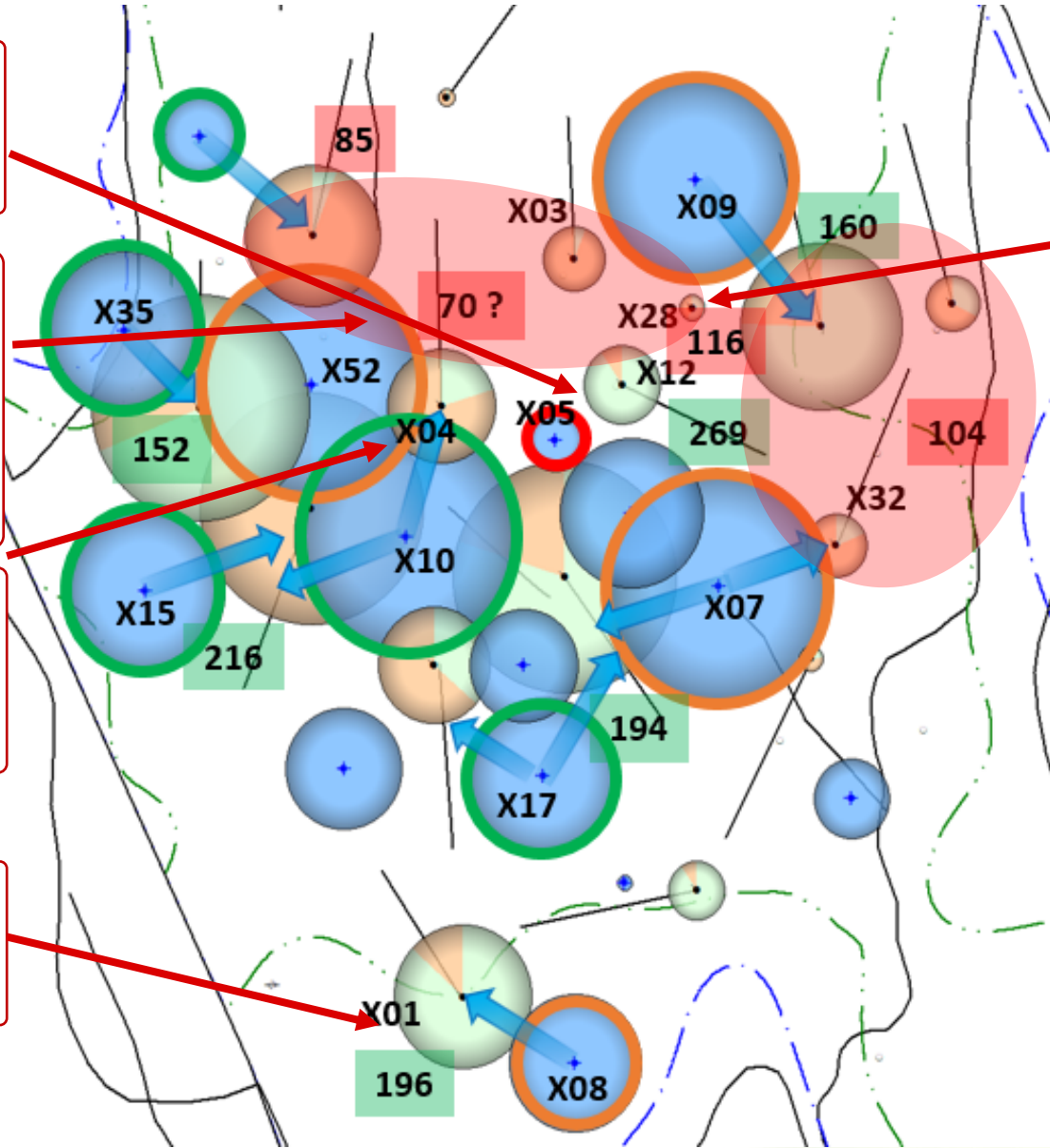


Low  $\sigma$  @ X05  $\rightarrow$  X12  
X05 breakthrough to X12

High  $\sigma$  @ X52, X07, X09, X08  $\rightarrow$  prod  
X52, X07, X09, X08 are losing most water into underlying pay

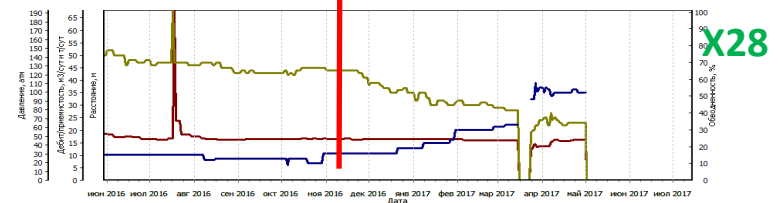
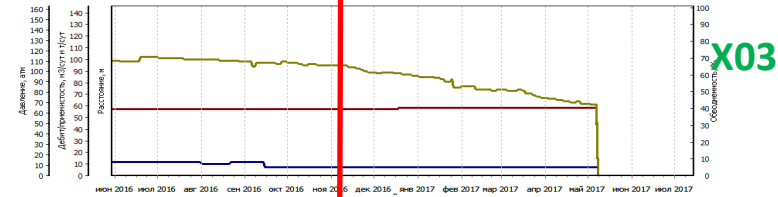
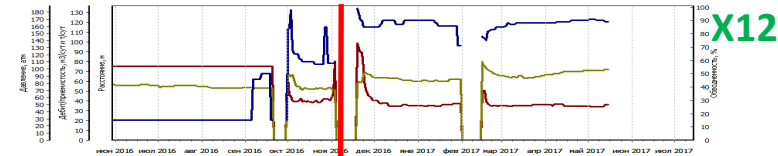
Low  $P_{frm}$  X04, low PI

**Recommendation:** reduce X01 drawdown to decrease watercut %

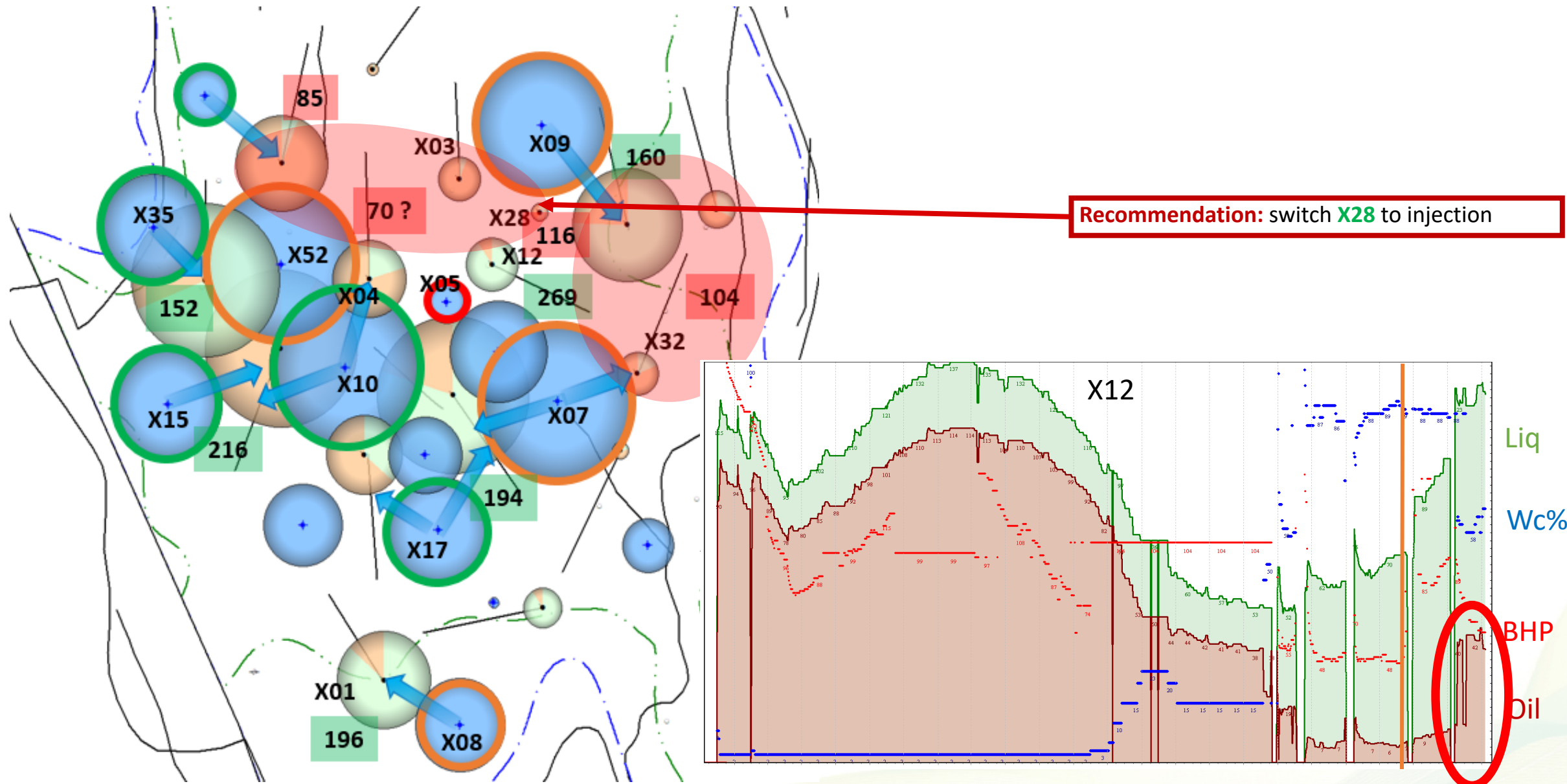


Low  $P_{frm}$  zones.  
X05 breakthrough to X12, causing pressure drop in X03 and X28.

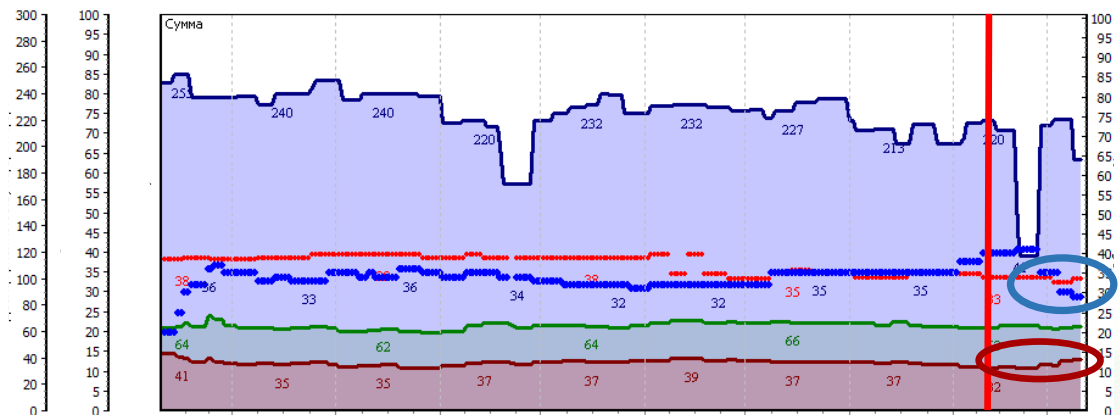
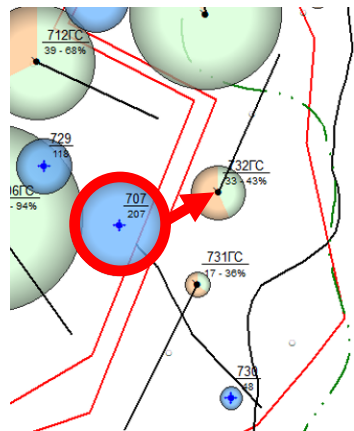
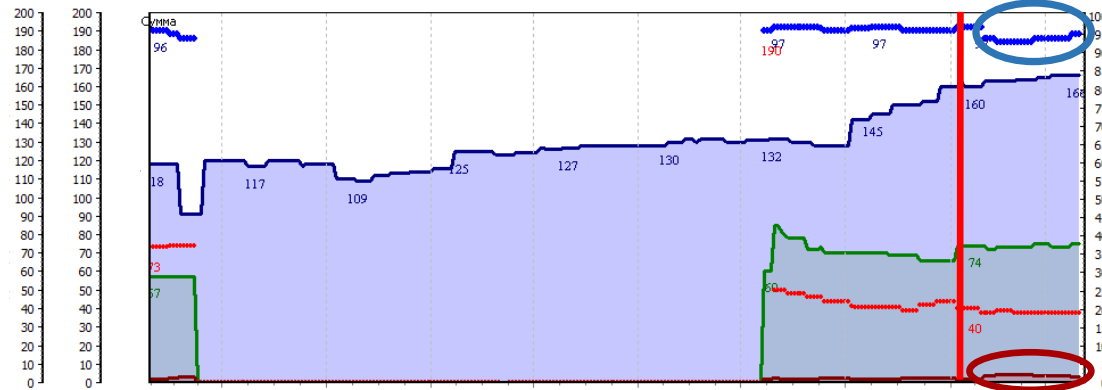
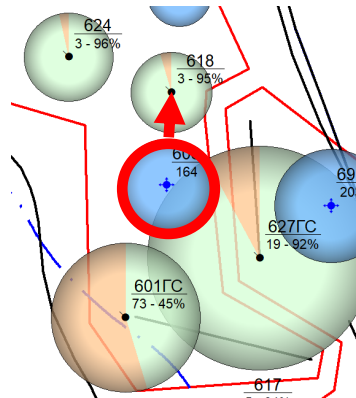
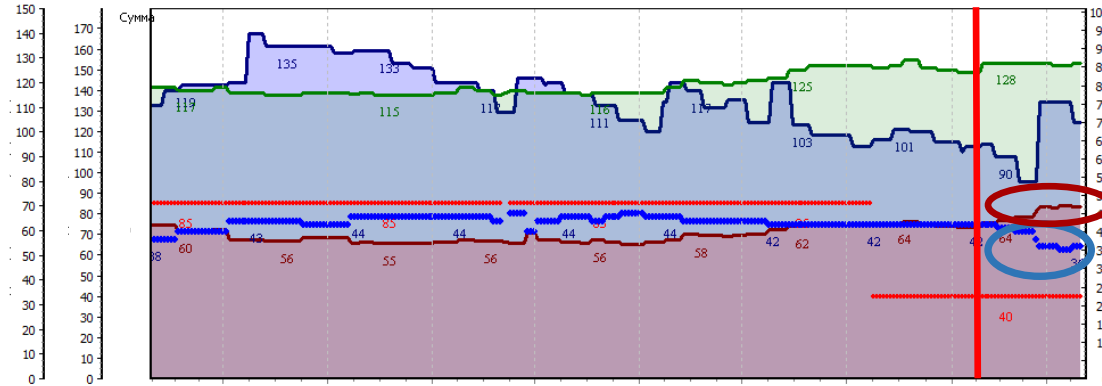
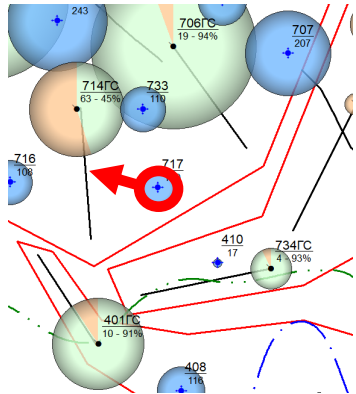
**Recommendation:** switch X28 to injection



# WATERFLOOD FINE TUNING WITH MRT

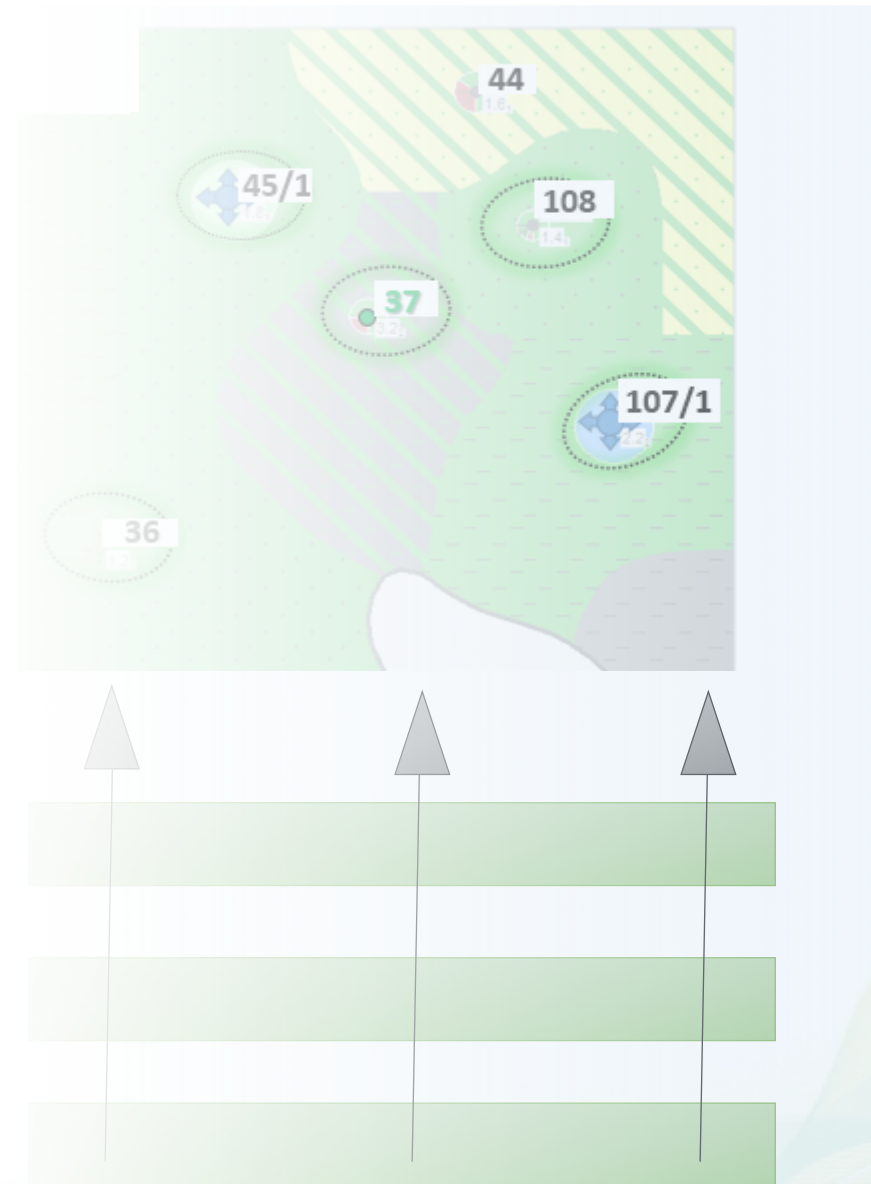


# WATERFLOOD FINE TUNING WITH MRT



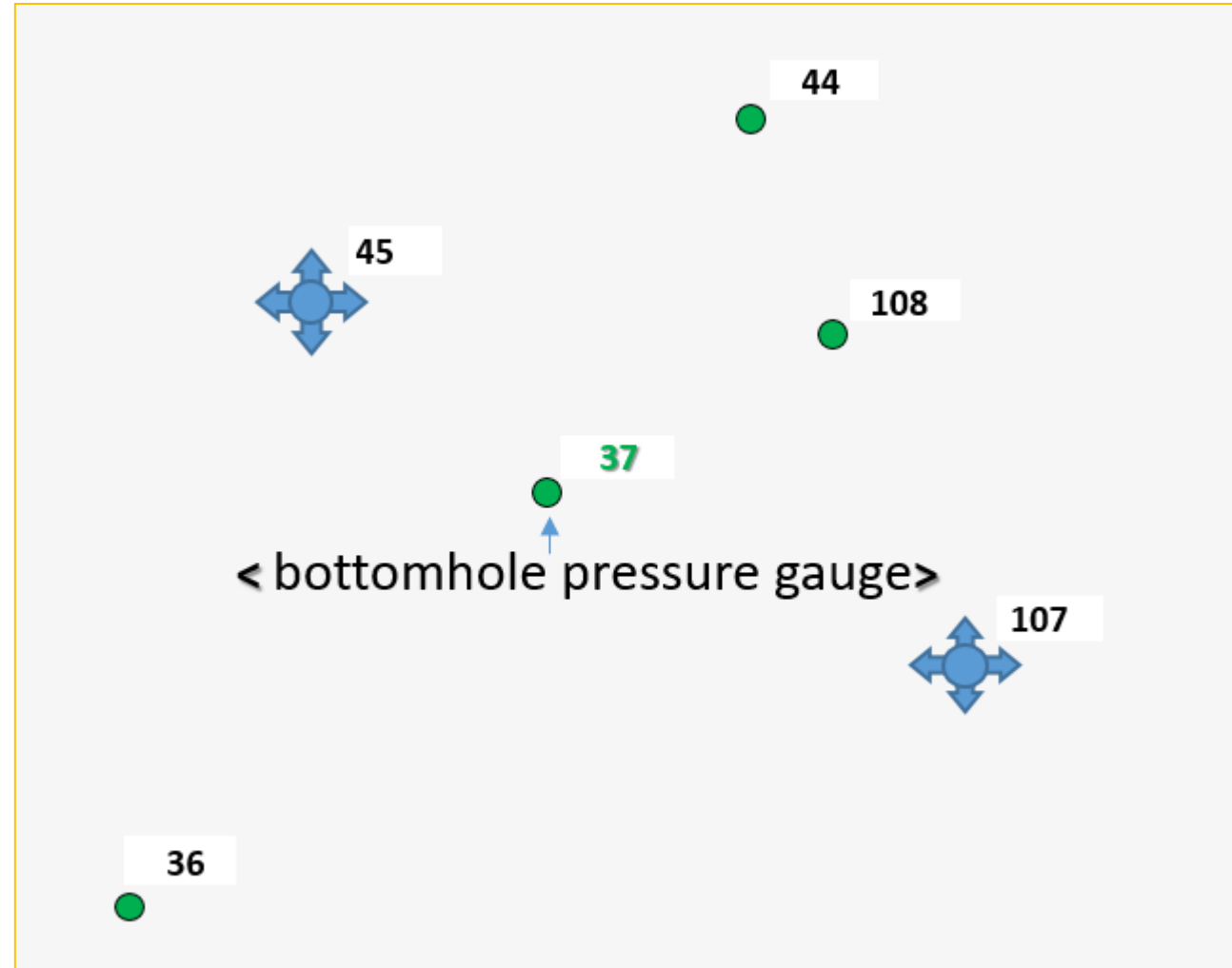


# Assessing efficiency of MRT in cross-well interference analysis and predicting Pi and BHP dynamics





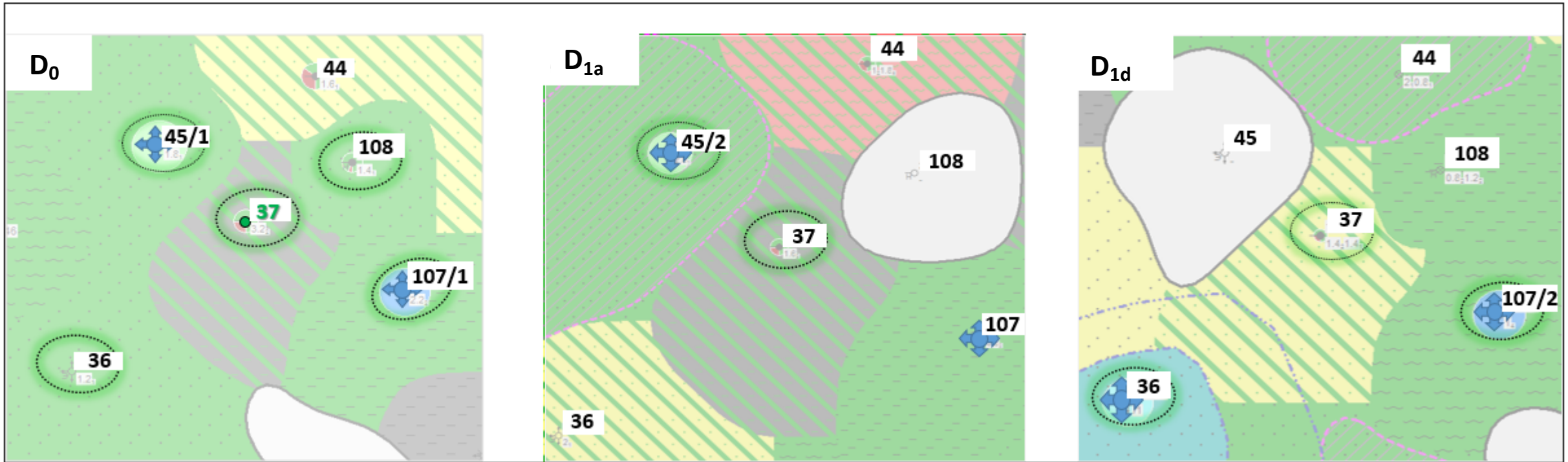
Key Issue: well **37** production decline







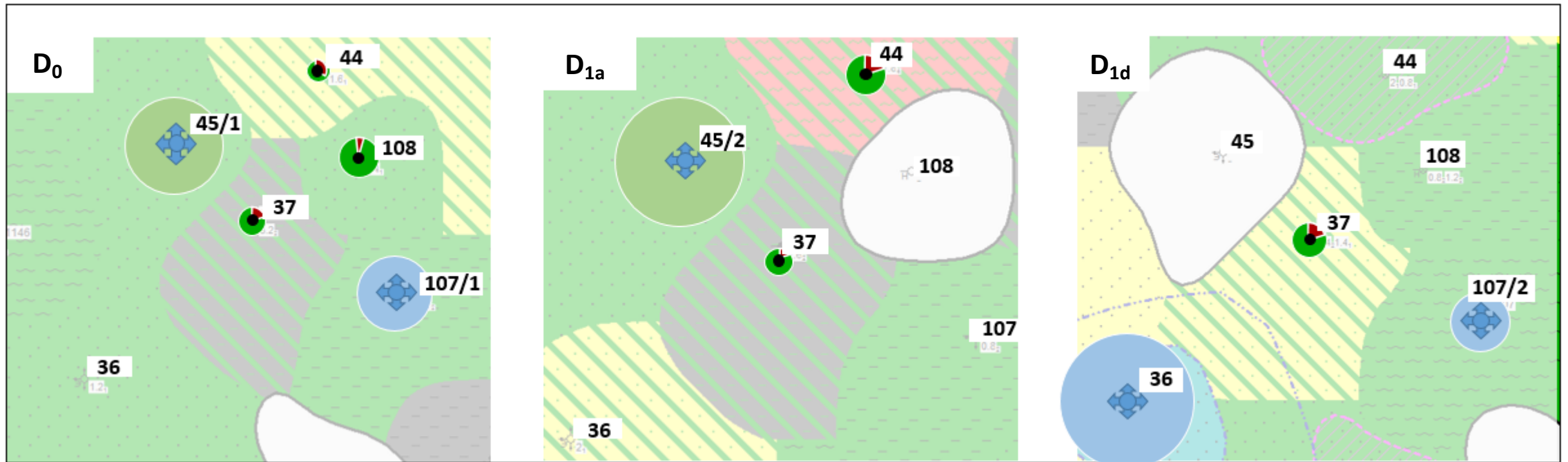
## Current production and injection map of the study block



- |  |   |  |   |  |  |
|--|---|--|---|--|--|
|  | Clay sandstone (totally flushed by injection water) |  | Oil-saturated siltite                                 |  | Sandstone (totally flushed by reservoir water) |
|  | Sandstone (totally flushed by injection water)      |  | Siltite (partially flushed by injection water)        |  | Tight rocks                                    |
|  | Siltite (totally flushed by injection water)        |  | Clay sandstone (partially flushed by injection water) |  |  |
|  | Sandstone (partially flushed by injection water)    |  | Oil-saturated sandstone                               |  |  |



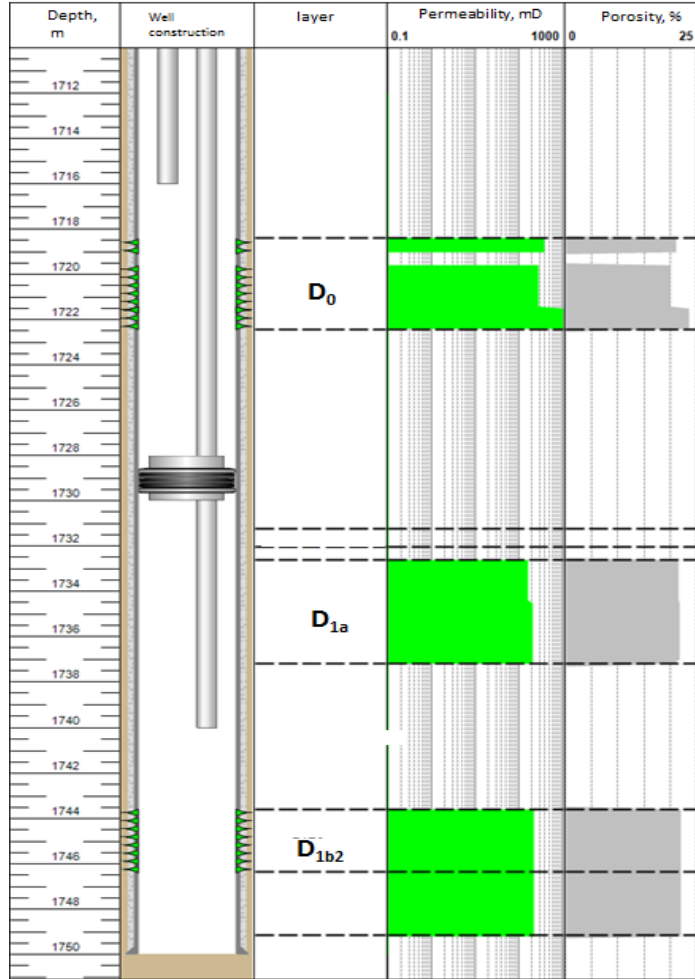
## Cumulative production and injection map of the study block



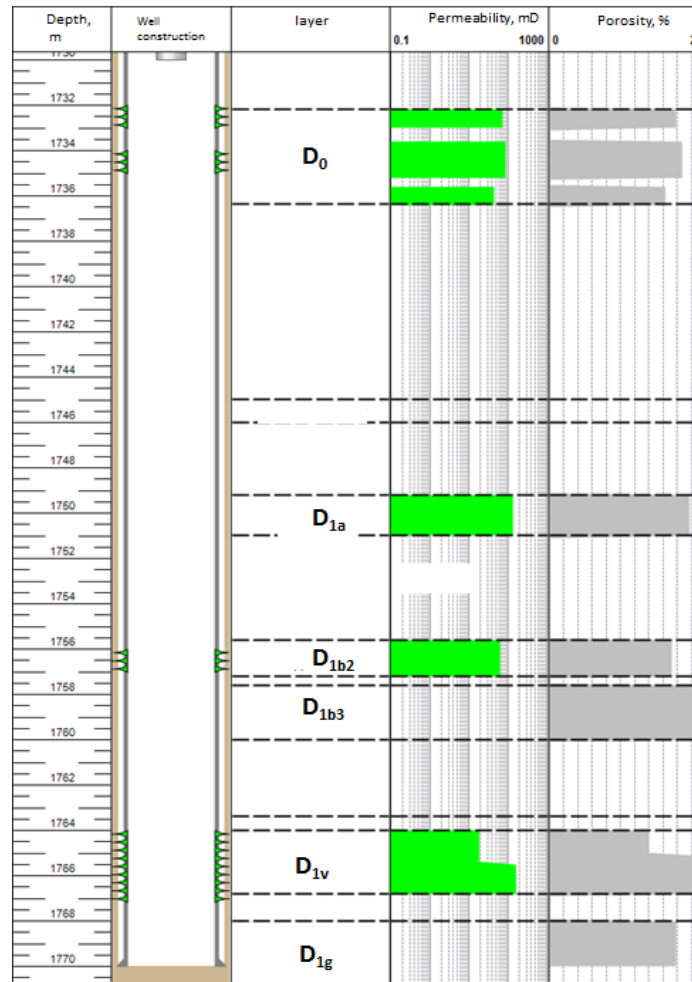
# WELL CONSTRUCTION



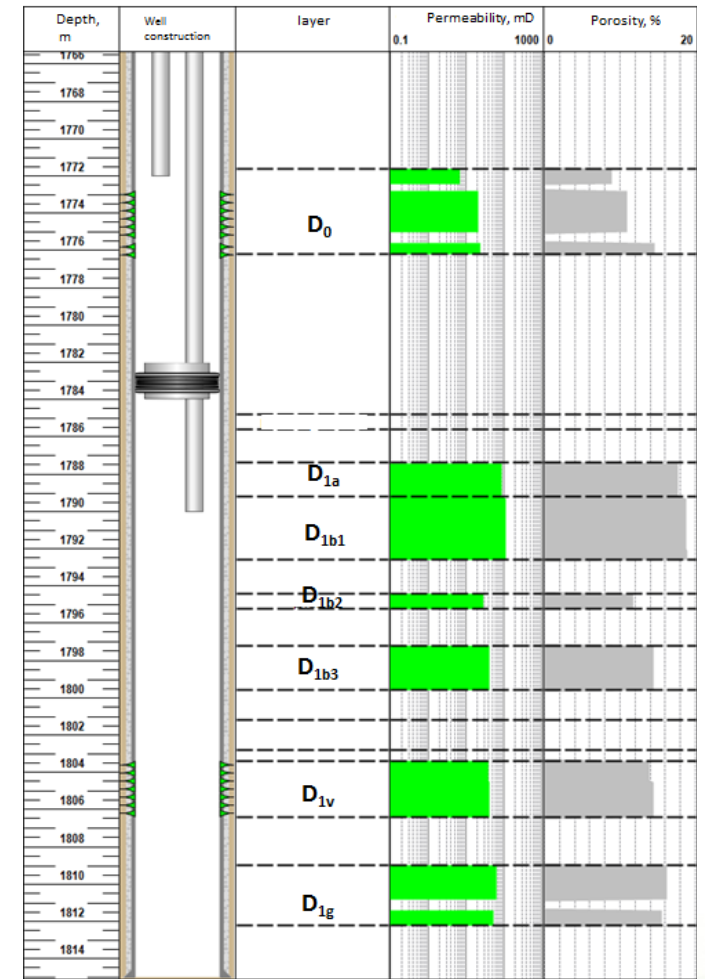
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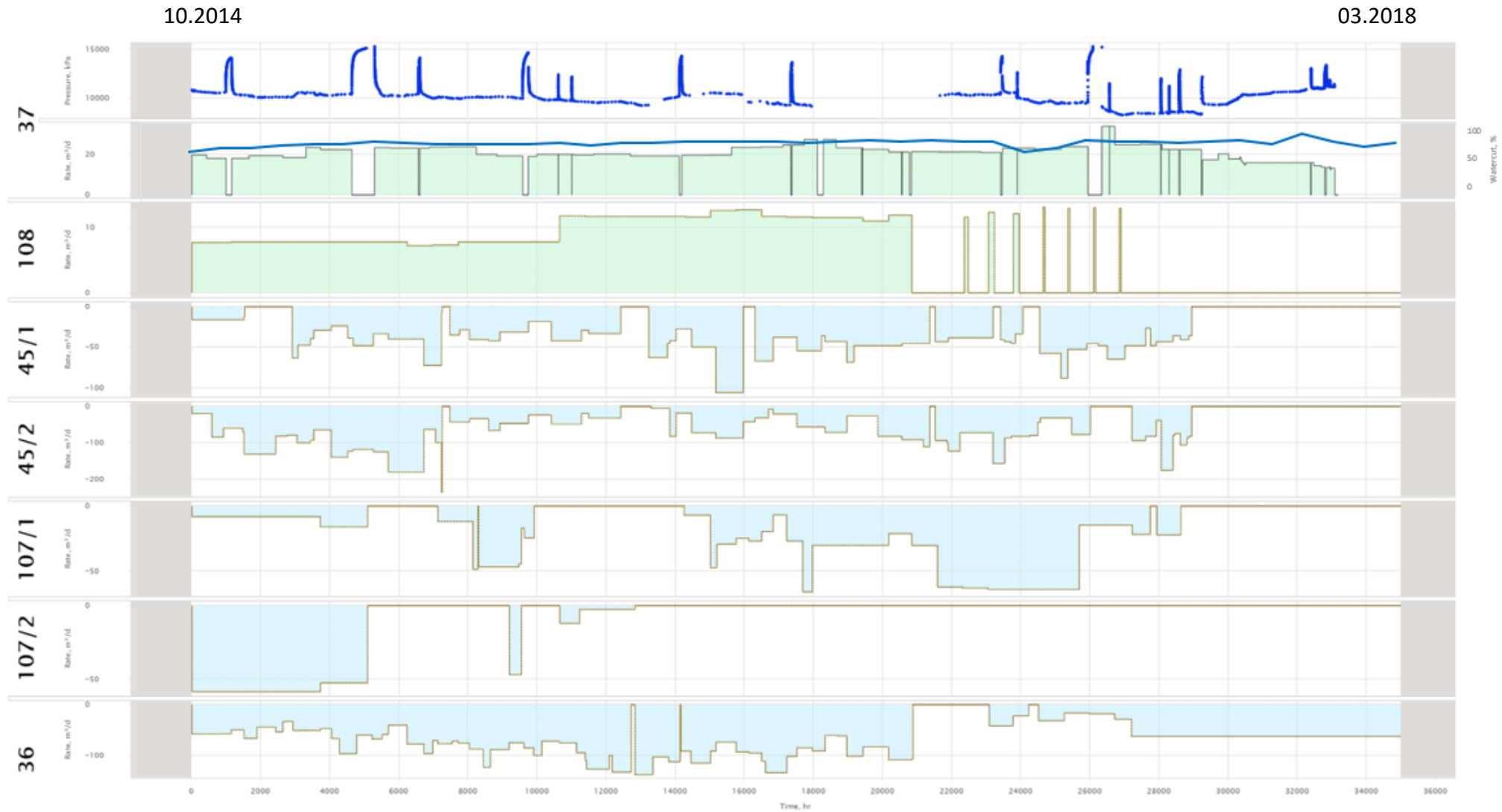
37



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# HISTORY PLOT



# GOALS & OBJECTIVES



## Goals

#1	To assess cross-well interference of the well 37
----	--

## Objectives

#1	Reconstruct formation pressure history for well 37
#2	Predict formation pressure based on the current rate of well 37
#3	Reconstruct productivity index history for well 37
#4	Estimate skin-factor, transmissibility and drainage area of well 37
#5	Reconstruct the history of cross-well interference with well 37
#6	Estimate cross-well transmissibility ( $kh/\mu$ ) from offset wells towards well 37

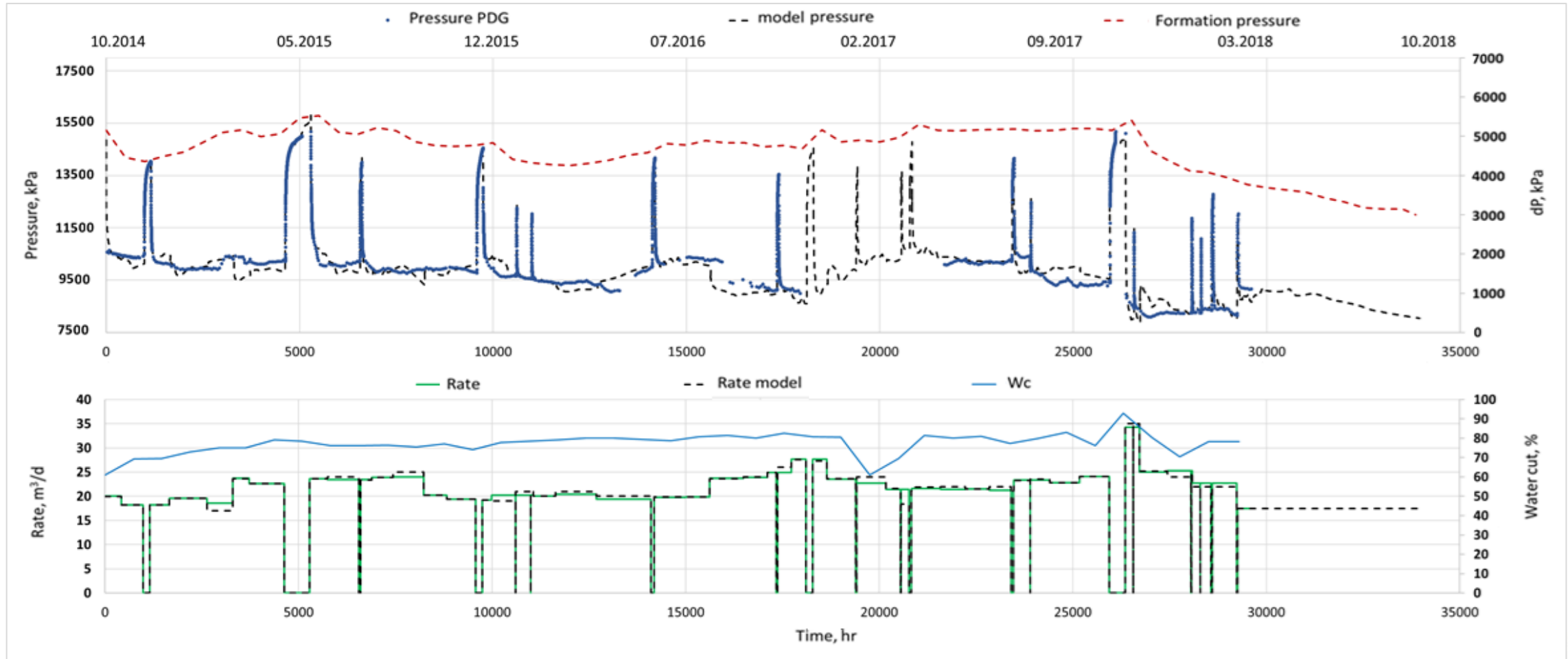
# 1. WELL 37. RECONSTRUCT FORMATION PRESSURE



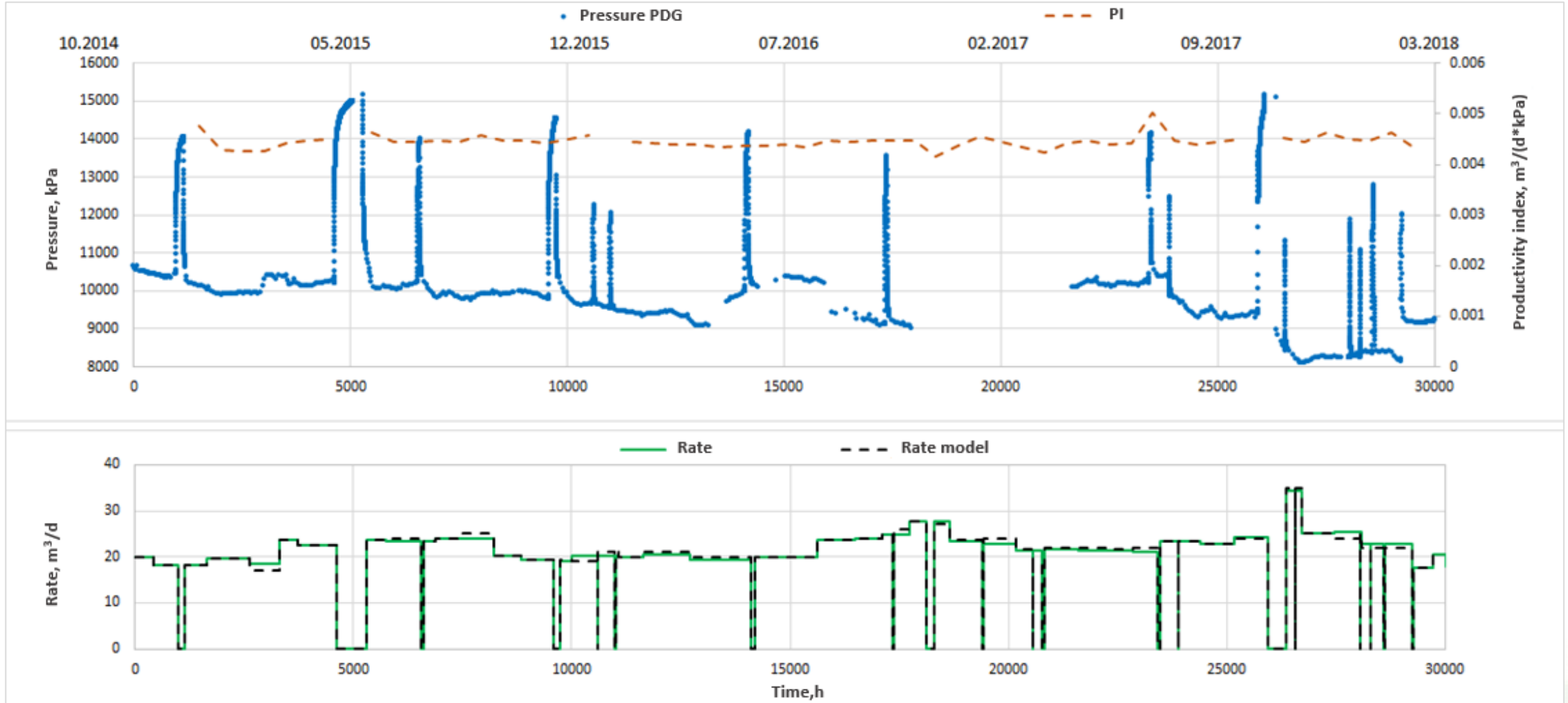
## 2. WELL 37. FORMATION PRESSURE FORECAST



Predicting formation pressure based on the current rate for the well 37

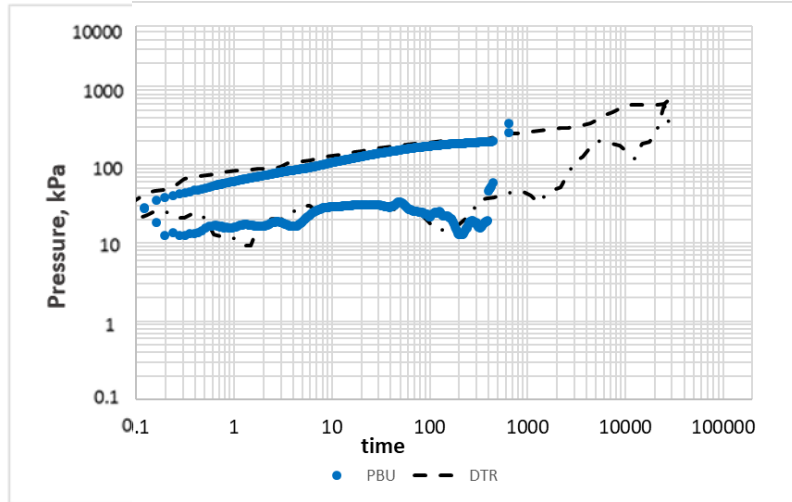


### 3. RECONSTRUCTION OF PRODUCTIVITY INDEX HISTORY

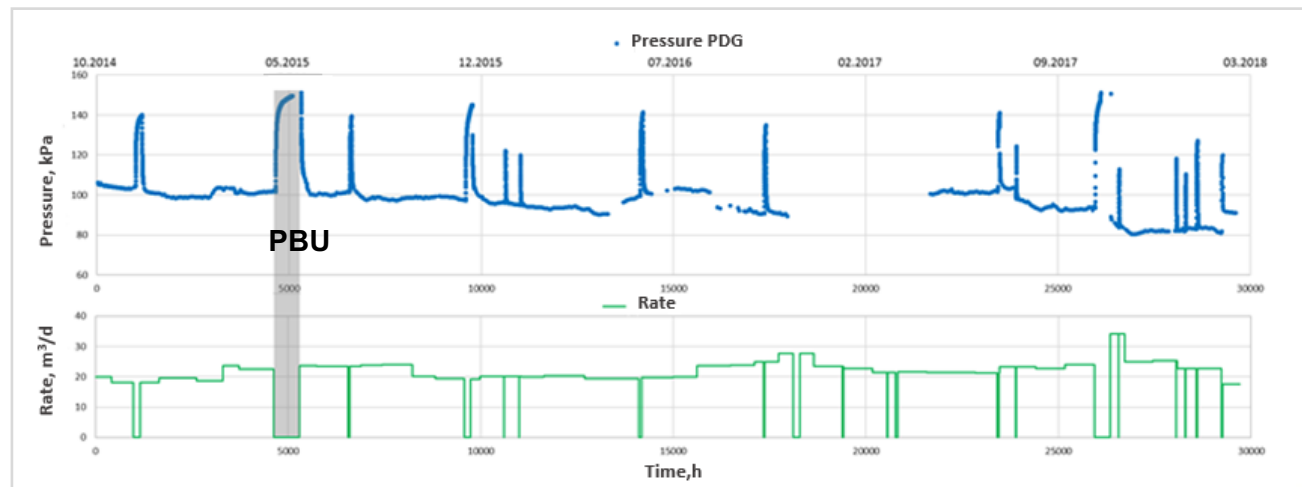




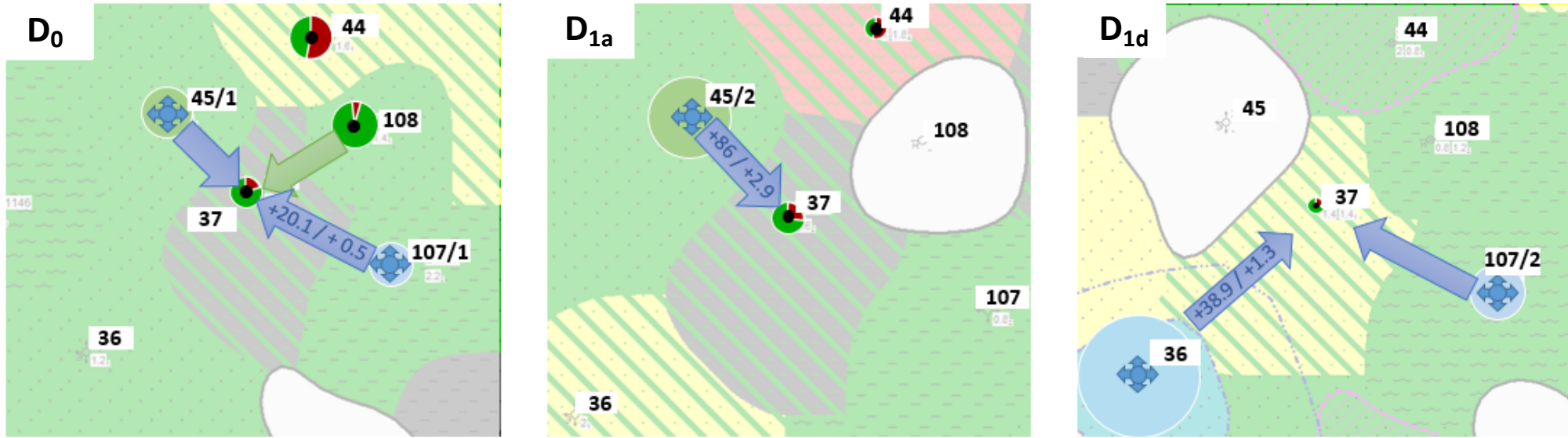
# 4. ESTIMATE SKIN-FACTOR AND TRANSMISSIBILITY



Parameters	Interpretation	OH	Units
Transmissibility	36.1	204	(mD · m)/sp
Total skin	-3.5	-	
Half-length fracture	10	-	m
Absolute permeability	38.3	75.6	mD
Phase permeability*	6.5	37.8	mD
Net thickness	→	6.8	m
Productivity index@ 03.2018	0.47		m <sup>3</sup> /(day · atm)

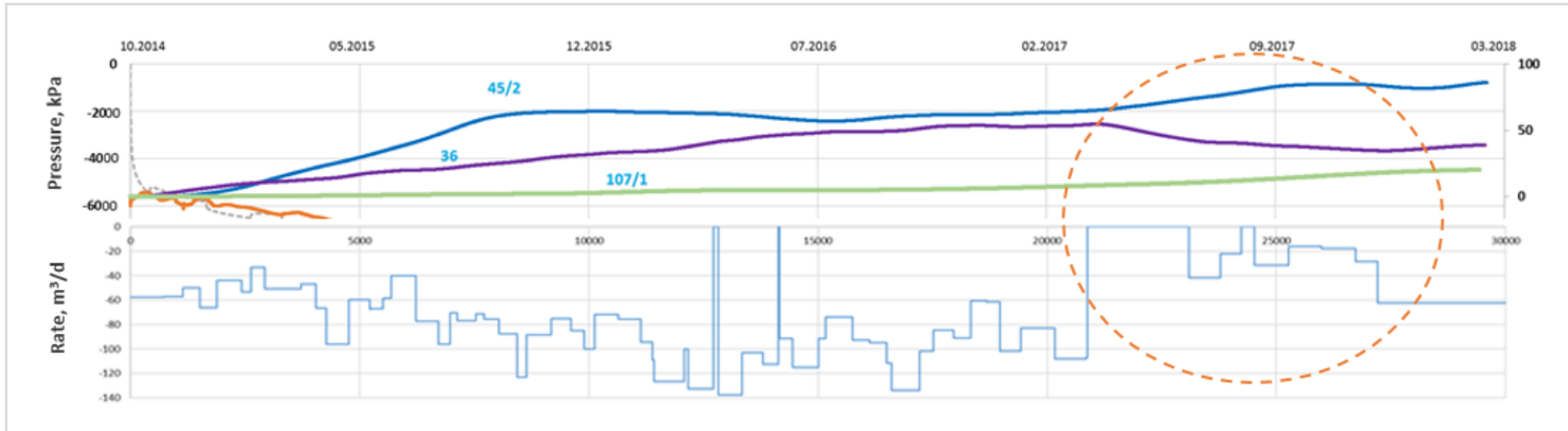


# 5. RECONSTRUCT THE HISTORY OF CROSS-WELL INTERFERENCE WITH WELL 37

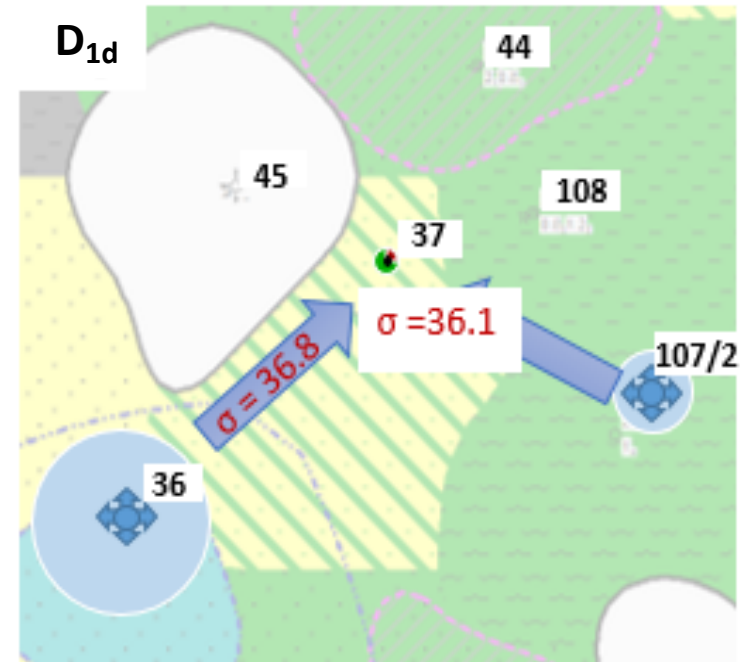
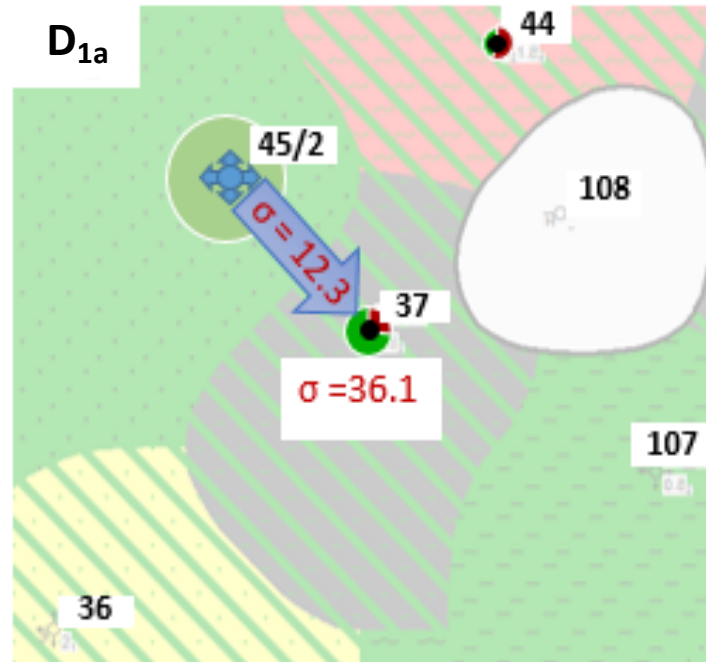
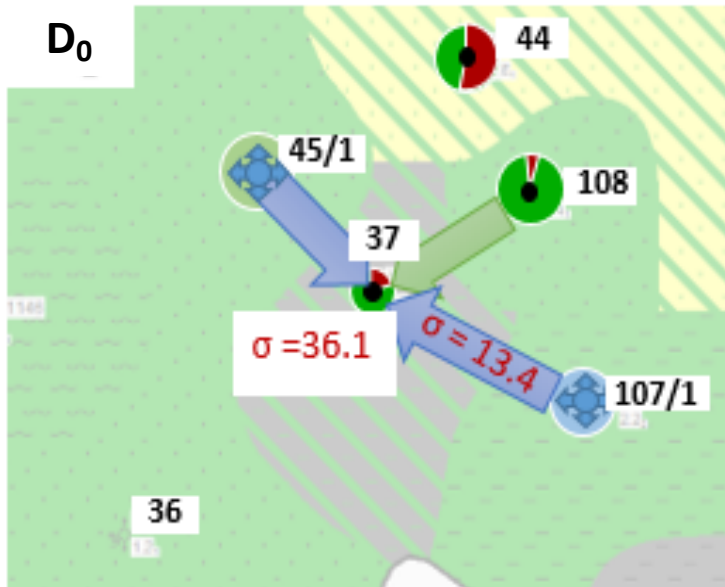


37 pressure impact

36 rate

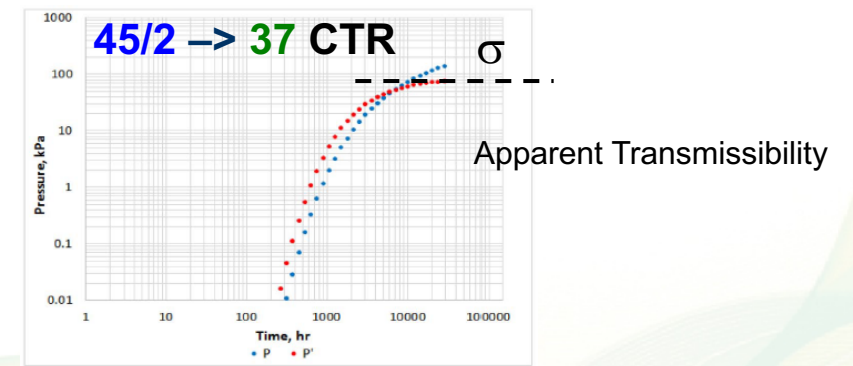


# 6. OFFSET WELLS -> WELL 37. ESTIMATE CROSS-WELL TRANSMISSIBILITY

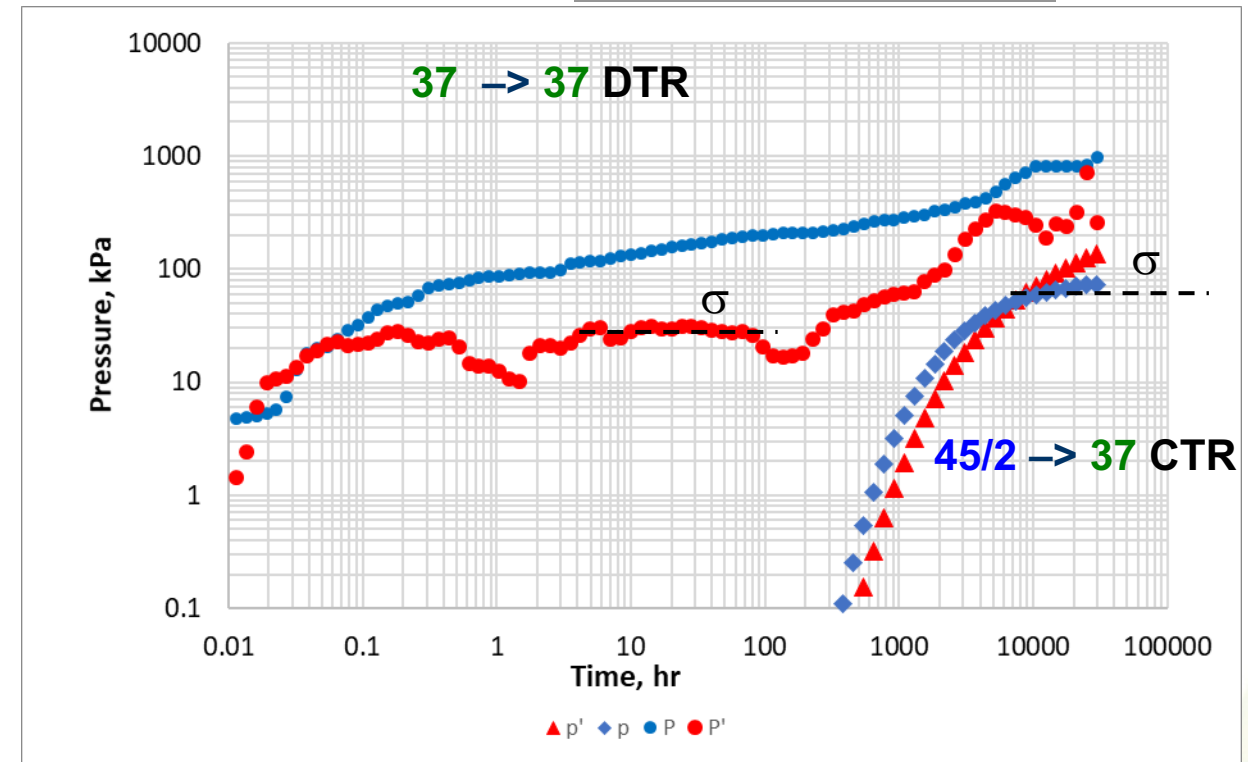
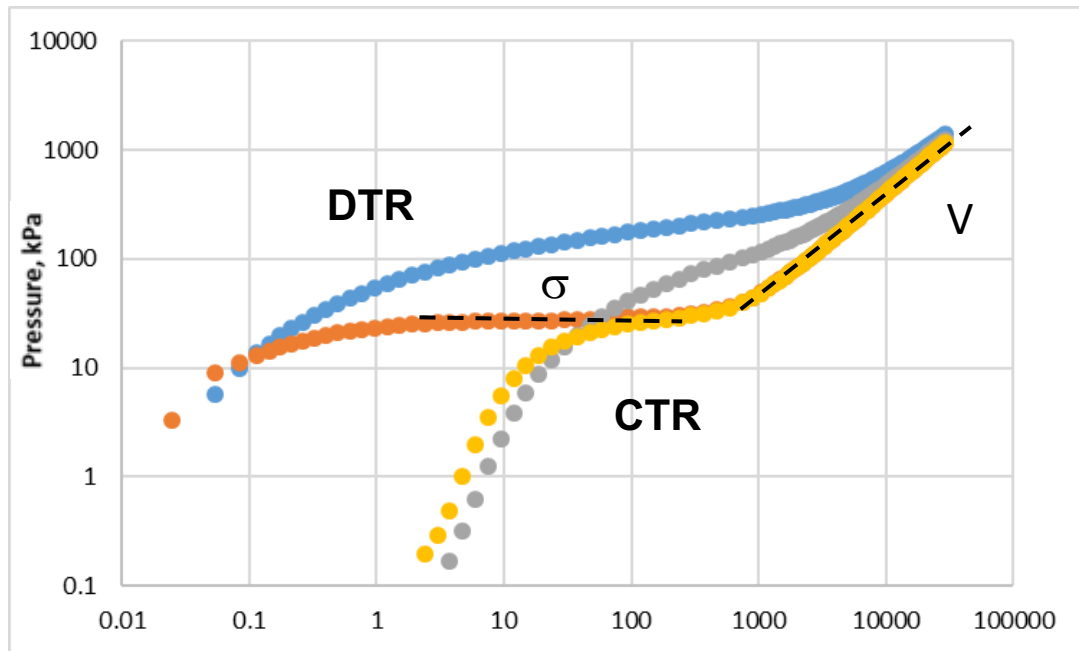
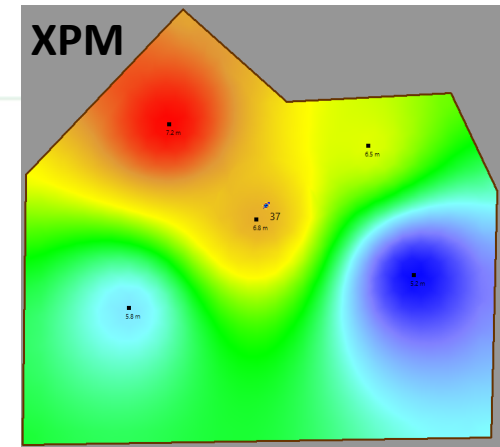
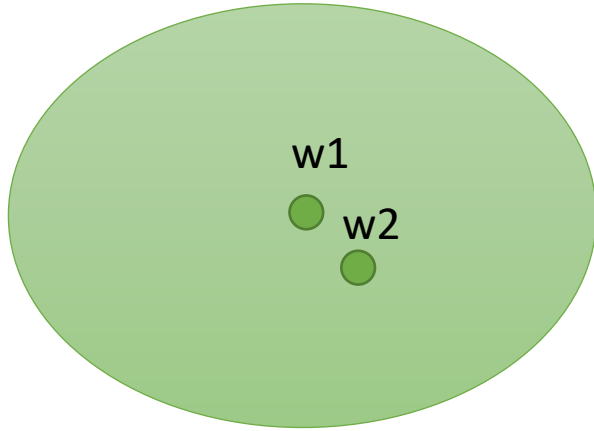


$\sigma$  – Transmissibility, mD\*m/cp

No	Interval	Transmissibility mD*m/cp	Transmissibility (OH) mD*m/cp
1	45/2 -> 37	12.3	300
2	107/1 -> 37	13.4	190
3	36 -> 37	36.8	248
4	37 -> 37	36.1	204

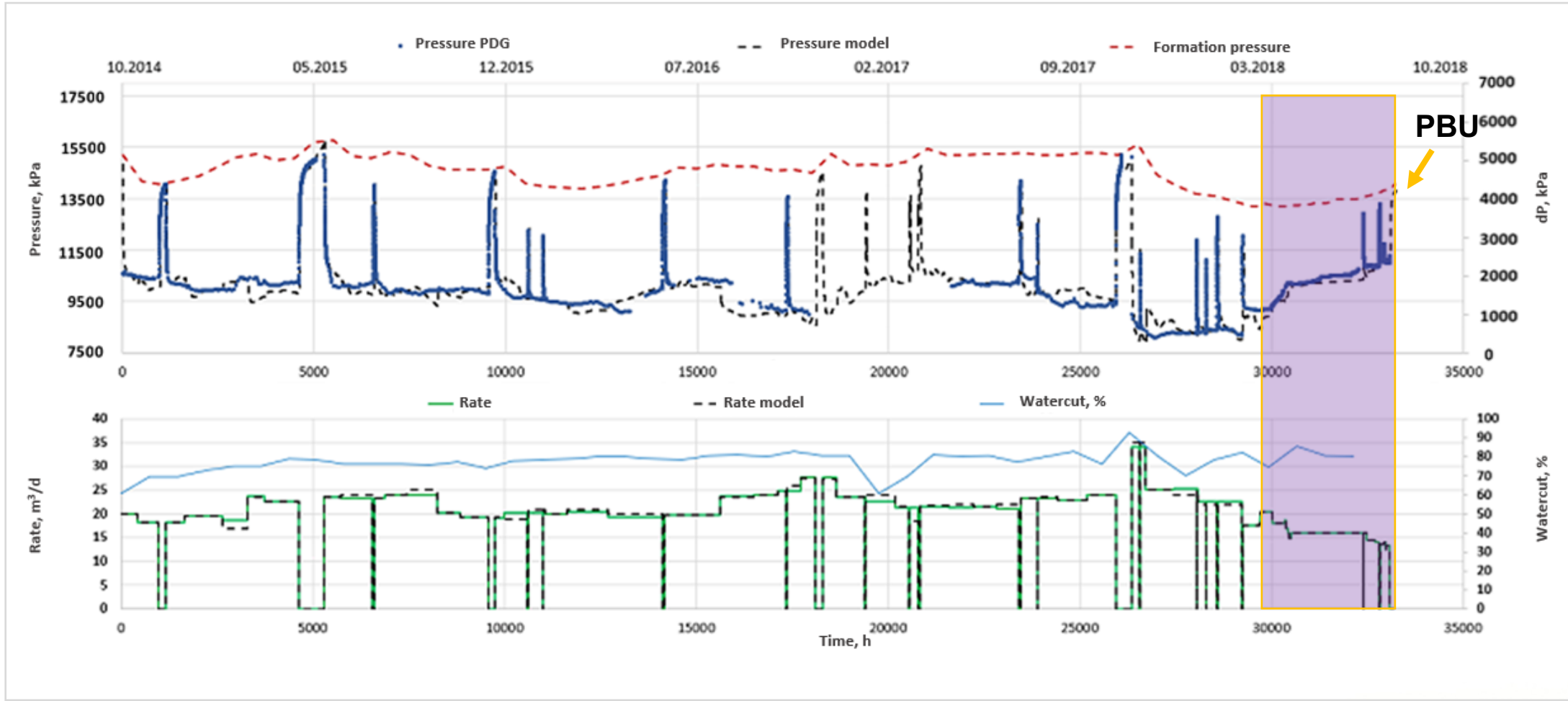


# DTR AND CTR COMPARISON





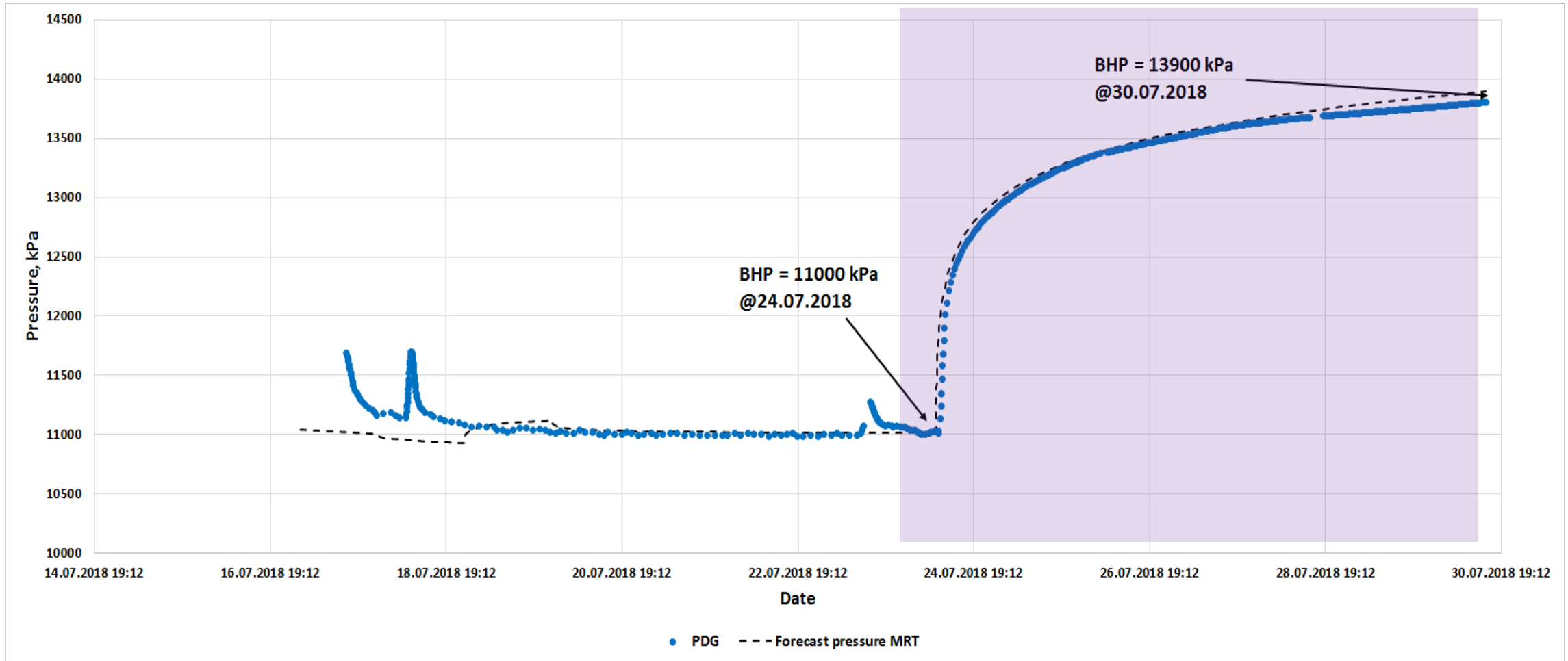
## Cross validation period



# WELL 37. FORMATION PRESSURE FORECAST



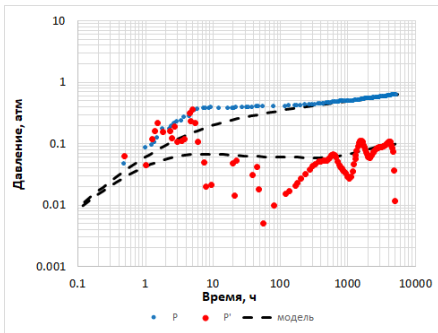
Prediction of formation pressure in the well 37 for further comparison with the actual shutdown of the well





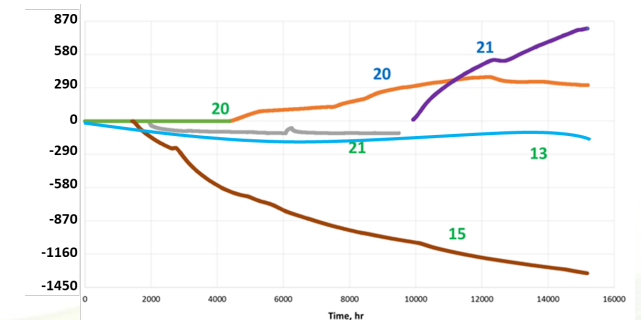
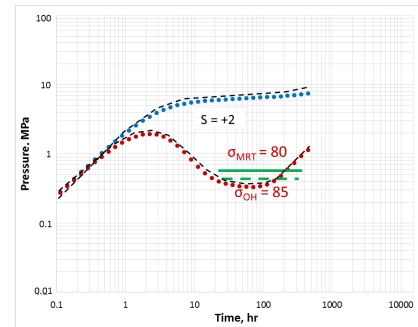
## RTA

- Formation pressure
- Productivity index
- Well skin-factor
- Well drainage area and reserves (if there is no gas cap)
- Formation transmissibility ( $kh/\mu$ ) -> permeability
- Presence of no flow or constant pressure boundaries due to geology or interference (without ability to separate them)



## MRT

- Formation pressure dynamic
- Productivity index dynamic
- Well skin-factor dynamic
- Interference free well drainage area and reserves
- Formation transmissibility ( $kh/\mu$ ) -> permeability
- Presence of geological boundaries and quantitative interference analysis for production optimization
- Quantitative history of aquifer support





- Pressure tested well must have a **bottom-hole pressure** record
  - injectors may have THP pressure records
  - offset wells may not have the bottom hole pressure records
- All tested wells should have historical production/injection data records, both from well-tests and reallocations (including GOR and water cut)
- Tested period must be long enough to have **a lot of well rate changes**, they must **not** be always simultaneous





**Thank You**