Alpine Rhine Decolmation Experiment

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Motivation

Flood protection project at the Alpine Rhine

- To protect the densely populated valley from flooding, the Rhine channel will be widened
- 24 drinking water wells must be temporarily taken out of operation during construction works
- Due to the expected higher bed permeability, drainage channels will be constructed on both sides of the Rhine

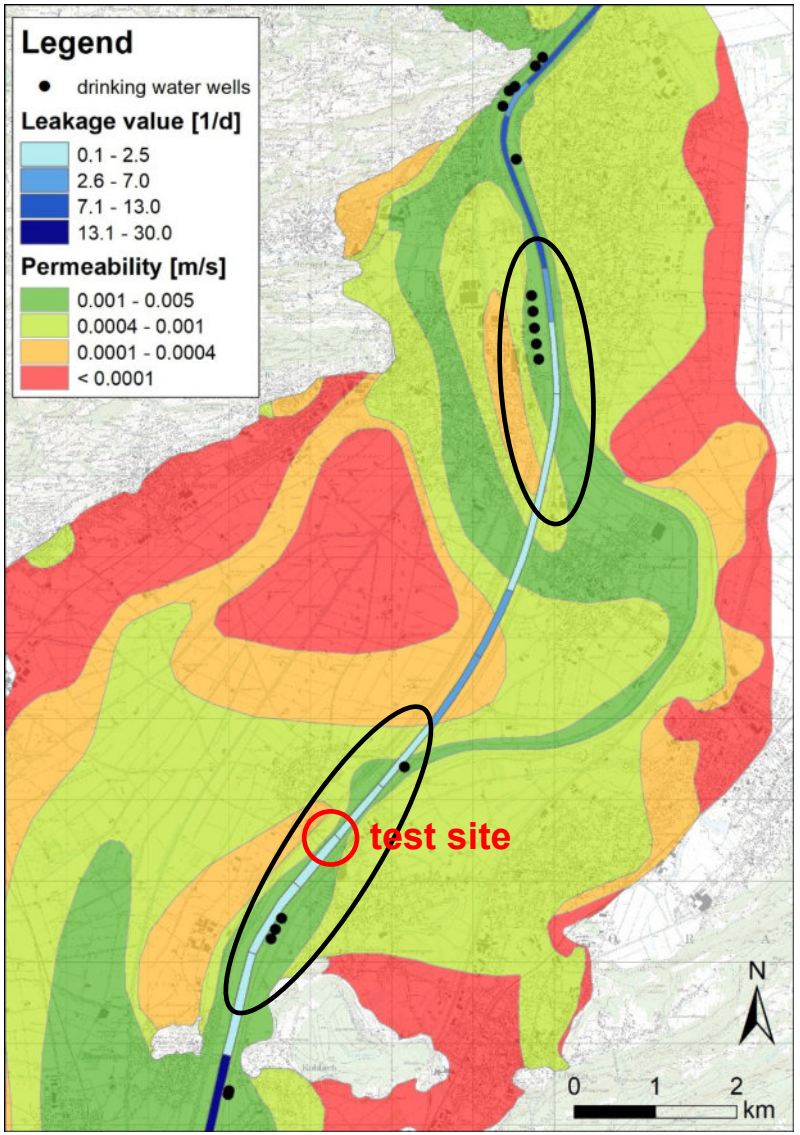
Questions to answer

- How much will the riverbed permeability increase during construction?
- Will the quality of the infiltrating groundwater change?
- How long will it take to colmatise the riverbed again?
- How long will it take until groundwater quality is good enough again?

Test site evaluation

Site requirements

- Representative for existing drinking water catchments
- High permeable aquifer
- Heavily colmated Rhine bed
- Infiltration zone (all season)
- No risk for drinking water wells



Experimental setup

Pumping well

- force the flow direction to slightly inwards

Monitoring wells

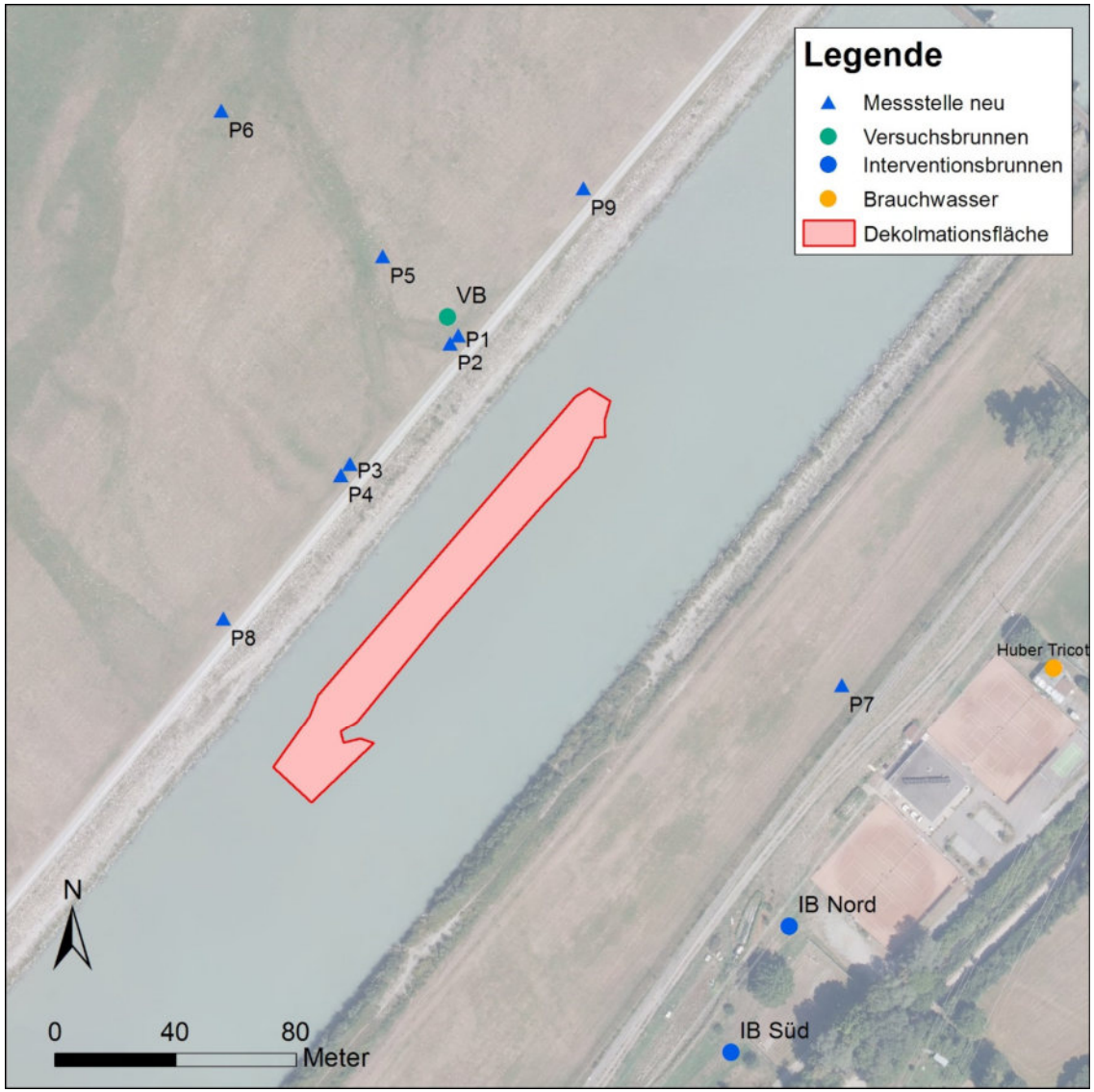
- along the riverbank
- perpendicular to the riverbank
- In two depth levels

Intervention wells

- prevent high ground-water levels

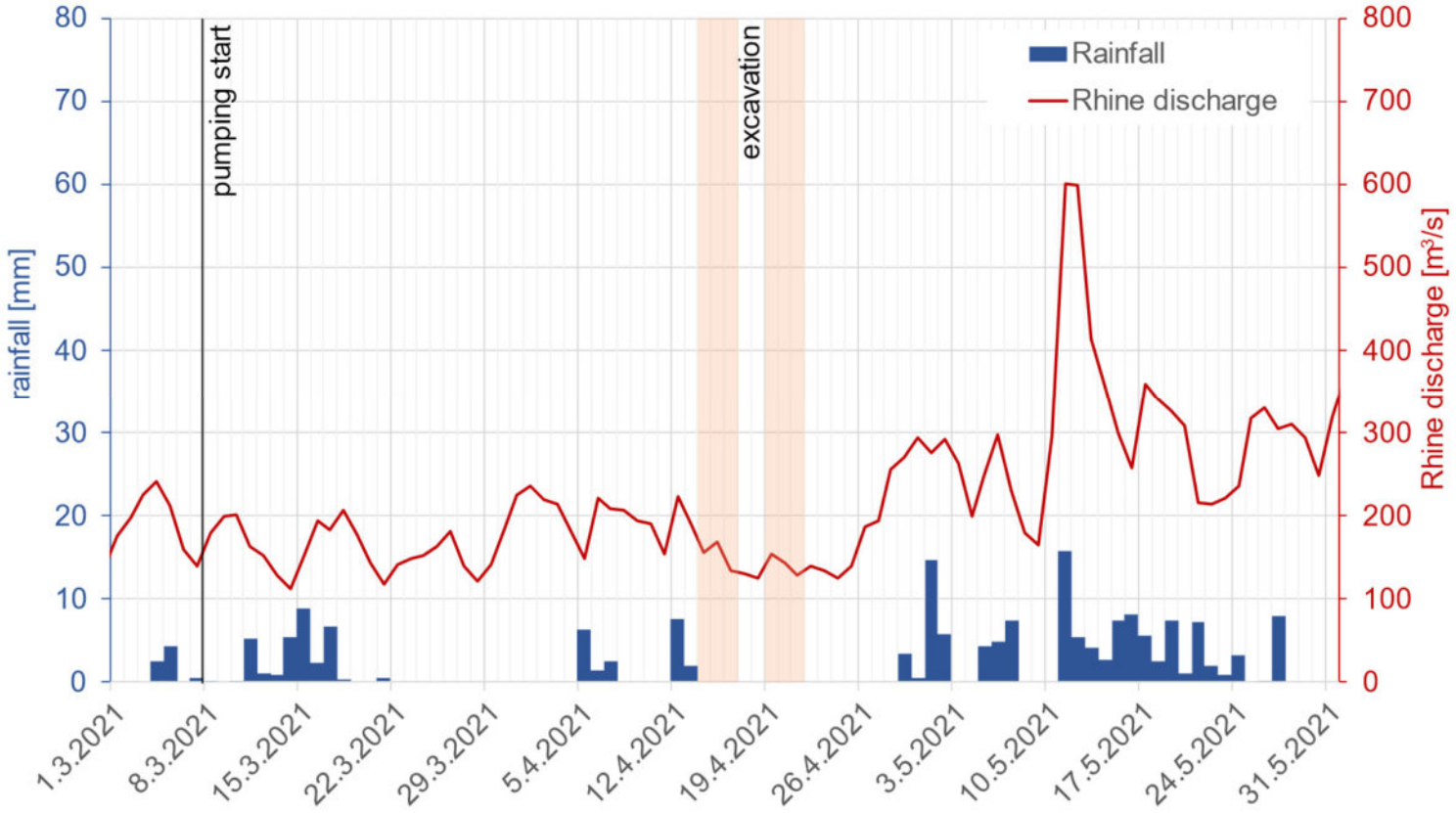
Excavation

- Area: 15 x 150 m
- Depth: 1 m

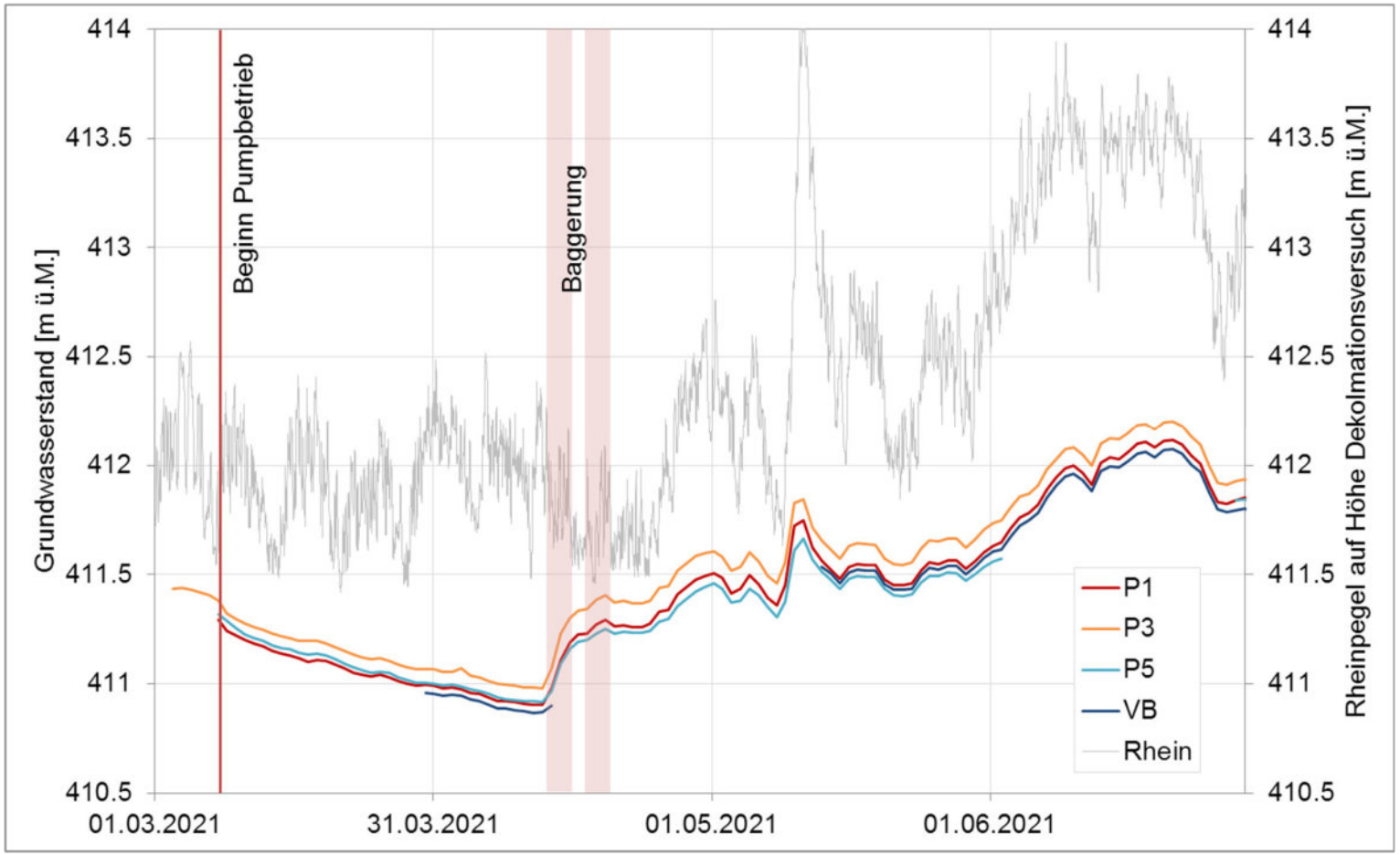


Test Period

- No heavy rainfall before and after excavation
- Rhine discharge low and constant

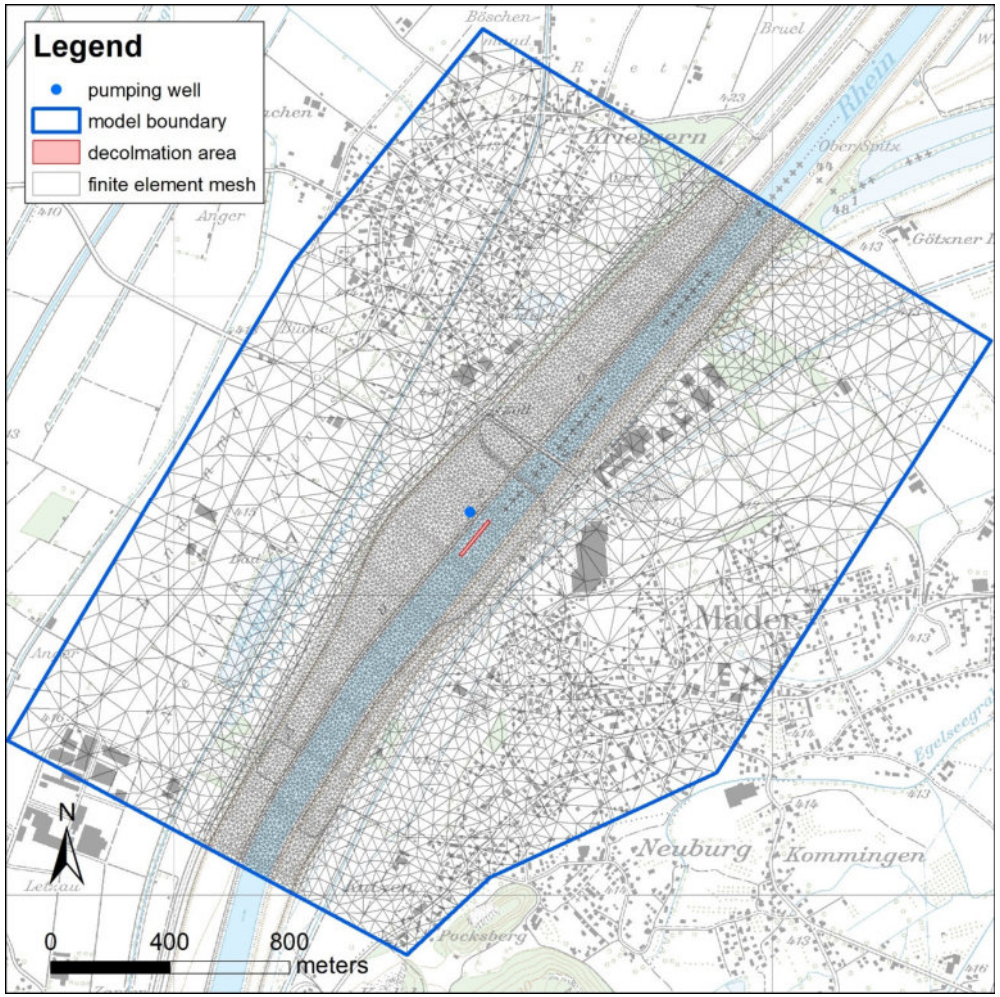


Groundwater table rise



Observations

Groundwater model



Regional model

- Calibrated to get good boundary conditions

Magnifier model

- Embedded in the regional model
- Automatic calibration of the Rhine leakage with PEST
- Calibration parameters are the daily values of the Rhine leakage in the excavation area

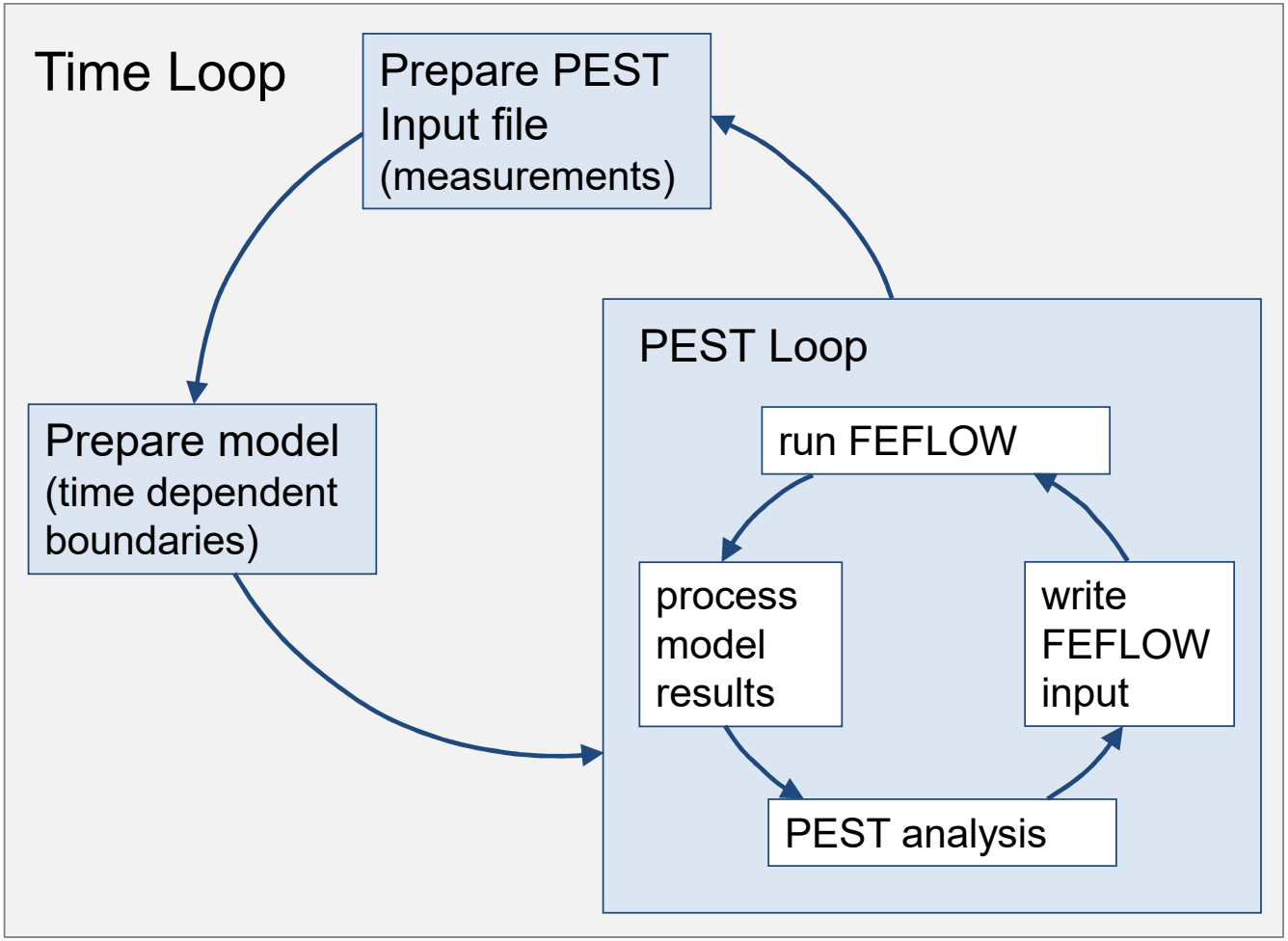
Calibration method

High time demand

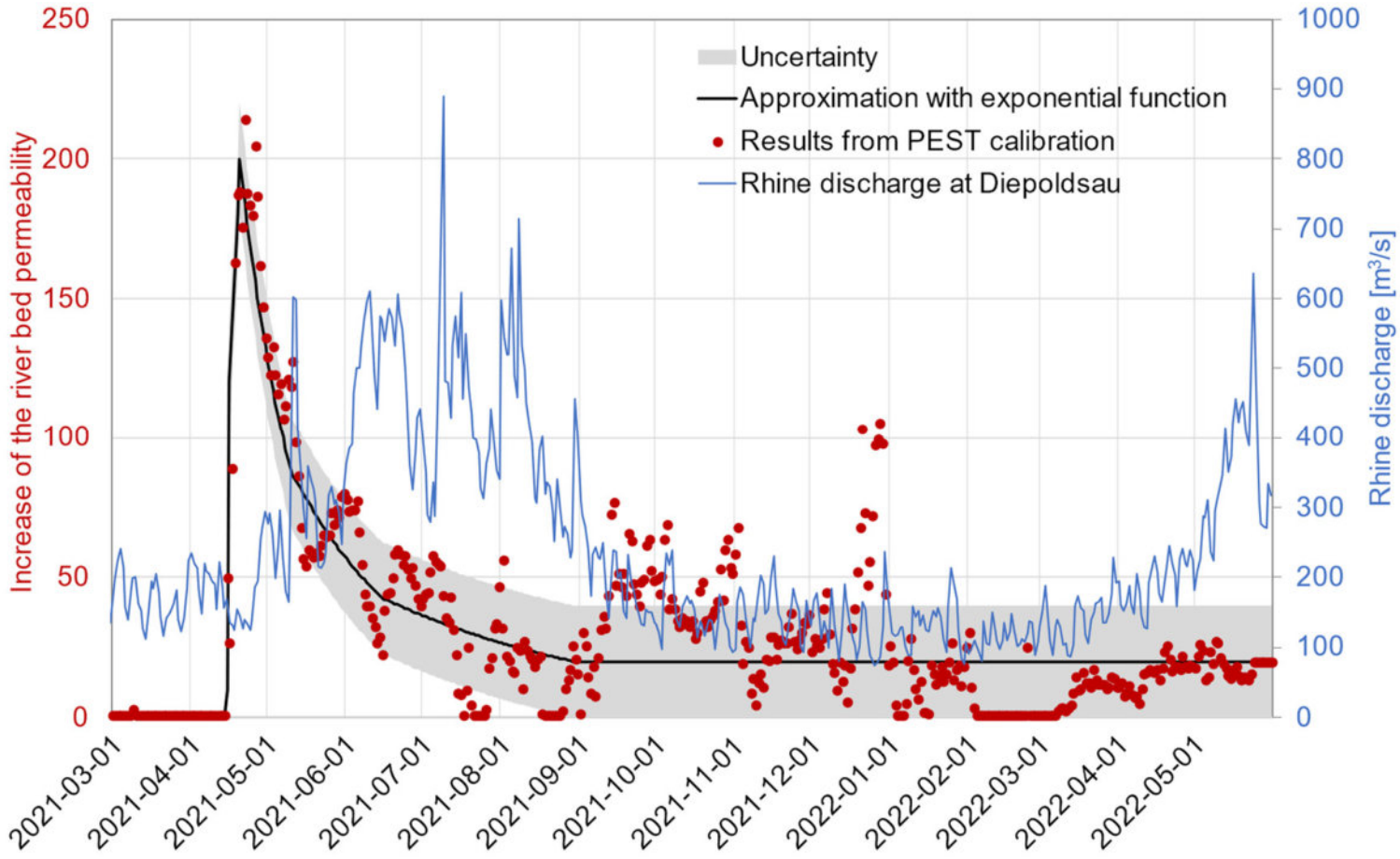
- 441 parameter
- Direct calibration would need 20 days of calculation time

Solution: Time loop

- 10 time segments
- Small overlap
- 2 days of calculation time



Calibration results



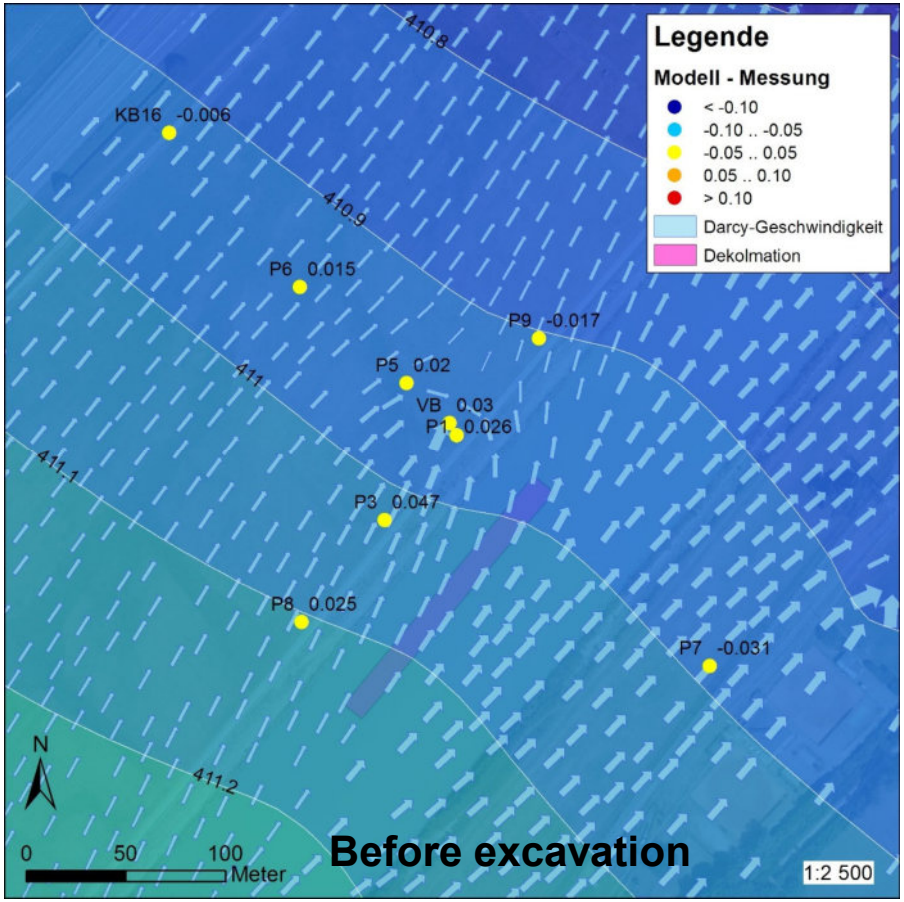
Comments

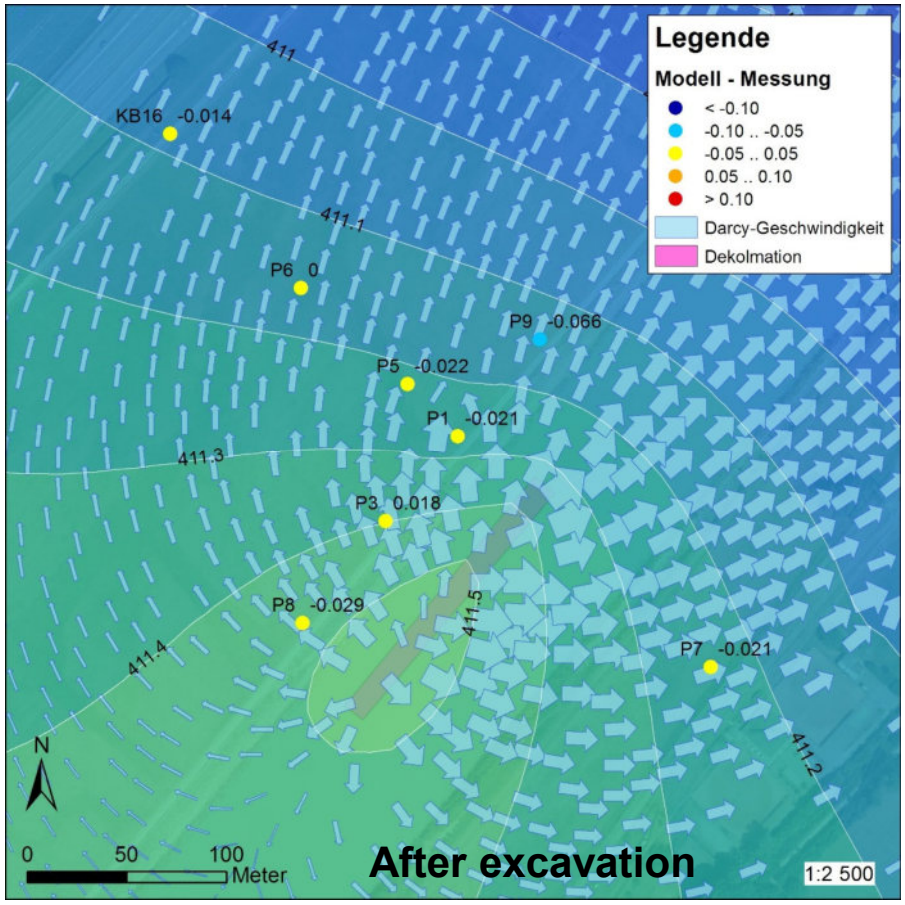
- Mean error was 4 cm over the whole period (3034 measurements)
- Decolmation area is less than 1% of the Rhine area inside the model
- Errors in the remaining area must be compensated by the decolmation area

→ estimated uncertainty

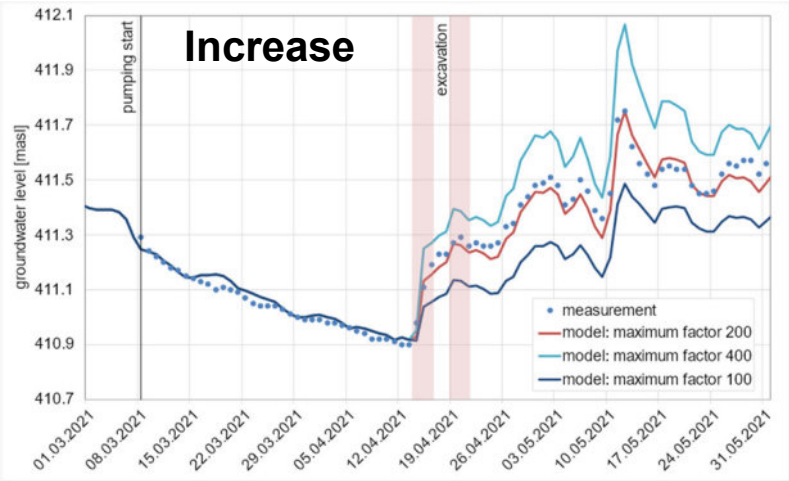
Flow direction

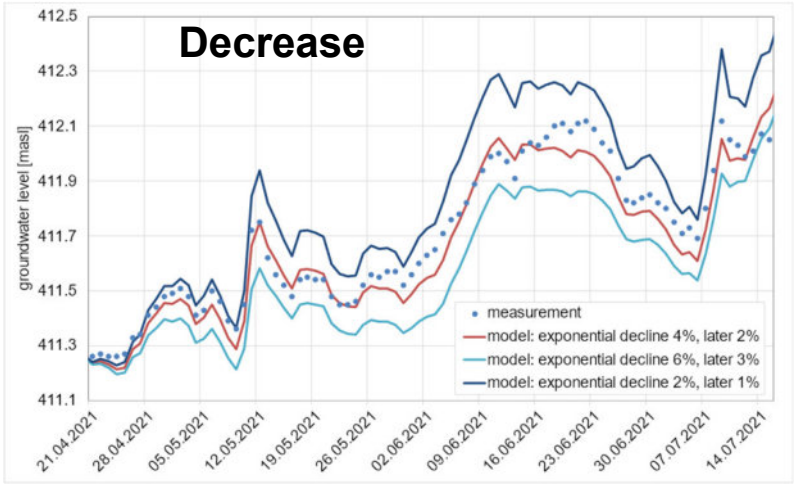
– Flow direction changes from nearly parallel to nearly perpendiculat to the Rhine





Sensitivity analysis of the resulting leakage value





Increase

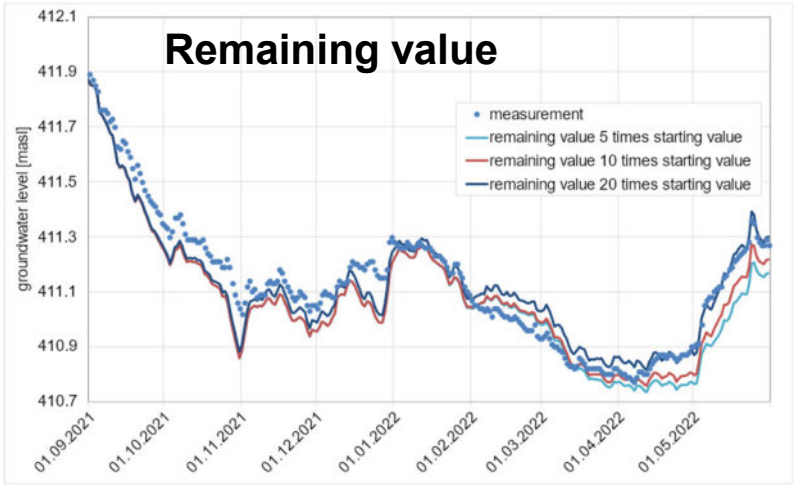
– Sensitive, factor 200

Decrease

– Sensitive, exponential, 4%, later 2% daily decrease

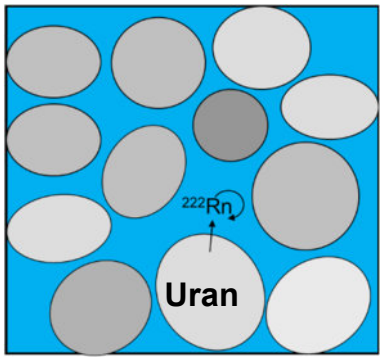
Remaining value

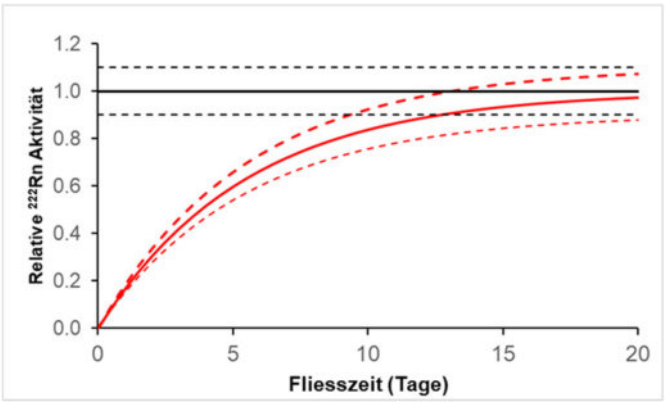
– Not sensitive, factor 5 - 20

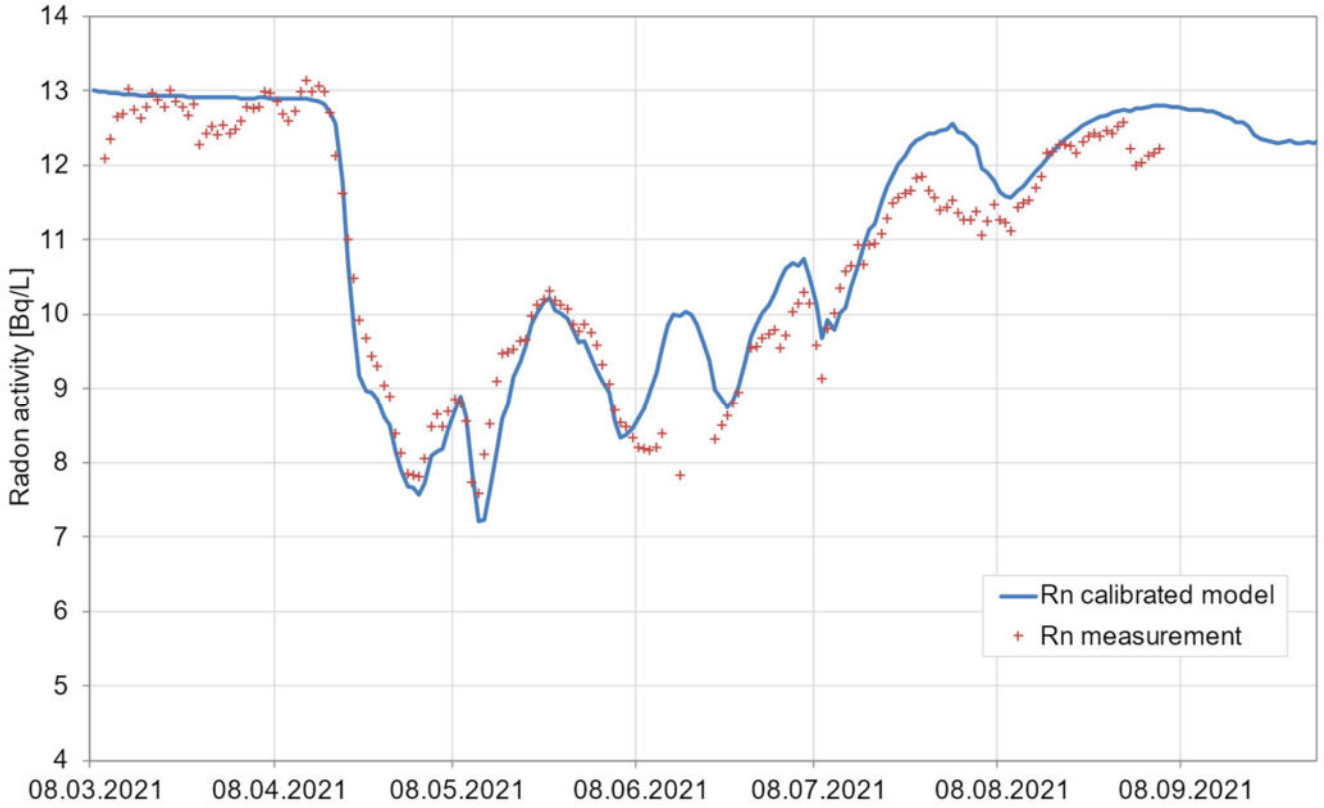


Natural tracers: Radon

- No ^{222}Rn in the Rine, half-live time of the saturation: 3.8 days
- Resulting flow-effective porosity: 10%



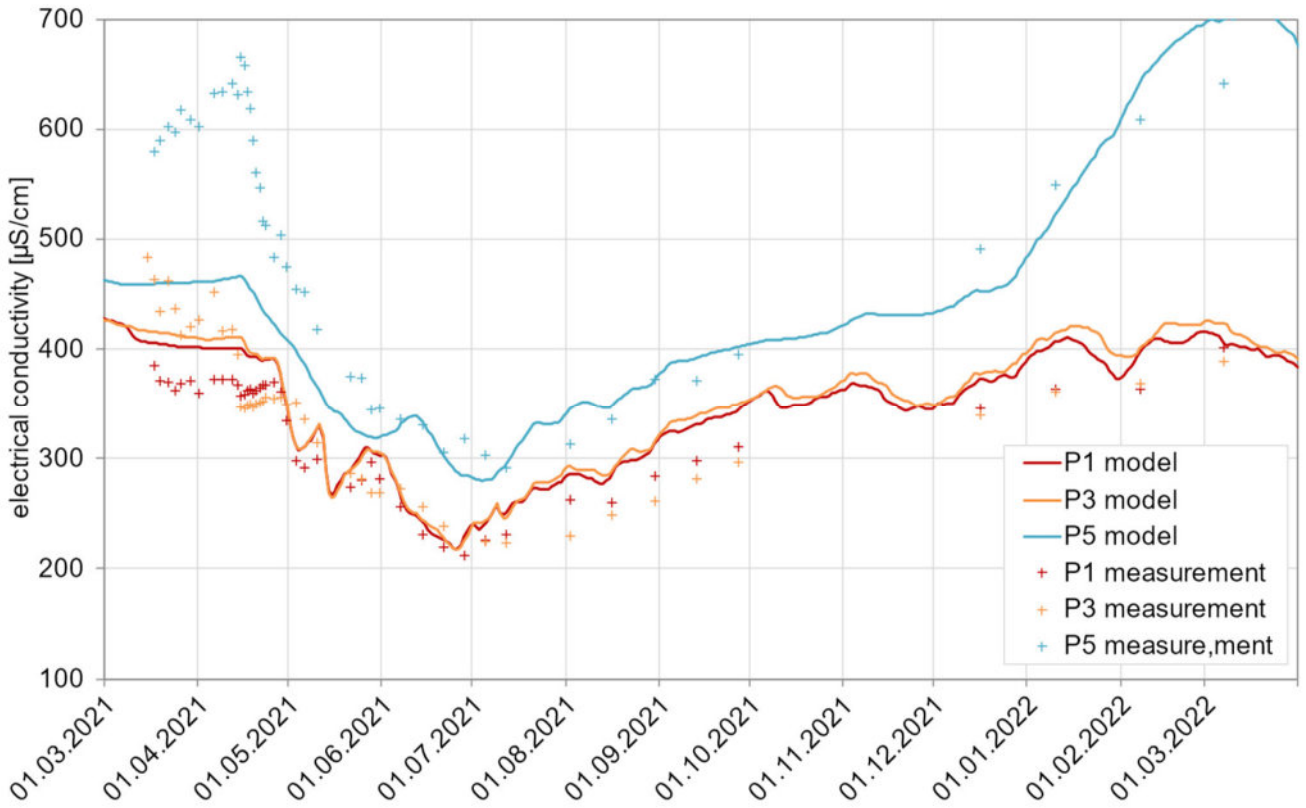




Test interpretation

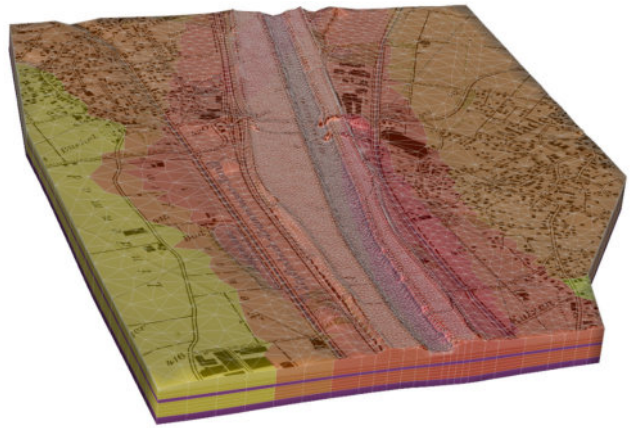
Natural tracers: electrical conductivity

- Useful to distinguish between landside and riverside flow direction
- Saturation process unknown – hypothesis needed



Hypothesis

- Background value 800 µS/cm
- Saturation by passing rock matrix up to 450 µS/cm with half-time of 100 days

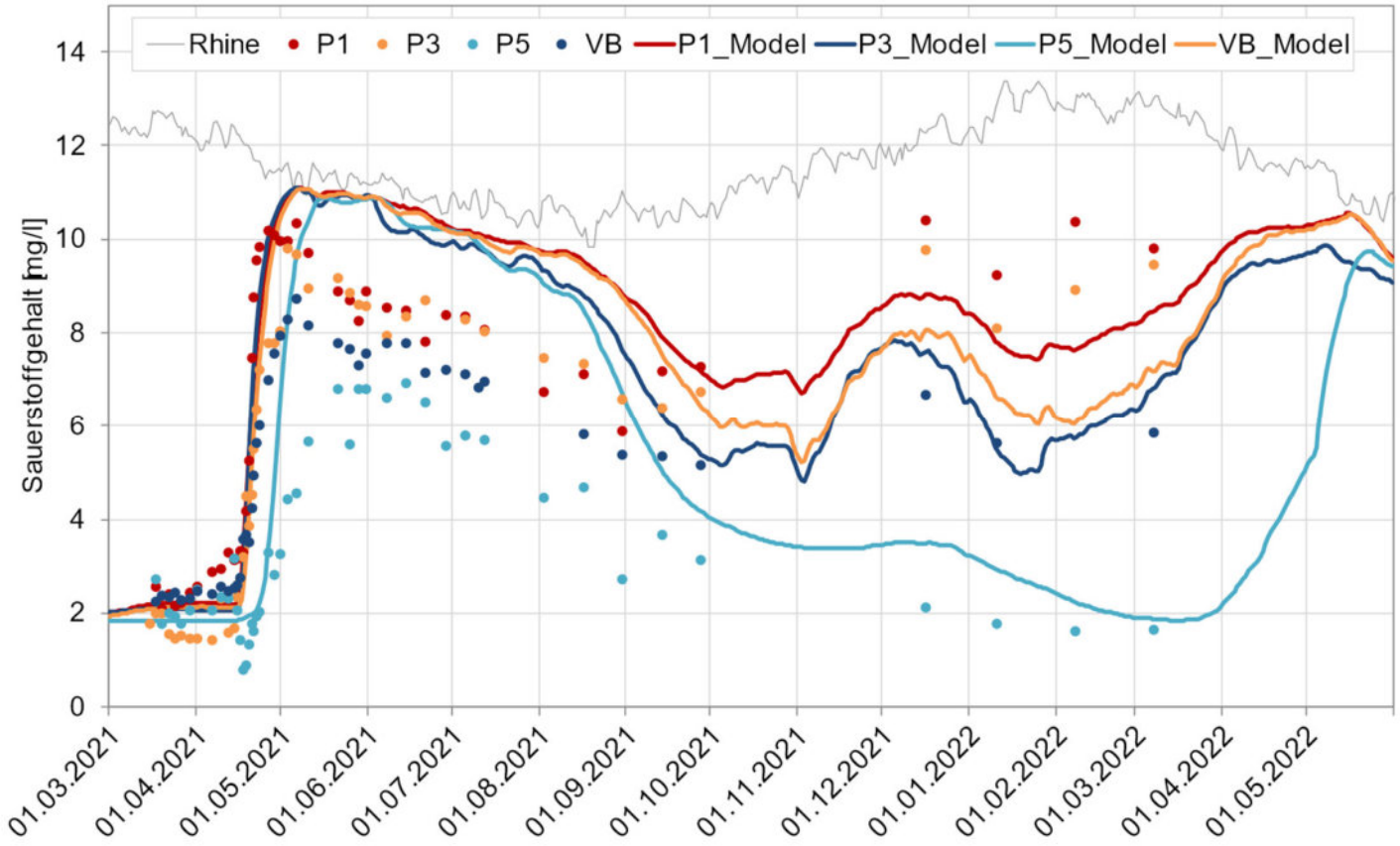


3D-model

Test interpretation

Natural tracers: oxygen concentration

– High oxygene values remain until today



Hypothesis Nr. 8

- The high values are due to the remaining higher permeability in the excavation area
- The biofilm may have a restricted capacity to reduce oxygene
- Only parameter introduced: reduction capacity

Results

- Not so nice but simpler
- Must be combined with other effects (layered aquifer, mixing with immobile water)

Thanks for your attention
Questions?