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14th International HCH and Pesticides Forum

TRACER TESTS IN THE HCH-AFFECTED ALLUVIAL AQUIFER DOWNSTREAM THE SARDAS LANDFILL (HUESCA, SPAIN)

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Outline

- Introduction & motivation
- Tracer tests
- Numerical model
- Interpretation: model results
- Conclusions & future work

Introduction

- HCH and other COCs have migrated through the Gállego river alluvial aquifer downstream the Sardas landfill, which is located on the left bank of the Gállego river, less than 500 m from the Sabiñánigo reservoir
- Piezometric measured data show that
  - Hydraulic heads in the alluvial aquifer fluctuate due to the tidal effect produced by reservoir water level daily fluctuations
  - The gradient of the piezometric heads is extremely small
  - There are uncertainties in quantifying groundwater flow: q
  - 2D groundwater flow models indicate that groundwater flow is mostly from the alluvial to the reservoir (E - W), but velocities fluctuate and change direction
- There is a need to perform field tests to estimate the direction of groundwater flow and groundwater velocity

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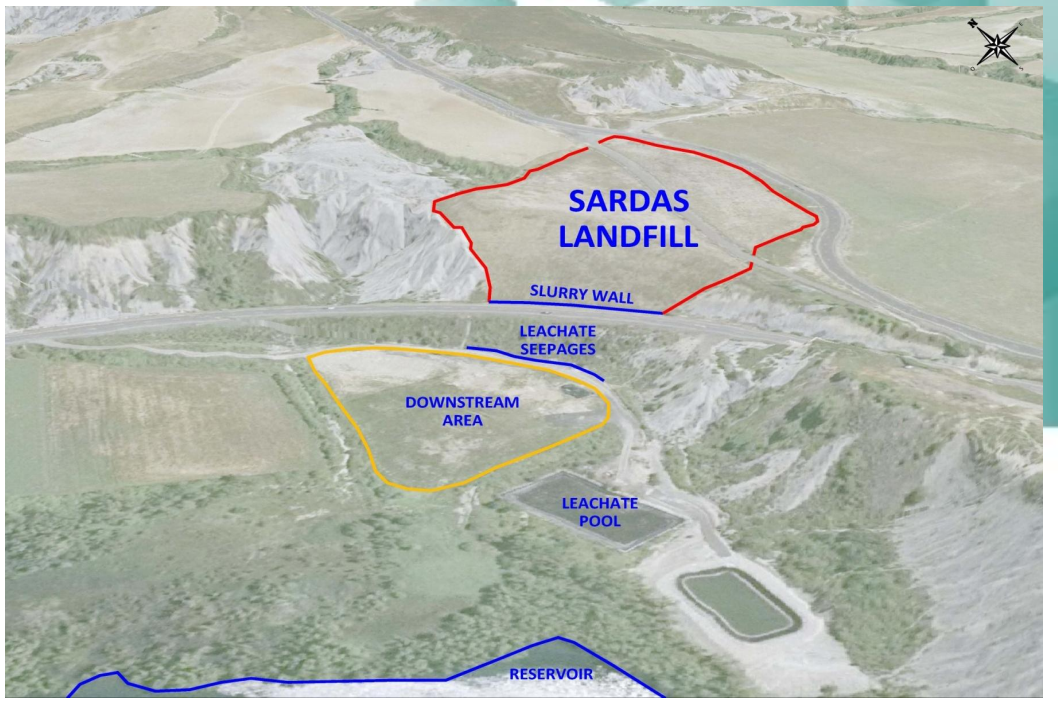
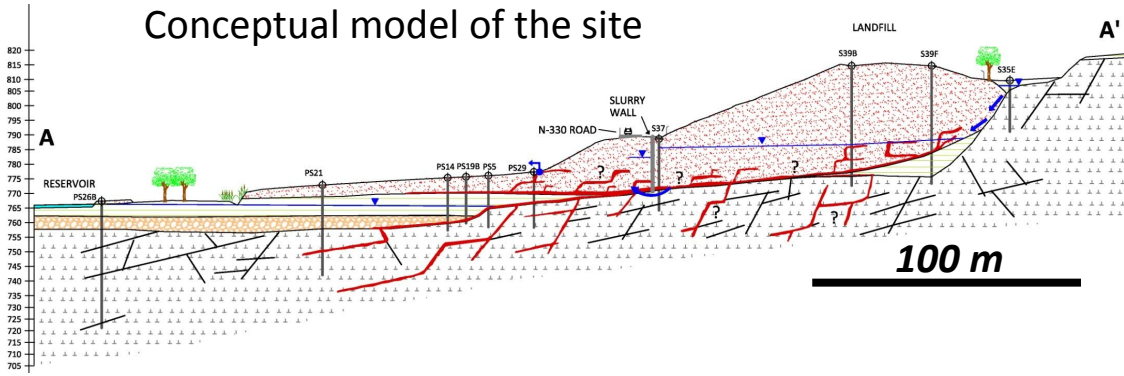


Conceptual model of the site

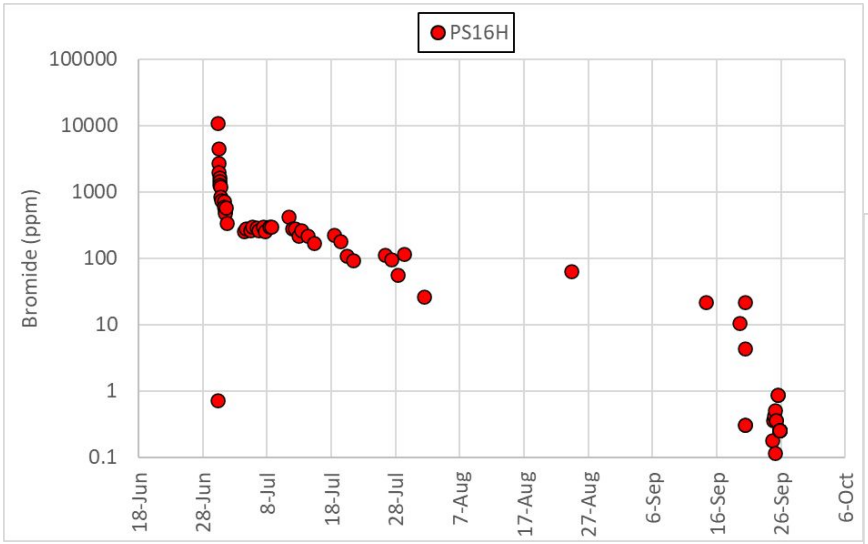


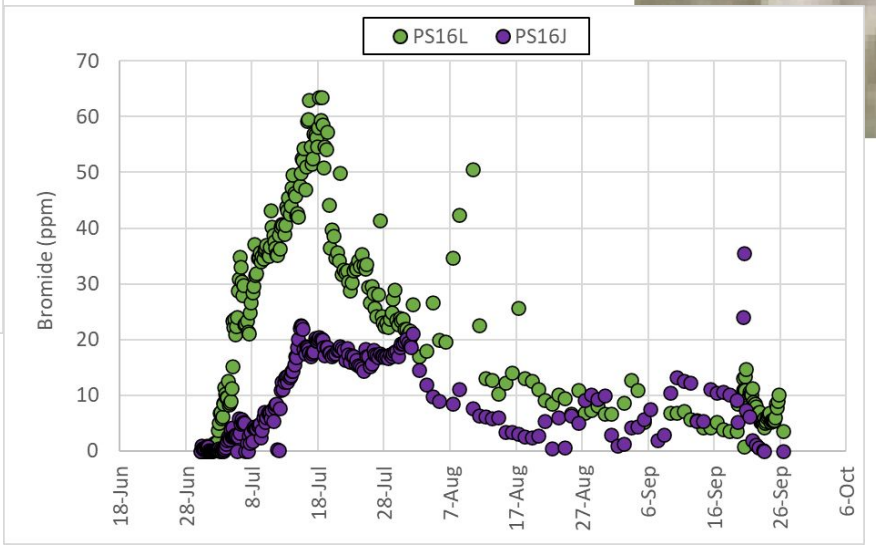
Tracer tests

- Tracer tests were performed in 2022 to
  - Quantify groundwater velocity under ambient conditions: direction and magnitude
  - Characterize aquifer parameters and heterogeneities
- A dilution test was performed on Feb 8th by adding salt water in borehole PS16H and recording electrical conductivity logs
- A long-term Br tracer test was performed from June 30 to September 23 by injecting 300 L of a traced NaBr solution in 1 hour into the PS16H borehole.
- Tracer concentrations were monitored periodically for three months in downstream boreholes

Tracer tests

- Dilution test provided estimates of Darcy velocity q
  - From 0.022 m/d to 0.052 m/d.
- Long-term Br tracer test
  - Be concentration data measured at UCM laboratory
  - Tracer dilution in injection borehole PS16H
  - Tracer breakthrough curves in PS16L and PS16J

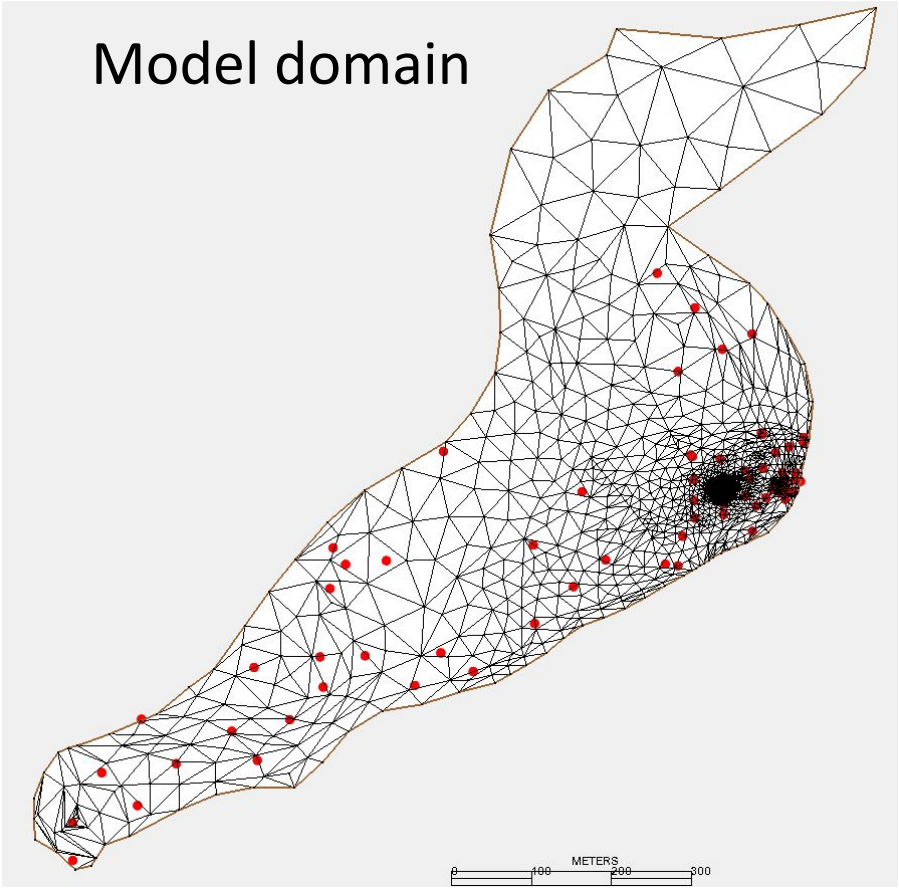




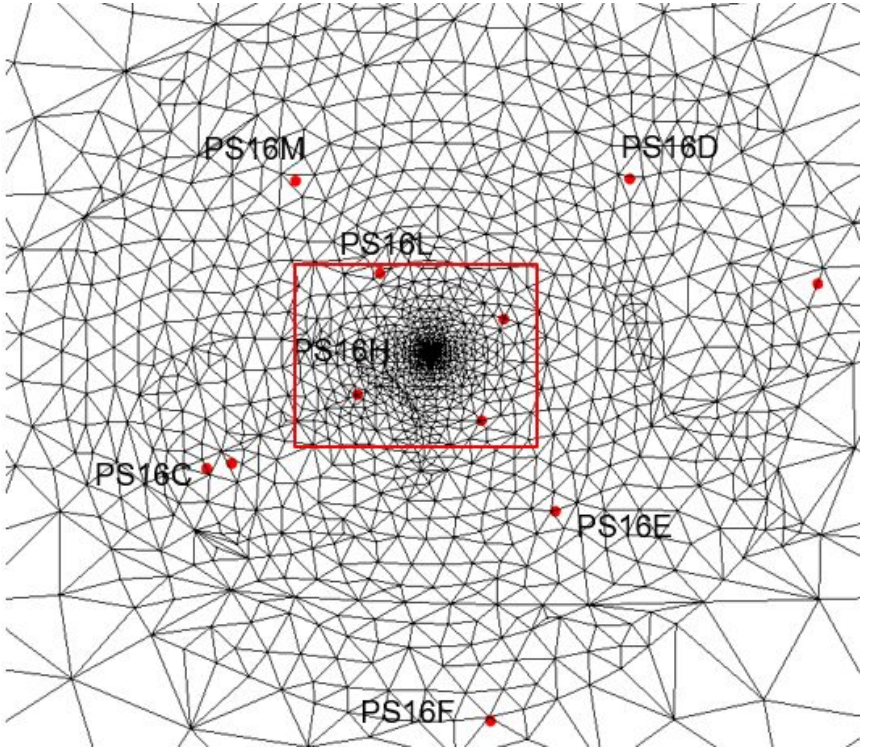
Numerical model of the long-term tracer test

- The tracer test is modeled with the finite element flow and transport model of the entire alluvial aquifer
  - Transient flow with reservoir oscillations
- Model predictions were performed for planning the test
- Predictions were updated as data became available

Model domain

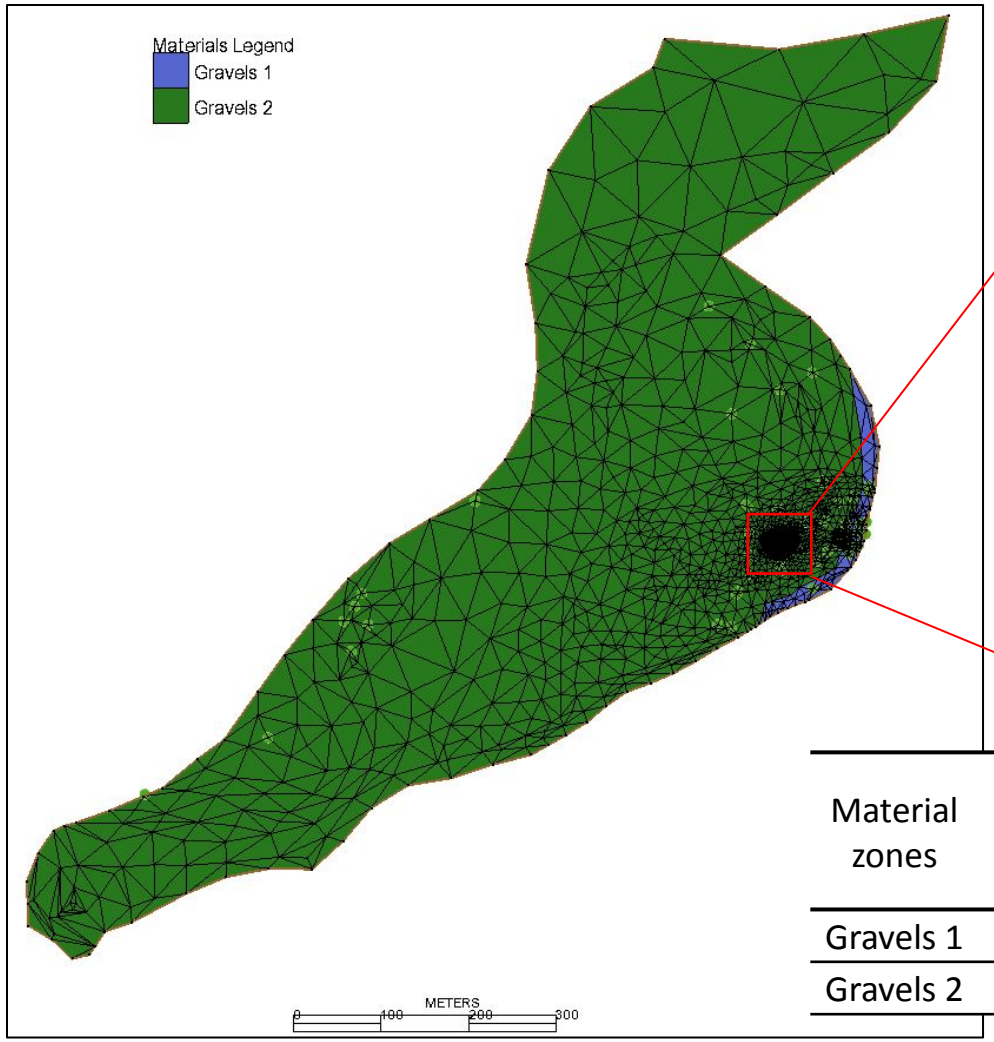


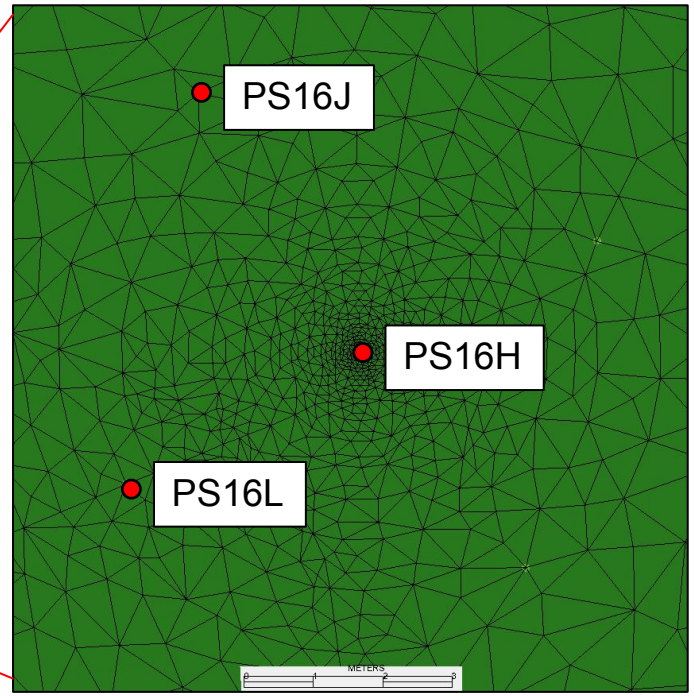
Zoom of the test area



Numerical model of the long-term tracer test

Material zones and solute transport parameters

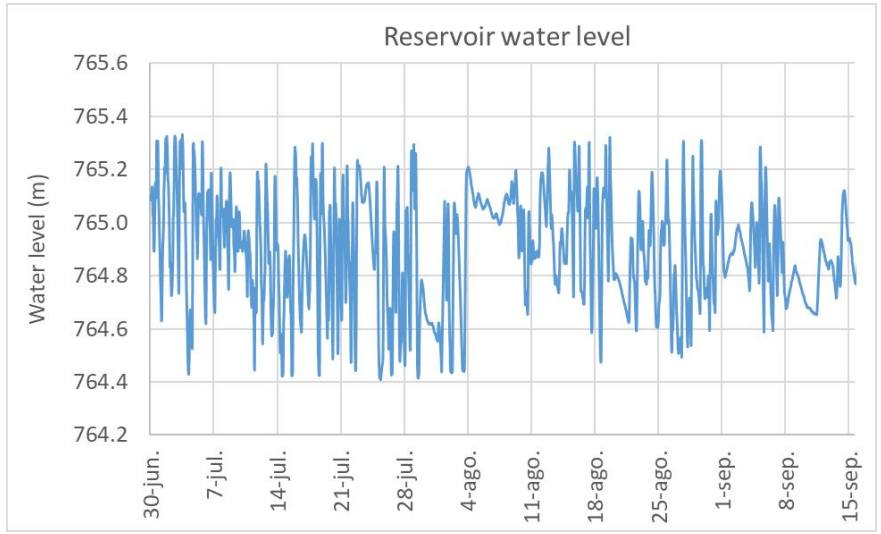


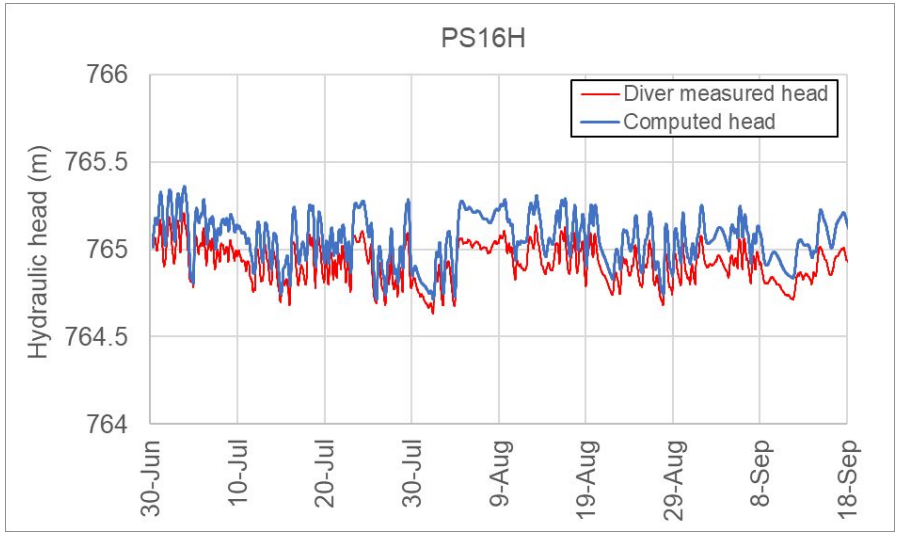


Material zones	Hydraulic conductivity, K (m/d)	Specific storage coefficient, S_s (m^{-1})	Porosity, φ	Longitudinal dispersivity (m)	Transversal dispersivity (m)
Gravels 1	600	$6 \cdot 10^{-4}$	0.15 – 0.2	0.5 – 2	0.25
Gravels 2	300	$6 \cdot 10^{-4}$	0.15 – 0.2	0.5 – 2	0.25

Numerical model of the long-term tracer test

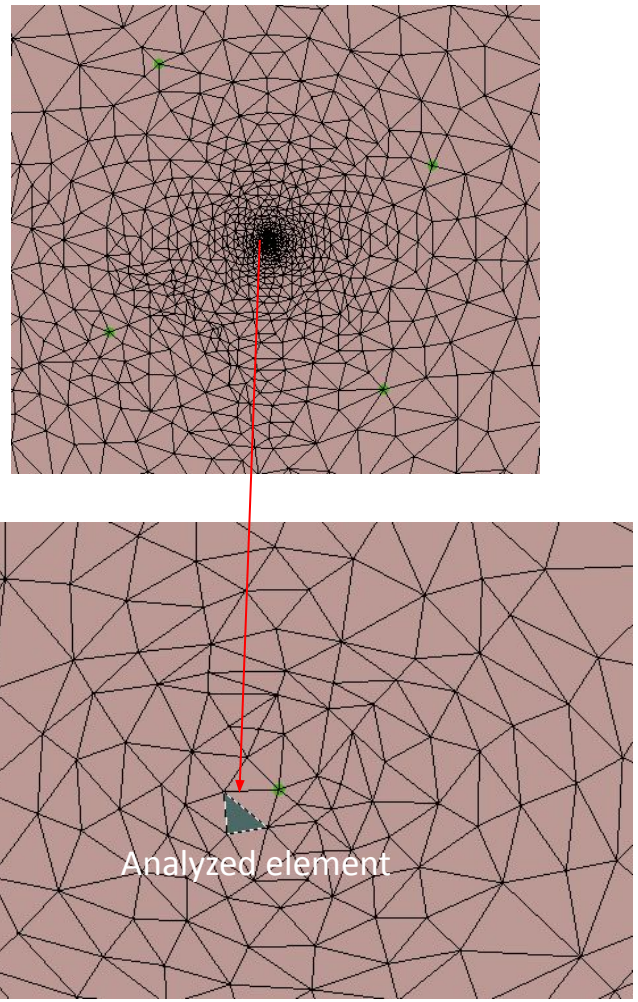
- Model results reproduce the measured oscillations of the groundwater heads
  - Small discrepancy

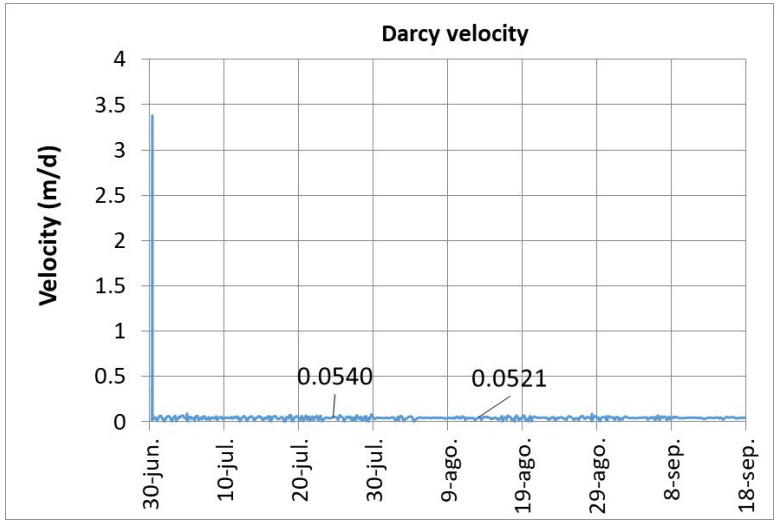


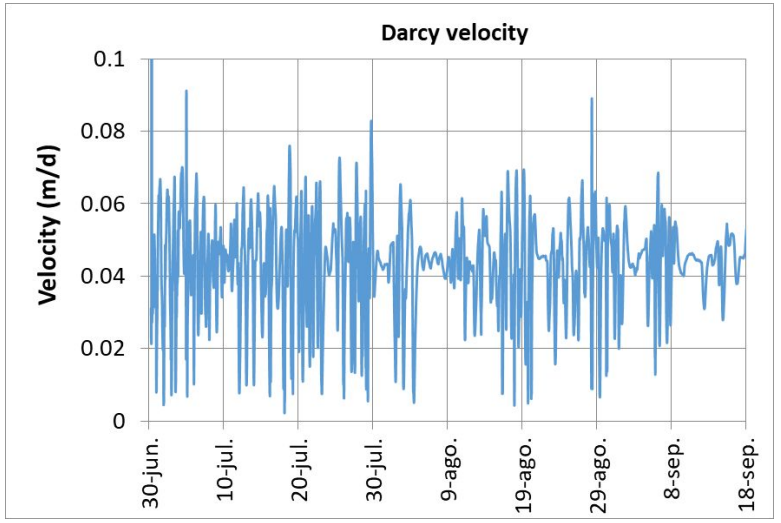


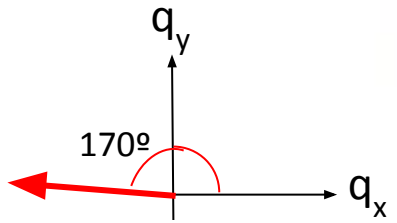
Numerical model of the long-term tracer test

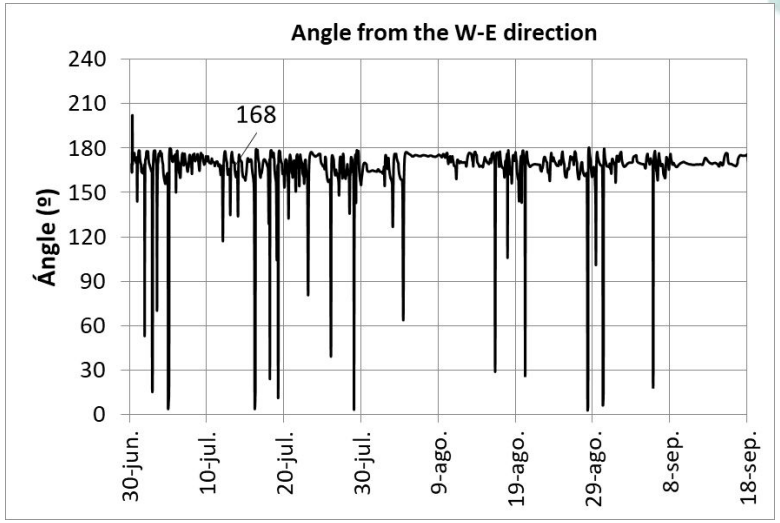
- Model results for groundwater velocity near the injection well





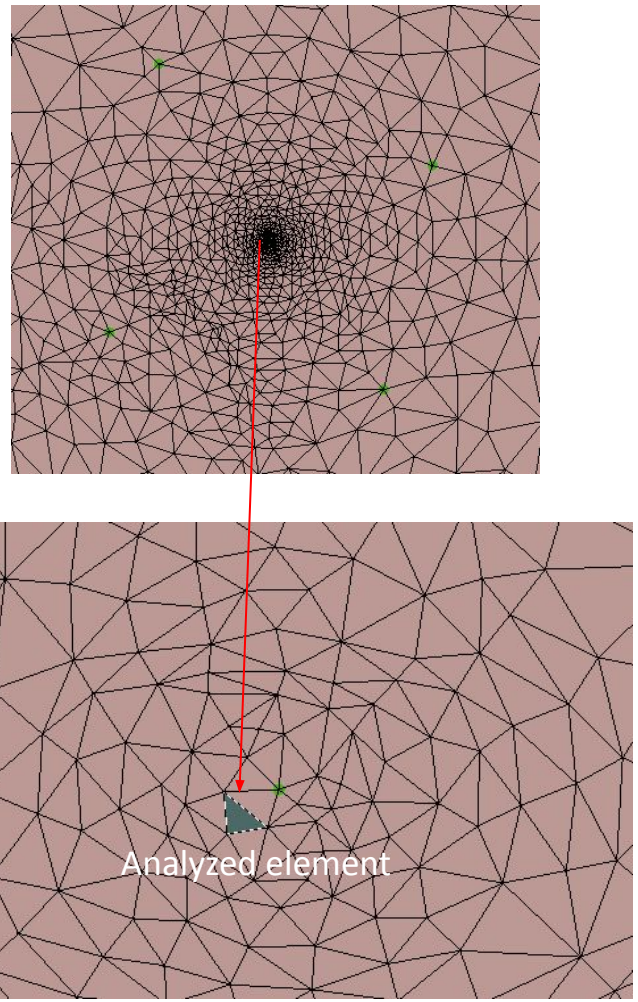


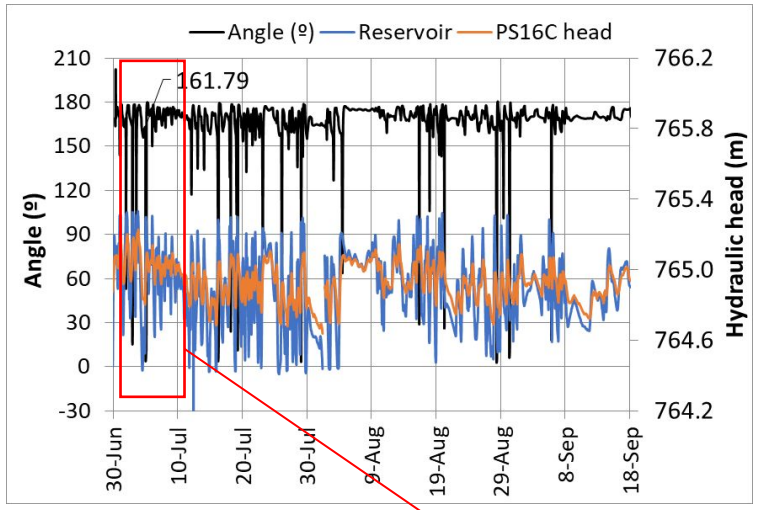


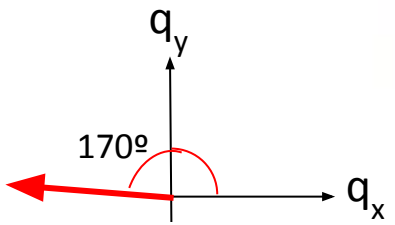


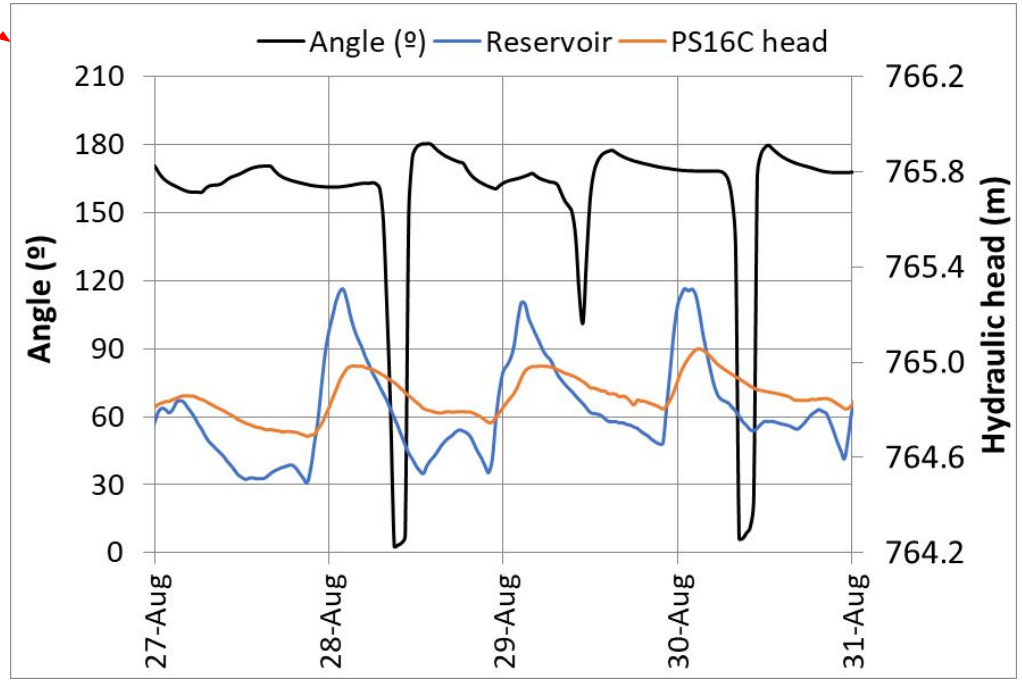
Numerical model of the long-term tracer test

- Reversal of the direction of groundwater flow



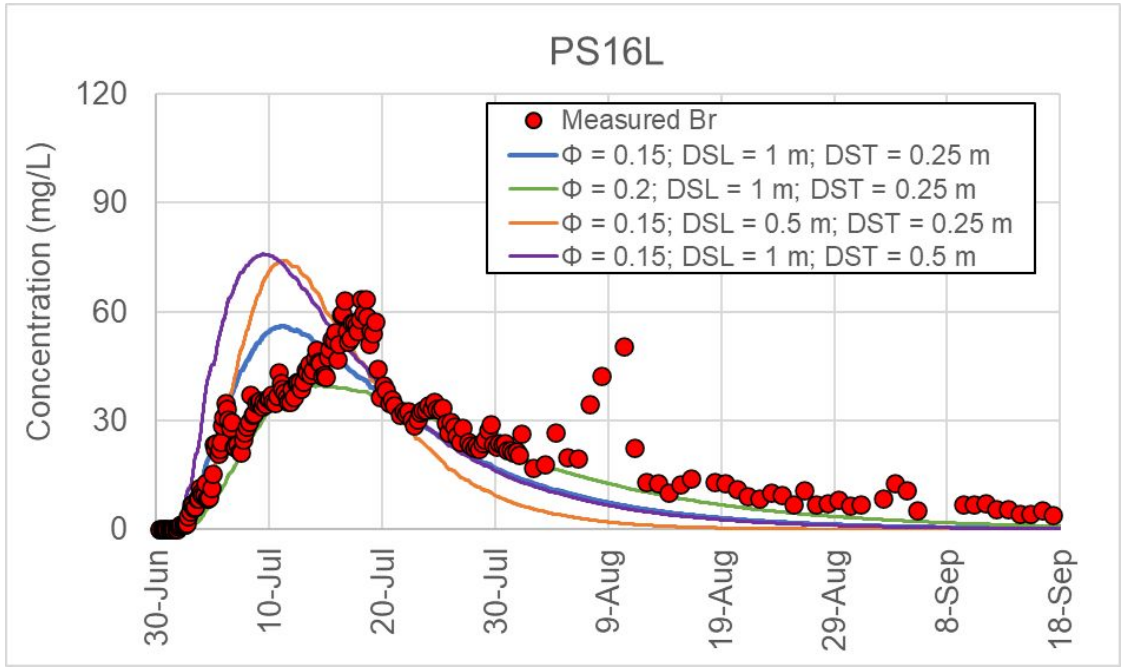


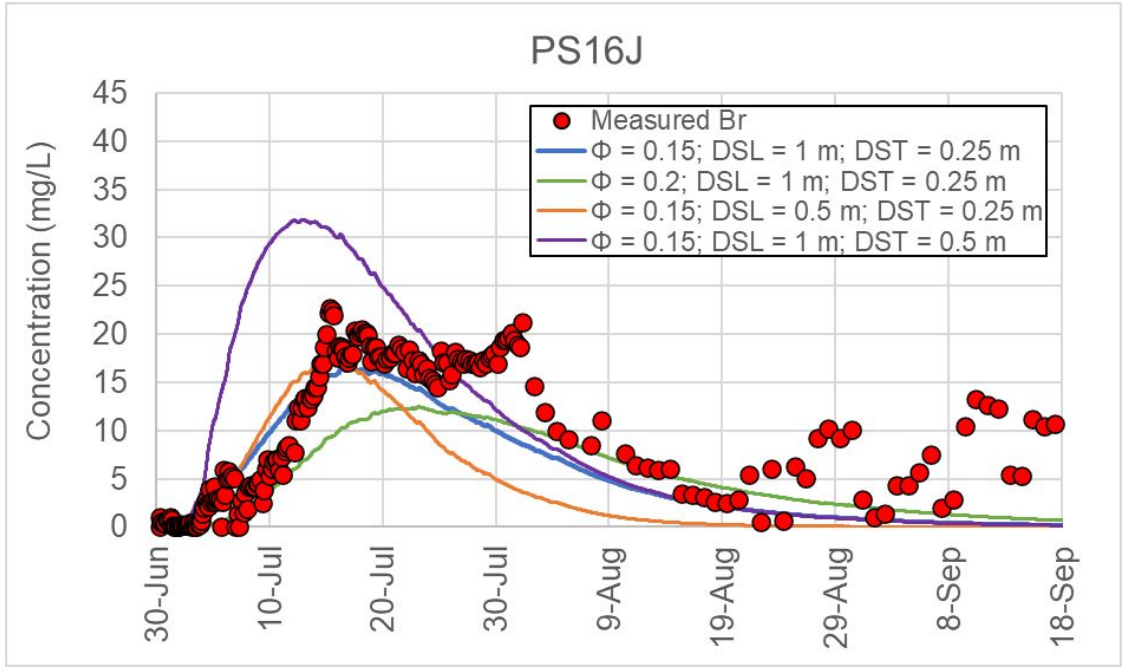




Numerical model of the long-term tracer test

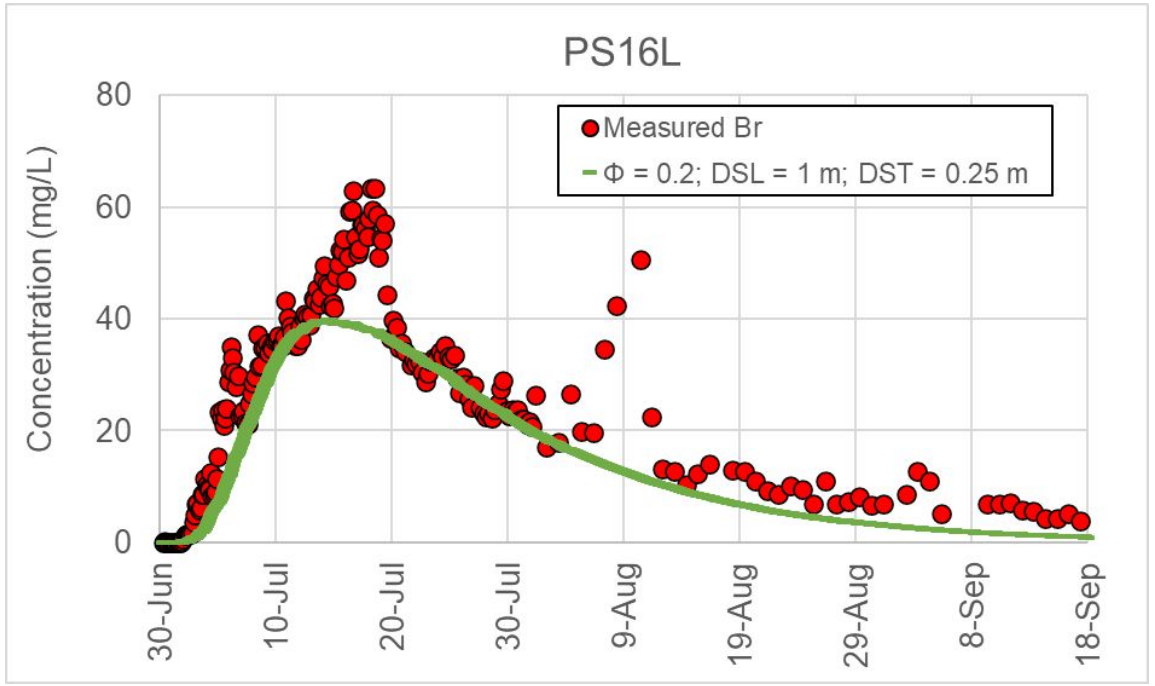
- Model results for Br breakthrough curve (BC)
  - Detailed sensitivity analysis of model parameters and processes
  - Br BC is most sensitive to the porosity
  - Less sensitive to dispersivities





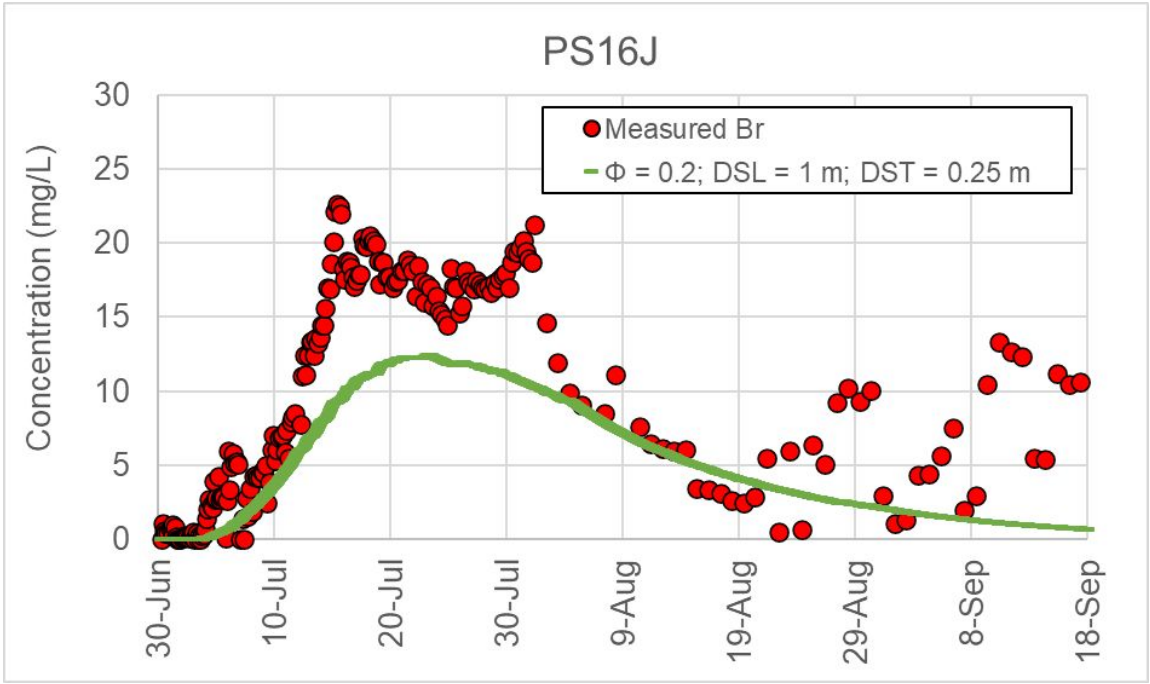
Numerical model of the long-term tracer test

- Model results for Br breakthrough curve
  - Best fit for the BC in PS16L
  - The model captures the main trend of concentrations
  - But, there are some discrepancies



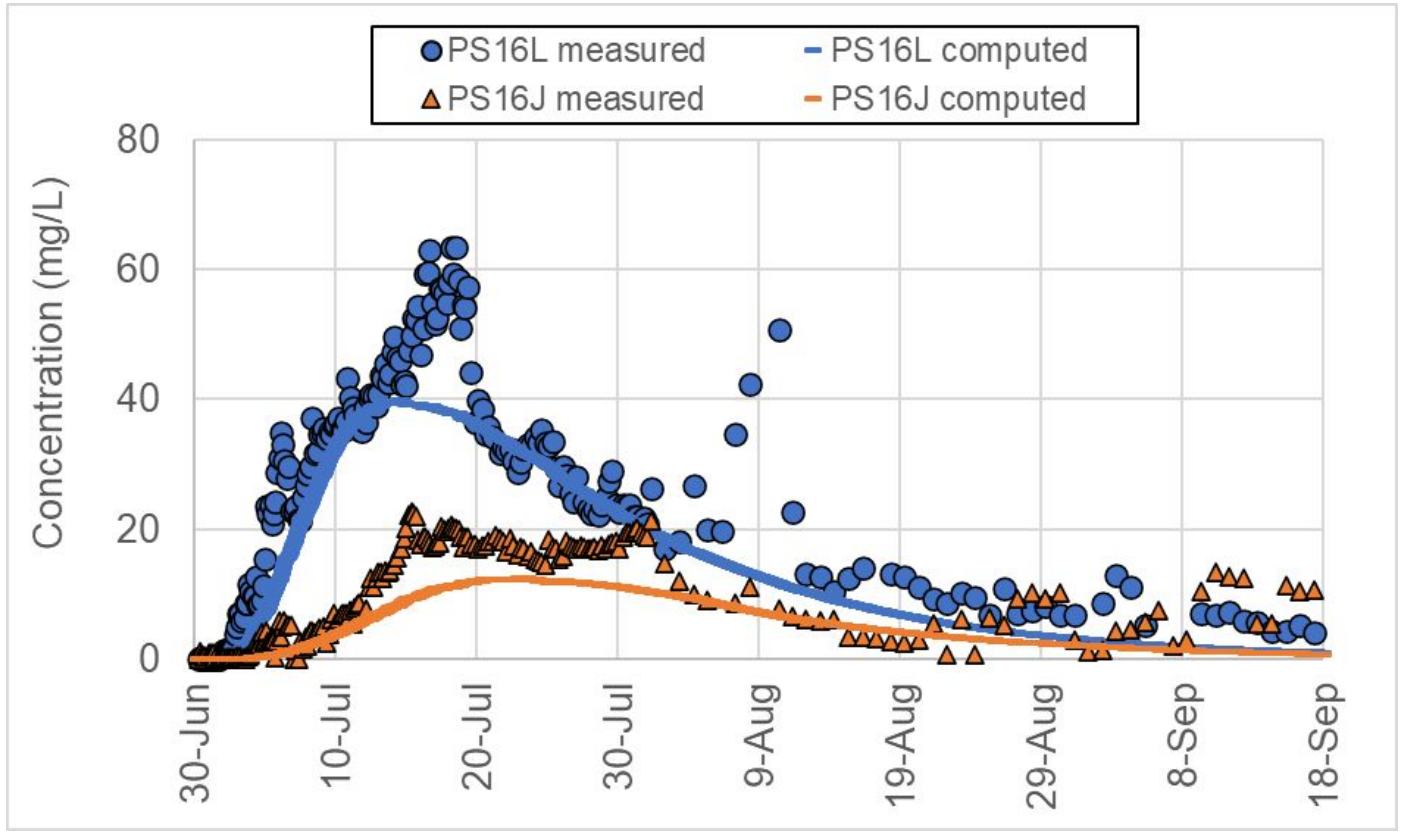
Numerical model of the long-term tracer test

- Model results for Br breakthrough curve
  - Best fit for the BC in PS16J
  - The model captures the main trend of concentrations
  - But, there are some significant discrepancies



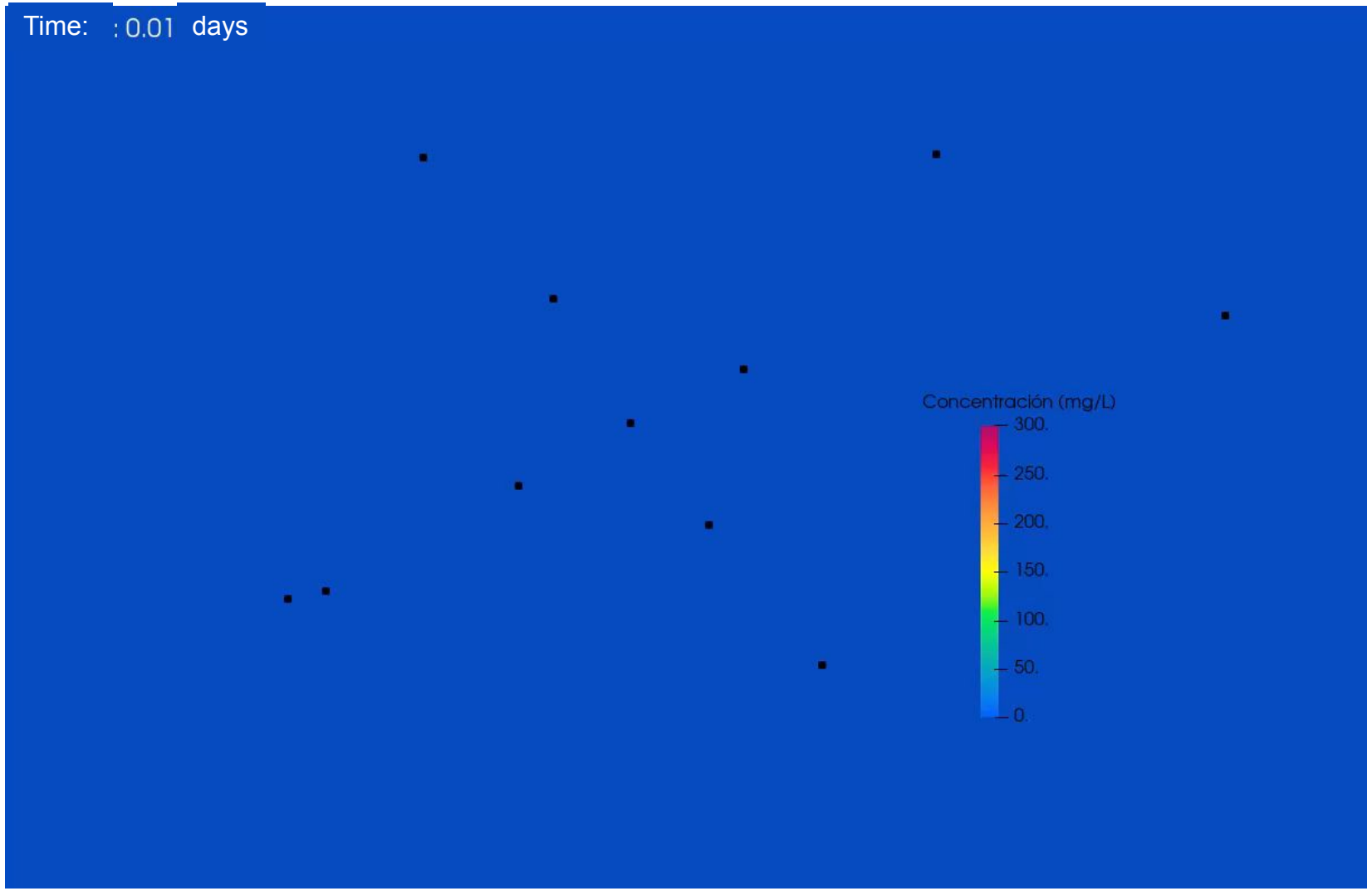
Numerical model of the long-term tracer test

- Model results for both Br breakthrough curves
  - The model captures the main trends of concentrations
  - Measured data show patterns and peaks which cannot be reproduced with the model



Numerical model of the long-term tracer test

- Movie of the time evolution of the Br plume



Conclusions & future work

- Tracer tests were conducted at the Sardas site to quantify groundwater velocity under ambient conditions and characterize aquifer parameters and heterogeneities
- A dilution test provided an estimate of the Darcy velocity (0.022 - 0.052) m/d
  - This range is consistent with model values
- The long-term Br tracer test was successful in providing the tracer breakthrough curves in boreholes PS16K and PS16L located around 4 m away from the injection borehole
- The numerical model of the tracer test
  - Useful design the test
  - It was dynamically updated during the test by incorporating the measured tracer data
  - It was useful to interpret measured data
- Model results
  - Reproduce the measured head data
  - Reproduce the general trends of the tracer curves

Conclusions & future work

- Model results of Darcy velocity
  - Fluctuates during the test due to the oscillations of the reservoir level
  - Ranges from 0.01 m/d to 0.09 m/d.
  - The best fit is achieved with a porosity range (0.15, 0.25), longitudinal dispersivity (1, 2) m & transversal dispersivity (0.25, 0.5) m
- Average water velocity = 0.25 m/d
- The results of the tracer test confirm the conceptual model of the groundwater flow through the alluvial aquifer and provide useful information about the heterogeneities of the sands and gravels and the solute transport parameters
- There are uncertainties related to
  - Imperfect vertical mixing
  - Aquifer local heterogeneities
- Future work
  - Account for local heterogeneities (anisotropy?)
  - Additional tests with forced water flow (convergent flow)

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THANK YOU FOR YOUR ATTENTION

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https://cica.udc.gal/group/aquaterra/

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EMGRISA

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