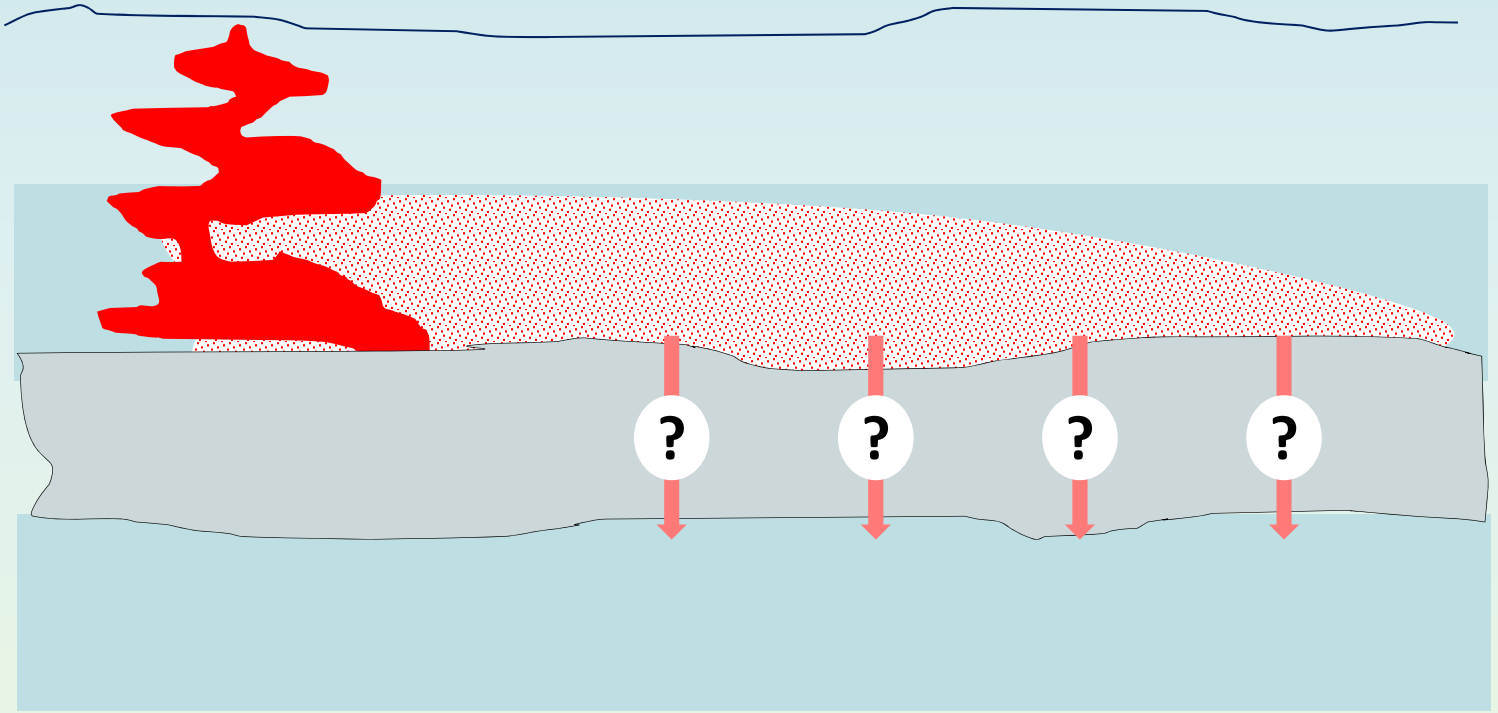
Is there a conceptual model in a 3D heterogeneous multilayer aquifer, and how to approach it?

O. Atteia, M. Annable, C. Portois, N. Guiserix, A. Joubert

Transfer through « aquitards »?



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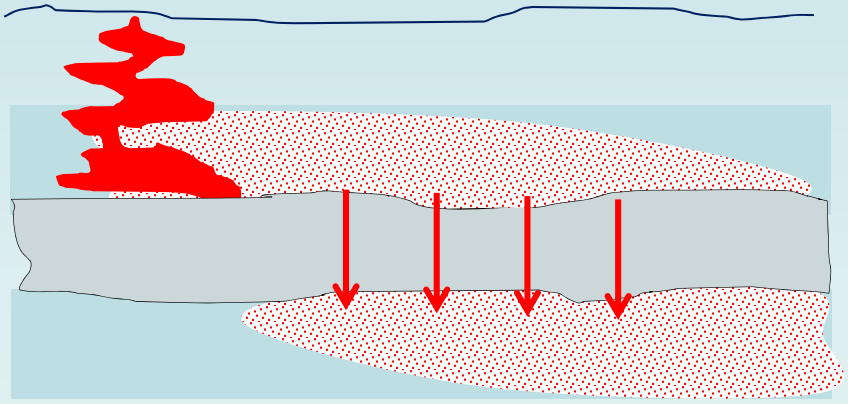
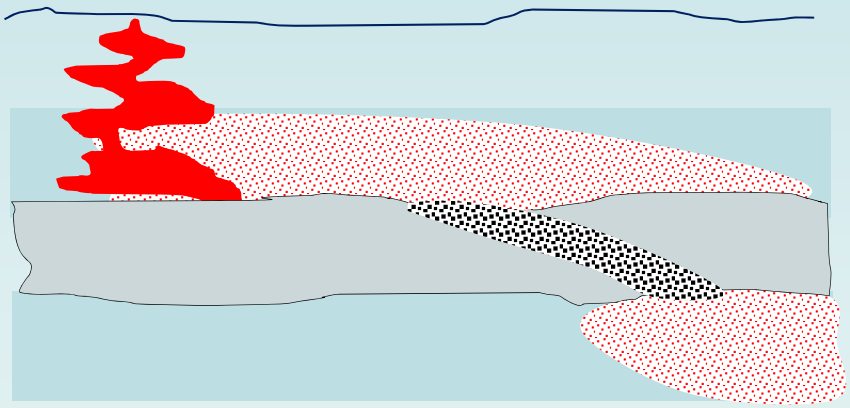
Conceptual models

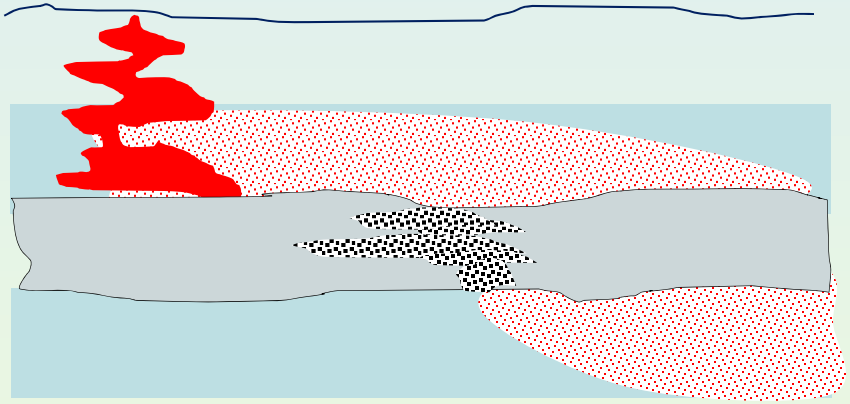
Leakage



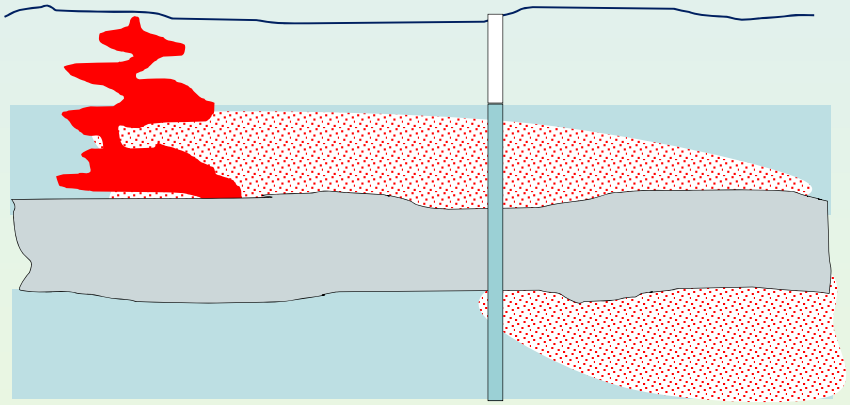
Sandy prograding layer



Stream deposit



Leaky well



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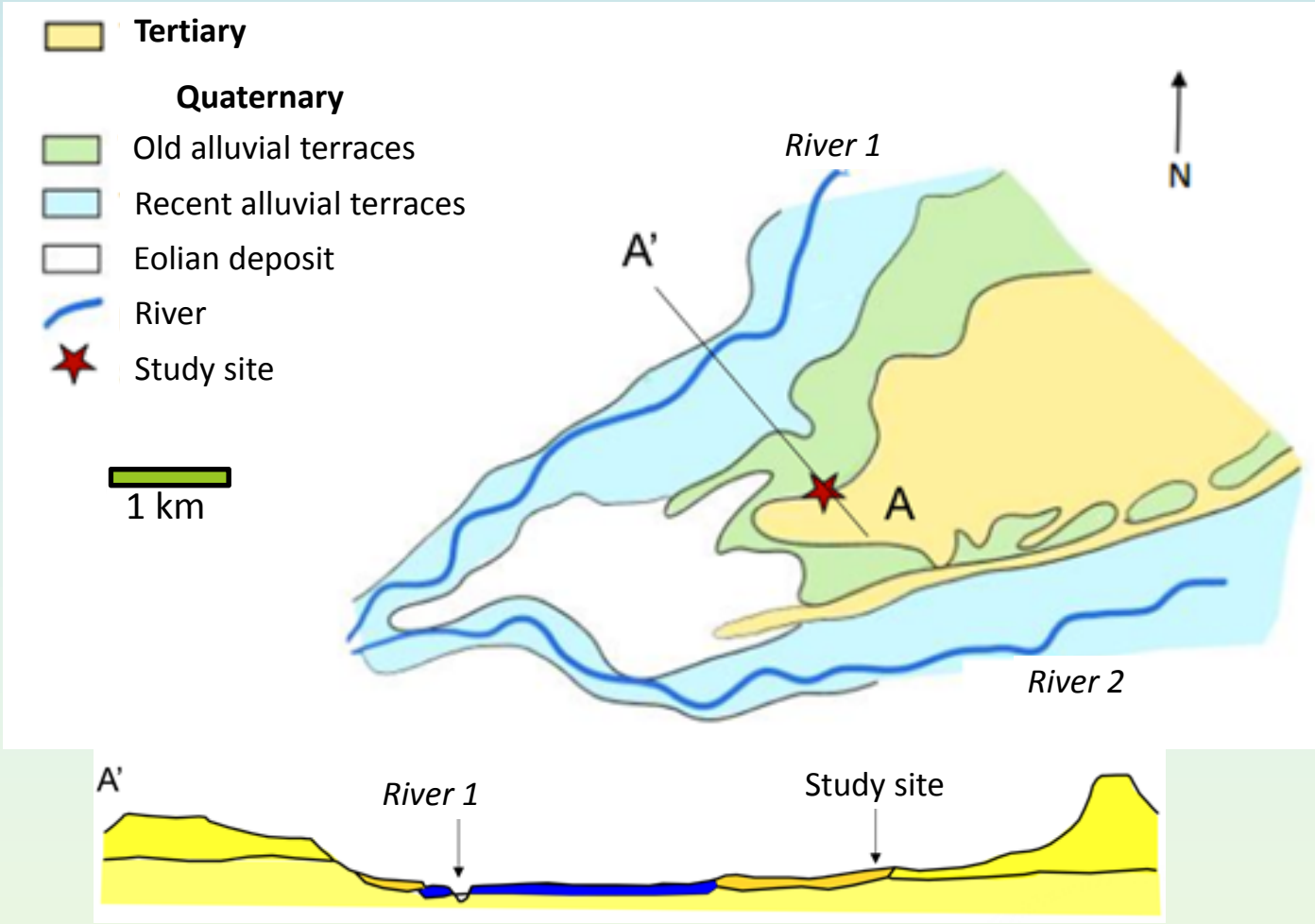
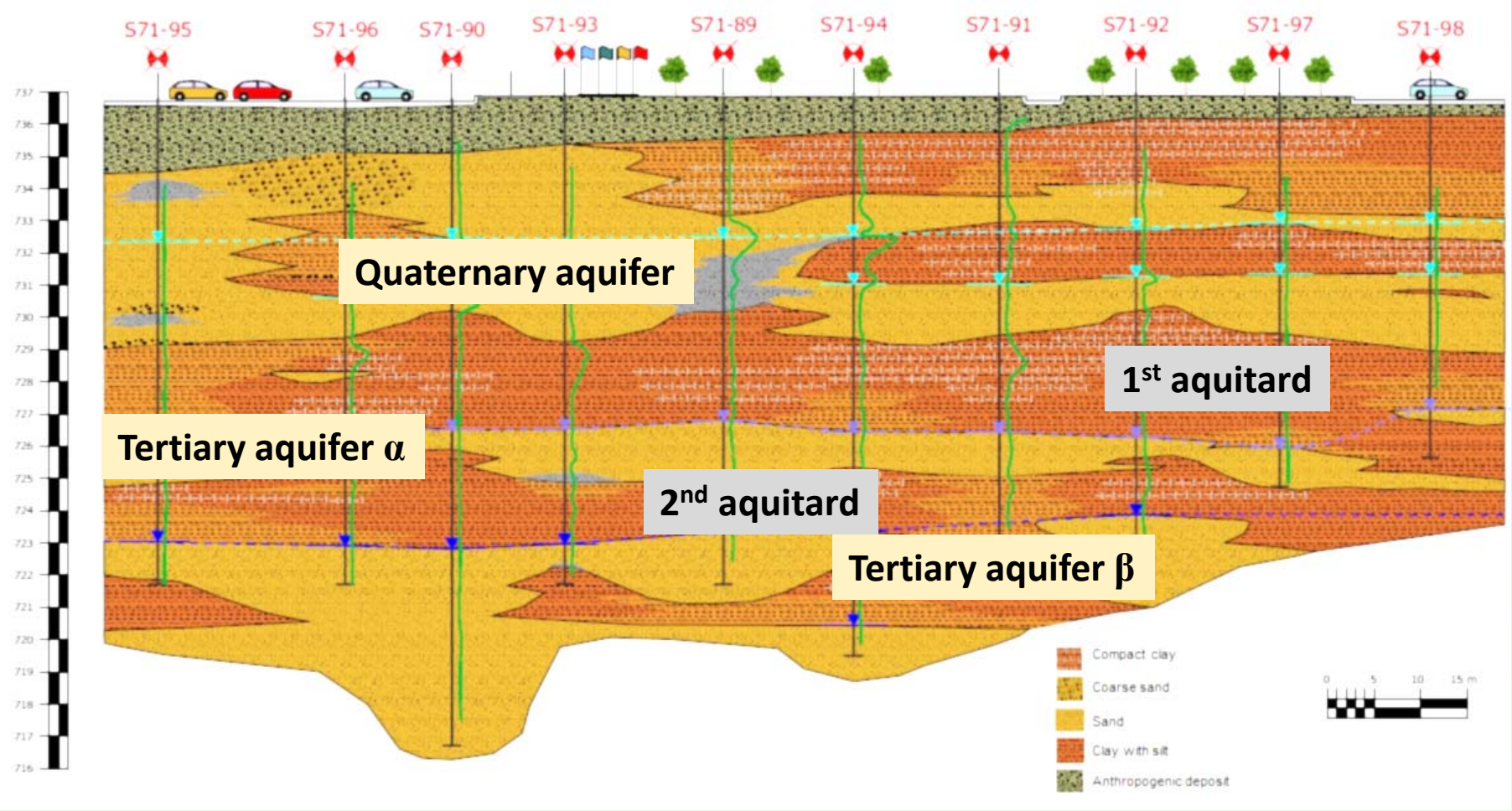
ONE CASE STUDY

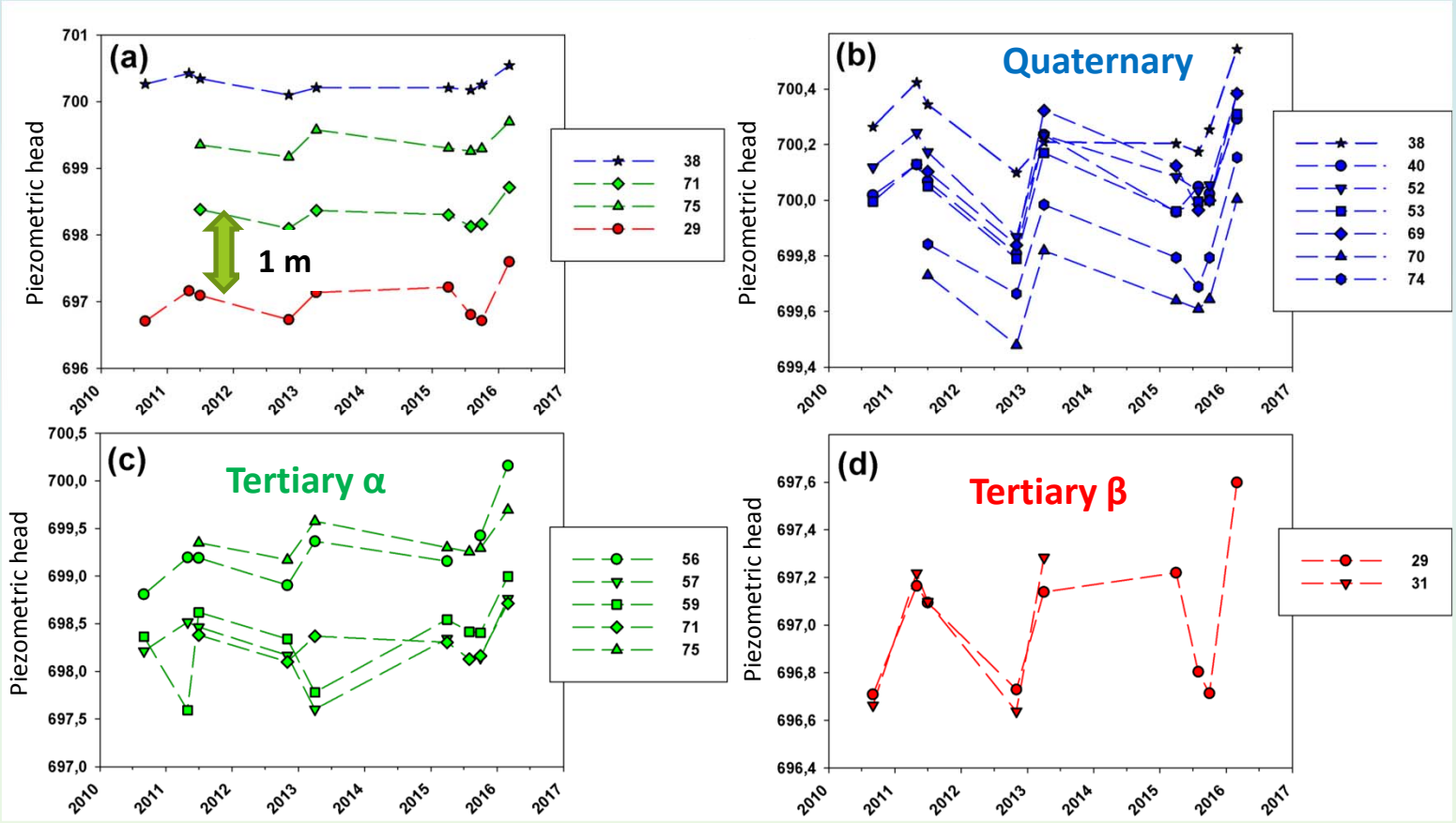
Geological context



A typical cross-cut



Temporal evolution of heads



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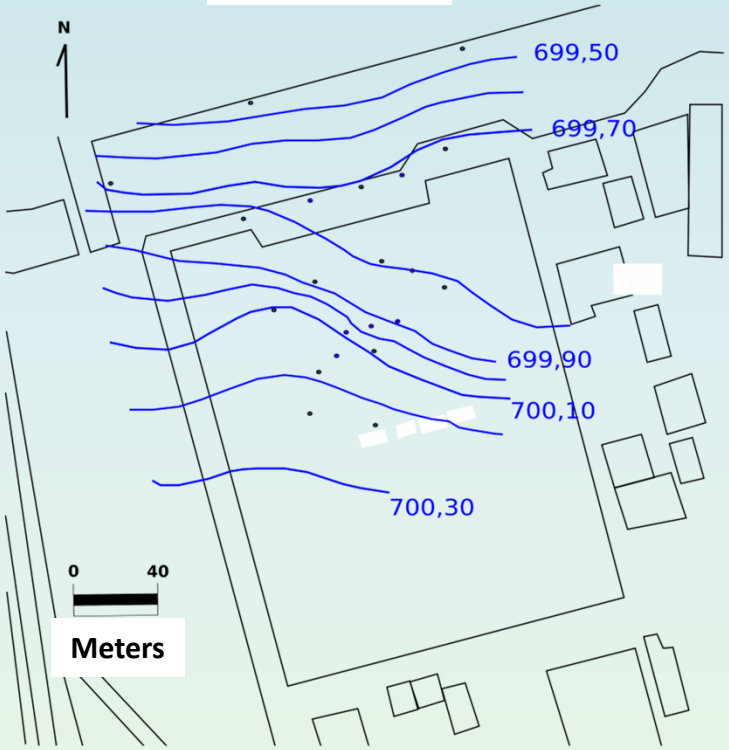
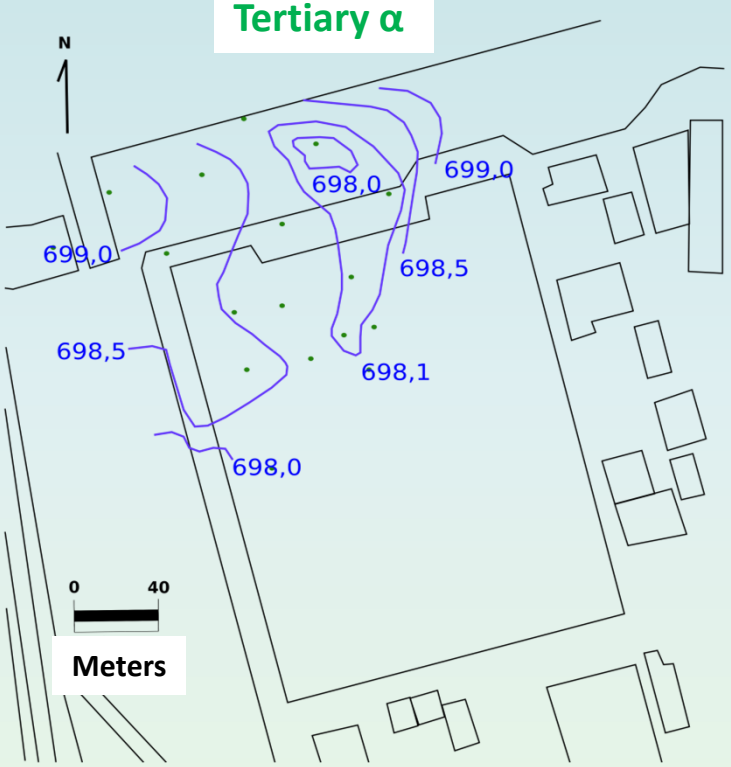
Piezometric maps

Quaternary



Tertiary α



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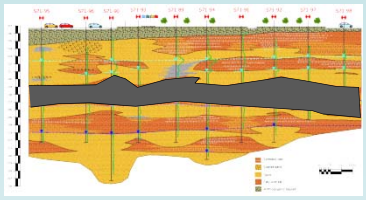
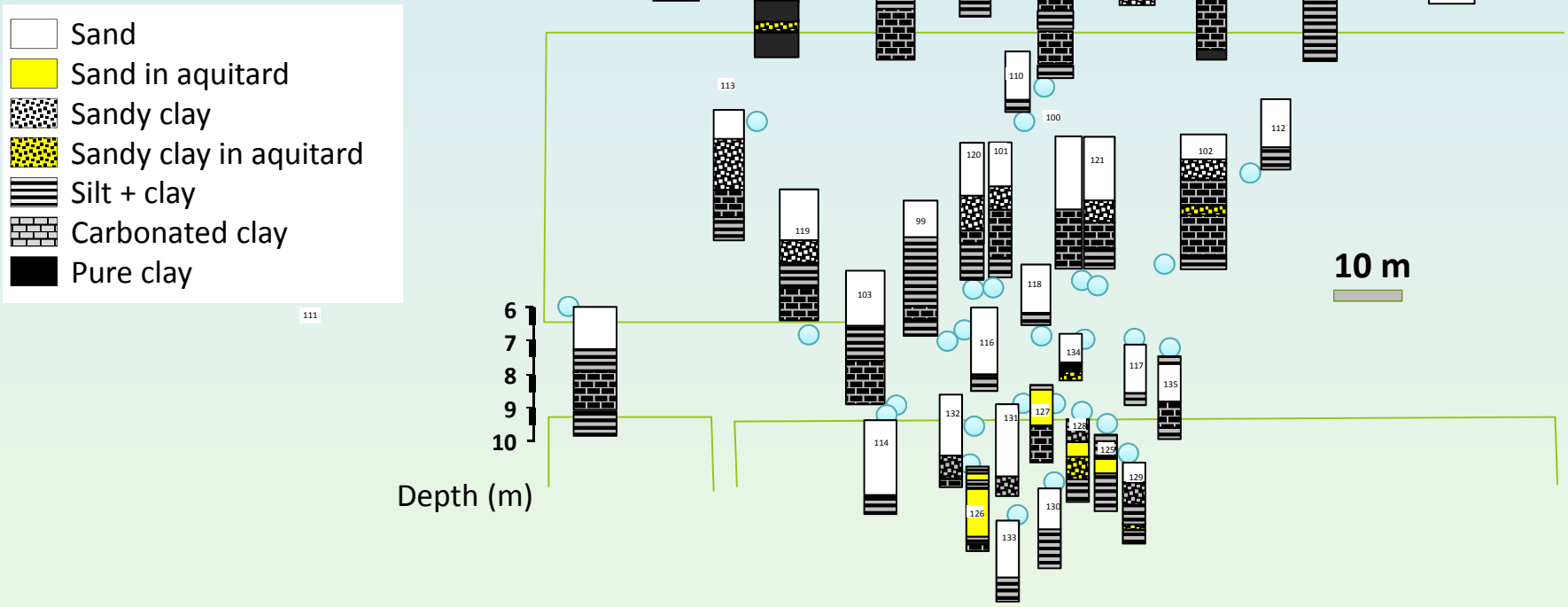
GEOLOGICAL ANALYSIS

1st aquitard logs





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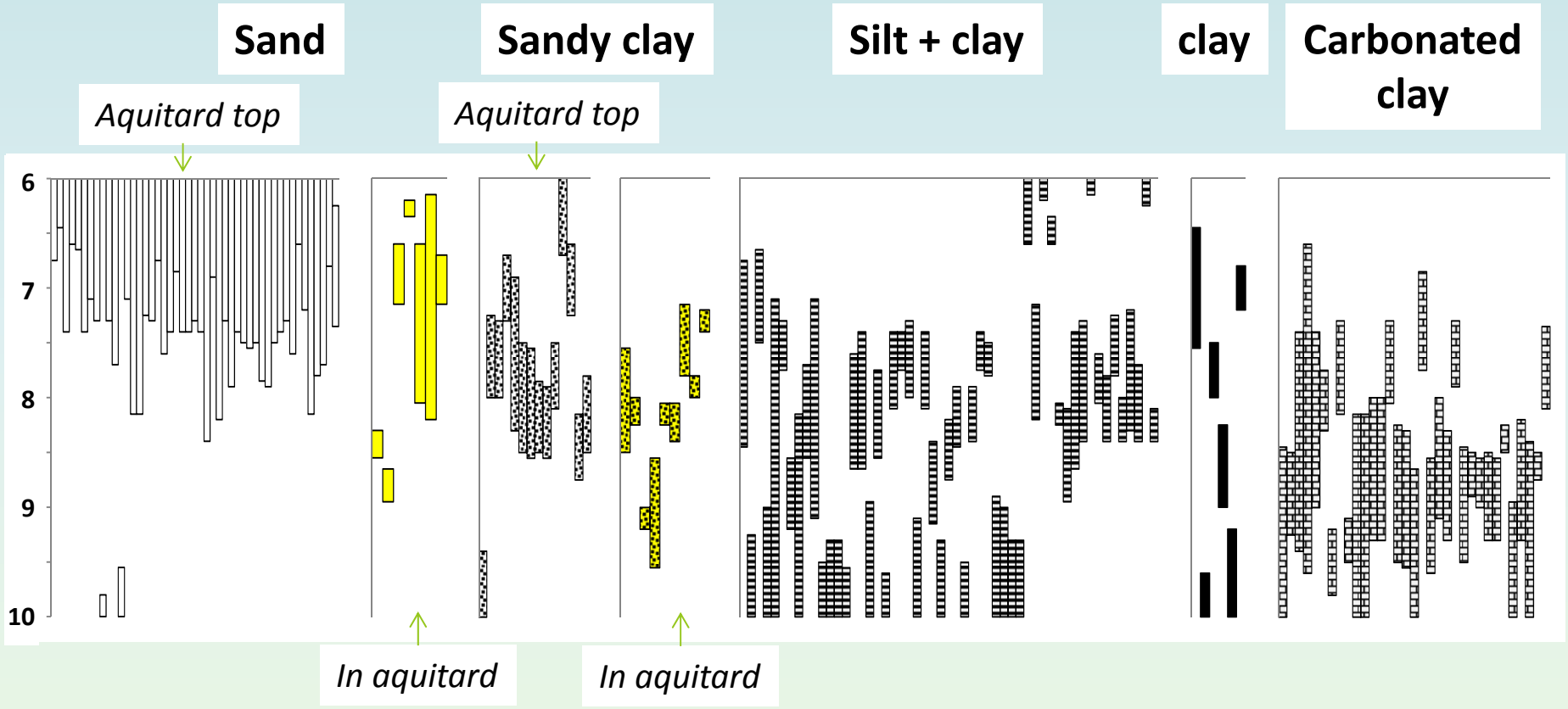
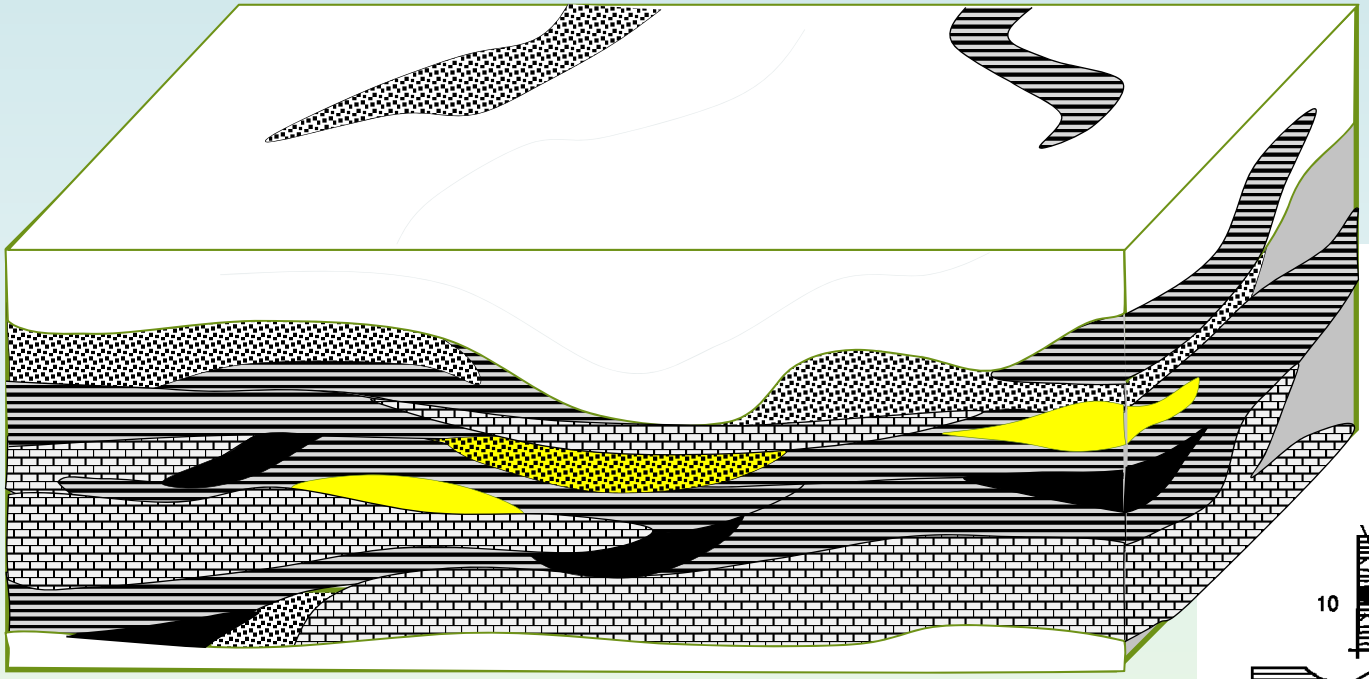
Vertical position of layers

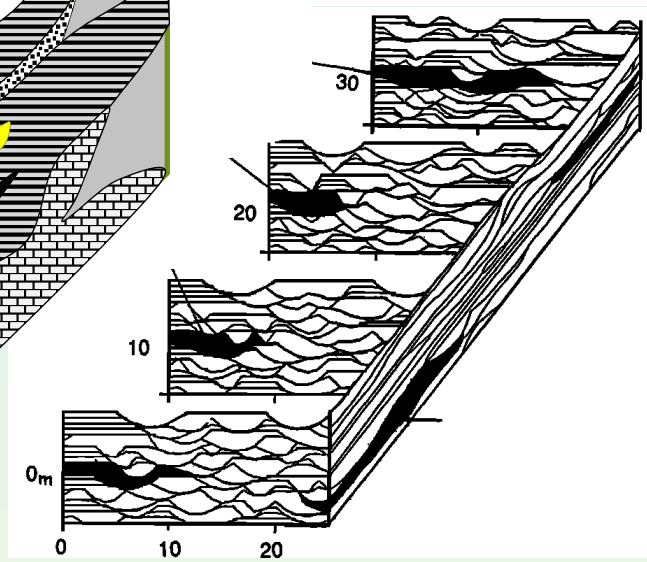


One interpretation

Size of the objects ?

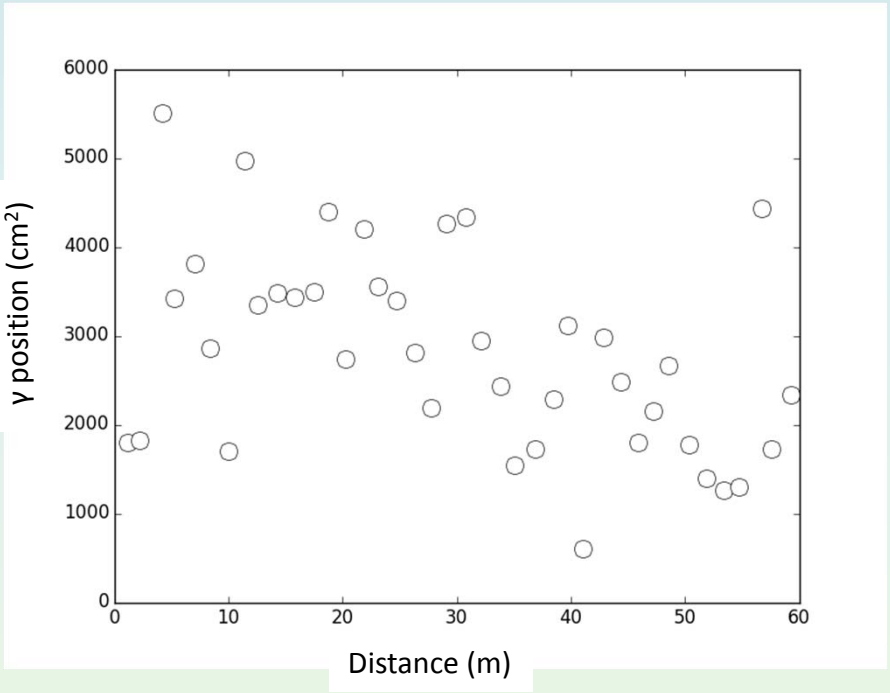


Braided stream deposits
Koltermann & Gorelick 1996

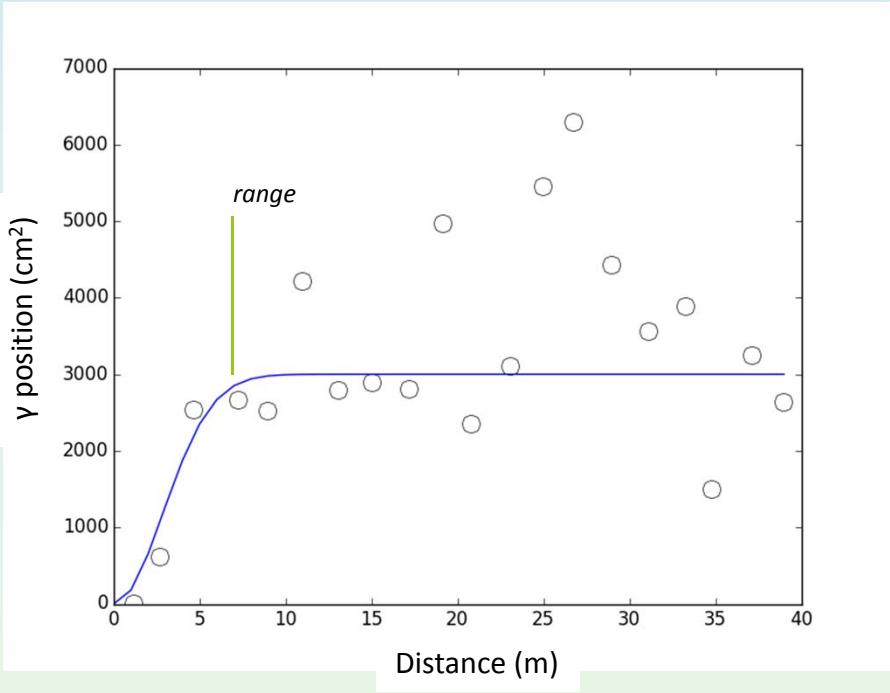


Spatial correlation

Top of the sand : no spatial correlation



Silt+clay : spatial correlation, range 7 m



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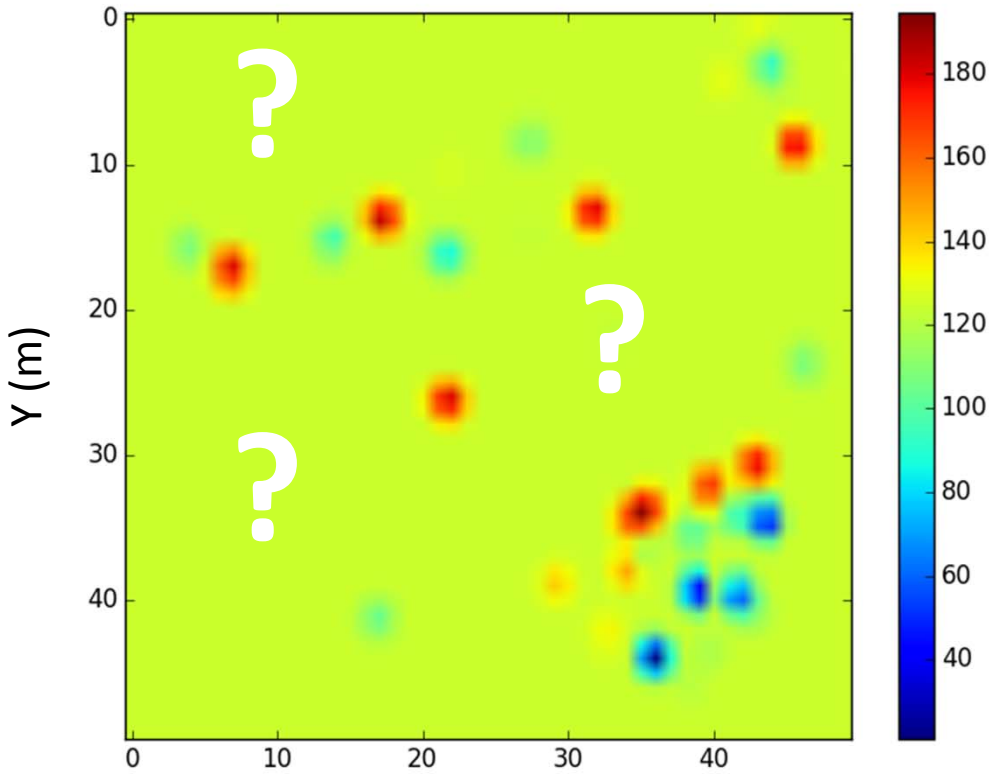
Map of silt vertical position



Depth (cm)
From top of
« Aquitard »

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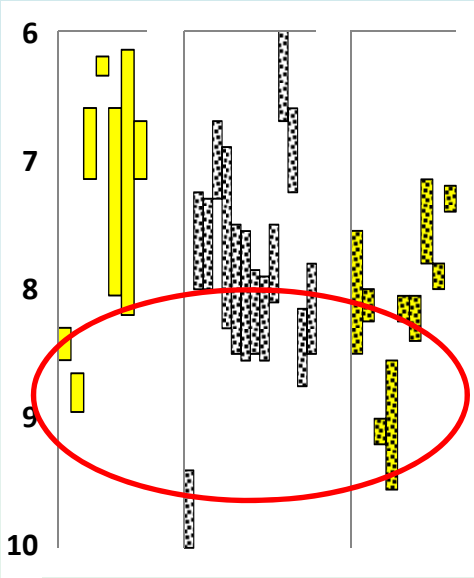
Sandy stream deposits?



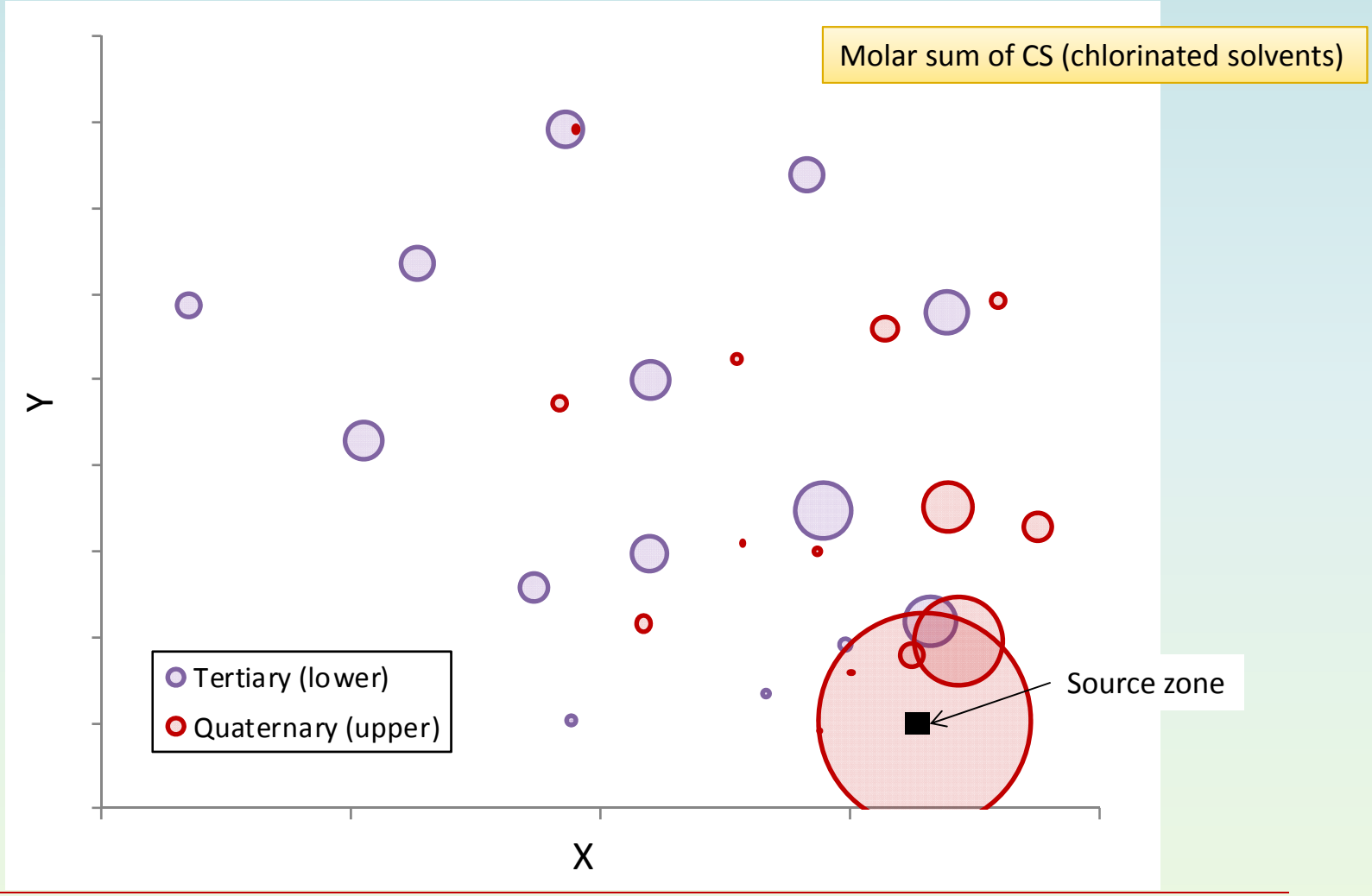
At least 1 values of sandy clay in the most impermeable layer among 41 wells

Overall surface : 140 x 120 = 16 800 m^2

Potential sandy deposits : 400 m^2
four 100 m^2
or ten 40 m^2

CONTAMINANT BEHAVIOR

Contaminant distribution



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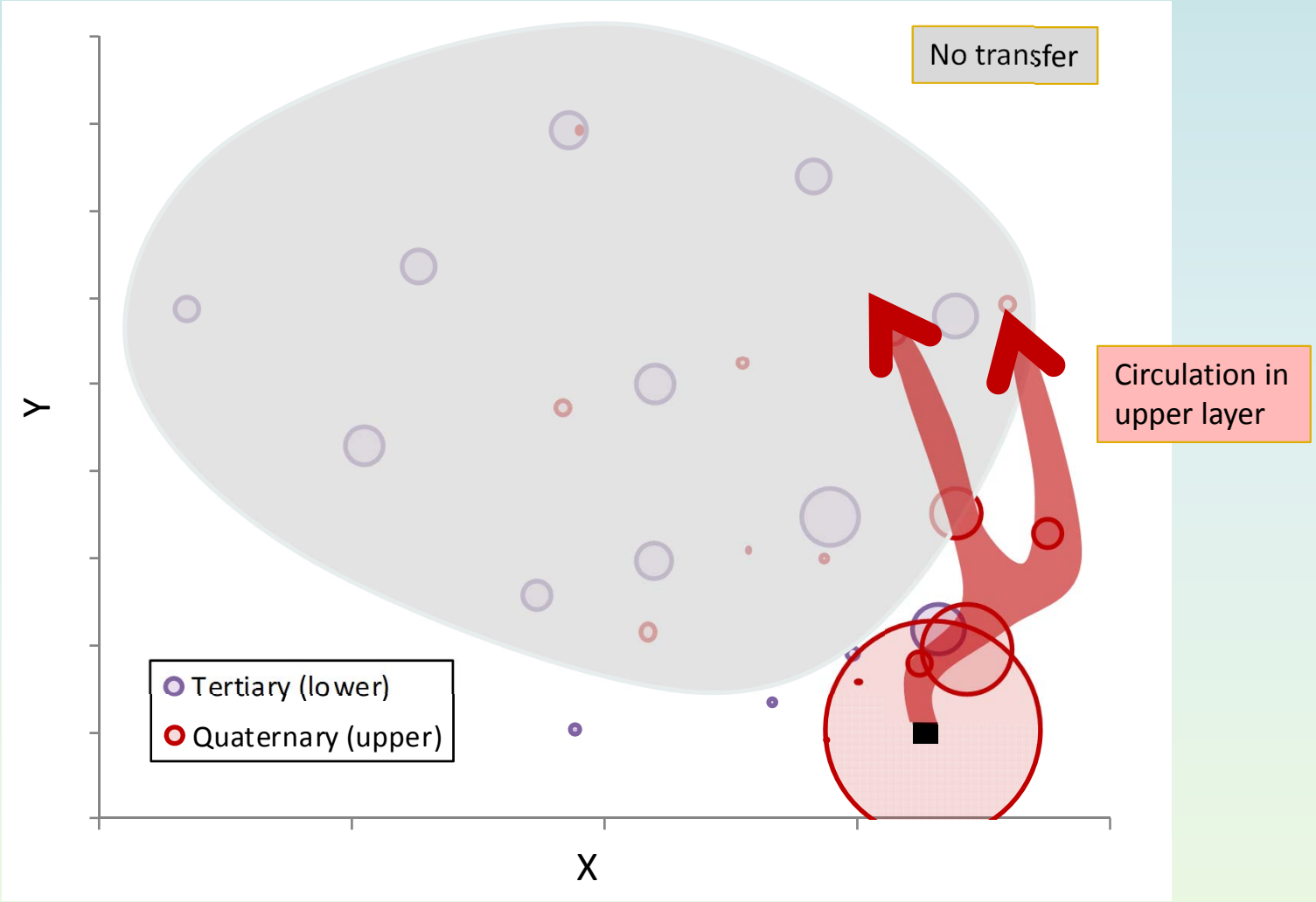
Transfer



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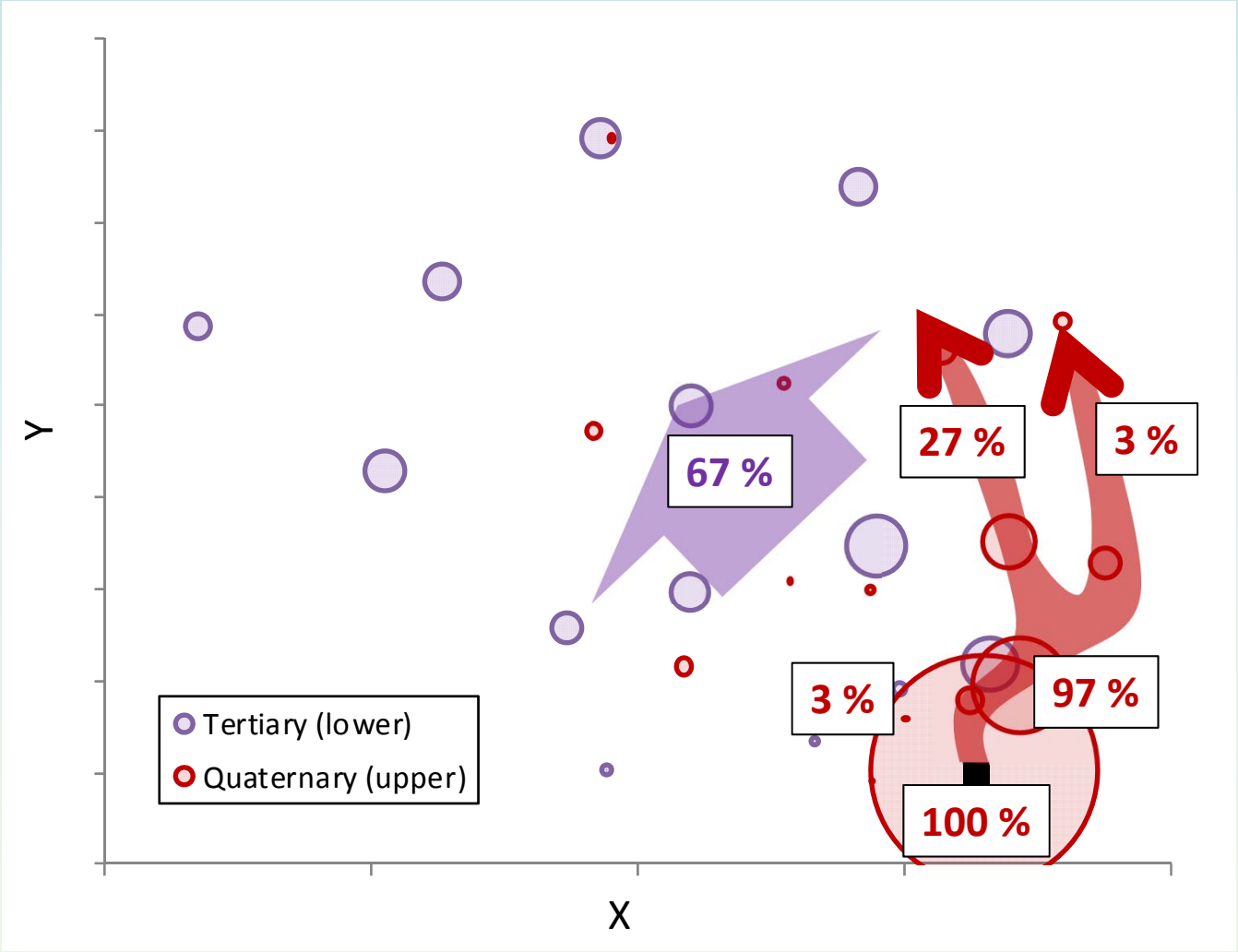
Fluxes



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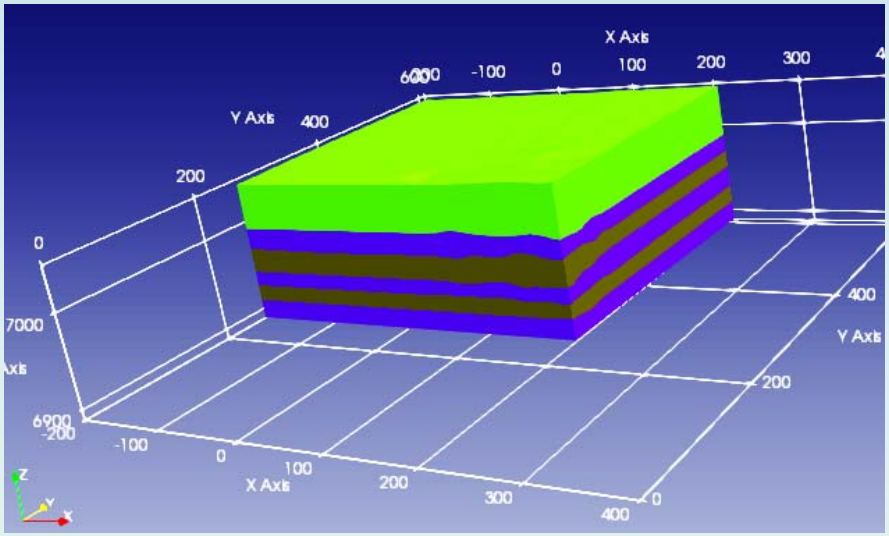
FLOW & TRANSPORT MODELLING

3D Model properties



Modflow

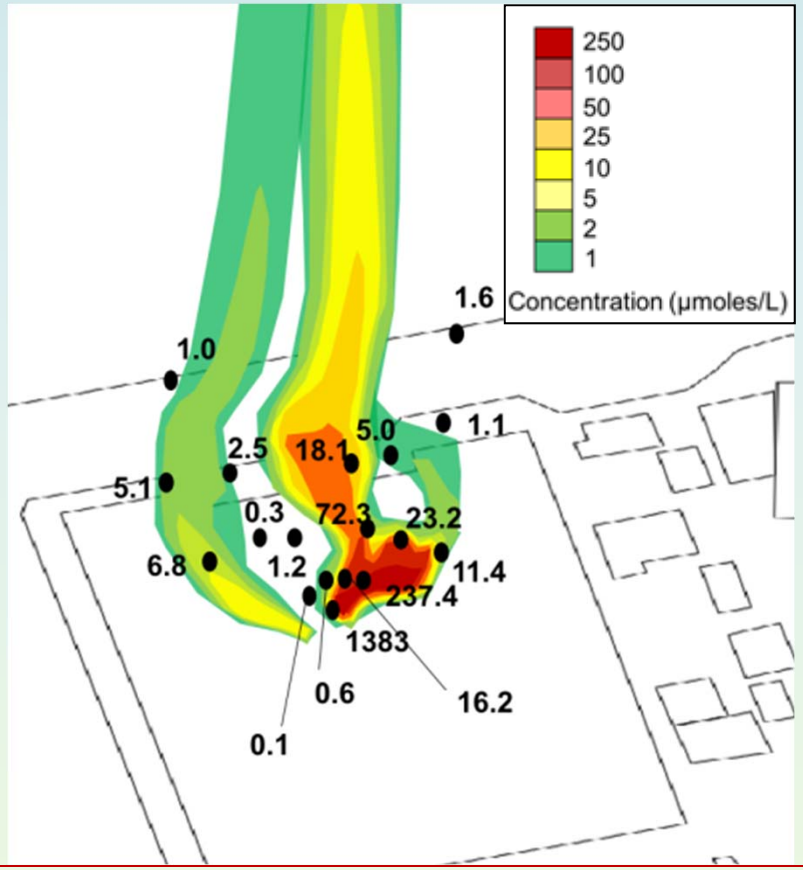
- Fixed head BC (far from the plume)
- Different directions in IV and III aquifer
- 6 media subdivided in 20 layers
- 1 m cells at the center
- 400 000 cells

MT3DMS

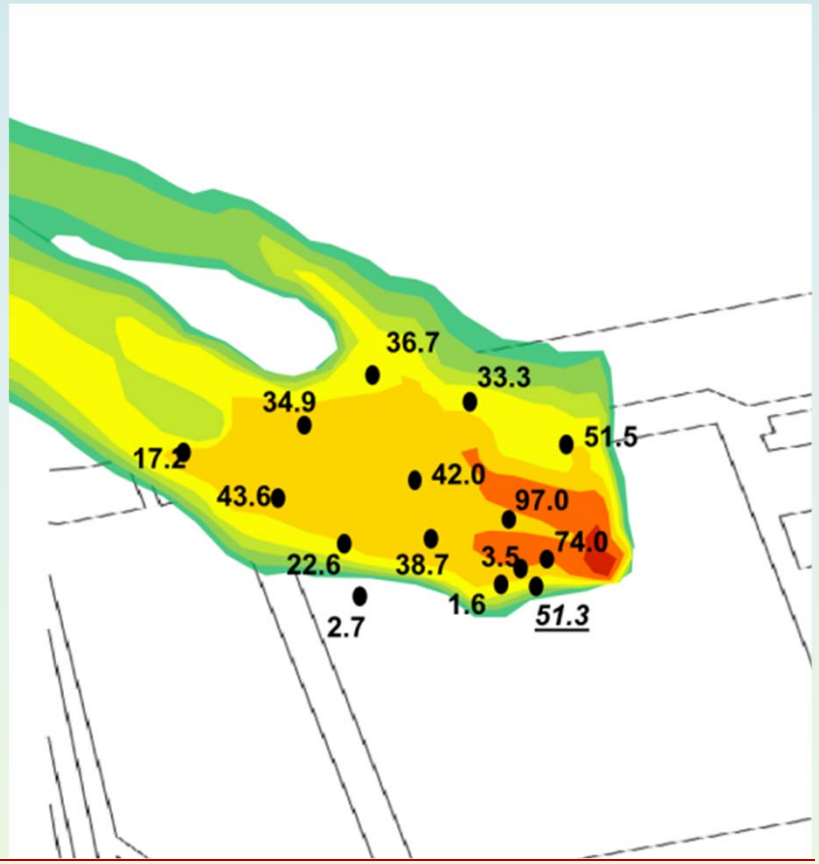
- Small source (4x1 m)
- Fixed concentration
- α_T 0.1 m
- TVD scheme

3D model results

Quaternary aquifer (upper)



Tertiary aquifer (lower)



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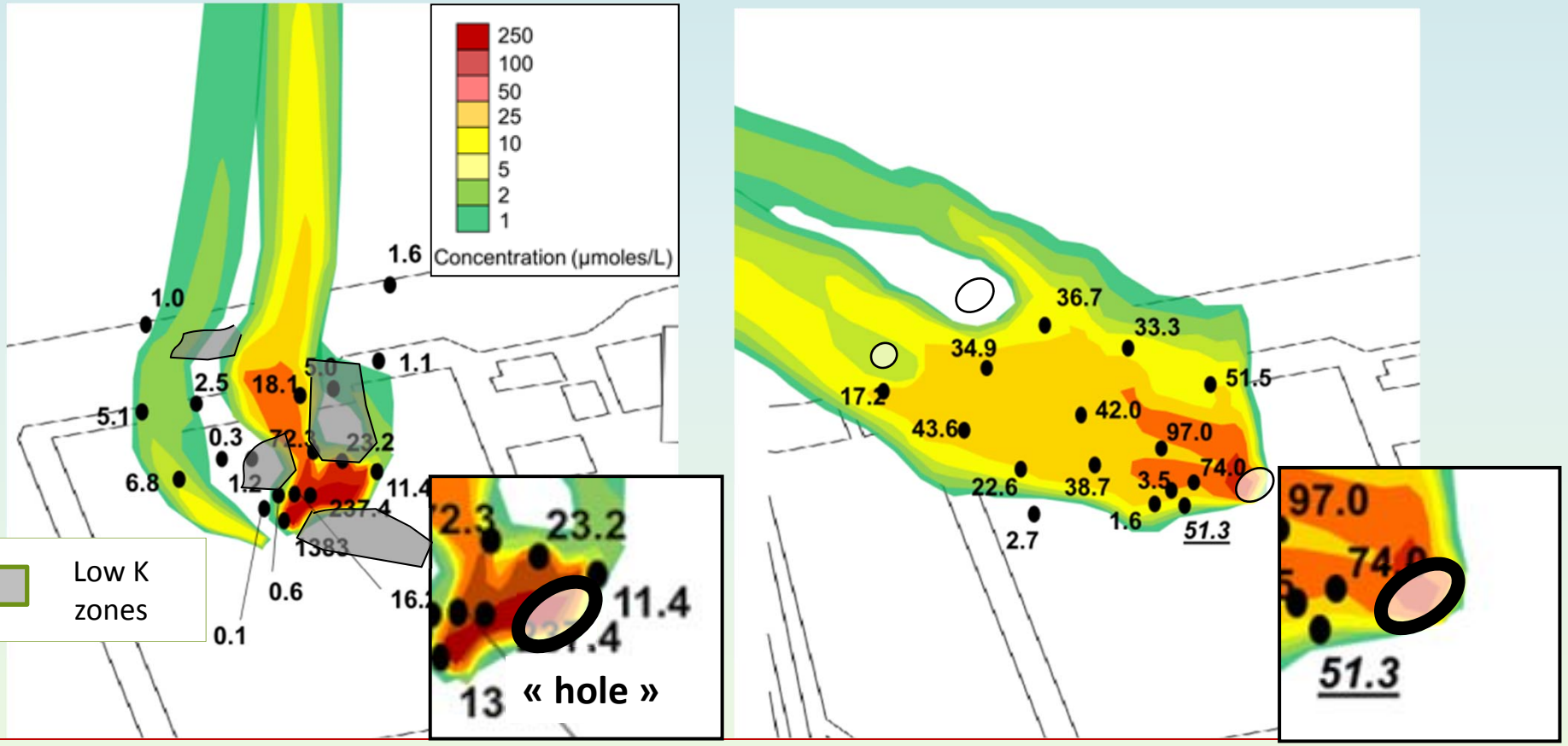
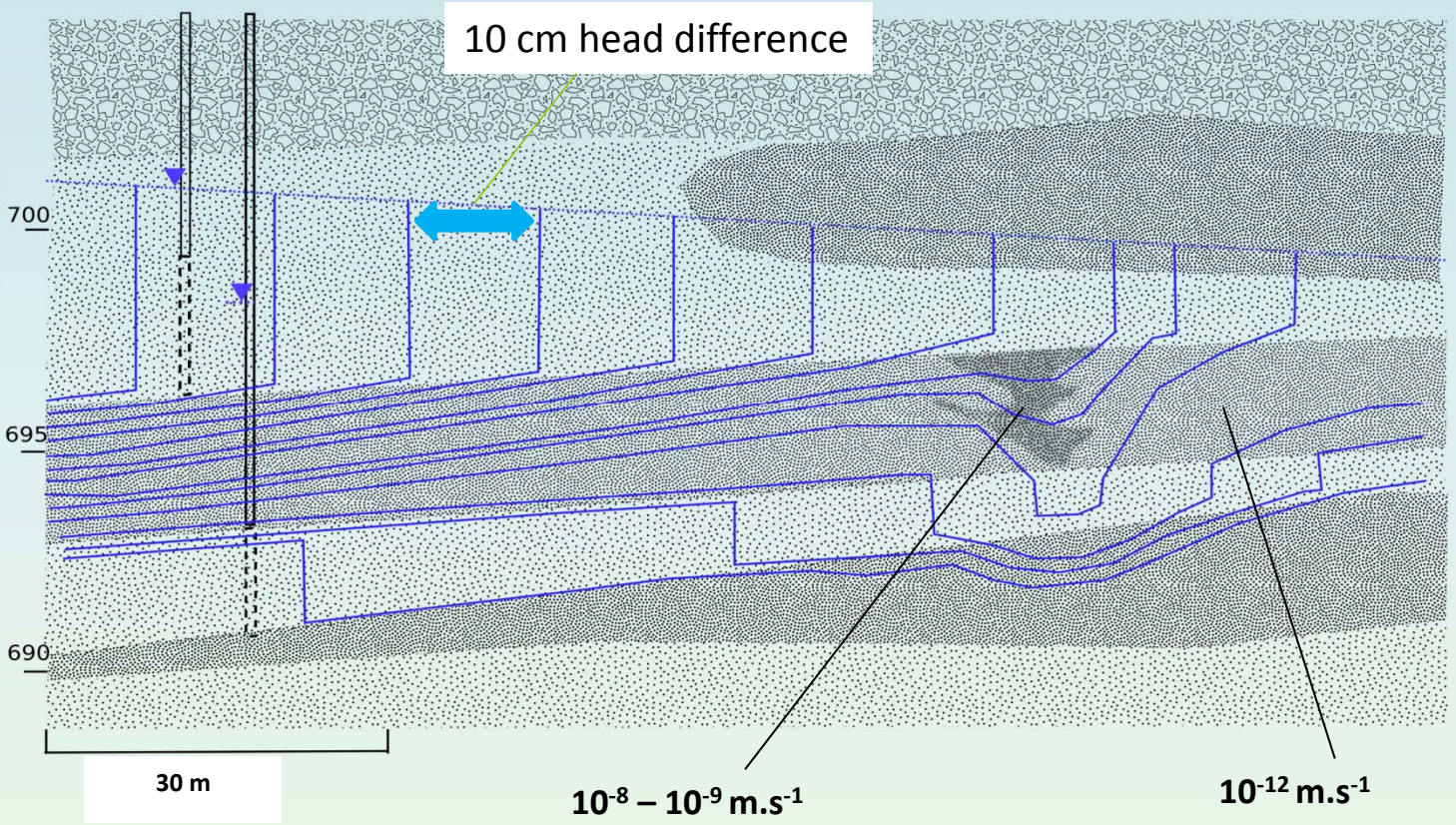
3D model results

Quaternary aquifer (upper)

Tertiary aquifer (lower)



Head profile through the « hole »



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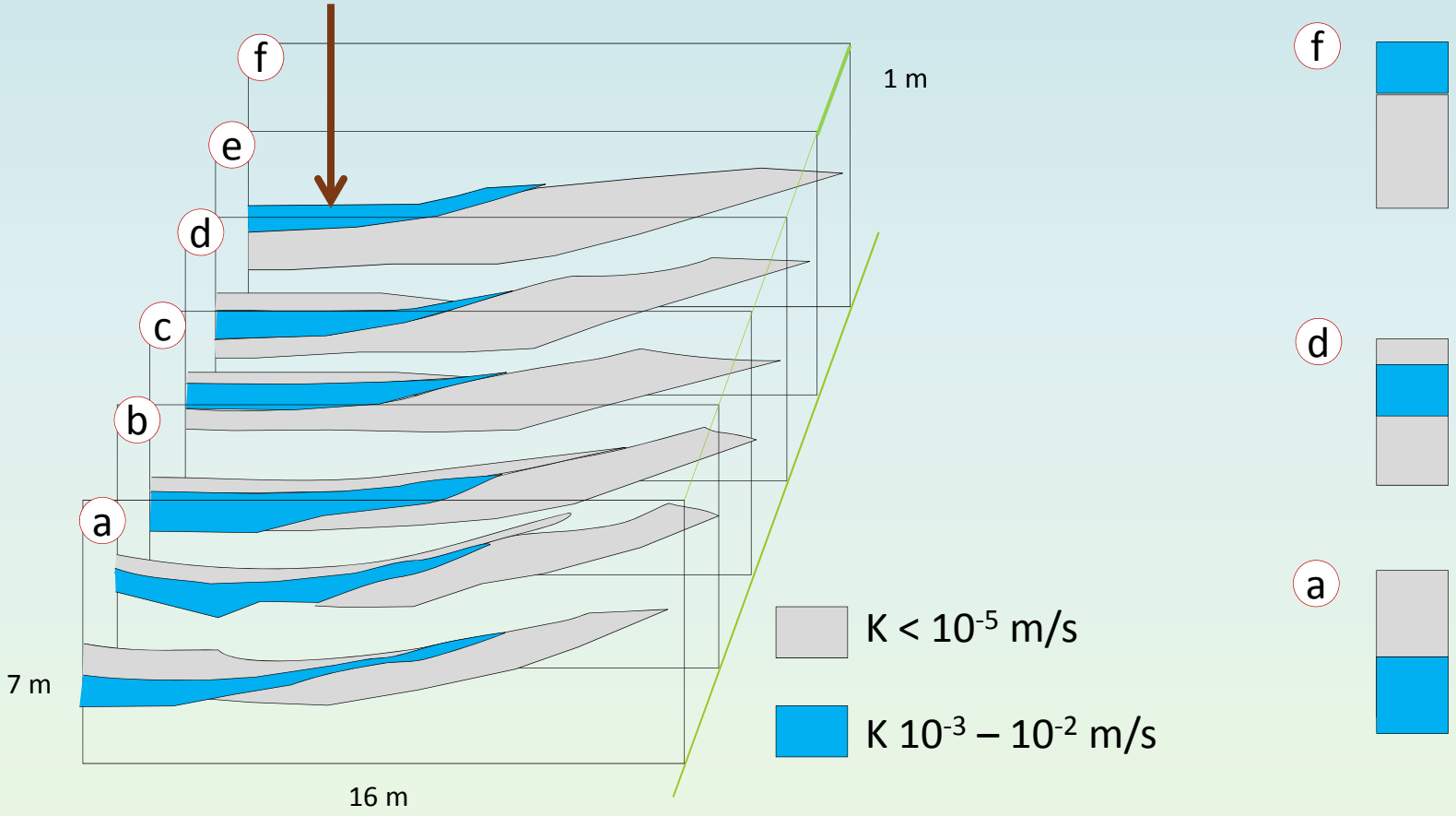
LESSONS LEARNED

Approach for the presented case

- CS concentrations in two aquifers: ~~Homogeneous leakage~~
- Vertical distribution of sediments: ~~prograding layers~~
- Significant SC fluxes: ~~leaking well~~
- Size of sedimentary objects + probability: potential « holes »
- Positioning the holes : 3D flow & transport model

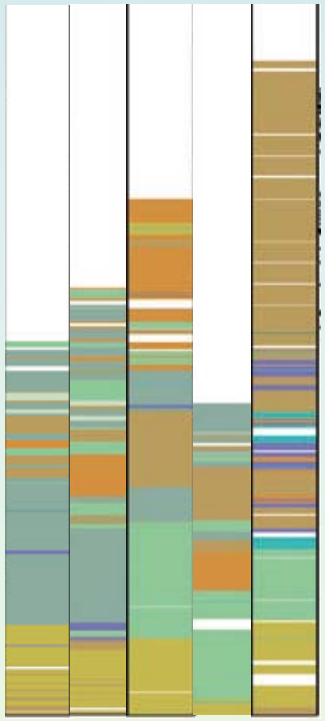
A detailed site: m scale

Bayer et al. 2011 (J. Hydrol.) : fluvio-glacial analog

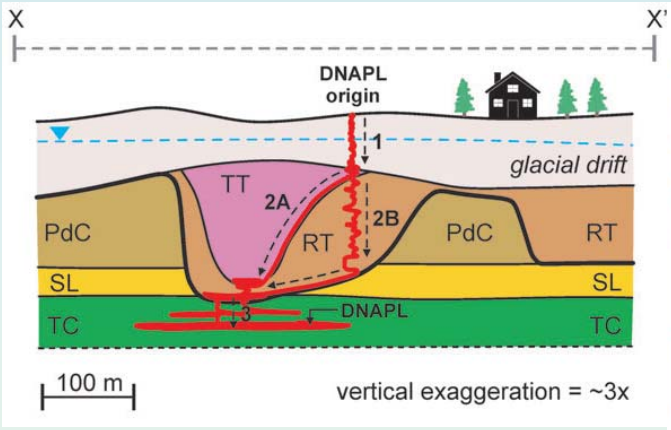


Larger scale

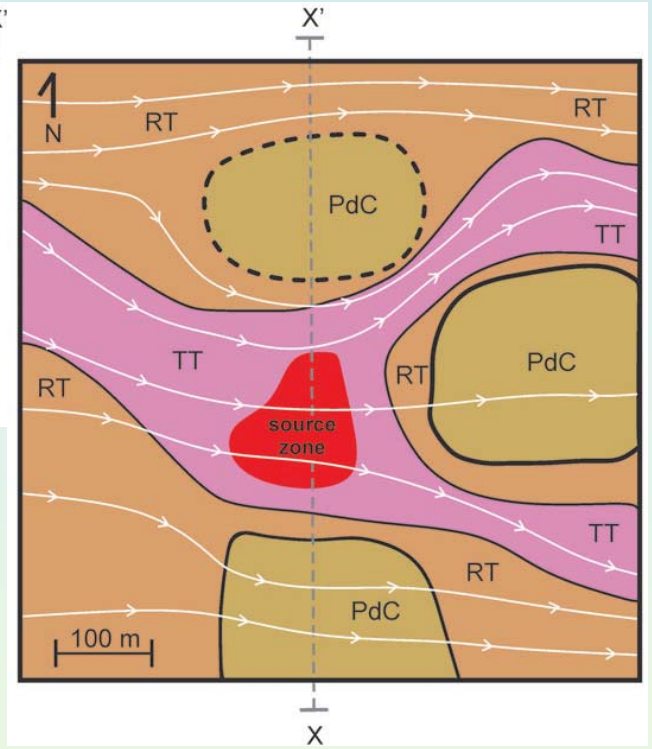
Steelman et al. 2017 (Groundwater) Glacial deposits



Cross section



Plane view



Conclusions

- Braided deposits are common in river related sediments
- No correlation between the logs → sandy channels probable
- Geostatistics → estimation of objects size
- 3D channeling → Not visible on individual logs
- **Joint** use of heads, concentrations, geology, modelling to locate the « holes »