Model of the influence of meanders and time varying stream levels on groundwater discharge to streams

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Motivation and Aims

- Required the evaluation of contaminated sites impact on streams:
  - EU Water Framework Directive
  - New Danish law on contaminated sites assessment

- Lack of knowledge on the discharge variability because of:
  - Meander bends
  - Stream water level changes

- Challenges in designing appropriate monitoring campaigns for contaminant discharge to streams
Study site: Grindsted stream
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![Graph showing Log(Conc.) [ug/L] vs Distance (m) with various contaminants and their concentrations.](image-url)
Model Area and Boundary conditions

Fixed head = 35.25 m

No flow
Conceptual model

Scenario 1
- Recharge
- Fixed head
- No flow
- 580 m
- 550 m
- 380 m
- 330 m

Scenario 2
- Recharge
- Fixed head
- No flow
- 580 m
- 550 m
- 380 m
- 330 m

Quaternary formation
- Sand

Odderup/Tertiary formation
- Miocene sand

Arnem formation
- Miocene clay with internal sand layers
- Bastrup formation
- Sand

DTU Environment
Department of Environmental Engineering
**Numerical groundwater flow model**

Finite element method in COMSOL Multiphysics

\[ \nabla \cdot (K \cdot \nabla h) + \frac{S_y}{b} \frac{\partial h}{\partial t} = R \]

Transient simulation accounting for
- Stream water level
- precipitation

![Graph showing stream water level and precipitation over time](image)
Temporal variations

Screen 6 (8 – 9 mbt.)

- Observed groundwater head
- Stream water level
- Modelled groundwater head: scenario 1
- Modelled groundwater head: scenario 2

Screen 5 (21 – 22 mbt.)
Temporal variations

Stream water level [m] vs. Groundwater discharge to stream [m^3/d]

- Stream water level
- Simulated discharge to stream: scenario 2
Effect of stream meanders

Groundwater fluxes [m/d]

North stream side

Groundwater fluxes [m/d]

South stream side

Groundwater fluxes [m/d]

Stream bed
Effect of stream meanders

Temperature measurements

August/September 2012 – $T_{SW} - T_{20}$

Groundwater fluxes [m/d]

North stream side
South stream side
Stream bed

Groundwater fluxes [m/d]
Effect of stream meanders

Contaminant concentrations

Groundwater fluxes [m/d]
Effect of stream meanders
Effect of stream meanders

(a) Particles released in depth $z = 35$ [m DVR90]
(d) Particles released in depth $z = -30$ [m DVR90]
Flow directions: comparison with PVPs data
Contaminant inflow to stream
Conclusion

- Groundwater discharge is concentrated at the extreme edges of stream meanders

- Groundwater discharge varies with time

- Stream monitoring data must be interpreted very carefully to avoid mistakes in risk assessments

- Models are very useful for designing field campaigns and for interpreting monitoring results
Acknowledgements