

# A Comparison of Field Techniques for the Analysis of Groundwater - Surface-Water Interactions: Porewater Sampling, Hyporheic Temperature and EC Time Series

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# Porewater sampling: Induced Hyporheic Flow?

Does porewater sampling frequency effect hyporheic flow?

Flow direction	Sampling Depth (cm)	Increase in hyporheic EC relative to surface EC (%), after 2.5 hours of constant-rate injection		
		High Sampling frequency	Medium Sampling frequency	Low Sampling frequency
Downwelling: $-0.10 \text{ cm cm}^{-1}$	5	101	99	97
	10	98	99	97
	15	95	95	92
	20	<b>88</b>	<b>86</b>	<b>76</b>
Neutral: $0.03 \text{ cm cm}^{-1}$	5	<b>90</b>	<b>85</b>	<b>77</b>
	10	<b>83</b>	<b>60</b>	<b>38</b>
Upwelling: $0.13 \text{ cm cm}^{-1}$	5	51	55	48



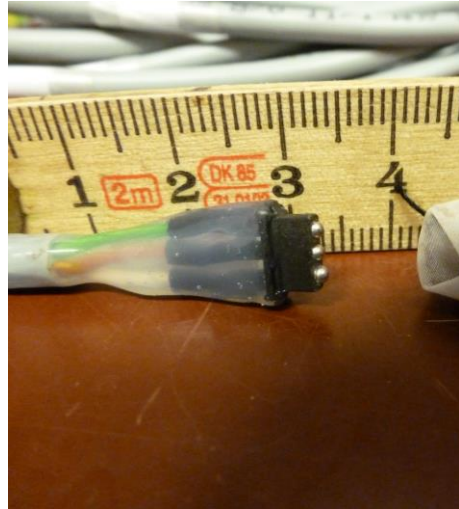
- 3 separate, nearly identical, 3-hour constant-rate NaCl injections on 3 consecutive days during baseflow period
- Sampling of three multi-level piezometers in downwelling, near neutral and upwelling locations at various depths
- Sampling after SW plateau has been reached: only once after 2.5 hours (**Low**); after ca 90 min and 2.5 hours (**Medium**); after ca every 45 min and 2.5 hours (**High**)
- Sampling rate:  $1 \text{ ml min}^{-1}$ ; sampling volume: 10 ml

# Low-cost EC sensor

We developed a small, low-cost EC sensor to measure hyporheic salt tracer breakthrough curves

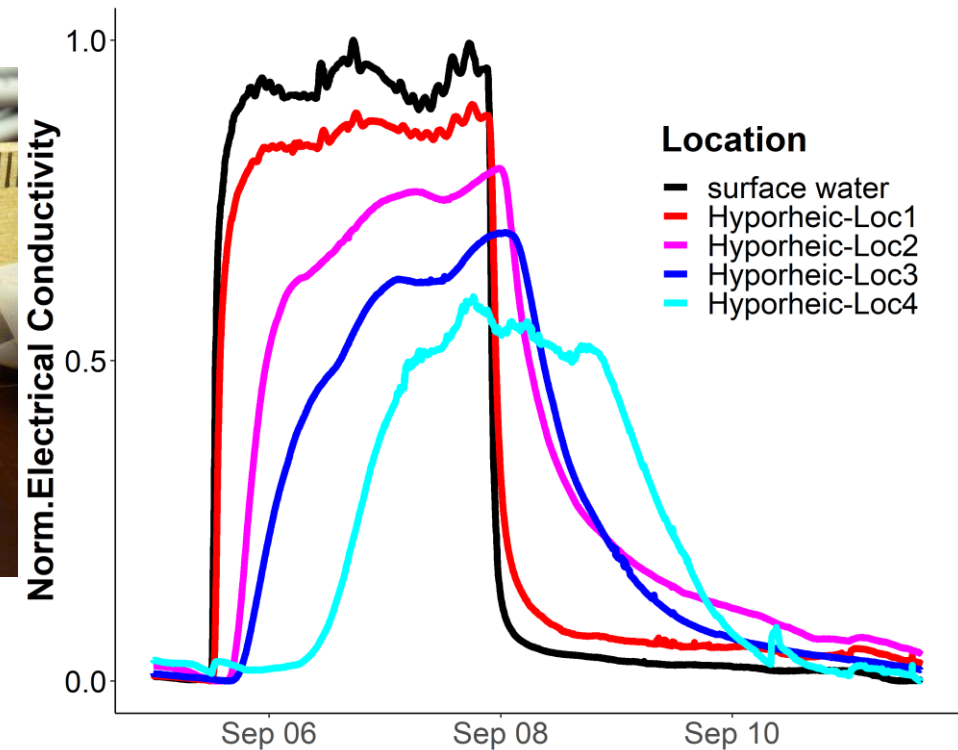
-> reduction of porewater sampling to a minimum

- Small (< 1 cm): low disturbance of hyporheic flow paths
- Low-cost (< 10 EUR): therefore large numbers for high spatial sensor densities
- Hyporheic BTCs without porewater sampling: hyporheic flow paths and residence times on small scale
  - Only for sites with significant proportion of SW
  - -> therefore combining with porewater sampling advantageous
- Induced hyporheic flow due to porewater sampling possible to detect
  - If EC of porewater is distinct from EC of SW



Low-cost EC sensor

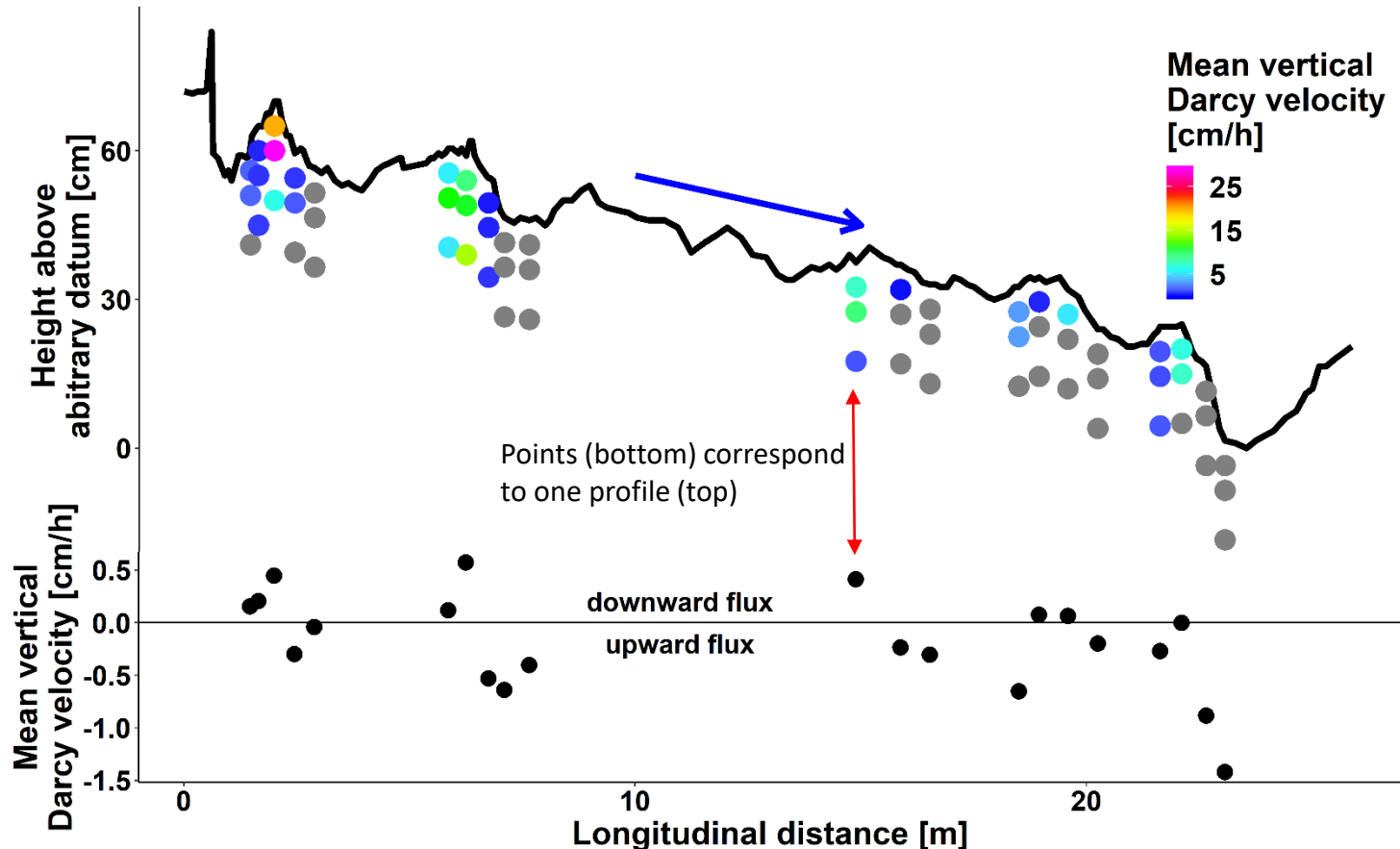
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# Low-cost EC sensor and temperature time series

## Comparison of vertical fluxes based on low-cost EC sensor and time series of temperature profiles

- EC-sensor: possible to detect dynamic and shallow flow paths
- Temperature time series: also possible to calculate upward fluxes



### Fluxes based on EC-sensor data:

- Measurement of BTCs at 5, 10, 20 cm
- Mean tracer arrival times ranging from 0.3 to 57 hours
- Grey points: no observable BTC after 90 hours

### Fluxes based on temperature time series:

- Temperature measurements every 5 to 20 cm up until 40 cm depth
- 1D flow and heat transport modelling (*Vandersteen, G. et al. (2015): WRR*)