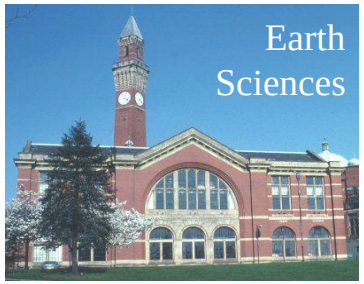
UNIVERSITY OF BIRMINGHAM



The SWITCH Hyporheic Zone Test Site, Birmingham: Overview of Baseline and Extraction Test 1 data

Rivett, M.O., *Durand, V., Aller M.F., Cuthbert, M., Mackay, R., Greswell, R.B., Tellam, J.H., Kisz, D.*

M.O.Rivett@bham.ac.uk

School of Geography, Earth & Environmental Sciences,
University of Birmingham, B15 2TT, UK

Funders:

Sixth Framework Programme (2002-2006)

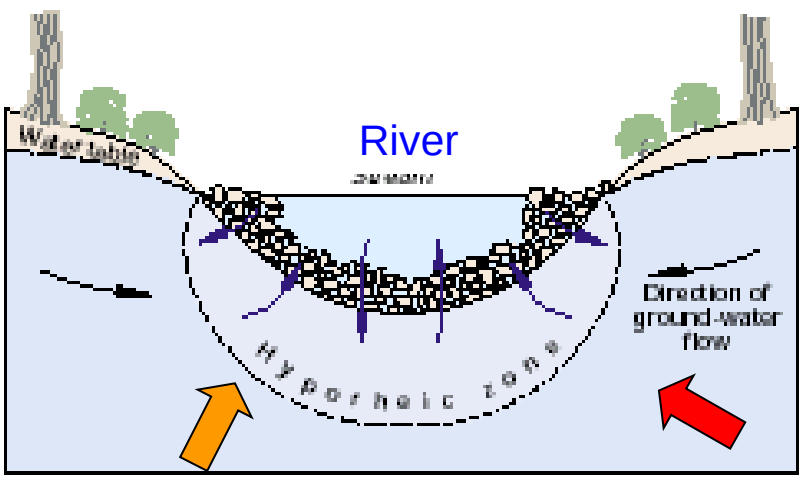
Environment Agency

SWITCH

3rd SWITCH Scientific Meeting
30 Nov – 4 Dec.,2008 - Belo Horizonte, Brazil

Hyporheic zone (HZ) riverbed

- An important natural system for water self purification



(USGS Circular 1139, 2001)

- Infiltration of oxygenated SW
- High organic carbon, nutrients
- High microbiological activity
- Steep redox gradients
- Dynamic flows

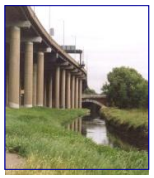
→ Potential attenuation of discharging groundwater pollutants?

- **Aim** is to learn enough about the dynamic behaviour of the urban hyporheic zone to confirm the continuous spatial and temporal attenuation capacity of the zone and to develop appropriate concepts that can be employed as part of any river restoration project for the purposes of minimising future potential risks from contaminated groundwater discharges to the river.

Science

Application

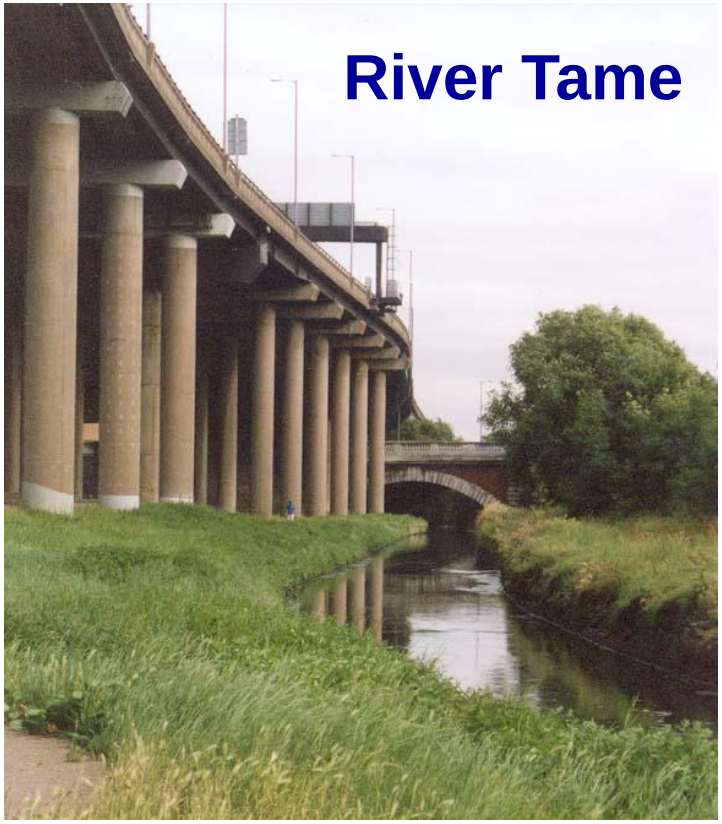
Outcome

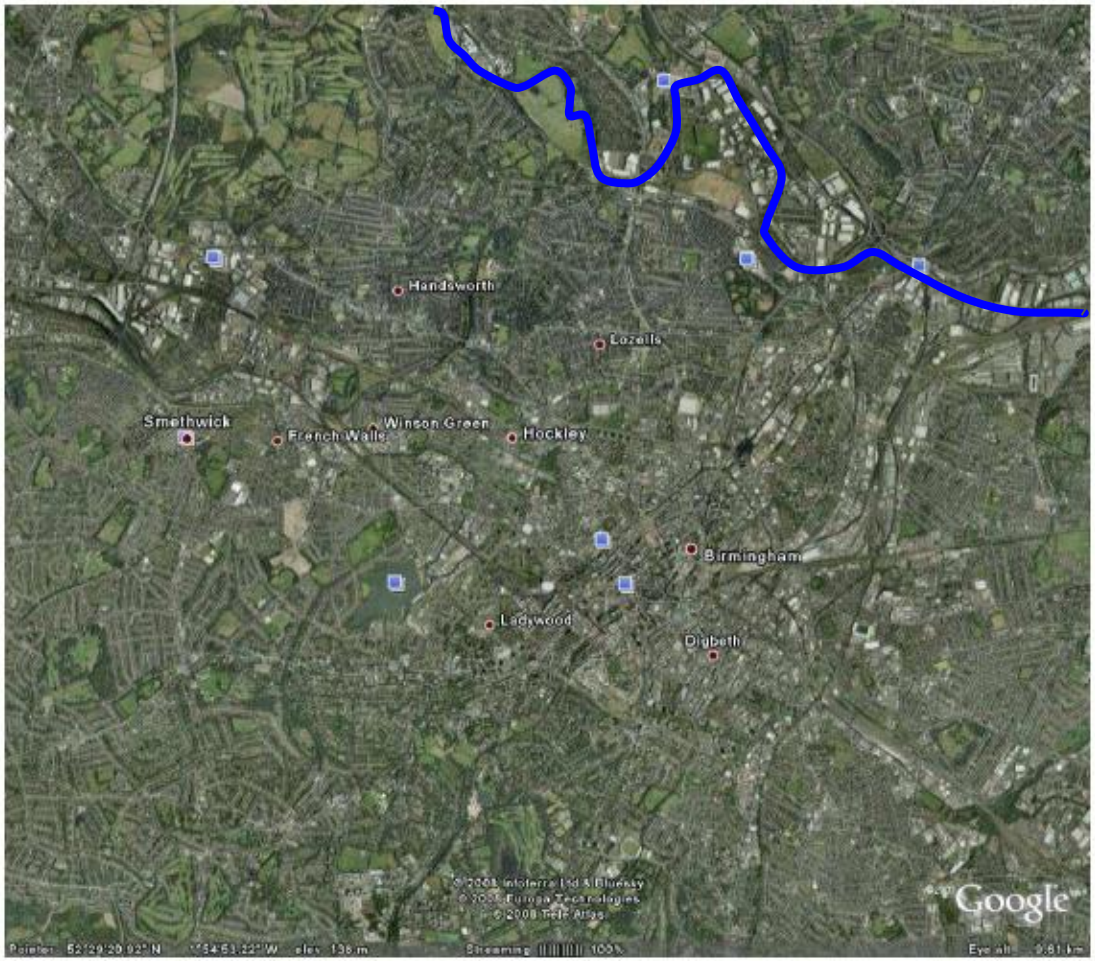






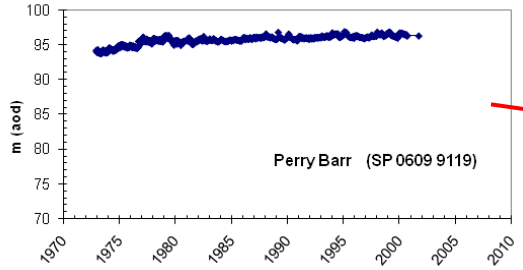

Demonstration City of Birmingham

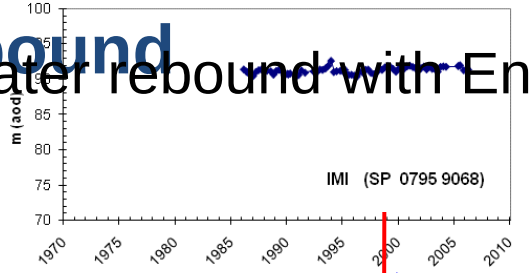


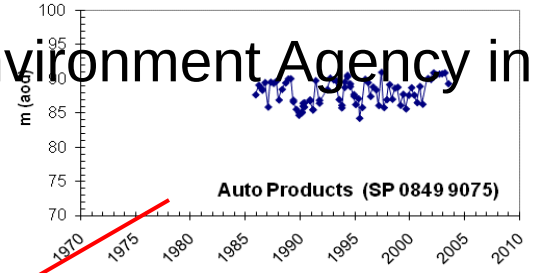


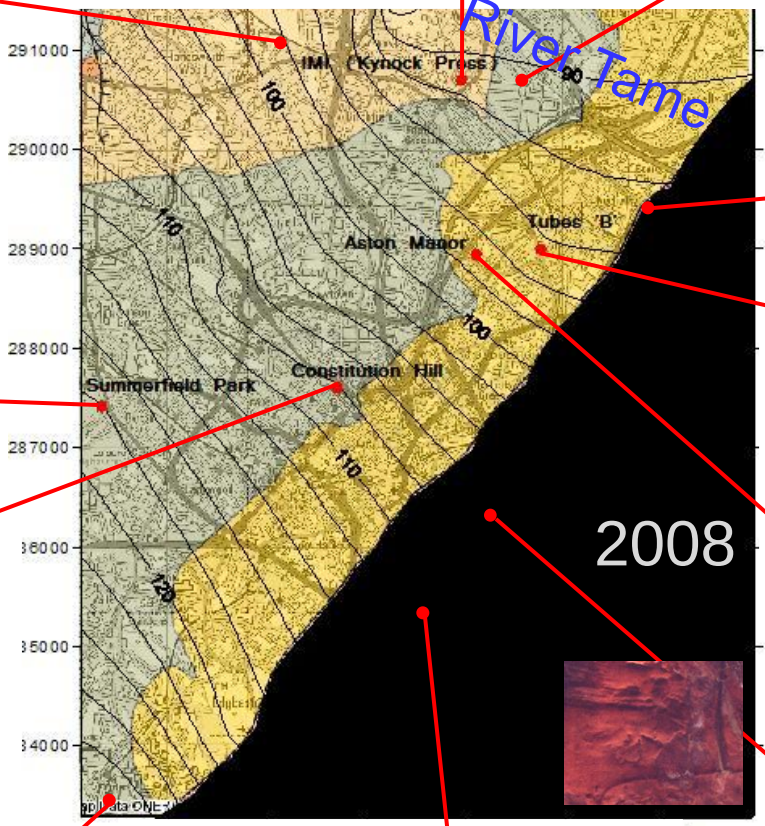
Groundwater rebound

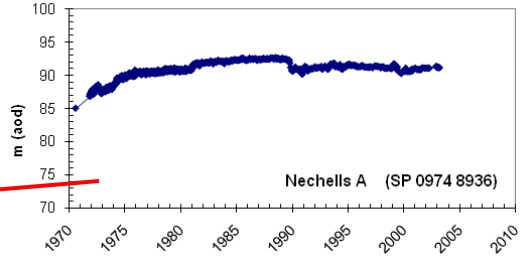
Investigated groundwater rebound with Environment Agency in 2008
(hydrographs: 1970 – ..

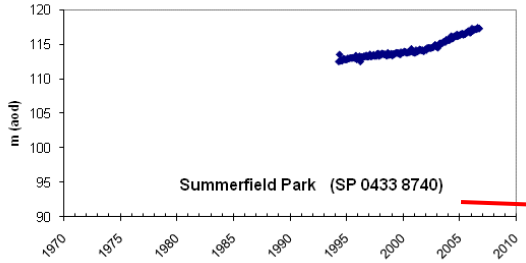


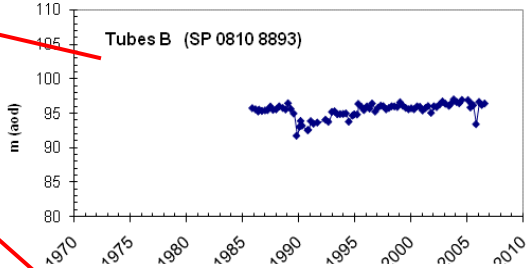


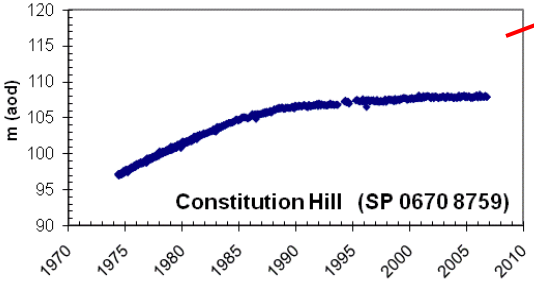


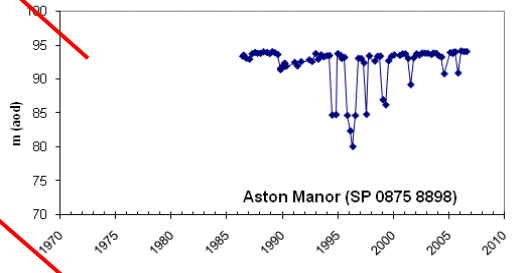


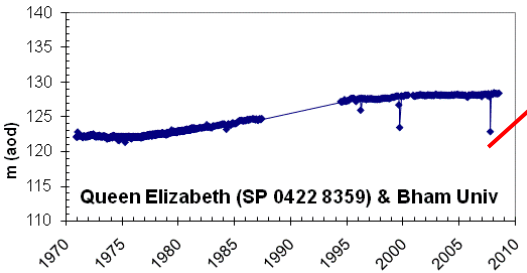


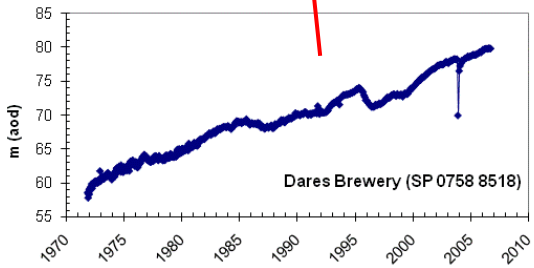


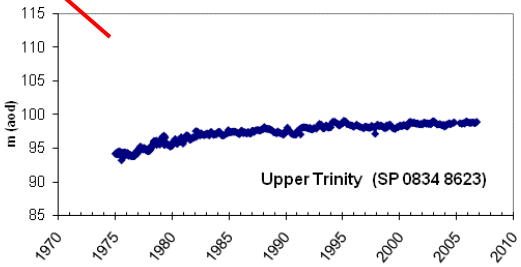




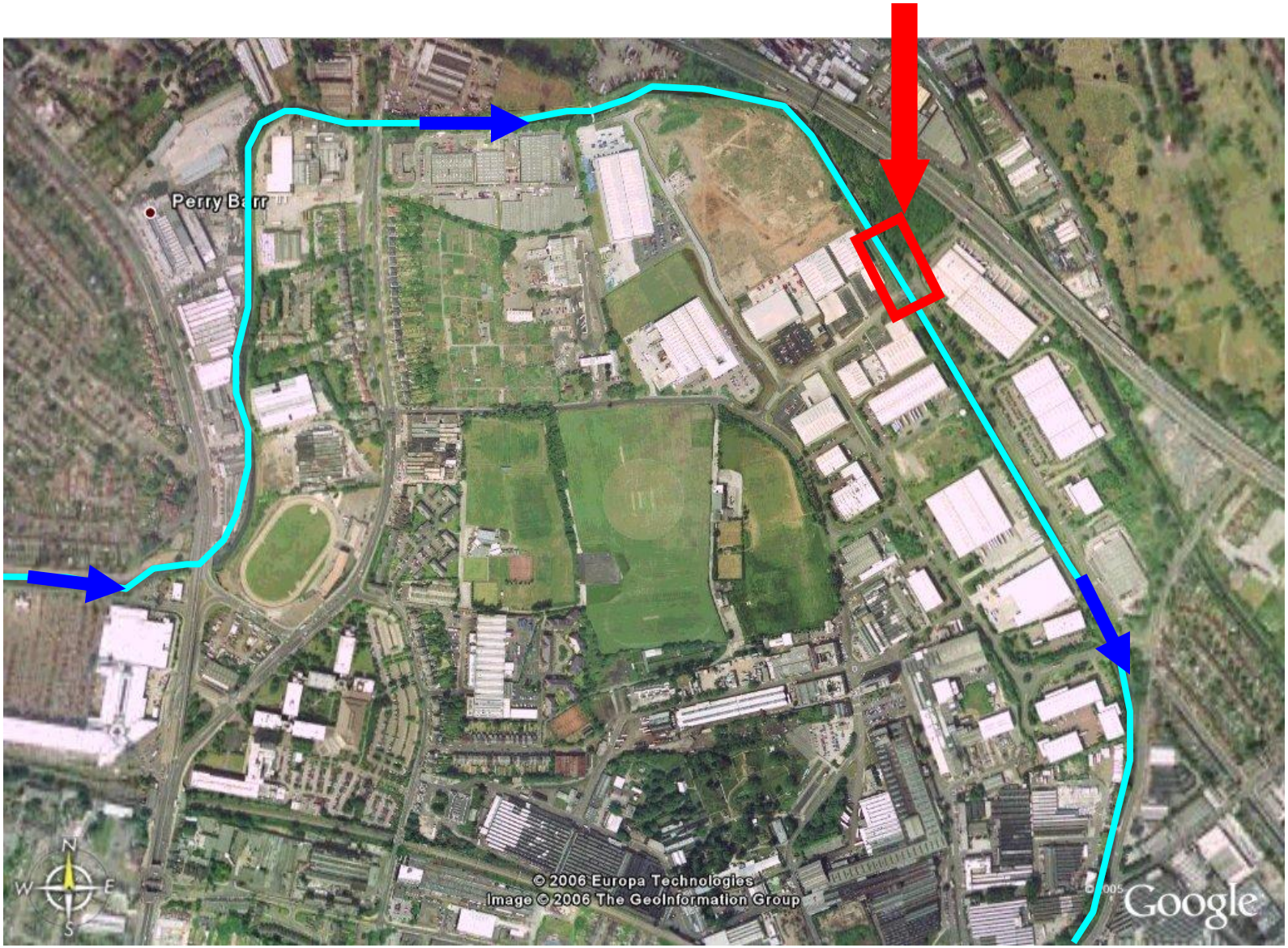






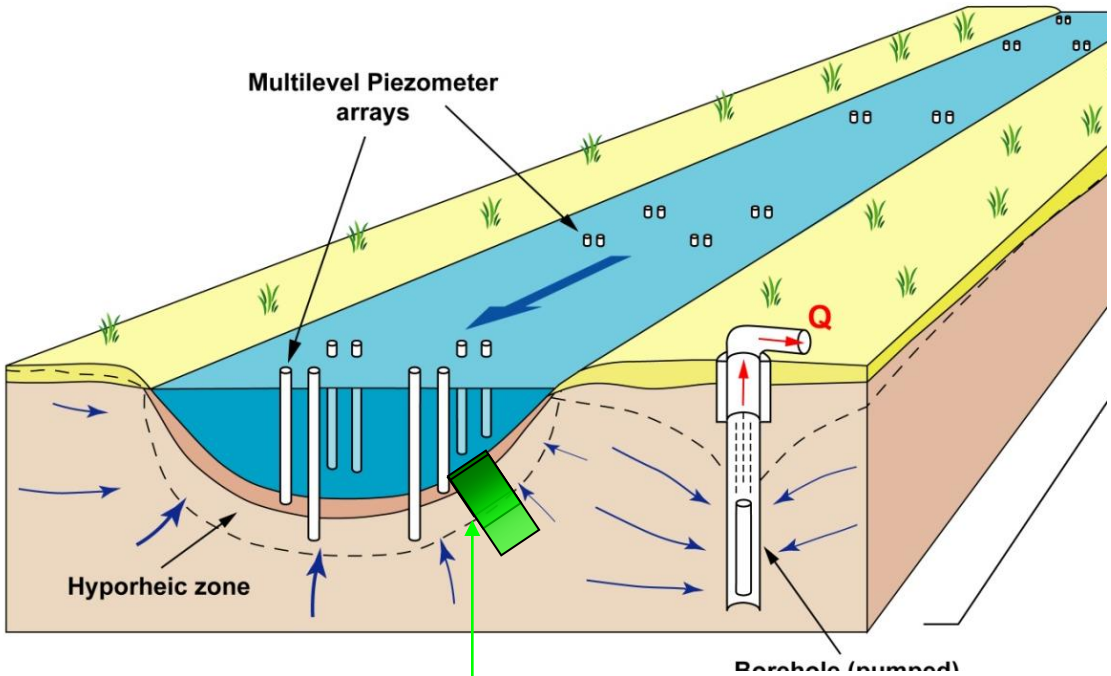


Hyporheic Zone Test Site



Approach

- Extraction borehole pumped at different rates to perturb flows across the HZ and modify travel times and attenuation



Experiment phases:

- Baseline period

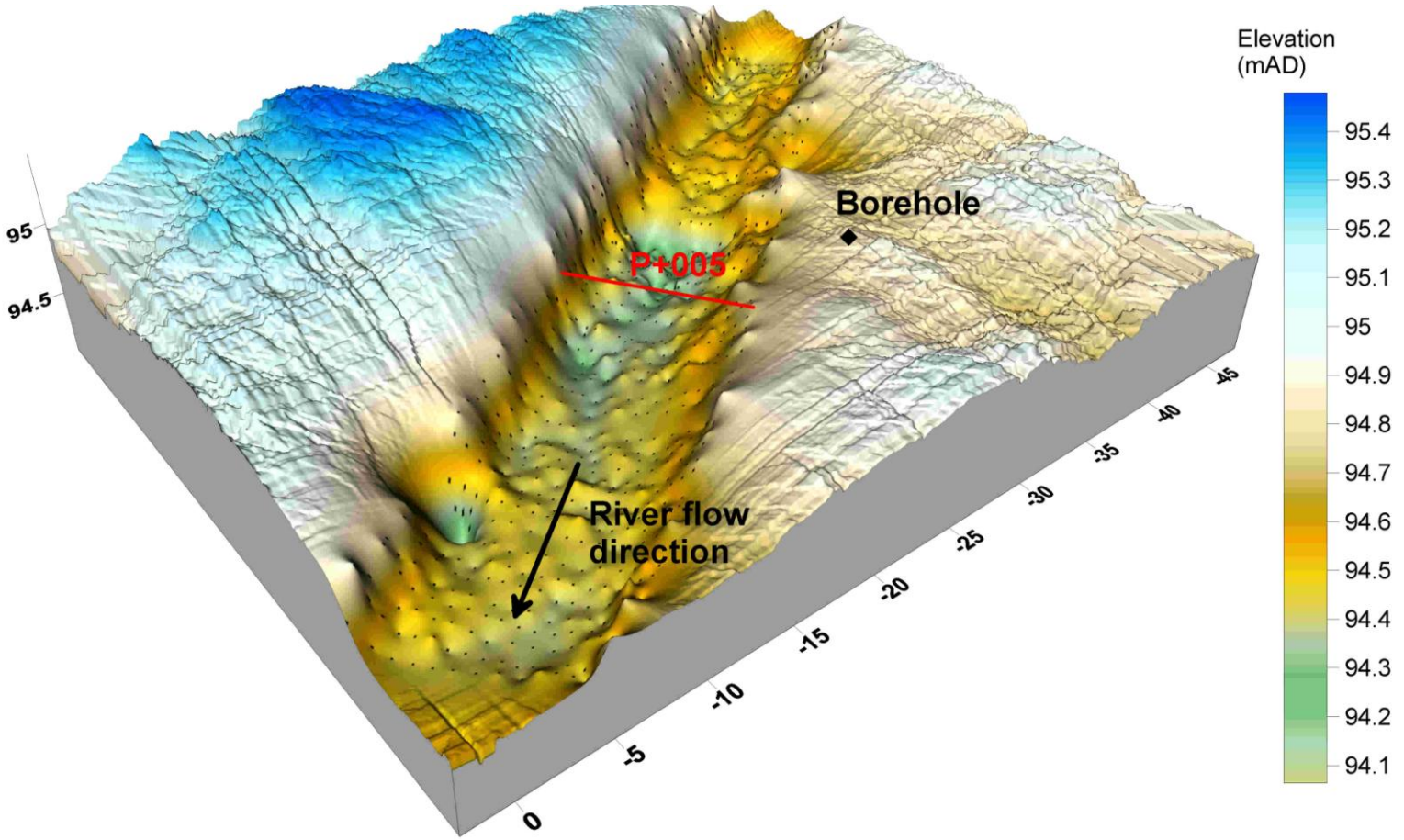
  Natural variability of HZ
- Extraction test 1

  Q = 78 l/min
- Extraction test 2

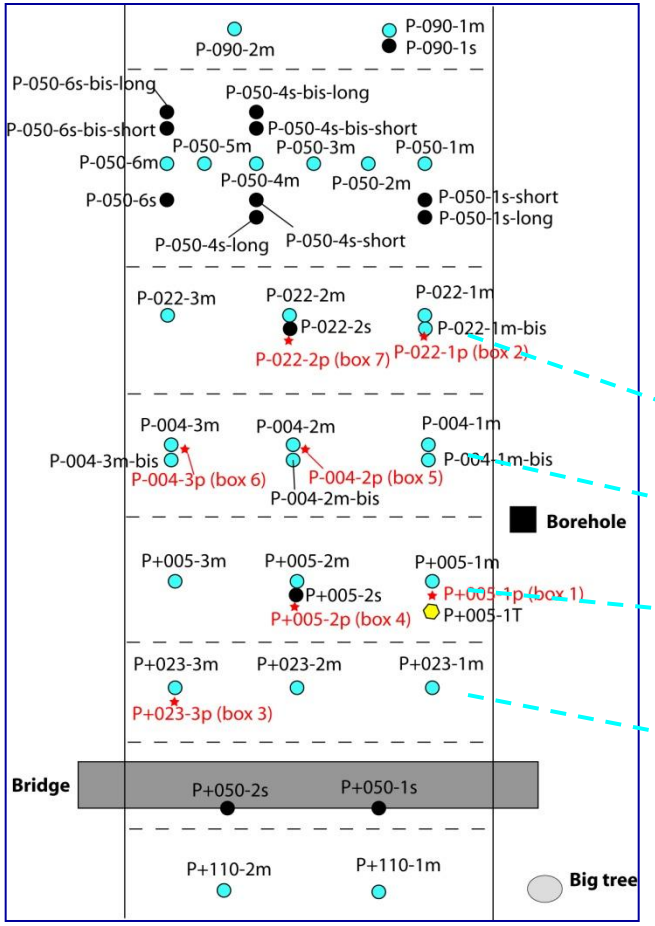
  Q = 150 l/min

- HZ attenuation zone is then “stretched” by increased borehole extraction

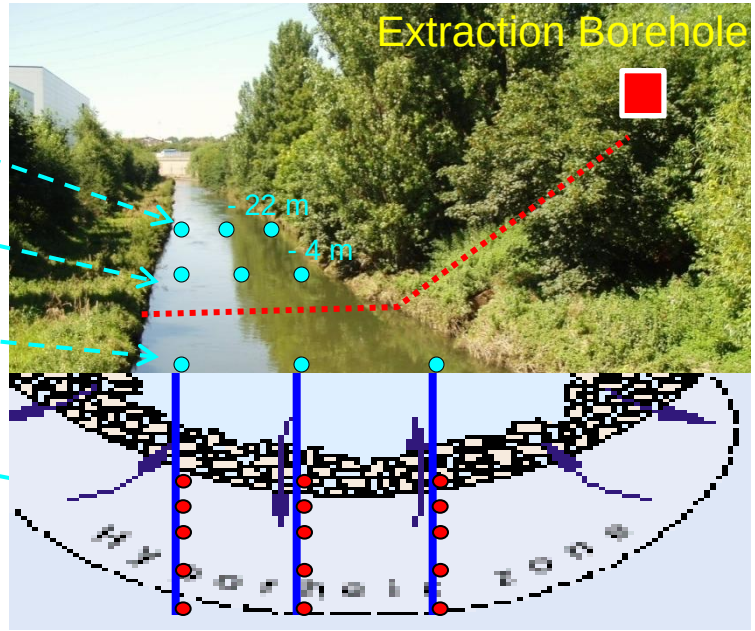
HZ Test Site:
- Riverbed topography



Monitoring network



- Water flow (head)
- Water quality

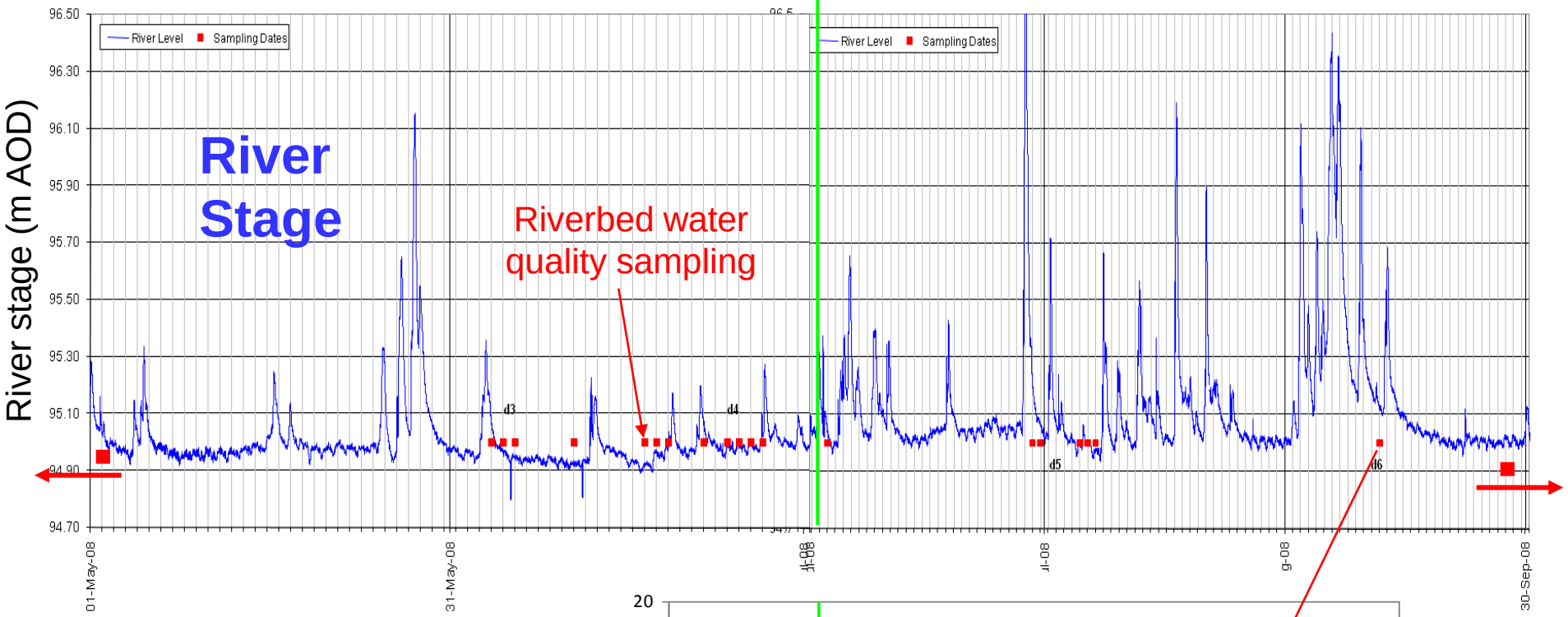


Baseline

Extraction test 1

Borehole rate Q = zero

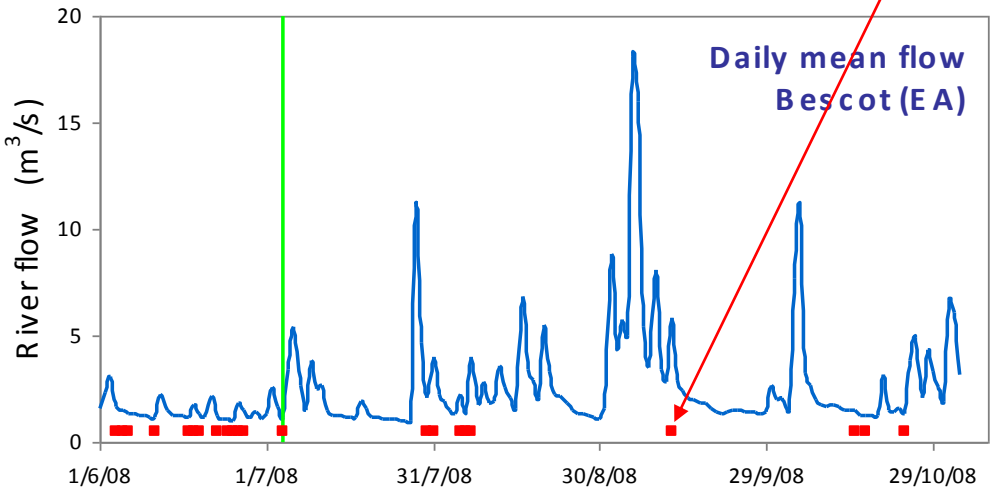
Borehole rate Q = 78 l/min



River Stage

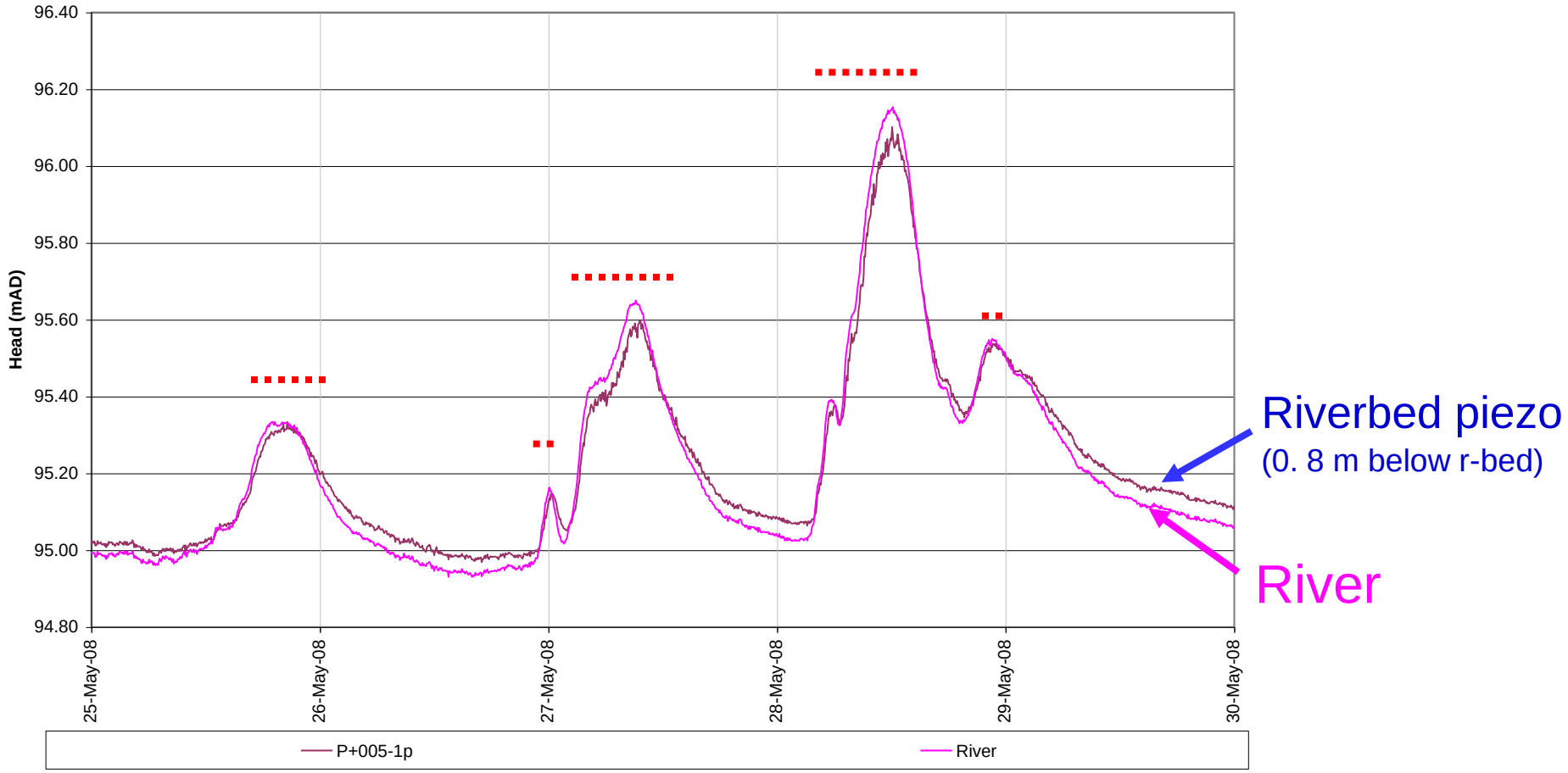
Riverbed water quality sampling

River Flow

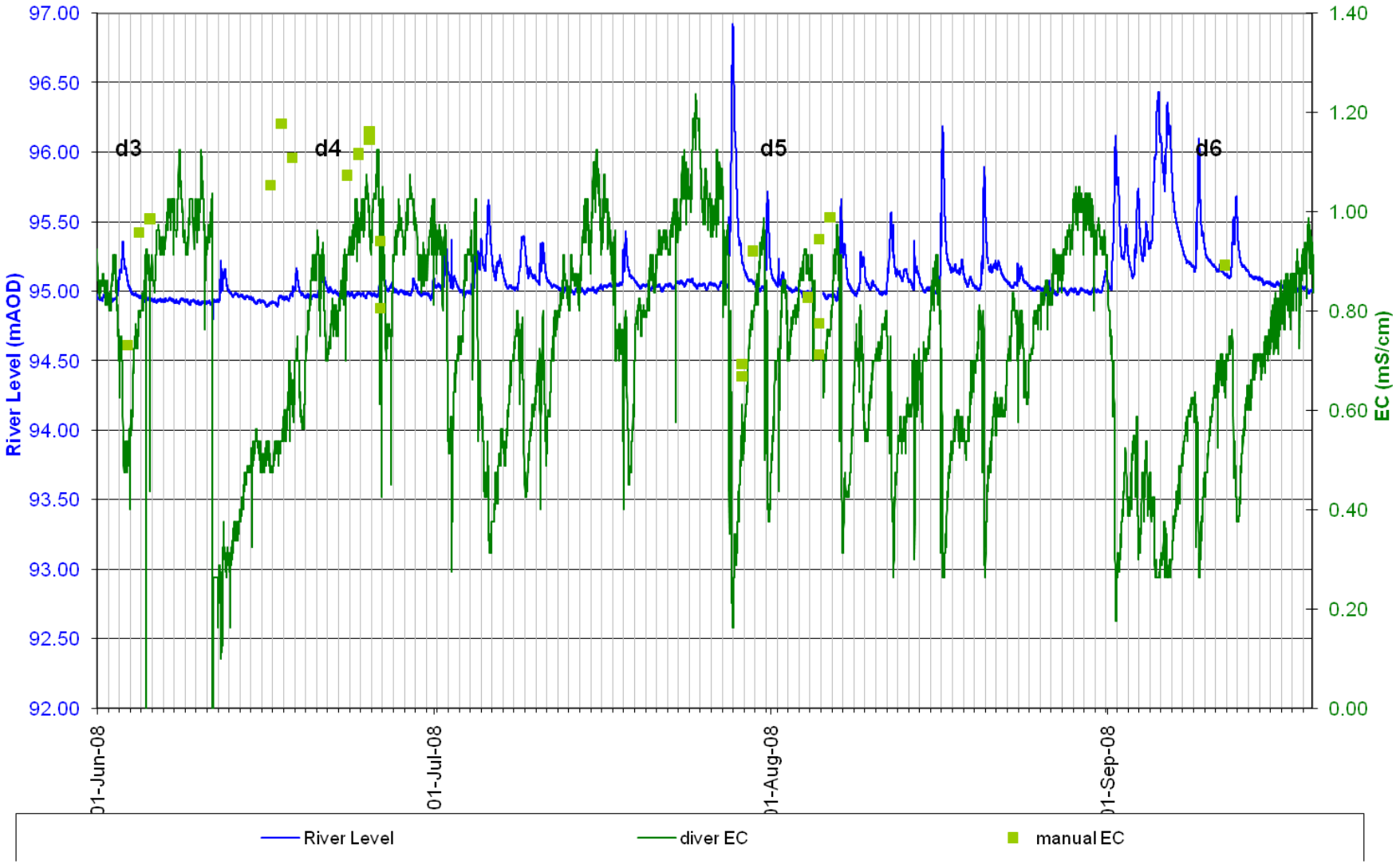


Water level (head) data

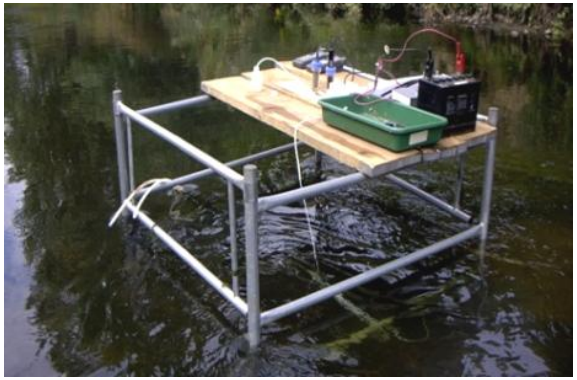
- Flow normally: from riverbed groundwater → river
- Rainfall events → flow reversal: river → riverbed groundwater
- Extraction Test 1: this natural trend still appears dominant

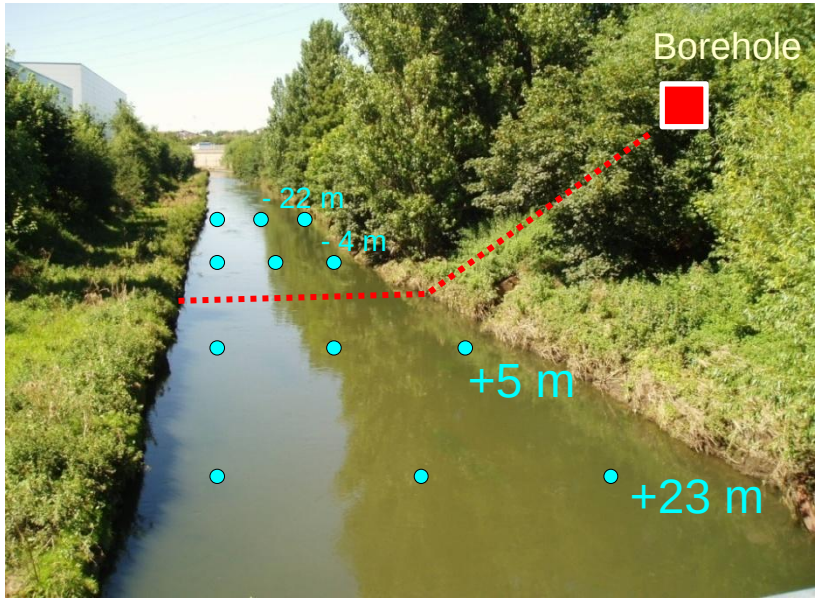


River: Level & EC (Electrical conductivity)



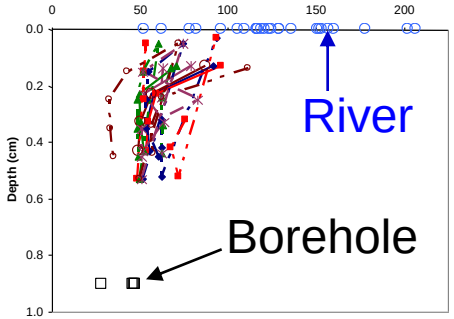
Riverbed profiles



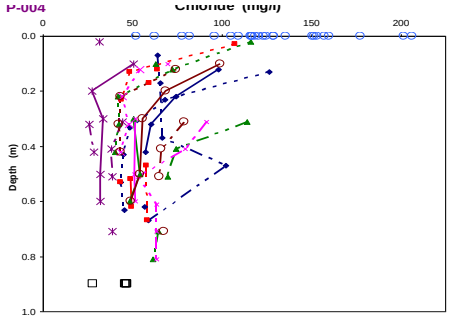


- Baseline = ◆ ■ ▲
- Extraction test 1 = △ x ✳ ○

Chloride / Cloreto

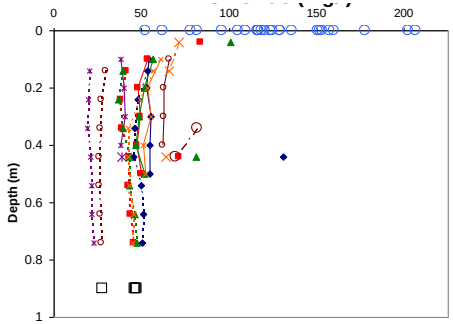


- 22 m

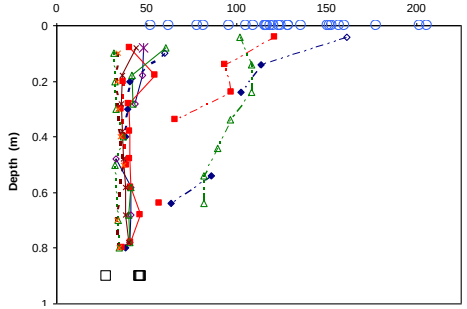


- 4 m

Borehole



+ 5 m



+ 23 m

Chloride / Cloreto

Nitrate / Nitrato

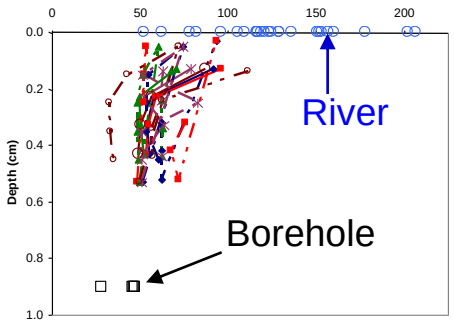
Phosphate / fosfato

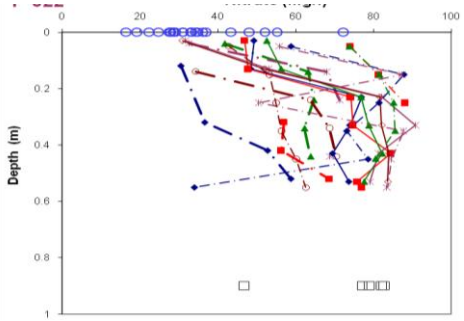
- 22 m

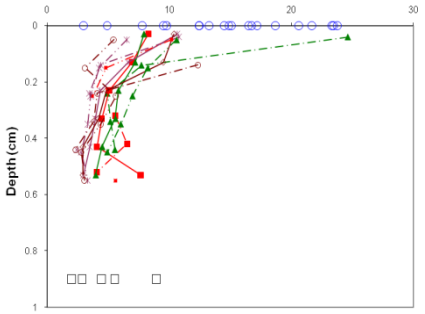
- 4 m

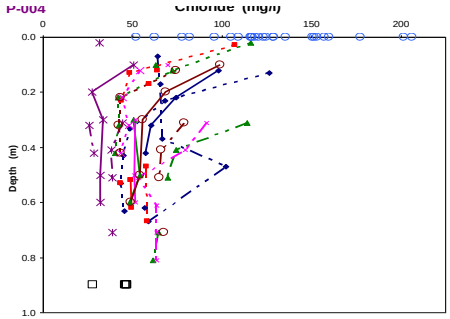
+ 5 m

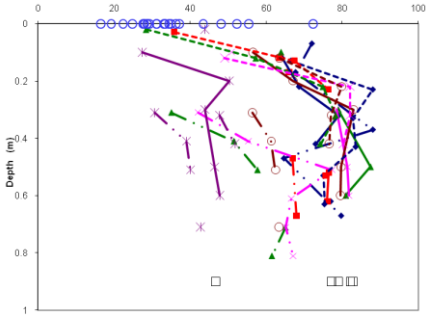
+ 23 m

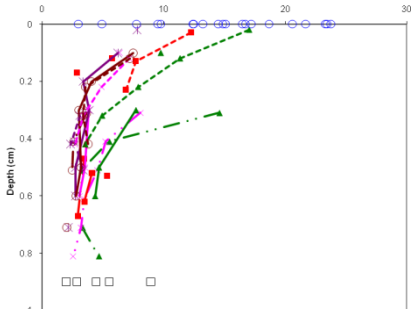


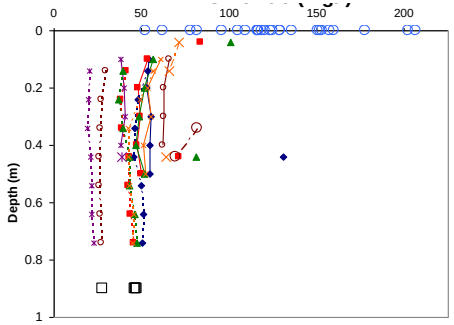


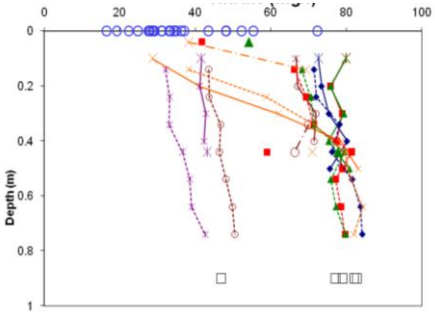


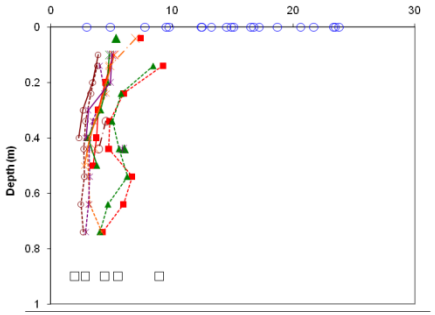


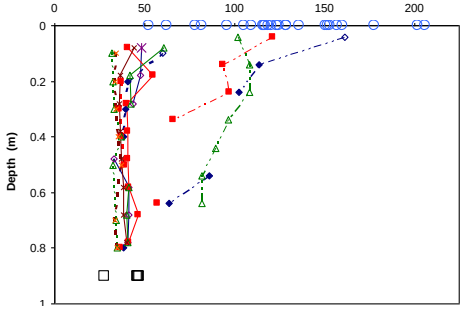


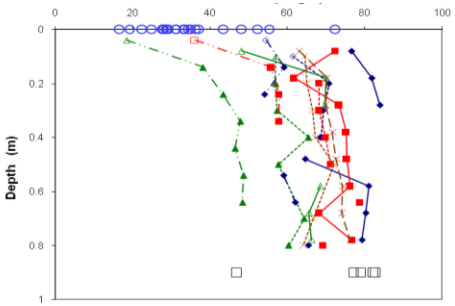


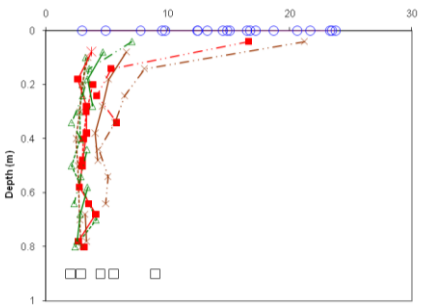






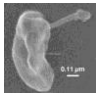


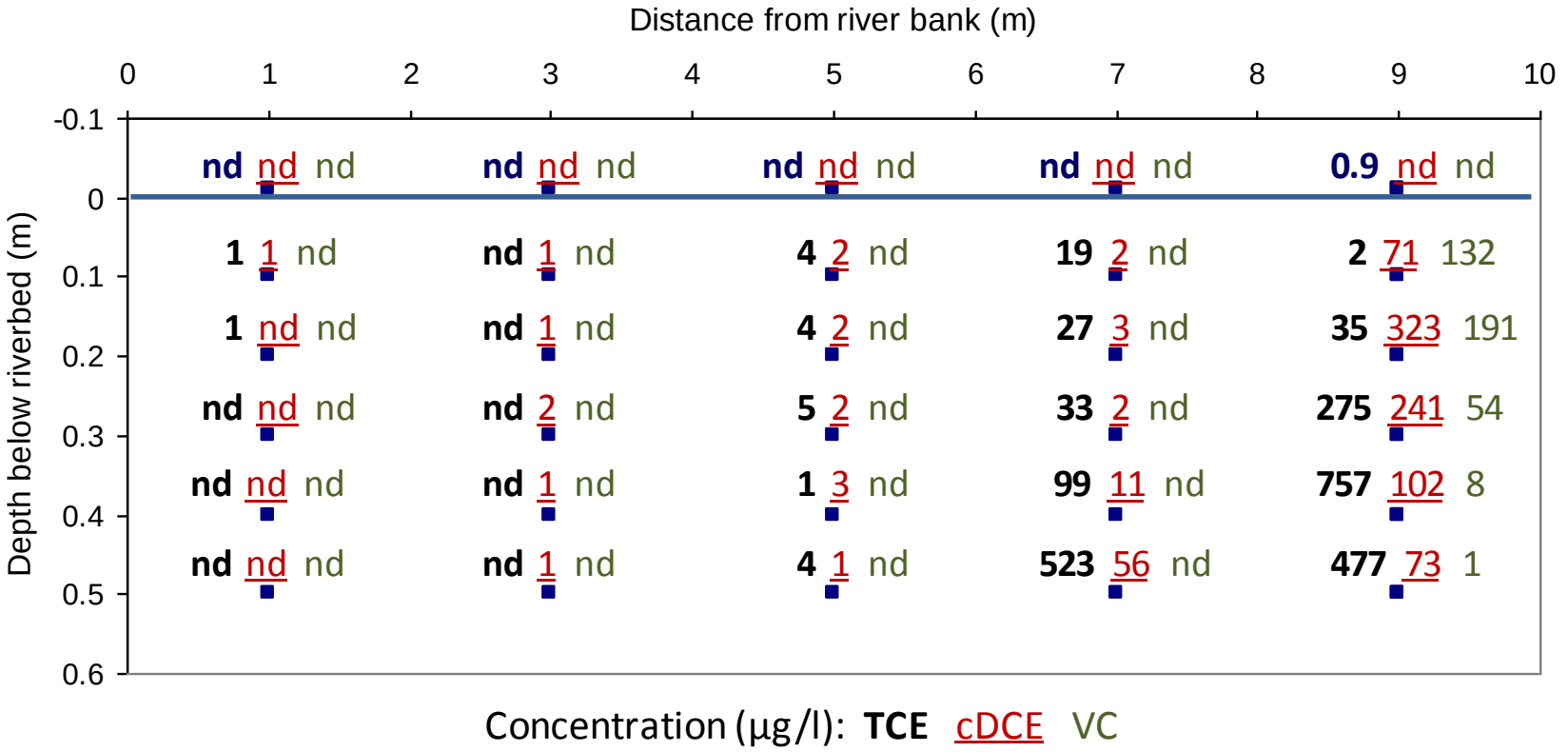




Natural attenuation at our “other Tame site”

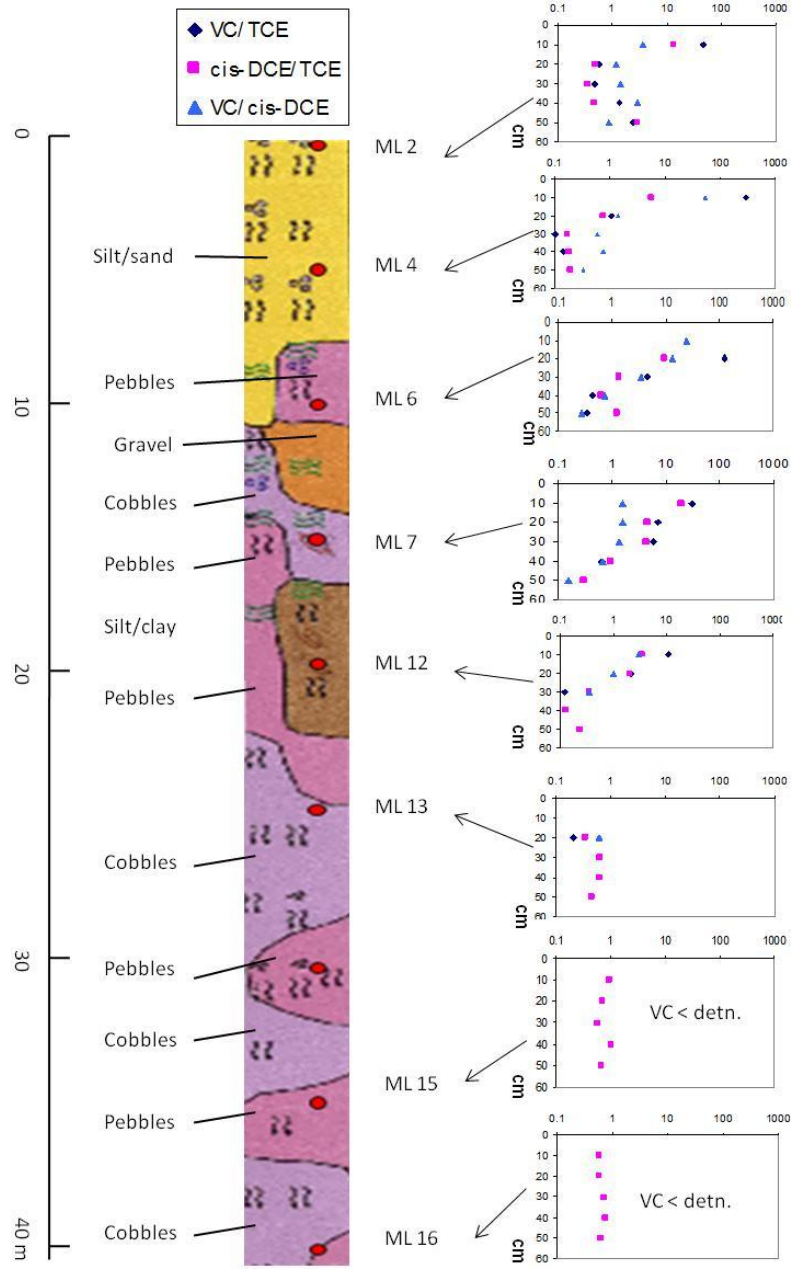
TCE → **cDCE** → **VC**



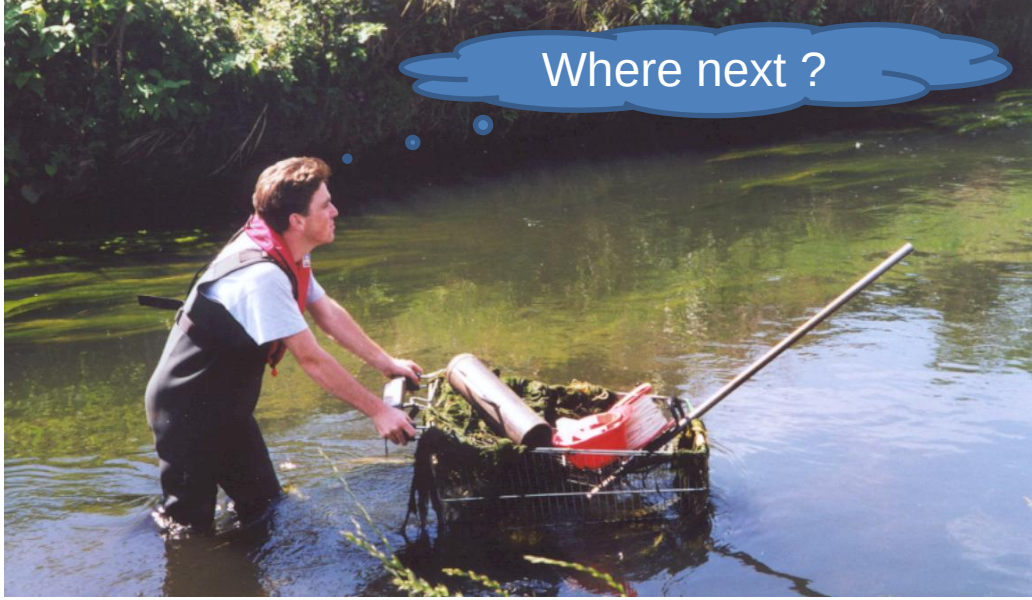


Daughter / parent ratio depth profiles

- cDCE / TCE etc.
- Ratio increases indicative of biodegradation
- Concerned contaminant bypasses in the high permeability, low attenuation zones



2008-09 plans



- Start Extraction Test 2 at maximum rate until Feb ’09
  - incl. Targeted isotopes, fluorescence, geophysics
- Continue data interpretation with numerical modelling
- Complete field data interpretation report by March ’09 for Environment Agency
- Development of: (i) HZ natural attenuation guidelines; (ii) river restoration design implications (incl. modelling)
- Reporting and publications

Post 2006 peer-review relevant publications:

Hyporheic zone, Birmingham – Tame, Natural Attenuation

- *Roche, R.S., Rivett, M.O., Tellam, J.H., Cleverly, M.G., Walker, M., **in press**.* Natural attenuation of a TCE plume at the groundwater – surface-water interface: Spatial and temporal variability within a 50 m reach. In: Groundwater Quality 2007 - Securing Groundwater Quality in Urban and Industrial Environments, **IAHS Publ**.
- *Rivett, M.O., Thornton, S.F., **in press***. Monitored natural attenuation of organic contaminants in groundwater. **Water Management (Journal of Institute of Civil Engineers)**, 161(6), XXX-XXX. doi 10.1680/wama.2008.161.6.xx
- *Rivett, M.O., Buss, S.R., Morgan, P., Smith, J.W.N., Bemment, C.D.,**2008**.* Nitrate attenuation in groundwater: a review of biogeochemical controlling processes. **Water Research** 42 (2008), 4215-4232.
- *Rivett, M.O., Ellis, P.A., Greswell, R.B., Ward, R.S., Roche, R.S., Cleverly, M., Walker, C., Conran, D., Fitzgerald, P.J., Willcox, T., Dowle, J., **2008**.* Cost-effective mini drive-point piezometers and multilevel samplers for monitoring the hyporheic zone. ***Quarterly Journal of Engineering Geology & Hydrogeology***, 41(1) 49-60.
- *Ellis, P.A., Mackay, R., Rivett, M.O., **2007**.* Quantifying urban river–aquifer fluid exchange processes: A multi-scale problem. ***Journal of Contaminant Hydrology*** 91, 51-80.
- Ellis, P.A., Rivett, M.O., **2007**. Assessing the impact of VOC-contaminated groundwater on surface-water at the city scale. ***Journal of Contaminant Hydrology*** 91, 107-127.
- *Shepherd, K.A., Ellis, P.A., Rivett, M.O., **2006**.* Integrated understanding of urban land, groundwater, baseflow and surface-water quality – The City of Birmingham, UK. ***Science of the Total Environment*** 360, 180-195.

Proposed peer-review publications:

Hyporheic zone, Birmingham – Tame, Natural Attenuation

SWITCH HZ Site

- **Journal:** Switch HZ Site – groundwater – surface-water flow interactions
- **Journal:** Switch HZ Site – water quality controls
- **Journal:** Switch HZ Site - urban HZ: monitored natural attenuation (MNA) options
- **Journal:** Switch HZ Site – development of HZ engineered options
- **Environment Agency Science Report:** Switch HZ Site – evaluation of field data (EA Publ.)

Birmingham aquifer – River Tame system

- **Journal:** Urban groundwater baseflow influence on surface-water inorganic chemical quality: the Birmingham aquifer – river Tame system, UK
- **Journal:** VOC distributions in the Birmingham aquifer over two decades (with EA)
- **Journal:** Groundwater rebound in the Birmingham aquifer (with EA)
- **Environment Agency pamphlet:** Rising groundwater in the Birmingham aquifer (EA lead)