


# River Mixing Studies

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Dye Tracing Workshop  
17<sup>th</sup> April 2008




### Why needed?

To predict:


- travel time, velocity
- dispersion (spread)

From:

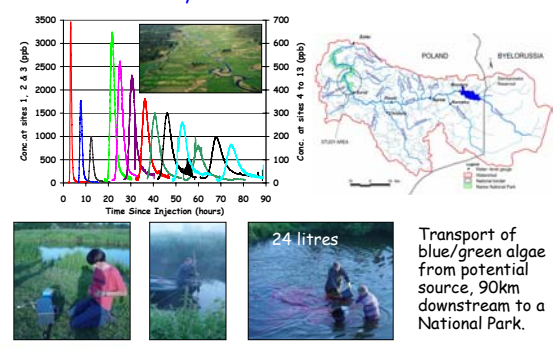
- accidental spills
- water quality variations



**Benzene levels 108 times above safe level**  
Travel time, 11 days for 380 km




### River Narew Study - Poland



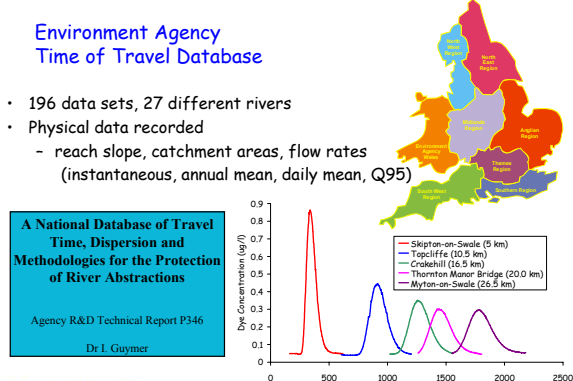
Transport of blue/green algae from potential source, 90km downstream to a National Park.

24 litres




### Environment Agency Time of Travel Database

- 196 data sets, 27 different rivers
- Physical data recorded
  - reach slope, catchment areas, flow rates (instantaneous, annual mean, daily mean, Q95)



A National Database of Travel Time, Dispersion and Methodologies for the Protection of River Abstractions

Agency R&D Technical Report P346  
Dr I. Guymer

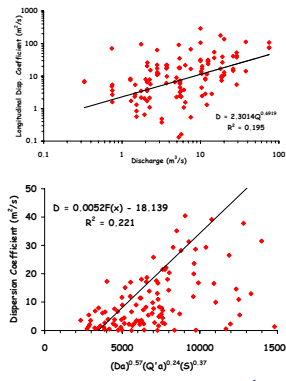


### Environment Agency Time of Travel Database

To provide:


- a national time of travel and dispersion database
- coupled with simple empirical equations
- for predicting the travel time and spread of pollutant in a river

Attempt to develop generic description of dispersion



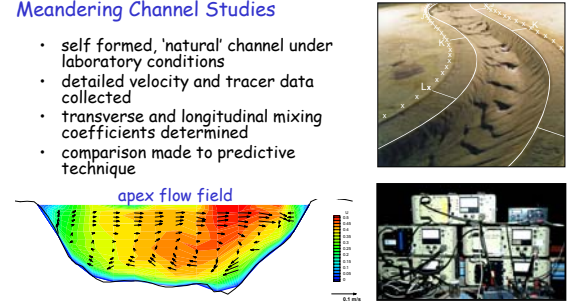
$D = 2.3014Q^{0.6919}$   
 $R^2 = 0.195$

$D = 0.0052F(x) - 18.139$   
 $R^2 = 0.221$




### Meandering Channel Studies

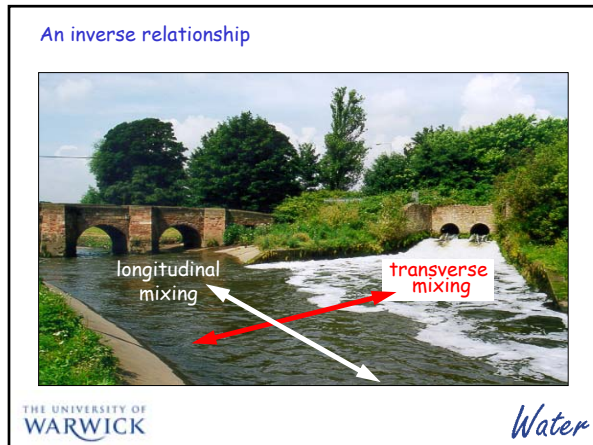
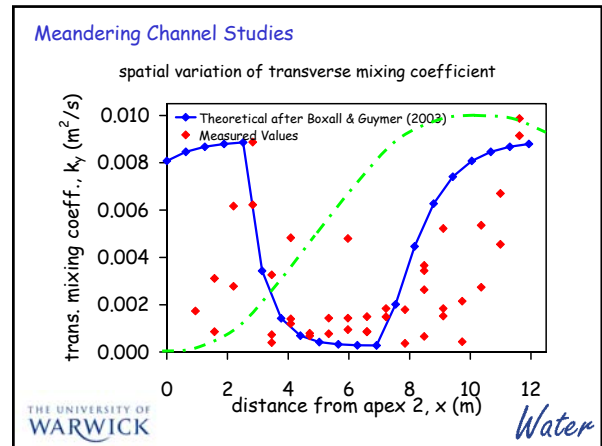
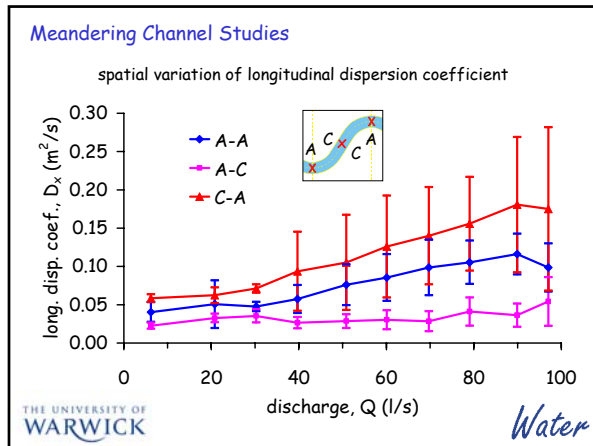
- self formed, 'natural' channel under laboratory conditions
- detailed velocity and tracer data collected
- transverse and longitudinal mixing coefficients determined
- comparison made to predictive technique



apex flow field

Transverse mixing - continuous injection  
Longitudinal dispersion - instantaneous injection



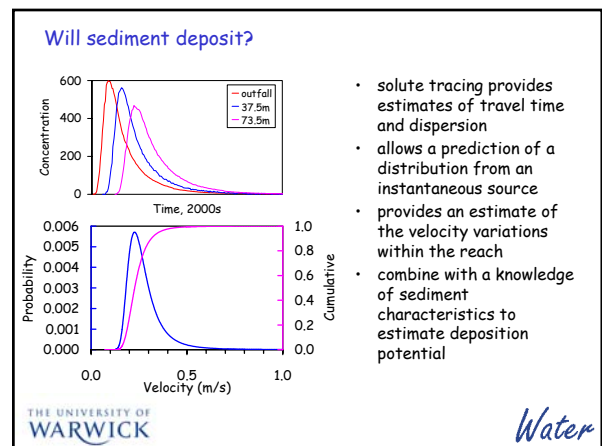
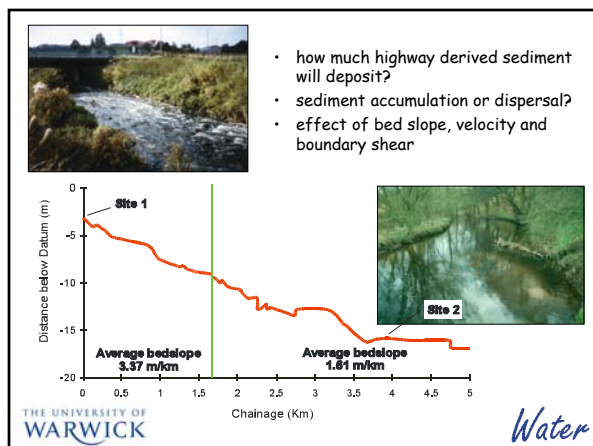


**HIGHWAYS AGENCY** Environment Agency

- investigated impact of highway derived sediment on receiving water ecology
- sediment was contaminated with metals & PAHs
- there was a negative impact on the ecology where sediment accumulated

ECUS The University of Sheffield.

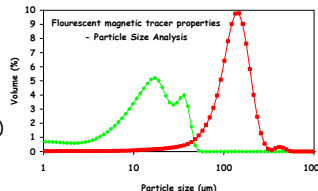
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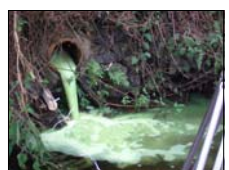

### Sediment tracing study

water pumped from river through outfall pipe

coarse (red) and fine (green) particles injected into flow in outfall pipe




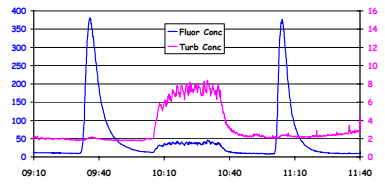


Flourescent magnetic tracer properties - Particle Size Analysis

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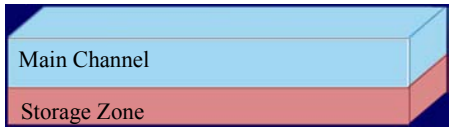
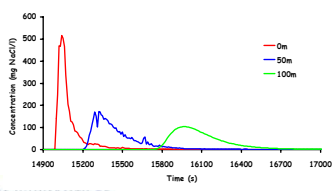
Water

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Water

### Bed/hyporheic exchange

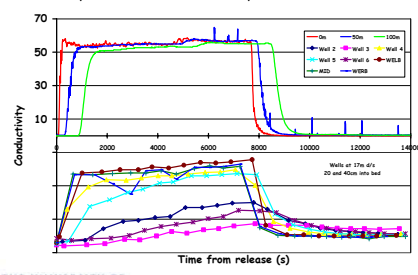


- instantaneous injection of tracer
- instream measurements at 3 sites

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### Bed/hyporheic exchange - field study

- step release, in-stream and in-bed monitoring
- estimating parameters from in-stream data:
  - 2 parameter model - consistent parameter estimation
  - 4 parameter model - over-parameterised


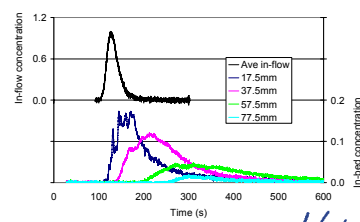




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### Bed/hyporheic exchange - laboratory study

- flat or undulating bed
- gravel & styrofoam
- different depths of sediment

- flat gravel
- flow rate 3.1 l/s
- 100mm thick

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### Bed/hyporheic exchange - laboratory study

Comments:

- difficulty in quantifying exchange parameters for 4 parameter model
- to ensure a 'unique' solution, in-stream longitudinal dispersion coefficient defined by fitting to the rising limb of the downstream profile
- 4 parameter transient storage model then reduced to estimating three parameters

From three parameter optimisation technique:

- bed exchange rate parameter is proportional to discharge,
  - suggests that exchange is a turbulence driven process
- rate of exchange into storage is constant over all bed shapes and bed forms
  - exception for flow over the 100 mm undulating thick bed (pumping effect?)

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Final comments

- solute tracing within rivers allows mean travel times (velocity) and dispersion (spreading) to be easily determined
- not easy to accurately estimate without field studies
- controlled laboratory studies confirm the inverse relationship between longitudinal and transverse mixing
- knowledge of mixing characteristics allows estimation of spatial velocity variations within a reach
  - (useful for assessing potential for sediment deposition)
- difficulty in accurately assessing bed (hyporheic) exchange parameters in transient storage models