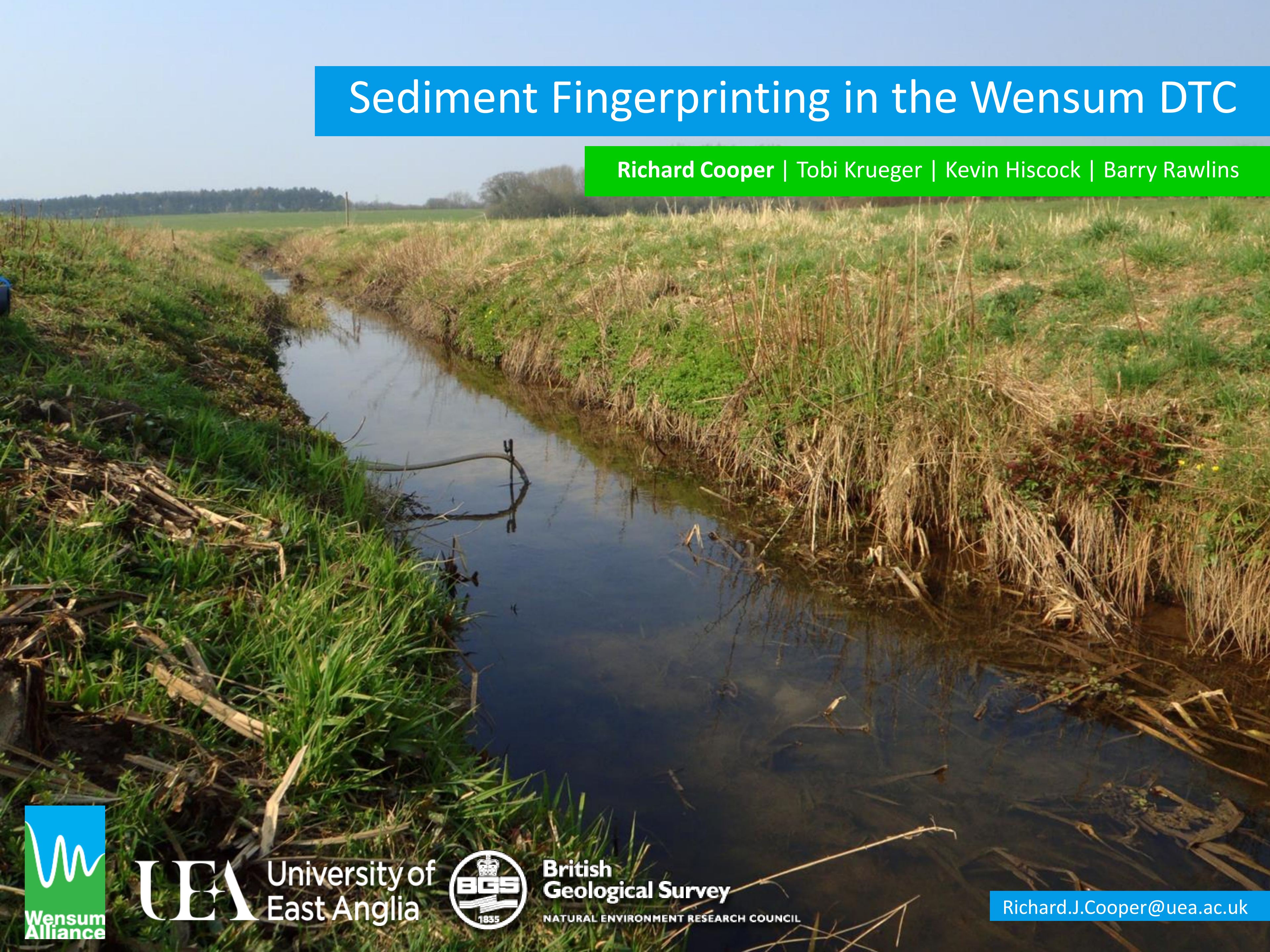

Sediment Fingerprinting in the Wensum DTC

Richard Cooper | Tobi Krueger | Kevin Hiscock | Barry Rawlins

Wensum Alliance

University of East Anglia

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

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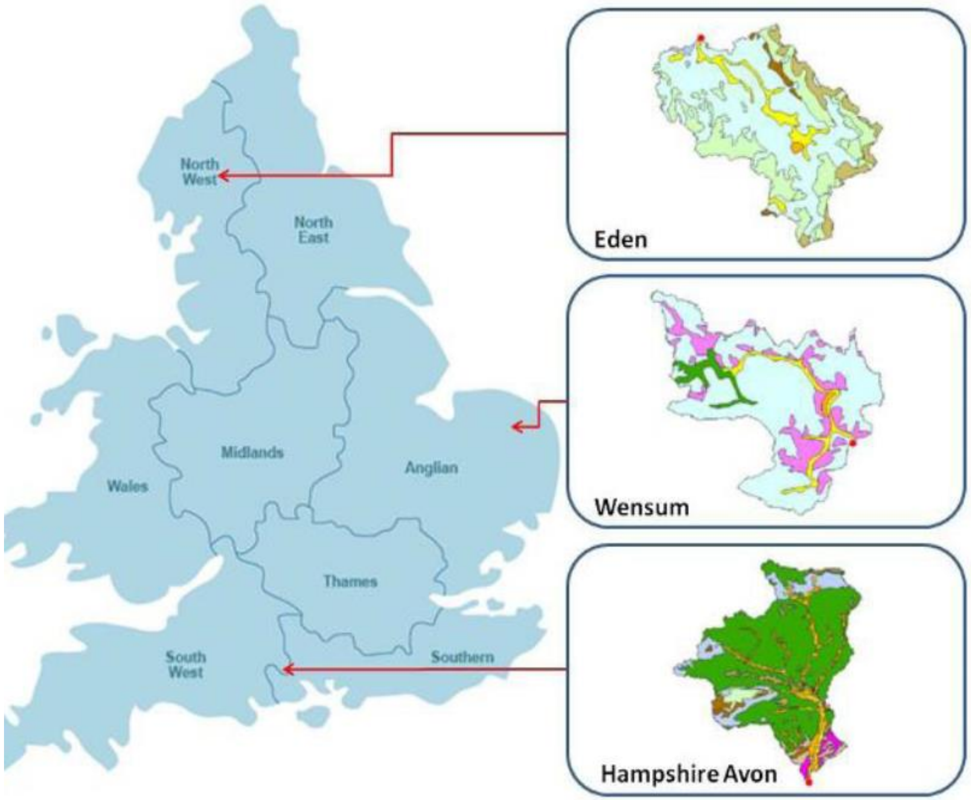
Goal of the DTC Project

- Demonstration Test Catchment (**DTC**)
- Joint initiative between Defra, EA and the Welsh Assembly Government working in three river catchments – Wensum, Eden, Avon.
- *“evaluate the extent to which on-farm mitigation measures can cost effectively reduce the impacts of diffuse agricultural pollution on river ecology whilst maintaining food production capacity”.*

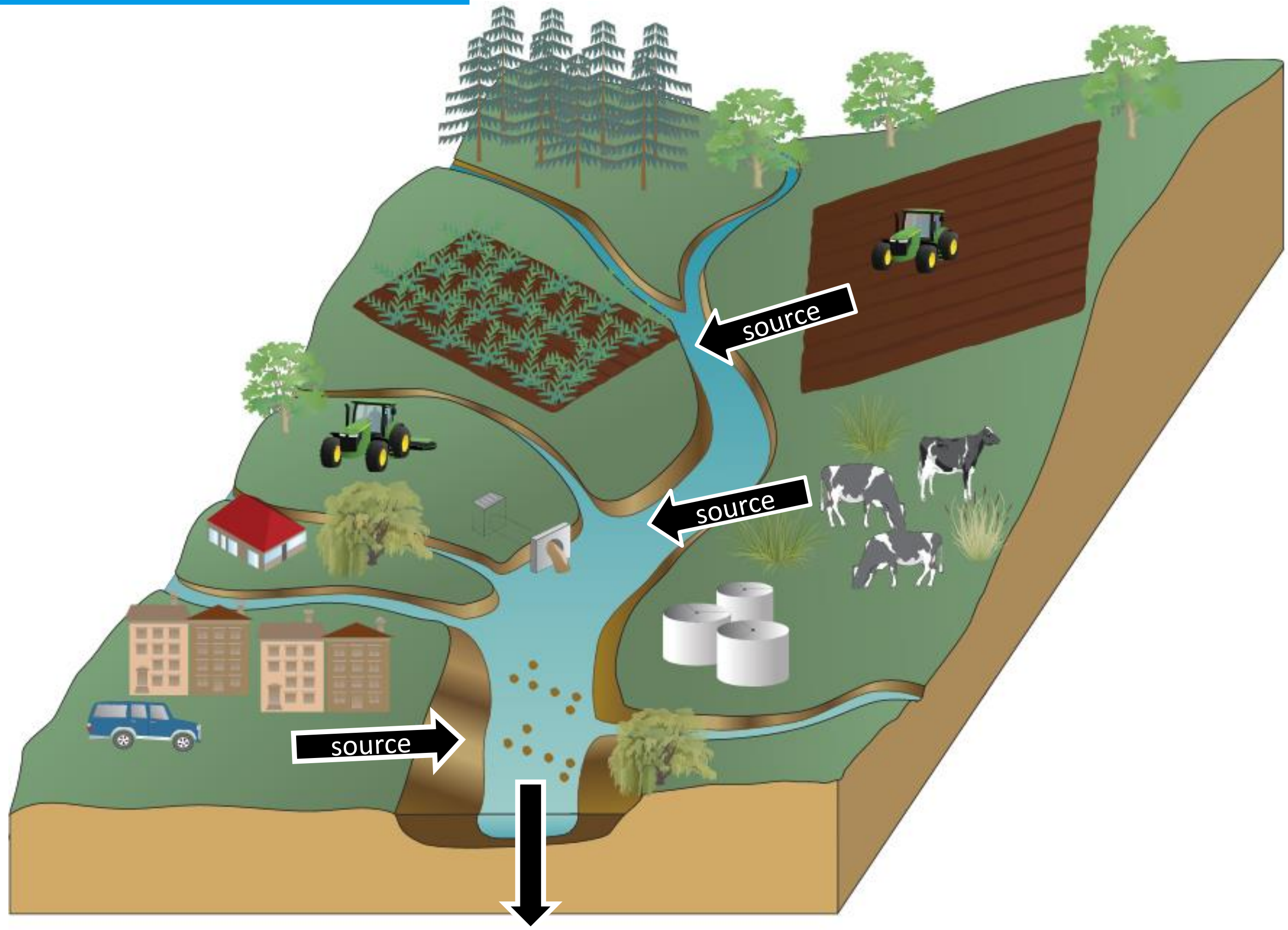


defra
Department for Environment Food and Rural Affairs

Environment Agency

Llywodraeth Cynulliad Cymru
Welsh Assembly Government

Fingerprinting Principle



Suspended sediment geochemistry

Primary Research Aims

- Develop high-temporal resolution fluvial sediment source apportionment technique.

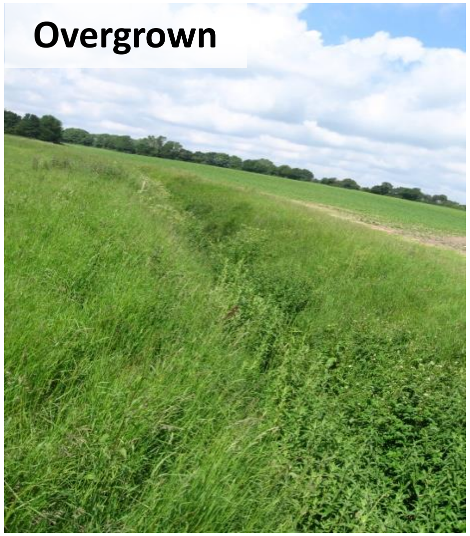
  - How to **improve the temporal resolution** of source apportionment estimates whilst minimising analytical costs.

  - How to **consistently quantify all perceived uncertainties** associated with the sediment mixing model procedure.

Why is this Important?

- Rivers affected by high sediment volumes suffer from:
  - Elevated turbidity
  - Smothering of benthic habitats
  - Loss of spawning gravels
  - Damage to fish gills
  - Eutrophication
  - Dredging costs
- Essential to understand sediment sources to enable mitigation measures to be targeted accordingly.
- Other fingerprinting studies - low resolution & lack comprehensive uncertainty assessment.

Visual Impacts



Overgrown

Sedimentation

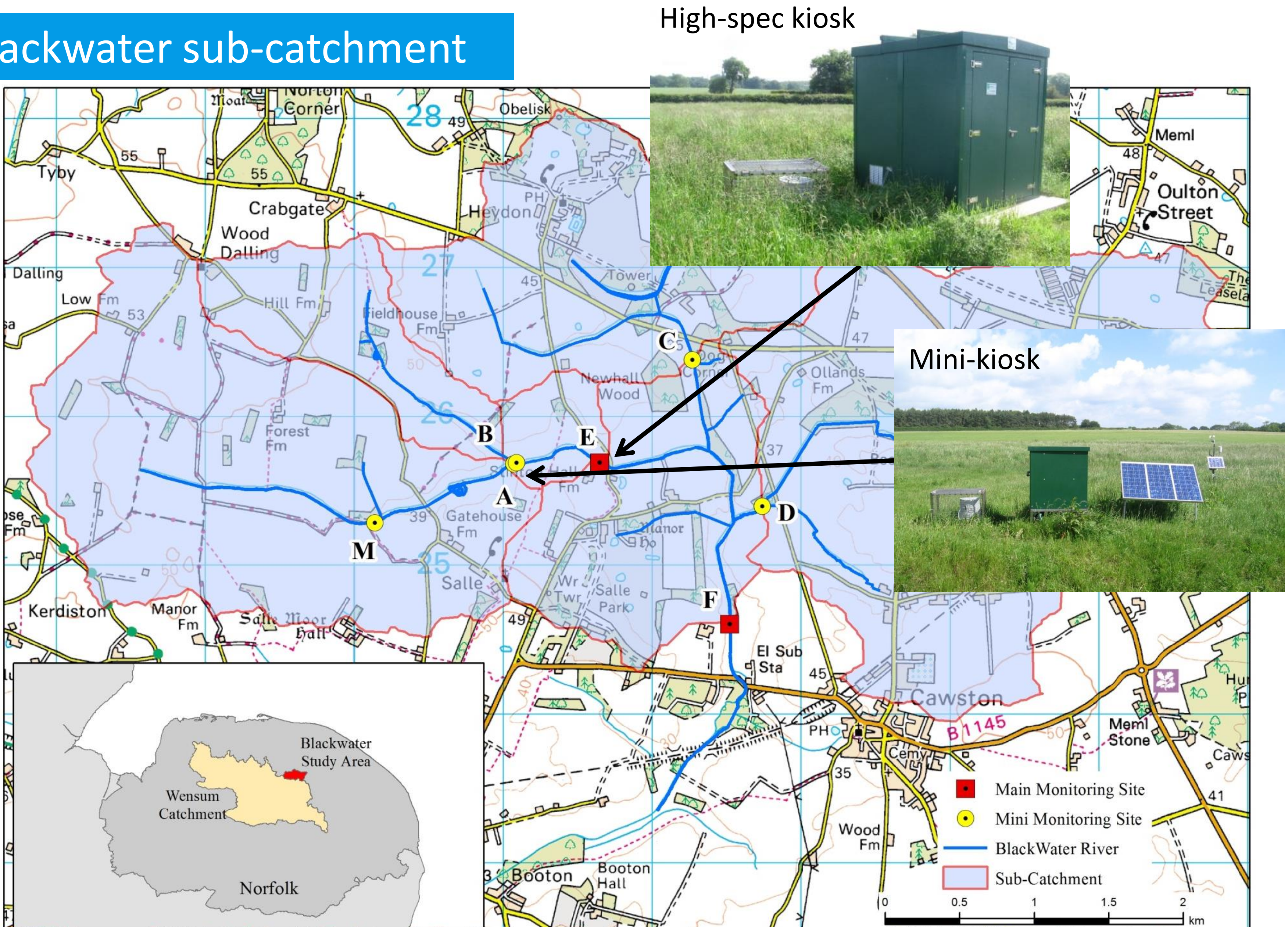
Smothering equipment

Algal films

Turbidity

Benthic algae

Blackwater sub-catchment



What are the Possible Sources?

Channel Banks

Field Drains

Arable Topsoils

Road Verges

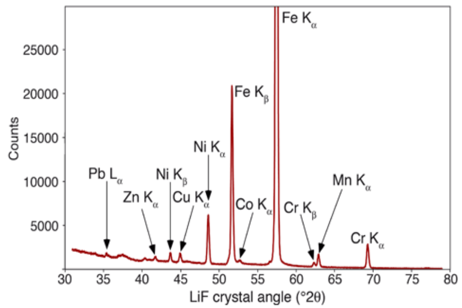
Collecting Sediments

- Instream **suspended sediment** samples collected from sites A, B & E during heavy rainfall events (>10 mm) via **ISCO automatic samplers**.

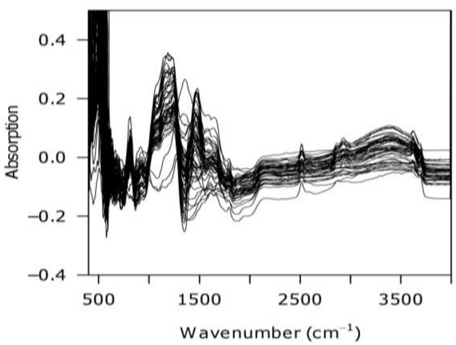
- Sediment samples collected from each of the **4 potential source areas** – surface scrapes (<50 mm) and grab samples.
  - ➢ Target **critical source areas**.

Analysing Sediment Geochemistry

All samples sonicated, wet sieved <63 µm, and vacuum filtered through **quartz fibre filter (QFF) papers**.



XRFS: X-ray Fluorescence Spectroscopy (Al, Ca, Ce, Fe, K, Mg, Mn, Na, P, Si, Ti) - '**Geochemical Fingerprints**'.



DRIFTS: Diffuse Reflectance Infra-red Spectroscopy - Organic Carbon, Fe/Al oxyhydroxides

- **Rapid**, **accurate**, **inexpensive** and **non-destructive** – contrast with ICP, acid digestion, LOI etc….

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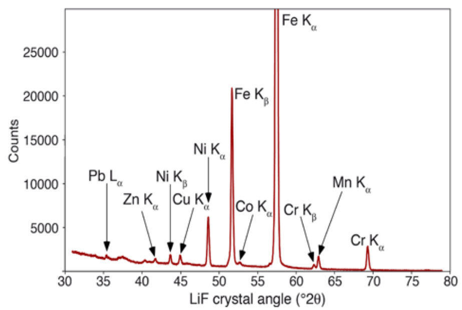

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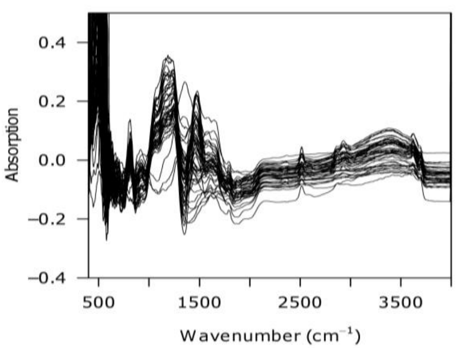

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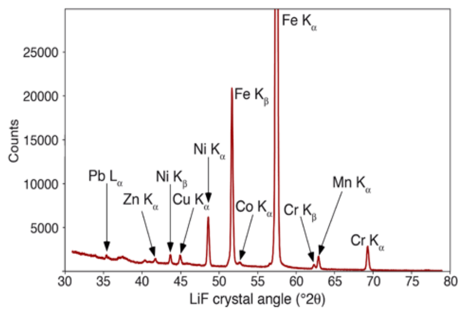

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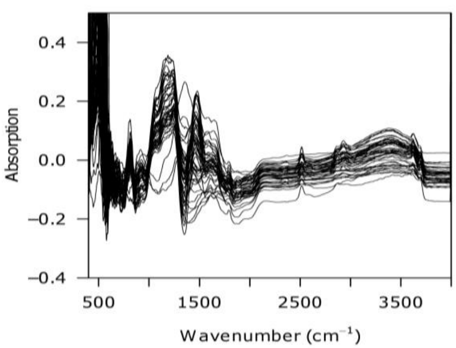

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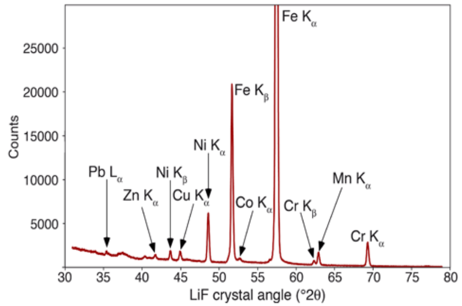

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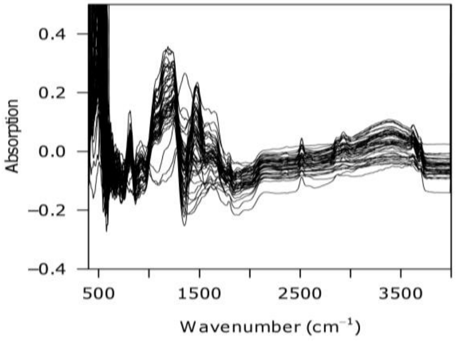

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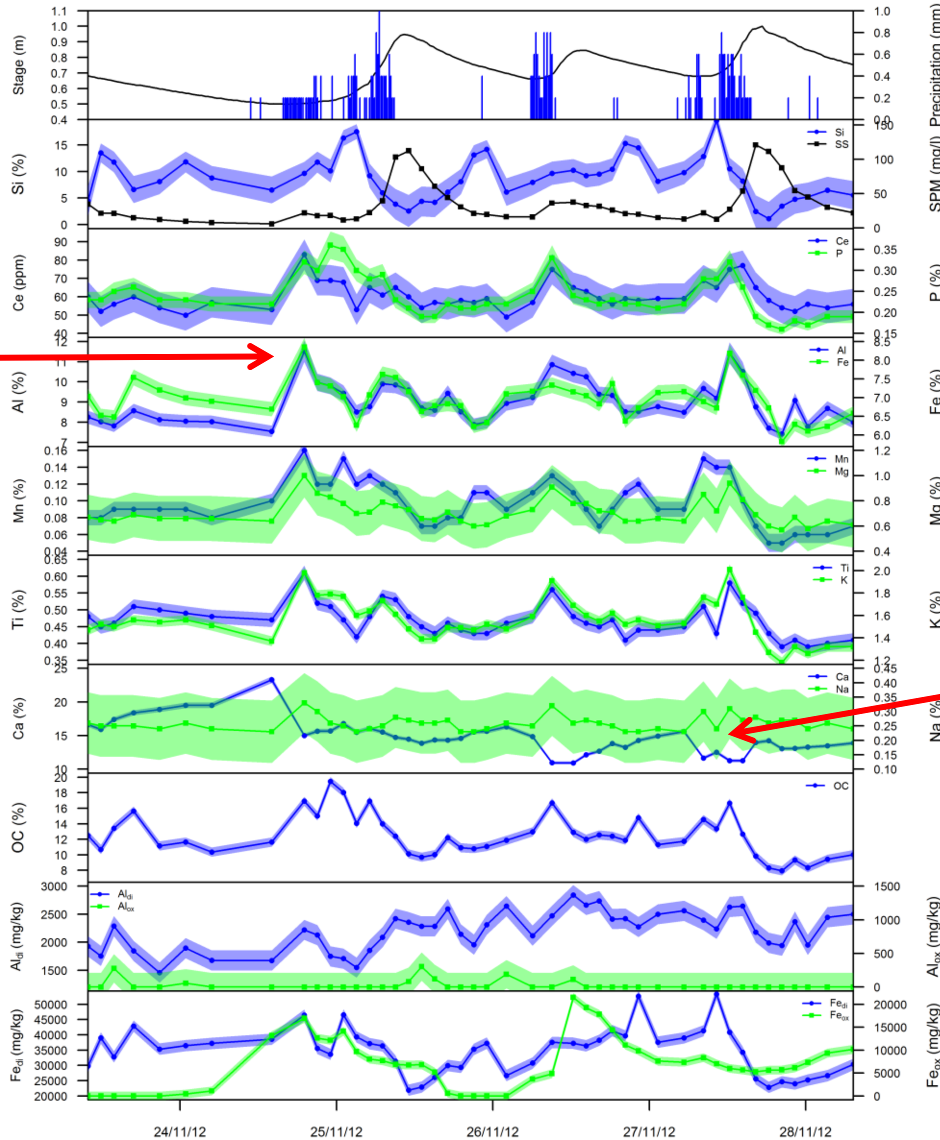
High-resolution time series

60-120 minute resolution

Peaks in clay-mineral associated elements during rainfall – indicative of surface sources



Decline in Ca – reduced importance of subsurfaces

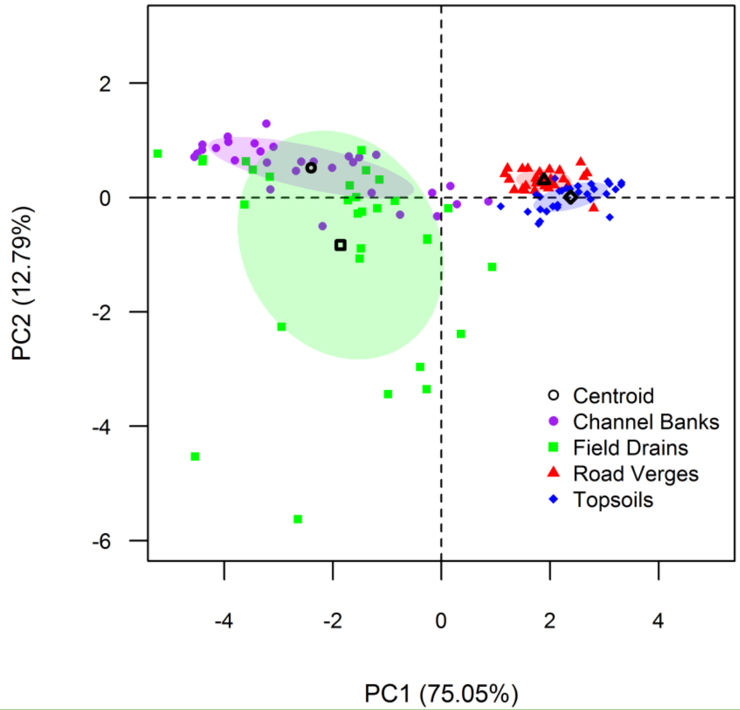
www.wensumalliance.org.uk
email: wensumalliance@uea.ac.uk

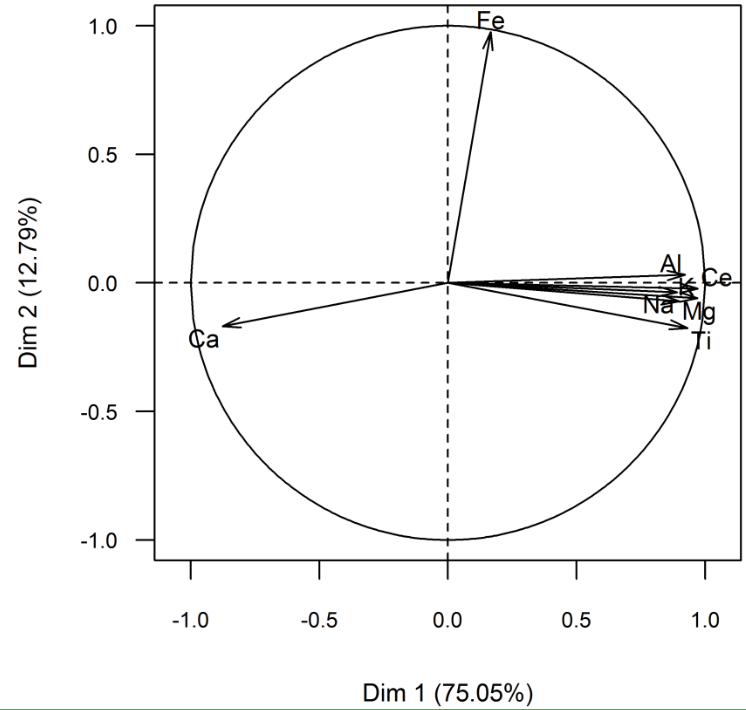
Identifying Fingerprints

- **Kruskal-Wallis rank sum test** and **Linear Discriminant Analysis** (LDA) to determine optimum combination of geochemical fingerprints capable of differentiating the source areas.

- 8 geochemical fingerprints selected (**Ca, K, Mg, Al, Ce, Fe, Na, Ti**).

- **Channel bank** and **field drain** data merged into a combined **subsurface** sediment source.

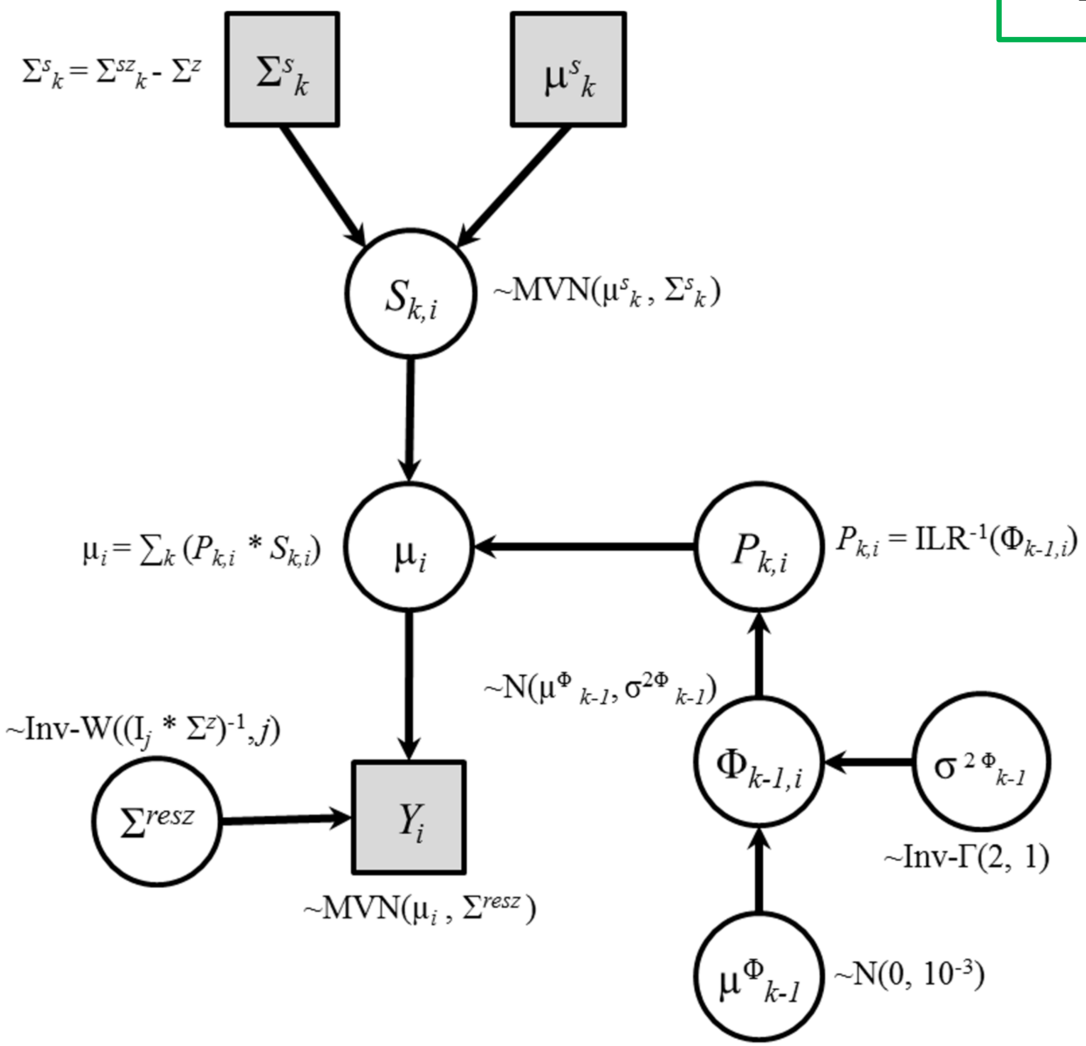




Bayesian Mixing Model

Gibbs Sampling Markov-chain Monte-Carlo procedure

L (*S*, *P* | *Y*)



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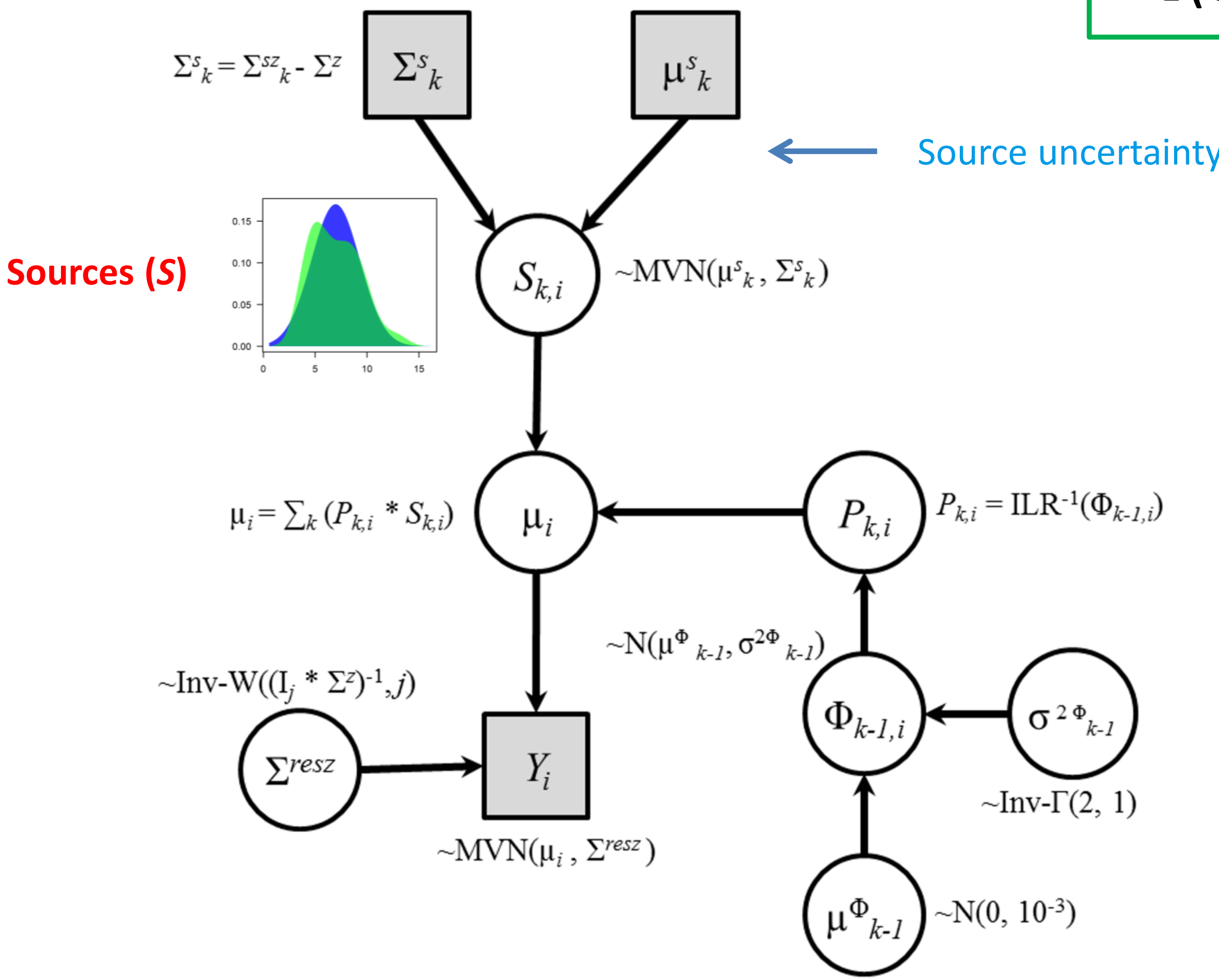

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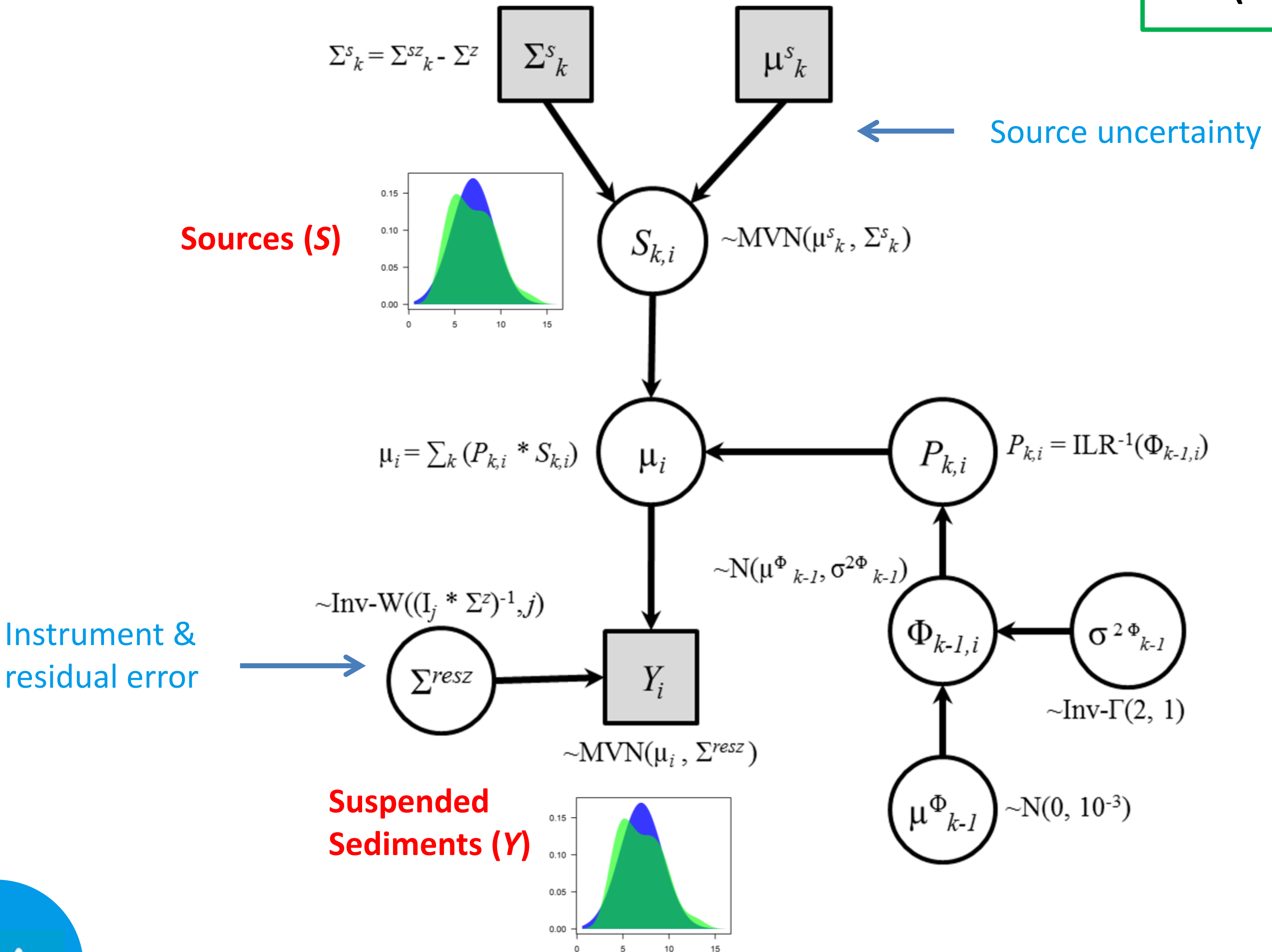

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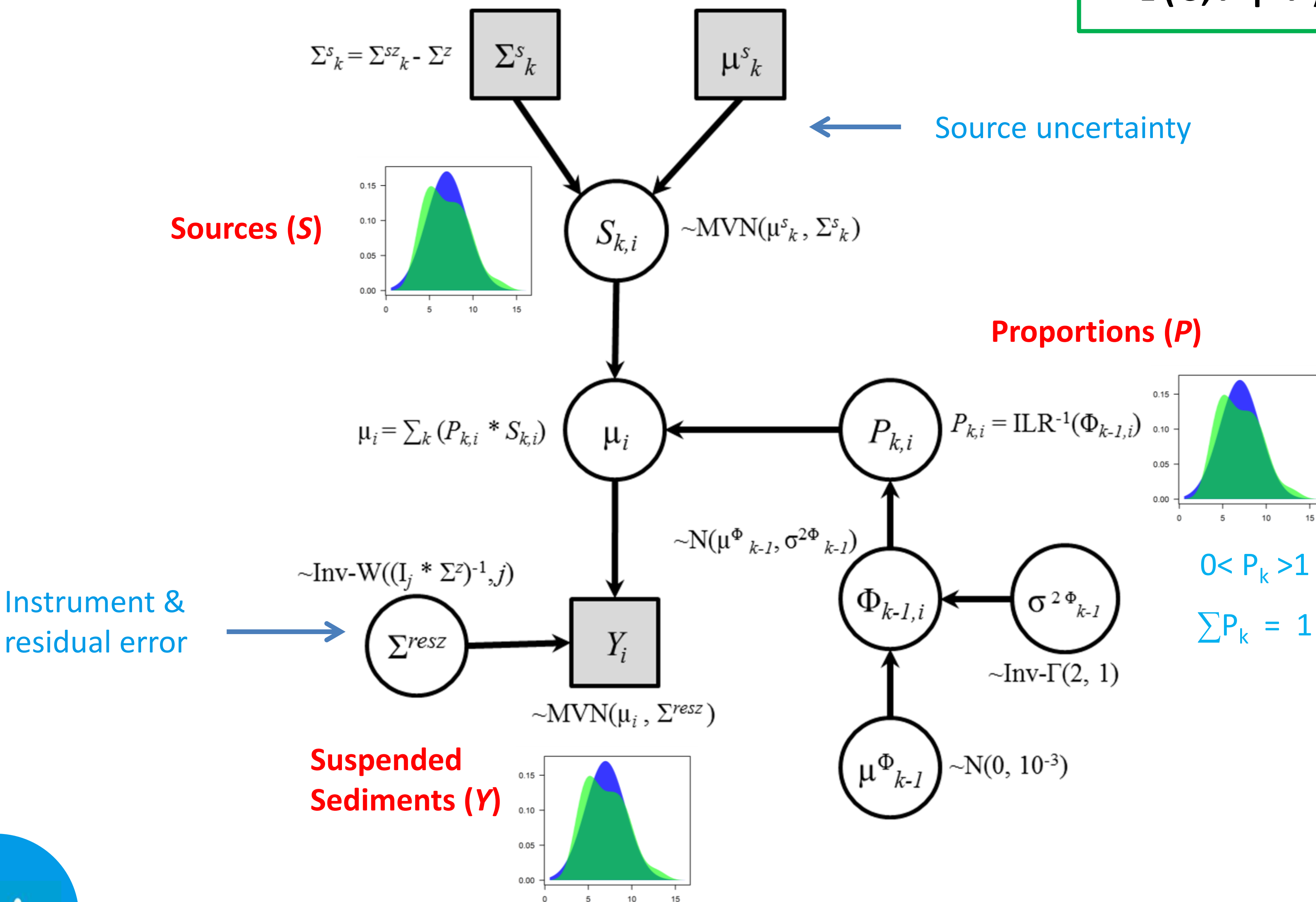
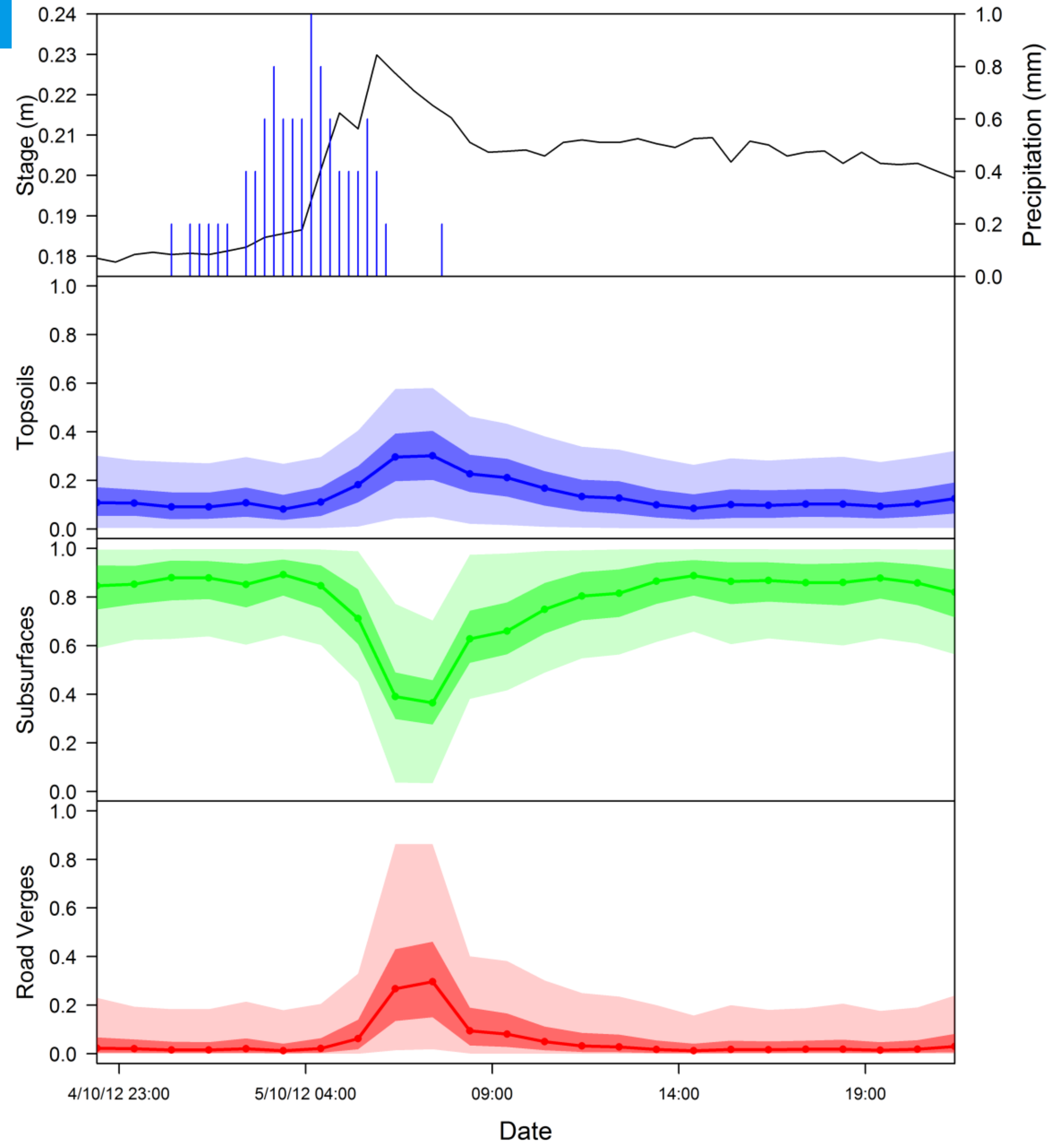


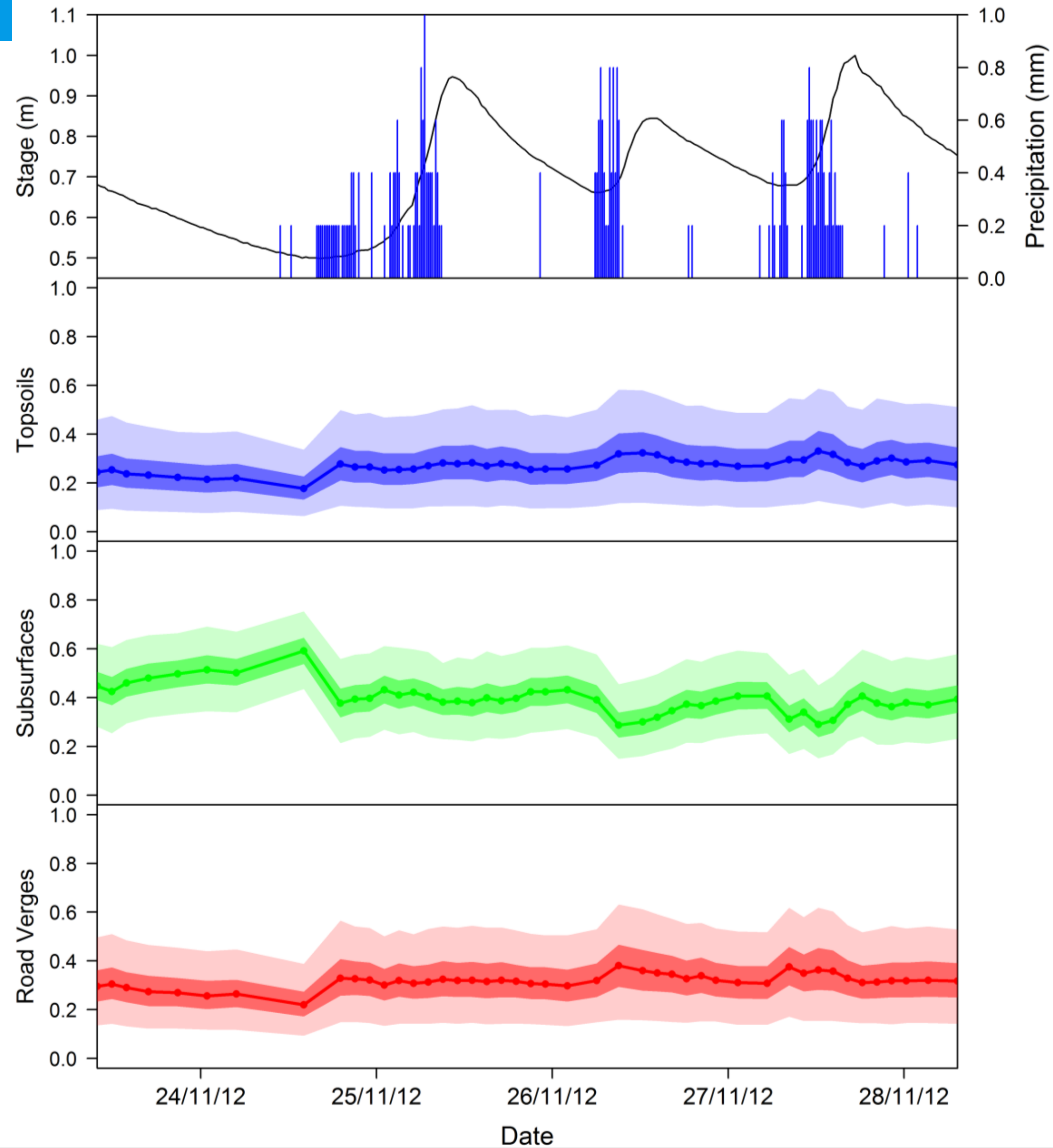
4-5th October 2012

- **10.2 mm** rainfall
- Response **2 hours** after onset of heaviest rainfall.
- **Subsurface** calcium-rich material dominates pre- & post-event.
- Rapid increase in carbonate-depleted **Topsoil** and **Road Verge** contribution as surface runoff generated.



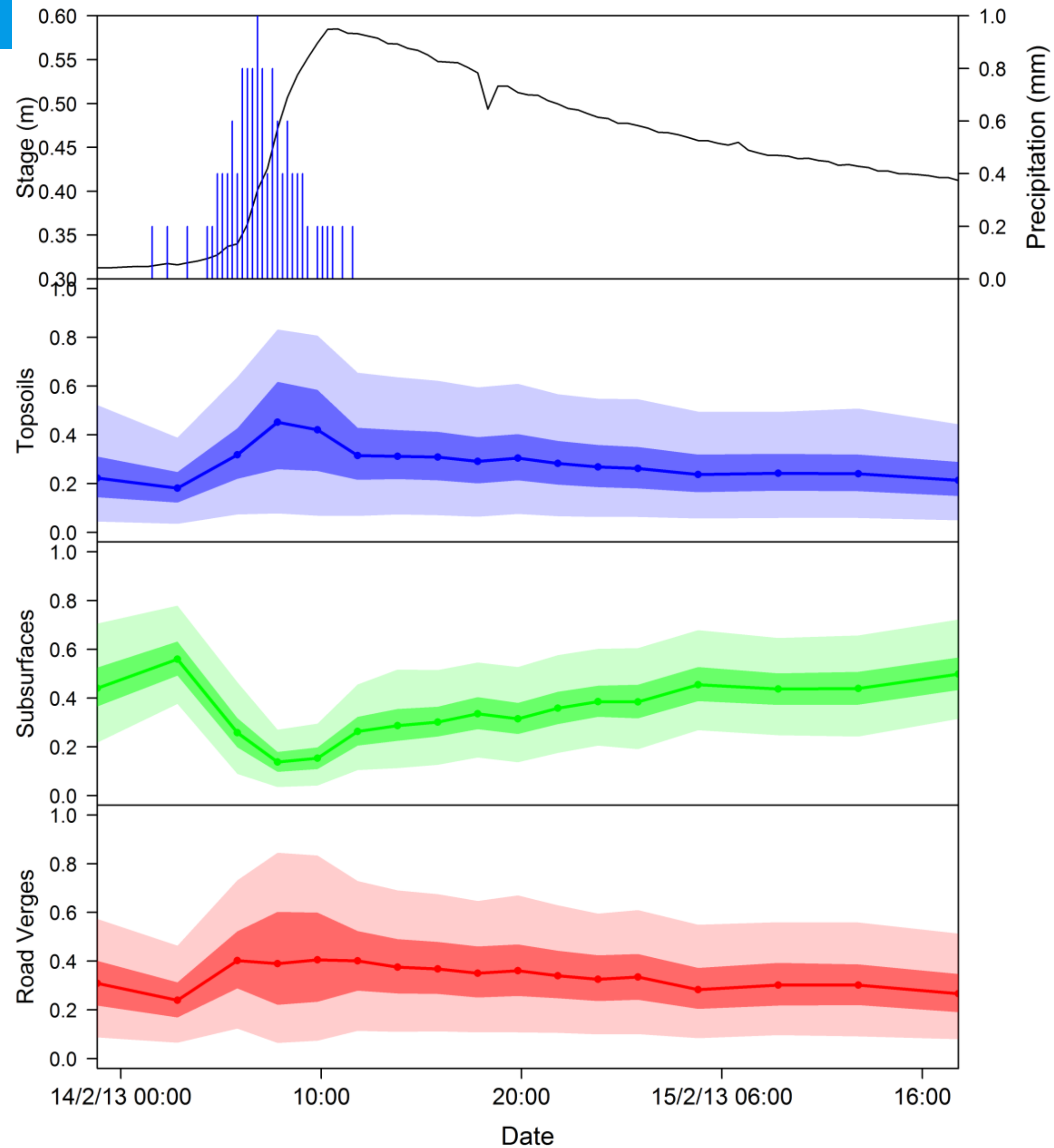
24-28th November 2012

- **36.4 mm** rainfall
- **Increase** in **Road Verge** and **Topsoil** contribution as rainfall events pass through the catchment generating surface runoff.
- **Declining** contribution from **subsurface sources** as successive precipitation episodes increase importance of surface sources.



14-15th February 2013

- **12.8 mm** rainfall
- Similar pattern to previous events.
- Large increase in **Topsoil** and **Road Verge** contribution within first few hours.
- **Subsurface sources** less important as land-to-river sediment transfer increases.



The Main Problem?

Potential Solutions?

- Roadside sediment traps

- Cover crops

- Field Entrances

Summary

- Developed **rapid**, **accurate**, **inexpensive** and **non-destructive** method for high-temporal resolution sediment source apportionment.

- Developed **Bayesian mixing model** procedure to coherently quantify all perceived uncertainties.

- **Subsurface** material dominates under lower flow pre- & post-event conditions.

- **Surface source** inputs increase during rainfall – metalled road appear to increase field-to-river connectivity.

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What's next?

Aquatic Organics

Vs

Terrestrial Organics

- $^{2}H/^{1}H$ and $^{13}C/^{12}C$ isotopic ratios of lipids; TAR of n-alkanes.
- Fractionation differences between macrophytes and terrestrial plants.
- Less negative δD in terrestrial organics due to greater transpiration?

Thank You for Listening

Wensum Alliance

UEA University of East Anglia

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