



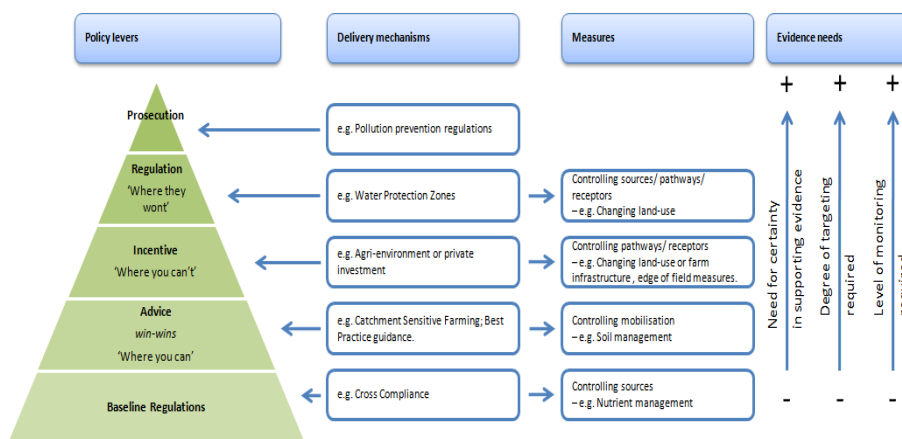
Tracing and tracking sediment sources in river catchments

Adrian Collins and Yusheng Zhang



www.adas.co.uk

Delivering the WFD



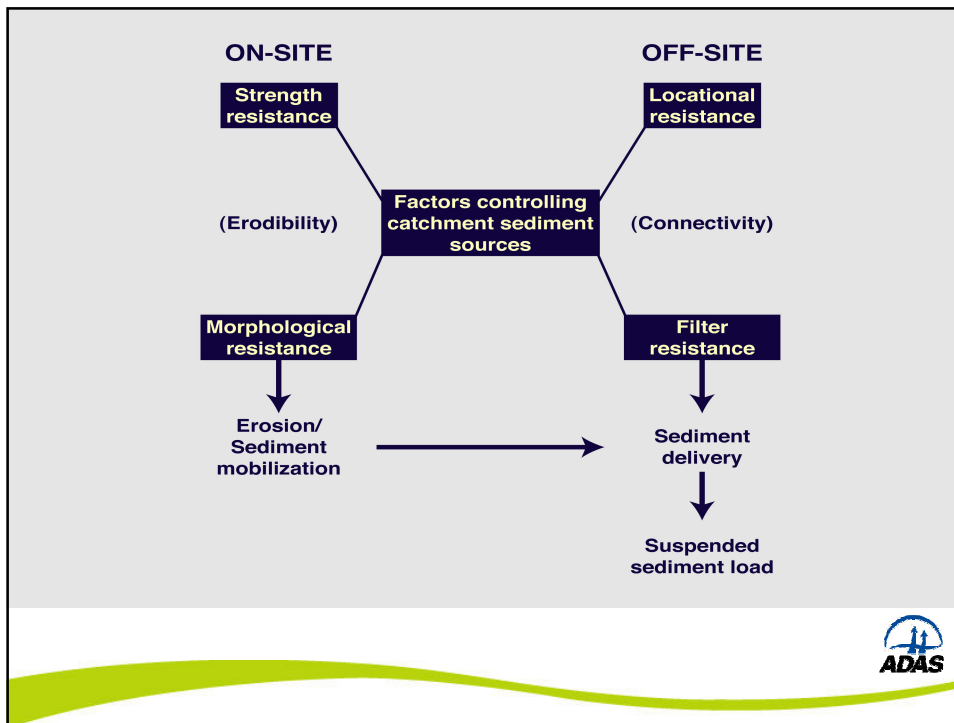
The sediment problem

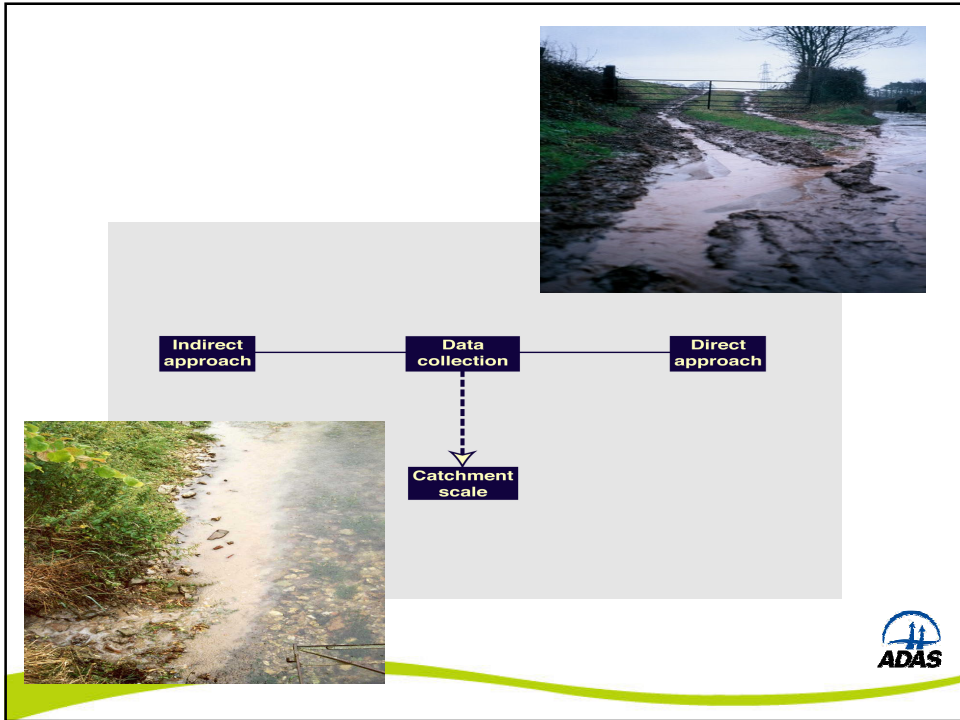
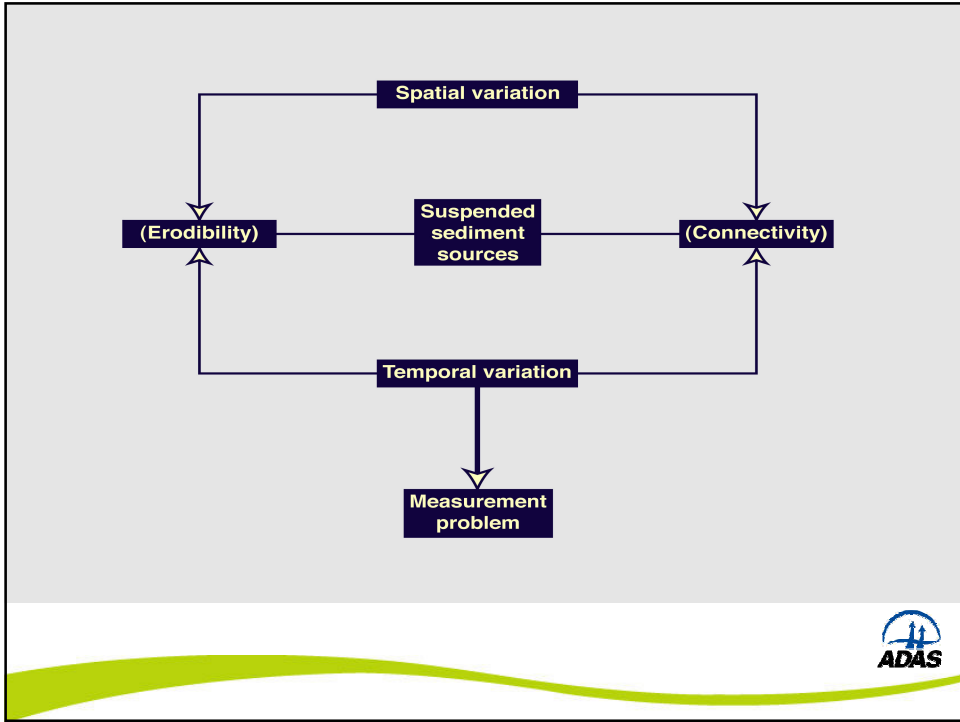
- information on sediment **SOURCES** is urgently required to target mitigation options
- information on the **EFFICACY** of mitigation options is urgently required



Understanding sediment sources







The measurement/monitoring problem

- **INDIRECT APPROACH**
 - erosion mapping
 - surveying
 - profilometers
 - erosion pins/PEEP
 - GPS
 - photogrammetry
 - erosion plots
 - bounded / unbounded

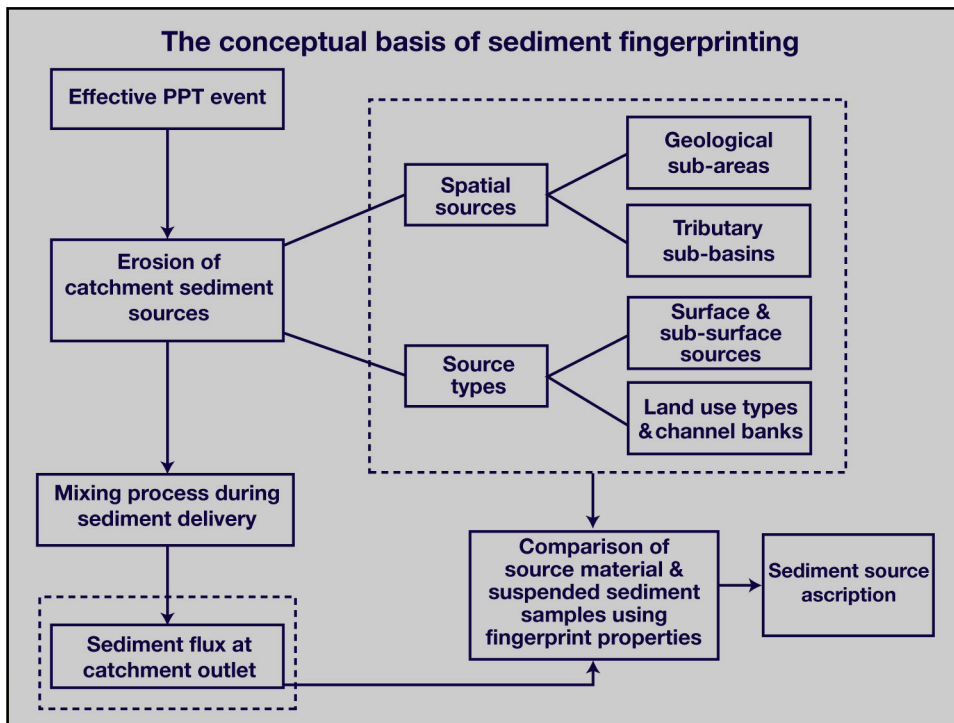


The measurement/monitoring problem

- **DIRECT APPROACH**

- **SEDIMENT TRACING**



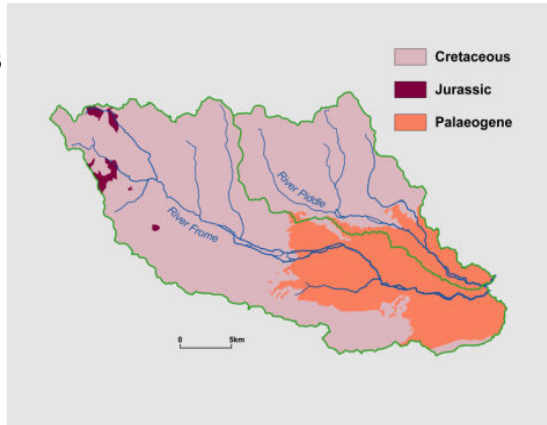


Sediment source classification



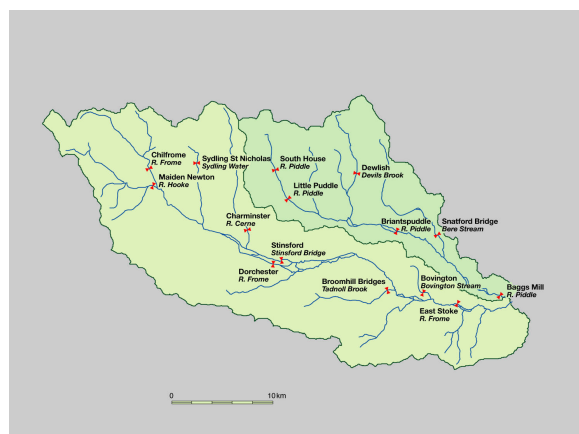
Spatial sources

- geological zones



Spatial sources

- tributary sub-catchments



Spatial sediment sourcing

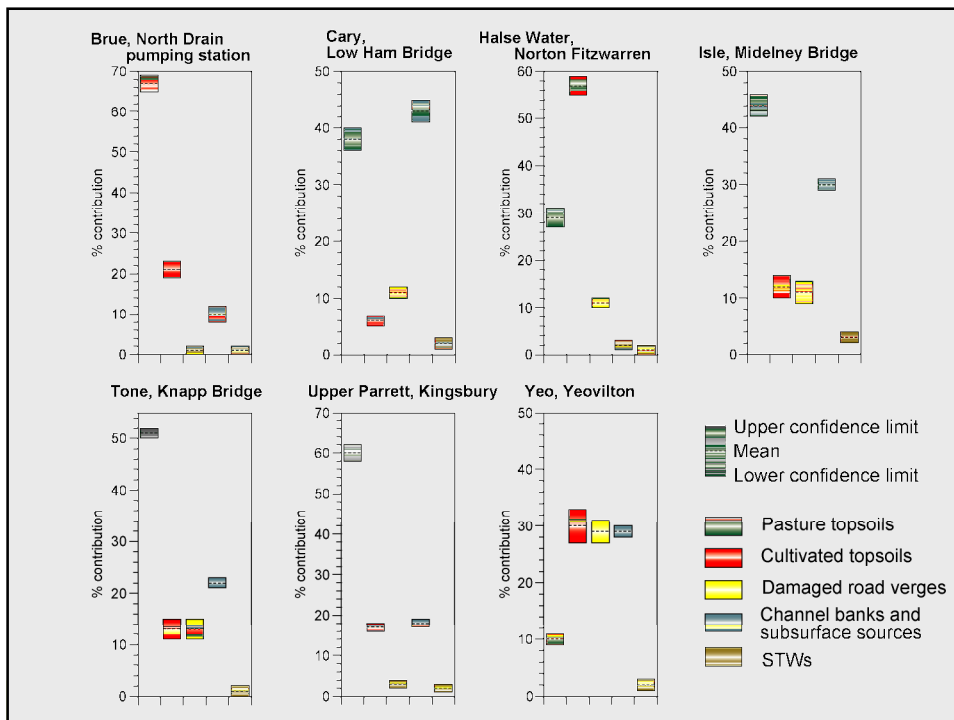
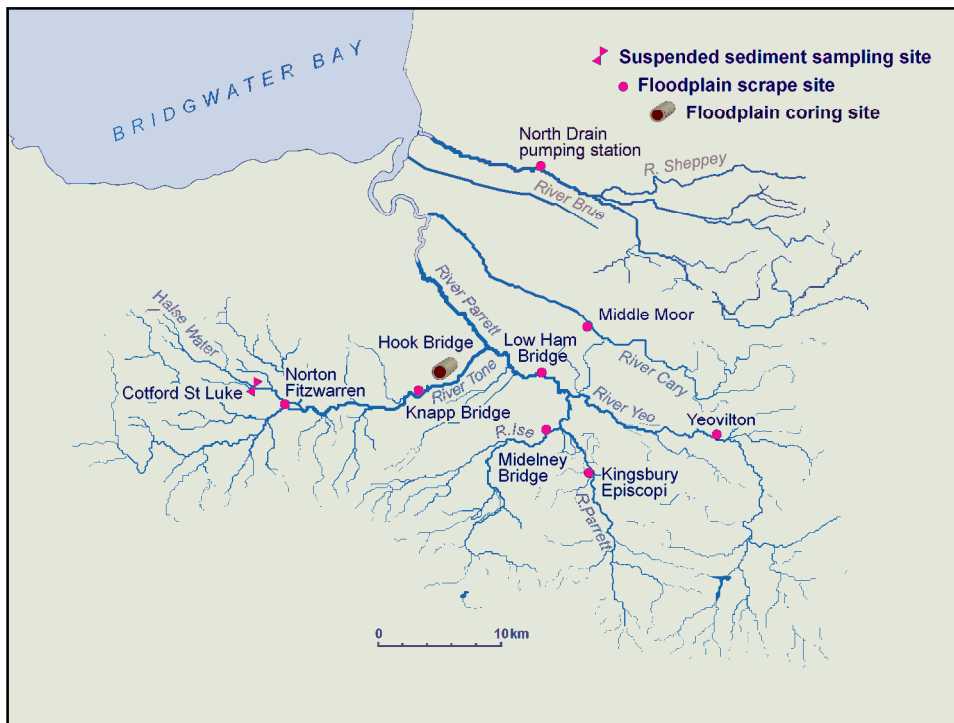
- dual-pronged sediment sampling
 - instantaneous bed sediment remobilisation
 - time-integrated sampling using retrievable baskets



Generic sediment source types

- pasture topsoils
- cultivated topsoils
- damaged road verges
- channel banks/subsurface sources
- STWs



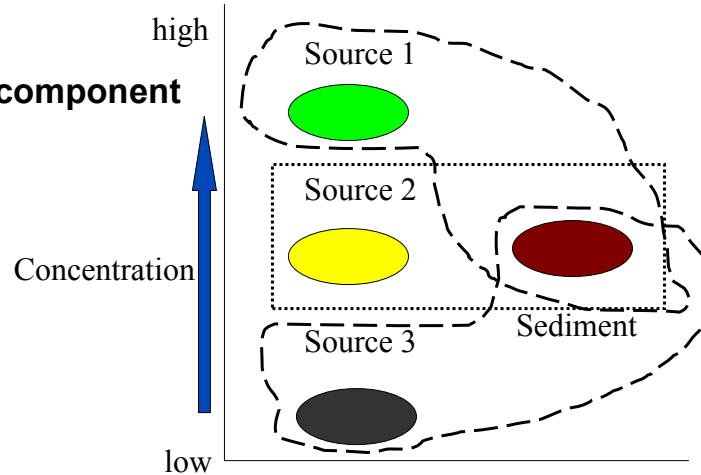


Sediment source discrimination



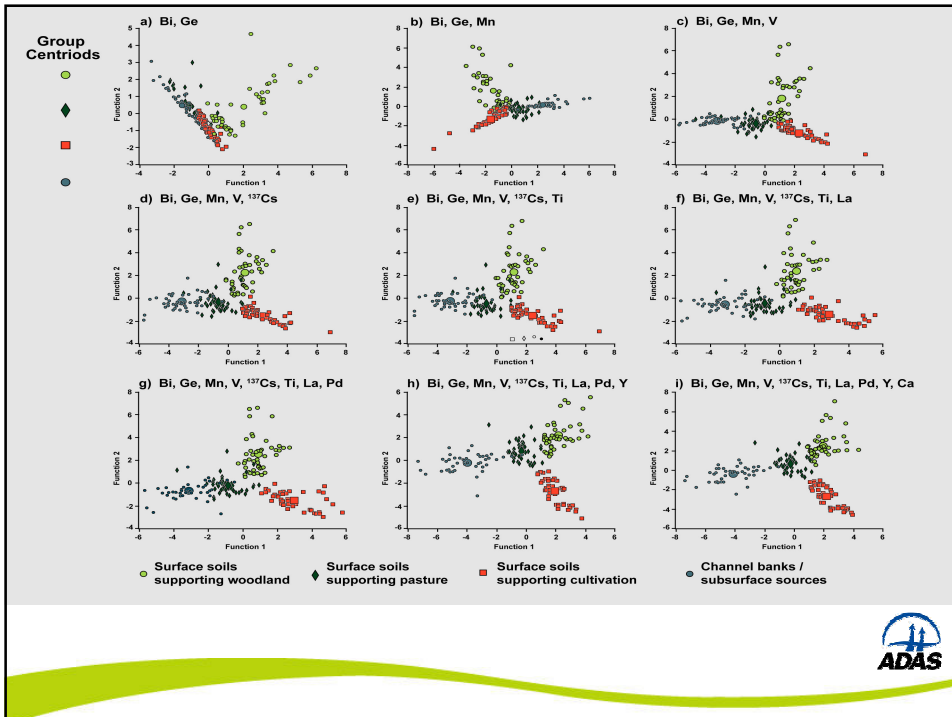
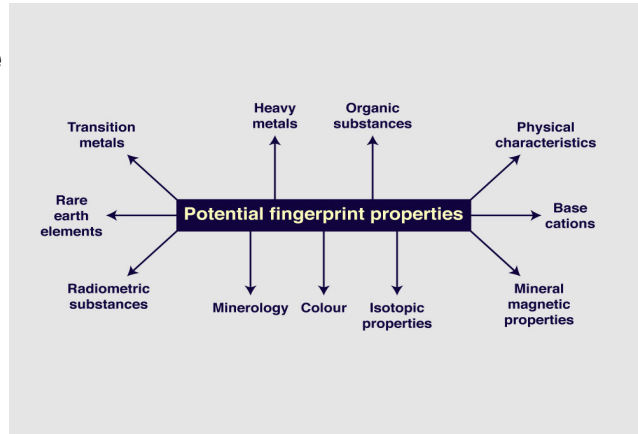
Sediment fingerprints

- **single component**



Sediment fingerprints

- composite



Sediment source apportionment



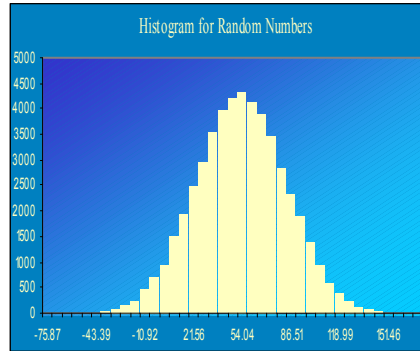
Revised numerical mass balance modelling

- **particle size selectivity**
- **organic matter selectivity**
- **within-source variation in tracer properties**
- **tracer discriminatory power**
- **prior information on bank erosion inputs**
- **uncertainty in characterising input property values for sources and sediment**
- **combination of local and global optimisation tools**



Revised uncertainty analysis

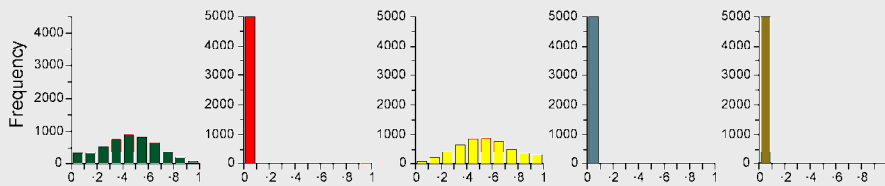
- random sampling with conventional statistics
- random sampling with robust statistics
- LHS sampling with conventional statistics
- LHS sampling with robust statistics
- pdfs for sources and sediment



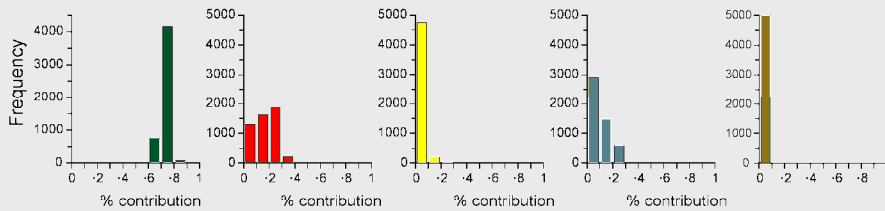
Bampton Beck

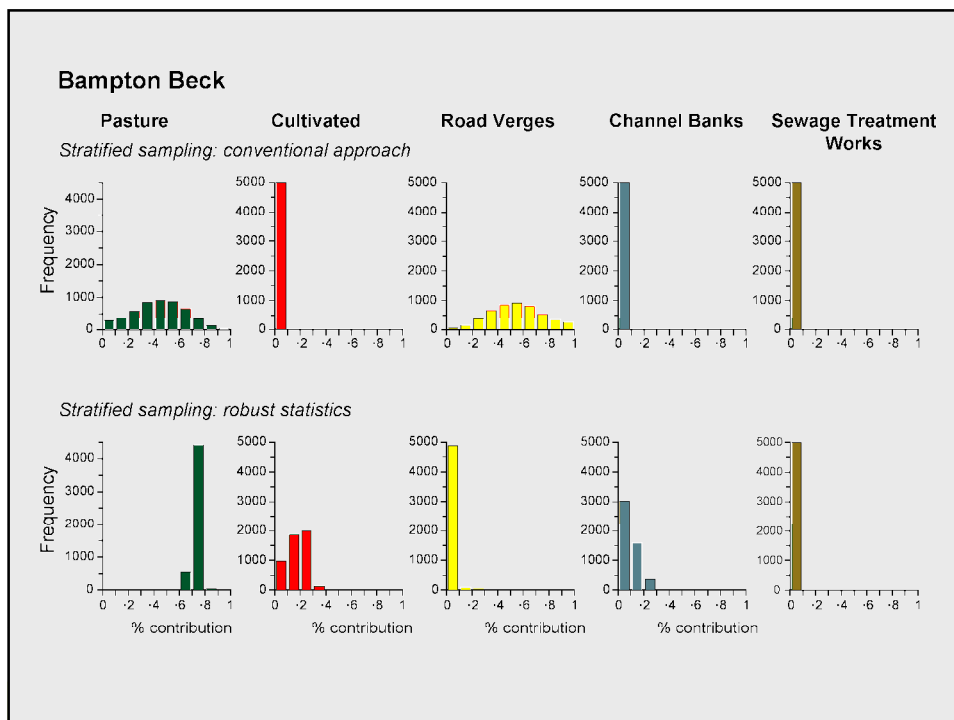
Pasture Cultivated Road Verges Channel Banks Sewage Treatment Works

Random sampling: conventional approach



Random sampling: robust statistics





Local and global optimisation

Date	Random start	Local start
29/10/02 - 19/11/02	5 out of 5000	12 out of 5000
19/11/02 - 17/12/02	1 out of 5000	4 out of 5000
17/12/02 - 7/01/03	3 out of 5000	6 out of 5000
7/01/03 - 4/02/03	6 out of 5000	6 out of 5000
4/02/03 - 11/03/03	4 out of 5000	7 out of 5000
11/03/03 - 3/07/03	2 out of 5000	7 out of 5000



Local and global optimisation

Sub-catchment	Local start	Select GA
Upper Axe	2817	Y
Temple Brook	3855	Y
River Synderford	4964	Y
Blackwater River	604	N
Kit Brook	3948	Y
River Yarty	4904	Y

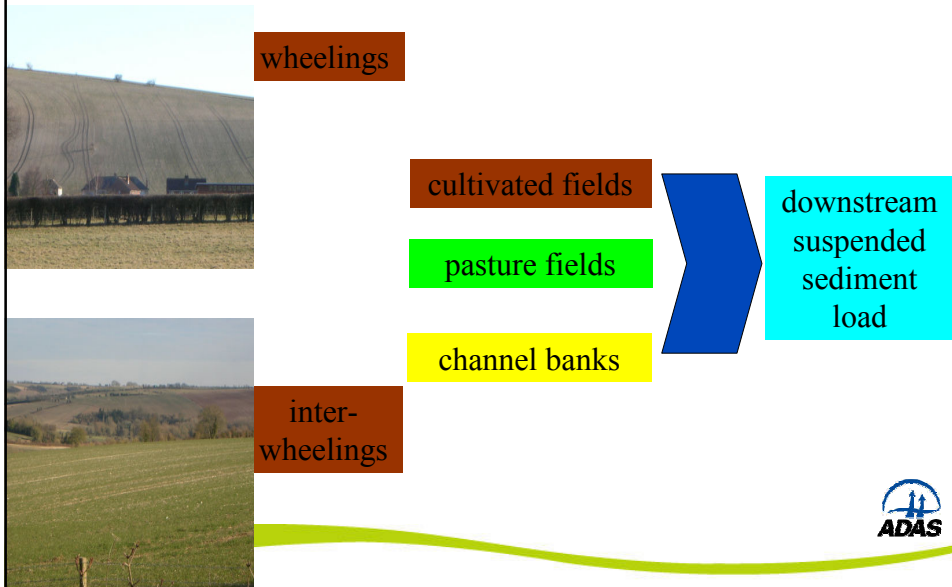


Improving the resolution of sediment source information

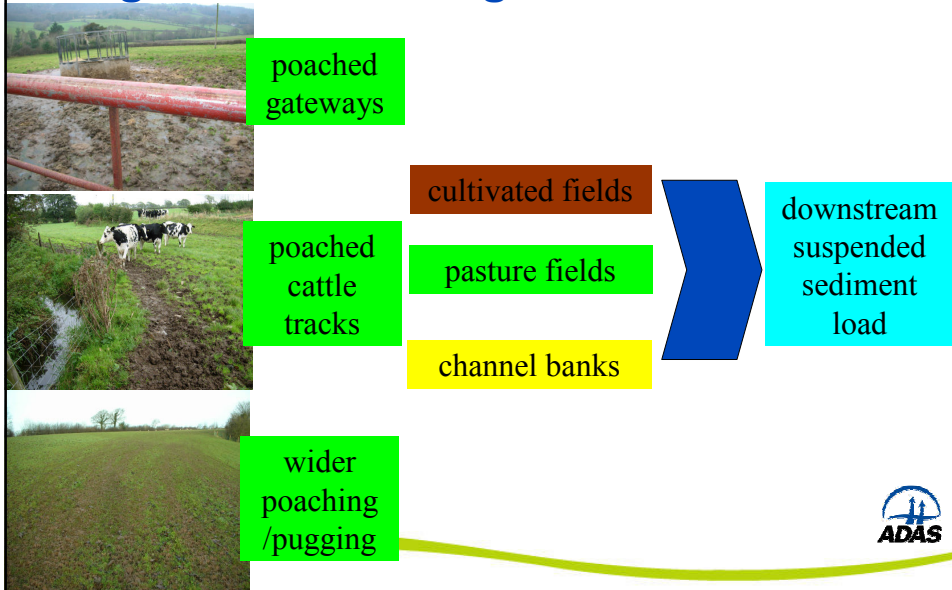
- work to date provides generic information
- e.g. % input from grassland
- need to improve the resolution to assist mitigation targeting further



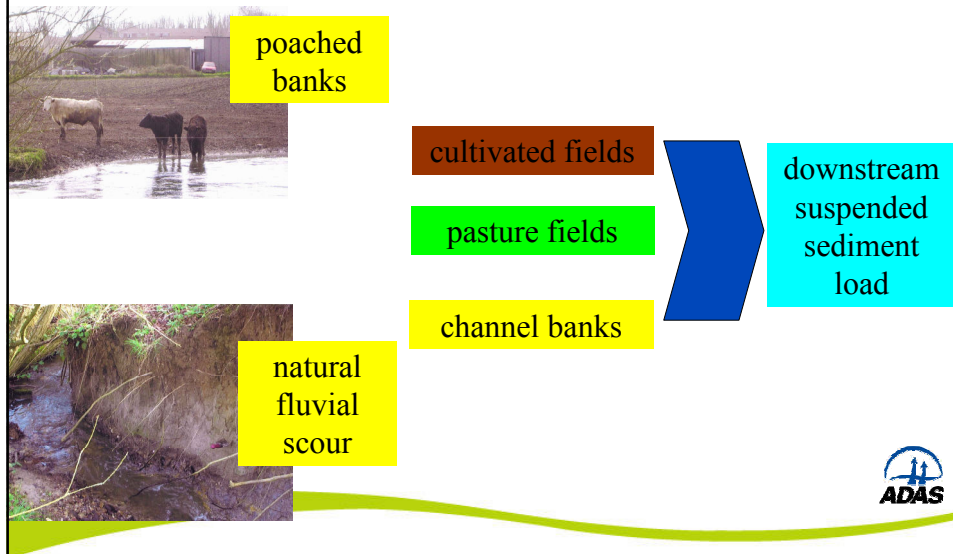
Higher resolution arable sources



Higher resolution grassland sources



Higher resolution bank sources



Coupling to CSF capital grant options

Code	Capital item	Payment per unit (£)
Fences and gates		
CSFo01	Relocation of gates (per gate)	£136.00
CSFo02	Water gates (per gate)	£120.00
CSFo03	Water course fencing	
	A: sheep netting (per m)	£1.80
	B: high tensile (per m)	£1.25
	C: post and wire (per m)	£1.20
CSFo04	Fencing for buffer strips, marshes, wet grassland, wet woodland, ponds	
	A: sheep netting (per m)	£1.80
	B: high tensile (per m)	£1.25
CSFo05	Solar powered electric fence kits for seasonal fencing (per unit)	£40.00
Water provision for grazing livestock		
CSFo06	Livestock drinking bays (per unit)	£300.00
CSFo07	Livestock drinkers and feeders with hard bases	
	A: livestock drinkers with hard base (per unit)	£85.00
	B: livestock feeders with hard base (per unit)	£120.00
CSFo08	Pasture pumps and associated pipe work (per unit)	£195.00
CSFo09	Ram pumps and associated pipe work (per unit)	£3850.00
CSFo10	Livestock troughs with associated pipe work (as an alternative to livestock drinking from watercourses) (per unit)	£85.00
Management of run-off and drainage water, dirty water and sediments		
CSFo11	Cross drains under farm tracks (per unit)	£139.00
CSFo12	Sediment ponds and traps (per m ²)	£6.00

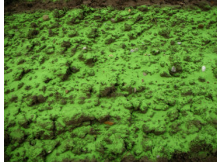
England Catchment Sensitive Farming (CSF)
Capital Grant Scheme:
Farmer Handbook (CSF 3)

www.naturalengland.org.uk

NATURAL ENGLAND

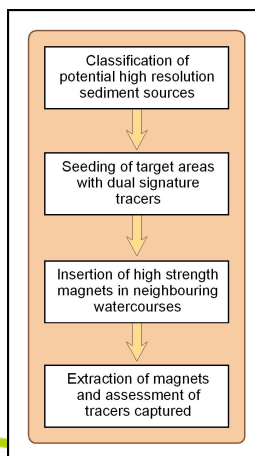
Sediment tracking

- labelling of target areas using synthetic tracers

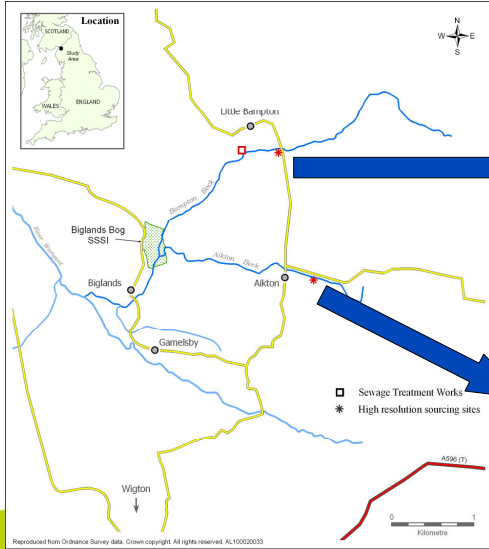


Sediment tracking

- 11,000 gauss magnets inserted in watercourses



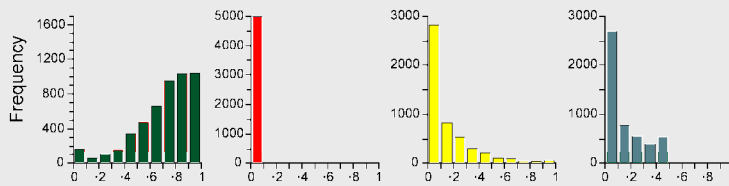
Sediment tracking



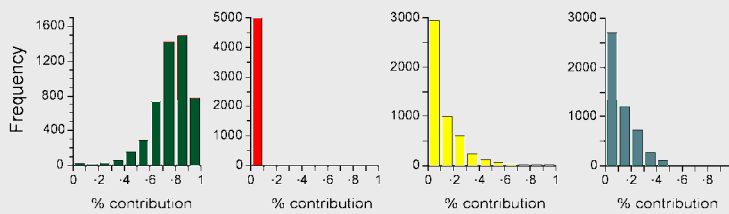
Aikton Beck

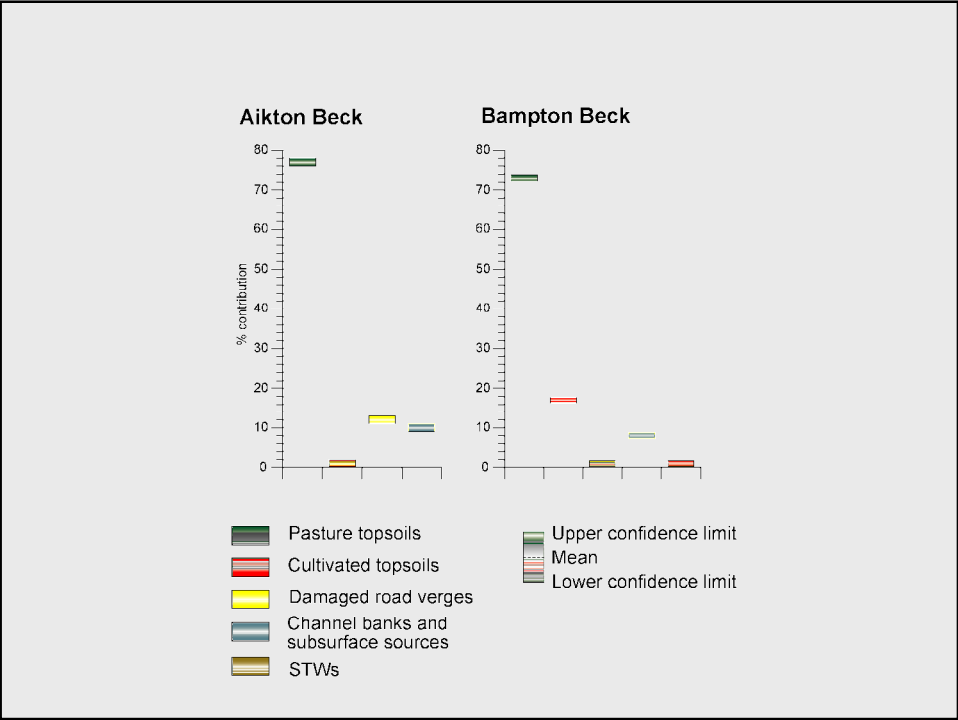
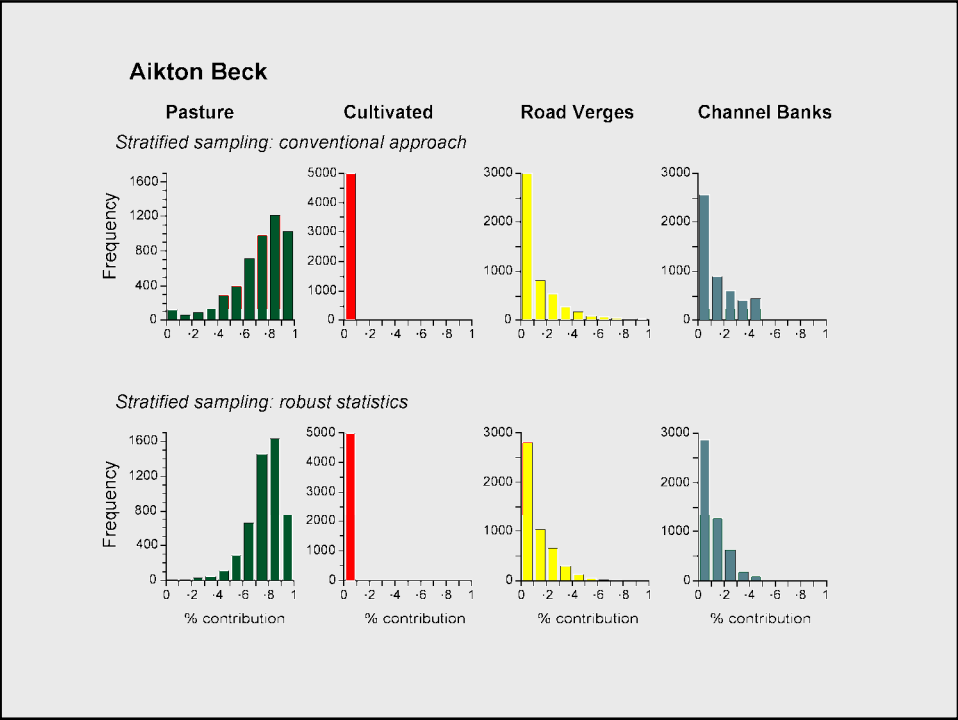
Pasture Cultivated Road Verges Channel Banks

Random sampling: conventional approach



Random sampling: robust statistics



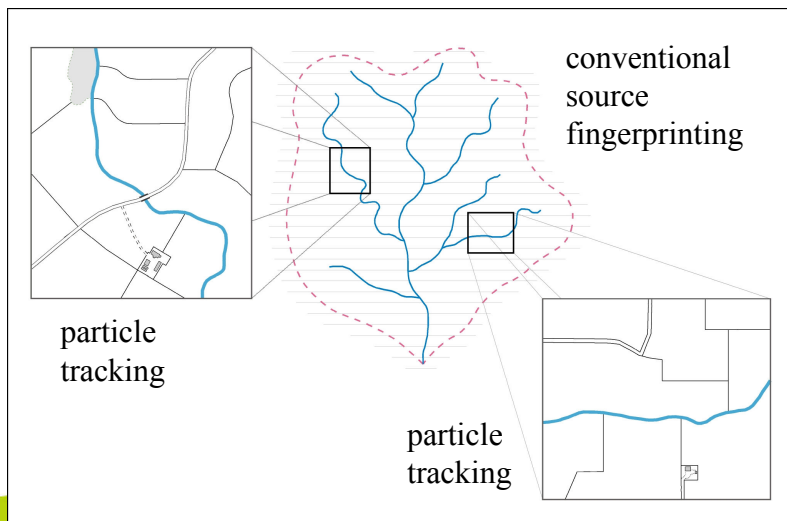


Biglands Bog: high resolution sources

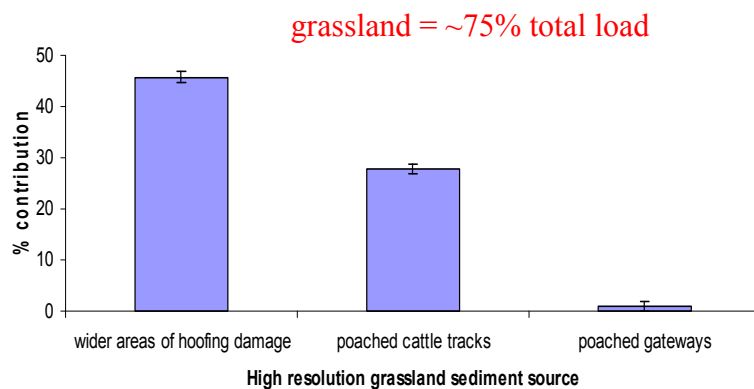
- configurations of high risk in grassland
- wider poached areas
- poached cattle tracks
- poached gateways



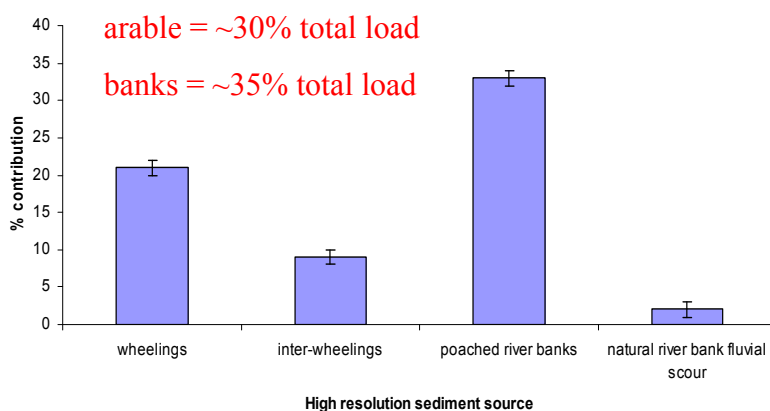
The approach



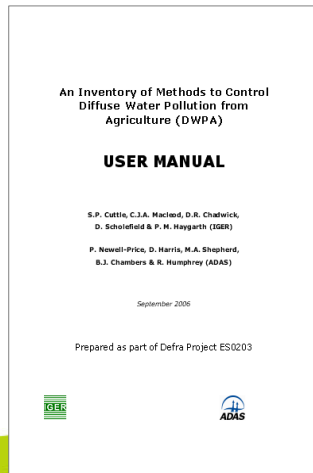
Biglands Bog: high resolution sediment sources



High resolution arable and bank sources (River Glaven, Norfolk)



Assessing the efficacy of sediment mitigation options

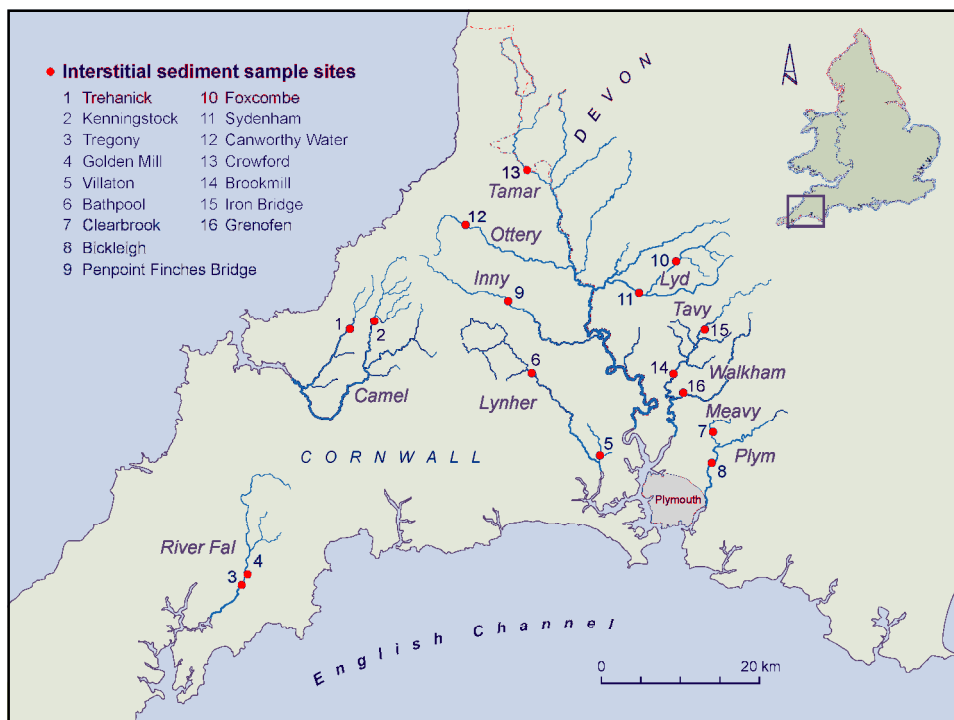


Mitigation method effectiveness

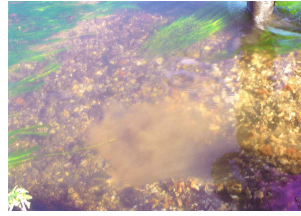
ID	Mitigation Method	Arable		Grass	
		Clay Loam	Sandy Loam	Clay Loam	Sandy Loam
1	Convert arable land to extensive grassland	30	80	-	-
2	Establish cover crops in the autumn	5	10	-	-
3	Cultivate land for crop establishment in spring, not autumn	5	10	-	-
4	Adopt minimal cultivation systems	5	-	-	-
5	Cultivate compacted tillage soils	5	5	-	-
6	Cultivate and drill across the slope	1	1	-	-
7	Leave autumn seedbeds rough	5	5	-	-
8	Avoid tramlines over winter	5	10	-	-
9	Establish in-field grass buffer strips	5	50	-	-
10	Loosen compacted soil layers in grassland fields	-	-	1	1
11	Maintain and enhance soil organic matter levels	1	5	-	-
12	Allow field drainage systems to deteriorate	1	-	1	-
13	Reduce overall stocking rates on livestock farms	-	-	10	10
14	Reduce the length of the grazing day or grazing season	-	-	5	5
15	Reduce field stocking rates when soils are wet	-	-	20	20
16	Move feed and water troughs at regular intervals	-	-	5	5
...					
39	Fence off rivers and streams from livestock	-	-	10	20
40	Construct bridges for livestock crossing rivers and streams	-	-	5	5
41	Re-site gateways away from high-risk areas	1	1	5	5
42	Establish new hedges	5	20	5	5
43	Establish riparian buffer strips	5	30	5	15
44	Establish and maintain artificial (constructed) wetlands	40	-	40	-



Efficacy of river bank fencing



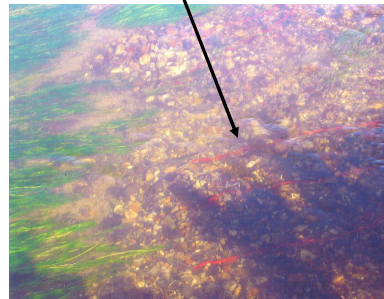
Insertion of basket samplers



Insertion of basket samplers



use of coloured string to mark inserted basket

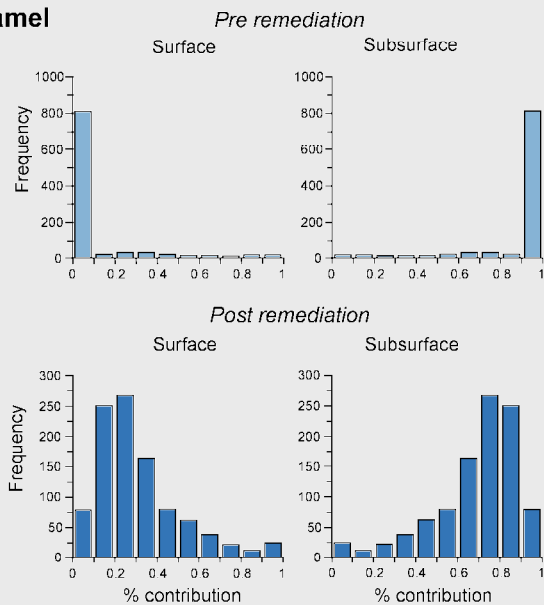


Retrieval of basket samplers

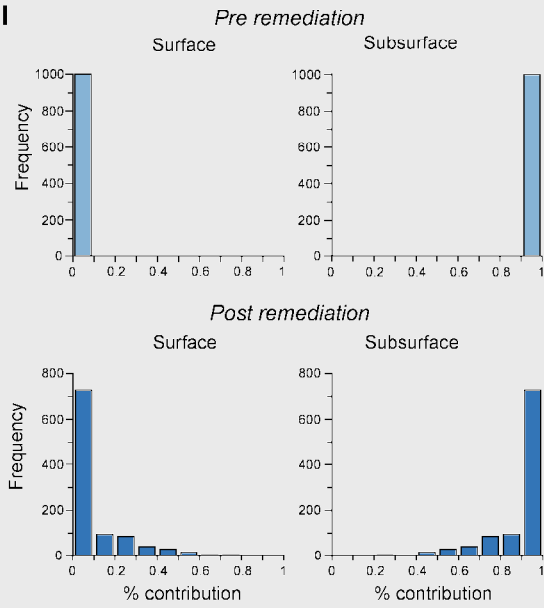
- use of outer sleeve to prevent the winnowing of fine interstitial sediment during basket removal from the river bed



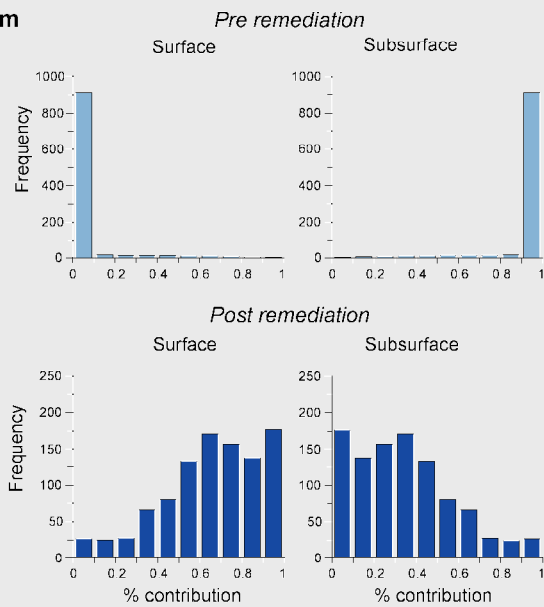
River Camel



River Fal



River Plym



Efficacy of river bank fencing


- success undermined by insertion of drinking bays



Efficacy of river bank fencing

- success undermined by poor maintenance



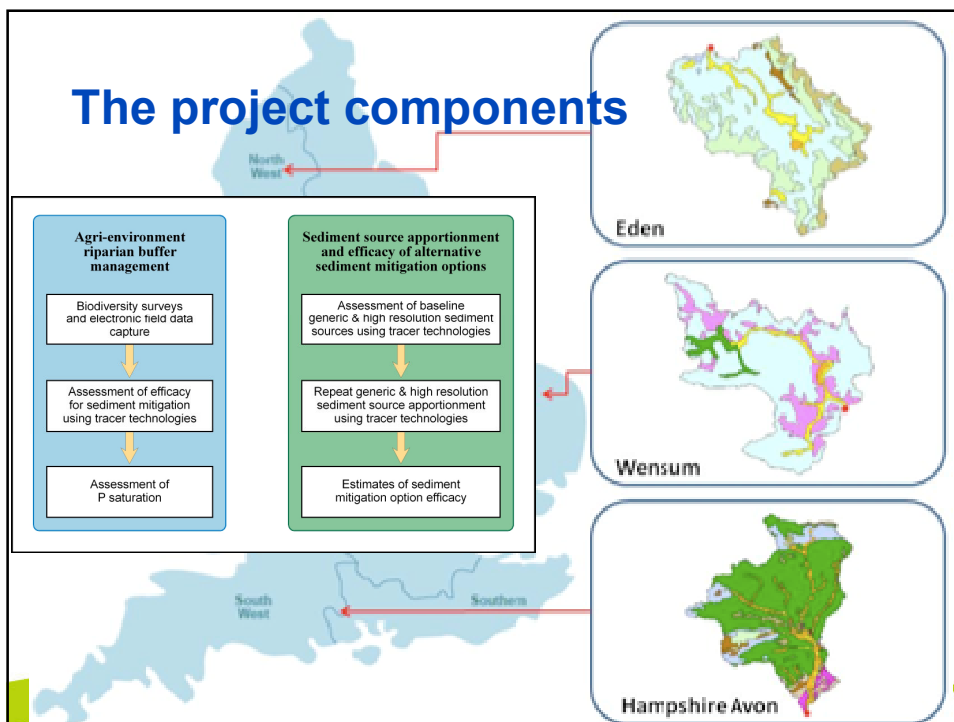


The Demonstration Test Catchment project

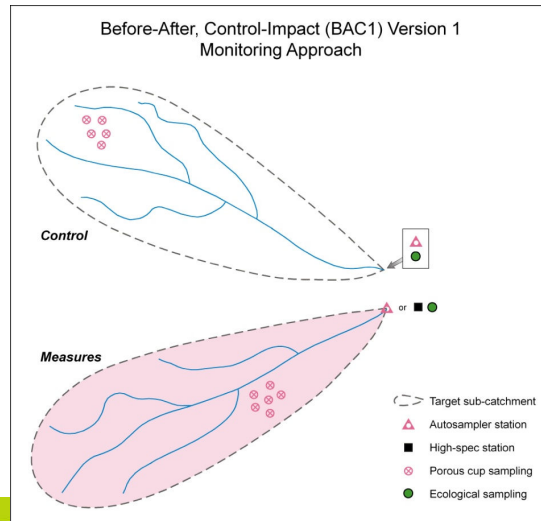
Hampshire Avon
Demonstration Test Catchment

Logos at the top: defra (Department for Environment, Food and Rural Affairs), Living With Environmental Change, Environment Agency, and Lymington Coastal Centre Water Authority Government.

Logos at the bottom: ADAS, University of Reading, University of Bristol, University of Exeter, Queen Mary University of London, Game & Wildlife Conservation Trust, Entec, Botanic Research, PRIFYSGOL ABERYSTWYTH UNIVERSITY, Kingston University London, BROOKLYNDHURST, British Geological Survey, National Environmental Research Council, University of Plymouth, NATIONAL ENVIRONMENTAL RESEARCH INSTITUTE, HR Wallingford, CER, Centre for Ecology & Hydrology, National Environment Research Council, and Geospatial.



Experimental design



Organic and inorganic sources in a single framework

- **source apportionment of organic sources using**

- fluorescence-excitation-emission-spectra (EEMS) and PARAFAC analysis
- NIR reflectance
- TC, TN, TOC analysis
- bulk stable isotopes for ^{15}N and ^{13}C



- **potential organic sediment sources**

- agriculture – slurries, manures
- damaged road verges (decaying vegetation)
- banks (decaying riparian and instream vegetation)
- point sources (STWs / septic tanks)



Mitigation options

- stream bank fencing
- improved maize management
- improved slurry storage
- improved cultivation timings
- feeder ring management



Advantages of the developing framework

applicable at a range of scales	✓
links inorganic, organic and high resolution sources to channels (not edge of field)	✓
encourages assessment of multiple sources / pollutants / configurations of risk	✓
contributor to 'weight of evidence' on catchment scale sediment sources and mitigation option efficacy	✓



