sediment matters

A practical guide to sediment and its impacts in UK rivers

Environment Agency

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contents

Sediment matters / introduction

The Sediment Matters handbook is a practical guide to understanding how, when and where sediment matters in your catchment. This can help you to identify priorities for management of sediment problems and work out where you need to know more.

'Sediment' is the mineral and organic material that is eroded, transported and deposited in catchments. Sediment has two components: fine material that can be transported by the river flow in suspension and coarser material that comprises the bedload.

Sediment matters in every catchment but not all sediment is a problem. Sediment is an important part of a healthy river system and is an essential component of many aquatic ecosystems. However, problems can arise when the amount of sediment in a river is too high or too low and is out of step with the river's natural processes. Importantly, the EU Water Framework Directive 2000/60/EC[1] requires these problems to be identified and managed in order for watercourses to meet good ecological status. Understanding sediment impacts and sources can help to work out whether sediment is a problem in your catchment.

Every catchment is unique. Sediment problems are not simple. Sediment can be a problem itself and can transport contaminants. Sediment problems can affect urban and rural areas and can arise throughout a catchment or in isolated hotspots. They can occur in a few hours during a single storm or build up gradually over many years. They can be triggered by different amounts or sizes of sediment depending on the characteristics of the river system. Our changing climate also means that these problems could increase in the future. Understanding sediment problems in your catchment can help to inform sustainable management.

Sediment problems are cross-sectoral. They can relate to a wide variety of receptors that include habitats, navigation, flood risk, water quality and amenity. The Sediment Matters approach provides an integrated understanding of sediment sources, impacts and problems based on communication and readily available data. Sediment Matters can help you to identify opportunities for management and make your next steps cost-effective.

Sediment Matters considers all sediment that could be a resource or a problem in your catchment.

[1]The European Water Framework Directive came into force in December 2000 and became part of UK law in December 2003.

Why sediment matters

Habitats

Sediment deposited on the river bed can reduce the populations of bottom-dwelling animals and can bury fish eggs. This can reduce the amount of food available to fish and can threaten their survival.

Suspended sediment can block light penetration and smother plants. This can lower the level of oxygen in water and can suffocate aquatic life. These impacts could affect the WFD status of a watercourse.

Navigation

Sediment deposition can lead to siltation of navigation channels. This in turn may require expensive dredging to maintain the passage of traffic.

Flood risk

Sediment deposition can reduce the space for water in river channels. This can increase the risk of flooding.

Sediment can clog drains and increase surface runoff and flood risk.

Water pollution

Suspended sediment can reduce light penetration and cause direct physical damage to organisms. Sediment can also carry nutrients and chemical contaminants from rural and urban surfaces. These may pollute the water and prevent a watercourse from reaching its ecological targets for the WFD, as well as impacting on the quality of the water.

Amenity

Fisheries are particularly vulnerable to sediment impacts. Salmon and trout eggs can be smothered on the river bed or coated with sediment, causing suffocation. Sediment can damage fish gills and lead to reduced growth, disease resistance and death.

Organic matter and nutrients transported with sediment can trigger excessive bacterial, fungal and algal growth. Water quality may be impacted. This may reduce the aesthetic appearance of watercourses and even have health and safety implications such as on bathing water quality.

Case study / the River Nene

Sediment Matters in the River Nene

The location

Anglian Region - Brampton and Whilton branches of the River Nene, Northamptonshire.

The issue

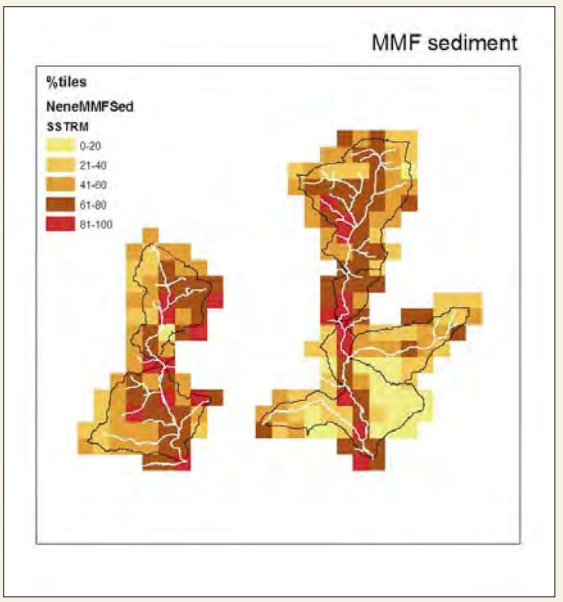
Sediment deposition could affect WFD status.

Concerns about sediment were raised by the Environment Agency Area ecologist, Chris Extence in 2008. The macro-invertebrate data appeared to suggest a change in species composition that could be linked to an increase in sedimentation of the river channels, possibly with contaminated sediment.

The approach

The Sediment Matters handbook was used as a first step to investigate the sediment impacts and sources in the catchment in order to understand the sediment problems.

Communication was the key to a successful investigation. Environment Agency area staff from a range of functions were consulted in order to develop a cross-sectoral understanding of sediment dynamics and sediment impacts. External consultees included dredging contractors.



Modelling outputs can help to identify where sediment comes from

Desk-study was used to get a good background understanding of the catchment. The Environment Agency Easinet, General Quality Analysis data and readily available publications such as the River Basin Management Plans (RBMPs) and Catchment Flood Management Plans (CFMPs) all proved helpful.

Wet-weather reconnaissance was undertaken to work out where sediment was coming from and to identify its pathways to the river channel.

'...on the basis of the initial Nene work, we saw great potential in the approach and went on to successfully apply the methodology on the Welland...'

Dr Chris Extence

Case study / the River Nene

Rill erosion on waterlogged soil transfers sediment from the field to the river

Sediment matters

The integrated approach helped to explain sediment matters in the Nene catchment.

Dredging for flood risk management and amenity was found to be an expensive problem in the lower reaches of the catchment.

Fine sediment deposition was linked to impacts on invertebrate populations at a number of sites throughout the catchment using a technique that looks at the Proportion of Silt Sensitive Invertebrates (PSI). Further analysis to confirm this link was recommended.

Catchment land use was identified as the main factor influencing sediment supply, with erosion of vulnerable soils in wet weather occurring all year round. Although the catchment has gentle slopes, linkage between the field and river is high.

Improved land use management to control sediment problems at source and reduce the need for dredging was recommended as a solution.

Next steps

The team saw great potential in the Sediment Matters approach and went on to apply it to the River Welland.

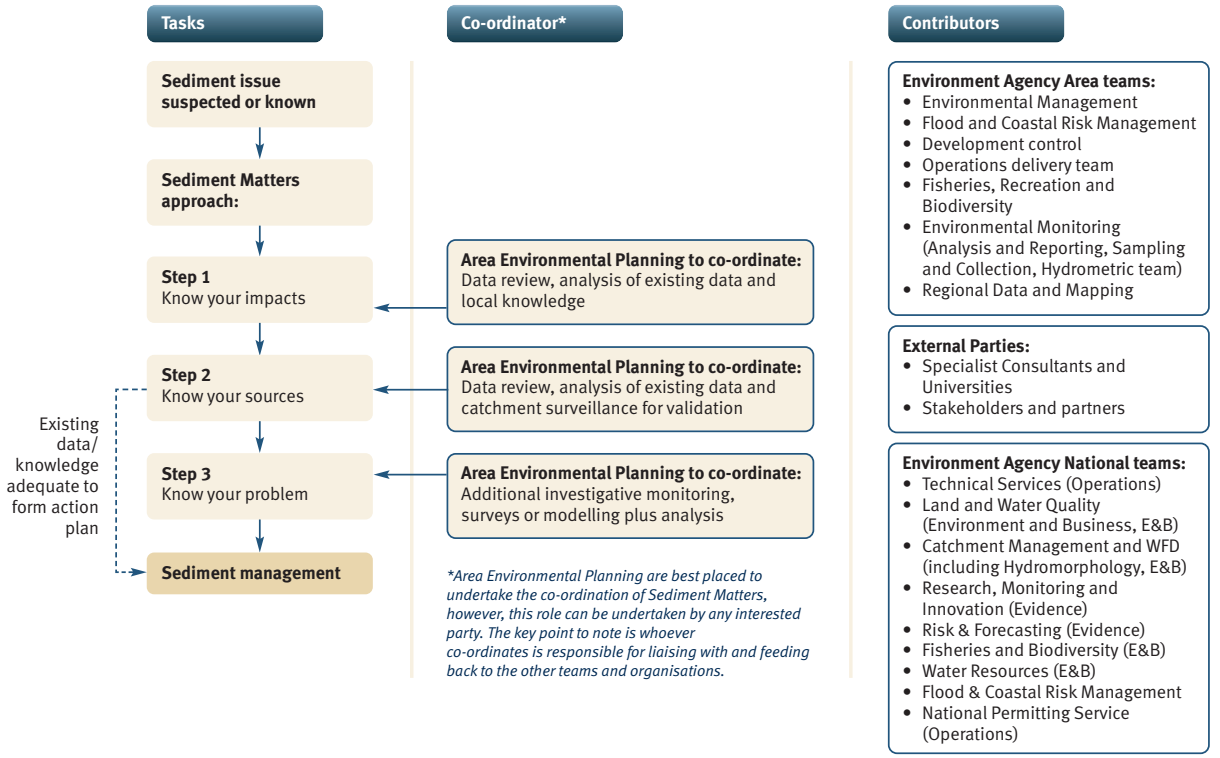
How to use this handbook

The Sediment Matters handbook is designed for non-experts who need to understand how sediment matters in their catchment or for more experienced specialists to use as a quick reference guide.

It can be used by people from a range of backgrounds and assumes no specialist knowledge of sediment or catchment processes. The handbook refers to specific data and information sources that are readily available within the Environment Agency and indicates the appropriate team to speak to for further information. Some information held by other organisations is also identified where this is not available within the Environment Agency.

The handbook is primarily designed for use by Environment Agency staff. External audiences can access many data sources via the internet. Alternatively, requests for data can be made via the National Customer Contact Centre at *enquiries@environment-agency.gov.uk* There may be a minimal charge to cover the resource required to supply data.

The diagram below is intended to show how different Environment Agency teams might be able to contribute.

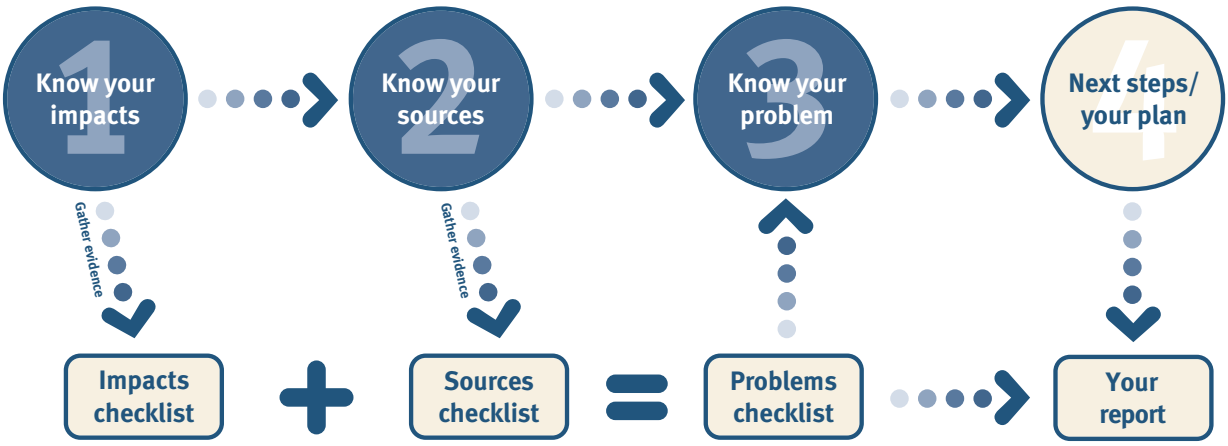


Remember

- Sediment matters in every catchment but not all sediment is a problem
- Communicate - ask your colleagues how sediment matters to their function
- Use the resource CD to record your findings on the blank document and fill in the checklists
- Feed back your findings to make management happen

How to use this handbook

There are three steps to understanding how sediment matters in your catchment.



Step 1: Use Section 1 to identify sediment impacts in your catchment

- Gather information relating to a range of receptors by using the support in the 'your catchment' boxes. Communication with a range of staff is key.

Step 2: Use Section 2 to identify sediment sources in your catchment

- Find out about the physical characteristics of your catchment and use wet weather field survey to find out where sediment comes from and how it reaches the river channel.

Step 3: Use Section 3 to link sediment impacts with sediment sources to understand sediment problems in your catchment and work out where you need to know more

- Use your findings to work out how sediment matters in your catchment. Use the inventory of monitoring techniques to see how to fill your data gaps.

Step 4: Use your findings from Sections 1 to 3 to identify and plan opportunities formanagement and monitoring

- Communicate your findings to raise awareness of sediment matters in your catchment and influence next steps for integrated management.
- Log your findings in the blank sediment handbook on the resource CD.

Sediment Matters is flexible. Use this step-by-step approach to identify and plan next steps for managing and monitoring sediment in your catchment. Alternatively, you can use the handbook on an *ad hoc* basis as an information resource.

The approach is based on gathering readily available data from on line sources, field evidence and discussion with colleagues. Communication with staff from a range of functions to develop an integrated picture of sediment impacts and sources is important.

Not all of the data and information identified in the handbook will be relevant for all catchments. Only spend time collating harder to find information if it is necessary to improve understanding or confidence.

Know your impacts

Sediment impacts in your catchment

Know your impacts / introduction

Ranunculus (water crowfoot) important fish and aquatic invertebrate habitat and can be an indicator of sediment issues

Image courtesy of the River Restoration Centre

Know your impacts / introduction

Find out about the sediment impacts in your catchment. This will give you an overall understanding of sediment issues and identify how sediment might be affecting specific receptors.

You are here

Use this section to understand sediment impacts in your catchment

- First, find out about the overall sediment issues in your catchment. This will help you to understand the broad concerns that relate to sediment in your catchment.
- Next, find out what the indicators of specific sediment impacts are in your catchment. These could relate to habitats, navigation, flood risk, water resources, recreation and water quality. Try to find out where and when the impacts occur.

Use the 'Your Catchment' boxes to guide your investigation

- These will show you what to find out, where to look for information and who to talk to.

Use the questionnaire to help you to record information

- Talking to colleagues from different teams is the best place to start. You can record your information on copies of the questionnaire. The questionnaire can be found on the accompanying resource CD.

Complete the Impacts Checklist to summarise your findings

- The purpose of the checklist is to ensure that all the possible impacts of sediment in your catchment have been considered. You will need this to work out your sediment problem in Part 3. The checklist can be found on the accompanying resource CD.

Go to Part 2 to find out about sediment sources in your catchment

Know your impacts / introduction

Remember, all catchments are unique. Evidence of a sediment-related impact does not necessarily mean that sediment is the only issue – river systems are complex and different factors often work together.

Remember, sediment impacts may relate to more than one receptor and may be conflicting. For example, sediment deposition may benefit some species but compromise flood risk management downstream.

Remember, sediment is part of a healthy river system. Sediment matters in your catchment whether there is evidence of a sediment-related impact or not.

Section 1 helps you to understand sediment impacts in your catchment by looking at possible sediment-related issues for a range of key receptors.

Overall impacts help to provide an indication of the potential level of sediment-related concerns within the context of your catchment as a whole.

Habitat impacts include a range of ecological receptors for which sediment could be a problem. These may be linked to indicators for the Water Framework Directive.

Navigation impacts may relate to restricted boat passage due to sediment deposition – or to costly dredging to maintain navigable waterways.

Flood risk impacts can link to sediment deposition and reduced standards of service in engineered channels or urban drainage networks. There may be a need to dredge and clear gulley pots for maintenance. Flood events require costly clean up, repair and insurance claims.

Water resources impacts may include outages due to high suspended sediment concentrations and sediment deposition can reduce availability of water stored for supply.

Water quality can be affected by sediment. Sediment can be a contaminant itself and can also carry nutrient and chemical contaminants. Poor water quality can be linked to habitat and recreation impacts.

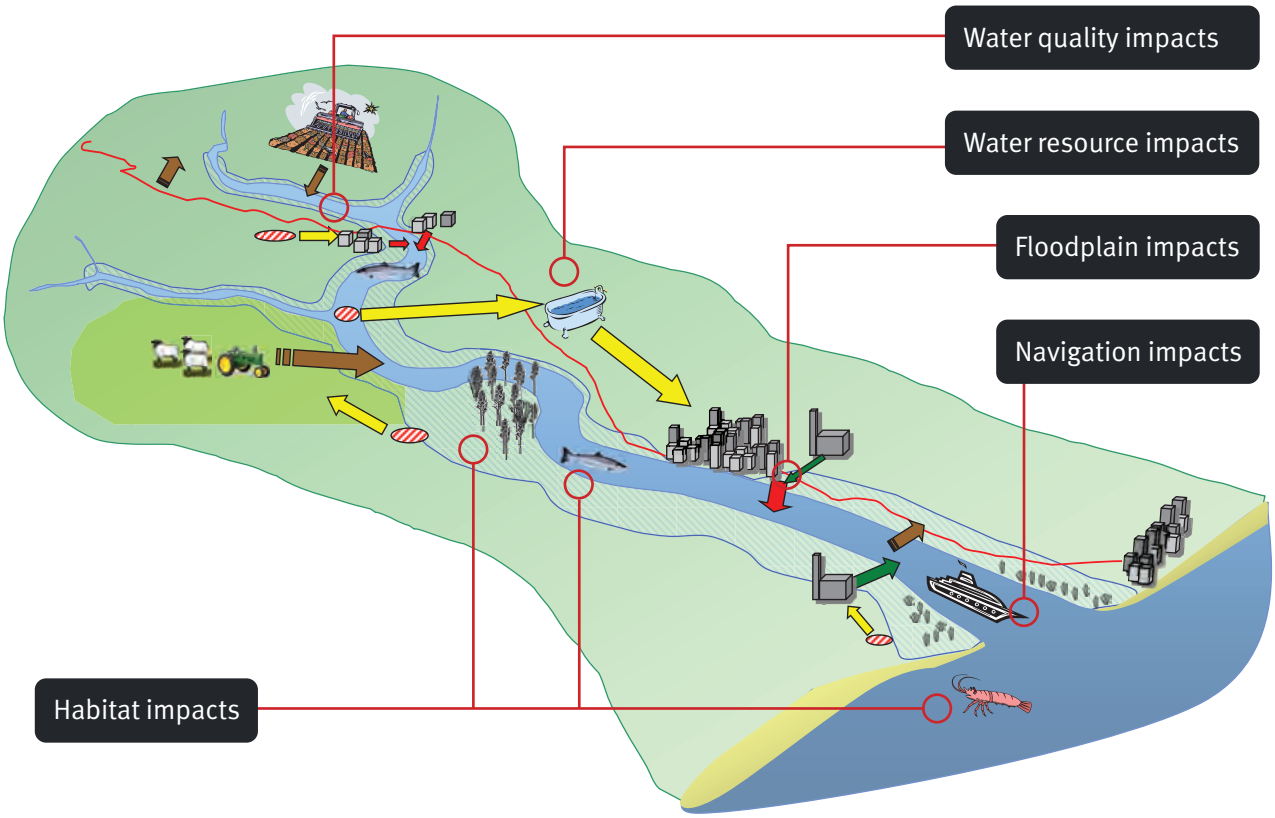
Recreation issues link to amenity use of the river. For example, angling, canoeing and bathing may be affected if water quality is poor.

Agriculture impacts: accelerated soil erosion from farm land can lead to loss of top soil containing nutrients, seeds and soil microbes (bacteria, fungi etc) and macrofauna (e.g. worms and springtails). This is a significant financial and resource loss to the land owner.

Data relating to sediment impacts can come from a range of sources. It may be anecdotal and qualitative or it may be based on quantitative monitoring.

By collecting data from a range of sources about a range of receptors, you will be able to build up a weight of evidence of sediment concerns that is multi-sectoral and catchment-wide.

Know your impacts / introduction



Sediment impacts

Overall potential for impacts

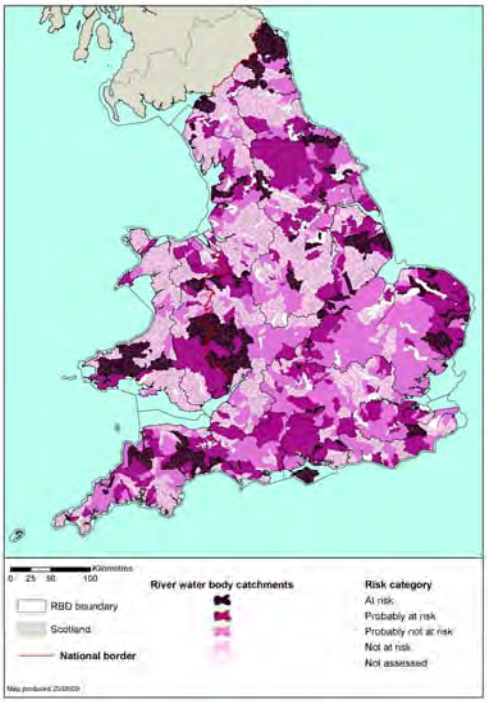
What is the overall sediment risk?

River Basin Management Plans have been developed for the Water Framework Directive. Each River Basin District (RBD) has a River Basin Management Plan (RBMP) that identifies the risks and pressures within the catchment. A key role of the plan is to identify where and why catchments are at risk of not achieving their ecological targets under the Water Framework Directive.

By looking at the RBMP that relates to your catchment you should get an overall idea of key risks and pressures and historic issues.

Risks relating to sediment from diffuse sources are presented on a map for each RBD.

Look at the map for your catchment – this will give you an overall idea of the likely scale of concerns relating to sediment in your catchment and a context for understanding your sediment matters.



The map shown is a generic map and may need validation with local evidence

Your Catchment

Find out

- The overall Water Framework Directive assessment of sediment risk in your catchment.

Look at

- The River Basin Management Plan for your area and in particular the risk map for sediment. You can find the sediment risk map in 'Annex G: Pressures and Risks' of the plan.
- MapExplorer. The pathway is *Idrive, National, EU Directives, Water_Framework_Directive, WFD river catchments.shp*.

Speak to

- Your regional river basin district programme manager.
- The National Risk and Forecasting team.
- Area Environmental Planning team.

Overall potential for impacts

Sediment-related concerns about protected species or designated areas?

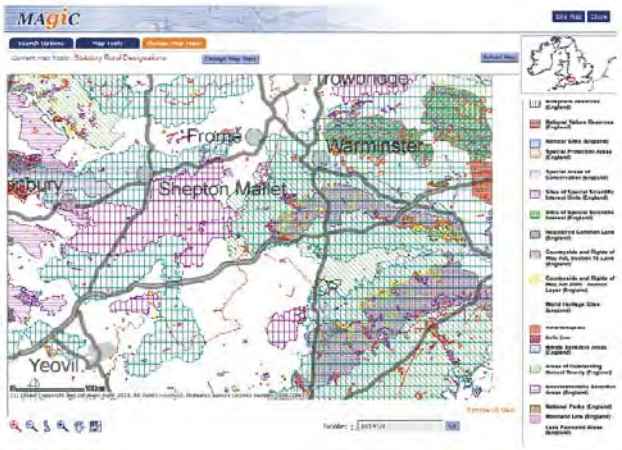
Knowing whether there are designated areas or species in your catchment can help to give you an idea of sediment issues in your catchment.

Sediment issues may have already been recognised as a problem for some species or areas. Monitoring and management measures may be in place.

Alternatively, knowing whether designated species or habitats sensitive to sediment are present can help to establish whether your catchment could be vulnerable to sediment-related pressures.

Use the Environment Agency's Easimap for information on National Permitting, including sites of high priority for nature conservation and layers showing Protected species.

Use the NetRegs, Joint Nature Conservation Committee (JNCC) and Natural England (NE)/Countryside Council for Wales (CCW) websites to find out more about designated areas and protected species and any links to sediment identified.



From magic.gov.uk – layer Rural Designations - statutory

Your Catchment

Find out

- Designated areas of nature conservation importance within your catchment.
- Whether there are any UK Biodiversity Action Plan priority species or habitats.
- Whether any of the designated areas have any links to sediment.
- Whether any investigations have been undertaken to understand sediment on the designated sites.

Look at

- Easimap National Permitting: 'Priority species and habitats' layer and 'Designations' layer.
- *www.magic.gov.uk* (rural designations – statutory layer).
- NetRegs, JNCC, NE or CCW websites for further information on individual designated sites.
- National Biodiversity Network (NBN).

Speak to

- Environment Agency Area teams - Fisheries, Recreation and Biodiversity; and Analysis and Reporting.
- Other groups such as NE/CCW, JNCC.

Overall potential for impacts

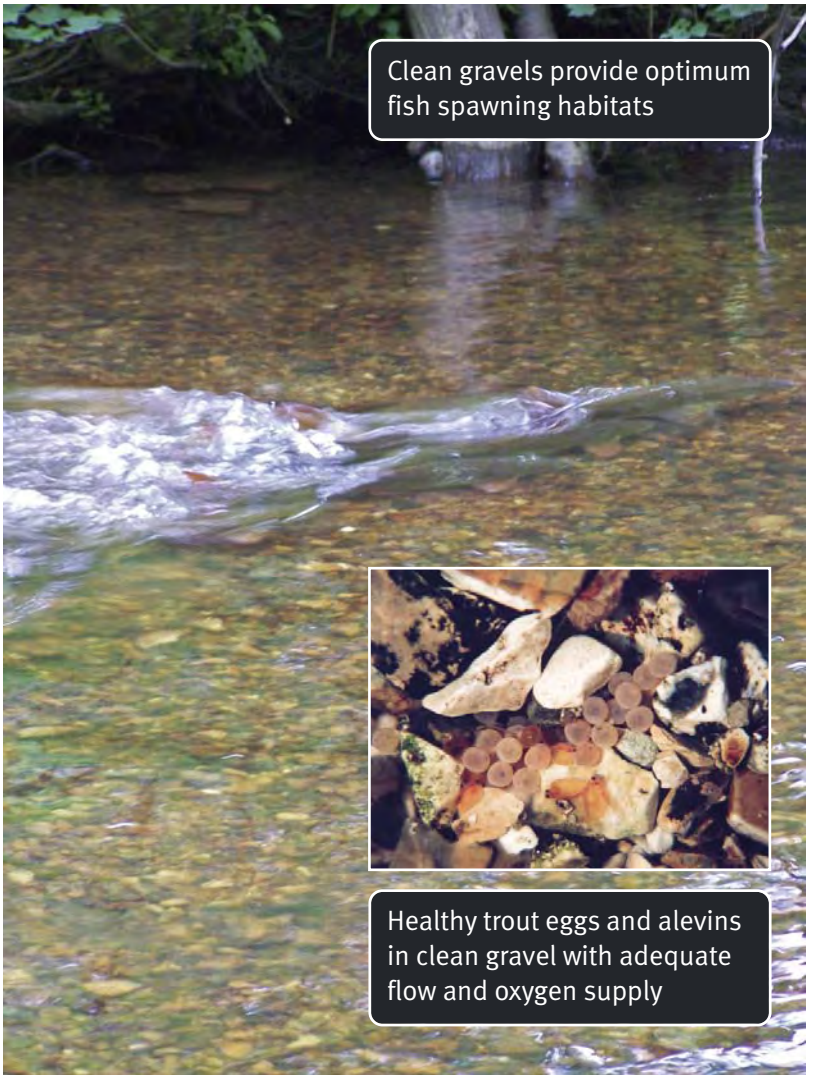
Freshwater Fish Directive?

The EC Freshwater Fish Directive (2006/44/EC) seeks to protect freshwater bodies that can sustain fish populations. For these waters, it sets physical and chemical water quality targets for salmonid waters and cyprinid waters.

The Directive gives a guideline standard of an annual average of 25 mg/l for suspended solids to prevent chronic damage to fish gills.

Compliance with the Directive will give an initial indication of a sediment-related problem in your catchment. Look on the Environment Agency or Department for Environment, Food and Rural Affairs (Defra) websites to see if your catchment is designated.

Use the Environment Agency's Map Explorer to get an idea of compliance in your catchment. The pathway is i drive, Local, EU_Directives, freshwater_fish.



Clean gravels provide optimum fish spawning habitats

Healthy trout eggs and alevins in clean gravel with adequate flow and oxygen supply

Your Catchment

Find out

- Whether your catchment is designated under the Freshwater Fish Directive.
- Whether the catchment is compliant with the Directive.

Look at

- MapExplorer. The pathway is *i drive, Local, EU_Directives, freshwater_fish*.

Speak to

- Environment Agency Area teams - Fisheries, Recreation and Biodiversity; and Analysis and Reporting.

Habitats / spawning gravels

Are your gravels smothered?

Sediment deposited on spawning gravels known as redds can smother and suffocate salmonid eggs such as those of salmon and trout.

Silt build-up can affect juvenile fish mobility, growth and their resistance to disease.

Deposition can also reduce the populations of bottom-dwelling animals such as macro-invertebrates and protected species like the freshwater pearl mussel. This can reduce the amount of food available for fish and can threaten their survival.

Fine sediments compacted within the gravel matrix may not be visible during routine inspection, but can have an ecological impact nevertheless.

Dead trout eggs due to smothering of gravels

Photograph courtesy of Brian Shields

Your Catchment

Find out

- If there is any evidence of siltation on spawning gravels and record by using the questionnaire and desk study.
- About compliance with the Freshwater Fish Directive.
- If there is evidence of fine sediment deposition, particularly deposition on the channel bed.

Look at

- River Basin Management Plans, Biodiversity Action Plans, Salmon Action Plans, River Corridor Surveys (RCS), River Habitat Surveys (RHS).
- Locations of fish spawning gravels.

Speak to

- Environment Agency Area teams – Fisheries, Recreation and Biodiversity; Analysis and Reporting; and Sampling and Collection.
- Natural England, Countryside Council for Wales, local angling clubs, fisheries board, fisheries consultative groups.

For more information

- More information could be available on a site-by-site basis; for example, water companies might have data where they have been involved in developments. You could also try rivers trusts, wildlife trusts and consultancies.
- **See Section 3 techniques: Bed sediment (8 and 10) and Redd Surveys (14).**

Habitats / fish stocks

Are your fish stocks impacted?

Fish can be affected by issues relating to sediment quantity and quality.

Firstly, excessive amounts of fine sediments may affect fish populations over time. Sediment can damage fish gills, reduce available food, and reduce the oxygen in the water.

Fish species have different tolerances to sediment during their life cycle. Some, such as juvenile river lamprey, carp and tench prefer silty conditions. Others, such a salmonids, barbel, chub and dace are less tolerant of fine sediment at different stages during their lives.

Secondly, evidence of fish kills can indicate the presence of sediment-associated toxins or low dissolved oxygen levels. However, causes unrelated to sediments such as pollution may also be responsible, so caution is needed when interpreting the fish kill situations.

Your Catchment

Find out

- About the status of fish populations in your catchment and trends over time. Use the Environmental Quality Ratio (EQR), which compares the observed number of fish to the number expected if the river were in pristine condition, to tell you about the status of your fish. Look for evidence for a change in fish stocks or EQR that may be due to sediment. The expert opinion of an Environment Agency officer may be the best place to start.
- If there is evidence of fish kills.
- About compliance with the Freshwater Fish Directive
- If there is evidence of fine sediment deposition, particularly deposition on the channel bed.

Look at

- River Basin Management Plans, Biodiversity Action Plans, Salmon Action Plans, River Corridor Surveys (RCS), River Habitat Surveys (RHS).
- Publications from the Natural England LIFE in UK rivers project, available via their website.

Speak to

- Environment Agency Area teams - Fisheries, Recreation and Biodiversity team; and Analysis and Reporting.
- Other groups such as Natural England/CCW, local angling clubs or the fisheries board.

For more information

- More information could be available on a site-by-site basis; for example, water companies might have data where they have been involved in developments. You could also try wildlife trusts and consultancies.
- **See Section 3 techniques: Electro-fishing (13).**

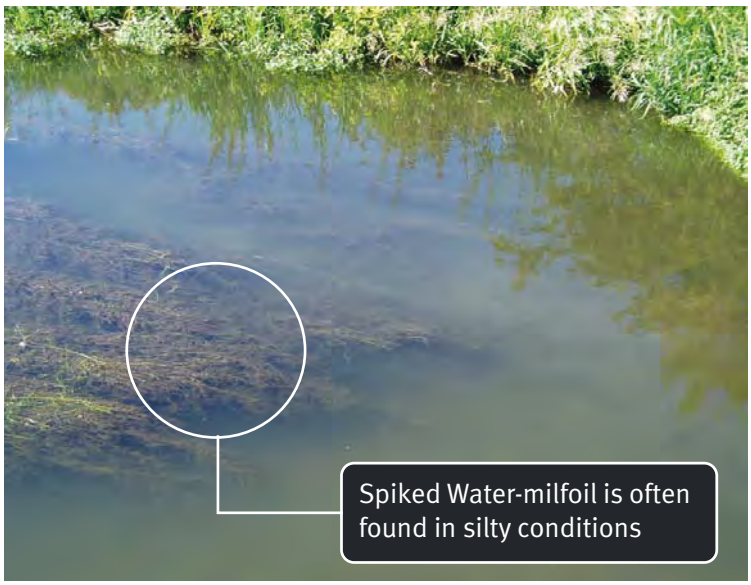
Habitats / aquatic plants

Are your aquatic plants affected?

Sediment deposition and lower light penetration in turbid waters can change the aquatic plant community in a river.

Aquatic plant species known as macrophytes have different tolerances to sediment and can help to indicate the sediment characteristics of your river channel.

An increase in species with a high tolerance to sediment, or a reduction in species with a low tolerance to sediment can result from a change in sediment supply which could be natural or could indicate a sediment-related problem.



Your Catchment

Find out

- About the status of the aquatic plant community structure in your catchment and trends over time. Use the Environmental Quality Ratio (EQR), which compares the observed aquatic plant community to the expected community if the river were in pristine condition, to tell you about the status of your river. Look for evidence for a change in aquatic plant community structure or EQR that may be due to sediment pressures. The expert opinion of an Environment Agency officer may be the best place to start.

Look at

- Macrophyte data collected routinely by the Environment Agency for the WFD.
- Surveys carried out under the Urban Waste Water Treatment Directive or for other purposes by the Environment Agency or consultants.
- Publications from the Natural England LIFE in UK rivers project, available via their website.
- The LEAFPACS model will also provide information of the status of macrophytes.

Speak to

- Environment Agency Area teams - Fisheries, Recreation and Biodiversity; and, Analysis and Reporting.
- Other groups such as Natural England/CCW, JNCC, local angling clubs or the fisheries board.

For more information

- More information could be available on a site-by-site basis; for example, water companies might have data where they have been involved in developments. You could also try wildlife trusts and consultancies.
- **See Section 3 techniques: River Habitat Surveys (RHS) and GeoRHS (11), River Corridor Survey (12).**

Habitats / macro-invertebrates

Are your macro-invertebrates affected?

Macro-invertebrates are the most powerful indicators of a sediment-related impact in a river channel.

Sediment deposition and reduced oxygen in turbid waters can change the macro-invertebrate community in a river. There may also be nutrient and chemical contaminants associated with sediment.

Macro-invertebrate species have different tolerances to sediment and can help to indicate the sediment characteristics of your river channel.

An increase in species with a high tolerance to sediment, or a reduction in species with a low tolerance to sediment could indicate a sediment-related problem.

Myriophyllum spicatum (Spiked Water-milfoil) is often found in silty conditions

Your Catchment

Find out

- About the status of macro-invertebrate populations in your catchment and trends over time. Use the Environmental Quality Ratio (EQR), which compares the observed number of macro-invertebrate to the number expected if the river were in pristine condition, to tell you about the status of your macro-invertebrates. Look for evidence for a change in macro-invertebrate populations or EQR that may be due to sediment pressures. The expert opinion of an Environment Agency officer may be the best place to start.

Look at

- Macro-invertebrate data collected routinely by the Environment Agency.
- An ecologically based sediment-indexing method (PSI see Extence 2010 *et al.*, 2010) is available to assess the sensitivity of observed species to sediment.
- Surveys carried out under the Urban Waste Water Treatment Directive or for other purposes by the Environment Agency or consultants.
- Ecological tools developed for the WFD such as River Invertebrate Classification Tool (RICT).
- Artificial intelligence-based diagnostic and modelling systems for river invertebrate data.
- Publications from the Natural England LIFE in UK rivers project, available via their website.

Speak to

- Environment Agency Area teams – Environmental Monitoring (Sampling & Collection and Analysis & Reporting). Conservation and Ecology Technical Services for artificial intelligence advice.
- Natural England/CCW, wildlife trusts and JNCC.

For more information

- More information could be available on a site-by-site basis; for example, water companies might have data where they have been involved in developments.
- **See section 3 techniques: Core samples (17), grab samples (18), kick samples (15) and PSI (16).**

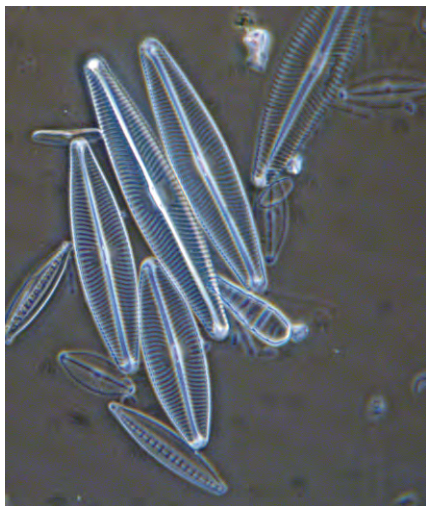
Habitats / diatom communities

Are your diatom communities affected?

Sediment deposition can change the diatom community in a river.

The different growth forms of diatoms can be used to identify factors influencing community composition, such as sedimentation.

Motile diatoms are able to avoid smothering by new sediment layers whereas diatoms attached to rocks and plants are not. An increase in the percentage of motile taxa may indicate an increase in sediment deposition.



Your Catchment

Find out

- About the status of the diatom community structure in your catchment and trends over time. Consider comparing the observed community against expected conditions to determine the EQR. Look for evidence for a change in community structure or EQR that may be due to sediment pressures. The expert opinion of an Environment Agency officer may be the best place to start.

Look at

- Diatom monitoring data has been collected routinely since 2007 for the WFD but there may still be some catchments without data.
- Surveys carried out under the Urban Waste Water Treatment Directive (UWWTD) and the WFD.
- Trophic Diatom Index results, which will include the percentage motile taxa.
- The nutrient-specific diatom tool Diatom Assessment of River and Lake Ecological Quality (DARLEQ) available for Environment Agency staff. The DARLEQ model for diatoms is particularly sensitive to nutrients.

Speak to

- Environment Agency Area teams – Environmental Monitoring (Sampling & Collection and Analysis & Reporting).
- Additional data may be available from Natural England/CCW or the Freshwater Biological Association.

For more information

- More information could be available on a site-by-site basis. A survey method was developed by the Environment Agency specifically for the UWWTD to identify eutrophic conditions. Other surveys may have been carried out by specialist consultants.
- **See Section 3 techniques: Core samples (17), grab samples (18).**

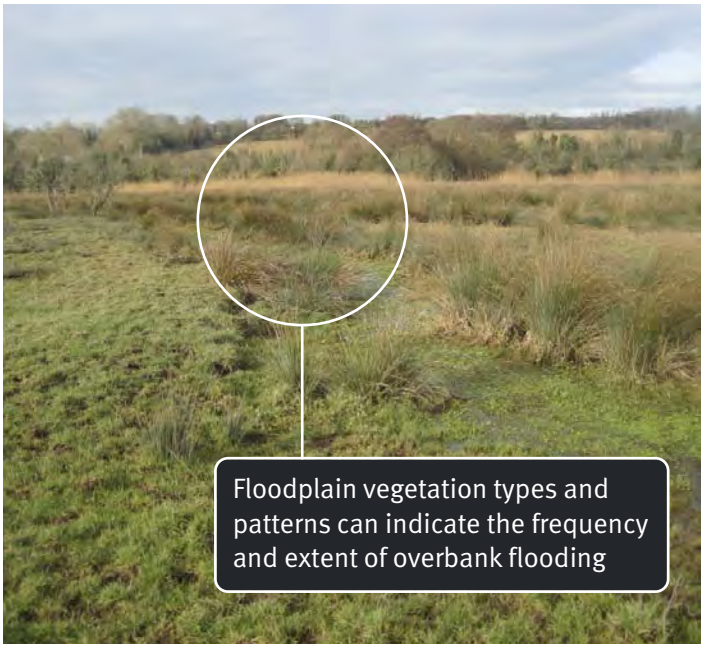
Habitats / Changing floodplain habitat

Is the floodplain changing composition?

The floodplain is a river's natural storage space for excess water which can't flow in the channel. Sediment in the excess flood water will deposit when flow velocity drops on the wide floodplain or where water ponds. The sediment can be an important part of the floodplain habitat.

Where sediment load is increased from its natural levels, this can lead to excess deposition. The excess deposition can change conditions. For example, sediment deposition can change the nutrient status of the soil and lead to a change in plant species composition.

Deposition of contaminated sediment can also change habitats. These changes may result from current or past deposition.



Floodplain vegetation types and patterns can indicate the frequency and extent of overbank flooding

Your Catchment

Find out

- If there is evidence of sediment deposition on the floodplain.
- If there is evidence of contaminated sediment.
- If there is evidence of changes in vegetation on the floodplain of the river.
- The extent of the natural floodplain, and how regularly it is flooded.

Look at

- Aerial photos at different time steps for evidence of change.
- Evidence of deposition on the floodplain.
- Records for disposal of contaminated sediments and dredged material.

Speak to

- Environment Agency Area teams – Flood and Coastal Risk Management; Environmental Monitoring (Sampling & Collection and Analysis & Reporting).
- National Permitting Service teams for disposal of dredged material.

For more information

- National Capital Programme Management Service, National Environmental Assessment Service.
- Environment Agency research on the impacts of contaminated sediment on floodplains is ongoing (see http://publications.environment-agency.gov.uk/pdf/SCHO1108BOZE-e-e.pdf).
- **See Section 3 techniques: Floodplain deposition (20), River Corridor Survey (12).**

Navigation

Are there restrictions on navigation?

Sediment deposition in navigation channels can reduce their depth. This can restrict the passage of traffic and increase the risk of grounding.

Dredging is often needed to manage this problem.

Disposal of sediment off site can be costly, especially if sediments are contaminated.

Your Catchment

Find out

- Whether you have a problem, using the questionnaire and desk study given in this handbook. Indicators are traffic restrictions and dredging patterns.
- The quality and quantity of dredged sediments.
- The cost of disposal of sediments.
- Whether there are any historic records of dredging which may have changed.

Look at

- Water depth measurements. These will show the amount of sediment accumulation over time and can help prevent unnecessary dredging.
- Catchment Flood Management Plans (CFMP).
- Records for the disposal of dredged material.

Speak to

- Environment Agency Area Hydrometric team, Navigation Officer, FCRM Asset Management team.
- British Waterways, Association of Inland Navigation Authorities.

For more information

- Local boating and amenity organisations, Natural England/CCW.
- **See Section 3 techniques: Channel cross section survey (6) and bed sediment (7 and 10).**

Flood risk / deposition

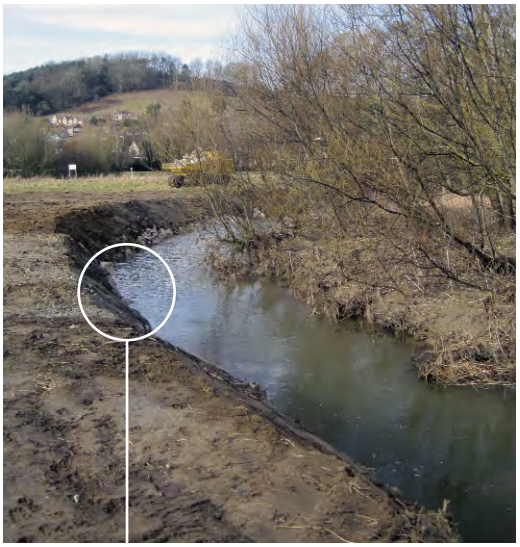
Is deposition increasing flood risk?

Deposition in watercourses can lead to a decrease in conveyance, the channel's capacity to transport flood water. This can increase the flood risk locally. Many factors can cause sediment build-up including channel modifications and management up and downstream.

Some sediment deposition in temporary stores such as bars or riffles is part of the natural transfer of sediment in rivers and creation of habitats. Excess supply or channel modification can result in storage beyond natural levels.

Routine depth monitoring can help assess sediment build up in channels. The reasons for sediment accumulation and the sources of sediment should be clearly identified. Upstream sources of sediment can often can be managed in a way to reduce delivery to the reach in question.

Dredging may be carried out to remove sediment and widen or deepen a river but the problem is likely to recur unless the supply of sediment is addressed and may create problems with sludge disposal and damage to habitats. Weed cutting may be carried out to help prevent the build-up of sediment within the river.



Channel work in progress to reduce flood risk. Works can lead to a temporary increase of sediment supply

Your Catchment

Find out

- Whether you have a problem with channel capacity, using the questionnaire and desk study given in this handbook. Indicators include increased flood risk and maintenance regime.
- The quality and quantity of dredged sediments.
- The cost of disposal of sediments.

Look at

- CFMP, River Habitat Survey (RHS), River Corridor Survey (RCS).
- Records for the disposal of dredged material.

Speak to

- Environment Agency Flood and Coastal Risk Management teams (especially Asset Management), Area Hydrometry teams.

For more information

- Environment Agency NCPMS and NEAS teams.
- **See Section 3 techniques: Bed sediment (7 and 10), catchment surveillance (2) and source tracing (26, 29).**

Flood risk / muddy deposits

Is mud a problem with flooded properties?

Flooding of property in itself is a serious problem. Where property is flooded with sediment-loaded water, the deposition of mud from the water increases the problem. The cost of clearing up after flooding with muddy water is considerably higher. There is also the risk of contamination from the sediment deposited.

Beer, Devon, August 2004

Your Catchment

Find out

- The level of risk to property from flooding.
- Whether there are records of the nature of flooding, and sediment associated with it.

Look at

- Flood zone mapping.
- Catchment Flood Management Plans (CFMP).

Speak to

- Environment Agency Flood and Coastal Risk Management (FCRM) and Operations delivery staff.

For more information

- Insurance companies.
- Local cleaning companies that deal with removal of muddy deposits.
- Local authorities.
- **See Section 3 techniques: Flow estimation (21), spot samples of flood water (22) and turbidity and flow monitoring during a flood (23).**

Flood risk / urban drainage

Flood risk in urban drainage?

Sediment that collects on urban hard surfaces can get washed into the drainage network in runoff. The efficient nature of runoff in urban areas means the capacity to wash sediment into drains is high.

Sediment deposition in urban drainage pathways can lead to localised drainage flooding where build up of material causes reduced capacity or blockages.

Urban sediment accumulations may also be associated with pollutants and may cause peaks of poor water quality as sediment is washed into the drainage system.

Sustainable Drainage Systems (SuDS) may help divert sediment away from critical infrastructure and drains by keeping sediment in settling ponds or wetlands.

Maintenance and cleaning out of drains and systems may be required.

Vegetation in a SuDS attenuation pond can trap sediment before it reaches the river

Your Catchment

Find out

- Whether you have a problem, using the questionnaire and desk study given in this handbook. Indicators are maintenance activities and the installation of sustainable drainage systems.

Look at

- CFMPs, RCS, RHS.
- Gully pot clearance records from the Highways Authority.

Speak to

- Environmental Agency staff in Flood and Coastal Risk Management (maintenance and warning staff), Development Control.
- Local council staff, Highways Agency, Internal Drainage Board (IDB,) water and sewage companies.

For more information

- Natural England/CCW.
- **See Section 3 techniques: Spot samples (22) and turbidity and flow monitoring (23).**

Water resources

Is sediment affecting your water supply?

Transport of suspended sediment can make water too turbid for abstraction leading to shortages in supply because water cannot be taken out of the river at these times.

Deposited sediment can build up at abstraction points by pump screens and restrict the volume of water that can be abstracted.

Deposition in water storage features such as reservoirs can reduce the capacity to store water and affect the supply of water.

Maintenance and decommissioning activities for water storage features can cause sediments that have accumulated to be flushed down stream.

Your Catchment

Find out

- Whether you have a problem, using the questionnaire and desk study given in this handbook. Indicators include abstraction returns from water companies.

Look at

- Catchment Abstraction Management Surveys (CAMS), Water Resource Plans, overflow outlet checks, consents data.

Speak to

- Environmental protection teams and water resource specialists, abstraction licensing staff, hydrometry teams within the Environment Agency.

For more information

- Try water company resource managers.
- **See Section 3 techniques: Flow estimation (21), Spot samples (22) and turbidity and flow monitoring (23).**

Water quality

Is sediment affecting your water quality?

Sediment itself can affect water quality. For example, it can lower the level of dissolved oxygen in the watercourse.

Fine sediment often acts as a medium for transport and deposition of nutrient and chemical contaminants within the catchment.

These contaminated sediments may be continuously re-worked by the river especially during a flood, resulting in dilution and dispersal of contaminants over time, or they may be buried and stored under new inputs of sediment.

Historic contaminated sediments can harm the aquatic environment if a natural or anthropogenic event results in their being exposed again.

Pollution incidents?

The National Incident Recording System (NIRS) holds information on river pollution incidents.

The NIRS can give you an idea of whether sediment has played a part in pollution incidents in your catchment.

Use the Environment Agency's Map Explorer to find out about pollution incidents in your catchment. The pathway is i drive, Local, Incidents, Pollution incidents.

Your Catchment

Find out

- Whether you have a problem, using the questionnaire and desk study given in this handbook. Indicators are failures to achieve water quality standards.

Look at

- General Quality Assessments (Chemical), RBMPs, CAMS and CFMPs.

Speak to

- Environment Agency Area staff working in Environmental Management, Environmental Planning, Environmental Monitoring (Sampling & Collection and Analysis & Reporting) and National Permitting Service.
- Catchment Sensitive Farming Officers or Catchment Coordinators in the Environment Agency.

For more information

- Natural England/CCW.
- **See Section 3 techniques: Sediment oxygen demand (19) and predictive models (30).**

Recreation

Is the amenity value of your river reduced?

Sediment in the river channel can reduce the amenity value of a river.

For example, fine sediment deposition and high suspended loads can affect angling by reducing fish catches. Poor water quality can reduce the aesthetic appeal of the water environment and lead to a deterioration in the use of waterways for recreation. It may also result in failure of bathing water quality standards.

Your Catchment

Find out

- Whether there are concerns about the amenity or recreation value of your river.

Look at

- Records of bathing water quality assessments.

Speak to

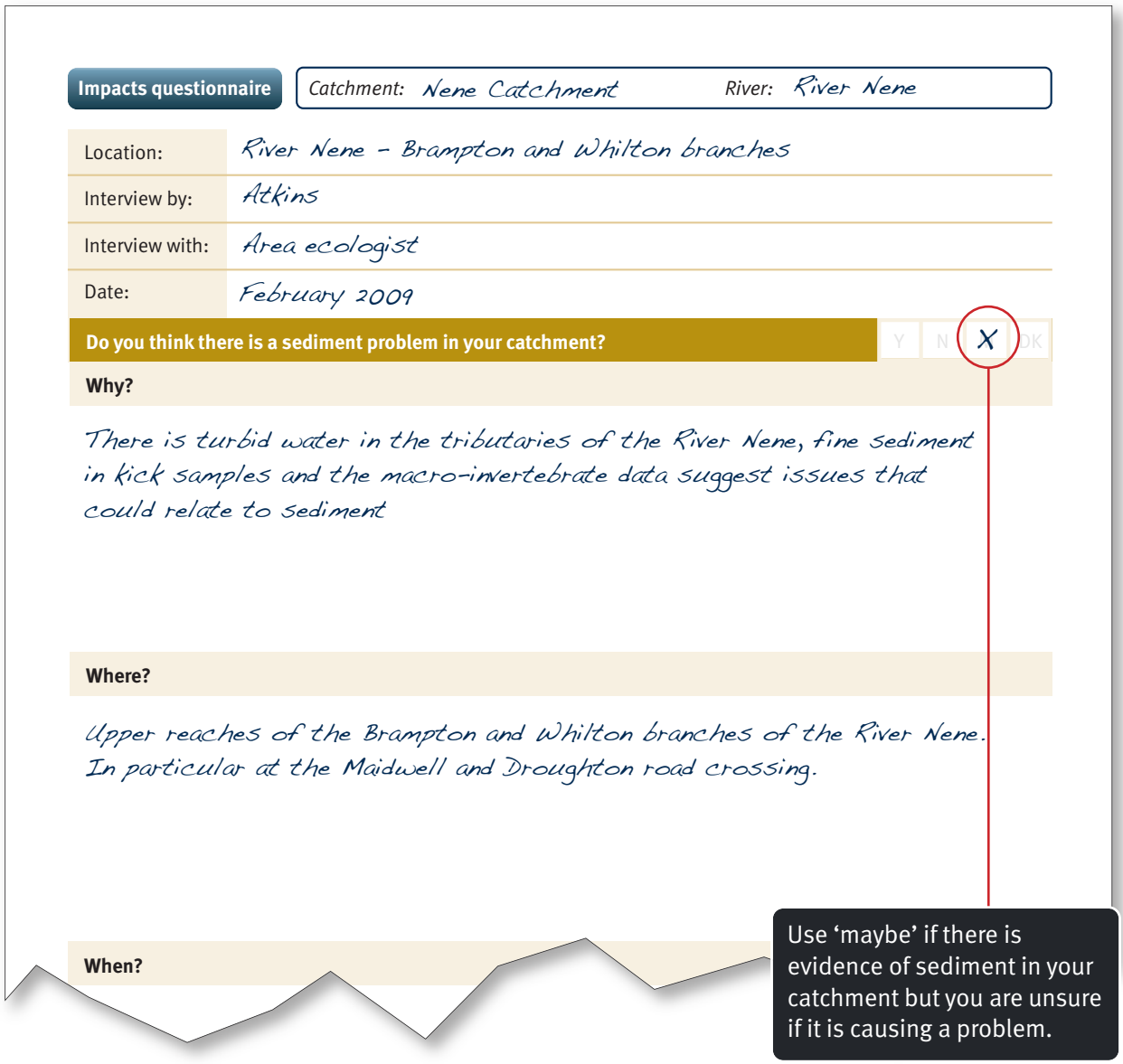
- Environment Agency Area Fisheries, Recreation and Biodiversity teams.
- Anglers, canoeists and boat clubs.
- Local wildlife trusts.
- Local recreation groups such as the Ramblers Association.
- Local residents and community groups.

For more information

- Look in the local paper for news stories relating to the river.
- **See Section 3 techniques: Anecdotal evidence (1), catchment surveillance (2), river corridor survey (12), electro-fishing (13).**

Impacts questionnaire

Use the Impacts questionnaire as a guide to prompt and record your communications with staff from a range of functions.



Impacts questionnaire Catchment: Nene Catchment River: River Nene

Location:	River Nene – Brampton and Whilton branches
Interview by:	Atkins
Interview with:	Area ecologist
Date:	February 2009

Do you think there is a sediment problem in your catchment? Y N X DK

Why?

There is turbid water in the tributaries of the River Nene, fine sediment in kick samples and the macro-invertebrate data suggest issues that could relate to sediment

Where?

Upper reaches of the Brampton and Whilton branches of the River Nene. In particular at the Maidwell and Droughton road crossing.

When?

Use 'maybe' if there is evidence of sediment in your catchment but you are unsure if it is causing a problem.

Completing the Impacts questionnaire

Use the questionnaire to record the findings of your communications with people from different functions within your catchment.

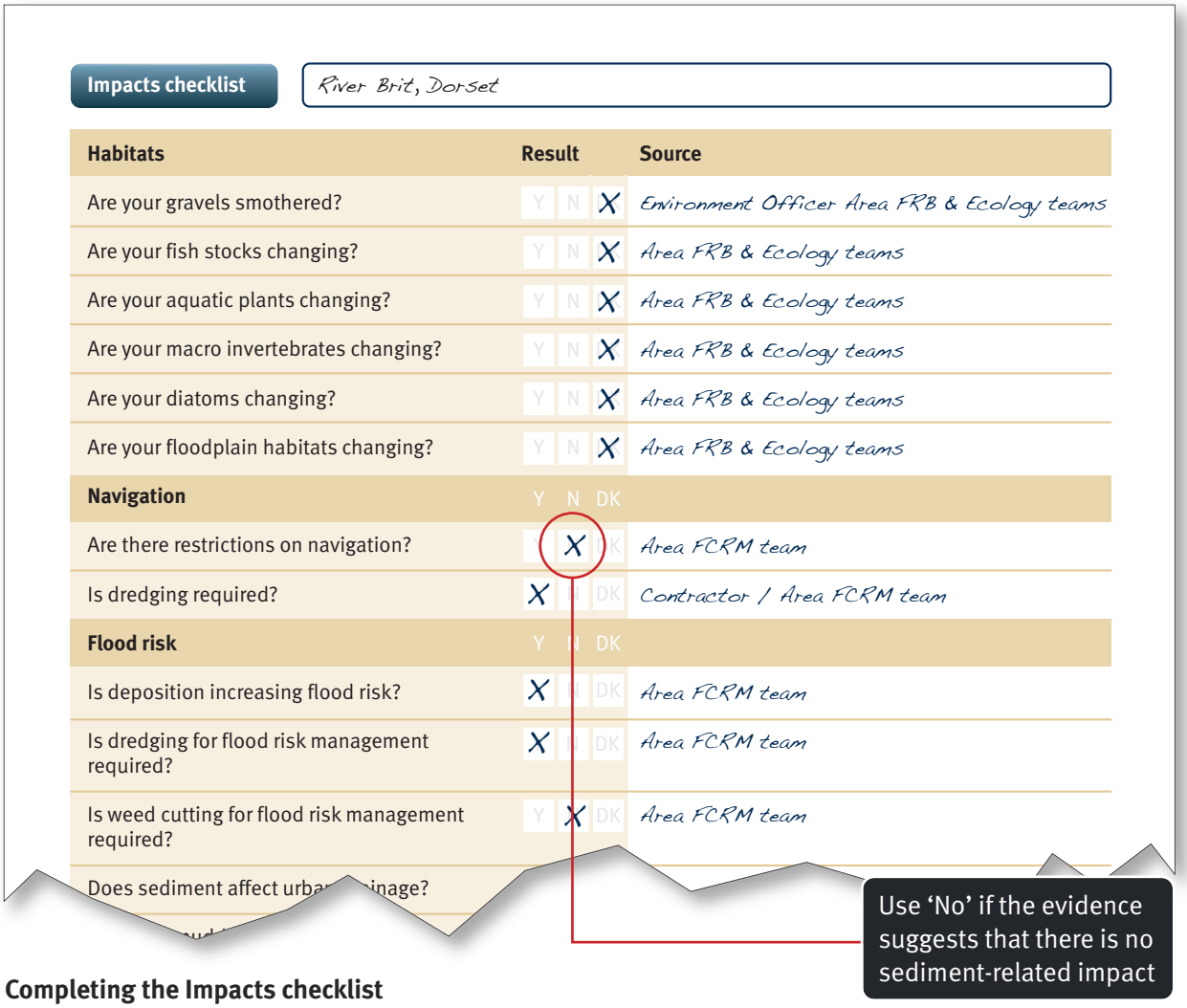
The completed questionnaires will help you to build up a 'weight of evidence' understanding about sediment-related issues in your catchment.

The questionnaire is available on the accompanying resource CD.

Remember, sediment issues may be perceived differently by different people. Listen to the viewpoints from staff from a range of functions to get an integrated understanding. Ask for data to back up anecdotal evidence where possible.

Impacts checklist

Use the Impacts checklist to record the findings of your investigation for all potential impacts. It will provide a summary of the sediment-related issues in your catchment.



Impacts checklist River Brit, Dorset

Habitats	Result	Source
Are your gravels smothered?	Y N X DK	Environment Officer Area FRB & Ecology teams
Are your fish stocks changing?	Y N X DK	Area FRB & Ecology teams
Are your aquatic plants changing?	Y N X DK	Area FRB & Ecology teams
Are your macro invertebrates changing?	Y N X DK	Area FRB & Ecology teams
Are your diatoms changing?	Y N X DK	Area FRB & Ecology teams
Are your floodplain habitats changing?	Y N X DK	Area FRB & Ecology teams
Navigation	Y N DK	
Are there restrictions on navigation?	Y X DK	Area FCRM team
Is dredging required?	X N DK	Contractor / Area FCRM team
Flood risk	Y N DK	
Is deposition increasing flood risk?	X N DK	Area FCRM team
Is dredging for flood risk management required?	X N DK	Area FCRM team
Is weed cutting for flood risk management required?	Y X DK	Area FCRM team
Does sediment affect urba… inage?		

Use 'No' if the evidence suggests that there is no sediment-related impact

Completing the Impacts checklist

The checklist provides a summary of your findings for each receptor identified in the handbook. It will help you to understand what the likely sediment issues are in your catchment. It will also provide a summary of the data sources you used to develop this understanding.

- Use the blank checklist provided on the accompanying resource CD.
- Record the result of your investigation for each of the potential impacts. Choose from:

  Yes: The evidence suggests that there is a sediment-related impact.

  No: The evidence suggests that there is no sediment-related impact.

  Don't know: The evidence is insufficient or unavailable to identify or rule out a sediment-related impact.
- Record your data sources for each potential impact.
- Use the Impacts checklist to complete the Problems checklist and help you to understand your sediment problem in Section 3.

Know your sources

Sediment sources in your catchment

Know your sources / introduction

Sediment in the river can come from a wide range of sources

Know your sources / introduction

Find out about the sediment sources in your catchment. This will give you an understanding of where sediment comes from and how, where and when it can enter the river channel.

You are here

Use this section to understand sediment sources in your catchment

- First, find out about your catchment's natural physical characteristics. By looking at the sediment system you can understand how the sediment sources work. The sediment system is made up of factors that link water, land and the river channel.
- Next, identify your sediment sources. Sources can relate to human impacts that increase the amount of sediment supplied to rivers as well as natural processes such as landslides. Sediment can come from erosion of the catchment surface or the river channel. Aerial photography and walk over surveys can help identify eroding areas whereas a wet weather survey can help you see fine sediment movement and plumes in the water.

Use the 'Your Catchment' boxes to guide your investigation

- These will show you what to find out, where to look for information and who to talk to.

Use the questionnaire to help you to record information

- Talking to colleagues from different teams is the best place to start. You can record your information on copies of the questionnaire. The questionnaire can be found on the accompanying resource CD.

Use a map of your catchment to help you to record information

- Where possible, record the location and timing of sources and look for evidence of pathways that link the catchment surface to the river channel.

Complete the Sources checklist

- You will need this to work out your sediment problem in Part 3. The checklist can be found on the accompanying resource CD.

Go to Part 3 to understand sediment problems in your catchment

Know your sources / introduction

Remember, sediment sources can be point sources and come from specific locations or can be diffuse and come from many different activities over a wide area.

Remember, sediment sources can be very variable and the type, location and timing of sources can change over time.

Section 2 helps you to understand sediment sources in your catchment by looking at the natural physical characteristics of your catchment and the risk factors that can accelerate erosion.

The natural physical characteristics of your catchment include factors that relate to water, land and the river channel. Knowing these factors can help to understand the sediment dynamics in your catchment and how your sediment sources work.

Weather factors such as rainfall drive the sediment system. They provide energy for erosion and transport of sediment.

Land factors such as soils and geology help to control how much runoff is generated and how much erosion can occur. Poor land management practices can play a major role in accelerating erosion.

Water factors such as discharge in the river which transports suspended sediment downstream.

Channel factors show how the river responds to inputs of flow and sediment and how sediment is supplied, transported and deposited as the river flows downstream.

The sediment sources in your catchment can be part of the natural sediment dynamics of your catchment. Where sediment supply is accelerated by human influence, there is a risk that sediment sources could lead to sediment-related problems.

Accelerated sediment sources can be linked to **land use** and can be due to agriculture, urban and industrial impacts.

Accelerated sediment sources can be linked to **channel use** and can be due to the management of the river channel for uses such as flood risk management and water resources.

Sediment sources can be complex. The balance between water, land and channel factors in each catchment is unique. It is important to find out how the sediment sources work in your catchment.

In catchments where rainfall is low and slopes are shallow, high connectivity between the catchment surface and the river channel can result in high sediment loads.

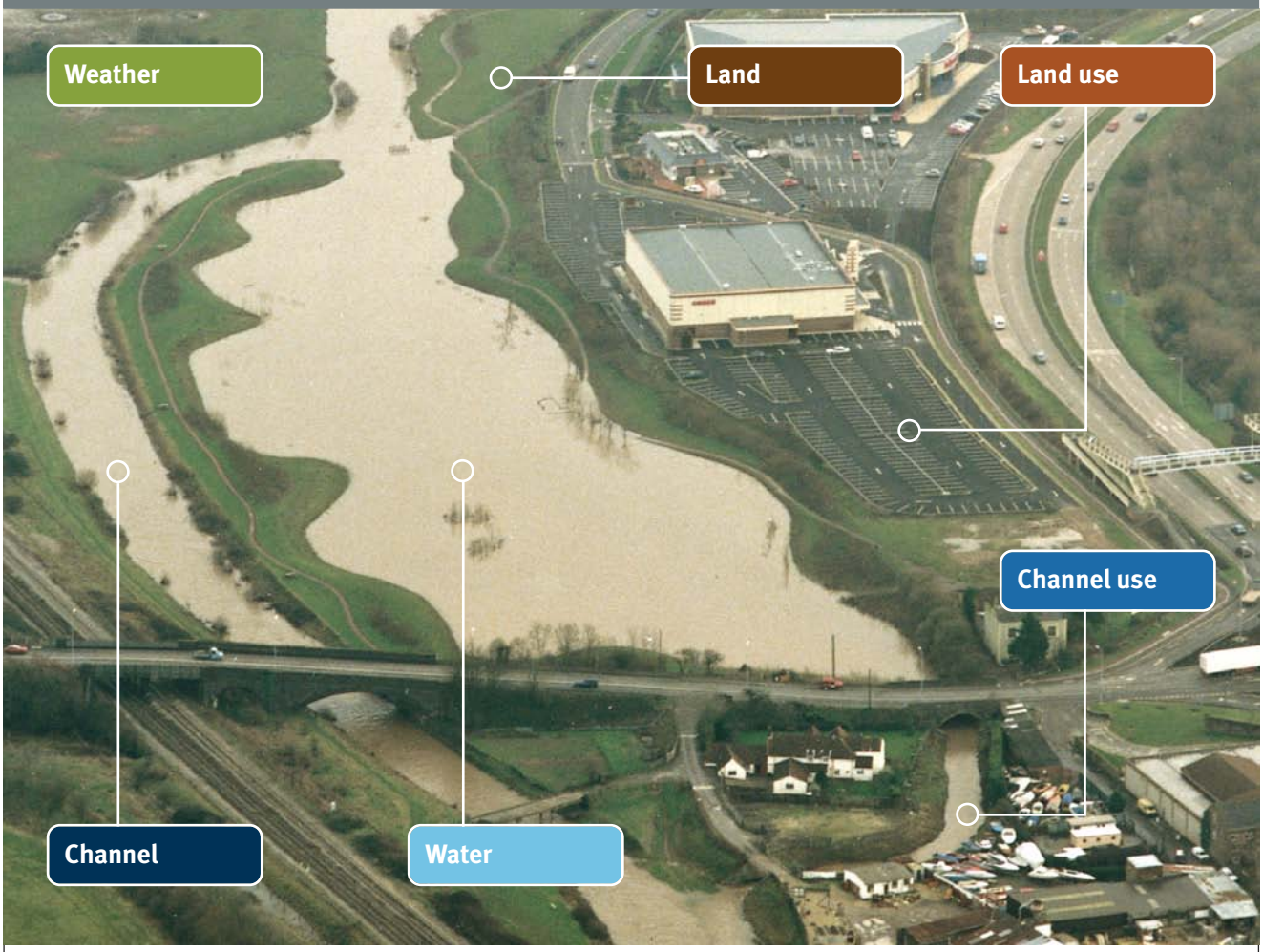
In catchments where rainfall is high and slopes are steep, good land management that reduces the link between the field and the river can result in low sediment loads.

The link between sediment sources and sediment problems in each catchment is unique. It is important to understand sediment supply so that you can link this to sediment impacts.

A high sediment load does not necessarily mean that there will be sediment problems. Dynamic channels may be more resilient to sediment inputs.

A low sediment load could lead to significant sediment problems. Chalk streams may be particularly sensitive to sediment inputs.

Know your sources / introduction



Catchment characteristics

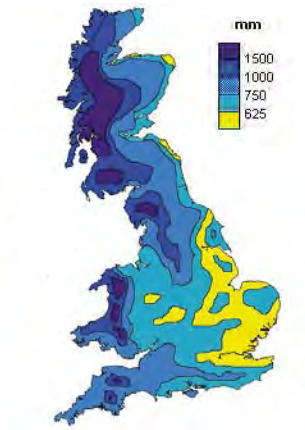
Sediment sources

Weather / rainfall

How much?

Rainfall and runoff provide energy for erosion and sediment transport. The impact of rainfall on the catchment surface can detach soil particles. Runoff can then carry the eroded soil towards the river channel.

The opportunity for runoff may be higher in the wetter parts of the country. However, higher rainfall and runoff does not necessarily mean more soil is eroded and transported to the river from the catchment. Factors that relate to land use and land management will determine how much sediment is produced and carried to the river channel as a result of the available rainfall and runoff.



Annual rainfall patterns

How intense?

Runoff occurs when rainfall intensity exceeds infiltration rate and the soil becomes saturated at the surface. Runoff can pick up soil from the catchment surface and transport it to the river channel.

Runoff is often greatest when rainfall intensity is highest. Heavier rainfall will have more soil erosion power and can create muddy runoff more quickly. This can lead to flashy river flow which, in turn, has more channel erosion power.

The relationship between rainfall intensity and sediment transport is not always straightforward. Higher intensity does not always mean higher sediment loads. Antecedent conditions and pathways are important: runoff can occur from saturated or urban surfaces when rainfall is as low as one mm/hour; and a small, well-connected, headwater stream may be more vulnerable to localised intense rainfall than a larger catchment where the link between the surface and the river is more indirect.

Rainfall intensity in the 2004 Boscastle flood reached a peak of 300 mm per hour

Weather / rainfall

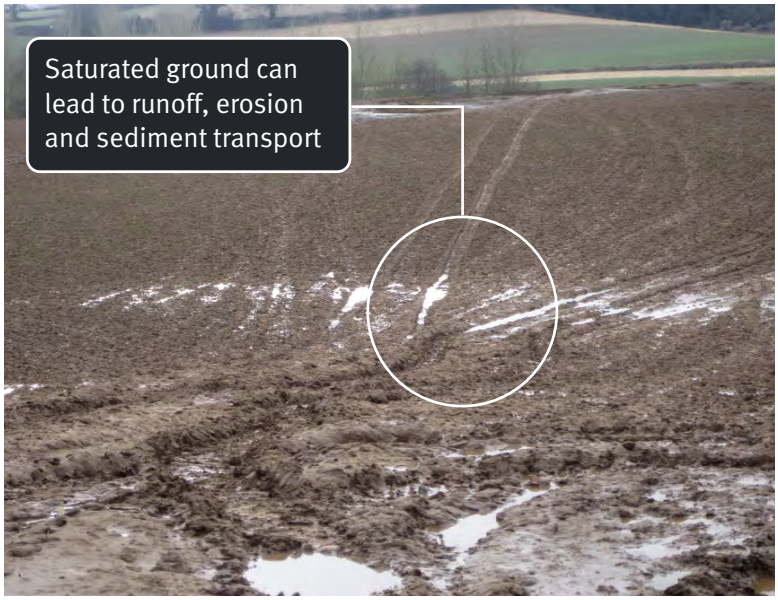
When?

Rainfall causes runoff which transports sediment from the catchment into the river.

The distribution of rainfall throughout the year can influence sediment transported to the river. More rainfall when the catchment is already wet combined with periods when soil is most susceptible to erosion can lead to more sediment in the river. This usually occurs during the winter months.

Intense rainfall during summer months can also generate high runoff when catchments are dry and the surface does not allow infiltration readily.

Monthly rainfall data (mm) will help show you when the catchment is likely to be at its wettest or driest.



Your Catchment

Find out

- Total annual rainfall (mm).
- Average monthly rainfall (mm).
- Rainfall intensity (mm/hour).
- Patterns of rainfall over the catchment.

Look at

- Environment Agency Map Explorer on the i: drive.
  The pathway is: *Local, Physical, Meteorology, Rainfall_annual_isohyets*.
- Environment Agency Regional Information Hub on the n: drive, for example for Anglian Region.
  Look in the Water Resources section.
- Websites such as the Environment Agency's website, Hi-Flows UK, Centre for Ecology and Hydrology website.
- Reports for background information such as CAMS, CFMP.

Speak to

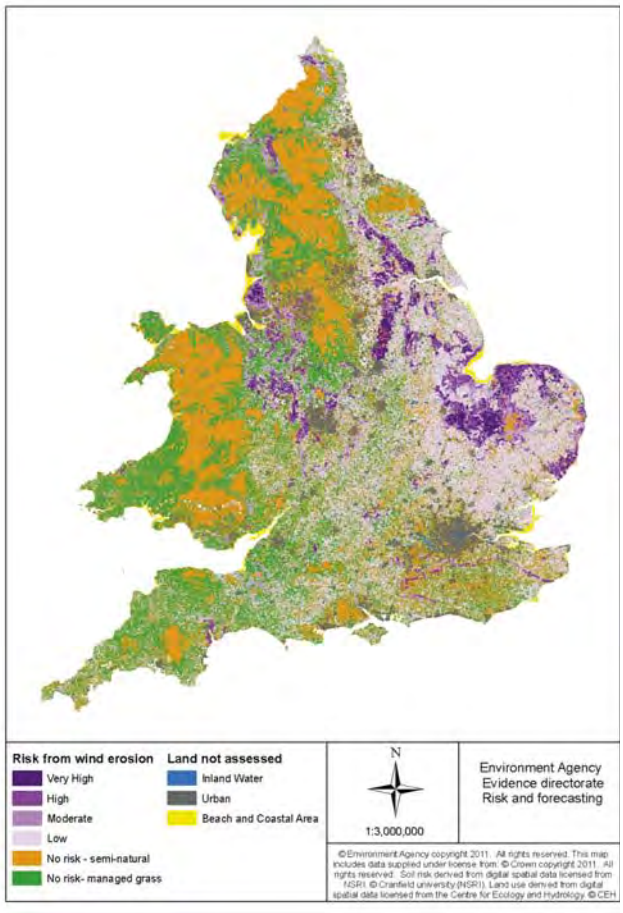
- Environment Agency Area Hydrometry team, regional data information team, regional hydrologists.

Weather / wind erosion

Wind erosion?

Wind erosion can transport fine soil particles directly to watercourses in the uplands and drier parts of the country.

Fine sandy soils and exposed, drained peaty soils are especially at risk.



Your Catchment

Find out

- Whether wind erosion is known to occur within your catchment.

Look at

- MapExplorer. The pathway will be I:drive/national/physical/soil.
- The erosion risk map in 'Controlling Soil Erosion' by Defra. The key areas at risk of wind erosion are shown in blue.

Speak to

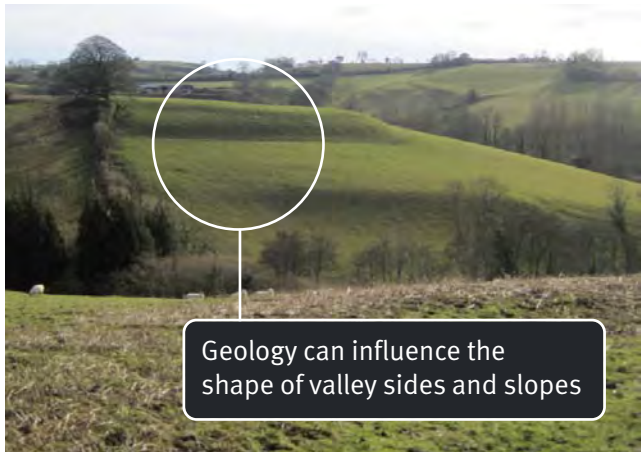
- Environment Agency risk and forecasting team.

Land / geology

What is the catchment geology?

Catchment geology can indicate the risk of runoff and erosion. This gives an idea of the potential for sediment supply to a watercourse. Solid geology refers to the underlying bedrock and drift geology refers to the overlying rock debris.

The geology of the catchment will influence the drainage density and river regime. In catchments underlain by permeable geologies, such as chalk, sandstone or limestone, some rainfall may percolate through the soil zone into the underlying rock where it may stay stored or enter the river as base flow some time later. Conversely, in catchments underlain by impermeable geologies such as igneous rocks, shale and clay the rainfall is confined to flow over the ground surface or through the soil zone and tends to reach the river more quickly. Thus for the same rainfall, impermeable catchments may promote higher drainage density and a flashy hydrograph during wetter periods with the potential for greater sediment loads. Jointed rocks can provide pathways for surface water to reach the channel quickly and promote a flashy hydrograph.



Your Catchment

Find out

- The solid and drift geology in your catchment. Use this information to work out whether your catchment is permeable, impermeable or mixed. Consider the drainage density and degree of linking between the catchment surface and river channels.

Look at

- Environment Agency Easimap on the i: drive. The pathway is: *Local, Physical Geology*. Add the Detailed River Network under the Hydrology layer too. Use the 'i' icon to find out more about each geology type.
- Environment Agency Map Explorer on the i: drive. The pathway is: *Local, Physical, Geology*.
- CAMS or CFMP reports.

Speak to

- An Environment Agency area or regional hydrogeologist.

Land / soils

What soil group?

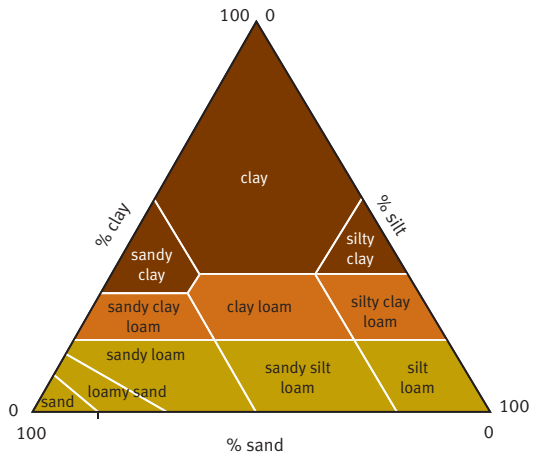
Soils can be grouped according to their risk of runoff and erosion. This gives an indication of the potential for eroded soil to be available as a source of sediment into water courses. For example:

- Sandy and light silty soils have low clay (‹18%) and organic matter content and low stability. Where runoff, poor drainage or structural damage is present the erosion risk is high. Fine sandy soils also have a high risk of wind erosion.
- Medium soils have a clay content of between 19 and 35 per cent. They are more stable than lighter soils. Where clay content is higher, or where structural damage or poor drainage is present, there is a risk of erosion.
- Heavy soils have a clay content of above 35 per cent. They tend to be slow draining and waterlogged. They have a high risk of structural damage and runoff but a lower risk of erosion.
- Shallow chalk and limestone soils are thin, at less than 30 cm deep. They tend to be well drained with a low risk of runoff and soil erosion. Land use factors can however reverse this.
- Peaty soils have an organic content of above 20 per cent. Flat, lowland peaty soils have a low risk of generating runoff and soil erosion whilst those found in the uplands have a high risk. Lowland peat soils are prone to wind erosion.

Identification of soil group

Soil can be placed into one of five broad groups.

- Sandy and light silty soils
- Medium soils
- Heavy soils
- Chalk and limestone soils (often shallow)
- Peaty soils (peat and organic soils that contain more than 20% organic matter)



Your Catchment

Find out

- The soil types in your catchment. Use this information to work out your soil groups and the potential for erosion.
- The HOST class of the soils in your catchment. The 29 HOST classes describe the dominant pathways of water movement through the soil and substrate.

Look at

- The Environment Agency's *Think Soils* manual to find out more about your soil type. This is available as free downloads from *http://publications.environment-agency.gov.uk/epages/eapublications.storefront/*
- Environment Agency Easimap on the i: drive. The pathway is: *Predominant Soil Type layer. Add the Detailed River Network under the Hydrology layer too.* Use the 'i' icon to find out more about each soil type.
- Environment Agency Map Explorer on the i: drive. The pathway is: *Local, Physical, Soils*.
- CAMS or CFMP reports.
- Electronic soil mapping by Soilscapes at *www.silsoe.cranfield.ac.uk/nsri*.

Land / topography

How steep?

Steep slopes can cause water to runoff at a rapid rate. Fast-flowing runoff can erode and transport sediment to the river channel.

Highest risk fields are those with a slope angle greater than seven degrees. Lowest risk fields are those less than three degrees.

Topographic contours give indications of where the steepest slopes occur and where topography can focus the pathway of runoff. At the field scale this could lead to the development of erosion and transport in rills or gullies.

How high?

Upland catchments tend to have steep gradients and rapid river flow. They are often rural. These factors combine to influence sediment erosion and transport.

Upland catchments can be characterised as those where 70 per cent of the catchment is above 300 m above ordnance datum (AOD).

Lowland catchments can be characterised as those where 70 per cent of the catchment is below 300 m AOD.

Catchments can be described as mixed where neither lowland nor upland is above 70 percent.

Your Catchment

Find out

- Whether there are steep slopes in your catchment.
- Whether your catchment is upland, lowland or mixed.

Look at

- Environment Agency Easimap layer on the i: drive.
  The pathway is: *FCRM layer, LiDAR extents, topographic map for slope analysis*.
- Environment Agency Map Explorer on the i: drive.
  The pathway is: *Local, Physical, Topography, SM contours*.
- Online aerial photography such as Google Earth.
- The Ordnance Survey map for your catchment.
- CAMS or CFMP reports.

Speak to

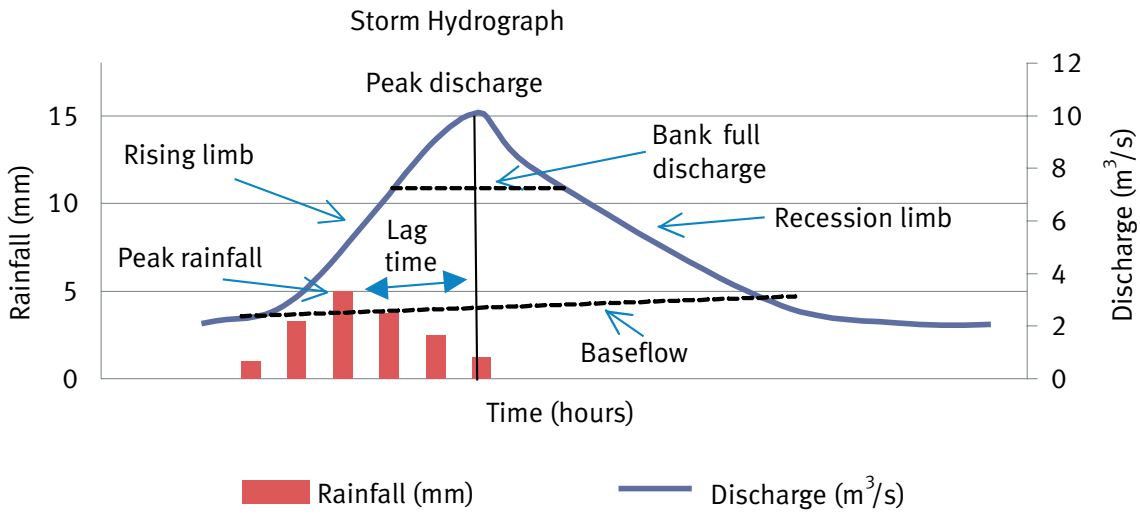
- Environment Agency Area Environment Officer.
- Ask for help with GIS if you wish to carry out a slope analysis.

For more information

- Drive or walk your catchment– take photographs.

Water / river flow

How flashy?



'Flashy' refers to the speed with which water moves from the catchment surface to the river channel and then downstream.

Rivers naturally respond to rainfall by rising water levels and flow. An increase can be for hours or days. Catchments that respond quickly to rainfall are termed flashy.

A flashy catchment tends to have higher energy to erode, transport and deliver sediment from the catchment surface to the river and further downstream. Flashy streams will also have more power to erode within the river channel itself and flashiness can influence how long sediment is carried in suspension in the river.

Sediment tends to move when flows are high. The height of the hydrograph and the time it takes to rise and fall can help explain sediment movement. Be aware that there may be human impacts on the hydrograph such as reservoirs and abstractions.

When?

The timing of rainfall, runoff, river flow and sediment transport are all linked.

Most sediment in the river moves when the river is responding to rainfall.

Looking at the flow record of a river will give you an idea of when sediment is most likely to be transported. The highest flows are likely to coincide with the times of highest sediment transport.

Sediment transport is variable. It can vary between seasons and storm events and even within individual storms. Often, a handful of storms generate a high proportion of the annual sediment transported by a river. Studies of the annual total of sediment transported in UK river catchments suggest that three quarters of the annual load is transported during storms in a total of less than three weeks of a year.

Although smaller storms can mobilise smaller amounts of sediment, these can add up to a bigger problem overall.

Water / river flow

Flood frequency?

Flood experts have a method for estimating how often a flood of a given magnitude is likely to occur. This Flood Frequency Analysis (FFA) can also indicate how often sediment is likely to be transported.

Peaks over threshold can also be used to assess the frequency of flows that may contribute to sediment transport. A peaks-over-threshold series consists of all distinct peak flows that are greater than a selected threshold flow. Further details are available on the Hi Flows database at http://www.environment-agency.gov.uk/hi-flows/91727.aspx. In Hi-Flows-UK, the threshold has generally been set to obtain an average of about five events per year.

Erosion and transport of sediment can be highest when rainfall and river flows are highest. However, the relationship between rainfall, flooding and sediment loads is complex and depends on a source of sediment being available.

Whilst erosion and transport of coarse sediment are associated with a small number of high flow events, fine sediment is also transported during a large number of small events throughout the year.

Your Catchment

Find out

- How your catchment responds to rainfall by looking at the importance of groundwater in the river as indicated by the baseflow index (BFI) link with river flow response time and magnitude.
- How flashy your catchment is by examining the link between rainfall and river flow.
- The baseflow index of your catchment.
- What times of year flows tend to be highest and lowest in your catchment. Look at data from daily flow records from the nearest gauging station.
- The detail of individual river events in response to rainfall, using water level or flow data collected every 15 minutes. This could help you to pinpoint the timing of key storms that are most likely to move sediment.

Look at

- The Environment Agency's Easimap.
  Look at the flood and coastal risk management layer and get the flood warning map.
- The Environment Agency's Regional Information Hub on the n: drive, for example for Anglian Region.
  Look in the Water Resources section.
- Environment Agency WISKI database for raw flow data.
- Websites such as the Environment Agency's website, Hi-Flows UK (for the BFI), Centre for Ecology and Hydrology website.
- Reports for background information, such as CAMS, CFMP.

Speak to

- Environment Agency Area teams - Area Hydrometry Team, Area Environmental Protection staff (water resources), and FCRM staff.

For more information

- Councils may have more details on flow in drainage.

Water / sediment

How much?

Sediment load in the river may increase as the water responds to higher rainfall. There is a link between storms that transport sediment and greater river flow, although it is not always a simple one: more river flow does not always mean more sediment.

It is possible to measure how much sediment is in the flow by sampling or by direct measurement. Direct measurement of fine suspended sediment is called turbidity measurement and can be done with spot samples or continuous monitoring. High frequency monitoring or event based monitoring is required to capture sediment concentrations before during and after a rainfall event.

A local sediment-discharge relationship can be derived by plotting suspended sediment data against discharge data from the nearest gauge. By relating sediment concentration to total flow in the river it is possible to estimate the total amount of suspended sediment being transported from the catchment. This is known as the suspended sediment load.

Rivers tend to have a natural sediment load - this can be increased by human impact in the catchment.

Sediment characteristics

When sediment is transported in suspension by the river it can go a muddy colour.

The colour of the river will vary with the amount of sediment being transported and the soil types in the catchment. With low sediment concentrations the water may just be cloudy and it may still be possible to see the bed through the water. When sediment concentrations are high, the channel flow can look very muddy.

Knowing the particle size of sediment can be important for understanding patterns of transport and deposition. For example, there may be clear links between fine sediment and the type of aquatic plants found in the river and so it can also help to understand the ecological impacts of sediment. The finer sediment is likely to have the greatest impact.

Knowing sediment composition can help to understand potential issues. The clay content can indicate the potential to transport contaminants because these associate with the finest particle sizes. The organic content of the suspended sediment links to biological oxygen demand (BOD).

Water / sediment

Sediment load

The link between the size of the sediment load and the size of the problem is not a direct one. A high load does not necessarily mean that there is a sediment problem. Conversely, a small load may be of serious concern in a sensitive catchment such as a chalk stream.

The ecological, geomorphologic and hydrological sensitivity of a river channel will help to determine whether sediment is a problem, particularly in terms of ecological impacts.

For example, preliminary research (Walling *et al.* 2007) suggests that a highly sensitive chalk stream may develop above natural sediment–delivery problems at annual sediment yield as low as four tonnes per km^2 per year. Alternatively, a less sensitive lowland channel may require an annual sediment yield of 80 tonnes per km^2 before sediment delivery is un-naturally accelerated.

These values are uncertain and provide a guide only, because data relating to high flows and sediment transport is scarce.

The situation of individual rivers needs to be considered as the relationship between sediment yield and sediment related problems is not straightforward.

Your Catchment

Find out

- Whether continuous monitoring of sediment is done in your catchment.
- Whether spot measurements of turbidity are done in your catchment.
- Whether samples of suspended sediment are collected as part of the General Quality Assessment (GQA).
- Whether there are any locations where river flow and sediment data are collected together. These could be used to estimate the total sediment load transported by the river.
- When sediment concentrations tend to be highest and lowest.

Look at

- Environment Agency Easimap for locations of monitoring.
- Environment Agency Intranet (WIMS) for data.

Speak to

- Environment Agency Area teams – Environmental Monitoring, Hydrometry, Environmental Protection (water resources), Fisheries, Recreation and Biodiversity and Analysis and Reporting.

For more information

- Monitoring may be carried out by research institutions. Ask the Environment Agency National Research, Monitoring & Innovation teams for further information.
- Natural England Research Report NERR007: *Investigations into the use of critical sediment yields for assessing and managing fine sediment inputs into aquatic ecosystems*. Ref: Walling *et al.* (2007)

Channel / characteristics

Channel characteristics?

An overview of the channel network for the whole catchment can give an indication of how active or dynamic it is. Evidence of channel change from current erosion sites to historic maps can help to understand this.

The density of the stream network can be an indication of how much the river erodes and how easily the catchment is eroded. It can also give an idea of how well connected the catchment surface is with the river channel.

The overview can give an indication of how much of the channel network is natural and where intervention such as straightening has taken place. Don't forget that field drains and ditches also form part of the channel network and are often more closely linked with sediment sources. Intervention can alter erosion, transport and deposition processes.

A meandering channel indicates an actively eroding river likely to be flowing in a floodplain. The size of the river floodplain and river meanders may indicate the extent of natural bank erosion. The link between the floodplain and the river can indicate what might happen to flow during storm events.

Features such as lakes and reservoirs can act as sediment stores which can trap sediment that may be released during a subsequent storm event.

Channel / characteristics

Your Catchment

Find out

- The broad characteristics of your river – how active or modified is it? Where are the main source and storage areas?

Look at

- River Habitat Survey data for your catchment.
- Aerial photographs, images on Google Earth and *www.bing.com/maps*, LiDAR data.
- Drive or walk around the catchment and take photographs.
- Reports such as CAMS, CFMP, RBMP.

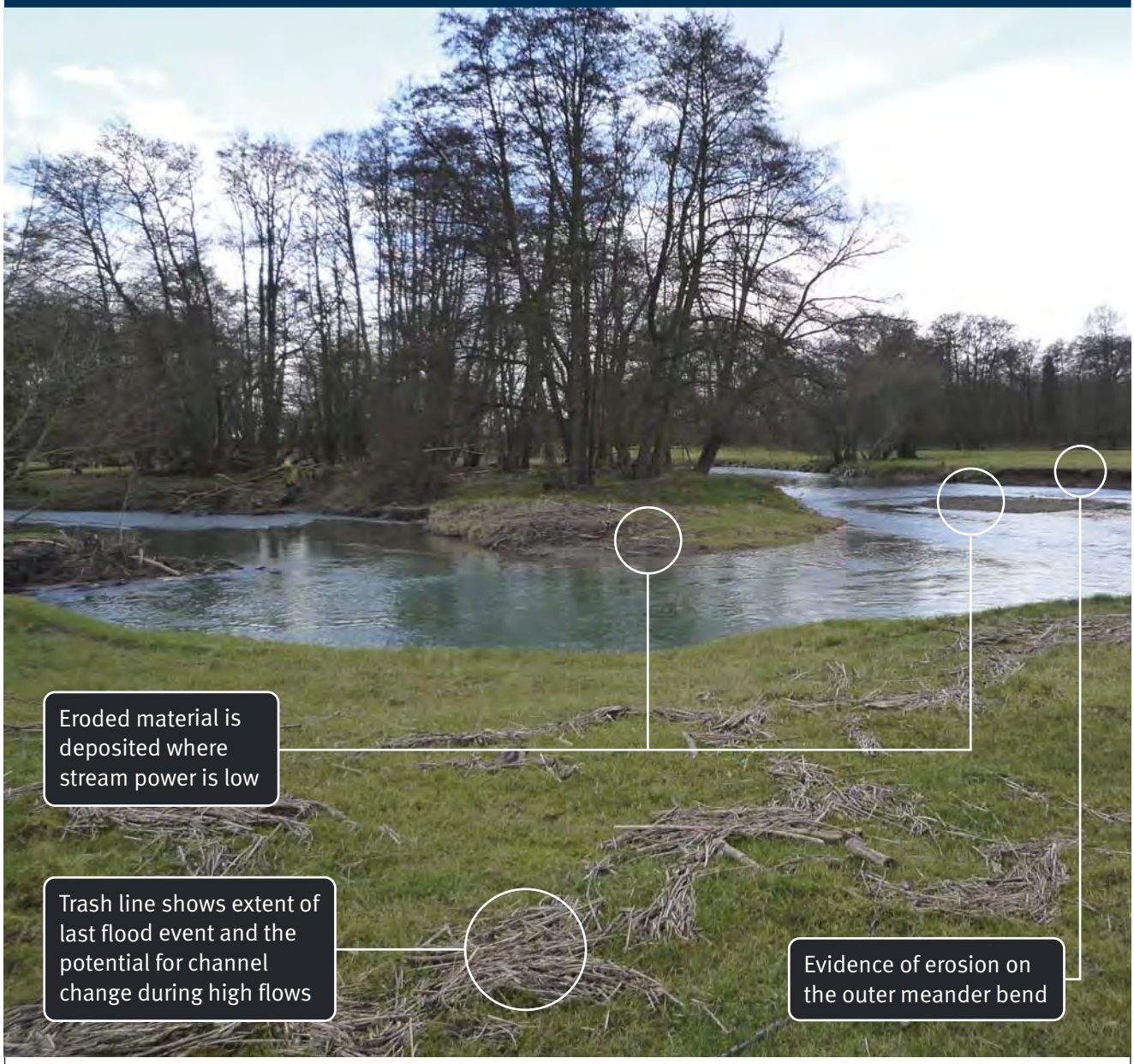
Speak to

- Environment Agency Development Control, FCRM Asset Systems Management.
- Environment Agency River Habitat Survey – National Team, Area FRB team.

For more information

- *Guidebook of Applied Fluvial Geomorphology.*
- E-learning introduction to geomorphology at *http://e-learning.geodata.soton.ac.uk/EA/*.

Channel / natural erosion



Natural erosion?

Erosion of river banks is a natural process that occurs in most catchments. It is an important part of the balance of sediment in a river system.

Erosion can be caused by river flow and can also be a result of frost, groundwater or slope failure. It can range from gradual undercutting at the base of the bank to sudden collapse of whole sections of bank during high flows.

Erosion can occur throughout the course of a river. For example, meander cliff erosion occurs in the lower reaches of a river as a dynamic river meanders across the floodplain. Incision can occur in the upper reaches of a catchment as high gradients lead to energy for channel development.

The extent of erosion is often linked to the speed of channel flow, the frequency of storm events and to how much vegetation is present on the bank sides and tops.

Sometimes, what looks like natural erosion can be caused by a modification to the channel elsewhere, so always look for causes up and downstream. Examples could include channel realignments, embankments or weirs.

Channel / natural erosion

Your Catchment

Find out

- The broad characteristics of your river – how active or modified is it? Where are the main sediment source and sink areas? Is the erosion natural or accelerated due to human interventions?

Look at

- River Habitat Survey data and GeoRHS data for your catchment.
- Aerial photographs, images on Google Earth, *www.flashearth.com* and *Local.Live.com,* Lidar data.
- Drive or walk around the catchment and take photographs.
- Reports e.g. CAMS, CFMP, RBMP.

Speak to

- Development Control, FCRM Asset Systems Management.
- The Environment Agency National Environmental Monitoring Service team and the Area FRB team restoration lead.

For more information

- Look at the Guidebook for Applied Fluvial Geomorphology.
- An e-learning introduction to geomorphology at *http://e-learning.geodata.soton.ac.uk/EA*.

Land use

Poaching has caused soil damage and waterlogging around this mobile feeder. There is also direct connectivity to the river.

Land use

Evidence of different land use types can help you to understand where human impact increases sediment supply and how, where and when sediment enters the river channel.

Use this section to work out the overall upland and lowland land use types in your catchment and identify examples of the sediment sources that link to land use in your catchment.

Catchment land use is a key control on the link between the catchment surface and the river channel. Rainfall and runoff provide the energy for soil particles to be detached, eroded and transported downslope towards the river. Land use can affect the availability of soil for erosion, the potential for runoff to be generated and the pathways available for delivery.

Sediment can be supplied from a range of **land use types** that include arable land, grassland, woodland and urban surfaces. The land uses included in this section all have the potential to increase the sediment load of a river as a result of human impact on the catchment surface. They accelerate sediment delivery because they increase the amount of soil available for erosion, or the efficiency of delivery of sediment from the catchment surface to the river channel through greater connectivity.

The timing of **land use activities** can result in temporal variability of vulnerability of soils to erosion. There are high risk times in cultivation such as around planting and following harvesting. Use of farm machinery when soils are wet can put them at risk of accelerated erosion.

An understanding of what land uses are present and how well-connected they are to the river channel can help to highlight possible risks of accelerated sediment delivery and greater sediment loads in your catchment.

Land use / agriculture

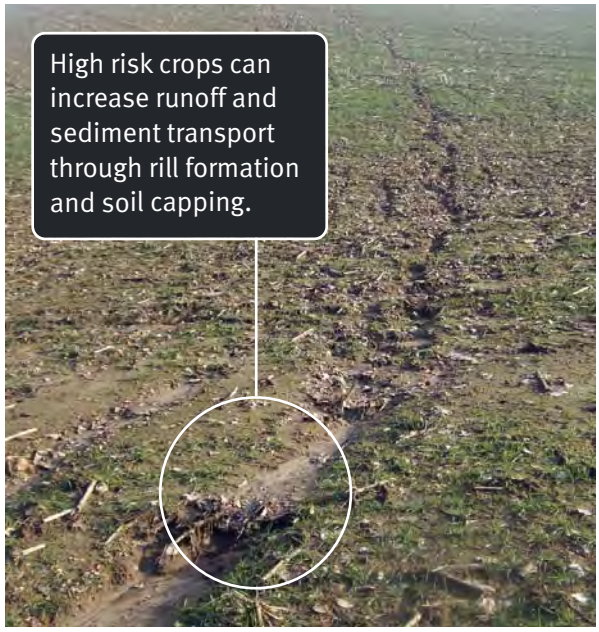
High risk crops?

Some land uses are high risk for soil erosion and runoff. They include:

- Late sown winter cereals
- Potatoes
- Sugar beet
- Field vegetables
- Outdoor pigs
- Grass re-seeds
- Forage maize
- Outwintering stock
- Grazing forage crops

These (crops) activities can result in damage to soils and, particularly where there is poor management can lead to accelerated erosion and greater sediment loads in the river channel. For example, harvesting root crops in wet conditions can lead to soil compaction. Similarly, downslope rows between maize and potato crops can channel increased runoff and erosion towards the river.

Look out for these land uses as they may indicate a 'hotspot' of sediment supply.



Horticulture?

Horticulture can potentially promote soil erosion and runoff, even on shallow slopes.

Plastic tunnels can reduce the area of a field that is available for infiltration and concentrate runoff into the narrow pathways between the rows. These pathways may also be compacted.

Downslope transport of excess runoff via these compacted pathways can increase the energy available for erosion and sediment transport and lead to rill development. Muddy runoff may be transmitted more efficiently to the river channel and boost sediment loads.

Land use / agriculture

Bare fields?

Lack of crop cover can put soils at risk of erosion, surface capping and runoff. This can increase the sediment load of a river.

Winter cereals sown during late October and November can put the land at risk due to the exposed soil surface at periods of high rainfall.

Catchments with sandy and light silty soils are particularly prone to erosion.

Impacts are likely to be worse when rainfall intensity is highest or in winter when soils are wet.

Look out for bare fields during wet weather.

Smooth seedbeds?

Fine, smooth seedbeds limit the amount of rainfall that can be stored on the catchment surface. The catchment surface may also become capped, especially on sandy and light silty soils.

The opportunity for runoff and soil erosion to transport sediment to the river channel is therefore increased.

Fine, dry, sandy tilths (for example for carrots, onion and sugar) are also vulnerable to wind erosion.

Look out for smooth seedbeds in wet weather.

Land use / agriculture

Soils compacted by machinery at the farm gate. Runoff occurs more quickly and potential for erosion increases

Compaction?

Soil can become compacted when land is worked when it is wet and by heavy machinery and loads. For example, harvesting and sowing in wet conditions can lead to compaction and development of wheelings.

Compacted soil reduces rainfall infiltration and increases runoff. More energy is therefore available for eroding and transporting sediment to the river channel.

Look out for evidence of compaction such as surface water or runoff in wet weather.

Land use / agriculture

Big fields?

Hedgerow removal to accommodate farm machinery and increase efficiency has led to an increase in field size in the UK.

Longer slopes increase the energy available for runoff and erosion and the connectivity between the field and the river. Valley floors can accumulate water and lead to rill development. Sediment loads may therefore rise as a result.

Riparian buffer zones and cross-slope interceptors such as beetle banks can help to reduce the effect of big fields on runoff and sediment delivery. However, these measures are only partially effective and can be breached. Buffer strips need to be appropriately sized and will not work in light soils and steep catchments.

Look for evidence of big fields and for evidence of management such as buffer strips. Check to see if these are intact – they may be breached by pathways to the river channel.

Land use / agriculture

Outdoor pigs?

Trampling of the soil surface by outdoor pigs can lead to soil damage such as compaction and sealing of the surface. Rills and gulleys may develop where flow is concentrated.

This means that high amounts of erosion and runoff leading to higher sediment loads in watercourses can occur even where slopes and rainfall are moderate.

Land use / agriculture

Grazing?

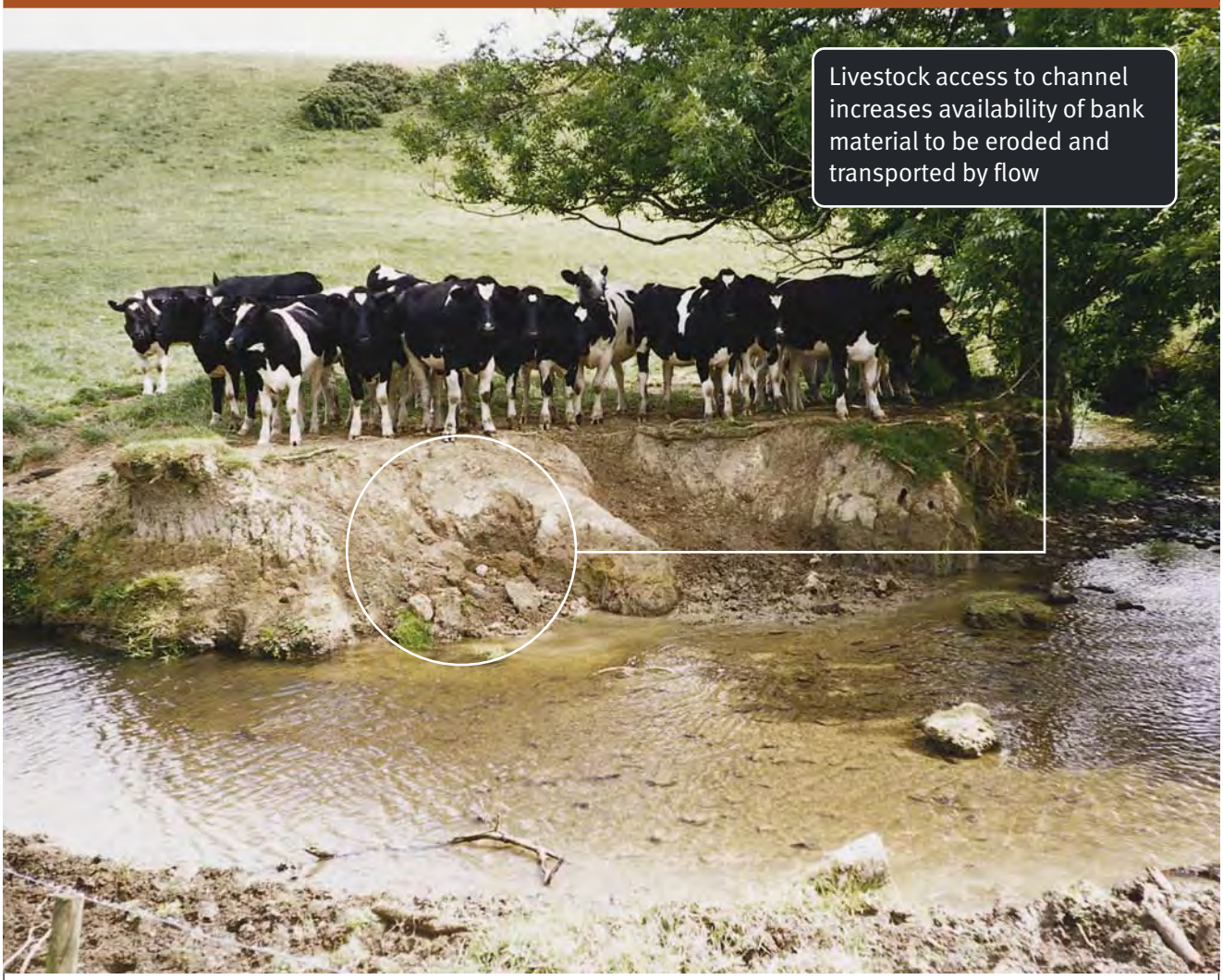
Poaching by stock can lead to erosion and runoff on grazing land and can increase the sediment load of the river.

Poaching is especially problematic where soils are wet or land is grazed during the winter. High stocking densities can also increase sediment delivery.

Grazing land can be deceptive – it can look as if accelerated sediment delivery is not a problem. However, the transformation from healthy pasture to mud can take just two to three days in wet periods and the soil may have already become badly compacted.

As a guide, if hoof marks from cattle appear, which are deeper than 50 mm (two inches) soil erosion could be a problem. However, problems can be present when no poaching is evident. This is often the case with sheep-grazed pasture.

Land use / agriculture



Stock access to the river channel?

Livestock access to the river bank for drinking, shade or crossing can lead to accelerated sediment supply to the river channel.

Livestock poaching can compact riparian areas and promote soil erosion and runoff. Channel access can lead to bank degradation and collapse and erosion of the channel bed. Localised sedimentation may occur.

Livestock access to the river bank may also increase the input of sediment-associated pathogens and present a risk to amenity use of the river.

Land use / agriculture

Out-wintering stock?

Out-wintering of stock runs a high risk of causing soil compaction and runoff, leading to higher sediment loads in watercourses.

Stock feeding can trample soils, leading to compaction and sealing. Trafficking can lead to development of pathways for runoff and the potential for rill development.

These impacts are exacerbated by higher winter rainfalls that provide energy for erosion and runoff.

Land use / agriculture

Field drainage?

Field drainage increases the connectivity between the catchment surface and the river channel. It can be rapid or slow.

In some cases, drainage ditches and tile drains can take muddy water rapidly from the field to the river.

Drainage grips (shallow drainage ditches) may be used to help drain water from the surface of fields into ditches. Drainage grips are an important mechanism by which upland moorland is drained.

In others, subsurface field drains can allow slow percolation of muddy water to the river, especially when they collapse or crack. This keeps river sediment loads in the river channel higher for longer and rivers can appear muddy for some time after rainfall events. Subsurface drainage can provide a direct and continuous connection to the river.

Land use / agriculture

Yard drainage?

Hard surfaces around farm buildings will reduce infiltration and increase runoff. Surfaces may be muddy due to movement of livestock or farm machinery. Runoff and drainage of farm yards may provide a pathway for transport of the available mud into the drainage system.

Land use / agriculture

Wheelings and rills and tracks?

Routes such as wheelings, rills and farm tracks provide pathways for muddy runoff and rapid delivery of sediment from the field to the river channel. They convey the sediment eroded from the catchment surface to the river.

These pathways can link fields with watercourses that are kilometres apart and increase the hydrological connectivity of the catchment. They also act as key sediment sources.

Research shows that these pathways may cover less that three per cent of the catchment surface but may be responsible for most of the sediment load.

Identification of key pathways is essential to build an understanding of how and where eroded sediment reaches the river channel. Remember, the pathways may change as new crops are cultivated each year.

Land use / agriculture

Road verge erosion?

Large and heavy farm machinery can damage unprotected grass verges on rural roads. Traffic can expose or compact soils and increase the opportunity for erosion and runoff.

Roads provide pathways for runoff and sediment transport and can convey muddy runoff quickly towards the river channel or towards adjacent fields, causing further erosion.

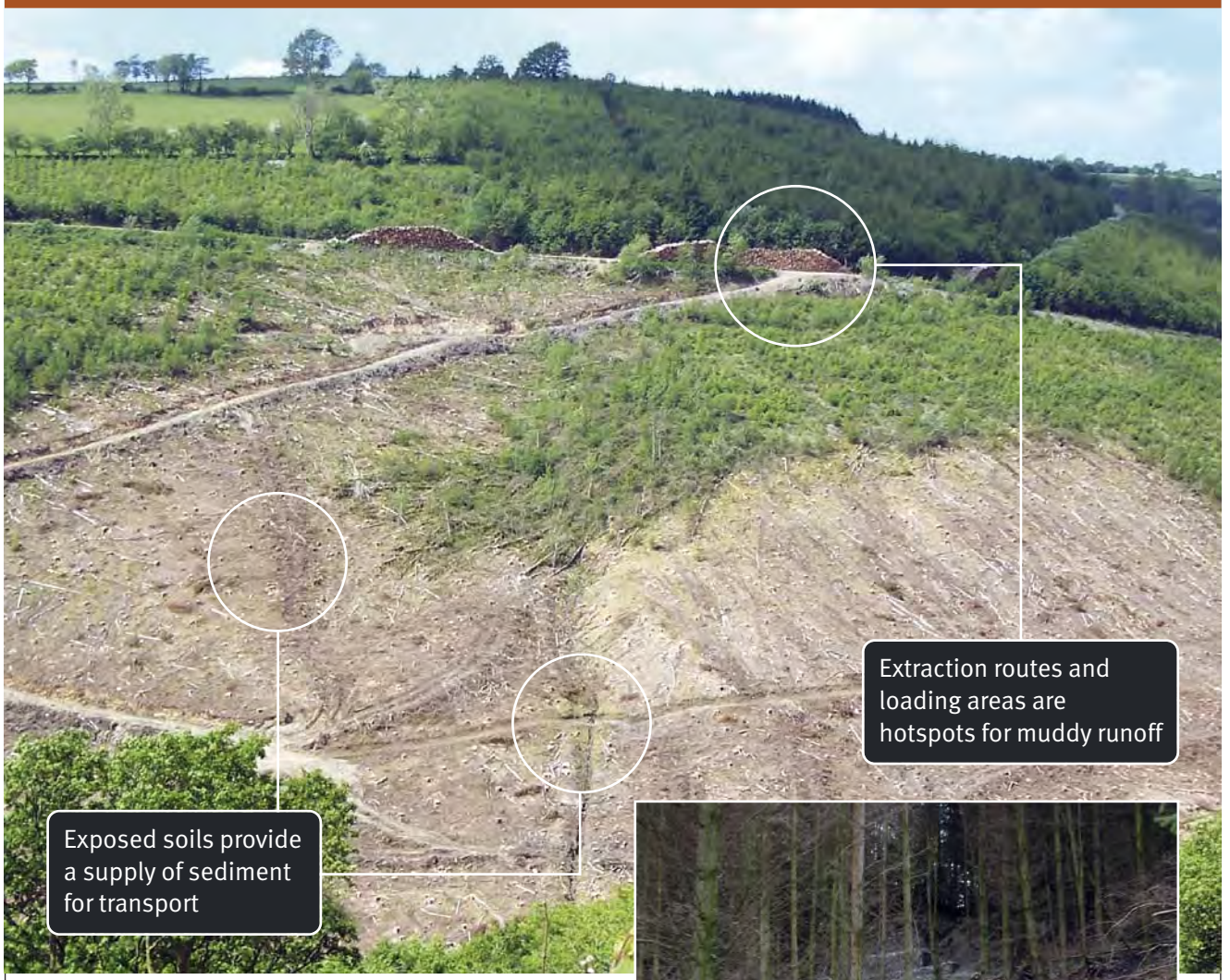
Land use / agriculture

Storage and spreading of slurry and manures?

Unwise storage and spreading of slurry and manures can lead to runoff of sediments rich in organics and create water quality problems if delivered to the river channel.

For example, untimely spreading in wet conditions, or spreading on compacted soils may cause problems downstream.

Land use / agriculture



Forestry?

Forestry, in particular broad-leafed forestry, can provide a dense canopy cover that can protect the catchment surface and channel banks from soil erosion. It can protect slopes that would otherwise be at risk of erosion and reduce the inputs of sediment and sediment-associated contaminants to the river channel.

There are risks associated with plantation forestry activities. Forestry tracks and drainage grips can provide pathways for the transport of muddy runoff. Extraction routes and landing areas are particular hotspots. Soils may become exposed during forest clearance and make sediment readily available for transport along forest tracks.

Suitable drainage, ground preparation, machinery and timing of operations are necessary to minimise potential impacts.

Speak to the Forestry Commission to find out about the Forest Design Plans and management plans in your catchment.

Land use / agriculture

Your Catchment

Find out

- The types and patterns of land use in your catchment. Be particularly aware of land use adjacent or linked to river channels.

Look at

- Environment Agency Easimap layer on the i: drive. The pathway is: *Master Map and Air Photos layer, Aerial Photography*. Also add the Detailed River Network from the Hydrology layer. The scale is 1:25 000 so pan around to see the catchment.
- Environment Agency Map Explorer on the i: drive. The pathway is: *Landcover* – look at the distribution and extent of each type.
- Environment Agency Regional Information Hub on the n: drive, for example for Anglian Region. Look in the Water Resources section.
- Websites such as Google Earth.
- Reports for background information such as CAMS, CFMP.
- Your catchment – get to know your catchment by driving or walking around it and take photographs.
- Rural sediment tracing reports.

Speak to

- Environment Agency Teams – FRB, Environment Officers.
- Other Environment Agency officers such as the local Catchment Sensitive Farming officer or Catchment Coordinators.
- Local residents such as landowners and farmers.
- Forestry Commission.

For more information

- Defra website, *http://www.defra.gov.uk/food-farm/land-manage/*.
- Environment Agency *Think Soils* manual.
- Environment Agency FARMS database, for example for stocking densities and manure practices
- See also: Resource Protection measures: *A practical Guidebook for Natural England policy and advisory staff* by Malcolm Newson. Resource Protection measures: Aggravated erosion and freshwater habitat siltation: definition, identification, remedial actions.

Land use / urban

Muddy puddles are evidence for the movement of sediment along roads. Sediment may be stored and transported during the next runoff-generating storm.

Roads?

Roads provide a transport route that can deliver runoff rapidly from the catchment surface to the river channel, particularly when they lie parallel to the direction of greatest slope. Impermeable road surfaces and drains that run alongside them are important pathways. Road runoff can increase the flashiness of a hydrograph and energy available for in-channel erosion and sediment transport. The impact is greater if the road network is dense.

Roads can also act as a source of sediment. Erosion of road verges by heavy vehicles can increase sediment supply. Car exhausts can supply dust and solids. Particles can come from tyres and breaks. Chemicals and grit used for maintenance of roads as well as debris of variable composition from road accidents can accumulate along roads and can then be washed into the river during rainstorms. This can occur on all types of roads including rural roads and high speed roads that have drainage.

As a result, sediment washed from roads may be contaminated with metals, chemicals or nutrients and have an impact on channel ecology.

Land use / urban

Roads are efficient pathways for runoff which can have high energy to transport sediment

Urban surfaces?

Urban areas have a greater proportion of hard impermeable surfaces. These surfaces prevent infiltration of rainfall into the ground and also provide pathways for efficient runoff from the catchment surface to the river channel. Urban runoff can increase the flashiness of a hydrograph and the energy available for in-channel erosion and sediment transport.

Urban surfaces include roads, developed areas and roof runoff. Paved front gardens have reduced infiltration in urban areas further.

Land use / urban

Urban drainage?

Drains can concentrate flow and deliver runoff to the river efficiently. They provide rapid transport pathways. Drain runoff can increase the flashiness of a hydrograph and energy available for in-channel erosion and sediment transport.

Where there are combined drains, combined sewer overflows (CSOs) are a potential source of suspended solids.

Sustainable drainage techniques (SuDS) are increasingly being applied to manage drainage. These techniques manage the flow of runoff from urban surfaces and can include features that retain flow and associated sediment.

Further information can be found at:

http://www.environment-agency.gov.uk/business/sectors/39909.aspx

Land use / urban

Floodplain development?

The pressure for land for development means floodplains have been used to provide land for housing and industry. Developments can also be associated with flood risk management which holds water within the river channel.

Such development decreases the space for water to flood as part of the river's natural mechanism for dealing with high flows.

A reduced floodplain decreases the natural overbank sediment store. There may therefore be an increase in sediment retained in the channel and more opportunities for channel erosion due to higher flood flows.

Land use / urban and industry

Industrial inputs?

Discharges such as effluent from industry into the river will increase flow. This can increase the flashiness of a hydrograph and the energy available for in-channel erosion and sediment transport.

Discharges may also input sediment directly into the river.

Other factors such as organic content and temperature of discharges may also have an impact on sediment and its impacts.

Minerals / quarrying?

Mining activity in the catchment can input water into the river through dewatering (pumping emerging groundwater). The water will increase flow and the energy available for in-channel erosion and sediment transport.

Mineral extraction may require washing of material to separate size fractions such as sand. Fine material removed in the washing process is removed by settling in ponds which may be linked to the river channel.

Construction?

Construction activities can provide a temporary source of sediment or runoff if they are not managed according to best practice guidelines.

Land use / urban and industry

Your Catchment

Find out

- The nature and extent of urban land uses in your catchment. Road types, their density and their direction in relation to the natural slope of the land. The URBEXT figure from the National Flow Archive can provide an overall indication of the urban influence.

Look at

- Websites such as Google Earth.
- Reports for background information such as CAMS, CFMP, RBMP.
- Your catchment – drive or walk to your catchment and take photographs.

Speak to

- Environment Agency teams – the Area Development Control team will help you find information on licences, consents and best practice guides for construction, quarrying and mineral extraction.
- Other Environment Agency officers such as the Catchment Sensitive Farming officer or Catchment Coordinators.
- Local residents such as landowners and farmers.
- Highways Agency for gulley sucking records for roads.

Channel use / accelerated erosion

Accelerated erosion?

Channel bank erosion is a natural process that over long timescales has resulted in the formation of river channel form, floodplains and alluvial terraces. It is part of the ongoing adjustment of river systems to the inputs of flow and sediment to the channel.

Land use and river management can change the inputs of flow and sediment and destabilise the natural adjustment of the river system. Instability can trigger erosion responses. The responses can be complex and can result in accelerated rates of erosion of the channel bed and banks that are out of step with the river's natural processes.

Erosion can be accelerated by factors that include:

- Over-clearing of catchment and riparian vegetation
- Poorly managed sand and gravel extraction
- Channel engineering
- Poorly managed stock grazing e.g. riparian poaching
- Increased runoff from the catchment surface due to land use changes e.g. urban surfaces, inappropriate farming practices
- In-stream structures such as weirs and bridges
- Burrowing animals such as crayfish
- removal of trees in upland areas from formally wooded ghylls.

Channel use / accelerated erosion

Your Catchment

Find out

- Evidence for active channel bank erosion that is accelerated due to human influence. Look for factors that could be promoting bank erosion.

Look at

- River Habitat Survey data and GeoRHS data for your catchment.
- Aerial photographs, images on Google Earth, www.flashearth.com and Local.Live.com, LiDAR data
- Drive or walk around the catchment and take photographs.
- Reports such as CAMS, CFMP, RBMP.

Speak to

- Environment Agency – Development Control, FCRM Asset Systems Management team, Area FRB team, Regional navigation team.
- Other Environment Agency officers e.g. Catchment Sensitive Farming officer or Catchment Coordinators.
- Other stakeholders e.g. landowners.

For more information

- Guidebook of *Applied Fluvial Geomorphology*.
- E-learning introduction to geomorphology at *http://e-learning.geodata.soton.ac.uk/EA/*.

Channel use / channel engineering

Channel engineering?

Channels are engineered for a range of reasons that include flood risk management, navigation and water resource management.

Channel modifications as a result of engineering include canalisation, re-sectioning, re-alignment and culverting. These modifications alter the natural function of the river system and can have impacts on sediment dynamics for some distance upstream and downstream.

Modifications alter the natural response of the river to increased flow following rainfall. Engineered channels are likely to transport flow more efficiently and to reduce linkage between the river channel and the floodplain. Channel bank sediment sources may become unavailable due to hard surfaces.

Engineered channels can therefore destabilise the sediment system. The impacts can be minor or extensive. For example, canalised reaches may promote accelerated erosion and associated deposition in reaches upstream and downstream. In-channel structures such as weirs may promote upstream deposition and downstream erosion. Reservoirs may cause attenuation of sediment and downstream erosion.

Channel use / channel engineering

Your catchment

Find out

- Locations of engineering intervention to the river channel. Identify if there are stretches of the river where flow is being managed.

Look at

- MapExplorer. The pathway is *Idrive, National, Physical, Hydrology, River_obstructions.shp*.
- River Habitat Survey data and GeoRHS data for your catchment.
- Aerial photographs, images on Google Earth, *www.flashearth.com* and *bing.com/maps*, LiDAR data.
- Drive or walk around the catchment and take photographs.
- Reports e.g. CAMS, CFMP, RBMP.

Speak to

- Environment Agency Teams – National Fisheries Monitoring team, FCRM assets team, area FRB team, regional navigation team.

Channel use / flood risk management

Flood risk management

Measures taken to manage flooding involve changes to channel bed, banks and planform.

Management may increase the capacity of the river channel to contain water by widening, deepening or raising banks. Engineering may straighten channels or reinforce the beds or banks.

Naturally a river in flood will spill excess water onto its floodplain, depositing sediment as part of the process. Measures to manage flooding may retain this sediment within the river channel.

Such changes can cause instability in a river's natural processes and lead to problematic erosion and deposition of sediment upstream and downstream.

The Environment Agency's WFD Mitigation Measures Online Manual is designed to help practitioners identify measures to mitigate the adverse effects on the environment of flood risk management and land drainage activities. This can be found at: *http://evidence.environment-agency.gov.uk/FCERM/en/SC060065.aspx*

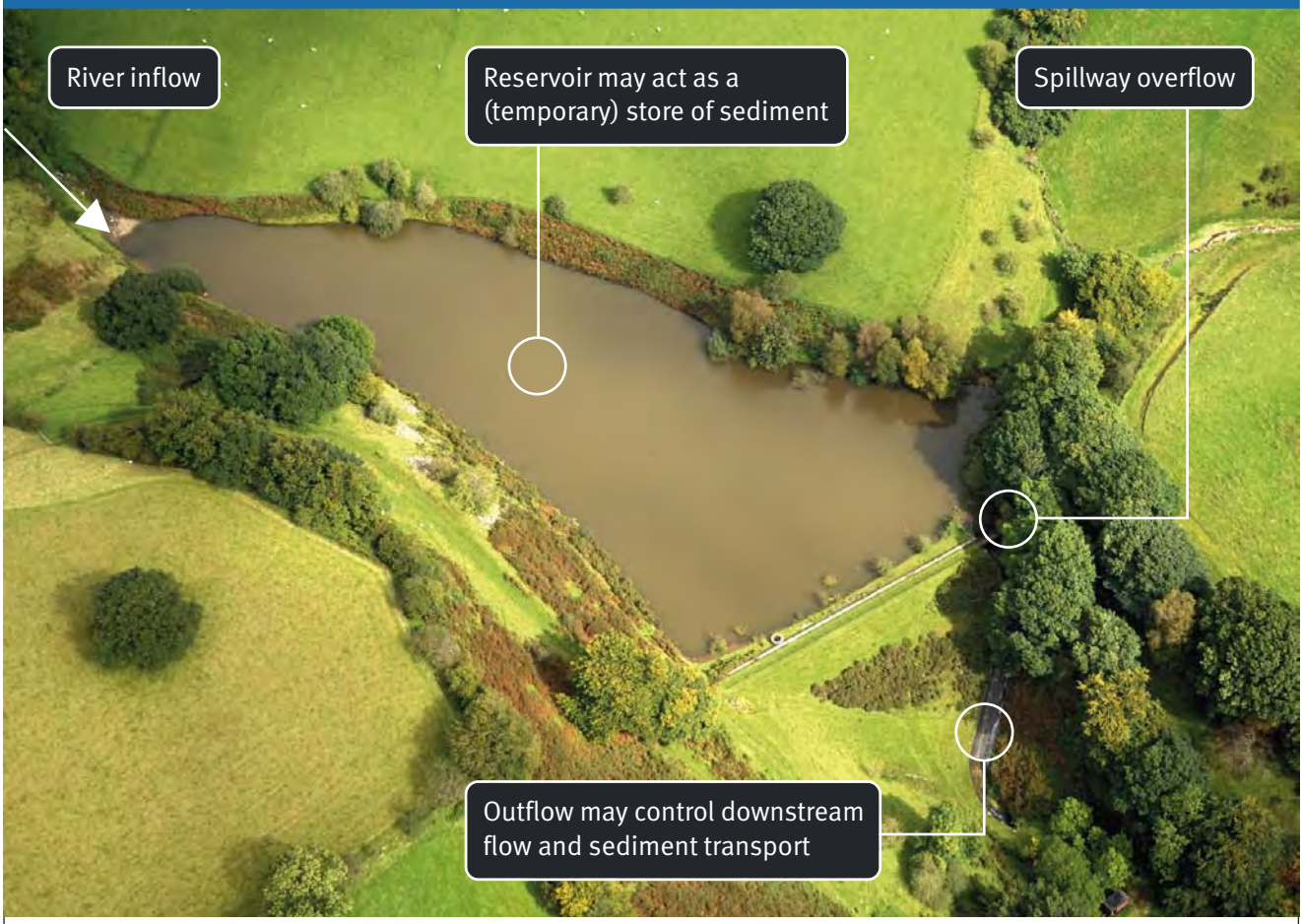
Channel use / water level management

Water level management

Water levels can be managed for a number of reasons. For example, levels may be managed for the benefit of the environment or for industrial use such as water mills.

Levels are typically managed using sluices. Water backing up behind these structures can lead to localised sediment deposition and restrict the downstream flow of water and sediment.

Channel use / water resource management



Typical impounding reservoir

Water resource management

The use of the river for water supply can take the form of storage or abstraction.

Storage of water within a catchment is usually in reservoirs which may be stores of sediment. Reservoirs will also control the downstream flow of water in a catchment. Reservoirs often reduce the supply of sediment downstream that can lead to greater channel erosion especially during high releases.

Abstraction of water from the river or from groundwater sources will usually not impact on the river at higher flows but can be an issue with low flows and lead to greater sediment deposition. Controlled releases can be used to wash out accumulated sediments.

High sediment loads can limit abstraction potential.

Channel use / navigation management

Navigation management

Management of the river for navigation can involve clearing the channel by dredging to ensure the water is sufficiently deep for boats to pass. Increasing channel capacity in this way can, however, slow flow and encourage further sediment deposition.

Management can involve attempts to control sediment sources and rate of supply.

Water levels can also be managed for navigation using locks (possibly in combination with weirs). These can restrict the downstream passage of water and lead to localised sediment deposition.

Your Catchment

Find out

- Whether FCRM (asset management, operations delivery), flood defences, water level management, navigation and water resource management are carried out in your catchment. The release regime from reservoirs is always worth looking at to see if it can be improved to manage sediment problems better. Try to find out their influence on sediment dynamics.
- Quantity and quality of sediments from dredging disposal records.

Look at

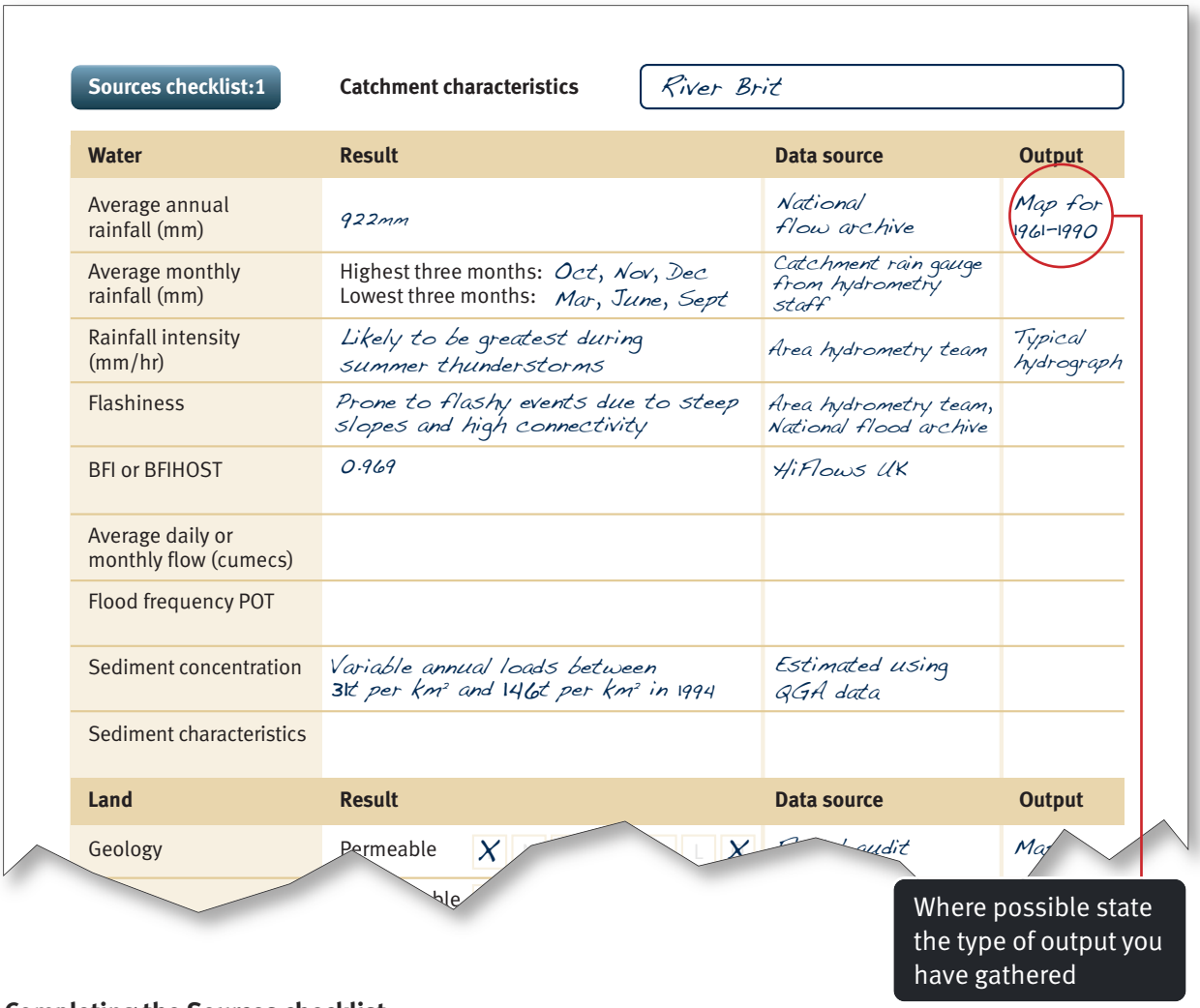
- Reports for background information such as CAMS, WLMP, CFMP, RBMP.

Speak to

- Environment Agency Teams – Area FCRM (asset management, operations delivery), Area FRB team and Regional navigation team.
- Other Environment Agency officers such as the Catchment Sensitive Farming officer or Catchment Coordinators.
- Local residents such as landowners.

Sources checklist

Use the sources checklist to record the findings of your investigation for catchment characteristics and sediment source types. It will provide a summary of the sediment sources in your catchment.



Sources checklist:1 **Catchment characteristics** River Brit

Water	Result	Data source	Output
Average annual rainfall (mm)	922mm	National flow archive	Map for 1961–1990
Average monthly rainfall (mm)	Highest three months: Oct, Nov, Dec Lowest three months: Mar, June, Sept	Catchment rain gauge from hydrometry staff	
Rainfall intensity (mm/hr)	Likely to be greatest during summer thunderstorms	Area hydrometry team	Typical hydrograph
Flashiness	Prone to flashy events due to steep slopes and high connectivity	Area hydrometry team, National flood archive	
BFI or BFIHOST	0.969	HiFlows UK	
Average daily or monthly flow (cumecs)			
Flood frequency POT			
Sediment concentration	Variable annual loads between 31t per km² and 146t per km² in 1994	Estimated using GGA data	
Sediment characteristics			

Land	Result	Data source	Output
Geology	Permeable X	audit	Ma

Where possible state the type of output you have gathered

Completing the Sources checklist

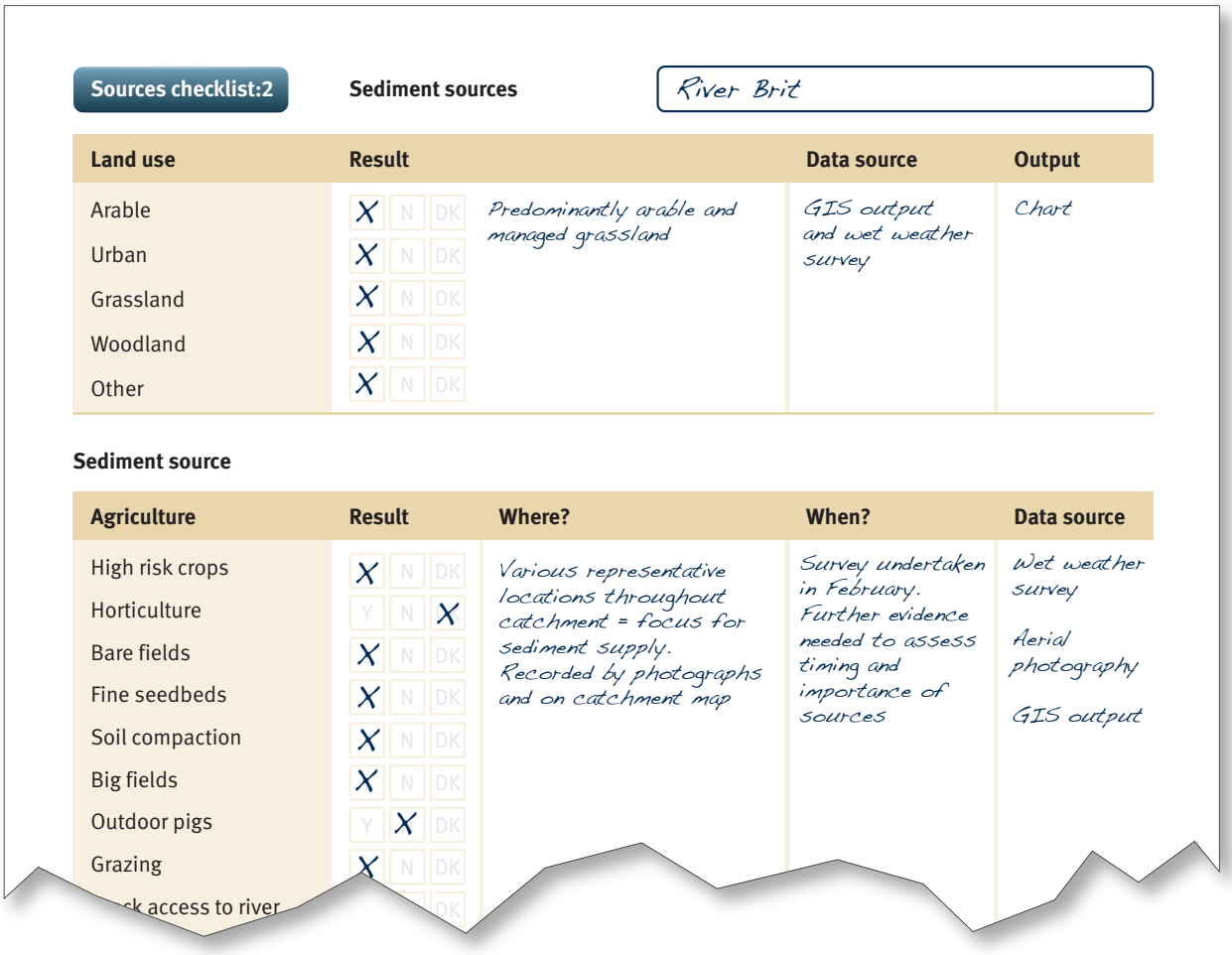
The checklist provides a summary of your findings for each catchment characteristic and sediment source type identified in the handbook.

The first page is a record of the existing available information on the understanding of sediment related catchment characteristics. It will also provide a summary of the data sources you used to develop this understanding.

- Use the blank checklist provided on the accompanying resource CD.
- Record the results of your investigation for each of the catchment characteristics.
- Record your data sources for each catchment characteristic.

Sources checklist

Sources checklist Part2



Sources checklist:2 **Sediment sources** River Brit

Land use	Result		Data source	Output
Arable	X N DK	Predominantly arable and managed grassland	GIS output and wet weather survey	Chart
Urban	X N DK			
Grassland	X N DK			
Woodland	X N DK			
Other	X N DK			

Sediment source

Agriculture	Result	Where?	When?	Data source
High risk crops	X N DK	Various representative locations throughout catchment = focus for sediment supply. Recorded by photographs and on catchment map	Survey undertaken in February. Further evidence needed to assess timing and importance of sources	Wet weather survey Aerial photography GIS output
Horticulture	Y N X			
Bare fields	X N DK			
Fine seedbeds	X N DK			
Soil compaction	X N DK			
Big fields	X N DK			
Outdoor pigs	Y X DK			
Grazing	X N DK			
ck access to river	DK			

Completing the Sources checklist

The second page will help you to understand what the likely sediment sources are in your catchment and how they function.

- Record the result of your investigation for each of the sediment sources.
- For each sediment source choose from:

  Yes: The evidence suggests that the sediment source is present.

  No: The evidence suggests that the sediment source is not present.

  Don't know: The evidence is insufficient or unavailable to identify or rule out a sediment source.
- Try to include information about the location and timing of sources where possible.
- Record your data sources for each sediment source type.

Use the sediment sources section of the Sources Checklist to complete the Problems Checklist and help you to understand your sediment problem in Section 3.

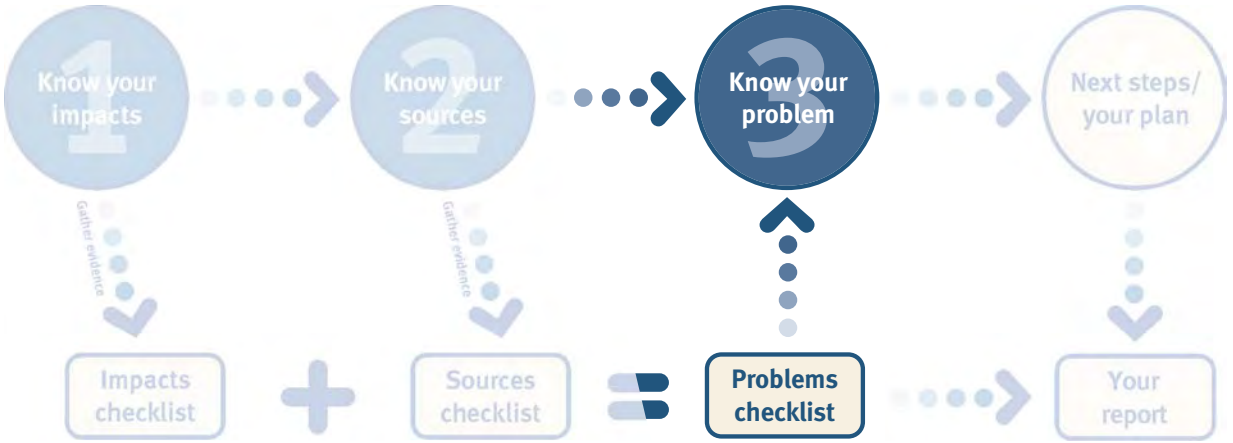
Know your problem

Understand sediment problems in your catchment

Know your problem

Find out about the sediment problems in your catchment. This will give you an understanding of how, when and where sediment matters and help you to work out what to do next.

You are here



Use this section to understand sediment problems in your catchment

- Sediment can be a problem where a link between sediment impacts and sediment sources can be identified.

Complete the Problems checklist

- Use the Impacts Checklist from Part 1 and the Sources Checklist from Part 2 to complete the Problems Checklist in this section. This will help you to identify key receptors and sources and understand how sediment matters in your catchment.

Identify and plan opportunities for monitoring and management

- You may not have all the answers yet. Use your Problems Checklist to identify where you need to find out more about sediment impacts and sources. A range of monitoring techniques to help you is provided in the 'need to know more' section.

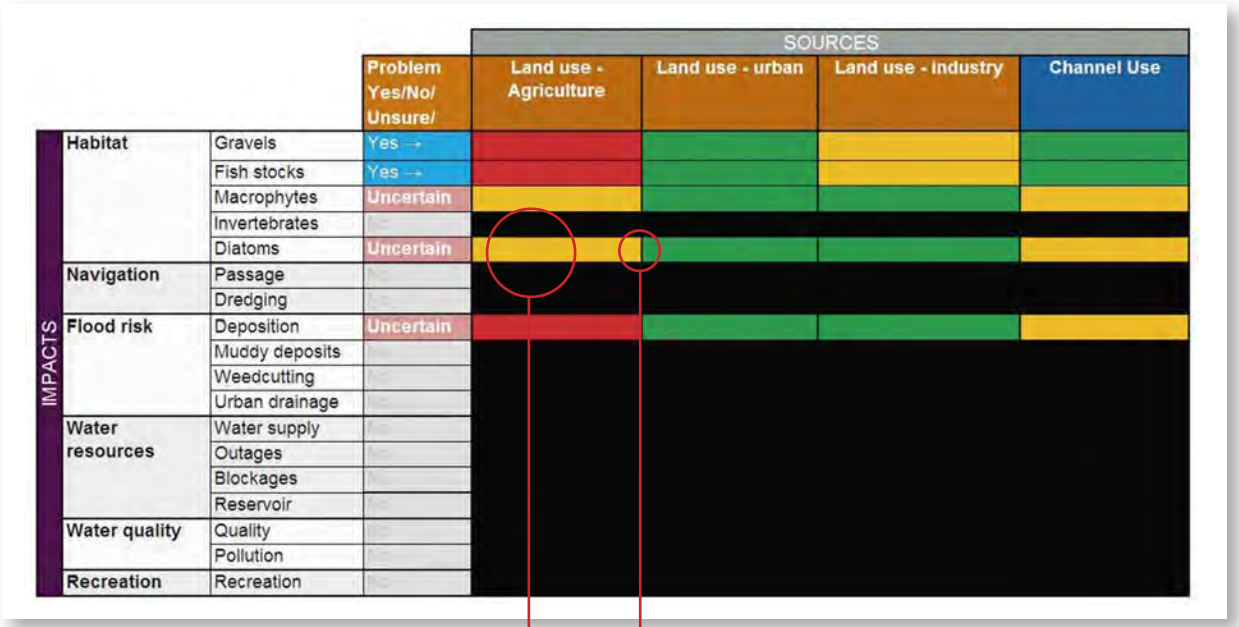
Communicate your findings

- Use your findings to influence integrated, multi-benefit sediment management in your catchment.

Remember, sediment matters in your catchment where sediment sources can be linked to sediment impacts. Sources are most important when there is clear linkage to the river channel.

Problems checklist

You will now have completed the Impacts checklist and the Sources checklist. Your findings can now be used to link sediment impacts to sediment sources and understand the sediment problems in your catchment using the Problems checklist.



For each potential impact, identify the potential source to give an assessment of the overall sediment problem in your catchment

Use the drop-down menu to input your findings

Completing the Problems checklist

Your findings can now be used to link sediment impacts to sediment sources and understand the sediment problems in your catchment using the Problems checklist.

Use the Problems checklist to understand why, where and when sediment matters in your catchment. It can help you to work out the most important sediment-related issues and to identify and plan management opportunities.

The Problems checklist is a visual tool that will help you to begin to link sediment impacts with sediment sources based on their location within the catchment. Sources are most important when there is clear linkage to the river channel.
The Problems checklist will help to summarise which sources are upstream of your impacts and which are linked to the river channel. Such sources are most likely to help explain your problem and give you a clearer understanding of when, where and why sediment matters.

Use the Problems checklist to understand where you need to know more. It can help you to identify and plan monitoring opportunities.

The value of the checklist to the user is significantly improved if a spatial, GIS, file is created to record impacts and sources spatially (e.g. the Local Issues tool developed by the National Research team). This handbook provides a range of techniques that could help you with further investigation of sediment impacts and sources.

Need to know more?

Use this section if you need to know more about sediment impacts, sediment sources or sediment problems in your catchment.

The Problems Checklist will have helped you to understand why, where and when sediment matters in your catchment and to identify where you need to know more. This will help you to make informed decisions for future management and monitoring of sediment in your catchment.

This section presents a range of techniques that can help you to find out more about sediment matters in your catchment. The techniques may relate to sediment impacts or to sediment sources or could relate to both. They vary in cost and complexity from simple wet weather reconnaissance to detailed sediment modelling and fingerprinting.

Use the summary table opposite to help you to decide what techniques might be right for your catchment. You can then refer to the individual techniques pages for further information. Help on individual techniques and the selection of techniques can be provided by the Process Help Desk *(http://intranet.ea.gov/knowledge/enquiries/processhelpdesk)*

Low cost techniques are simple and may be useful if:

- an improved overall understanding of sediment impacts and sources is required.

For example: You have completed sections 1 and 2 and suspect there is a sediment issue in your catchment but haven't identified impacts or sources.

Low to medium cost techniques are more complex and may be useful if:

- an improved understanding of specific sediment sources or impacts is required.
- the watercourse is sensitive or at risk of significant sediment impacts.

For example: You have completed sections 1 and 2 and suspect there is a sediment issue in your catchment but have insufficient evidence to take mitigation action.

Medium to high cost techniques are complex and may be useful if:

- a detailed understanding of specific sediment sources or impacts is required.
- the watercourse is particularly sensitive or at high risk of significant sediment impacts.

For example: You want to have more certainty about the source of your sediment in order to persuade others to change their behaviour and/or undertake costly mitigation action.

Need to know more?

Low cost techniques

Techniques	Impacts	Sources	Number
Anecdotal evidence	•	•	1
Catchment surveillance	•	•	2
Wet weather survey	•	•	3
Aerial survey	•	•	4
Repeat fixed point photography	•	•	5
Channel cross-section survey	•		6

Low - to medium - cost techniques

Techniques	Impacts	Sources	Number
Bed sediment analysis - bed trap	•		7
Bed sediment analysis - grab samples	•		8
Bed sediment analysis - core samples	•		9
Bed sediment analysis - re-suspension	•		10
RHS and GeoRHS	•		11
River Corridor Survey	•		12
Electrofishing	•		13
Redd surveys	•		14
Kick samples	•		15
PSI and RIVPACS	•		16
Floodplain deposition		•	20
Flow estimation		•	21
Spot samples		•	22
Turbidity and flow monitoring		•	23
Bank erosion		•	24
Rapid geomorphological assessment		•	25
Winter sediment runoff audit		•	26

Medium - to high - cost techniques

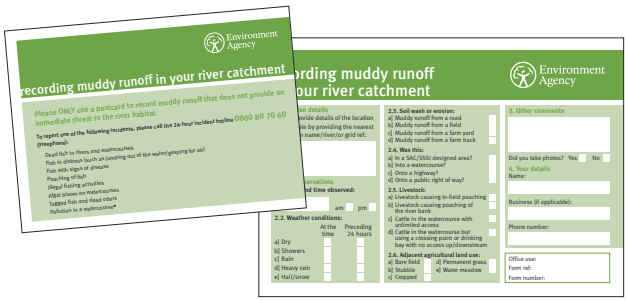
Techniques	Impacts	Sources	Number
Core samples - invertebrates	•		17
Grab samples - invertebrates	•		18
Sediment oxygen demand	•		19
Sediment particle size analysis		•	27
Fluvial audit		•	28
Sediment fingerprinting		•	29
Predictive models		•	30

1 Anecdotal evidence

Anecdotal evidence

The observations of people living and working within the catchment can provide important evidence of sediment sources, movement and deposition, especially during less frequent storm events.

Evidence from farmers, for example, can provide useful detail on the supply of sediment from the field to the river. This can include formal reports of muddy runoff such as using the 'recording muddy runoff in your catchment' postcard system



Possible groups for contact could include:

- long serving members of staff
- local residents
- parish groups
- recreational users of the river
- rivers trusts
- conservation groups.

The Environment Agency's area public relations officer is recommended as the initial point of call.

What do you get?

Evidence tends to be qualitative and can vary in detail. Information may cover concerns about specific, localised movement or deposition of sediment relating to particular rainfall events e.g. reported occurrences of muddy roads or long-term changes in catchment characteristics such as land use, ecology or flows. Useful for developing a broad, initial understanding of the catchment and sediment issues.

Where possible, information should be verified through follow-up work.

When do you use it?

Use it as a first-step when you need to improve your understanding of sediment sources, pathways and stores in the catchment and to help target monitoring. The survey can be used to identify links between the catchment surface and river channel, that is, to map the ephemeral drainage network.

Spatial scale

Likely to be field scale or river reach scale.

Temporal scale

Can range from storm specific to longer term landscape change.

Who can do it?

Environment Agency staff such as Environment Officers, CSF or FRB staff with some understanding of sediment dynamics.

Costs

Low cost – staff time and vehicle or telephone costs.

2 Catchment surveillance

Catchment Surveillance

A reconnaissance survey in the catchment is usually done by driving or walking and making observations of sediment related features, where access is possible. The survey is best done during wet weather or following wet weather.

The survey can help to confirm features and observation made from desk studies.

Take a camera to record evidence, noting the location of any pictures

Things to look our for:

- land use.
- evidence of erosion in fields.
- river uses.
- evidence of deposition of sediment in the river.
- pathways that link the field to the river.
- land management that restricts linkage between the field and the river, such as buffer zones and beetle banks.

What do you get?

A catchment surveillance run is useful for developing a general understanding of sediment sources, pathways and stores in the catchment, particularly during wet weather to map sediment delivery pathways. The survey can help to confirm understanding that has been gained from desk studies. It may identify specific sediment issues and help to target further detailed investigations. This is a complementary method to the desk study.

Observers will require some understanding of source, transport pathways and depositional features.

Spatial scale

Catchment scale to potentially river reach scale.

Temporal scale

Fixed point in time - a 'snapshot' approach
Carry it our during wet weather if possible.

Who can do it?

Environment Agency staff such as Environment Officers and FRB staff with some understanding of sediment dynamics.

Costs

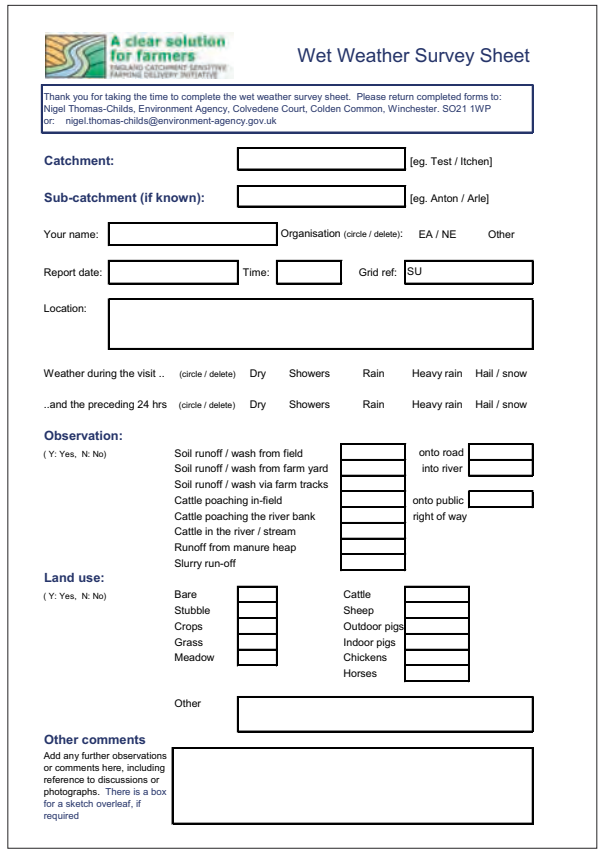
Low cost – staff time and vehicle.

3 Wet weather survey

Wet weather survey

The majority of sediment moves through a catchment in response to rainfall-runoff events. An understanding of sediment sources and transport pathways can be gained from a wet weather survey. The survey involves driving around the catchment to identify where muddy runoff is occurring and to identify the pathways where runoff is connected to the river channel.

The survey can be backed up with photographs and sampling which can be used for example to determine concentrations of sediment in runoff.



A clear solution for farmers
ENGLAND CATCHMENT SENSITIVE FARMING DELIVERY INITIATIVE

Wet Weather Survey Sheet

Thank you for taking the time to complete the wet weather survey sheet. Please return completed forms to:
Nigel Thomas-Childs, Environment Agency, Colvedene Court, Colden Common, Winchester. SO21 1WP
or: nigel.thomas-childs@environment-agency.gov.uk

Catchment: [eg. Test / Itchen]

Sub-catchment (if known): [eg. Anton / Arle]

Your name: Organisation (circle / delete): EA / NE Other

Report date: Time: Grid ref: SU

Location:

Weather during the visit .. (circle / delete) Dry Showers Rain Heavy rain Hail / snow

..and the preceding 24 hrs (circle / delete) Dry Showers Rain Heavy rain Hail / snow

Observation:
(Y: Yes, N: No)

Soil runoff / wash from field
Soil runoff / wash from farm yard
Soil runoff / wash via farm tracks
Cattle poaching in-field
Cattle poaching the river bank
Cattle in the river / stream
Runoff from manure heap
Slurry run-off
onto road
into river
onto public right of way

Land use:
(Y: Yes, N: No)

Bare, Stubble, Crops, Grass, Meadow
Cattle, Sheep, Outdoor pigs, Indoor pigs, Chickens, Horses
Other

Other comments
Add any further observations or comments here, including reference to discussions or photographs. There is a box for a sketch overleaf, if required

What do you get?

The survey will help to identify sources of sediment within the catchment and whether they are connected to the river. Sources can be related to particular land uses and an assessment of the importance of sources can be made by understanding the strength of connectivity to the river channel.

When do you use it?

The wet weather survey should be used to back up findings from initial desk study and potentially from catchment surveillance during dry conditions. It can be particularly useful for understanding of the connectivity between sources and sediment in the river.

Spatial scale

The survey can be localised or whole catchment.

Temporal scale

Individual event so may be dependent on rainfall characteristics and distribution.

Who can do it?

Environment Agency staff such as Environment Officers and FRB staff with some understanding of sediment dynamics. Staff involved in the initial desk study.

Costs

Low cost – staff time and a vehicle.

4 Aerial survey

Aerial survey

Aerial images such as photographs allow the identification of factors that may lead to sediment erosion, transport and deposition. They are useful for visual identification of potential sources, pathways and depositional features, particularly in areas that are not accessible from the ground.

Ideally, images should be collected in winter or early spring on a day with little cloud cover. This is when vegetation cover is minimal and erosional and depositional features are most visible.

Images can be available from Environment Agency FCRM teams, online sources such as Google Earth or bespoke flights can be made. Rivers Trusts may have river corridor data. The cost of obtaining high resolution data may not be justified by the greater information that can be derived.

What do you get?

Photos are useful for a conceptual understanding of sediment in the catchment. They may identify specific sediment issues. Useful for broad understanding of the catchment and an overall view of potential linkages.

The approach gives a limited understanding of processes operating in the catchment but can help to identify areas for surveillance.

When do you use it?

Aerial images can help to confirm features and observations made from desk studies. Use when you need to improve your overall, qualitative understanding of sediment sources, pathways and stores in the catchment and to help target detailed monitoring.

Spatial scale

Catchment scale to potentially river reach scale.

Temporal scale

Fixed point in time.

Who can do it?

Anyone with some understanding of sediment dynamics. Potentially being done by CSF staff. May be available from FCRM.

Costs

Low cost of acquiring some images. Google Earth is free of charge. High cost of acquiring new, high resolution images.

5 Repeat fixed point imagery

Repeat fixed point imagery

The technique involves taking images of specific features from the same point at different times. Locations can be geo-referenced using a GPS.

The images can be current images specifically commissioned or can be historic images which also give an indication of catchment changes.

Images may be simple photographs or more complex technologies such as LiDAR (radar images), although cost may restrict repeat imagery.

Images can be analysed qualitatively to identify key changes in features or can be digitally overlain and analysed quantitatively.

The Guidebook of Applied Fluvial Geomorphology provides more information and is available from the Defra website.

What do you get?

Comparing images taken at different times allows you to see how the landscape is evolving, in particular erosion or deposition features. It provides good evidence of landscape change but does not sufficiently reflect processes that are operating. Good for overall understanding of sediment sources, pathways and stores.

When do you use it?

Use it when you need to improve your understanding of sediment sources, pathways and stores in the catchment and to help target monitoring. The technique is good for identifying change in catchment features over time, such as bank erosion or channel evolution.

Spatial scale

Likely to be field scale or river reach scale.

Temporal scale

Potentially before and after storm events or for mitigation measures. Also to capture long-term changes over time.

Who can do it?

Environment Agency staff such as Environment Officers and FRB staff with some understanding of sediment dynamics.

Costs

Low cost of photography.

6 Channel cross-sections survey

Channel cross-sections survey

Repeat topographic survey of representative channel cross-sections enables changes in the profile of channel bed and banks to be assessed.

Surveys should be geo referenced and taken from a fixed point. Photographic evidence to accompany the survey data is recommended.

The results can indicate where bank erosion is occurring and where sediment is being deposited.

The data can be used to predict the rate of future erosion and deposition and to target management.

What do you get?

Cross-section survey data that can be compared to show the rate and location of channel change over time. Data can be presented as a spreadsheet or as a cross-section diagram.

When do you use it?

Use when sediment issues related to bank erosion and/or deposition on the river bed have been identified.

Spatial scale

Spot point data, potentially extrapolated up to the reach scale. Three cross-section points for each representative reach are recommended.

Temporal scale

Annual surveys are standard but surveys can be repeated at any interval depending on the perceived rate of channel change. The data provide an understanding of average rates of change between surveys.

Who can do it?

Environment Agency staff, consultant or contractor.

Costs

Low cost.

7 Bed sediment / bed trap

Bed trap

This technique provides point data on fine sediment deposition within the bed of the river channel.

Sediment is collected in a trap that is installed in the bed of the river. Traps collect sediment at a specific point as it moves through the river system. The sediment collected in the traps can be removed from the river for analysis.

There are several designs of traps which generally involve excavating a section of the river bed and installing a trap such as a metal basket filled with bed material which can be easily removed or emptied.

The Environment Agency report on sediment in salmon spawning gravels provides more detail and is available from the National Research, Monitoring & Innovation teams (Environment Agency 2002).

What do you get?

A measurement of how much sediment is deposited on the trap over a particular period of time. Analysis of flow data and the particle size of sediment can demonstrate the link between movement of particular sediment size grades and flow conditions. Analysis of chemical concentrations will show if contaminants are at elevated or harmful levels.

Estimates can be made of monthly or annual rates of sediment deposition (kg per m^2), which can be extrapolated to be representative of an area. Smothering of gravels by fine sediments can indicate a possible impact on habitats such as salmonid spawning.

When do you use it?

Use it when sediment issues related to deposition on the river bed have been identified.

Spatial scale

Spot point data, potentially extrapolated up to the reach scale.

Temporal scale

Traps collect sediment over a period of time ranging from specific sediment moving events to months.

Who can do it?

Environment Agency staff such as Environment Officers and FRB staff with some understanding of sediment dynamics. University researchers. Specialist consultants.

Costs

Low cost, although requires maintenance.

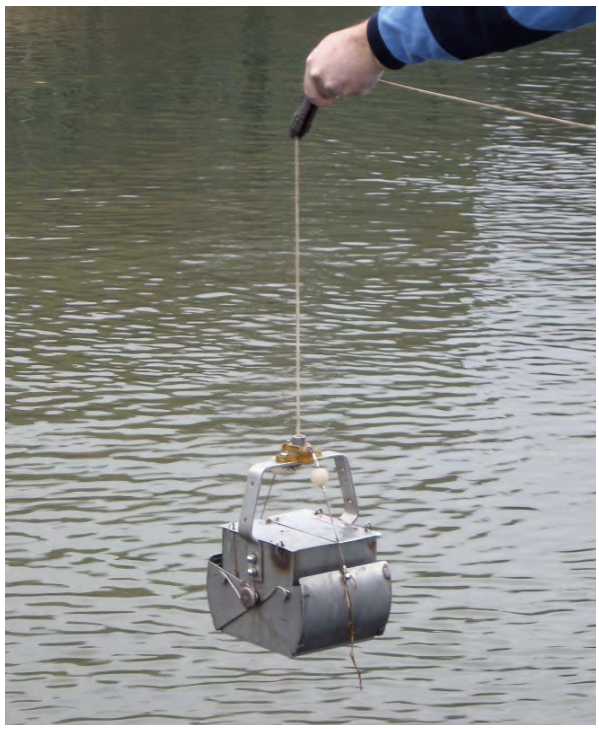
Medium cost for laboratory analysis of sediments.

8 Bed sediment / grab samples

Grab samples

This method provides specific point data on fine sediment content within the bed of the river channel. A sample of the bed of the river is made by taking a 'bite' of bed material using a device called a grab.

The sediment that is collected in the grab is removed from the river for analysis.



What do you get?

A simple estimate of how habitats can change through the deposition of sediment. Analysis of the particle size of sediment can help to understand the link between sediment and deposition of contaminants.

Grab samples of bed material provide an indication of the sediment composition at that specific location at that specific sample time.

When do you use it?

Use it when sediment issues related to deposition on the river bed have been identified. The technique is best suited to deep channels with sandy/silty beds, sampling off bridges when the river bed is not accessible.

Spatial scale

Spot point data, potentially extrapolated up to the reach scale.

Temporal scale

Spot point data means a snapshot in time is taken potentially covering several sediment transporting events.

Who can do it?

Environment Agency staff, consultant or contractor.

Costs

Low cost although requires maintenance.

9 Bed sediment / core sampling

Core sampling

The method provides specific point data on fine sediment content within the bed of the river channel. Sediment is collected using a core inserted into the bed of the river. A core of bed material is collected at a specific point and to a specific depth.

The sediment that is collected in the core can be removed from the river.

There are several methods of core collection ranging from hand operated, to suction techniques, to freeze coring.

The sediment collected can be tested to see if there are any sediment associated contaminants that have been deposited.

What do you get?

A simple estimate of depth of sediment deposited and an indication of the amount of sediment deposition by comparing horizons in the core. Analysis of the particle size of sediment can help to understand the link between sediment and deposition of contaminants.

When do you use it?

Use when sediment issues related to deposition on the river bed have been identified. Best used where there is deep fine sediment deposition as opposed to gravel deposits. Sampling from boat or bridge required.

Spatial scale

Spot point data, potentially extrapolated up to the reach scale.

Temporal scale

Spot point data means a snapshot in time is taken potentially covering several sediment transporting events.

Who can do it?

Environment Agency staff such as sampling and collection staff and FRB staff with some understanding of sediment dynamics. Consultant or contractor.

Costs

Low cost.

10 Bed sediment / re-suspension cylinder

Re-suspension cylinder

Samples of fine sediment deposited in the river bed can be collected using a cylinder placed on the bed of the river to confine an area of the bed. The bed is stirred up to release the stored fine sediment and a sample of the stirred-up sediment is collected. The concentration of fine sediment in the sample can be used to estimate a volume of sediment deposited.

Automated re-suspension cylinders apply a known velocity shear stress to an isolated section of the river bed in order to determine the re-suspension potential of particular sediment grades.

This technique is also part of the methodology for a Riffle Sedimentation Survey (RSS). The RSS has been developed by the Environment Agency with the Game and Wildlife Conservation Trust. It looks at overall riffle characteristics and sediment deposition to assess habitat quality.

What do you get?

A sample of bed sediment which can be used to look at sediment characteristics. The concentration of sediment in the sample can be extrapolated to indicate a volume of fine sediment stored in the river bed.

When do you use it?

Useful if you need to know how much fine sediment is deposited, for example to understand impacts on salmon spawning habitats. The technique works well for gravel bed rivers.

Spatial scale

Spot point data, potentially extrapolated up to the reach scale.

Temporal scale

Spot point data means a snapshot in time is taken potentially covering several sediment transporting events.

Who can do it?

Environment Agency staff such as. Environment Officers and FRB staff with some understanding of sediment dynamics. Consultant or contractor.

Costs

Low cost.

11 River Habitat Survey and GeoRHS

River Habitat Survey and GeoRHS

A survey is carried out walking 500 m reaches of the river bank/channel. Observations (including physical attributes, bank-top structure and land use and channel vegetation) are made at 10 equally spaced spot checks along the channel and a 'sweep up' assessment made to cover the whole 500 m. Information on valley form and land use in the river corridor provides additional context. RHS can also be used to assess how modified a reach is and how this compares to other rivers. The GeoRHS includes additional consideration of the linkage of the channel to the floodplain.

The *River Habitat Survey Guidance Manual: 2003* version and the *GeoRHS Guidance Manual* Environment Agency (2003) provide details of the survey method. Further information is available from the National Environmental Monitoring Service team – they can advise on accredited surveyors, costs and contracts.

The Urban RHS can be used in urban areas.

What do you get?

The survey is designed to characterise and assess in broad terms the physical structure and vegetation of freshwater streams and rivers. For sediment monitoring it identifies geomorphological features such as substrate, depositions, bars, berms, pools, eroding banks etc and land use (potential sediment sources). The survey is geo-referenced and repeatable.

When do you use it?

Use to link sediment to ecology. It can be used to assess habitat quality by calculating a Habitat Modification Score and Habitat Modification Class. The role of sediment in habitat quality can be assessed.

Spatial scale

Along 500 m reaches.

Temporal scale

May-June for lowland rivers; longer season for upland depending on vegetation growth. Generally during vegetation growing season (April/May to September). Not during spate or rain.

Who can do it?

Accredited consultants. Environment Agency staff trained in the current version of RHS. Speak to the National Environmental Monitoring Service team and Area Environmental Monitoring or FRB teams.

Costs

Medium to low cost requiring staff time for site based surveys. On average three reaches of 500 m can be surveyed in one day.

12 River Corridor Survey

River Corridor Survey

A survey is carried out by walking 500 m reaches of the river bank and channel mapping features on a basemap. A record is made of features within 50 m of banktop. It includes ecology and morphology; flow features, substrate, bank structure, vegetation types, landuse, eroding banks, bars or berms.

The River Corridor Surveys Conservation Technical Handbook (National Rivers Authority 1992) provides details of the methodology. Further information is available from Environment Agency FRB and Environmental Monitoring teams.

What do you get?

The survey identifies ecological and morphological features of a reach. Standardised maps of vegetation structure along 500 m stretches of river are produced (providing a detailed outline of the physical habitat available for aquatic animals) coupled with botanical survey of all vascular plants recorded in each stretch.

When do you use it?

It helps to give a broad overview of the links between ecology and sediment. The reach scale of the survey means it is unlikely to identify the source of sediment related effects.

Spatial scale

Along 500 m reaches.

Temporal scale

Late April to early October.

Who can do it?

Environment Agency FRB teams and consultants.

Costs

Similar to that for RHS - staff time for on site surveys on average completing three or four reaches of 500 m in a day.

13 Electro-fishing

Electro-fishing

Surveys of fish populations are undertaken by wading or from a boat and working between two stop nets. Operators move with a hand-held anode and net and with a trailing cathode passing a current through the water. This stuns fish which are then visible and can be captured.

Further information on methodology is available from Environment Agency Fisheries or Environmental Monitoring teams.

What do you get?

Fish population assessments. Can be used at anytime but not advisable in high temperatures, due to stress and low dissolved oxygen, or in winter due to possible fish aggregations. Results are annotated on maps and GIS outputs recording location of redds. The survey can help to identify areas of gravel bed sufficiently unimpacted by sediment ingress to still be used for spawning.

When do you use it?

Useful if observations show a high level of fine sediment deposition in gravels. It helps to make the link between fish populations and sediment related effects. The composition of the fish population may indicate species that are more tolerant to sediment.

Spatial scale

Reaches of 100-500 m.

Temporal scale

Spring, summer and autumn depending on temperatures.

Who can do it?

Environment Agency Sampling and Collection or FRB teams. Accredited consultants.

Costs

Cost of staff time per day plus equipment.

14 Redd surveys

Redd surveys

Surveys are undertaken to look at what changes are taking place where salmon spawn (changes due to spawning activity or floods and/or implications for embryo survival). Survey by walking the banks, identifying redds, taking photos and recording GPS coordinates.

Changing use of gravel areas for spawning may indicate a deterioration in gravel quality or availability.

Further information is available from Environment Agency FRB and Environmental Monitoring teams.

What do you get?

The technique is used to identify the spawning areas on gravel beds of rheophilic fish (preferring fast-flowing water) such as salmon, trout, dace and chubb. Annotated maps and GIS outputs recording location of redds are produced.

When do you use it?

Use a bed sediment technique to verify a suspected link between fine sediment deposition in gravels and changing fish populations.

Spatial scale

From specific sites to catchments.

Temporal scale

During the spawning season for fish species most likely to occur in watercourse.

Who can do it?

Environment Agency FRB team and consultants.

Costs

Cost of staff time per day.

15 Kick samples

Kick samples

Kick sampling is a semi-quantitative method of collecting a representative cross section of the macroinvertebrate community at any one point in a watercourse.

Kick sampling can also help to identify compacted fine sediments below the bed surface that may not normally be visible.

Further information on the sampling method and analysis is available in the Environment Agency report BT001: *Procedures for collecting and analysing macroinvertebrate samples* Environment Agency (1999).

What do you get?

Usually used in relation to water quality assessment but can also be used to assess flow and habitat issues. Species or family level taxa list for sites sampled and actual or estimated abundance or abundance categories.

When do you use it?

Use it as part of a wider assessment of the ecology of the river, especially if sediment deposition is felt to be a problem.

Spatial scale

Site - maximum 5-10 m.

Temporal scale

Usually in spring, summer or autumn but can be done anytime.

Who can do it?

Environment Agency Environmental Monitoring team and consultants.

Costs

Medium to low - day rates per staff per day for sample collection plus staff time per sample for analysis depending on whether species or family level data is needed.

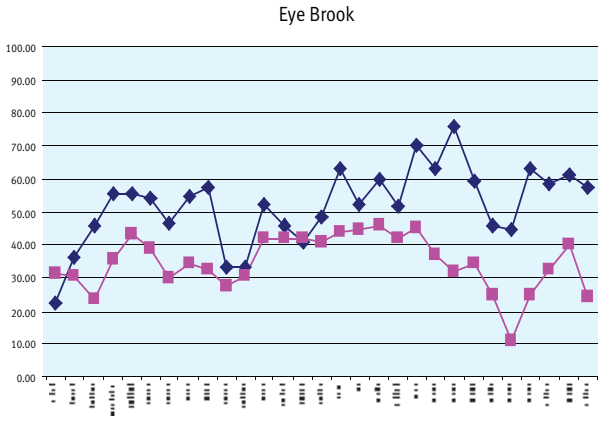
16 PSI and RIVPACS

PSI and RIVPACS

The PSI technique (Proportion of Silt-sensitive Invertebrates) is a newly-developed method. It can be used to quantify sedimentation impacts, or the lack of them, on benthic invertebrate communities.

Macro invertebrate data collected using BT001 protocols can be obtained from the Environment Agency's BIOSYS database.

In many instances it may also be advantageous to obtain seasonal PSI predictions from RICT in order to produce site-specific Environmental Quality Indices (EQIs).



Example output from Eye Brook Leicestershire, showing greater sedimentation impacts, increasing with time, at a heavily regulated site (red squares), compared to a control site (blue diamonds)

What do you get?

An understanding of changes over time in macroinvertebrates that are tolerant to silt. This could support an understanding of whether siltation is a problem in your catchment and help to identify the development of a problem over time.

Spatial scale

Data are available for specific monitoring stations.

Temporal scale

Change in the PSI over time can be assessed for the period for which data are available.

Who can do it?

Environment Agency Analysis and Reporting teams– see Extence *et al*. (2010) for help.

Costs

Low.

17 Core samples

Core samples

In addition to providing information about sediment composition, core samples can be used to look at macroinvertebrates to see if there have been changes in community, especially fauna of the hyporheic zone (wet river bed). A core is inserted into the riverbed to a set depth (10-20 cm), then capped with a rubber bung and withdraw. A sample is collected and taken away for analysis.

What do you get?

Used in quantitative assessment of macroinvertebrate fauna and fauna of hyporheic zone (wet river bed). From the core you can get species or family level taxa list for sites sampled and actual or estimated abundance or abundance categories. It can be difficult to determine the driving force for the results, that is water quality, habitat, flow and so on and you may require additional information for interpretation.

When do you use it?

Use as part of a wider assessment of the ecology of the river, especially if sediment deposition is considered to be a problem.

Spatial scale

From a single site right up to use in reach or catchment based surveys - number of samples needed increases accordingly.

Temporal scale

Usually in spring, summer or autumn but can be done anytime.

Who can do it?

Consultants.

Talk to the Environment Agency Environmental Monitoring team.

Costs

Medium - day rates per staff per day for sample collection plus equipment and staff time per sample for analysis depending on whether species or family level data is needed.

18 Grab samples

Grab samples

Sediment samples from the river bed are collected with a Grab. Grab samples can be used to look for macroinvertebrates to see if there have been changes in community, especially fauna of the hyporheic zone (wet river bed).

Use an Ekman grab to sample macroinvertebrate fauna of silty/muddy river beds, often in deep water.

An alternative technique is a Surber sampler. A Surber sampler may be more appropriate to collect macroinvertebrate fauna from eroding river reaches such as cobble/gravel bed rivers.

What do you get?

Samples are used in quantitative assessment of macroinvertebrate fauna of silty/muddy riverbeds. Species or family level taxa list for sites sampled and actual or estimated abundance or abundance categories.

When do you use it?

Use it as part of a wider assessment of the ecology of the river, especially if sediment deposition is felt to be a problem. Use in muddy/silty river beds. Requires access to the river channel.

Spatial scale

From a single site right up to use in reach or catchment-based surveys - numbers of samples needed increases accordingly.

Temporal scale

Usually in spring, summer or autumn but can be done anytime.

Who can do it?

Consultants.

Talk to the Environment Agency Environmental Monitoring team.

Costs

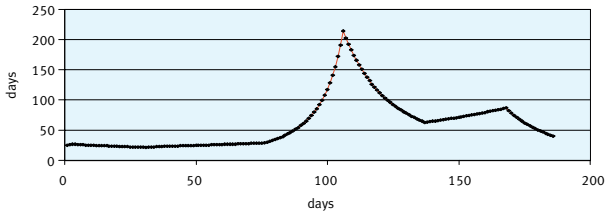
Medium to low - day rates per staff per day for sample collection plus staff time per sample for analysis depending on whether species or family level data is needed.

19 Sediment oxygen demand

Sediment oxygen demand

Oxygen conditions in spawning redds can be a critical factor in controlling spawning success. Excessive sediment deposition in these redds can reduce oxygen concentrations by limiting exchange with the surface water which replenishes oxygen supply and exerting an oxygen demand on the water within the redds.

Interstitial oxygen concentrations can be measured in conjunction with temperature, flow velocities and sediment accumulation to determine the factors affecting fish embryo survival rates at individual study sites.



Estimated time to hatching using original SIDO algorithm; an example of one of the outputs from the SIDO model.

What do you get?

Automatic oxygen sensors in the spawning redds can measure oxygen at a high temporal resolution. Survival rates for different redds with varying oxygen concentrations can then be compared.

Spatial scale

Limited to the individual spawning beds that the instrument is deployed in.

Temporal scale

Measurements can be taken over the spawning season incorporating both high and low flow events.

Who can do it?

Research establishments.
Talk to the Environment Agency Environmental Monitoring team.

Costs

Medium costs (equipment procurement and staff maintenance time).

20 Floodplain deposition

Floodplain deposition

When a river spills onto the floodplain the ability of the water to transport sediment is rapidly reduced. Water can become ponded and sediment will settle out.

Astroturf mats which simulate grass can be used trap sediment. The mats are washed off to give a sediment sample of floodplain deposited material.

What do you get?

The samples can be tested for sediment characteristics (grain size and composition) or the volume of sediment extrapolated to give an indication of the total amount of sediment deposited on the floodplain when combined with the extent of flooding.

Mats placed in the floodplain at different distances from the river indicate different deposition rates and may show variation in particle size. Coarser material will be deposited closer to the river.

When do you use it?

Use it for a river which regularly floods onto the floodplain and where there is a floodplain sediment-related issue – for example, concerns about changing riparian habitats or contamination.

Spatial scale

Spot point data, potentially extrapolated up to the floodplain scale.

Temporal scale

Spot point data means a snapshot in time is taken potentially covering several sediment transporting events.

Who can do it?

Environment Agency staff such as Environment Officers and FRB staff with some understanding of sediment dynamics. Consultant or contractor.

Costs

Low cost.

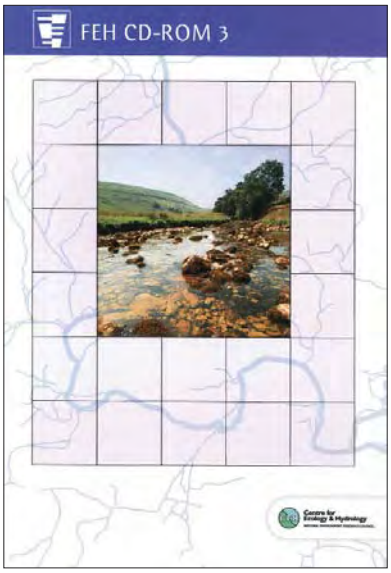
21 Flow estimation

Estimating flow in un-gauged catchments

The transport of suspended sediment is linked to the flow of the river. Understanding how sediment is moved through the catchment requires an understanding of flow in the river.

There is an extensive gauging station network in the UK but not all streams are gauged and not all the existing gauges will be at a suitable location within the catchment.

Flows can be estimated using the *Flood Estimation Handbook* (FEH) which estimates flow based on catchment characteristics and catchments with similar characteristics in the UK. No fieldwork is undertaken.



What do you get?

An estimate of flow where no flow gauging exists for a specified period of time. This can be analysed alongside suspended sediment concentration data to provide an understanding of sediment dynamics where a relationship to flow can be established.

When do you use it?

Use if you don't have river flow information for your catchment or at a specific point within the catchment.

Spatial scale

Specific location within the catchment. Small tributary to catchment outlet.

Temporal scale

Flow series derived over a specified period of time.

Who can do it?

Environment Agency FCRM staff, consultant or contractor.

Costs

Low cost.

22 Spot samples

Spot samples

Specific point data is collected on fine suspended sediment transported within the water column of the river. Samples can be collected by a number of methods; sampling by hand at a specific point in time, automatic samplers that collect samples at programmed intervals, or samplers that collect bulk samples over a longer period of time.

During baseflow conditions sampling frequency can be daily/weekly/monthly as concentration does not vary quickly. During response to storm events, sediment concentration can vary rapidly. Hourly data or more frequent may ideally be required during these periods, although events are likely to last for less than one day.

A routine monitoring programme of weekly or less frequent sampling will miss the full detail of sediment movement during storm events.

What do you get?

A sample of transported suspended sediment. Sediment recovered from the sampler can be analysed to provide an understanding of the characteristics and quality of sediment transported.

When do you use it?

Use it to understand the characteristics of sediment transported in your catchment. Characteristics can include particle size, organic matter content and presence of contaminants.

Concentrations of sediment in samples can be used in sediment load investigations but a long record is needed covering a range of concentrations beyond base flow conditions.

Spatial scale

Spot point data, potentially extrapolated up to the reach scale.

Temporal scale

Spot point data means a snapshot in time is taken potentially covering several sediment transporting events.

Who can do it?

Environment Agency staff such as Environment Officers and FRB staff with some understanding of sediment dynamics. Consultant or contractor.

Costs

Low cost.

23 Turbidity and flow monitoring

Turbidity and flow monitoring

Automatic monitoring data that allows detailed temporal understanding of suspended sediment in the river.

Flow is derived from automatic depth readings using stage discharge relationships.

Turbidity probes measure suspended solids levels at set intervals to allow changes in sediment concentration to be measured during individual storm events and longer term. Most of the suspended sediment load is transported during storm events perhaps lasting only a matter of hours. In total the storms represent a small proportion of overall time but transport around 80 per cent of the total load.

High frequency, event based monitoring is required to capture sediment concentrations before during and after a rainfall event. This allows detailed temporal understanding of suspended sediment in the river. Routinely collected monitoring data is generally limited by the frequency of collection.

What do you get?

Combining a turbidity-derived sediment concentration record with a record of flow collected at the same point and at the same time allows an estimate of sediment load to be made. Continuous monitoring allows you to see when the sediment is mobilised and transported by the river.

Data allows an estimate of the amount of sediment transported by the river and when it is transported.

When do you use it?

Use it to provide a detailed understanding of when sediment is transported and to establish how much sediment is transported.

In the long term it can help identify the effectiveness of sediment reduction measures implemented within the catchment.

Spatial scale

Spot point data, potentially extrapolated to represent a catchment estimate of sediment load.

Temporal scale

Detailed monitoring can be up to every two minutes. A record for at least a year is preferable. Spot samples of suspended sediment concentration are required under a range of flow conditions in order to derive the turbidity versus suspended sediment regression relationship.

Who can do it?

Environment Agency staff such as Hydrology, Water Resources Management and FRB staff with an understanding of sediment dynamics. Consultant or contractor.

Costs

Medium cost for equipment and maintenance.

24 Bank erosion

Marker techniques for bank erosion

The rate of bank erosion can be measured using simple markers in the river bank or on top.

Pins or rods can be driven into the bank and the distance from the top of the pin to the bank surface measured on a number of different occasions.

The rate of bank erosion can also be measured by using marker pegs on the top of the bank. The distance to the exposed bank face can be measured on a number of different occasions.

What do you get?

The markers allow an estimate of the rate of bank erosion, which can in turn be used to indicate how much sediment is being input into the river from bank sources.

When do you use it?

To boost understanding of the rate of bank erosion at a specific site and the contribution of bank erosion to the total sediment load of the river channel – or to compare the relative importance of different bank erosion sites in order to target mitigation. Sediment supply from other sources (such as catchment surface) can be assessed alongside bank erosion to develop a catchment sediment budget. The total sediment load of the river can be assessed using turbidity and flow monitoring.

This is most useful when all eroding banks have been identified and the relative importance of individual sources can be assessed. The rate of erosion may be important if a critical piece of infrastructure is threatened. However, more simple repeat photography of measuring the bank edge from a fixed point may be just as effective and much cheaper and easier.

Spatial scale

Spot point data, potentially extrapolated up to the reach scale.

Temporal scale

Spot point data means a snapshot in time is taken potentially covering several sediment transporting events.

Who can do it?

Environment Agency staff such as Environment Officers and FRB staff with some understanding of sediment dynamics. Consultant or contractor.

Costs

Low cost.

25 Rapid geomorphological assessment

Rapid geomorphological assessment

Rapid geomorphological assessments provide a basic level of information and are generally used to propose potential solutions to small-scale problems. The technique involves a field survey and desk-based study to find a simple explanation of the processes occurring.

The Guidebook of Applied Fluvial Geomorphology provides more information and is available from the Environment Agency website.

E-Learning Training Package on geomorphology, available to Environment Agency Staff via the link below:

http://e-learning.geodata.soton.ac.uk/EA/

What do you get?

The technique provides a high level understanding of processes that may be causing a specific sediment related problem. The focus tends to be on the geomorphological nature of the problem.

When do you use it?

The technique helps to understand the processes causing a specific sediment problem. It improves on understanding of geomorphological processes but will not necessarily identify specific sources of sediment.

Rapid assessment can quickly give you an overview of the catchment sediment regime and identify key areas or problems.

Spatial scale

River reach, channel-scale situations.

Temporal scale

Up to one month, including a site visit.

Who can do it?

Trained Environment Agency staff and consultants. Speak to National Environmental Monitoring Service team.

Costs

Low to medium.

26 Winter sediment runoff audit

Winter sediment runoff audit

A walkover field survey of the entire length of a river is used to identify potential sources of sediment in runoff.

A dry weather survey is undertaken mid-winter after sediment mobilising events to identify evidence of sediment entering the river. Locations are recorded on a map and a photographic record is taken. Locations are graded according to three categories depending on likelihood and magnitude of the source.

A follow-up wet weather survey during a runoff event re-visits the highest grade risk sites to confirm them. Runoff samples collected upstream, at the point of entry to the river and downstream of the source can be collected. Sediment concentration of the samples can be determined in a laboratory to give an indication of the magnitude and effect of the source.

Muddy runoff source entering the channel

What do you get?

A GIS map is produced which records the location of each graded source of sediment. Graded sources give an indication of the spatial extent of sediment input to the river and help to identify whether there are specific point sources of sediment input to the river. Sample analysis from wet weather survey indicated magnitude and impact of a source.

When do you use it?

The technique can be used to enhance understanding of sediment sources and to identify specific locations where management action can be taken.

Spatial scale

Catchment wide survey.

Temporal scale

Spot sample but identifies location of potential sources.

Who can do it?

Environment Agency staff or consultant. The length of river survey required means a team of surveyors is needed.

Costs

Medium cost due to need for a team of surveyors and for laboratory analysis of samples (depending on the number of samples).

27 Sediment particle size

Sediment particle size

Sediment spot samples or bed deposit samples are analysed for their particle size characteristics. Suspended sediment is generally composed of particles smaller than 63 µm. Particle size distributions can be compared to size range schemes in order to classify the sediment (percentage gravel, sand, silt, clay).

This technique can be complex. Particle size will vary spatially and temporally. Particles transported as suspended sediment can be transported as aggregates or flocculated clusters of particles so laboratory analysis ('absolute particle size') may not be a true reflection of the actual sediment size transported ('effective particle size').

What do you get?

Identification of suspended sediment. Can be used to provide some evidence of source of sediment. Detail on the proportion of clay fraction present (particles less than two µm) can be important because contaminants associate themselves preferentially with this smaller size fraction and can therefore be transported more readily.

Particle size distribution can also help to elucidate the types of sediment that are transported in different flow conditions.

When do you use it?

Use it in combination with other tools. Can help your understanding of deposition and the potential for associated contamination.

It is likely to be used in detailed investigations.

Spatial scale

Spot point data.

Temporal scale

Depends on the monitoring range and frequency of sampling.

Who can do it?

Consultant or contractor. University department.

Costs

Medium cost for laboratory analysis of samples (depending on the number of samples).

28 Fluvial audit

Fluvial audit

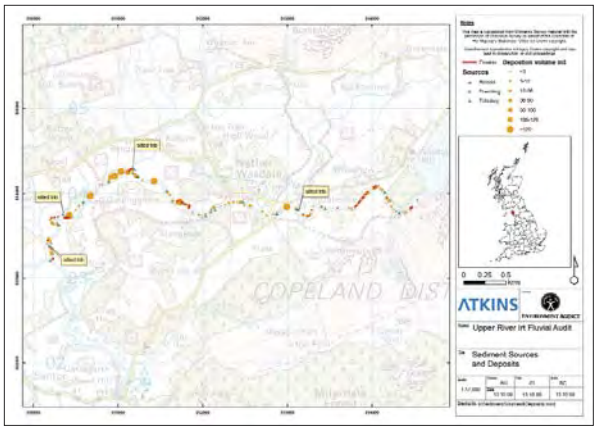
Detailed mapping of channel sediment features according to set format - see *Guidebook of Applied Fluvial Geomorphology* for guidance. The technique uses a combination of fieldwork to map features, historical maps and documented sources.

The audit records information on the river channel characteristics, potential sources of sediment such as bank erosion and deposition features. The focus of the audit is on in-river sediment.

The Guidebook of Applied Fluvial Geomorphology provides more information and is available from the Environment Agency website.

E-Learning Training Package, available to Environment Agency Staff via the link below:

http://e-learning.geodata.soton.ac.uk/EA/



Reach-scale mapping of sediment sources and deposits on the River Irt, Cumbria is used to plan land use management for good pearl mussel habitat

What do you get?

The audit provides a catchment-scale and reach-scale assessment of sediment sources, transport mechanisms and understanding about the drivers of change in sediment processes. The audit will often identify 'hotspots' for action and provide the basis for a catchment wide approach to more sustainable channel management.

When do you use it?

Use to provide a reach-scale understanding of where sediment comes from, how it is transported and where it is deposited. Helps to identify factors that influence sediment transport.

Spatial scale

Detailed, reach scale understanding with a focus on the river channel.

Temporal scale

Typically minimum of two months for a full audit.

Who can do it?

Consultants/specialist contractors.

Costs

Medium (but will depend on length of reach audited).

29 Sediment fingerprinting

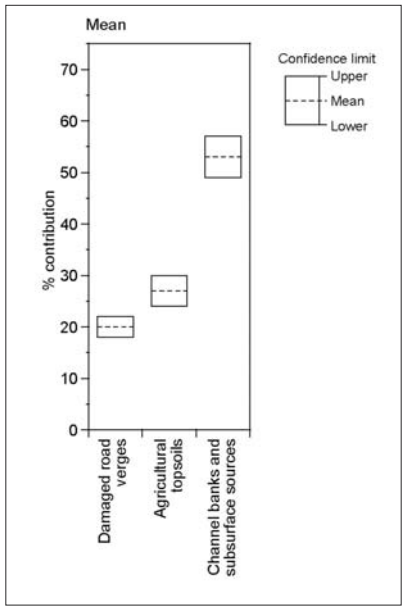
Sediment fingerprinting

A technique to identify the source of sediment by comparing physical and chemical sediment characteristics to those of potential source samples.

The characteristics include particle size, associated organic material and chemical properties.

The technique involves field collection of soil samples from potential land use sources and bank erosion sources. Samples of sediment in the river are collected for comparison.

Subsequent laboratory analysis identifies a signature or fingerprint for each source and this is compared with the characteristics of the sediment to identify a possible matching source.



What do you get?

A detailed assessment of source of sediment is produced. At a simple level this will indicate bank or surface sources. The relative importance of different land uses sources may also be indicated. The technique can indicate the temporal aspects of sediment movement and deposition.

It is most useful when used in conjunction with a fluvial audit or for specific sources.

When do you use it?

Use it to get a detailed understanding of the relative importance of different sources in high-risk catchments. It provides an indication of where but also when sediment moves. The technique is suitable when there is a major problem that is not solved through other techniques. Fingerprinting can be used to target remediation measures to the sources that are the key contributors of the sediment load.

Spatial scale

Catchment or sub-catchment.

Temporal scale

Storm sampling is required for a representative time period plus collection of reference samples - minimum one year.

Who can do it?

Not internal Environment Agency staff - more likely to be a university research project or specialist contractor.

Costs

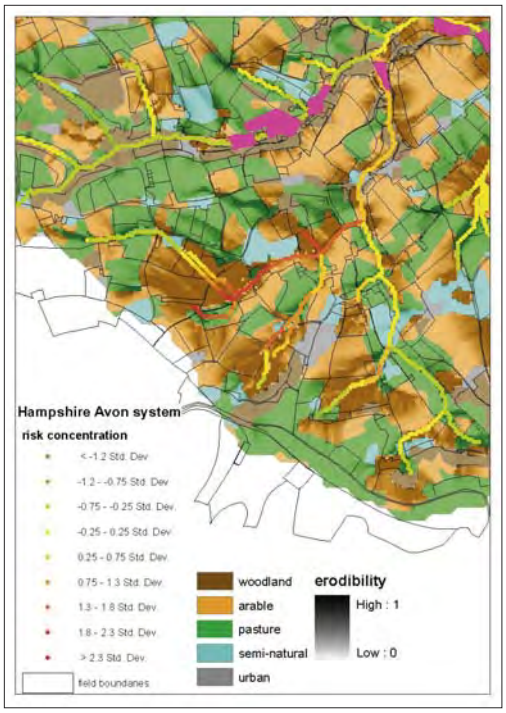
Potentially expensive due to sampling requirements, laboratory costs and degree of analysis. Could sponsor a PhD student for three years.

30 Predictive models

Predictive models

The Environment Agency holds a Decision Support Tool (DST) which can be used to identify land with a high or low risk of delivering sediment based on the type of land use. It can be used to assess the potential benefits of introducing buffer strips and other measures to reducing nutrient and sediment delivery to streams. This should only be used as a guide to exploring where to target sediment reduction measures and is best used in conjunction with other source mapping methods.

SCIMAP is a package available to model the connectivity of sediments and to give a indication of relative risk. The SCIMAP Framework can be used to generate of maps of diffuse pollution risk within catchments. Pollutants can be transported associated with sediment in runoff. SCIMAP aims to determine where within a catchment is the most probable source of diffuse pollution.



Example of a SCIMP output

What do you get?

The DST produces a graphical output that quantifies sediment delivery for one km by one km squares whilst SCIMAP provides the relative risk of sediment delivery at a 5m by 5m square resolution. The outputs can be compared to assess sediment delivery under a range of land use scenarios and spatial and temporal scales.

When do you use it?

Use it to get a detailed understanding of the relative spatial importance of different sources throughout a catchment.

Spatial scale

From one km by one km to the national scale. Models typically operate at the catchment scale and at the field scale.

Temporal scale

Models can operate on a monthly time step or on an annual time step.

Who can do it?

Environment Agency National Research, Risk and Forecasting teams. Specialist contractor.

Costs

Time for processing. Field data collection if required for verification.

Next steps

You are here

You will now have:

- Completed the Impacts checklist in Part 1
- Completed the Sources checklist in Part 2
- Completed the Problems checklist in Part 3
- Mapped your potential sources and impacts

You will have an idea about the important sediment impacts and sources in your catchment and the potential priorities for management of sediment problems.

You will have an idea about where you most need to know more and the potential techniques for monitoring sediment impacts and sources.

You now understand how sediment matters in your catchment.

Next steps

What next?

- **Complete the blank handbook template to record your information**
- **Summarise the sediment problems in your catchment**
- **Identify and plan opportunities for monitoring**
- **Communicate your findings**
- **Ensure data are archived where possible**
- **Use your report to help manage and monitor sediment matters in your catchment**
- **Identify and plan opportunities for management**

Sediment matters in my catchment – how do I feed back?

- Share your findings with your senior manager
- Share your findings with your consultees
- Do a presentation to your team
- Consider appointing a sediment mentor and spread the word to other teams
- Consider the need for enforcement action on point source pollution

Useful references

Websites

Hi-Flows UK	www.environment-agency.gov.uk/hiflowsuk
National Flow Archive	www.ceh.ac.uk/data/nrfa/index.html
Aerial photography	www.bing.com/maps/
	www.flashearth.com
Environmental	www.magic.gov.uk/
	www.naturalengland.org.uk/
	www.english-nature.org.uk/LIFEinUKRivers/publications/publications.html
	www.ccw.gov.uk/
	www.jncc.gov.uk/
	www.nbn.org.uk
	ww2.defra.gov.uk/
	www.fba.org.uk/
	www.britishwaterways.co.uk/
	See Publications, Developing techniques to address key conservation issues, Siltation in rivers
Environmental guides	www.netregs.gov.uk
Soilscapes	www.silsoe.cranfield.ac.uk/nsri
Soils	www.cranfield.ac.uk/sas/nsri/index.html
Geomorphology	http://e-learning.geodata.soton.ac.uk/EA/
Geology	www.bgs.ac.uk
Mining research	http://publications.environment-agency.gov.uk/pdf/SCHO1108BOZE-e-e.pdf
Think Soils	www.environment-agency.gov.uk/business/sectors/soils.aspx
Best Farming Practices	www.environment-agency.gov.uk/business/sectors/bestfarmingpractices.aspx
SuDS	www.environment-agency.gov.uk/business/sectors/39909.aspx

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Glossary

List of abbreviations:

BFI	Base flow index
BOD	Biological oxygen demand
CAMS	Catchment abstraction management strategy
CCW	Countryside commission for Wales
CFMP	Catchment flood management plan
CSF	Catchment Sensitive Farming
CSO	Combined sewer overflow
DST	Decision support tool
EQR	Environment quality ratio
FCRM	Flood and coastal erosion risk management
FEH	Flood estimation handbook
FFA	Flood frequency analysis
FRB	Fisheries, recreation and biodiversity
GPS	Global positioning system
GQA	General quality analysis
IDB	Internal drainage board
JNCC	Joint nature conservation committee
NCPMS	National capital programme management service
NE	Natural England
NEAS	National Environmental Assessment Service
NIRS	National incident reporting system
PSI	Proportion of silt-sensitive invertebrates
RBD	River basin district
RBMP	River basin management plan
RCS	River corridor survey
RHS	River habitat survey
RSS	Riffle sediment survey
SuDS	Sustainable drainage system
WFD	Water Framework Directive
WLMP	Water Level Management Plan
UWWTD	Urban waste water treatment directive

Glossary

Abstraction	Removal of water from a source of supply (surface or groundwater).
Abstraction licence	The authorisation granted by the Environment Agency to allow the removal of water from a source.
Baseflow	That part of the river flow that is derived from groundwater sources rather than surface runoff.
Baseflow Index (and Baseflow Index HOST)	Baseflow Index is an index of baseflow. It shows the proportion of flow derived from groundwater versus surface water. An index close to one shows groundwater-dominated flow. An index close to zero shows surface water dominated flow. Baseflow Index can be derived from flow data where available. It can also be derived by using the HOST classification. HOST is a delineation of UK soil types according to their hydrological properties to produce the 29-class Hydrology of Soil Types (HOST) classification. It is available as a one km grid.
Bedload	Sediment grains transported at the base of a river where the grains are moving by either rolling, sliding or saltation (bouncing).
Biodiversity	The living component of the natural world. It embraces all plant and animal species and communities associated with terrestrial, aquatic and marine habitats. It also includes genetic variation within species.
Biological Oxygen Demand (BOD)	A chemical procedure for determining the uptake rate of dissolved oxygen by the biological organisms in a body of water.
Catchment	The area from which precipitation and groundwater will collect and contribute to the flow of a specific river.
Catchment Abstraction Management Strategy (CAMS)	CAMS are strategies for the management of water resource at a local level. They will make more information on water resources allocation publicly available and allow the balance between the needs of abstractors and those of the aquatic environment to be determined in consultation with local interested parties.
Catchment Flood Management Plan (CFMP)	CFMP are a large-scale strategic planning framework for the integrated management of flood risks to people and the developed and natural environment in a sustainable manner.
Chalk streams	Chalk streams are streams which flow over Chalk and receive a significant proportion of their flow from groundwater. Because they are fed by groundwater, their flow volumes are more consistent throughout the year (rather than responding rapidly to rainfall events), and their water is clear with a more constant temperature. However, they typically change in length as groundwater levels rise and fall seasonally. This effect is sometimes called bourne flow. Chalk streams have unique ecological characteristics.
Discharge	The release of substances (water, sewage and so on) into surface waters.
Dredging	The removal of sediment that has settled out within a watercourse, both on the bank sides and channel bed, by artificial means
EU Water Framework Directive	European Union legislation establishing a framework for European Community action in the field of water policy.
Ecosystem or Ecological River Flow Objectives/level requirements	The minimum river flows (or water levels) required to protect ecological objectives.
Ecological potential	The status of a heavily modified or artificial water body measured against the maximum ecological quality it could achieve given the constraints imposed upon it

Glossary

	by those heavily modified or artificial characteristics necessary for its use. There are five ecological potential classes for Heavily Modified Water Bodies/Artificial Water Bodies (maximum, good, moderate, poor and bad).
Ecological status	Ecological status applies to surface water bodies and is based on the following quality elements: biological quality, general chemical and physicochemical quality, water quality with respect to specific pollutants (synthetic and non synthetic), and hydromorphological quality. There are five classes of ecological status (high, good, moderate, poor or bad). Ecological status and chemical status together define the overall status of a water.
Effluent	Liquid waste from industrial, agricultural or sewage plants.
Environmental impact	The total effect of any operation on the environment.
Erosion	The process of wearing away, and the subsequent transport of, a material by the action of natural forces
Fauna	Animal population of a particular area or epoch.
Floodplain	Land adjacent to a watercourse that is subject to flooding.
Flood Alleviation Scheme (FAS)	A scheme designed to reduce the risk of flooding at a specific location.
Flood defence	A structure (or system of structures) for the alleviation of flooding from rivers or the sea.
Flood Estimation Handbook (FEH)	The FEH outlines the current methodologies for estimating flood flows within the UK.
Flood Map	The Flood Map replaces the Indicative Floodplain Map and shows the floodplain for flooding from rivers and sea, with a one and 0.5 per cent chance respectively of happening in any year. The extreme flood outline (EFO) is also shown for both river and tidal flooding with a 0.1 per cent annual chance. The Flood Map also displays flood defences and areas that benefit from them.
Flood risk management	The activity of understanding the probability and consequences of flooding, and seeking to modify these factors to reduce flood risk to people, property and the environment. This should take account of other water level management and environmental requirements, and opportunities and constraints. It is not just the application of physical flood defence measures.
Flora	Plant population of a particular area or epoch.
Freshwater Fish Directive	EC Directive on Freshwater Fish aims to protect and improve water quality and forms part of the Environment Agency's water quality monitoring programme. The Freshwater Fish Directive sets standards to safeguard freshwater fisheries, mainly relating to the quality of the water, and requires that certain designated stretches of water meet these standards to enable fish to live or breed.
Gauging station	A site where the flow of a river is measured.
Geomorphology	The sediment erosion, deposition and transport processes that create the topography and shape of a river and its floodplain.
General Quality Assessment (GQA).	Method for assessing the general quality of inland and coastal waters

Glossary

Grip	A shallow runoff drainage channel
Groundwater	Water occurring below ground in natural formations (typically rocks, gravels and sands).
Habitat	Place in which a species or community of species live, with characteristic plants and animals.
Hands-Off Flow	A condition attached to the abstraction licence so that if the flow in the river falls below the flow specified on the licence, the abstractor may be required to stop or reduce the abstraction.
Hydrogeology	Branch of geology concerned with water within the Earth's crust.
Hydrology	The study of water on and below the earth's surface.
Hydrometric network	Networks of sites monitoring rainfall; river flow; river, lake, tidal and groundwater levels and some climate parameters. The data is used extensively for water management and planning, water quality and ecological protection and improvement, flood defence design, flood forecasting and flood warning.
Hydrometry	The measurement of water on or below the Earth's surface.
Hydromorphology	Describes the hydrological and geomorphological processes and attributes of surface water bodies. For example for rivers, hydromorphology describes the form and function of the channel as well as its connectivity (up and downstream and with groundwater) and flow regime, which defines its ability to allow migration of aquatic organisms and maintain natural continuity of sediment transport through the fluvial system. The Water Framework Directive requires surface waters to be managed in such a way as to safeguard their hydrology and geomorphology so that ecology is protected
Hyporheic	The hyporheic zone is a region beneath and lateral to a stream bed, where there is mixing of shallow groundwater and surface water. The flow dynamics and behavior in this zone (termed hyporheic flow) is recognized to be important for surface water/groundwater interactions, as well as fish spawning, among other processes.
Irrigation	Supply (land) with water by means of artificial canals, ditches and so on, especially to promote the growth of food crops.
Land Use	Various designations of activities, developments, cropping types, and so on, for which land is used.
LiDAR	Light Detection and Ranging (LiDAR) is an airborne topographical mapping technique that uses a laser to measure the distance between the aircraft and the ground.
Low flow	The flow that is exceeded for a given percentage of the time. For example Q95 is the flow that is exceeded 95 per cent of the time, this means that flow will only fall this low 5per cent of the time.
Main river	The watercourse shown on the statutory 'Main River Maps' held by the Environment Agency. The Environment Agency has powers to carry out works of maintenance and improvements on these rivers.
Macroinvertebrates	Collective name for larger animals without backbones, for example, insects or worms.
Macrophyte	Larger aquatic plants, typically including flowering plants, mosses and larger algae but not including single-celled phytoplankton or diatoms.

Glossary

Morphology	Describes the physical form and condition of a water body, for example the width, depth and perimeter of a river channel, the structure and condition of the riverbed and bank.
Ordinary watercourses	All watercourses not designated as 'Main Rivers'. Operating authorities have powers and duties to maintain ordinary watercourses within their boundaries. The Environment Agency has supervisory duties with respect to ordinary watercourses but overall responsibility for maintenance rests with the riparian (land) owner.
Public water supply	Term used to describe the supply of water provided by a water undertaker.
Peaks over threshold	A peaks-over-threshold series consists of all distinct peak flows that are greater than a selected threshold flow. In Hi-Flows-UK, the threshold has generally been set to obtain an average of about five events per year. 'Distinct peak flows' means that for events with more than one peak, only the largest is included. See the FEH for how this is done.
Reach	A length of river.
Redd	A spawning nest made in river bed gravel by a fish, especially a salmon or trout.
River	An open channel in which inland, surface water can flow.
River corridor	The continuous area of river, river banks and immediately adjacent land alongside a river and its tributaries.
River reach	Unit of a river between two assessment points, delineated for the purposes of abstraction licensing and resource management.
River Habitat Survey (RHS)	A RHS offers a semi-objective method of assessing the physical character and quality of river habitats. It utilises a standard field survey method with full accreditation controls, a computer database for rapid analysis and includes outputs for expressing habitat quality and artificial channel modification.
River basin	A river basin is the area of land from which all surface run-off and spring water flows through a sequence of streams, lakes and rivers into the sea at a single river mouth, estuary or delta. It comprises one or more catchments.
River Basin Management Plan	For each River Basin District, the Water Framework Directive requires a River Basin Management Plan to be published. These are plans that set out the environmental objectives for all the water bodies within the River Basin District and how they will be achieved. The plans are based upon a detailed analysis of the pressures on the water bodies and an assessment of their impacts. The plans must be reviewed and updated every six years.
Runoff	Water that flows over the surface of the land rather than infiltrating the soil. Caused by several factors including: topography, surface conditions, soil permeability/rock exposure.
Sediment	The mineral and organic material that is eroded, transported and deposited in catchments. Sediment has two components: fine material that can be transported by the river flow in suspension and coarser material that comprises the bedload.
Sediment concentration	The mass of sediment per unit of water. Usually expressed as mg per litre of water.
Sediment load	The total amount of suspended sediment transported by a river over a period of time. Can be expressed as a specific suspended sediment load per unit (km^2) of drainage area.
Soil	The upper layer of the Earth's crust composed of mineral parts, organic substance, water, air and living matter.

Glossary

Spate	A sudden heavy downpour or flood.
Special Area of Conservation (SAC)	A Special Area of Conservation is one classified under the EC Habitats Directive and agreed with the EC to contribute to biodiversity by maintaining and restoring habitats and species.
Special Protection Area (SPA)	A Special Protection Area is one classified as such under the EC Birds Directive to provide protection to birds, their nests, eggs and habitats.
Surface water	This is a general term used to describe all the water features such as rivers, streams, springs, ponds and lakes.
Suspended load	A mode of sediment transport in which the particles are supported, and are carried along by water.
Sustainable development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This involves meeting four objectives simultaneously: - social progress which recognises the needs of everyone; - effective protection of the environment; - prudent use of natural resources; - maintenance of high and stable levels of economic growth and employment.
Sustainable Drainage Systems (SUDS)	A sequence of management practices and control structures designed to drain surface water in a more sustainable fashion than some conventional techniques. May also be referred to as sustainable drainage techniques.
Tidal limit	The most upstream point within an estuary or river where water levels are subject to tidal variation.
Topography	Physical features of a geographical area.
Treatment works (also waste water treatment works)	Sewage treatment works or water treatment works.
Turbidity	The presence of fine suspended matter such as clay or silt in water causing the water to be cloudy or muddy in appearance. Specifically it is a measure of water clarity that expresses the degree to which light is scattered.
Water Framework Directive (WFD)	EC Directive (2000/60/EC) on integrated river basin management. The WFD sets out environmental objectives for water status based on: ecological and chemical parameters; common monitoring and assessment strategies; arrangements for river basin administration and planning; and a programme of measures in order to meet the objectives.
Water Level Management Plans (WLMP)	These provide a framework by which the water level requirements of a particular site can be discussed to incorporate and integrate a range of activities. The Environment Agency has a responsibility to be involved in the production of these plans in consultation with other interested bodies such as Natural England, CCW, Internal Drainage Boards, conservation groups and landowners.
Water resource	The naturally replenished flow or recharge of water in rivers or aquifers
Watercourse	A stream, river canal or channel along which water flows.
Wetland	An area of low-lying land where the water table is at or near the surface for most of the time, leading to characteristic habitats.

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