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River Sediments and Habitats Review of Maintenance and Capital Works

Project: SC040015/SR1

Flood and Coastal Erosion Risk Management Research and Development Programme

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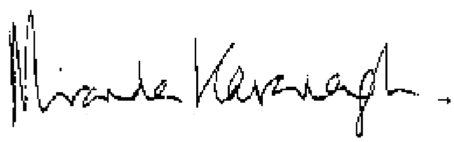

Miranda Kavanagh

Director of Evidence

Executive summary

Note that there is a separate Executive Report available for this project which provides a longer summary of the technical findings of the project than can be included in this Executive Summary.

This project is aimed at improving our understanding of the interactions of sediments, habitats and conveyance as affected by maintenance operations and capital works. The project approach was to study five field sites. These field sites were selected to provide a range of different river types and management interventions. The management interventions included vegetation management, dredging, narrowing an over-widened channel, re-meandering and construction of a capital scheme to reduce flood risk. Though careful attention was paid to ensure that the sites selected represented as wide a range of rivers and problems as possible it was not possible within the constraints of the project to cover all such problems. Where possible, the project has sought to generalise results from specific sites to wider river management issues. Each site was studied intensively with a coordinated investigation covering a wide range of disciplines that included: topographic and bathymetric site surveys, River Habitat Surveys, macrophyte, invertebrate and geomorphological surveys, hydrological analysis, hydraulic and morphological modelling and analysis. The study also included a review of the advice and guidance that is used by Environment Agency staff. The survey work was carried out over a three year period to enable surveys to be carried out over a number of years so that the changes through time could be assessed.

Sediment-related features occur naturally in alluvial channels. Their presence may not have a significant effect on channel conveyance, indeed, in some cases the presence of local bed features may increase channel conveyance. Sediment features will only begin to affect the channel conveyance if they occupy a significant portion of the channel over a significant distance. The presence of sediment features is important in providing a range of flow conditions in terms of both flows and depths and substrates and hence a diversity of habitats. There should only be a need to remove sediment for flood risk management purposes if the overall channel conveyance is affected and if such removal is the only means of achieving an acceptable flood risk. It is important in terms of flood risk management that the floodplain and channel system is considered as a whole. Thus control of flood risk may be achieved by using floodplain management in addition to in-channel works rather than just in-channel works alone.

On the basis of the site studies the impact of dredging and vegetation maintenance is described. The impact on flows, habitats, macrophytes, invertebrates and other biota are detailed. Though some impacts are intrinsic to the activity, such as the reduction of water levels following dredging, advice is given on how these impacts can be reduced in some cases. The recovery of sediment features, habitats and biological populations is described.

At some of the sites artificial riffles have been constructed and the impact of these on habitats is discussed and the need to construct riffles only in river types where riffles would naturally form.

The impact of a capital scheme carried out to mitigate flood risk is described.

The results are used to discuss the problem of establishing the conditions when sediment processes become self-regulatory and the use of modelling to investigate this is described. River managers are faced with the problem of determining the critical time at which intervention is required and this is discussed in the context of PAMS. The use of modelling to provide guidance on when intervention is required is described.

Reducing or stopping sediment related maintenance has a benefit for the environment and also ensures more efficient use of resources. Modelling can be used to assess the sensitivity of the system to reductions in sediment maintenance and to assess the impact of ceasing such maintenance on flood risk.

Sediment related management is discussed in the context adaptive management.

Though the impact of maintenance works was not always detectable in the overall RHS HQA and HMS scores there was a better correlation with some of the sub-scores such as Channel Features or Flow Type. A limitation of the RHS approach that was identified was that some sediment related features occur on a sufficiently small spatial scale that they may not be fully recorded in RHS. This is consistent with the RHS not being a geomorphological survey.

The project describes general principles that can be used to provide approaches to reducing the need for and impact of sediment related maintenance.

Contents

Abbreviations

ASPT	Average Score Per Taxa
BMWP	Biological Monitoring Working Party
CAMS	Catchment Abstraction Management Strategies
CES	Conveyance Estimation System
CFMP	Catchment Flood Management Plan
CVS	Cover Value Score
EA	Environment Agency
EIA	Environmental Impact Assessment
ERS	Exposed Riverine Sediments
FAS	Flood Alleviation Scheme
FRMRC	Flood Risk Management Research Consortium
GeoRHS	Extension to RHS which has a geomorphological component
GPS	Global Positioning System
HMC	Habitat Modification Class (RHS)
HMI	Habitat Modification Index
HMS	Habitat Modification Score (RHS)
HQA	Habitat Quality Assessment (RHS)
IDB	Internal Drainage Board
JNCC	Joint Nature Conservation Committee
MTR	Mean Trophic Rank
NGR	National Grid Reference
PAMS	Performance-based Asset Management System
PCA	Principal Component Analysis (RHS)
PPA	Post Project Appraisal
RCT	River Community Types
RHS	River Habitat Survey
SCV	Species Cover Value
std	standard deviation
SSSI	Site of Special Scientific Interest
STR	Species Trophic Rank
STW	Sewage Treatment Works
UK	United Kingdom
WFD	Water Framework Directive

1 Introduction

1.1 Background

This is the Science Report which describes in detail the methodology adopted, the sites that were investigated and the site specific conclusions. This Research Report contains the detailed information relating to the project. The data collected as part of the project is stored as part of the project record. There is a companion Executive Report which summarises the key findings and recommendations arising from the project.

The requirement for this project was identified as a priority at the Sediment and Habitats Concerted Action Workshop held by the Defra/EA Joint Flood and Coastal Defence R&D Programme in June 2001. This was attended by 45 invited technical delegates, including 14 Defra/EA staff and advisers. The priority issues in the fluvial sector were defined to be 'linkages' between sediment sources and pathways, habitats and channel conveyance for flood defence with an emphasis on:

- developing the science base for a more thorough understanding of sediment processes at the catchment, reach and site scales;
- applying this understanding to assess and analyse the impacts of sediments and habitats on flood defence when deciding whether or not to perform maintenance operations and works;
- if a decision is made to manage or maintain, supply best practice guidance on how operations should be undertaken in a cost effective and sustainable manner;
- if a decision is made to perform capital works (for flood defence or restoration) supply best practice guidance on designs which support self-sustaining, dynamic morphologies and habitats while meeting conveyance requirements for flood defence."

Consultation with river managers within the Agency, IDBs and local authorities during the concerted action to identify future O&M research identified a clear desire by river managers to embrace methods which reduce the environmental impact of their works and enhance the environment and in particular the habitats. Limitations in the understanding of the underlying processes and a need for validation of existing conflicting theories are currently working against this.

The impact of the design of schemes on maintenance should not be ignored. Much maintenance work associated with river schemes is a direct consequence of the design. An integral part of any design should be an assessment of the future maintenance that may be required. Thus the ability of improved design to contribute to self maintaining channels or environmentally friendly maintenance should not be ignored.

Under the Water Framework Directive (WFD) there is a requirement to put in place programmes of measures by 2016 to achieve 'good ecological status' for all water bodies, with the exception of 'heavily modified water bodies', which need to achieve 'Good Ecological Potential'. There is also a requirement for no degradation. It is imperative that if these responsibilities are to be met, there needs to be far greater understanding of the effects of maintenance on sediments and habitats, and ultimately the biology that the habitats support. Through greater understanding of the inter-linked processes, flood risk management could, in the future, hold the key to achieving sustainable river rehabilitation through management practices that encourage natural processes to sustain both habitats and conveyance.

There have been a number of projects within the UK aimed at integrating geomorphology into flood risk management, for example, Newson and Sear (1994) and Sear et al (2003). These projects have primarily been focused on making river practitioners aware of the principles of fluvial geomorphology and the processes that determine natural fluvial systems. They have not been primarily aimed at investigating the impact of human interventions such as channel maintenance on the performance of such systems and the environment.

In the past sediment related channel maintenance has been carried out with the objective of maintaining conveyance and providing land drainage. It provides a method for controlling flood risk within a catchment. In many cases this maintenance work has taken the form of sediment removal to maintain the cross-section of a channel which has reduced as a result of sediment deposition. In other cases it may take the form of trying to prevent sediment erosion where this has endangered structures or other assets (Newson and Sear,1994). When such sediment related maintenance is carried out the sediments and hence habitats are affected. Consideration has been given to environmental issues but there has been no consistency in application due to an incomplete understanding of the processes. The impact of such works on habitats, either directly or indirectly by impacting on sediments, has received little attention. Greater understanding about the effects of maintenance activities on habitats and sediments will allow the objectives of maintaining conveyance and flood defence to be achieved with environmental benefit or reduced impacts on habitats and conservation. What is required is a balance between:

- flood risk management,
- conveyance,
- conservation and biodiversity,
- recreation and navigation and

  fisheries.

The belief is that by understanding the interaction between sediments and habitats it should be possible to deliver flood risk management at reduced cost and with significant environmental benefit.

Within the Environment Agency, sediment related channel maintenance is the responsibility of Operations Delivery. Within Operations Delivery, Technical Support is responsible for planning maintenance while Operations Delivery is responsible for carrying out the work on the ground. Technical Support thus has a need to be able to specify the work that is required to achieve the required standard of flood risk management. Operations Delivery needs to be able to translate that specification into work instructions that can be carried out by staff in the field. This project should contribute both to the specification of sediment related maintenance work and to the translation of those specifications into work instructions.

This project was aimed at improving our understanding of the interactions of sediments, habitats and conveyance as affected by maintenance operations and capital works and was carried out in stages. The primary objective of Stage 1 was to identify the requirements for field trials, identify suitable locations, data collection requirements and protocols for data quality, checking and storage. Stage 1 was reported on in Environment Agency (2004). The primary objective of Stage 2 was to carry out field studies whose results could be interpreted to provide information on the self-regulatory nature of conveyance response, effective river management and new approaches to maintenance and channel design, including adaptive management for flood risk management.

There is a complex interaction between the flow characteristics (reach and catchment-scale hydrology and physical form) of a channel, the sediments and the habitats. The flow characteristics determine the movement of sediment and hence the composition of the sediment on the bed of the channel. The composition of the sediment is a major determinant of the nature of the habitat. The vegetation within the habitat affects the hydraulic roughness of the channel and hence the flow conditions. Any human intervention in the system can alter this interaction and lead to changes within the system. Examples of such interventions are the maintenance operations that are commonly carried out on UK rivers and capital works. Thus all these factors are interrelated. Channel maintenance acts to modify one, two or three of these factors and hence may radically alter the system. For example, sediment management through operational maintenance is disruptive to the benthic, in-stream and riparian ecosystems. These interactions are summarised in Figure 1.1.

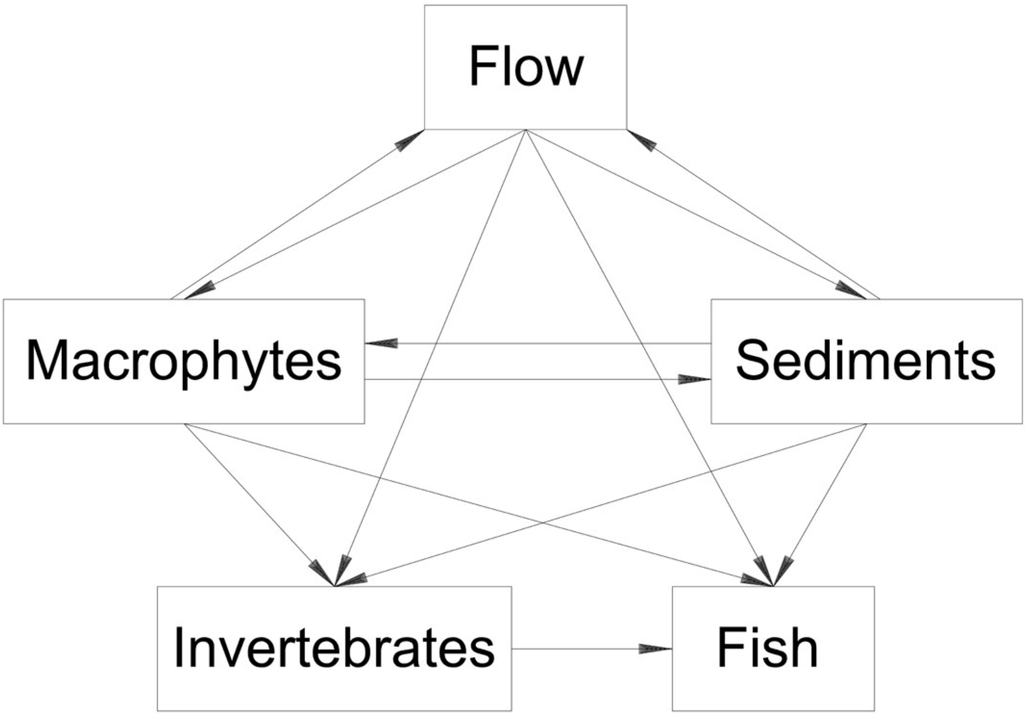

Figure 1.1 Interactions between in-channel flow, sediments and biota

The project does not address the issue of the potential future impact of climate change. For the present, the inter-year variability of rainfall and river flows exceeds any short-term impact of climate change. In addition the present predictions of climate change do not allow for the detailed prediction of future flow regimes with sufficient detail to allow inclusion in the present study.

1.2 Project Team

The project team was the same as for Stage 1 of the project and included:

HR Wallingford

Alconbury Consultants

KR Fisher Consultancy Ltd (Karen Fisher)

Haskoning

Nottingham University Consultants (Professor Colin Thorne)

River Restoration Centre (Dr Jenny Mant) and

Angela Walker (Independent consultant).

The project team was led by HR Wallingford. The report was drafted by HR Wallingford with significant inputs from the Project Team.

1.3 Interactions with other projects

It should be noted that the project interacted with other research projects. The Flood Risk Management Research Consortium (FRMRC) carried out morphological studies at some of the present projects field sites. The reaches considered by the FRMRC project extended further upstream and downstream then the present study sites and so provided a valuable context for the present work.

In addition the work on the Performance-based Asset Management System (PAMS) used the Great Eau as a pilot site and so valuable information was exchanged between the two projects.

2 Methodology

2.1 Introduction

This chapter outlines the methodology that was developed for the project. Each case study site comprised a reach of river, within which there were designated sub-reaches. The project investigated different maintenance techniques within the sub-reaches or the impact of capital works.

The objectives of the project were:

- Quantify the impacts, benefits and influences of management and maintenance on sediment and habitat features
- Establish if, when and how sediment processes become self-regulatory negating the need for further maintenance or management, where appropriate.
- Determine the critical time at which intervention is required to manage geomorphically created sediment habitats in restored rivers for conveyance purposes.
- Test and validate new approaches to maintenance and channel design.
- Provide guidance on appropriate management, and when safe and desirable to allow river reaches to have no management.
- Supply the experimental basis for adaptive management of flood control and restored channels.
- Develop improved links between RHS outputs and flood risk management, with the former providing a guide to when modifications to management would be desirable, and then as a monitoring tool to show benefits accrued.

Within the project, modelling and other analysis techniques were used in order to better understand the physical processes involved. It should be appreciated that the use of such models for research does not imply that their future use for EA Operations is necessary or recommended. It is only when a full understanding of the processes has been developed that it will be understood what any operational requirements might be.

The outcomes of the Sediments and Habitats project is of direct relevance to the Operations Delivery function of the Environment Agency. The primary route for ensuring that the Environment Agency takes advantage of the work is the incorporation of the results within the PAMS that is currently being developed. As the project concerns sediments and geomorphology there are potential links to GeoRHS. As the project is concerned with habitats there are potential links with the work being carried in relation to the Water Framework Directive and as the project is concerned with maintenance there are potential links to the work currently being carried out on aquatic plant management. These are discussed in greater detail below.

The project approach was to study five field sites. These field sites were selected to provide a range of different river types and management interventions. The description of the selection procedure is given below. Though careful attention was paid to ensure that the sites selected represented as wide a range of rivers and problems as possible it is not possible within the constraints of the project to cover all such problems. Where possible, the project has sought to generalise results from specific sites to wider river management issues. Each site was studies intensively with a coordinated investigation covering a wide range of disciplines. These studies were carried out over a three year period to enable surveys to be carried out over a number of years so that the changes through time could be assessed.

To quantify the impacts, benefits and influences of management and maintenance, it was necessary to look at the before and after scenarios of different sub-reaches which had been subject to different treatments. The study investigated the physical characteristics, flow, sediment, RHS characteristics and invertebrates at the five case study sites.

2.2 Site selection

Selection of sites

The site selection procedure was described in detail in Stage 1 Technical Report and is only summarised here. The procedure involved holding two Workshops. A Workshop involving the project team, Environment Agency staff and independent experts was held at which the long list of potential field sites was reviewed. In selecting field sites consideration was given to the type and nature of the river, the type of maintenance activity and the potential for scientific study related to the objectives of the project. In selecting sites attention was paid to the nature of the sediments at the sites and whether they contributed to the formation of habitats. Consideration was also given to the enthusiasm of local staff to be involved in the project. Using these factors as a basis, the attendees at the Workshop ranked the sites to produce the following shortlist of five sites:

- Eden: Kent
- Long Eau: Lincolnshire
- Dearne: South Yorkshire
- Kent: Cumbria and
- Harbourne: Devon.

The locations of the sites are shown in Figure 2.1. Detailed maps of the sites are in Appendix 9.

Figure 2.1 Locations of field sites

It should be stressed that the sites were selected to represent generic types of river and issues. The sites were studied to elucidate the aspects of sediment management that were of general application. It was not the intention of the project to develop detailed sediment management plans for the sites.

2.3 Data collection programme

2.3.1 Introduction

An extensive data collection programme was carried out at each of the five sites. The details of the data collected and the methods used are to be found in the Appendices and are only summarised here.

2.3.2 Hydrology and cross-section data

Flow data from gauging stations in or near each of the five field sites was collected and analysed to produce flow duration curves. In addition an assessment was carried out of the magnitude of floods with probabilities varying from the twice yearly flow to an annual probability of exceedence of 20%.

Detailed cross-section surveys of the site were carried out, see Appendix 1. The project compared changes in the different sub-reaches within each river reach. Physical changes in hydraulic roughness, hydraulic conditions and channel dimensions were investigated. The longitudinal and temporal variations in cross-sections and their properties were investigated by comparing cross-sections taken along each reach. Surveys were carried out separated by a period of two years to investigate temporal changes.

By modelling the reaches using the Conveyance Estimation System, which includes the Roughness Advisor it was possible to understand a wide range of conditions at each site. This provided information on stage-discharge relationships, velocity and roughness profile and calibrate estimates using the data that was collected. The modelling was carried out using INFOWORKS/ISIS. This was used to look at sediment transport, deposition and erosion using the sediments module.

2.3.3 River Habitat Survey Methodology

River Habitat Surveys (RHS) were carried out on all five rivers using the standard methodology developed by the Environment Agency and described in their Field Survey Guidance Manual (2003), see Appendix 2. The technique is designed to characterise and assess the physical structure of a freshwater river or stream by identifying the broad geomorphological features and processes, the vegetation types and other habitat components.

RHS is carried out along a 500m length of watercourse. Observations are made at ten 50m intervals along the channel (referred to as ‘spot-checks’) to record specific information about physical features of the channel and banks, man-made modifications, land use and vegetation structure. This is followed by a survey of the 500m as a whole to note features not present in the ‘spot-checks’ and record general information on other habitat components such as trees and associated features, bank profiles and valley form.

As part of the RHS digital photographs are taken to illustrate the general character of the river, key features and all major structures along the channel and banks. For this particular study a series of additional ‘spot-checks’ were carried out at 25m intervals in between the standard 50m points.

Following each survey the form is checked on site for completeness and clarity. After collating and duplicating, forms and photographs are submitted to the Environment Agency for checking and entering onto the database.

In the first year of this study pre-survey site visits were carried out with other members of the team. Site assessments were made to establish the optimum location for each 500m reach, taking into account the requirements of other surveys as well as the RHS.

The location of reaches and their co-ordinates are given in the Table below.

Table 2.1 Location of RHS Reaches

River	Reach[1]	GPS Upstream End	GPS Downstream End
Long Eau	Downstream	TF 41034 86605	TF 41258 86905
	Upstream	TF 40599 86033	TF 40847 86330
	Middle	TF 40105 85553	TF 40280 85887
Dearne	Upstream	SE 47751 01992	SE 48172 01799
	Middle	SE 48479 01843	SE 48897 01603
	Downstream	SE 49230 01245	SE 49612 00980
Eden	Upstream	TQ 49801 46400	TQ 50019 46106
	Middle	TQ 49988 46019	TQ 50212 45653
	Downstream	TQ 50491 45662	TQ 50771 45530
Harbourne	Upstream	SX 77736 55970	SX 77999 56126
	Downstream	SX 78456 56174	SX 78936 56244
Kent	Downstreaml[2]	SD 51383 90106 SD 51313 90171 in 07	SD 51262 89943
	Upstream	SD 51918 92957	SD 51631 92556
	Middle	SD 51662 91935	SD 51806 91516

Notes: [1] Reaches are not necessarily in upstream to downstream order.
[2] Extended 50m upstream in 2007 for comparison with national database.

The RHS surveys results were reviewed in the light of the other environmental data that was collected and the information that was available on the channel management within the study reaches. The potential use of RHS to indicate the impact of sediment related maintenance was investigated. In the case of the River Eden in Kent the RHS database was used in order to put the data from the Eden into a local context and to investigate the RHS results from rivers in the area.

2.3.4 Macrophyte Survey

Macrophytes, that is plants visible to the naked eye and identifiable in the field, were surveyed on all five river reaches. Surveys on the Long Eau, Dearne, Eden and Harbourne were carried out in 2005 and 2006; on the Kent surveys were carried out in the three years 2005-2007. The data collection is described in Appendix 3.

The main survey method employed was the Mean Trophic Rank (MTR) system (Holmes *et al.* 1999a). Using the MTR system, an indication of the trophic (nutrient) status of the water and sediment can be gained from the results of the survey. Details of what the cover value scores mean in terms of cover, and how they are used for calculating trophic scores, is given in Appendix 3. Two MTR sites were surveyed in each of the 500m RHS sites except the Kent downstream site. In total, therefore, 27 MTR sites were surveyed.

In addition to the MTR surveys that were carried out, a one-off 500m site was surveyed on the Long Eau, Dearne, Eden and Kent using another standard method that can be used to characterise watercourses in a national classification. The Joint Nature Conservation Committee (JNCC) method (Holmes *et al.* 1999b) is the standard approach used by conservation agencies (in England - Natural England) to survey streams for macrophytes and assess their conservation value. The method involves recording species occurring in 500m lengths, coding the occurrences on a three-point scale of abundance, and making separate records for species within the bed of the channel, and those at the base of the bank. Data from these surveys have been entered on to the national database. A site on the Harbourne was not surveyed since the control and managed sites were so different.

The Mean Trophic Rank (MTR) method (Holmes *et al* 1999a) involves recording species on a defined check-list occurring in 100m lengths and coding abundance on a nine point scale. Originally the method was developed to enable plants to be used for water quality assessment, but recently (Environment Agency 2007) the check-list has been extended to enable use for water resources Catchment Abstraction Management Strategies (CAMS) and Water Framework Directive characterisation. The survey at the sites included searching for, and recording if present, all the additional taxa on the extended check-list. The taxa on the new EA check-list have been identified on the survey result sheets so that these data can be added to the BIOS database of the EA as consistent with the 2007 methodology. Data have been provided to Area biologists for this purpose should they wish to do so.

The 500m JNCC sites were identical to one of the RHS survey sites in each of the four rivers Long Eau, Dearne, Eden and Kent; for locations of MTR sites selected, see Appendix 3. The smaller 100 m MTR sites were selected within all the 500m RHS sites in the five river reaches so that two representative samples were taken. These sites were also chosen in locations where the exact upstream and downstream limits could be clearly defined and determined in the field (thus allowing repeat surveys at anytime in the future by different personnel). GPS references for the upstream and downstream limits of the sites were recorded. Maps were drawn to help define the sites, and these have been sent to EA Area biologists for future reference. The macrophyte surveys at each site were carried out by walking the banks of the sites first, noting all taxa present (as well as rough proportions of each taxon) before wading within the rivers for closer inspection. More intensive searches were made within the 100m sites until one complete traverse of the site failed to find any additional taxa, and no re-adjustments to cover value scores were made.

Data from the MTR surveys for each river were entered on to excel spreadsheets, with separate spreadsheets for each river. Data from the JNCC surveys were entered alongside each other for the four rivers on one spreadsheet prior to the data being entered on to the dedicated JNCC templates before submission to the JNCC lead freshwater coordinating officer (Alison Lee) in Edinburgh.

2.3.5 Invertebrate data collection

The invertebrate sampling strategy was driven by the need to ensure representative sampling of the sites studied and to facilitate assessment of the data obtained against the findings of previous surveys. The adopted approach is described in Appendix 4

Site visits were made to select typical river sections, about 500m long, representative of different maintenance/capital works regimes. Within each of these sections a suitable 10m stretch, encompassing the range of habitat sites present throughout the section, was chosen for survey.

In each 10m stretch selected, six replicate samples of the macroinvertebrate community were collected by timed sweep netting, kick sampling and visual examination of surfaces for attached species. The aim was to obtain comparable rather than exhaustive samples. Consequently, the sampling was all undertaken by the same surveyor, in accordance with the defined protocol, using a standard FBA pattern long-handled net with a 250mm wide frame and a 1mm mesh net 0.3m deep.

Each sample was preserved in isopropyl alcohol and transported to the laboratory for sorting and analysis. The organisms obtained were enumerated and identified to the level of family to facilitate calculation of the Biological Monitoring Working Party (BMWP) score and the Average Score Per Taxon (ASPT). The calculation of these metrics facilitated direct comparison with previous survey data supplied by the

Agency). As a quality check some of the samples taken were subject to analysis by independent taxonomists to confirm the identifications made.

The statistical analysis of the various sample sets was based on the total number of individuals and taxa recorded. These samples were then set in the context of other data derived from Environment Agency sampling in the area.

2.3.6 Geomorphology data collection

The study approach employed geomorphological field reconnaissance to assess the morphological features and forms in the watercourses[1]. This involved filling-out check-sheets for the sub-reaches following a site walk-over to gain a general overview of the morphologies of the reaches. Separate sets of reconnaissance sheets were completed for each sub-reach. This gave the following baseline information on the five sites:

- River valley; type, features and conditions, vertical and lateral relationship of channel to valley.
- Channel; physical descriptions of the channel e.g. size and shape and the sediments: types and size with a sketch
- Banks; material, vegetation, erosion and failure features.

Though local changes to the catchment in the neighbourhood of the sites may affect the sediment inputs, it is unlikely that changes to the upstream catchment during the project will significantly affect the sediment inputs to the study reach. Variability of sediment input due to flow variability is likely to far exceed any changes due to the general catchment upstream.

The geomorphological element of the project focused on the field identification of morphological features in the maintained and unmaintained sub-reaches at the five project sites, coupled with interpretation of the links between channel morphology, sediment dynamics and maintenance practices. The methods used are described in Appendix 6. The aim was to establish the impacts of past and current maintenance regimes on channel morphology and evaluate the potential for morphological features and sediment forms to recover if maintenance ceased or was modified to allow or even promote the development of sediment features and the physical biotopes they provide.

2.3.7 Sediment data collection

Visits to the sites were made during which bed sediment samples were collected and subsequently analysed to determine bed sediment size gradings. This work overlapped with work being carried out by the FRMRC project and so the work was split between the project teams the collected data shared between the projects. The data collected is described in Appendix 7

2.3.8 Sediment transport modelling

In order to gain a full understanding of sediment transport at a range of flows and under different maintenance procedures, sediment modelling was carried out at selected sites using the sediment module of ISIS/INFOWORKS. This provided an indication of the

[1] Thorne, C R (1998) *Stream Reconnaissance Guidebook: Geomorphological Investigation and Analysis of River Channels*, Wiley, Chichester, ISBN 0-471-968560, 127p.

sediment movement for a range of flows. Different maintenance procedures were assessed using the model to quantify the most beneficial procedures.

The sediment modelling was used to provide estimates of the present sediment load in the river reaches. The modelling was also used to carry out sensitivity tests to ascertain the magnitude of the change required in the river channel in order to achieve self-regulatory conditions.

2.3.9 Guidance on channel maintenance

Documentation related to channel maintenance was collected and reviewed to provide an assessment of local area Environment Agency office river management protocols. Each EA Area office was contacted and additional information on the impacts of maintenance was collected. This information was summarised and reviewed in Appendix 8.

3 Results and Data analysis

3.1 Analysis of field data sites

3.1.1 Introduction

The following sections provide a summary of the results of the studies for each site. Table 3.1 gives a brief description of the overall site characteristics. Table 3.2 provides a brief outline of the issues at the various sites and Table 3.3 contains a summary of the main features of the data associated with each site. The detailed descriptions by discipline are given in the Appendices (for example a site by site hydraulic and hydrological description can be found in appendix 5). and these should be referred to if more detailed information is required. Detailed maps of the river reaches are in Appendix 9.

Name	Availability of discharge data	Maintenance activity	Capital works	Region	Urban/Rural	High Energy/Low Energy	Existing studies	Flood risk	Research Issues to be addressed
Long Eau	Yes	Weed cutting/Dredging in past	Modifications in 1995	Anglian	Rural	Low	No	Low	Impact of removing flood bank to allow the generation of sediment related habitats
Dearne	Yes	Annual dredging		North-east	Rural	Low			The response of a river to changes in management regime. The river was altered in the 1970s to take account of mining subsidence. This channel was too wide and subsequently the channel was reinstated with the creation of a smaller low flow channel
Eden	Yes	Spot deshoaling		Southern	Rural	Low	No		The Eden site represents a site where maintenance is carried out in a sensitive manner and hence represents good practise
Harbourne	Yes, but short record	Some dredging and weed cutting carried out pre-scheme	Flood storage reservoir upstream/Channel widening and lowering/Completed 2002	South-west	Mixed	High	Yes, data available from studies for works		A flood control scheme involving channel improvements in the village of Harbertonford and an upstream impoundment was carried out with one of the aims being to improve habitats and aesthetics in the stream. The impact of such alternative methods for flood control would be investigated
Kent	Yes	Periodic dredging	Flood relief scheme carried out in 1970s	North-west	Urban/Rural	High	Yes	High	Impact of periodic dredging in a high energy, gravel bed river

Table 3.1 Description of sites

Table 3.2 Summary of sites

Summary of sites

Long Eau			Dearne			Eden			Harbourne		Kent		
u/s	middle	d/s	u/s	middle	d/s	u/s	middle	d/s	u/s	d/s	u/s	middle	d/s
Right embankment lowered to allow flooding of wetland	Left embankment lowered to allow flooding of wetland	Embanked	Low energy channel that has been widened and straightened in past			Reach has been subject to periodic sediment removal and vegetation clearing			More natural section though with some works to stabilise bank toe	Flood Risk Management scheme implemented shortly before study began	Artificial banks		Natural bed and banks
	Artificial riffles contructed	Artificial riffles contructed	Flood embankments along whole reach set back from channel edge			Intermediate between Middle and downstream sub-reaches	Longest period of recovery from maintenance	Recently maintained			Bed stabilised by weirs		Starved of upstream sediment
	Vegetation management leaves margins uncut	Vegetation cutting over most of section	Maintenance has ceased in this sub-reach	Channel has been artificially narrowed and slightly meandered	Channel has been arificially narrowed, meandering more in evidence than middle sub-reach						Subject to frequent removal of gravel shoals		

Table 3.3 Summary of main features of data

		Long Eau			Dearne			Eden			Harbourne		Kent		
		u/s	**middle**	**d/s**	**u/s**	**middle**	**d/s**	**u/s**	**middle**	**d/s**	**u/s**	**d/s**	**u/s**	**middle**	**d/s**
Velocity readings (max) (m/s)								0.3					0.34		
RHS Surveys	HQA scores	24, 24, 28	34, 36, 33	29, 30, 28	39, 41, 39	32, 30, 31	35, 37, 42	43, 44, 43	36, 38, 39	46, 45, 47	46, 50	52, 55	42, 43, 43	45, 46, 47	39
	HMS (average)	3224	3523	3220	2870	2832	3350	2665	2583	2305	442	3950	4313	5902	430
											HQA score affected by blockstone at toe of banks	High HQA score engineered into channel			
	HMS assessment	Severely			Severely modified			Severely modified Comparison with Arun	Slow development of sediment related features in Arun		Severely		Severely		
Macrophytes	MTR scores (2005)	25	22	24	21	20	24	32	32	35	47	45	54	55	51
	MTR scores (2006)	32	28	26	21	23	24	31	31	33	52	47	53	55	53
	No of Taxa (av)	11.75	11	6.75	10.25	12.5	13.25	10.25	10	13.5	17.25	18.25	13.2	12.2	19.3
		Low MTR indicating poor water quality			Low MTR indicating poor water quality										
			Riffles not providing improved habitats in middle reach	Riffles do provide improved habitat in lower reach	Sediment feature developing at margins in absence of management	Narrowing not effective in promoting habitats	Narrowing in d/s section modifying bed sediments		Dredging had created dry berms	Variable flow depth and bankside mature trees	Reasonably natural with limited sediment features				MTR impacted by discharge from STW
							Fixed banks inhibiting development of marginal habitat					No discernible impact of FAS on macrophytes			
							Channel has been narrowed so much no chance for marginal sediment deposits								
Other biota															
	Fish				Improving - may be due to improvements in water quality			Good							
	Invertebrates														
		Clay/silty bed	Riffle	Marginal vegetation										Shoal removal	Stable shoal
	BMWP scores	18	33	42	40	34	36	101		37	126	108		36	67
	No of Taxa	6	9	11	11	10	10	22		10	21	19		8	13
	ASPT	3	3.7	3.6	3.6	3.4	3.6	4.6		3.7	6	5.7		4.2	5.3
	No individuals	19	34	26	31	27	28	99		22	80	54		13	30
	Category	Moderate/poor			Moderate			Very good/moderate			Very good		Good		
		Affected by water quality			Affected by water quality			Eden shows ability of invertebrates to recover cf reach d/s Vexour bridge		ASPT and No of Taxa significantly reduced in comparison with other reaches				Very reduced No of individuals	
														Issue of ERS	
														Different maintenance strategies will favour different habitats	

Hydraulics	Slope	0.001			0.0007		0.005		0.002	
	Energy	Low energy		Intermediate energy Increased shear stress associated with greater depth variability	Intermediate energy Changes in channel shape affecting flow characteristics	Dredging upstream of structure which controls water levels not effective		High energy Increases in shoal height would lead to small increases in flood levels		
				No future maintenance would increase velocity variability but reduce conveyance	Dredging reduces flow diversity					
				Lowering flood embankment has not impacted on inchannel velocities and depths	Dredging lowers water levels and affects value of sediment berms					
					High shear stress promotes development of sediment related features					
					After dredging redevelopment of sediment related features can be rapid					
	General	Correlation between modelling results and RHS scores of flow type - modelling can predict impact of channel change								
Geomorphology		Artificial riffles inappropriate	Setting back embankments may be FRM alternative to inchannel works	Narrowing should be carefully selected	May be potential to reduce inchannel sediment problem by reducing sediment yield using buffer strips		Flood relief scheme performing as expected in design		Need for maintenance might be reduced by treating sediment sources upstream	
		Any interventions should be attuned to lowland nature of river	May be potential to reduce inchannel sediment problem by reducing sediment yield using buffer strips	Narrowing should avoid use of rigid rock berms	Reduce in channel sediment problem by addressing localised bank erosion problems				Maintenance may interupt downstream sediment movement	
		Creating over widened and deep channel reduces inhibits development of sediment features and hence reduces flow diversity		Need for bank management						
Sediment management		Modelling predicts very small rate of bed level change			Rate of response of bed levels to stopping sediment maintenance is slow		Achieved increased flood conveyance but no sedimentation		Ceasing sediment removal will lead to bed level rise	Downstream sub-reach is starved of sediment by removal upstream
									Bed levels stabilise after approximately 8 years	
	General	Sediment transport rate is sensitive to flow depth so minor increases in bed level can reduce maintenance requirements								

3.1.2 Long Eau, Lincolnshire

Site description

The Long Eau is a low energy river system in Lincolnshire. Historically, over-deepening of the channel, coupled with the construction of high flood embankments, has reduced floodplain connectivity. In the upstream sub-reach an enhancement scheme had been carried out that involved lowering the right embankment to allow more frequent fluvial flooding of the adjacent wetland while in the middle sub-reach artificial riffles had been introduced. The study reach represented, therefore, an example of carrying out engineering works to improve a low energy stream. Vegetation cutting is also carried out in the reach and so the site gave the opportunity to investigate aspects of vegetation maintenance.

Plate 3.1 Long Eau: Sub-reach 1 looking downstream

Plate 3.2: Long Eau, Middle sub-reach

Plate 3.3: Long Eau, Downstream sub-reach

Summary of findings

The enhancement scheme does not yet appear to have provided any in-channel benefit in terms of habitat improvement. The introduction of riffles into a low energy river reach has done little to enhance habitat diversity and has led to ponding of the water upstream. The works have improved the RHS HQA score, however, due to improved bankside vegetation diversity and providing an increased flow type diversity.

In general, the introduction of gravel riffles in a predominantly low energy river is not effective in the development of useful habitat. It is recommended that gravel riffles are only introduced into channels where this type of bed feature is appropriate.
The macrophyte and invertebrate populations are currently impacted by the water quality in the reach. The marginal vegetation supports the most invertebrate taxa, showing the importance of retaining marginal sediment features and vegetation.

The development of sediment related features might be encouraged by modifying the existing vegetation management regime by reducing the proportion of the channel over which the vegetation is cut and always cutting in the same location each year. This would increase summer flood levels and would tend to increase the overall amount of sediment deposition.

The flow analysis shows that there are benefits in terms of conveyance if vegetation cutting extends over the deepest part of the channel. Where sediment features are developing, for example, in shallower areas and on the insides of bends, it is important that any vegetation cutting should avoid these areas. If such a practice were to be continued for a number of years then there is a risk that in the areas of the channel that are left uncut for a number of years, woody vegetation would develop. This would alter the nature of the maintenance required and any problems that this might cause would need to be considered.

In the lower reaches of the Long Eau system, flood risk is tidally dominated. In this case the flood risk is determined by the available storage not the conveyance of the channel. Sedimentation acts to reduce both but in a river system whether one is concerned about conveyance or storage will depend upon the nature of the river system and one's location on that system.

3.1.3 River Dearne, Yorkshire

Site description

The reach of the Dearne that has been studied is an example of a low energy, river reach that has been widened in the past. This has created uniform, low-velocity conditions which have led to a restricted range of habitats. The lower two sub-reaches provide examples of attempts to re-engineer the channel to improve the habitat, while in the upper sub-reach the withdrawal of maintenance demonstrates how a channel reach may respond if maintenance is reduced or ceases.

Plate 3.4 River Dearne: Upstream sub-reach

Plate 3.5 River Dearne: Middle sub-reach

Plate 3.6 River Dearne: Downstream sub-reach showing re-meandering

Summary of findings

Since the reduction of sediment maintenance in the upper reach a sequence of changes have been taking place:

a) low scrub and reeds have been developing on the margins of the channel which have attracted silt deposits,

b) these silt deposits act as flow 'deflectors', which modify the in-channel flow velocities,

c) the presence of the silt deflectors encourages sedimentation in their lee which results in narrowing of the low flow channel,

d) the nature of the bed sediments has been responding to this altered lateral flow distribution within the channel, leading to a greater proportion of coarser sediments in the area of the low flow channel than in the margins and hence a wide range of substrate types.

Thus the reduction in sediment maintenance is encouraging natural sediment processes and initiating the creation of sediment related habitat.

In the two downstream sub-reaches attempts have been made to promote habitat improvement by carrying out engineering works. In the middle sub-reach the armouring of the banks with stone has inhibited the development of sediment related habitat features along the banks. The armouring of the banks means that there is no opportunity for the channel to move laterally. The channel has been narrowed through this middle sub-reach but not sufficiently to promote the creation of sediment related habitat.

The downstream reach has been narrowed. This channel narrowing has successfully increased flow velocities so that sediment deposition does not take place but the sediment transport rate through this narrowed reach is such that no sediment is deposited and as a result no sediment related features have developed. This demonstrates a number of points:

a) conditions which minimise the need for sediment maintenance may not promote the development of sediment related habitat

b) the narrowing of a previously widened channel has to be carefully designed to take the sediment conditions into account.

In the narrowed reach the substrate has become coarser and it is believed that this has provided enhanced habitat for fish spawning.

3.1.4 River Eden, Kent

Site description

The total reach of the river under study has been subject to periodic maintenance involving sediment removal and clearing vegetation. The difference between the study sub-reaches was the time period since the last maintenance had been carried out. The study reach thus demonstrates the impact of periodic sediment removal and subsequent channel recovery.

Plate 3.7 Section of River Eden recently subject to plant cutting and dredging works

Plate 3.8 Section of River Eden exhibiting substantial recovery from plant cutting and dredging works

Summary of findings

The work shows that even when dredging is carried out in an exemplary fashion, leaving low berms and shelves and not carrying out full-width sediment removal, can significantly reduce the ecological value of sediment features. Sediment removal from the bed of the channel reduces the normal water levels. This means that features that were normally wet become effectively terrestrial as a result of the lowered water levels and as a result lose much of their ecological value. This reduction in water level and exposure of sediment features would appear to be an intrinsic result of sediment removal to control water levels. Thus even limited sediment removal can largely destroy the ecological benefits of sediment berms along the margins of channels
It would appear that dredging in the upper reach of the site has reduced the sediment supply to the downstream reach and has induced sediment erosion.

The invertebrate sampling suggests that when dredging is carried out in a sensitive manner and marginal habitats are retained, invertebrate populations are either little affected, or recover quickly.

The regular, routine removal of sediment point bars and other sediment features on the bed of the channel appears to have fossilised the plan form of the river so that bed sediment features do not develop. This inhibits bank processes and the development of bank features and the introduction of sediment into the system from the banks

The flow and sediment modelling suggest that the rate of accumulation of sediment is low and so it may be that if there was no significant flood risk sediment removal from the reach could be carried out less frequently or even stopped. This would provide more time for natural sediment processes to establish in the channel.

3.1.5 River Harbourne, Devon

Site description

The reach of the Harbourne considered is related to the capital works carried out in Harbertonford to control the flood risk through the village. The village had been subject to frequent flooding in the past and one of the challenges of the proposed flood relief works was to reduce the flood risk by increasing the conveyance of the river channel but to maintain the sediment transporting capacity of the channel so that a long-term sediment maintenance commitment was not created. As part of the scheme a flood retention dam was constructed upstream of the village.

Plate 3.9: Reach of the River Harbourne upstream of Harbertonford

Plate 3.10 River Harbourne showing some of the works carried out in the centre of Harbertonford

Summary of findings

The capital flood control works that have been carried out through Harbertonford seem to address the flooding problems by providing the required flood conveyance through the village but at the same time ensure that sediment deposition does not cause a significant maintenance commitment. This demonstrates that such a combination can be achieved despite that fact that in the past many flood alleviation schemes have only provided increased flood conveyance at the cost of a significant sediment maintenance commitment.

The evidence from the invertebrate study is that recovery of the invertebrate population has taken place within two years of the capital scheme being carried out.

3.1.6 River Kent, Cumbria

Site description

The reach of the River Kent that was studied forms a high-energy gravel bed river through the centre of Kendal. The river channel has been subject to major changes in the past and now has artificial banks while the bed level is constrained by a number of weirs. There has been a history of fluvial flooding in the urban area and a flood scheme was implemented in the 1970s. Sediment is deposited in the form of gravel shoals within the channel and these have to be removed relatively frequently to control the flood risk. The site was used to investigate the impact of sediment removal and the impact of different sediment removal strategies.

Plate 3.11 River Kent showing mid-channel gravel bar downstream of Stramongate weir

Summary of findings

The main issue at this site is the impact of gravel deposition and the need for and potential impact of maintenance activities. The sediment modelling suggests that if gravel removal ceased then the bed levels would rise over a period of time but eventually reach a stable profile. Unfortunately there would be an associated increase in flood level.

Without the flood risk constraint, it would be possible to allow bed levels to rise immediately downstream of Stromongate Weir. This would increase the movement of sediment downstream. There is a possibility that this would increase the sediment maintenance required in the reach downstream. Removal of the weir would increase the available headloss in the reach and would aid the movement of sediment through the reach.
If the frequency of maintenance could be reduced then the in-channel gravel shoals would continue to develop. After a period of time it is likely that these would colonise with macrophytes so that a more varied range of in-channel habitats would develop. An alternative management strategy would be the periodic ‘scalping’ of the gravel shoals to inhibit the colonisation of macrophytes and promote ERS habitat. In this case different management practises have very different impacts on the habitats and the selection of the appropriate maintenance approach must depend in part on priorities related to the resulting habitats.

The removal of sediment in the middle sub-reach reduces the supply of sediment to the downstream reach which is inhibiting the development of sediment related features in the downstream reach.

The invertebrate surveys suggested that following gravel removal the aquatic invertebrates recovered, in terms of number of taxa, in a period of a few months though the population appeared to have been reduced by approximately a factor of two.

3.2 Analysis of other sites from the RHS data base

The project was very aware that the work carried out at the five field sites was very intensive and it would not be possible to reproduce this widely. There was thus an interest in whether readily available information could be used in order to assess the interaction between maintenance practises, sediment and habitat at other locations. An extensive, nationally available and valuable database of information on habitat is provided by the results of the RHS surveys. The project thus investigated whether the RHS database could be utilised to assess and compare different management strategies.

Using the RHS database it was possible to generate the HMS and HQA scores for the sites surveyed during the project. Taken in isolation, these scores tell us little about how the sites compare with rivers of a similar type across the UK. To determine this, the RHS team generated HMS and HQA scores for the 150 nearest sites on the PCA map; for this purpose the 1994-1996 baseline survey data set was used so that the comparisons were made against randomly selected site locations, unbiased by surveying more in one area than another, or surveying proportionally more of one river type than another.

The nearest 150 baseline sites were selected in terms of site altitude, slope, distance to source and height of source. The same procedure was followed to calculate the range of HMS scores for the project sites, and the 150 nearest neighbour river types for the five rivers.

The comparison put all the study sites into the context of similar sites around the UK. In the case of the River Eden, a detailed assessment was made to look at similar rivers in the same geographic area. This showed that the River Arun was a similar river but it had consistently higher HQA scores and lower HMS values. Investigation revealed that the sites on the River Arun had not been subject to maintenance, other than ‘pioneering’ for 10 years. This initially suggested that this was a clear demonstration of how the RHS database could be used to provide information on the impact of management practices. The sites on the River Arun were, therefore, investigated in greater detail. Photographic evidence was available for 1996 and this was used to investigate the changes that had taken place during the last 10 years during which no significant in channel maintenance had been carried out. The comparison revealed that there had been, in general, little change to the in channel sediment features.

This raises two issues. The first is the extent to which the difference in RHS scores between the Eden and the Arun are possibly misleading and secondly the slow rate of development of sediment features in lower energy water courses.

The comparison of the RHS data for the Eden and the Arun would suggest that just looking at the HQA scores and HMS may not be sufficient to indicate the impact of in-channel sediment management practises. The overall HQA and HMS values depend upon a wide range of factors that are not affected by in channel sediment maintenance. Individual sub-scores for features such as ‘Channel features’ or ‘Flow type’ provide a better indication of the impact of in-channel maintenance.

It has to be recognised that the response of fluvial sediment systems to changes in management procedures may be slow. For example, the River Kent in Kendal is a high-energy system in which one would expect changes to occur more quickly than in lower energy environments but even in this river the numerical modelling suggested that the period required for bed levels to adjust to stopping sediment removal is of the order of 10 years. In lower energy systems the period of adjustment might be much longer. An important factor is also the length of river over which the sediment management is changed. If management is changed over a long reach of a river then the adjustment may take a long time to be fully effective but a shorter reach will respond more quickly.

4 Summary of conclusions and recommendations

4.1 Main contributions of project

The project has provided direct evidence for the impact of a range of maintenance activities on sediment-related habitats in river systems. The study has increased our appreciation of the mechanisms by which channel dredging impacts on sediment related habitats. Dredging causes a reduction in normal and low water levels and this has a direct impact on the value as habitat of sediment features within the channel. This effect is an intrinsic impact of dredging and it would appear cannot be avoided by altering the details of how the dredging is carried out.

The project has provided direct evidence for the impact of maintenance works in invertebrates and has also provided evidence on rates of recovery.

The project has provided evidence for the importance of considering marginal habitats and the impact of capital and maintenance works on such habitats. The work has shown that the use of bank protection materials, such as rip-rap, can inhibit the development of marginal habitats.

The project has provided evidence for the need to adopt adaptive management within FRM activities. Works carried out in the past have not always have achieved their objectives or priorities have changed so that there are now new or additional objectives. There are advantages if schemes can be modified to take account of both past performance and changed priorities. In the past schemes have not always incorporated such flexibility and so it can be difficult to adapt schemes to changed circumstances.

The project has demonstrated a Flood Alleviation Scheme that has increased flood capacity in an urban context but does not appear to have a significant long-term sediment maintenance problem.

The project has developed and demonstrated modelling tools to simulate the impact of maintenance activities on flow and habitat diversity. Such tools and approaches have the potential to enable other FRM activities to be investigated to determine their impact on diversity.

4.2 General conclusions

The picture that emerges from this work is as follows:

<u>Natural processes</u>
Impact of sediment-related features on flow conditions

Sediment-related features occur naturally in river channels. These features affect the flow within the channel and result in a range of velocity and depth conditions. The varied flow conditions affects the movement and sediments and results in a range of different substrate types. Thus the presence of sediment related features within a river channel results in a wide diversity of habitats.

Impact of sediment related features on macrophyte populations

The wide range of sediment and flow conditions provides varied habitats which can support a range of macrophytes. Thus a channel with sediment-related features be capable of supporting a wider range of marcophytes than a similar channel from which sediment-related features have been removed. Macrophytes contribute to the hydraulic roughness of the channel and so act to modify both the flow and the sediment movement within the channel. The presence of the macrophytes also influences sediment movement by trapping sediment. The influence of the macrophytes on the flow and sediment movement creates a detailed mosaic of habitats within the channel.

Impact of sediment-related features on invertebrate populations

The invertebrate population is influenced by the nature of the flow, substrate and macrophyte population as the macrophytes provide food and shelter for the invertebrates. Studies have shown that it is possible to associate distinct macrophytes with certain invertebrate populations.

Impact of sediment-related features on fish

The fish population is affected by the character of the flow, the presence of the macrophytes and also invertebrates. The diversity that results from the presence of sediment-related features provides greater opportunities for population diversity that channels without such features.

These interactions are summarised in Figure 4.1.

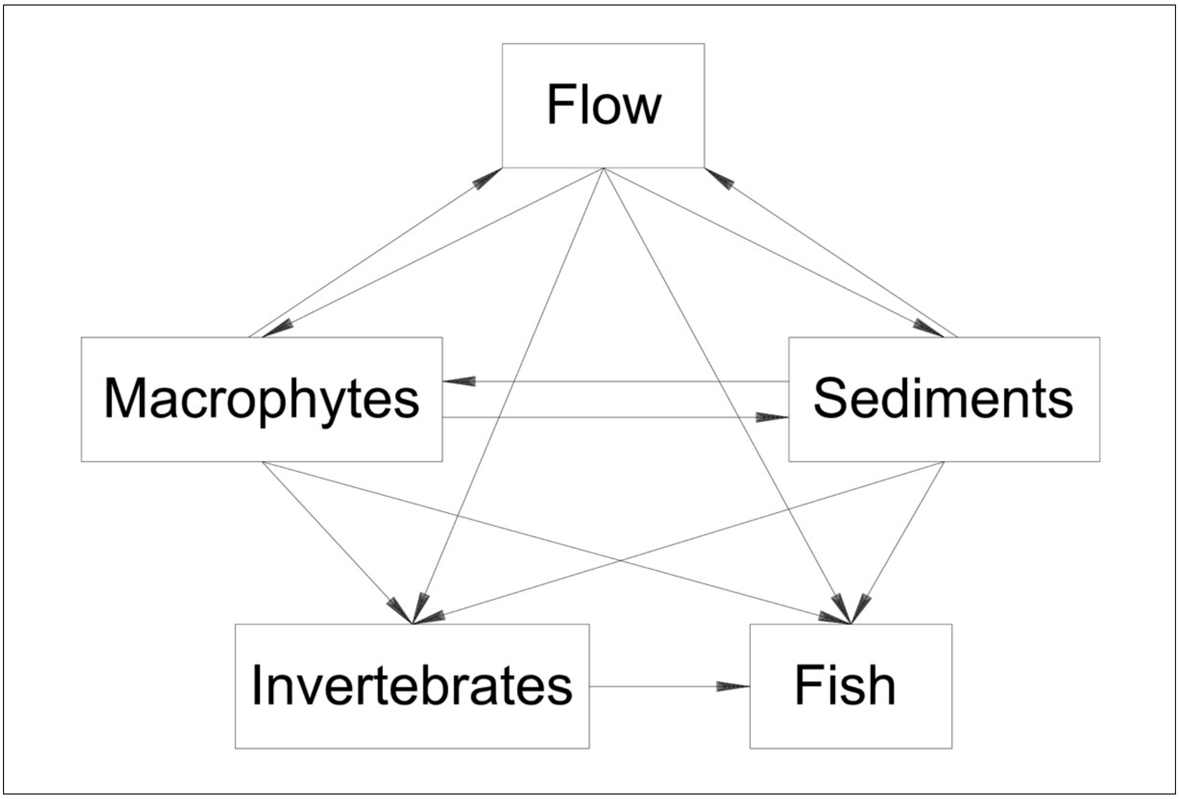

Figure 4.1 Interactions between in-channel flow, sediments and biota

<u>Influence of vegetation management</u>
Impact on macrophyte populations

Vegetation cutting modifies the flow conditions and hence influences the channel morphology. By changing the physical habitat, vegetation cutting changes the macrophyte population. The periodic disturbance of weed cutting affects the overall macrophyte community structure. In general the impact of weedcutting is to reduce species diversity, richness and macrophyte patch complexity. For some macrophyte species colonisation may take place from upstream. It has been suggested that a potentially important aspect is that were a stream consists of a complex matrix of reaches with and without weed cutting then the influence of colonisation from upstream may mean that the impact of weed cutting spreads over the entire length of the river. Thus it is possible that the macrophyte population in a reach may be affected by weed cutting in adjacent reaches even though that particular reach is not itself subject to cutting.

Impact on invertebrate population

Changes in the flow characteristics and the macrophyte population result in changes in the invertebrate population. In addition, some invertebrate species are directly vulnerable to frequent habitat disturbance that results from vegetation management. Thus, in general, vegetation management reduces both invertebrate diversity and the number of individuals.

Impact on fish populations

Species of fish which rely on macrophytes to provide shelter and invertebrates to provide food will be impacted by the changes in the macrophyte and invertebrate populations induced by vegetation management. Thus fish populations are likely to be impacted by vegetation management

Summary

The implications are that weedcutting should be regarded as potentially detrimental to in-channel habitats, careful evaluation should be carried out before implementation and should be avoided whenever possible.

Impact of dredging

General impact of dredging

The impact of dredging has similarities with the impact of weed cutting. Dredging has an impact on macrophyte populations in a similar way to weed cutting though the impact may be more extreme. In general, dredging has a more profound impact on the channel morphology and water level than weed cutting and so the impact may be more severe and longer lasting. In addition the removal of sediment at one location has the impact of starving the downstream reach of sediment which will also have an impact on channel morphology and hence an impact on habitats.

Options other than sediment removal

Before removing sediment, it is recommended that consideration should be given as to whether the sediment that is present in the channel is having a significant impact on the conveyance. To minimise or remove the need for dredging, it is recommended that investigations are made into upstream sediment sources that may be the source or contributing to the problem. Sediment issues should be seen in their catchment-wide context. In general it is better to treat the upstream sources than the treat the problem created downstream. Where sediment features are limited in size and spatial distribution it is likely that sediment-related maintenance could be reduced or stopped. If sediment has to be removed from the system it may be possible to reduce the impact by the use of a specifically designed sediment trap. This will still have an environmental impact but it may reduce problems associated with the removal of sediment.

Frequency of maintenance and rate of recovery

Flood Risk Management maintenance activities, such as vegetation cutting and dredging, have an impact on in-channel habitats that are intrinsic to the nature of the activities and their impact on habitats can range from minor to severe depending upon the nature of the river and the works carried out.

The rate of recovery depends upon the nature of the work carried out and the factors being considered. In general, high energy sediment systems adjust and recover more rapidly than low energy systems, though the period of recovery is still measured in years. For high energy systems recovery may take place in two or three years but in low energy systems the period required to reform sediment features may be measured in decades. The number of invertebrate taxa recovers within months of work being carried out but the number of individuals may be severely affected for a significant period.

Adaptive Flood Risk Management

As it is difficult to fully predict the impact of river management actiovities Adaptive management should be adopted to ensure that future management can be modified to take into account developments within the physical and biological systems or changed management objectives. This implies that the impact of management works should be monitored and the management approach modified on the basis of that monitoring.

Availability of tools to assess the impact of channel management

There are a range of tools and methods currently available which can be used to assess in channel flow diversity. These can be used to investigate the impacts of potential future management strategies so that their impact can be assessed before they are implemented.

Performance-based Asset Management

There will always be a need to carry out sediment-related habitat in channels where otherwise the flood risk would be unacceptable. In these circumstances it is important that the work that is carried out is appropriate to manage the flood risk. The Performance-based Asset Management System (PAMS(that is currently being developed by the Environment Agency provides a framework to ensure that maintenance is necessary and appropriate for the performance of the system.

Summary

In summary, when specifying channel maintenance and capital works consideration should be given to the following:

a. Has the origin of the sediment problem been identified and is the proposed works addressing the source of the problem or a symptom,

b. Will sediment removal increase the conveyance of the system

c. The environmental impact of different option will be different and this should be taken into account when selecting the most appropriate option

d. As appropriate, modelling can be used assess the impact of proposed works and to indicate impact and recovery rates

e. Sediment removal is likely to have a significant impact on vegetation, invertebrates and fish

f. Review the methods used for sediment removal to minimise the potential environmental impact

g. When considering modifying an engineered channel consider whether the channel can be left to recover naturally

h. Where possible adaptive management should be adopted

i. When designing capital works the future maintenance needs should be assessed and reduced where feasible

j. Vegetation management can potentially impact on invertebrates, fish and sediment movement

k. Vegetation management should be minimised consistent with achieving flood risk management requirements

l. When specifying different vegetation management options consider different cutting strategies and timings

m. Review the methods by which the work will be carried out in order to minimise their environmental impact.

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Appendices

The appendices are available from the joint Defra and Environment Agency Flood and Coastal Erosion Risk Management (FCERM) research and development programme website:

Appendices 1 - 8

http://evidence.environment-agency.gov.uk/FCERM/Libraries/FCERM_Project_Documents/Appendices_1_to_8.sflb.ashx

Appendix 9

http://evidence.environment-agency.gov.uk/FCERM/Libraries/FCERM_Project_Documents/Appendix_9_Maps.sflb.ashx

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