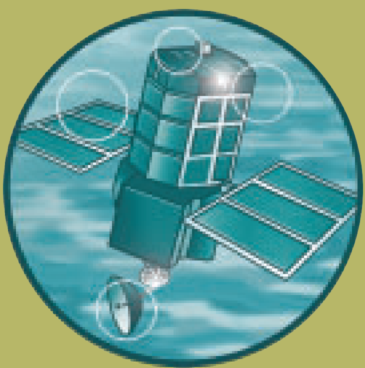
Joint Defra/EA Flood and Coastal Erosion
Risk Management R&D Programme

River sediments and habitats and the impact of maintenance operations and capital works

Report on Stage 1

R&D Technical Report FD1920/TR



Environment Agency

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River sediments and habitats and the impact of maintenance operations and capital works

Report on Stage 1

R&D Technical Report FD1920/TR

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Statement of use
This report describes the first stage of a project to improve the understanding of the interactions of sediments, habitats and conveyance as affected by maintenance operations and capital works. The primary objective of this first stage is to identify the requirements for field trials, identify suitable locations, data collection requirements and protocols for data quality, checking and storage.

The results of this project will be used to develop Stage 2 of the project, in which it is intended that field trials and demonstrations will be carried out and the results interpreted to provide information on the self-regulatory nature of conveyance response, effective river management and new approaches to sustainable maintenance and channel design, including adaptive management for flood defence. The benefits to Defra/Environment Agency (EA) of the overall project are that it should be possible to deliver present Standards of Service in terms of flood defence and land drainage while reducing adverse impacts on channel eco-systems and preferably bringing about habitat rehabilitation through natural processes.

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Executive summary

In the past channel maintenance has been carried out with the objective of maintaining river channel conveyance and providing land drainage. In selecting methods of channel maintenance sometimes little regard has been paid to the impact that removal of vegetation or sediments may have on habitats and the whole sediment dynamics of the river at the reach and catchment scales. There is a growing realisation that by understanding the interactions between sediments, habitats and conveyance it should be possible to develop methods and advice on best practise for carrying out maintenance that is effective, minimises the adverse impacts on the environment and potentially brings environmental benefits.

This report describes the first stage of a project to improve our understanding of the interactions of sediments, habitats and conveyance as affected by maintenance operations and capital works. The primary objective of this first stage is to identify the requirements for field trials, identify suitable locations, data collection requirements and protocols for data quality, checking and storage.

The results of this project will be used to specify Stage 2 of the project. It is recommended that this consist of a programme of study based on new field data that would be collected as part of Stage 2 and analysis of existing data. A list of field sites has been compiled and the issues that can be addressed at each site identified. The data that needs to be collected can be classified under the headings:

- Historic data
- Hydrological data
- Maintenance regime and forward planning data
- Morphology and sediment data
- Habitat data and
- Biotic data.

In addition it is recommended that data from the RHS database is analysed to provide supplementary information relating to river types and maintenance works that are not covered by the field sites.

A recommended programme has been developed for Stage 2. The risks associated with Stage 2 have also been considered and methods to manage them have been suggested. The primary risks are associated with the flow conditions that may be experienced during the period of the field investigations. These flow conditions will be monitored during the period of the field work and this information will be used in interpreting the data that is collected.

An estimate of the potential benefits of Stage 2 has been prepared and compared with the likely costs. These indicate that the payback period for Stage 2 is less than a year and that the Benefit/ cost ratio exceeds 10 if the discounted benefits are calculated over a 20 year period with a discount rate of 5%.

Contents

1. Introduction

1.1 Introduction

In the past channel maintenance has been carried out with the objective of maintaining river channel conveyance and providing land drainage. In selecting methods of channel maintenance sometimes little regard has been paid to the impact that removal of vegetation or sediments may have on habitats and the whole sediment dynamics of the river at the reach and catchment scales. There is a growing realisation that by understanding the interactions between sediments, habitats and conveyance it should be possible to develop methods and advice on best practise for carrying out maintenance that is effective, minimises the adverse impacts on the environment and potentially brings environmental benefits.

This report describes the first stage of a project to improve our understanding of the interactions of sediments, habitats and conveyance as affected by maintenance operations and capital works. The primary objective of this first stage is to identify the requirements for field trials, identify suitable locations, data collection requirements and protocols for data quality, checking and storage.

The results of this project will be used to develop Stage 2 of the project. In Stage 2 it is intended that field trials and demonstrations will be carried out and the results interpreted to provide information on the self-regulatory nature of conveyance response, effective river management and new approaches to sustainable maintenance and channel design, including adaptive management for flood defence.

1.2 Scientific setting

The sciences of geomorphology and eco-hydraulics describe the 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 and sediment 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, such as sediment removal or vegetation cutting, 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 dynamic stability of the channels and hence the benthic, in-stream and riparian ecosystems it supports.

At present the interaction between flow, sediment and habitats is poorly understood. If this understanding could be improved then it should be possible to integrate this knowledge into improved approaches to operational maintenance. This should lead to sustainable channels that operate satisfactorily in terms of water flow, sediment transport, morphology and habitats with minimum maintenance. The purpose of the overall project (Stages 1 and 2) is to improve our knowledge of the interactions between flow, sediments and habitats and the impact of channel maintenance. More targeted maintenance would also have economic and operational benefits.

In the past, the main considerations in carrying out channel maintenance work have been to improve conveyance and flood defence. Consideration has been given to environmental issues but there has been no consistency in application due to poor understanding of the processes. The impact of such works on habitats, either directly or indirectly by impacting on sediments, has received little attention. If more was understood about the effects of maintenance activities on habitats and sediments then the objectives of maintaining conveyance and flood defence could be achieved with environmental benefit or reduced impacts on habitats and conservation. What is required is a balance between:

- flood defence
- conveyance
- conservation
- recreation and navigation (in some reaches)
- fisheries.

Consultation with river managers within the Agency, Internal Drainage Boards (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 engineered 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 is significant.

There are some situations where good practice in maintenance has improved the quality and sustainability of the habitat. This project will draw together that best practice in addition to enhancing and improving existing knowledge. The improved knowledge of sediments and habitats and the effects of maintenance/capital works on them arising from this project should enable design engineers and managers to work better with the systems, leading to more sustainable, economical management methods. This will be important at both the strategic and local scales.

This present Stage 1 of the project was required to scope out an effective and efficient programme for the next stage of the research to ensure that the investigations carried out in Stage 2 are effective. Stage 1, by addressing existing and proposed work, will ensure that Stage 2 will capitalise on existing knowledge and opportunities presented by other research programmes. Stage 1 has developed a research programme for Stage 2 which will ensure that any field trials and demonstrations carried out under Stage 2 are effective in addressing the identified problems.

The benefits to Defra/Environment Agency (EA) of the overall project are that it should be possible to deliver present Standards of Service in terms of flood defence and land drainage while reducing adverse impacts on channel eco-systems and preferably bringing about habitat rehabilitation through natural processes.

Under the new EC 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'. 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 defence management could, in the future, hold the key to achieving sustainable river rehabilitation through improved management practices that encourage natural processes to sustain both habitats and conveyance.

At present it is known that operational channel maintenance has an impact on sediments and habitats within the river system. The nature of this impact is, however, not well understood. The overall project will deliver an improved understanding of these processes and how the design of maintenance operations can capitalise on this improved understanding to deliver improved methods of carrying out maintenance.

To date, there have been few data collected to identify quantitative effects of modified management regimes on habitats and the ability of different river types to maintain adequate conveyance whilst at the same time create, and sustain habitats of importance in supporting typical/rare river biota, and landscape and recreational interests of rivers. The overall project (Stages 1 and 2) should build upon what little is known. Through field trials and monitoring of existing contrasting practices on different reaches of the same rivers the research should lead to knowledge-based modifications to management in the future that meet both local and catchment flood defence needs, as well as meeting environmental responsibilities and aspirations and requirements of the WFD.

Objectives

The objectives of the overall project include:

1. quantify the impacts, benefits and influences of management and maintenance on sediment and habitat features
2. establish if, when and how sediment processes become self-regulatory negating the need for further maintenance or management, where appropriate
3. determine the critical time at which intervention is required to manage geomorphically created sediment habitats in restored rivers for conveyance purposes
4. test and validate new approaches to maintenance and channel design
5. provide guidance on appropriate management, and when safe and desirable to allow river reaches to have no management (i.e. Identifying effects of 'controlled retreat' at reach and catchment scales)
6. supply the experimental basis for adaptive management of flood control and restored channels
7. develop improved links between RHS outputs and flood defence 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.

The objectives for Stage 1 included:

A) establishing the availability of relevant data from past, on-going, or planned programmes that might contribute to the objectives of Stage 2, develop protocols for data collection and management
B) determining examples where contrasting management is undertaken on the same river in different locations, but where hydraulic conditions are similar, to:
    1. select sites where investigation and monitoring of the sediment/habitat characteristics and conveyance performance can be compared for reaches receiving different management regimes for many years and
    2. determine if some sites can have subtle or radically modified management practices in the future that would allow the effects of such changes on sediments, habitats and conveyance to be monitored without risk to flood defence responsibilities
C) the provision of a well-designed, scientific programme for investigating the impact of channel maintenance on flow, sediments and habitats that takes account of other past, on-going and planned programmes of research in the area. This will include:
    1. the identification of suitable sites for field trials and demonstrations and
    2. the specification of the measurements that will be required.

Project Team

The project team consisted of:

Alconbury Environmental Consultants (Dr N Holmes)
University of Birmingham (Mrs K Fisher).
HR Wallingford
Nottingham University Consultants (Professor C Thorne)
Posford Haskoning,
River Restoration Centre (Mrs J Mant),

The project team was led by HR Wallingford.

2. Project approach

2.1 Introduction

The project was multi-disciplinary requiring a wide range of knowledge that was not available in any one individual. The expertise that was required included knowledge of:

- river habitats
- catchment and reach geomorphology
- river sediment dynamics
- conveyance
- operation and maintenance and
- design.

It was with these needs in mind that the project team had been assembled. The success of the project depended upon bringing such experts together and ensuring the appropriate interactions between them. As a result it was decided to structure the project as a number of intense periods of work involving all the relevant experts separated by periods for the collection of information. The intense periods of activity were in the form of a series of workshops.

It was important that any existing relevant data was utilised, as using existing data is more cost-effective than collecting new data. Thus it was important that in the project due attention was paid to identifying appropriate existing data. The project team had extensive knowledge of complete or on-going research work in this area. They also had extensive contacts within the subject area and so were in an ideal position to identify any suitable existing data.

There are a wide range of geomorphological river types, habitats and human interventions that potentially needed to be addressed. Despite the size of the budget for Stage 2 it is extremely unlikely that it will be possible to carry out field work that covers the full range of possible situations. In this situation we see it as being important to supplement the field studies with other forms of data. We feel that in Stage 2 data sources such as the RHS and enhanced RHS could be used to extend the results of any field investigations to a wider range of river and habitat types.

In assessing the impact of maintenance or capital works it is important not to limit attention to the modified reach. It is quite possible for the impact of change to extend both upstream and downstream. This was considered when planning the field trials for Stage 2.

2.2 Workshop 1

An initial workshop was held on 1 August 2003 at HR Wallingford. The purpose of the workshop was to identify the nature of the data to be collected for Stage 2 and the characteristics of the sites for which information would be required. For the workshop the project team was supplemented by invitees from outside the project. The invitees were selected in consultation with and with the agreement of Defra and the EA. They included staff from the EA, Centre for Aquatic Plant Management and Reading University. The workshop:

- identified the range of management practises to be considered
- selected the range of river sediment and habitat types that will need to be studied in Stage 2
- defined the approach to any field investigations
- selected the parameters to be monitored, particularly the ones relating to habitats and sediments
- identified potential sources of existing relevant data.

The range of management interventions that should be addressed in Stage 2 was discussed. A summary of the conclusions is given in Section 4.

Following some discussions a list of the requirements for potential field sites was prepared. Details are given in Section 3.

2.3 Workshop 2

The second workshop was held on 9 January 2004 at the University of Birmingham to select the sites for the field trials. The first part of the Workshop was concerned with reporting back to the participants the results of the work that had been undertaken since the previous workshop. Then the issue of site selection was addressed. A long list of potential sites had been produced, see Appendix 2. A short-list of sites was drawn up and the issues to be investigated at each site were agreed. These are summarised in Table 7.1.

During the discussion of potential sites the issue of the role of sediment at the sites was raised. The consensus was that the project should only be concerned with sites at which sediment contributed to the formation of habitat, that is, those sites where sediment is involved in the construction of a habitat and where maintenance work removes that habitat. There are artificial channels which are periodically cleaned of sediment that has been deposited. In such sites the sediment deposition blankets the bed of the river and has to be removed periodically on flood defence grounds but the sediment deposition does not lead to the formation of habitats. It was considered that such channels should be outside the scope of Stage 2.

The draft programme for Stage 2 and an outline of costs were also discussed.

3. Nature of maintenance work considered

The nature of the river management activities that should be considered was discussed at Workshop 1. It was considered that the management interventions that were selected should affect sediment and the impact on the sediment must be important for habitat. The selection of management interventions to be studied should take into account:

- the overall cost of such works
- the amount of impact
- the overall length of river affected.

It was considered that the regular management interventions with the largest impact were probably:

- dredging/sediment removal
- vegetation cutting
- sediment traps.

The objectives of the project also imply that the impact of capital works needs to be addressed and this was confirmed during discussions with the Environment Agency. As is discussed in greater detail below, the sites have been selected to include examples that have been impacted by recent capital works so that the impact of such works and the recovery of river reaches can be investigated.

4. Characteristics of required sites

The characteristics associated with suitable sites were discussed extensively at Workshop1. There were a number of requirements for proposed fieldwork sites. One requirement was that there should be a range of river types, that is, that the sites should not be on the same type of river. The requirements for individual field sites included:

- availability of suitable flow data
- history of site including any maintenance work or other intervention
- the maintenance activity should fit with the requirements of the project
- the site and the management activity should be such that study of them should be able to contribute to the project objectives
- there should be suitable site access and a sympathetic riparian owner
- sites should be representative of river types and maintenance problems commonly experienced.

5. Existing sources of data

5.1 Introduction

A number of relevant programmes of data collection in Great Britain were identified during the project. Each had been designed around particular research objectives which did not fully coincide with the research objectives of the present study. The general result, therefore, was that the nature of the identified sites where data were available were not ideal to achieve the objectives of Stage 2. Thus either the nature of the sediments was not appropriate or there were no or unsuitable management interventions. Thus it was considered that it was not possible to use these existing sites as primary field sites for Stage 2. This does not exclude their potential for providing data to supplement that obtained from the Stage 2 field investigations. In addition to the work carried out in Great Britain the project also identified relevant work that has been carried out in the USA. The more important relevant data collection programmes are described below.

5.2 River Habitat Survey

The River Habitat Survey (RHS) is a method to characterise and assess, in broad terms, the physical structure of freshwater streams and rivers. It has been wildly applied in England and Wales so there is an extensive data set available. The RHS records information related to both the channel, the banks and the area within 5m of the banks. Observations are made at 10 locations within a 500 m reach. It is hoped that in many cases the impact of channel maintenance work will be discernible from the RHS data. If this is the case then this data set will give an opportunity to extend the results of the field data collected in this project to a much wider range of river and maintenance types.

5.3 LOCAR

LOCAR (LOwland CAtchment Research) is a Natural Environment Research Council funded research programme which is undertaking detailed, interdisciplinary programmes of integrated hydro-environmental research relating to the input-storage-discharge cycle and in-stream, riparian and wetland habitats within groundwater dominated systems. The programme has set up data collection exercises in three permeable lowland catchments:

- the Frome/Piddle in Dorset
- the Pang/Lambourn in Berkshire
- the Tern in Shropshire.

LOCAR sites on the Frome and Piddle were included in the long list of sites considered at Workshop 2, see Appendix 2. These sites were discarded on the grounds that their sediment regimes were not appropriate for a Stage 2 site.

5.4 Central Fisheries Board, Eire

The Central Fisheries Board (CFB) of Eire has been carrying out studies looking at ‘experimental’ maintenance regimes to try and increase the fisheries value of sites. The work has involves setting up trials involving control, standard maintenance and experimental maintenance sites. The maintenance topics studied included:

- excessive in-channel growth
- heavy growth of emergent and submerged ‘water celery’ type of vegetation
- bank erosion
- excessive tree and shrub cover in the channel cross-section
- lateral siltation.

The range of changes resulting from these studies is interesting. They can be classified as follows:

- management: development of structured liaison between the Office of Public Works who are responsible for carrying out the maintenance work and the Regional Fisheries Boards
- timing of works: cessation of maintenance activities in channels identified as salmon and trout spawning waters during winter-spring periods
- maintenance operations: leaving untouched gravel areas in reaches with ‘good’ bed gradients
- transition from using draglines to use of long-reach hydraulic machinery in medium and smaller channels.

The results demonstrate that the implementation of improved maintenance techniques requires a wide range of approaches and is not limited to identifying alternative maintenance operations.

The study identified that many reaches could be self-cleansing and that in these reaches what was required was ‘restorative’ maintenance to create hydraulic diversity.

It is recommended that Stage 2 of the project liaises with the CFB to take advantage of results from any on-going studies.

5.5 Experiences in the USA

During the study information was gleaned about maintenance practices in the USA. The legislative context in the USA is very different from the UK and the nature of the maintenance problems can be very different but a number of general conclusions could be drawn:

- legislation and technical guidelines cannot be used to solve maintenance problems and optimise maintenance regimes

- changing the perceptions of people with out-of-date ideas and convincing professionals of the need to work as team members and overcome special interest groups with narrow agendas is required
- consensus building must start at an early stage in project design and be carried through to completion and post-project monitoring and appraisal.

The USA experience highlighted that the adoption of changes in management practice is not just a technical issue. It also includes issues such as education, training and working with all the stakeholders involved. The main implications of the USA experience is that in designing sustainable river maintenance regimes, the physical, social, institutional and behavioural dimensions are all, in practise, equally important in achieving success.

6. Approach to Phase 2

6.1 Introduction

The main effort should be directed at collecting targeted field data and to supplement it wherever possible by existing, relevant data. It was considered that wherever possible the data collection methods and protocols should be based on existing, well-established approaches.

These data would provide the experimental basis for all the recommendations of management of channels and so will form a major contribution to Project Objective (6). The analysis of different aspects of the data would then contribute to Project Objectives (1) to (4).

As part of Stage 1 field sites were selected to provide a range of river types and management interventions. In addition Stage 1 identified the issues that should be addressed at each site that would contribute towards the objectives (1) to (5). These issues are discussed in detail below.

6.2 Monitoring and data collection recommended for Stage 2

It is envisaged that at each site there would be a period of intense data collection to characterise the site and collect baseline data. This would be followed by a period of data collection spread out over approximately 2 years in which further data would be collected in order to provide time series data.

It is recommended that wherever possible the field data collection methods and protocols should be based on existing, well-established approaches: The following data will be required at each site:

- *Historic data*
  - Historic data on;
  - the history of the river
    - any human interventions in the past
    - any historic data relevant to the study such as biotic data
- *Hydrological data*
  - Time series data on flow regime
- *Sediment data*
  - Appraisal of sediment dynamics and maintenance regime
  - Bed sediment sampling
- *Habitat data*
  - River Habitat Survey
  - Topographic, bathymetric and velocity data
- *Biotic data*
  - Data on macrophytes, the parameters of interest should be species composition, diversity and abundance. Data on invertebrates and fish should be used depending upon the nature of the site and existing data sets.

- *Numerical modelling*
  Flow modelling for a range of different discharges and levels

6.2.1 Historic data

It is proposed that historic data on river development and past maintenance at the site should be collected. This will provide insight into the existing river form and the present maintenance regime. Much of these data would be collected from local Environment Agency Area offices and will require the co-operation of EA staff to locate the relevant data but it is expected that detailed searches will be carried out by the project team.

Where they are available, historic, bathymetric data should be collected in order to compare with the surveys that are recommended as part of the present study.

All available historic biotic, geo-morphological and other data will be collected and reviewed.

6.2.2 Hydrological data

It will be important to characterise the habitats at the sites in terms of the flow conditions, including flow velocities and depths. In many situations, the impact of sediment features is to provide a wider range of flow velocities and depths than would be found in the absence of such features. Correspondingly the impact of, for example, dredging is often to reduce the range of flow velocities and depths. The project needs to be able to quantify the change in habitat characteristics that takes place as the result of different management strategies.

While it is possible to collect such data during a field visit this only provides the data for one flow condition that may not be representative. There is a need to assess the conditions for a range of flow conditions. Thus it is important to know how the flows at each site vary. One of the factors considered in site selection was the availability of flow data and so it is important that suitable data should be available for all sites.

The intention would be to establish flow exceedance curves for the sites so that the variability in flow conditions and habitats can be investigated.

6.2.3 Sediment data

To establish the connection between sediments and habitats it is important to characterise the sediments at each site. A catchment baseline survey should be carried out together with a detailed geomorphic survey of the relevant reach for each river. This will establish the overall context of the site and should help to explain the detailed sediment conditions at the site. Particular attention should be paid to sediment dynamics, sediment features and the effects of past and present maintenance regimes on the continuity of sediment movement through the reach.

In addition bed sediment sampling should be carried out to provide a detailed characterisation of the sediments at the site.

6.2.4 Habitat data

The River Habitat Survey techniques will be used to describe the habitat. These should include the use of the GeoRHS which is the Geomorphological and Floodplain component of RHS. While the approach used will be based on RHS it may be that the spatial density of sampling should be adjusted to correspond to the spatial scales of the habitats and features present in the river channel. In order to improve the description of in-channel features that may be affected by management, it is recommended that the RHS surveys be carried with a spatial resolution of 25 m. It is recommended that RHS surveys are carried out at least three times during the duration of the project. These surveys should include both the affected reach and the control reach.

6.2.5 Biotic data

The collection of biotic data, though not strictly necessary to satisfy the objectives of the project, would add significantly to the overall value of the data collected during Stage 2. The cost of such data collection would be modest and the potential benefits are such that it is recommended that this is included in Stage 2.

All data for affected and control reaches relating to fish, invertebrates and macrophytes will be reviewed. To be worthwhile good historic data must exist for fish or invertebrates as their mobility means that a short series of isolated surveys are difficult to interpret. For the sites considered there appeared to be no comprehensive pre-scheme data for both controls and affected reaches. Though dedicated biotic surveys of fish and invertebrates would be valuable we cannot recommend them as part of this project. If additional funding could be obtained to undertake this monitoring then it would be invaluable in improving our understanding of the relationships between habitat and species and also broadening the application of RHS.

Sampling of macrophytes does not pose the same problem as they are not mobile. Macrophytes are also of interest as they are often a target for maintenance work and also a component of the habitat for fauna. We recommend that suitable surveys of the macrophyte populations are carried out at suitable sites.

6.2.6 Topographic, bathymetric and velocity data

Topographic and bathymetric data will be required in order to describe the habitat present and also to provide data for numerical flow modelling in order to predict the flow characteristics at each site.

It is also recommended that limited velocity data are collected at each site to aid in the calibration and verification of the numerical modelling. It is envisaged that velocity transects would be taken at two to three cross-sections.

6.2.7 Numerical modelling

An important parameter describing any river habitat is the flow regime. This is normally described in terms of flow velocity and depth. Both these parameters vary with discharge. To establish the values in a particular river reach it is possible to carry out a number of surveys under different flow conditions and use this data to establish the flow regime for that reach. This is often expensive and time consuming as it relies on carrying out a number of field surveys under different flow conditions. An alternative approach is to use a suitable numerical river model to simulate different flow conditions in the river reach. This requires detailed topographic data but once calibrated the model can provide detailed information on velocities and depths for a range of flow conditions. These data can be used to assess the extent and diversity of the habitat.

One-dimensional numerical river models calculate section-averaged values of velocity. In reality there can be significant variations in flow velocity across a river cross-section and so it is recommended that a model is used which is capable of predicting the lateral variation of flow velocity across a cross-section. It is recommended that numerical modelling be carried out at each site.

6.3 Use of existing data

The field sites will only cover a restricted range of river types and maintenance activities. It is hoped to be able to supplement these by using data derived from the RHS database. It is hoped that comparison of surveys from maintained and non-maintained reaches of the same or similar rivers will be able to provide information on the differences in the sediment regime and the habitats.

If this is feasible then this will provide a source of information which has a wider coverage than the field data but is less detailed. The intention would be to apply this approach on some of the field sites to test its validity and sensitivity. If successful then it would be applied to a range of other river types and maintenance activities.

6.4 Approach to the analysis of the data related to the project objectives

In the following section there is a discussion of how Stage 2 of the project will meet the specified objectives.

Objective 1: Quantify the impacts, benefits and influences of management and maintenance on sediment and habitat features

Approach: Investigate managed and unmanaged reaches of a river that would otherwise be identical. At the study sites differences in habitat and sediment features would be assessed. To carry this out one would need to have at least one pair of sites for each combination of river type and management intervention

Objective 2: Establish if, when and how sediment processes become self-regulatory negating the need for further maintenance or management, where appropriate

Stable river channels are often described as being in 'regime'. The research objective is to devise a method to establish how far an existing channel is away from 'regime' conditions. The answer depends upon individual sites and so all one can hope to offer is a method of taking measurements at a site and on the basis of these determining how far away the site is from 'self-regulatory' conditions.

Objective 3: Determine the critical time at which intervention is required to manage geomorphically created sediment habitats in restored rivers for conveyance purposes

The timing has to be determined by the objectives of the maintenance. Thus maintenance is required when the channel is about to fail the criteria that the maintenance is required to meet. The frequency of maintenance will depend upon the rate of deterioration of the conveyance and also on the degree of risk that is acceptable.

Objective 4: Test and validate new approaches to maintenance and channel design,

A wide variety of approaches to channel maintenance and design have been used in the past and are being used presently. This objective is interpreted as meaning the use of approaches that are new to a river reach. The time scale of the project is relatively short and so it is unlikely that new approaches could be validated.

Objective 5: Provide guidance on appropriate management, and when safe and desirable to allow river reaches to have no management (i.e. Identifying effects of 'controlled retreat' at reach and catchment scales)

This is similar in concept to Objective 2.

Objective 6: Supply the experimental basis for adaptive management of flood control and restored channels

In essence Stage 2 will not be 'experimental'. The field work carried out in Stage 2 will determine the impacts of different maintenance regimes. The objective to supply the field evidence to support management methods for flood control which are sympathetic to the environment is likely to be achievable.

Objective 7: Improved links between RHS outputs and flood defence 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.

There are really two objectives here. One is to use RHS as an initial guide to the nature of management that would be desirable and the other is to use RHS as a monitoring tool to assess the impact of modified maintenance regimes. It should be possible to explore the potential for using RHS to guide management practises from the data from the field sites from Stage 2. As part of the project RHS data from other sites could be investigated to establish whether the impact of different management practises is discernible using RHS output.

RHS surveys may be used to identify degraded reaches of river. In such reaches the maintenance procedures that are currently being carried out could be reviewed to see if an alternative management regime could be put in place which would have a lesser impact on the river system.

The second objective should be achievable if maintenance work which significantly affects river habitats is detectable by the RHS.

As indicated above we would recommend that the RHS work should include the use of GeoRHS, that is, the geomorphological and floodplain component.

6.5 River management procedures and costs

There are issues with maintenance procedures and cost of related studies which can be illustrated using Objectives 2 and 3. There are methods available to consider channel parameters such as width, depth, slope and sediment size and to determine whether this combination is in 'regime'. This would suggest that the sediment processes in the channel were self-regulatory and would not require maintenance. One could also use the same methods to determine how far the channel was from regime, that is, how far it was away from being self-regulatory. The cost of data collection and analysis to determine how close a long river reach was to being self-regulating is likely to be substantial and may not be justifiable. A question then arises as to how to justify the cost of studies to try and improve the way that maintenance is carried out. In some cases the cost of the studies to determine an optimum management strategy may be large in comparison with the overall budget for the maintenance work.

6.6 Analysis of data

At all the sites there will be two different states that will be separated either temporally or spatially. For example, we may have a managed reach and a nearby control reach, in which case the states are divided spatially or we may have a reach which is recovering or which is subject to a different maintenance regime. In this case the difference between the states is temporal.

For each state the field work will provide data on sediments and habitats. The sediment data will include information about sediment features, their type and frequency of occurrence. The habitat data will provide information on the range of habitat types, their diversity and extent. The factors that will be used to characterise the habitat will include the spatial and temporal distributions of flow velocity and depth and how these relate to the sediment characteristics.

The assumption will be that differences between the observed states in terms of sediments and habitats are due to the differing maintenance regimes.

The data will be used to assess the relationship between management activity and the associated sediment regime and habitat types and ranges.

7. Selection of sites

At Workshop 2 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. As explained in Section 2.3 above 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 short-list of five sites:

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

If funding were available for six sites then the additional site

- Mortons Leam: Cambridgeshire

would be added.

It should be noted that during discussions at Workshop 2 it was decided that the two sites described in Appendix 2 as Eden and Teise should be combined into a single site Eden/Teise.

Other possible field sites included:

- Gaywood: Norfolk,
- Sussex Rifes: Sussex,
- Willow Brook: Cambridgeshire,
- Ise: Northamptonshire.

These latter sites would be candidates for substitutes if sites on the short-list proved to be impractical.

In the following Table 7.1 we describe the particular issues that could be addressed at each site and relate these to the overall objectives of the project. Objectives 1 and 6 are very generalised and all the sites would contribute to these objectives. Objective 7 will be addressed at all the field sites and would also be addressed during a separate part of the project which involves studies at other river sites based specifically on the RHS data.

Table 7.1 List of sites and research issues

Site	*Research issue to be investigated*
Eden/Teise	The Eden site represents a site where maintenance is carried out in a sensitive manner and hence represents good practise (Objectives 5). The issues on the Teise site concern the timing of maintenance (Objective 3) and the potential to test new approaches to maintenance on a featureless river that cannot develop sediment-dependent habitat forms without intervention (Objective 4).
Long Eau	Impact of removing flood bank to allow the generation of sediment related habitats (Objectives 4 and 5).
Dearne	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 (Objective 4).
Kent	Investigate methods for reducing the impact of maintenance following a capital scheme. The issues that need to be addressed are: the type of maintenance that is carried out (Objectives 2 and 4) and its timing (Objective 3).
Harbourne	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 (Objectives 2, 4 and 5).
(Mortons Leam) – six site option only	This river reach is subject to regular weed cutting. Dredging will carried out in 500 m lengths with 500 m intervals. The site provides an opportunity for investigating different approaches to the maintenance of such reaches (Objective 4).

The breakdown of sites by Objectives is as follows:

Objective 1	Quantify the impacts, benefits and influences of management and maintenance on sediment and habitat features. Sites: All
Objective2	Establish if, when and how sediment processes become self-regulatory negating the need for further maintenance or management, where appropriate. Sites: Kent Harbourne Eden
Objective3	Determine the critical time at which intervention is required to manage geomorphically created sediment habitats in restored rivers for conveyance purposes. Sites: Eden/Teise Kent
Objective 4	Test and validate new approaches to maintenance and channel design. Sites: Eden/Teise Long Eau Dearne Kent Harbourne Mortons Leam (if six sites are selected)
Objective 5	Provide guidance on appropriate management, and when safe and desirable to allow river reaches to have no management (i.e. Identifying effects of ‘controlled retreat’ at reach and catchment scales). Sites: Eden/Teise Long Eau Harbourne
Objective 6	Supply the experimental basis for adaptive management of flood control and restored channels. Sites: All
Objective 7	Improved links between RHS outputs and flood defence 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. Sites: All with additional data provided by sites where only RHS data is available.

8. Specification of data protocols for measurements to be taken at sites

Section 6.2 describes the recommendations for data collection at the proposed field sites. Data protocols have been prepared to aid the collection of data at these sites. As much as possible these have been based on existing data protocols. This has been done to ease data collection in the field and also to ensure that data collected under this project are compatible with other data sets.

The recommendation is that in Stage 2 these data are combined into a database/spreadsheet for each site. This will ensure that data are readily accessible. It is recommended that these data sets be made available to interested parties on a CD-ROM so that they can easily be used by others.

The outline of the data protocols is given in Appendix 3.

9. Programme for Phase 2

The proposed programme of works is shown in Figure 9.1. It is intended that the programme should be flexible to take account of any unforeseen circumstances and need to up-date it during the project. Resources can be transferred between field sites in the light of data from the monitoring, as they become available. If insurmountable problems are experienced at particular sites we have identified additional sites that could be used instead.

The project programme envisages a mobilisation period of 2 months followed by the initial work at the field sites. This work will involve a range of surveys including bathymetric surveys. Carrying out these surveys will be dependent upon the weather conditions and may be delayed if they have to be carried out during the winter. A further constraint is the need to undertake RHS work at each site. This is best carried out when in-channel vegetation is low. This acts as an additional constraint on the timing of the work. Thus if the project start date is between the 1 September and 1 February there is a risk that there may be delays in implementing some of the field work due to high river flows. Any such delays may affect the overall project. To prevent this happening it is recommended that the project should start either before September 2004 or after February 2005.

If the start date is delayed until 2005 then there may be problems with the Eden/Teise site as works are planned for 2004 and so it would not be possible to establish pre-works conditions.

Periodic re-surveys should then be carried out at the sites to investigate temporal changes. These re-surveys should extend over a period of approximately 2 years. The objective should be to carry out re-surveys over as long a time period as possible consistent with meeting the end date of the project. It is expected that the re-surveys will concentrate on repeat RHS surveys as it is expected that other factors such as the geomorphological setting of the rivers will not change during the project period.

In parallel with the surveys at the selected field sites, it is recommended that investigations be carried out to explore the potential for using existing RHS data to provide a source of information on other river types that are not covered by the field sites.

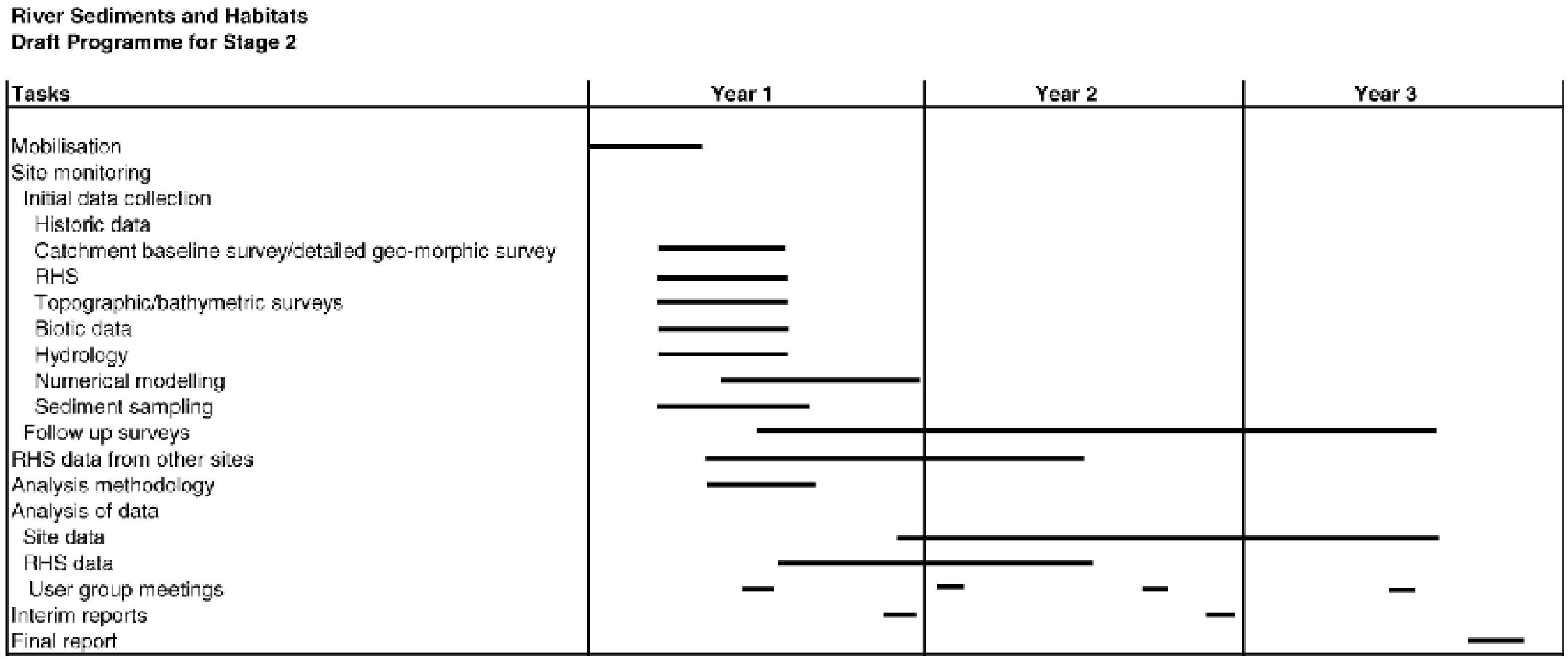


Figure 9.1 Outline programme for Stage 2

10. Dissemination

Stage 1 of this project develops and provides a justification for Stage 2 of the project. Thus the outputs from Stage 1 are aimed internally within the Environment Agency and the Defra/EA Research Theme Advisory Groups (TAGS).

The major beneficiaries of Stage 2 of the project will be the staff within the EA. It is important that the staff in the Areas which will be host to field sites should be fully aware of the project. It is recommended that during Stage 2 of the project a series of meetings are held for all relevant EA staff so that they can be kept informed of progress on the project. These meetings would also act as a forum for the transfer of information about maintenance activities. The issue of the adoption of new management approaches is not just technical but also has a strong social component. The perceptions of people must be changed. The project should make every effort to do this but the EA must recognise that perceptions will only change if a concerted effort is made over a significant period of time. The time required is likely to be longer than the duration of this project.

It is recommended that as part of Stage 2 articles should be prepared for suitable technical journals, such as the ADAS Gazette and New Civil Engineer. It is also recommended that during Stage 2 of the project papers are submitted at suitable conferences or seminars such as the Defra Conference and the Robson Meeting.

The River Restoration Centre makes data available on all aspects of river restoration. It is recommended that under Stage 2 they should be approached to explore the possibility of them disseminating information derived from the project.

11. Costs for Phase 2 and potential benefits

The proposed costs for Stage 2 are shown in Table 11.1. The cost estimates have been based on the assumption that the overall budget is of the order of £300K. This overall budget is the major factor in determining the number of field sites that can be investigated under Stage 2. There are potentially a wide range of river types and management interventions that could be studied using field investigations but there is a limit to the overall project budget and duration. Selecting 5 or 6 field sites for investigation enables a number of river types and management activities to be investigated though it should be made clear that not all river types and problems will be covered.

Table 11.1 Indicative costs for Stage 2

	Cost (£K)
Historic data collection	4
Initial surveys and modelling	114
Follow-up surveys	25
Data analysis	94
Meetings, reporting and dissemination	58
Expenses	15
Total	310

Within the costs we have allowed a sum of money for collecting biotic data. This is not strictly necessary to satisfy the Terms of Reference for the study but the collection of these data is recommended as it would add to the overall value of the data set. The costs of the biotic data collection has been estimated at approximately £10,000 for 5 field sites. In the light of the modest cost and the potential large benefits in the future we believe that this cost is justified.

We have also included in the cost a significant element for Dissemination. This includes the cost of holding regular meetings for all the EA participants and other interested parties. We believe that this cost is justifiable as dissemination will be essential if the results of this research are to be converted into practise.

There are benefits to carrying out field work at as wide a range of sites as possible which suggests that one should carry out field work at as many sites as possible. In addition the marginal cost of an additional site reduces as one increases the overall number of field sites. Within the overall budget of the order of £300,000, the project looked at the option of studying 6 field sites but omitting any collection of biotic data and reducing the expenditure on dissemination. It was felt that the benefits of data from an additional site did not outweigh the benefits provided by collecting the biotic data and the expenditure on dissemination.

If Stage 2 is successful in terms of providing environmental benefits with reduced maintenance costs then the expansion of the work to additional field sites should be considered.

In 1994 Newson and Sear carried out a study for the then National River Authority which considered the annual costs associated with sediment-related maintenance in England and Wales. This was done on the basis of a questionnaire. From the questionnaires that were returned the annual spend on sediment related maintenance problems was £30M. The authors estimated a 60% response to the questionnaire and so the total cost is likely to be significantly larger. If this cost of £30M/year is up-dated for inflation then the present day cost would be of the order of £40M/year.

To consider the potential benefits of Stage 2 we have:

- assumed different percentage reductions in the maintenance spend as a result of the project
- calculated a pay-back period for the cost, that is, the period of time that would be required for the savings to pay for the cost of Stage 2
- calculated the discounted benefits over a 20 year period assuming a discount rate of 5%
- calculated a benefit/cost ratio based on the discounted benefits.

The results of these estimates are as follows.

Table 11.2

Assumed % reduction in sediment related maintenance (%)	Annual saving (£)	Project payback period (months)	Discounted saving over 20 years (£M)	Benefit/cost ratio
1	400K	9	5.3	17.7
2	800K	4.5	10.5	35.1

The expected potential for reducing the cost of sediment related maintenance is expected to be much larger than 2% but even with such a low target figure it is clear that the costs of Stage 2 can be easily justified.

It should be noted that this economic analysis does not take into account the additional benefits associated with improved habitats.

12. Risks and risk management

The main factors that might cause delays to the project are associated with the field trials. There may be delays in setting up the field sites. The risk of this has been minimised as a result of careful planning and selection in Stage 1 of the project. One of the factors considered in the selection of the site was the commitment of local EA staff and riparian owners. There may also be delays if the flow regime during the period of monitoring is not appropriate for the investigation. Thus if the flow regime was extreme, either in terms of high flows or low flows then the data collected may not represent typical conditions. At any site in any year there is a 20% probability that the flows will fall outside the envelope of flows with a 10 year return period. The more extreme the flow conditions experienced then the more difficult it would be to draw general conclusions. There may be advantages, however, to having some extreme flows at one or two sites so that a full range of flow conditions are sampled.

There is a particular issue related to the start date of the project. The project programme envisages a mobilisation period of 2 months followed by the initial work at the field sites. This work will involve a range of surveys including bathymetric surveys. Carrying out these surveys will be dependent on the weather conditions. Thus if the project start date is between the 1 September and 1 February there is a risk that there may be delays in implementing some of the field work. Any such delays may delay the overall project. To prevent this happening it is recommended that the project should start either before 1 September 2004 or after 1 February 2005.

The inquiries of local Environment Agency staff associated with the 5 sites recommended above that have been made as part of Stage 1 have created an interest and enthusiasm for Stage 2. There is a risk that a prolonged delay in the start of Stage 2 would destroy this enthusiasm.

The project team considered whether the Construction Design and Management (CDM) regulations 1996 would apply to any of the Stage 2 projects. As currently envisaged it is believed that these regulations would not apply to the proposed project work. If a temporary platform were to be constructed from which to carry out any of the monitoring then it is likely that the CDM regulations would apply. The field sites have been selected as they are or have been subject to maintenance or capital works. Any such works may come under the CDM regulations but we believe that this concern is outside of the scope of this project.

The Stage 2 project would involve staff working in close proximity to water and it is recommended that a risk analysis is carried out prior to any work and appropriate Health and Safety precautions are taken. Such precautions are likely to depend upon the particular method of working that is adopted.

13. Conclusions and recommendations

The requirements for Stage 2 of the project have been reviewed. It is recommended that Stage 2 is carried out using a combination of field work and using existing data sets. The following is a list of the recommended five sites for the field trials:

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

If funding were available for six sites then

- Mortons Leam, Cambridgeshire

would be added.

The specific problems to be addressed at each site are:

Site	*Research issue to be investigated*
Eden/Teise	The Eden site represents a site where maintenance is carried out in a sensitive manner and hence represents good practise (Objectives 5). The issues on the Teise site are to do with the timing of maintenance (Objective 3) and the potential to test new approaches to maintenance on a featureless river that cannot develop sediment-dependent habitat forms without help (Objective 4).
Long Eau	Impact of removing flood bank to allow the generation of sediment related habitats (Objectives 4 and 5).
Dearne	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 reinstalled with the creation of a smaller low flow channel (Objective 4).
Kent	Investigate methods for reducing the impact of maintenance following a capital scheme. The issues that need to be addressed are: the type of maintenance that is carried out (Objectives 2 and 4) and its timing (Objective 3).

Harbourne	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 (Objectives 2, 4 and 5).
(Mortons Leam) – six site option	This river reach is subject to regular weed cutting. Dredging will carried out in 500 m lengths with 500 m gaps. The site provides an opportunity for investigating different approaches to the maintenance of such reaches. (Objective 4).

The monitoring requirements for the field sites and associated data protocols have been identified. As far as possible these have been based on existing, recognised methods of data collection.

A programme for Stage 2 has been developed. This programme is flexible and can be adjusted in the light of information gathered during Stage 2.

A CSG7 proposal for Stage 2 has been prepared and will be delivered as a separate document.

The risks associated with Stage 2 have been considered and methods to manage them have been suggested. The primary risks are associated with the flow conditions that may be experienced during the field investigations. Unfortunately there is little that can be done to mitigate these risks.

A simple estimate of the potential benefits of Stage 2 has been prepared and compared with the likely costs. These show that the payback period for Stage 2 is less than a year and that the benefit/cost ratio exceeds 10 if the discounted benefits are calculated over a 20 year period with a discount rate of 5%.

14. References

Newson, M D and Sear, D A, 1994, Sediment and gravel transportation in Rivers, National River Authority, R and D Note C5/384/2, Bristol.

Appendix 1 Attendees of Workshops

1 Attendees of Workshop 1: 1 August 2003

Jenny Mant	RRC
Fola Ogunyoye	Posford Haskoning
Karen Fisher	Consultant
Colin Thorne	Nottingham University
Nigel Holmes	Alconbury
Donald Knight	Birmingham University
Mike Thorn	Defra – theme leader
Jim Walker	EA
Phillipa Harrison	EA (ceased to represent EA on project in late 2003
Miran Aprahamian	EA
Jonathan Newman	Centre for Aquatic Plant Management
Deborah Lawrence	Reading University
Matthew Hardwick	Posford Haskoning
Roger Bettess	HR Wallingford
Michelle Malcolm	HR Wallingford
David Ramsbottom	HR Wallingford
Albert Nottage	HR Wallingford

Apologies

Michelle Verrecchia	Defra

2 Attendees of Workshop 2: 9 January 2004

Roger Bettess	HR Wallingford
Valerie Bain	HR Wallingford
Karen Fisher	University of Birmingham
Nigel Holmes	Alconbury Consultants
Donald Knight	University of Birmingham
Jenny Mant	River Restoration Centre
Nigel Milner	Environment Agency Fisheries
Jonathan Newman	Centre for Aquatic Plant Management
Albert Nottage	HR Wallingford
Fola Ogunyoye	Posford Haskoning
Mike Thorn	Defra Theme Leader
Colin Thorne	University of Nottingham
Jim Walker	Environment Agency
Paul Whitehead	University of Reading

Appendix 2 Details of sites considered

Summary site information: Gaywood Stream

The Gaywood Stream is a watercourse within the Gaywood IDB, part of the Kings Lynn Consortium of IDBs. A recent project 2002/3 was primarily carried out to stop Leziate Sugar and Derby Fen SSSI from drying out and safeguarding them for the future. The river restoration scheme was implemented to rejoin/replace the river with its original meandering course and higher bed levels along a 1km reach, hence re-wetting the surrounding fen.

Location

Name of Watercourse: Gaywood stream *County:* Norfolk

Upstream NGR: TF 706206
Downstream NGR: TF 697205

Management Intervention
Restoration of old course of river.

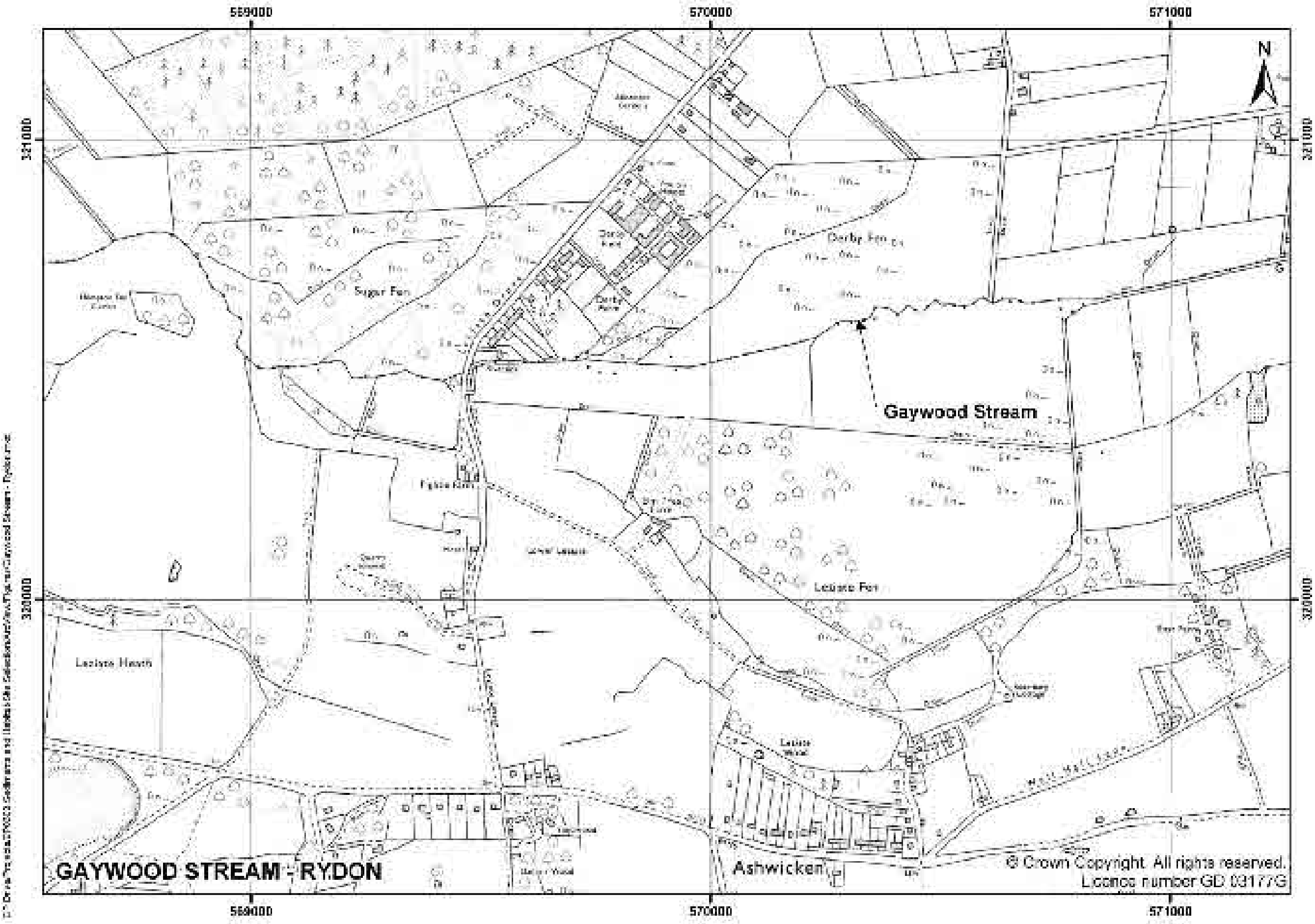


Figure 1 Gaywood Stream Location Map

Plate 1 Previous straight course of river is visible against restored meanders.

Plate 2 Restored meander at Gaywood Stream

Contact details

Contact Name: Lou Mayer	Organisation:
Also Jenny Mant, RRC	Lings Lynn Consortium of IDBs
Contact address	
	Tel No: 01553 669528 *Email: Lou@klcidb.co.uk*

Details

Hydrology/soil/sediment information
River flows through three remnant fens. Drainage of surrounding agricultural land has caused fens to dry out. River is fed by chalk springs. Locally, there are species-rich calcareous grassland and chalky soils.

Description of river and character
Reach is a lowland rural watercourse and comprises of a meandering planform, which was previously straight and over deepened. The adjacent land use is a mixture of pasture and grass land, with arable land further upstream.

What parameters are gauged and where?
Flow gauging exists downstream of site. Data are available from EA Brampton office. Implementation of further telemetry outstation within the restored sections to measure water level, flow, wind speed and direction, and rainfall are being considered. There is a sampling programme in place to assess the effects of restoration. This includes a control site.

Land ownership/access issues
Vehicle access is very good although the problems increase when the site becomes wetter. Land to the South is more accessible. Land owners are very approachable and were helpful to the scheme.

Other environmental and water quality information
The site is located within an SSSI, with watervole populations also being present.
There is a sewage treatment works situated upstream of the site, although discharge from this point should be monitored by the Environment Agency.

Summary pros and cons for site
A recent sediment and habitat study completed in 2003 conducted by University of Northampton. There is an ongoing monitoring programme. One may use the site to consider the effects of channel form change or bed level raising. However as the primary aim of the scheme is restoration, it may not be ideal for this project. Furthermore, it is thought that the river is yet to reach new equilibrium in response to the new scheme.

Summary site information: Gravel drain

Gravel drain is a tributary of the Counter drain within the Welland and Deepings IDB system. Dredging is planned within a 4km length of the drain over a three year period, 2004-2006 (about 500m/annum) with monitoring of the effects on Spined Loach already planned. The watercourse is typically 1.5 to 3m wide at the river bed. There is presently no gauging of water levels or flows within the drain. The IDB is willing to supply further information on past interventions.

Location

Name of Watercourse: Gravel Drain

Location: Welland and Deeping IDB Area, South Lincolnshire.

Upstream NGR:
Downstream NGR:

Management Intervention
Dredging is staged in 500m sections over 3 years. First phase of dredging commences in January 2004.

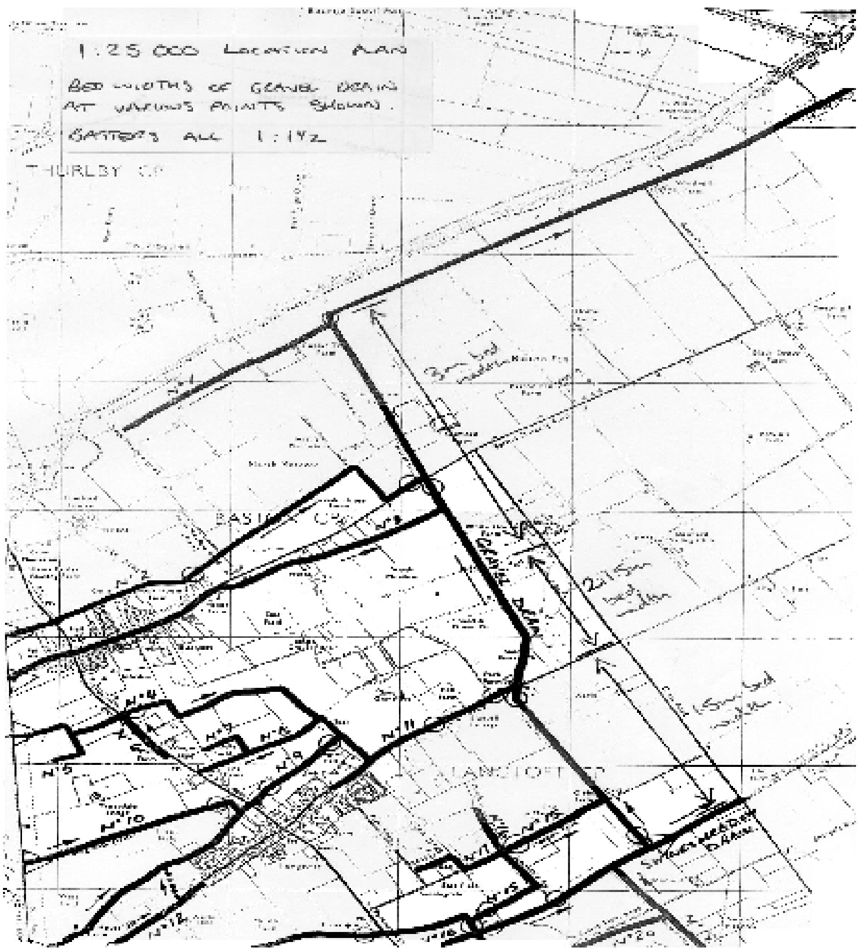


Figure 1 Location map of Gravel Drain, Lincolnshire

Plate 1 Site Work on Gravel Drain

Plate 2 Gravel Drain, Welland and Deeping IDB Area, South Lincolnshire.

Contact details

Contact Name: Stan Pywell/Nick Morris	*Organisation:*
Also Jenny Mant, RRC	Welland & Deepings IDB
Contact address	
Welland and Deepings IDB Deeping House Welland Terrace Spalding	*Tel No:* 01775 725861 *Email:*

Details

Hydrology/soil/sediment information:
Bed material is typically silt/gravel. There are weirs along the channel for summer water retention. Some sediments build up behind the weirs, but not rapidly. Last dredged 12 years ago.

Description of river and character:
Straight channel, with very little bankside vegetation, therefore limited shading. Bed width varies from 1.5 to 3m.

What parameters are gauged and where?
None

Land ownership/access issues:
The land is owned by the IDB and Environment Agency.

Other environmental and water quality information:
Concerns about effect of dredging on Spined Loach. The dredging works are already phased to reduce effect and works will include monitoring.

Summary pros and cons for site:
The staged dredging and proposed monitoring should provide benefits to this project. The IDB is also happy for this site to be part of the trials and therefore no restrictions expected. The non-availability of gauged levels and flows is however a major factor that limits its potential.

Summary site information: River Harbourne

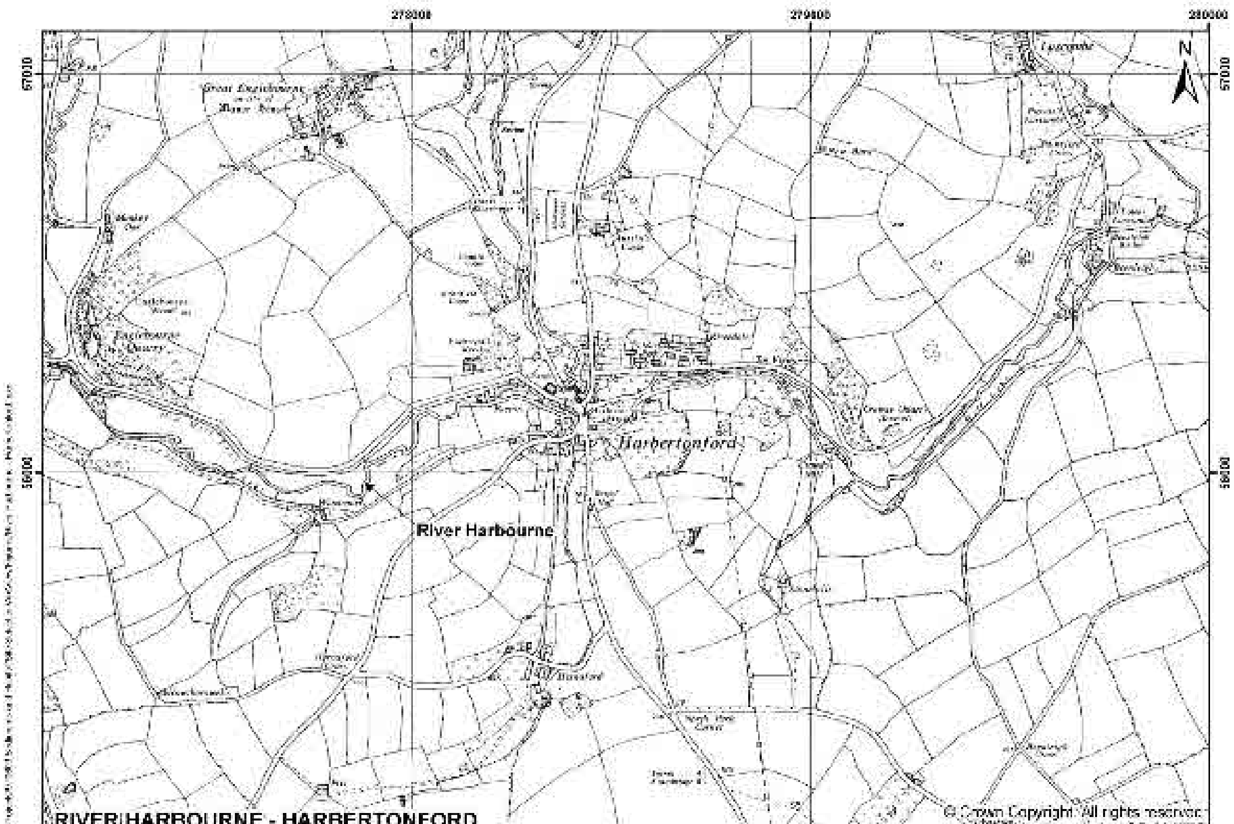
River Harbourne is a main river within the Southwest Region. A recent flood alleviation scheme on the River Harbourne, Devon involved the construction of a flood storage reservoir upstream of Harbertonford village, bridge works and channel widening and lowering through the village. The scheme was completed in 2002, to reduce the risk of flooding through the village. Prior to the scheme, the village had been flooded a total of 21 times in the past 60 years, including 6 times in 1998.

Location

Name of Watercourse: River Harbourne *County:* Devon

Upstream NGR:
Downstream NGR:

Management Intervention
Some dredging and weed cutting was carried out prior to the flood defence scheme on an *ad hoc* basis. Possibly no longer required or reduced in scale due to construction of new flood storage reservoir.



River Lowering Works at Harbertonford 2002

Photo 1: Village green riffle at low flow

Photo 2: Village green riffle under construction

Works to the Village Green at Harbertonford 2002

Photo 1: View of river before works

Photo 2: View of river after works

Contact details

Contact Name: Graham Buxton-Smith/Phil Monk	*Organisation:*
	Environment Agency
Contact address	
Environment Agency Exminster House Exeter Engineering contact – Warren Bradley (Halcrow) Richard Vivash – (RRC) Geomorphology – Colin Thorne	*Tel No:* 01392 444000 *Email:*

Details

Hydrology/soil/sediment information
The river is a gravel bed river, which exhibits gravel bed dynamics.

Description of river and character
The river channel is located in a lowland rural catchment, which flows though the urbanised village of Harbertonford.

What parameters are gauged and where?
Water level and flow gauges are installed at the flood storage site.

Land ownership/access issues
The land is privately owned with good access and good working relations. Also have access to storage facilities at dam site.

Other environmental and water quality information
A Nature Reserve is located upstream of the site. There have been in-house fisheries and invertebrate monitoring.

Canoeing takes place on the river, which may affect the monitoring of any potential trial site.

Summary pros and cons for site
The site has scope for assessing the effects of flood storage and channel improvements. Ability to separate their effects and other parts of the scheme (removed weir, channel lowering, bridge works etc.) may be worth reviewing. Flow and level monitoring available. River sediment is fairly dynamic. Some assessments of sediment loads already carried out by Professor Colin Thorne.

Summary site information: Hithermoor stream

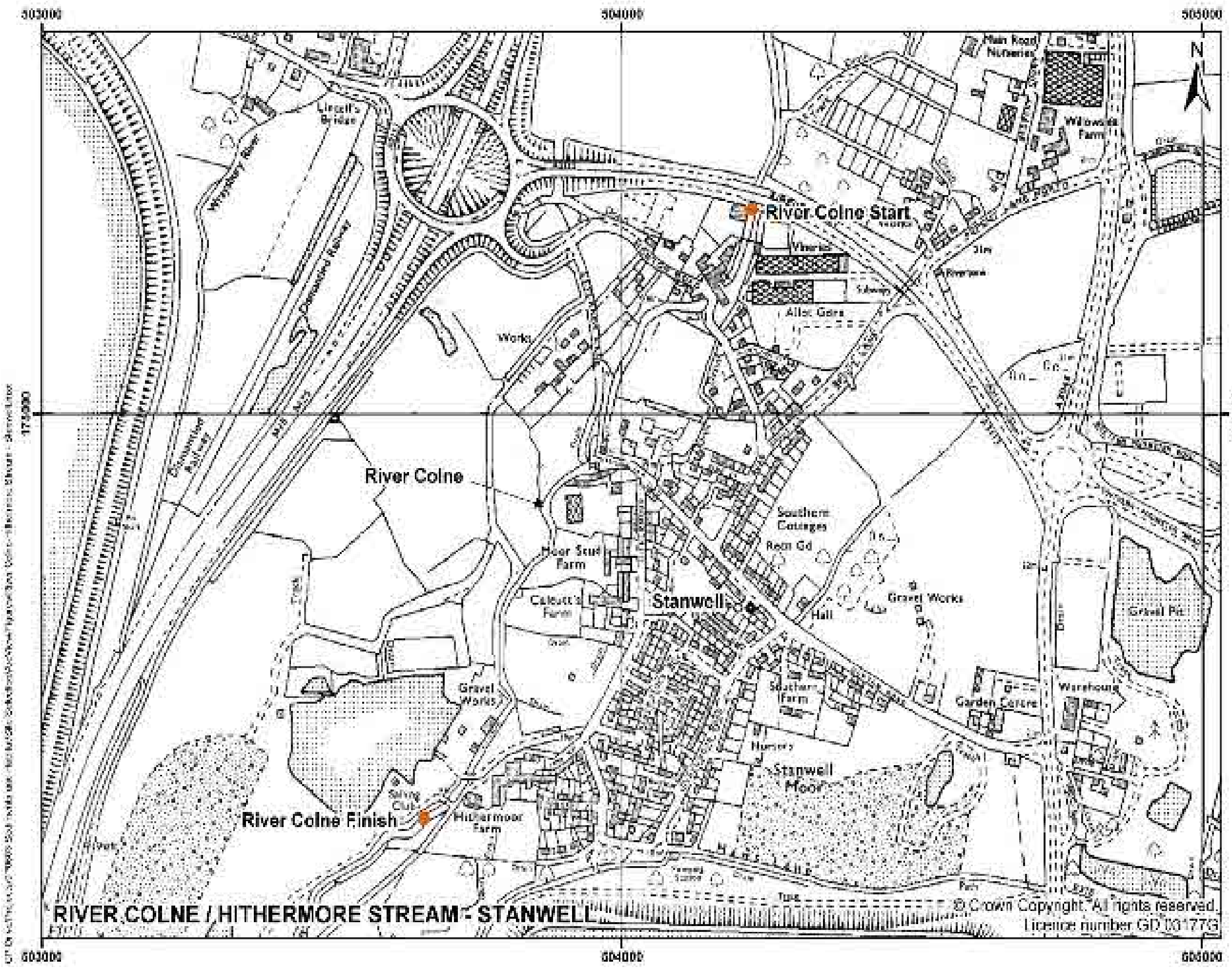
Hithermoor stream is a tributary of the lower Colne, in Surrey, within the Thames region. The site comprises of two lengths of channel each approximately 650m long, created as part of a river diversion scheme to protect properties in Stanwell.

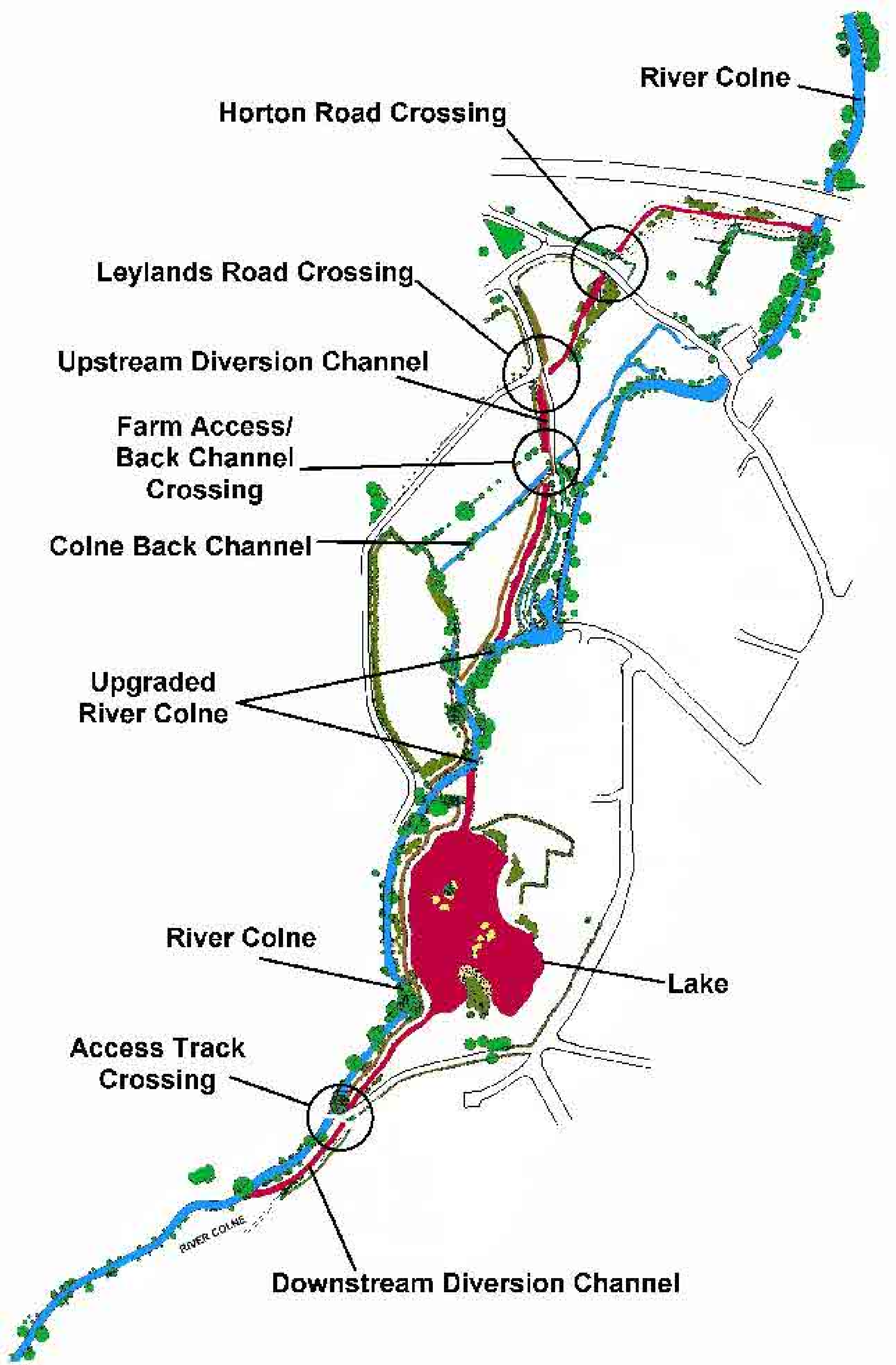
Location

Name of Watercourse: Hithermoor Stream *County:* Surrey

Upstream NGR: TQ0421 7532
Downstream NGR: TQ 0366 7436

Management Intervention
Recent diversion scheme involving two lengths and some channel works.
Some sporadic weed cutting is also undertaken.




River Colne
Horton Road Crossing
Leylands Road Crossing
Upstream Diversion Channel
Farm Access/
Back Channel
Crossing
Colne Back Channel
Upgraded
River Colne
River Colne
Lake
Access Track
Crossing
RIVER COLNE
Downstream Diversion Channel

Leylands Lane culvert and new channel

New bridleway bridge

Contact details

Contact Name: Andrew Pepper	*Organisation:*
	Environment Agency, Thames Region
Contact address	
Environment Agency Swift House Frimley Business Park Camberley Surrey GU16 7SQ	*Tel No:* 01276454464 *Email:* atpec-ltd@ntlworld.com

Details

Hydrology/soil/sediment information
Soils within this region are generally topsoil and alluvial subsoil overlying gravel. Below this is London Clay. The river bed is generally gravel. The river is low energy and therefore not very dynamic.

Description of river and character
Lowland Semi-rural reach with new channels being largely unshaded at present and existing River Colne channel having many trees. Catchment is 1000km^2, which is 80% chalk (Chilterns). The remainder is clay. Some areas are highly urbanised, although a large proportion is farmed – grassland, pasture and woods.

***What parameters are gauged and where*?**
Existing gauge boards at Silver Beck Weir (head and tail). Gauge boards are to be installed at control structures. Flow is gauged at Staines about 3.5km downstream. Being adjacent to Heathrow airport, good rainfall monitoring must exist.

Land ownership/access issues
Land is Environment Agency owned with good vehicle access.

Other environmental and water quality information
Staines SSSI downstream of site, with watervoles in the vicinity. River and banks are used by anglers, pedestrians (bridleway) and equestrians. It is believed that a number of river corridor, habitat surveys etc have been carried out over the past ten years.

Summary pros and cons for site
The site selected presents no abnormal risk and is free from legal constraints. Also has significant amount of general information relating to the site due to recent works. The site has a number of channel/diversion works, which provide scope for monitoring their effects. Identifying effects of each may need to be carefully considered. Also there is the possibility of disturbance by local anglers, pedestrians and horse riders.

Summary site information: River Kent

The Kent in Kendal is a high energy, active gravel bed river in the midst of an urban environment where flood defence maintenance and ecological issues are of the highest importance.

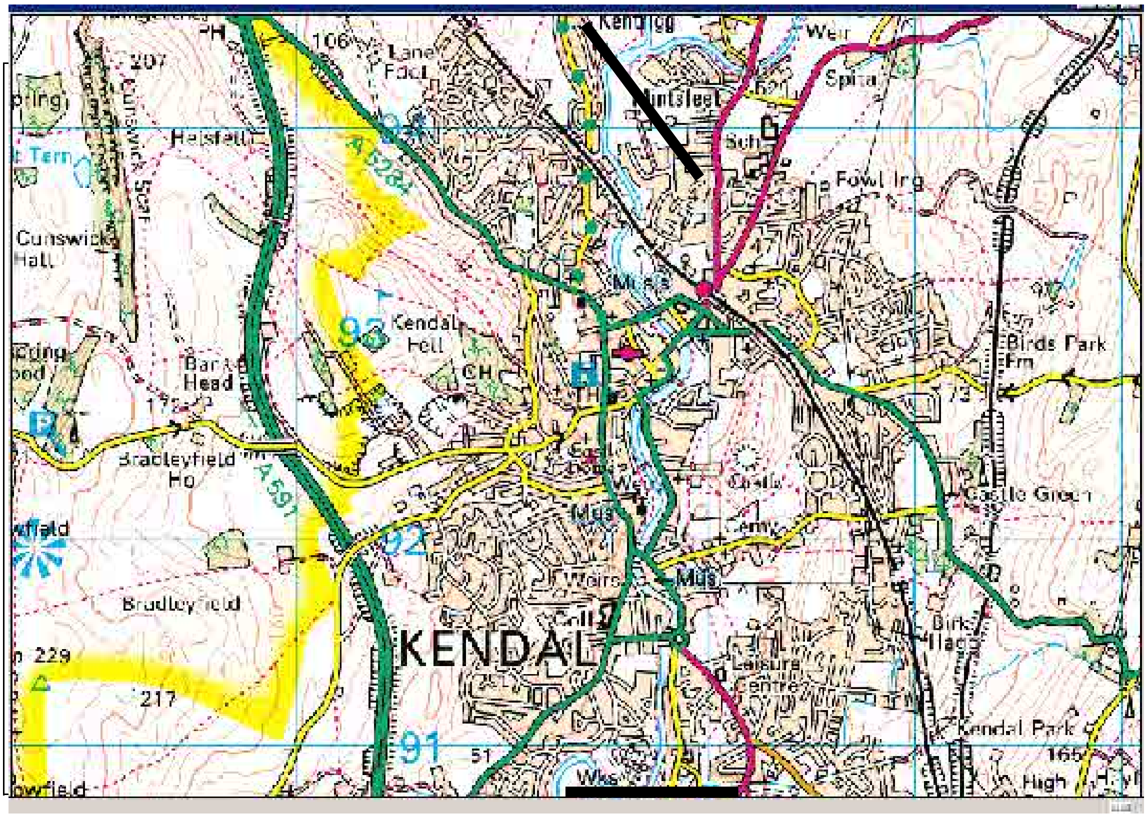
A capital scheme was carried out in Kendal in the 1970s. This scheme has a requirement for dredging to maintain the design level of service. A gravel trap has been installed upstream of the town which is emptied regularly. Gravel is also dredged from shoals throughout the town on an annual basis. Brush-cutting is undertaken, as are repairs to rip-rap and check-weirs (which are part of the capital works) on an ‘as-needed basis’.

The river is a Special Area for Conservation (SAC) for salmon and several other species, ecological considerations are therefore of major interest as concerns the maintenance works and all works are subject to approval from English Nature. Because of this the records of what is done where, and how much of what is removed and when are very good. The Flood Defence Maintenance Engineer for the Kent is very interested in this project, he has worked on the Kent for the last 25 years and so he has excellent local knowledge. There is also good hydrometric info available for the site (see below) and a full hydrodynamic model has been built for the Kent catchment covering the site in 2000 (as part of the EA section 105 floodplain mapping exercise). As part of this work modelling was also undertaken in an effort to optimise the shoal removal regime – so there is good recent history of interest in the sort of work that the R&D is promoting. Also there is a full fluvial audit (undertaken in 2000) available for the whole of the Kent catchment upstream of and including the site.

Location

Name of Watercourse: River Kent *County:Cumbria*
Upstream NGR:SD 515 944
Downstream NGR:SD 517 910

Management Intervention (Dredging, channel improvement, storage, weedcutting)
Capital scheme in 1970s that has a maintenance requirement for dregding to provide the designed flood protection (in places the bed is maintained at a level up to 1m below natural levels).
Removal of gravel from shoaling sites by dredging annually.
Gravel trap emptying.
Brush-cutting ‘as-needed basis’
Repairs to rip-rap and check-weirs (which are part of the capital works) ‘as-needed basis’.



Contact details

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Contact address	
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(Note, at his request I have emailed Morgan's line-manager to ask for approval for his involvement in providing further info on this site if it is selected, I anticipate his line-manager's support)

Details

Hydrology/soil/sediment information
This is in the Kent Fluvial Audit (H.Orr, Lancaster University, 2000).

Description of river and character
The Kent in Kendal is a high energy, active gravel bed river in the midst of an urban environment.

What parameters are gauged and where?
Stage and flow are gauged at the site (Victoria Bridge) there is also another gauging 2km upstream at Burneside (stage and flow with a 30+ year record). There are several other GS in the Kent catchment.

Land ownership/access issues
Great access. Public footpaths run at bank top for the majority of the area of interest.

Other environmental and water quality information
High ecological value (SAC), good water quality. The study site is an area of salmon spawning.

Summary pros and cons for site
This site has everything going for it. It has real maintenance issues, a regular and well documented maintenance regime, a site engineer with decades of experience who is interested in the research that we are proposing. It also has very real ecological interest and importance. It has an existing hydraulic model and an extensive fluvial audit and the hydrometric info and access are also good.

Summary site information: Lesser Teise

Location: c3km of river upstream of the confluence with the Beult TQ 732458 to TQ 715482.

FD Contact: Richard Harris, Tonbridge, Kent. 01732 703022.

Biodiversity: Edward Bradbrook 01732 223103.

Access & Services: Private land; good EA working relationships; heavy plant access been OK; no service details.

Maintenance: 'Desilting' with a minimum frequency of 10 years. Works completed Autumn 2003.

River character: EA report as lowland and rural; confirmed. Planform reported by EA as 'meandering'; meanders are rare and not of a natural appearance. EA report occasional trees and bushes; confirmed, and along one section for c700m there is a continuous dense hedge precluding machine access from the right side of the river. A key feature noted was the presence of three weirs that control water levels within the reach. Substrate reported by EA to be silt over gravel….evidence from dredgings suggests silt is not widespread, and gravel predominates.

Land-use: EA report arable character; confirmed.

Gauging on site: Not known.

Soils: Alluvial deposits and gravels over clay in the catchment.

Environmental: EA reports that otters have been recorded from the reach, and EA has generic (if not site-specific) fishery data for the river. There are no conservation designations. RCS, RHS, otter and biological GQA data are available.

Site Assessment – 18th December 22, 2003 - River character

The river had been recently dredged, so the importance of habitat features could not be assessed. The key feature noted for the river was the total lack of any deposition features in the river for almost 3km. Three weirs retain water levels, and the very low gradient precludes the potential for riffles etc. to develop. It also results in a totally uniform flow-type – smooth/no perceptible. Two pseudo-riffles and small bars were present downstream of the last weir, where there is a bit of gradient between the Lesser Teise and the confluence with the Beult.

Substrate was totally dominated by gravel-pebble, and banks were all cohesive clay.

Site Assessment – 18th December 22, 2003 - River processes

As elsewhere, the site assessment concentrated on looking for signs of fluvial activity. Effort concentrated on noting, very roughly, the extent and type of erosion and deposition features within the reaches; by assessing these it should be possible to gain a rudimentary understanding of the types and sources of sediments that are building habitats within the reaches (surrogate for fluvial audit).

The table shows a summary of the key features noted for the river. The key point noted, in addition to the virtual total absence of any sediment-dependent habitats (except in the lower 750m) was the extent of gravel dredged from the river and dumped on the bank.

Table Lesser Teise Fluvial Features

		<10m long	10-50m long	>50m long
Bank slips/slumps		2	6	
Stable cliffs		2	3	1
Unstable cliffs		2	2	
Shelves/berms		2	2	
Vegetated side bars				
Vegetated point bars				
Unvegetated side bars	2			
Unvegetated point bars				
'Riffles' (d/s last weir)	2			
Pools				
Tree boughs				
Unvegetated mid-channel bar (d/s last weir)	1			

Site observations, read in conjunction with the information in the table above suggest:

- Gravel would not be expected to form habitats in this reach, as such sediment would not be carried over the weirs, and the clay banks would not provide it as they are comprised of clay;
- The low energy that would result from the gradient being c<1:1,000 is virtually dissipated completely in the scour pools below three weirs;
- There were NO pools, and just two shallow areas similar to riffle habitats in over 3km of river;
- The flow-type was most uniformly slow (smooth) flow, and in the summer low flows would be mainly described as 'no perceptible flow' in RHS terms;
- Any major berms are derived either from sediment washed into the reach from upstream, or from bank-slips, were removed during the de-silting;
- Bank slips were evident in many places,

- No, or minimal, material is derived from *in situ* bank erosion as this is extremely rare;
- As the river is predominantly straight, few opportunities are afforded to the river to create habitat through erosion or deposition of sediment on meanders;
- Justification for de-silting, which included removal of substantial amounts of coarse gravel, was not clearly apparent.

Site Assessment – 18th December 22, 2003 - Type of maintenance effecting sediments and habitats

De-silting was carried out in autumn 2003; it was reported to be spot-dredging, but gravel and silt appears to have been removed from around 70% of the reaches length. This has left a relatively uniform bed grade in the two reaches between the three weirs (the majority of the site). From a single visit it is not possible to fully understand all subtleties of site conditions, and appreciate what the river was like before the works were carried out.

It was not possible to contact the Biodiversity office as he was on Christmas leave, and Richard Harris had only recently taken his EA FD post, and relies on his assessments and guidance. Clarification will be sought before the workshop meeting.

Site Assessment – 18th December 22, 2003 – Suitability for R&D

The potential value of this site is limited due to the virtual absence of any sediment-derived habitats still present at the site. The site has potential if R&D here is done in conjunction with monitoring responses on the Eden (and possibly Teise also). R&D here would focus on assessing first the channel dimensions and conveyance performance against the design standards. Then monitoring over 2-3 years would identify how sediments move (either within the site, or brought in from upstream) to form habitats.

As suggested for the Teise, the most fundamental requirement would be to assess what the existing channel dimensions (e.g. cross-sections) are, and what its conveyance performance is, compared with the design of the capital scheme. If the conveyance is greater than the design standard, which is what is expected, then the R&D could advise on how, in the future, FD staff can better identify when sediment-related habitats are causing unacceptable reductions in capacity, and when they are self-regulating.

Pros	Cons
Chance to link to complementary management on adjacent rivers of a broadly similar character (especially the Eden)	Minimal sediment-dependent habitats present, and extent in the past not known
Good access and potentially landownership cooperation	Justification for removing gravel not clear – removal of considerable quantities of the building blocks for habitats is important
Possible lack of existing ability of the river to form major sediment-related habitats	Potential for sediment-dependent habitats to develop may be very limited due to lack of building-block material, or the river being able to move available material due to the effects of existing weirs
Opportunity to undertake R&D to help determine better when fluvial features are 'acceptable' and when 'not' in terms of conveyance	
Opportunity to compare rate and extent of recovery within stretches with retained heads, and one where there is a gradient	

Recommendation: Take forward in combination with other local sites only. Potential to undertake invaluable assessment of conveyance and channel morphology 'status' in relation to capital design, and assessment procedures for determining when 'maintenance trigger should be pulled'. Potential to monitor pace of development of sediment-dependent habitats following 'desilting'.

The lower 750m offers contrast between development of habitats where gradient can work to form habitats, and between weirs where there is much more limited potential (see photos).

Upper Limit of site before and after: LEFT: after dredging in December; RIGHT: before dredging in autumn – note sluggish water flow and marginal emergent reeds

Typical dredged section – no toe left, and predominance of gravel and pebbles in dredgings

Left: top half of site – dense hedge-line along right bank, and typical featureless channel with smooth/no perceptible flow-type; Right; downstream limit where sediment is forming bars in the steeper gradient as the river drops down into the Beult. NOTE IMPORTANT DIFFERENCE IN GRADIENT AND FLOW TYPE ON RIGHT – R&D COMPARISONS POSSIBLE

Summary site information: Long Eau River

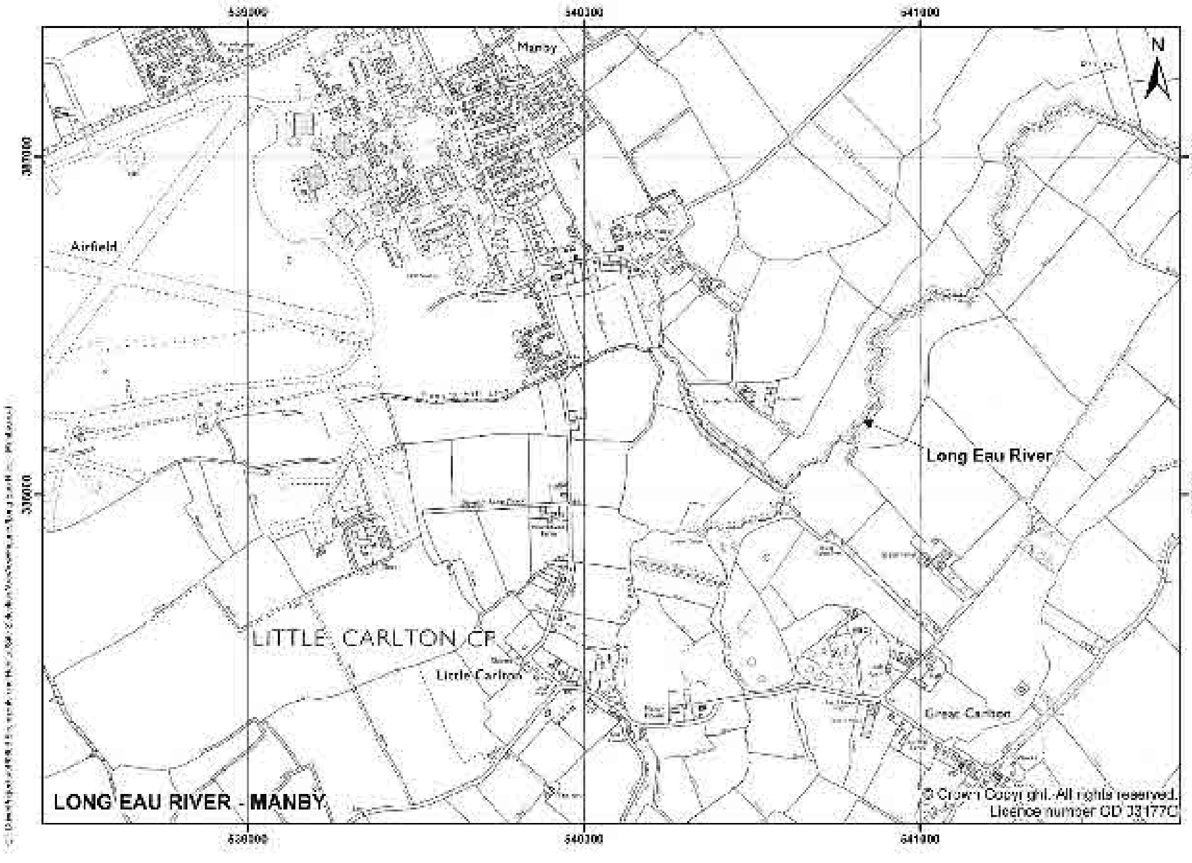
The Long Eau River is a main river within the Anglian region. It is an embanked highland carrier with a typical bed width of about 3m. In 1995 the existing flood banks to the east of the Manby sewage works was set back to create a flood storage area and improved habitat. Due to the success of the 1995 scheme, another length, about half a km upstream is planned for set back commencing January 2004.

Location

Name of Watercourse: Long Eau *County:* Lincolnshire

Upstream NGR: 38605406
Downstream NGR: 38705413

Management Intervention
Dredging and weed cutting of river channel following channel improvements in 1995. Maintenance has decreased slightly since the scheme was completed, but still requires annual weed cutting.



Contact details

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Environment Agency Manby Park Manby Louth	*Tel No:* 01507 328102 *Email:*

Details

Hydrology/soil/sediment information
River sediments exist, but there are no known excessive siltation problems. A hydraulic model covering the area exists and is currenlty being used to assess siltation issues further downstream.

Description of river and character
The Long Eau river is a highland carrier with a typical bed width of 3m. It is sinuous with no shading from trees. Surrounding land is predominantly pasture, but arable pre-1995.

What parameters are gauged and where?
A level and flow gauging station exists about 1km upstream of the site.

Land ownership/access issues
The land is privately owned with good working relations.

Other environmental and water quality information
Sewage treatment works located close to the site. No known environmental designation within the reach. River corridor survey about 10 years old exists.

Summary pros and cons for site
The existing scheme and the new one proposed for 2004 provide good opportunity for assessing short and long-term effects. Also river corridor survey pre-1995 should be useful. The sediment dynamics of this watercourse is relatively unknown. A hydraulic model currently exists for the area. River level and flow gauging available. The effect of the sewage works may need to be assessed.

Summary site information: Mortons Leam

Mortons Leam is a 20km watercourse that spans the length of the Whittlesey Washes within the Anglian region. Whittlesey Washes is the flood storage area that protects Peterborough from flooding from the River Nene. Due to concerns about the Spined Loach, a trial 500m section of the Leam was dredged in 2002. Results from this paved the way for a staged dredging over a four-year period. The bed of the watercourse is gravel, overlain with about a foot of organic soil.

Location

Name of Watercourse: Mortons Leam *County:* Cambridgeshire
Upstream NGR: TL 208974
Downstream NGR: TF 397028

Management Intervention
It is proposed to maintain 5km per annum of the Leam by dredging 500m and leaving 500m, over a 10km reach. The effects on Spined Loach will be monitored over a 4-year period starting in January 2004. Routine maintenance on the channel is weed cutting once a year throughout the entire length (October) using hydraulic excavator & bradshaw bucket and weed-boat (for the deeper sections downstream). This is to continue during and after the proposed dredging.

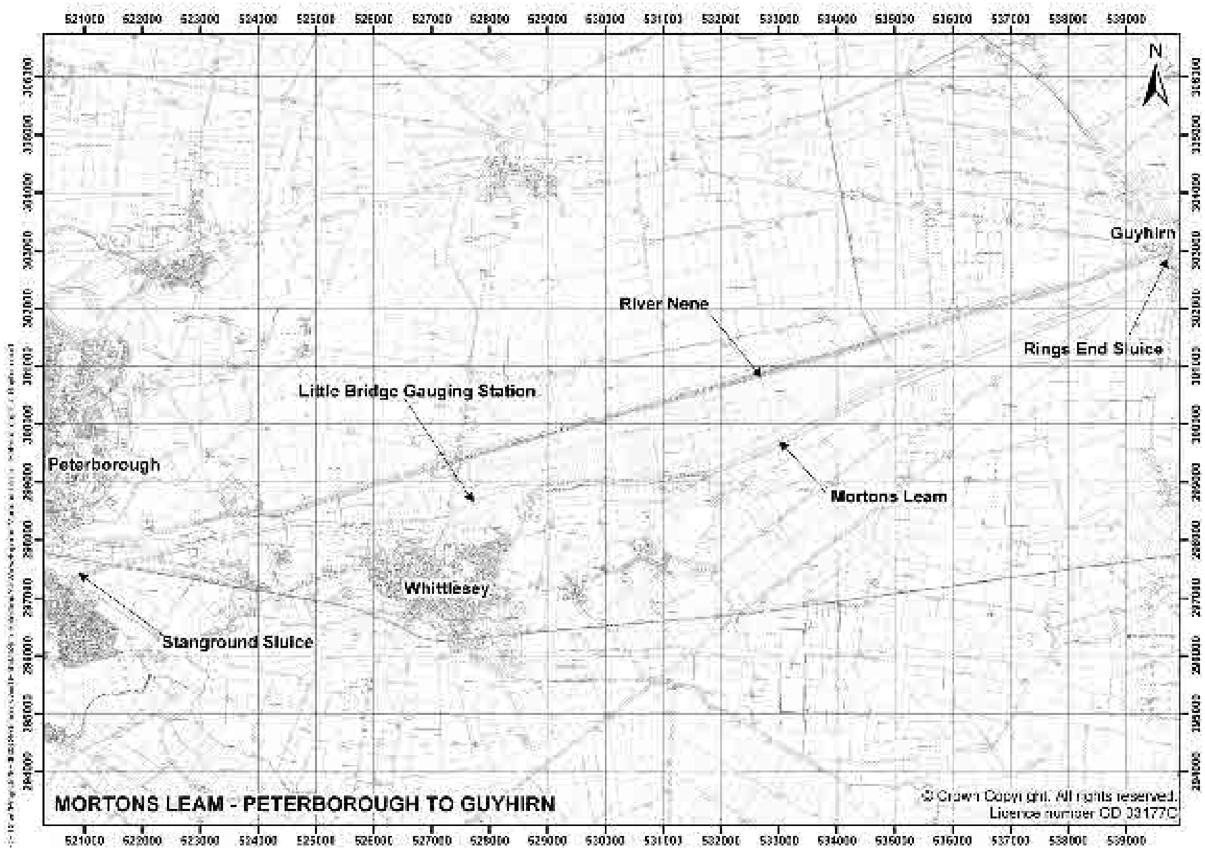

Figure 1 Location Map of Mortons Leam, Cambridgeshire

Plate 1 Mortons Leam, Cambridgeshire

Contact details

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Stepping Stone Walk Winfrey Avenue Spalding PE11 1DA	*Tel No:* 01775 762123 *Email:*

Details

Hydrology/soil/sediment information

Geology typically comprises of drift deposits overlying Upper Jurassic Clays across most of the site.

The most notable aquifer is the River Terrace gravels, which are well sorted sand and gravel deposits containing small silt fractions.

The channel velocities are likely to be modest as water overflows at modest depths onto the Whittlesey Washes. This may also imply that sediment is fairly stable.

Description of river and character
The river channel is straight and artificial with little shading from vegetation. Water levels are controlled during the summer for use within the washes.

What parameters are gauged and where?
Level gauge boards are located at Stanground Sluice (inlet), Eldernell Sluice and Rings End Sluice (outfall). Flow gauge is at Little Bridge near Whittlesey, about halfway along the Leam. There is a raingauge at Dog in a Doublet sluice near Whittlesey.

Land ownership/access issues
The Environment Agency owns the land. There is vehicular access at various points and 4-wheeled type access along the length of the Leam.

Other environmental and water quality information
The Mortons Leam (entire length) is within the Whittlesey Washes which is an SSSI, candidate SAR and SPA. Spined Loach is present within the watercourse and general catchment. There is concern about impact of dredging / weed cutting on it. A trial 500m length was dredged in 2002, during which the potential effect on the Spined Loach was monitored. As a result the dredging is planned in sections over a 4-year period, with further monitoring required.

Summary pros and cons for site
There is good scope for monitoring various sections as the dredging work is phased over the monitoring period. There is good flow and level information. There are however, concerns that the sediments may be fairly stable. Also the spined Loach monitoring may lead to change in the proposed dredging programme (although thought unlikely).

Summary site information: River Dearne

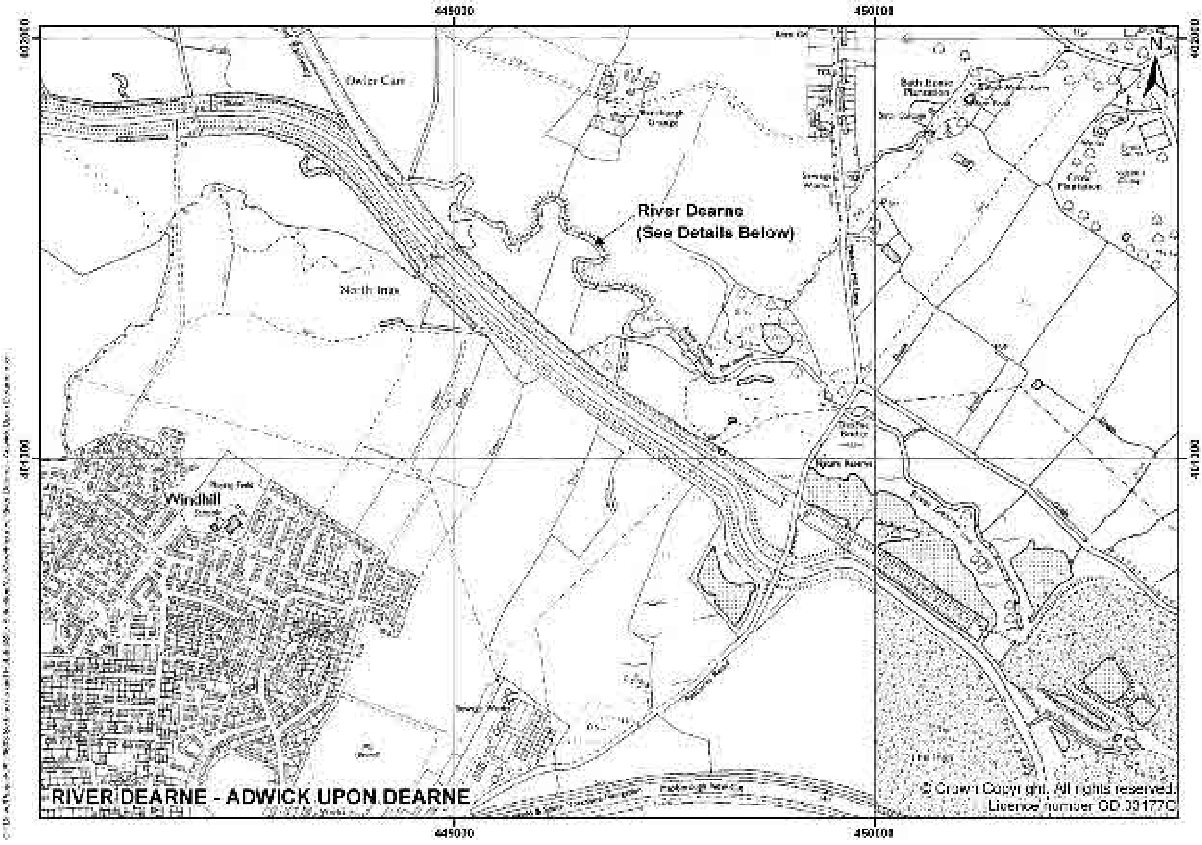
River Dearne is a main river within the North-East Region of the Environment Agency, near Doncaster. Settlement of the river channel between 1960 and 1975 occurred due to past mining activity, leading to loss of natural gradient and drainage problems. Works to remedy the problem in the 1970s included the river construction of a new straight channel. This channel was too wide and led to siltation, high weed growth and limited habitats. Two lengths of the watercourse were re-installed with the creation of much narrower low flow channel with adjacent berms at varying levels for conveyance of high flows, within the existing wide channel.

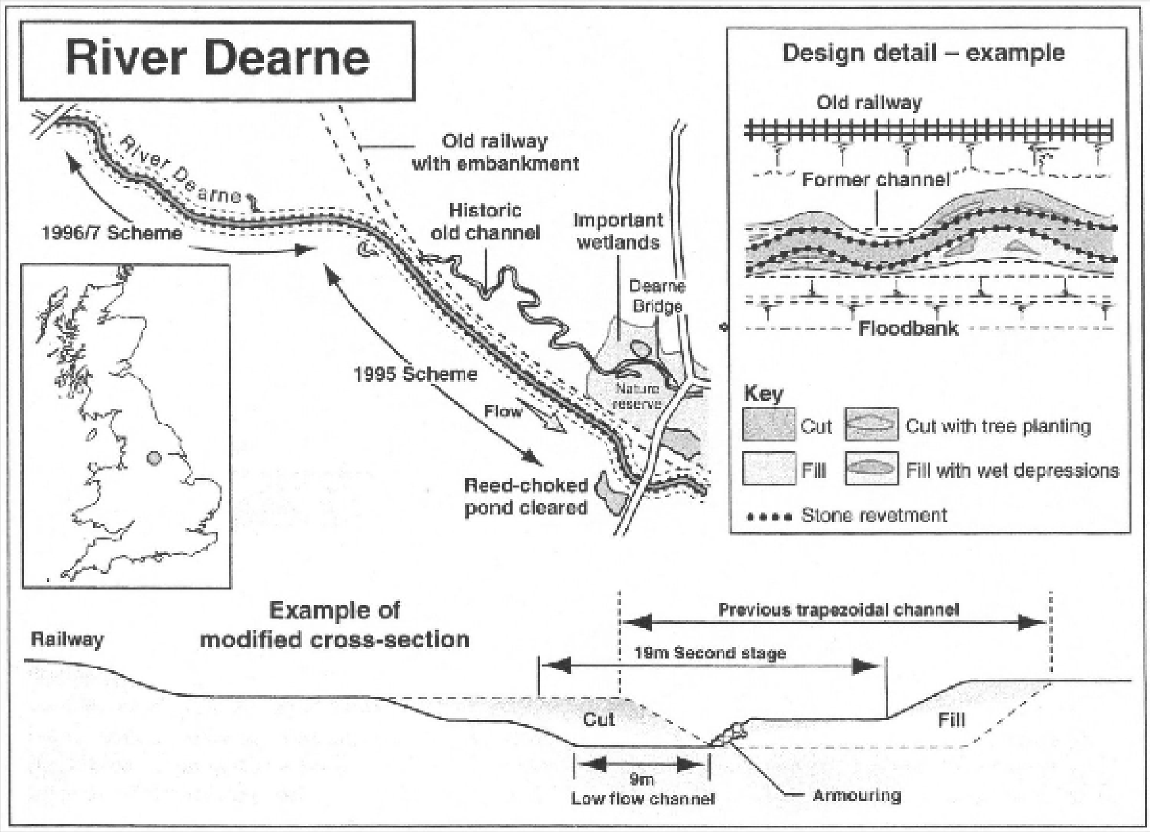
Location

Name of Watercourse: River Dearne *County:* South Yorkshire

Upstream NGR: SE 4901
Downstream NGR: SE 4801

Management Intervention
Annual dredging required as a result of the channel improvements. Prior to scheme annual sediment and intrusive weed was removed.





Contact details

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Details

Hydrology/soil/sediment information
Nigel Holmes carried out assessment. River backs up from the Don and is not very flashy. It is likely that sediments are not very dynamic. Riverbed is generally shale overlain with silt.

Description of river and character
The river channel is a meandering artificial channel, in a lowland, semi-rural catchment. It has occassional trees (a few willows) along the reach. The adjacent land use is mainly arable, but some residential upstream.

What parameters are gauged and where?
Existing Aldwick on Deane G.S. about 1km upstream of the reach can be used for flow and level monitoring. There is some RHS information and local fishery monitoring.

Land ownership/access issues
All the land is owned by the Environment Agency. Nearby pumping station can be used to store equipment.

Other environmental and water quality information
Site is adjacent to SSSI and also a Nature Reserve is located approximately 300m downstream of site. Is a popular location for anglers and watervoles have also been seen at this site. Water quality is reasonably good. It supports a good quality coarse fishery.

Summary pros and cons for site
The 2 sites in close proximity can be used for assessing the effect of the channel works and comparison of the two different designs. There is potential for a control site upstream and also within the 600m length between both schemes.

Summary site information: East Stour

Location: Flood storage scheme on the river East Stour upstream of the B2069 (Evergate Mill) SE of Ashford. TR 067381

FD Contact: Mark Stephens, Kent. 01227 762981. Geoff Gibbs, project manager for the scheme in 1980s – 01903 832278.

Biodiversity: Edward Bradbrook 01732 223103

Access & Services: EA own some land, rest in private ownership; good EA working relationships.

Maintenance: 'Desilting' of silt traps periodically needed, and also evidence of channel maintenance to the evacuation areas from the flood storage area.

River character: EA report as lowland and rural; confirmed. Channels all straight and artificial; above the flood storage area the main chalk stream inflow is 'perched'.

Land-use: Mixed arable and grassland; and open water; amazingly arable farming continues on much of the private land within the flood storage area (on either side of the perched inflow stream).

Gauging on site: Not known – not needed (see later).

Soils: Not known.

Environmental: Not known.

Site Assessment – 18th December 22, 2003 - River character

All channels are very artificial. There were no signs of any sediment-dependent habitats in all channels investigated (main inflow channels, and the cross-connecting channels that carry floodwater through 'throttles' from the flood storage area). The flood storage area is a very elegant example of its type, but the 'lake habitat' created as part of the scheme appears to have not reached its ecological potential.

Site Assessment – 18th December 22, 2003 - River processes

No sediment features were noted at all, apart from evidence that siltation occurs in the main channel that is perched high above the flood storage area, and in widened parts of feeder 'drains' to throttles. Therefore no cliffs, berms, bars, riffles or pools were seen.

Site Assessment – 18th December 22, 2003 - Type of maintenance effecting sediments and habitats

De-silting periodically occurs to ensure water can evacuate the flood storage area as planned. Dedicated silt traps need regular cleaning.

Site Assessment – 18th December 22, 2003 – Suitability for R&D

The reasons why the site was suggested for consideration are clear; there is on-going maintenance that has to be carried out, but there is only silt deposition occurring, and nothing else. Discrete habitats are not being created, so the site is an inappropriate one for the research proposed.

Recommendation: Consider no further as part of this R&D project.

LEFT: perched main channel with arable and pasture; RIGHT: main flood storage area

Main evacuation channel to 'throttle' – note large over-spill weir, top right, on photo on right (over-spill from main channel into flood storage area)

Summary site information: River Eden

Location: Two contiguous sites east of Edenbridge – 1. TQ 495463 to TQ 503456; 2. TQ503456 to TQ511455.

FD Contact: Richard Harris, Tonbridge, Kent. 01732 703022

Biodiversity: Edward Bradbrook 01732 223103

Access & Services: Private land; good EA working relationships; heavy plant access been OK; no service details

Maintenance: 'Desilting', about every 10 years…….two contiguous sites – upstream reach (1) already completed, downstream reached (2) no work planned (control reach).

River character: EA report as lowland and rural; confirmed. Planform reported by EA as 'meandering'; confirmed. EA report occasional trees and bushes, and that control and intervention reaches have similar character; confirmed.

Land-use: EA report mixed arable, pasture and grassland; confirmed.

Gauging on site: EA report level, flow, velocity gauged on site – there is, what is assumed to be, a flow gauge within 300m of the top of site 1.

Soils: EA report alluvial deposits and gravels over clay in the catchment, with silts over gravel as river sediments; confirmed, with also solid clay present as a river substrate in places.

Environmental: EA reports the river is a SNCI, and RCS, RHS otter and biological GQA (invertebrate) data exist for the reach. Otters reported from the control reach, and EA will have generic (if not site-specific) fishery data. There is angling in the reaches.

Site Assessment – 18th December 22, 2003 - River character

The two reaches are broadly similar, but the lower reach (2) is probably of a slightly lower gradient. Both are characterised by being meandering in a clay catchment, and therefore rivers have a flashy hydrology. Historic dredging means that the river is deeply incised, and much larger than it would be naturally.

Site Assessment – 18th December 22, 2003 - River processes

Being meandering, wider than is natural, and carrying sediments, the Eden is constantly attempting to create habitats from the sediment it is carrying. Once formed, these 'habitats' also affects flow characteristics and sediments; in turn, the way in which the river can self-regulate the erosion and deposition rates of ‘deposit features’, and the vegetation that grow upon them, ultimately determines the effect on ‘conveyance’, and the need for, and type of, FD maintenance.

The site assessment concentrated on looking for signs of fluvial activity. Effort concentrated on noting, very roughly, the extent and type of erosion and deposition features within the reaches; by assessing these it should be possible to gain a rudimentary understanding of the types and sources of sediments that are building habitats within the reaches (surrogate for fluvial audit).

The table shows a summary of the key features noted for the two reaches assessed – note reach 1 had just had maintenance carried out, and therefore some of the features previously present were either reduced in size (width or height) and extent (length along river bank) or may have been lost altogether (RCS and RHS data should help determine accurately).

Table Eden 1 Fluvial Features

		<10m long	10-50m long	>50m long
Bank slips/slumps				
Stable cliffs		1	2	
Unstable cliffs				
Shelves/berms		4	6	8
Vegetated side bars				
Vegetated point bars	1			
Unvegetated side bars				
Unvegetated point bars				
‘Riffles’	5			
Pools				
Tree boughs	4			
Revetments			1	

This was the first site assessed, and in dense fog, so clarity on how sites were to be assessed had not been developed!! Site observations, read in conjunction with the information in the table above suggest:

- Only sediment from fluvial features (i.e. only the berms) was removed;
- All (or the vast majority) of fluvial features (i.e. the berms) are derived from sediment washed into the reach from upstream, or the land adjacent;
- No, or minimal, material is derived from *in situ* bank erosion;
- The habitat building block material is silt, held by marginal reeds initially to enable its development;
- As no bed material is dredged, water levels only fluctuate in relation to flow volumes, and banks are composed of cohesive clays, there is minimal evidence of bank slips.

Table Eden 2 Fluvial Features

		<10m long	10-50m long	>50m long
Bank slips/slumps				
Stable cliffs		2	2	
Unstable cliffs				
Shelves/berms		7	7	3
Vegetated side bars				
Vegetated point bars	2			
Unvegetated side bars				
Unvegetated point bars				
'Riffles'	4			
Pools	6			
Tree boughs	7			
Revetments			1	

Site observations in the downstream, non-dredged, reach, read in conjunction with the information in the table confirm observations from the upstream, recently managed, reach, namely:

- All (or the vast majority) of fluvial features (i.e. the berms) are derived from sediment washed into the reach from upstream, or the land adjacent;
- No, or minimal, material is derived from *in situ* bank erosion;
- The habitat building block material is silt, held by marginal reeds initially to enable its development;
- As no bed material is dredged, water levels only fluctuate in relation to flow volumes, and banks are composed of cohesive clays, there is minimal evidence of bank slips.

Site Assessment – 18th December 22, 2003 - Type of maintenance effecting sediments and habitats

De-silting of reach 1 has taken the form of predominantly reducing the width of marginal shelves (berms), occasionally lowering some shelves, and removing some marginal shelves (this appears very rarely). Apart from where dense patches of reeds may have been present, no in-channel dredging/de-silting has taken place other than to reduce the extent of the berms. It would appear that only between 10-15% of the channel had been disturbed in what might be described as 'spot de-shoaling' rather than wholesale de-silting.

In terms of following EA maintenance best practice, the work on this site represents extremely sensitive maintenance, and worthy of being extolled as an example of the best ever seen. The only evidence of not acting within EA guidelines was the very clear lack of returning to the river masses of swan mussels held within the dredgings (see photo). There was absolutely no evidence of 'over-dredging' resulting in gravel or clay being present within the dredgings.

No works are proposed to be carried out on this downstream reach (2), but it is assumed that it would be within the rolling programme for de-silting of a similar nature to that upstream at some time in the future. It has had such management in the past, and if not required in the future it would be very important to know why.

Site Assessment – 18th December 22, 2003 – Suitability for R&D

The paired sites, receiving virtually identical discharges, make this site an ideal R&D site for the work envisaged. It is unfortunate that the maintenance has been carried out already, as ideally we were looking for similar sites pre-works, then one would receive management and the other would not.

Having RCS and RHS already for the reaches is very useful, especially for hind-casting the likely pre-works character of reach 1 (already managed).

Pros	Cons
Paired sites, ± identical flows and physical character	Paired sites do not offer pre-management conveyance performance and habitat character
Can monitor habitat stability/change and conveyance within unmanaged reach with similar features as managed reach	
Can monitor habitat development and effects on conveyance within unmanaged reach with managed reach as it restores fluvial features modified or lost in management	
Flow gauging station within site	
Biological data appears to be good	
Site access and ownership issues appear to be positive	
RCS and RHS data already available	
Would be monitoring exceptionally ‘good’ practice – may be atypical, and viewed as +ve or –ve.	

Recommendation: take forward in absence of very good alternative site that enables collection of conveyance and habitat character prior to autumn 2004………..such sites may exist on the Eden system. It would have added value if it was paired with monitoring response to what appears to be insensitive dredging on the Lesser Teise; this way recovery of habitat, and the effect on conveyance, of two contrasting operations could be compared.


Left: probable removal of berm on inside of meander; Right: previously berms on both banks, one with edge ‘nibbled’


Left: area of clear gravel indicates reed fringe/berm removed to gravel bed only; Right: typical pile of mussels not returned to the river following completion of dredging


Left: paired berms and ‘riffle’ – site in Reach 2 - probable character in parts of Reach 1 upstream; Right: Cut-off meander ‘ox-bow lake’.

Summary site information: River Frome

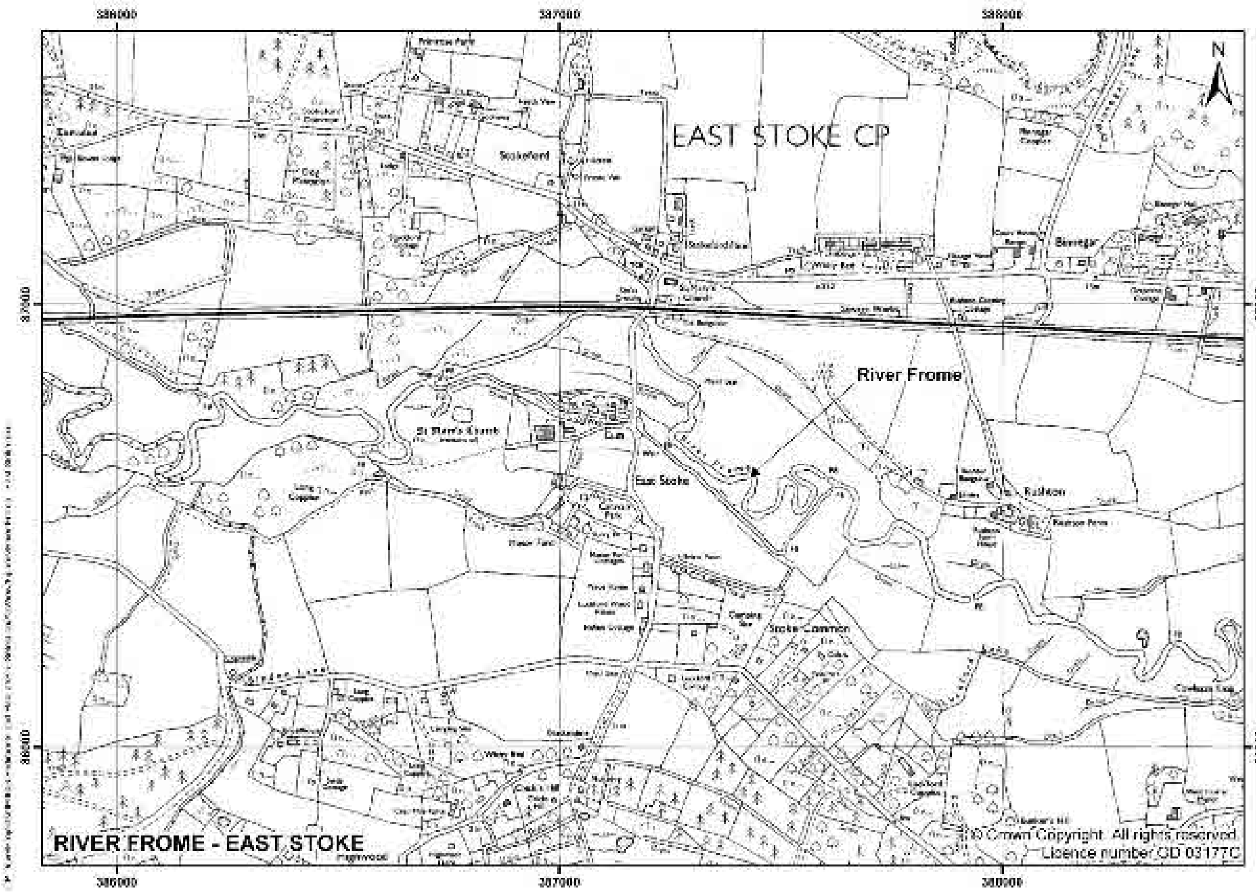
River Frome is a main river within the Southwest region. It is a focus of current NERC-LOCAR thematic programme project by CEH and University of Queen Mary's. The river is maintained by weed cutting around the gauging station, but differently elsewhere.

Location

Name of Watercourse: River Frome   *County:* Dorset

Upstream NGR: 3870 0869 (approximate site NGR)
Downstream NGR:

Management Intervention
Weed cutting directly upstream of the gauge site once a year.



Contact details

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EA Hydrometry – Geoff Hardwick
EA Environmental Management – Amanda Jenkins
EA Conservation – Denise Exton

Details

Hydrology/soil/sediment information
Velocity cross section measurements and sediment sampling have been conducted during the NERC-LOCAR project.

Description of river and character
Lowland meandering reach with occasional shading from overgrown bushes and trees.

What parameters are gauged and where?
Water level and flow gauging at East Stoke, with additional rainfall monitoring

Land ownership/access issues
Access to site is very good. The right bank of the channel is a public right of way, but belongs to Wield Estate. The left bank is privately owned (Farmer- Mr Beverage) with very good relations.

Other environmental and water quality information
Located within SSSI. Medicinal leech and white-clawed crayfish within reach.

Scheduled Ancient Monument (Site of St Mary's Church). Located adjacent to East Stoke reach of the river. Cattle poaching and angling are potential problems. RHS information available for entire lengths (2002).

Summary pros and cons for site
Current projects by Centre for Ecology and Hydrology, Queen Mary's University and Exeter University as part of the NERC–LOCAR thematic programme. However, the reach is located within an SSSI and so may caused restrictions to any trial site. Furthermore, poaching on the channel banks and local angling interests may cause problems. If not part of the proposed sites, the project needs to keep up-to-date with monitoring and results from the CEH work. The length of weed cutting may be too short for our proposed monitoring.

Summary site information: River Gowry

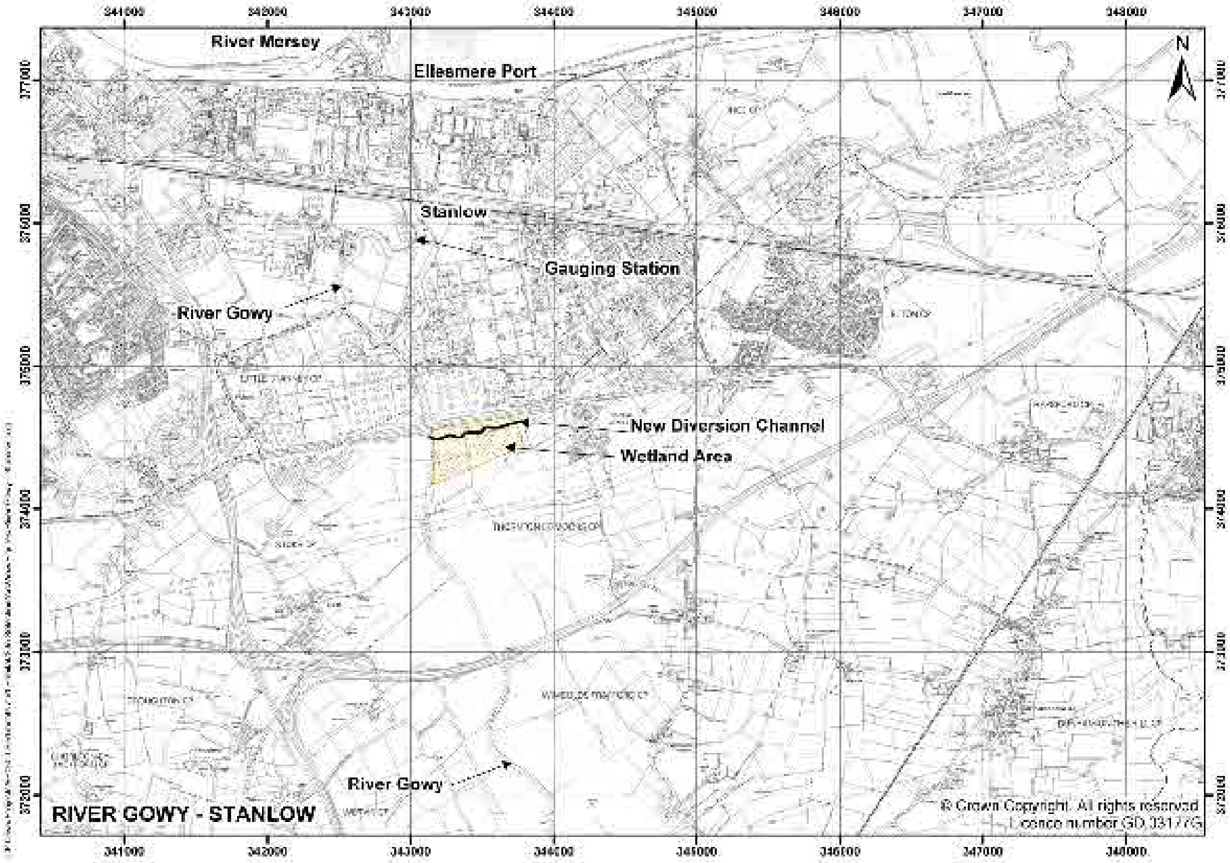
A capital scheme was carried out in 2002 on the River Gowy in the Northwest region to improve flood defences to Stanlow Refinery. The River Gowy runs through the middle of the refinery. The capital scheme involved replacing flow control structures, bank improvements works to outfalls. As part of the scheme, the owners of the refinery donated land upstream of the A5117 road for use as a wetland area. The wetland creation involved works to change the straight channel to a meandering one with low berms and installation of new structures to allow water into the new wetland area.

Location

Name of Watercourse: River Gowy *County:* Cheshire

Upstream NGR: SJ 42997690
Downstream NGR: SJ 44927190

Management Intervention
Restoration of the river to its original meandering course with creation of wetland area, which includes annual weed cutting.



Contact details

Contact Name: Michael McElroy	Organisation:
Also CJ Wright and M Middleton	Environment Agency, North West Region
Contact address	
Environment Agency North West Region Appleton House 430 Birchwood Boulevard Birchwood Warrington Cheshire WA3 7WD EA Environmental Officer- Tracy Rimmer	*Tel No:* 01925840000 *Email:* m.mcelroy@environment-agency.gov.uk

Details

Hydrology/soil/sediment information

Description of river and character
The river channel is situated in a lowland catchment. It exhibits a meandering planform, with no shading.

What parameters are gauged and where?
Existing flow gauges can be used for monitoring.

Land ownership/access issues
The land is privately owned by the refinery, EA has access all through. Vehicular access is possible along the lower reaches on the flood berms, during non-flood dry conditions, otherwise on foot. Several petrochemcial installations on the lower reaches should allow storage of equipment. There are some potentially hostile sites in the area, need to check local hostile sites register with local EA staff.

Other environmental and water quality information
The site is popular for angling. There is a wetland reserve/environmentally designated sites within the reach.

Summary pros and cons for site
The site offers several intervention scenarios such as channel improvement and upstream storage to investigate all within close proximity. The hydrology, sediment characteristics/dynamics are largely unknown.

Summary site information: River Gwash

The River Gwash is a main river tributary of the River Welland within the Anglian region. As a result of reduced flood risk post construction of the Empingham Reservoir in 1976, maintenance has now been reduced to weed cutting in a few sub-reaches (typically around residential areas). No maintenance work is carried out upstream of Ryhall until Little Casterton, except occasional blockage removal.

Location

Name of Watercourse: River Gwash *County:* Rutland
Upstream NGR:
Downstream NGR:

Management Intervention (Dredging, channel improvement, Storage, weedcutting)
Weed cutting from weir 500m downstream of Belmesthorpe Gauging Station to Mill Lane, Ryhall in October each year, using hydraulic excavator and weed cutting basket.

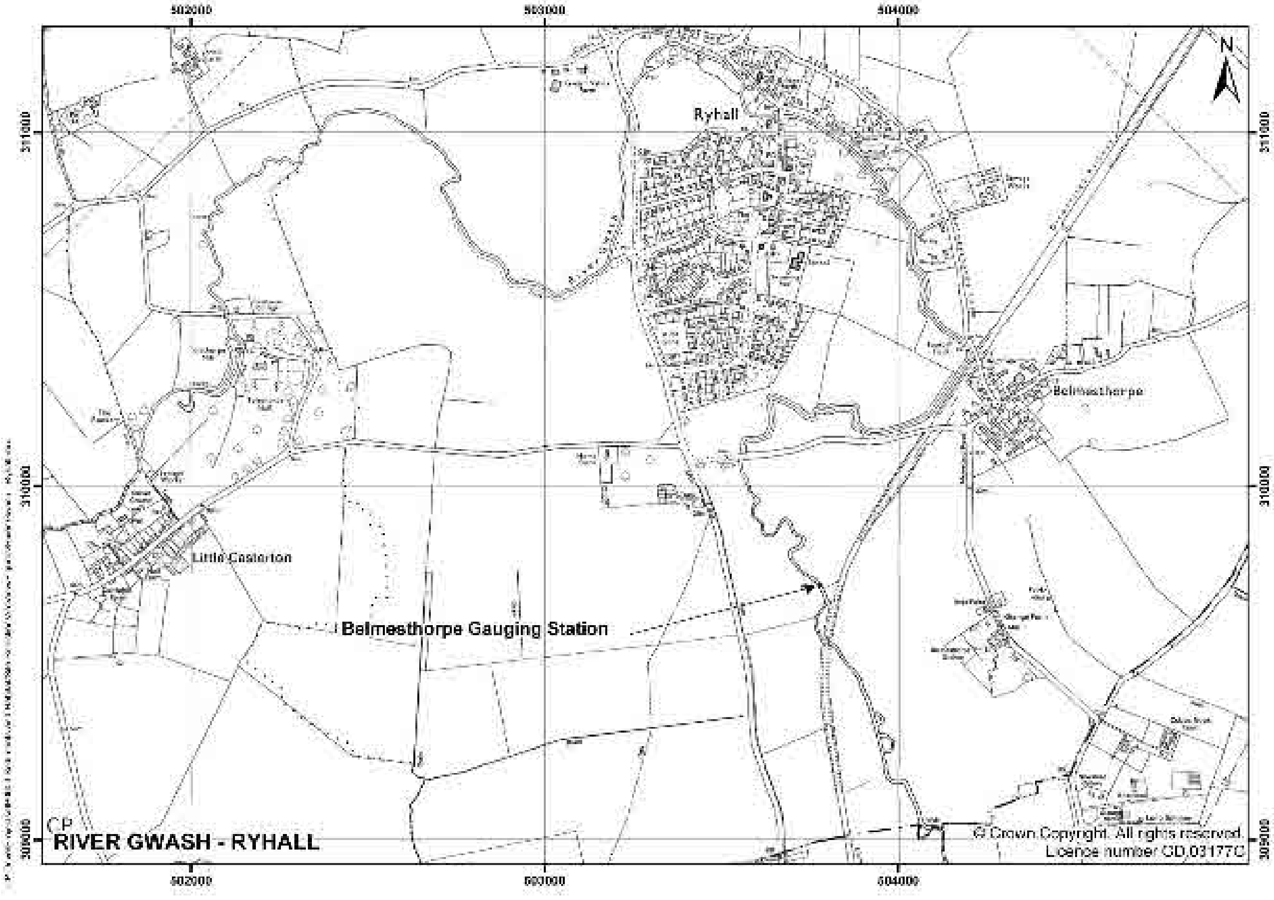


Figure 1 Location Map of River Gwash, Rutland

Plate 1 River Gwash, right bank looking upstream and downstream.

Plate 2 River Gwash, left bank looking upstream and downstream.

Contact details

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Lodge Estate
Kettering
Northhamptonshire
NN15 6JN

Organisation:
Environment Agency, Anglian Region

Tel No: 01536517721
Email:

DETAILS

Hydrology/soil/sediment information
Soils within the local area are predominantly clay with pockets of limestone. Since the construction of Empingham Reservoir (1976) the reduced flooding has led to siltation of river channel. As flood risk is low, the silt is not removed except at a few locations. Channel is fairly stable.

Description of river and character
It is a lowland meandering river. Some local areas of shading exist along the reach. Land use in the catchment is predominantly arable and pasture. River water level is typically about 1m deep, with swallow holes present within reach.

What parameters are gauged and where?
Water level and flow levels are monitored at the Belmesthorpe GS, with a rainfall gauge at Ryhall pumping station.

Land ownership/access issues
Land is privately owned (Steve Achurch) with good relations with the EA. Access to the site is by foot only, with access to a storage facility nearby (Ryhall PS).

Other environmental and water quality information
There is a local fish farm nearby. The water quality is very good.

Summary pros and cons for site
Most of the river has been relatively untouched for over 20 years, with weed cutting in a few sections. This provides potential for assessing the effects of weed cutting. There may also be the possibility of comparing the part of the River Gwash upstream of Empingham Reservoir (Rutland Water) with the downstream reach to study the long-term effect of reservoir 28 years on.

Summary site information: River Ise

Recent capital scheme on the River Ise at Geddington, within the Anglian Region, involved the construction of a new diversion channel, about 100m long downstream of the Town Bridge. The work was carried out to improve the channel capacity through Geddington. The new channel is an over flow channel usually dry except during high flows.

Location

Name of Watercourse: River Ise | *County:* Northamptonshire

Upstream NGR: 28284874 (Approximate NGR)
Downstream NGR:

Management Intervention
Bypass channel has been implemented. Hand strimming between A43 and the village bridge twice a year, during June and August. Weed cutting is also carried out from the outfall of the new channel to Boughton Estate once a year August to October.

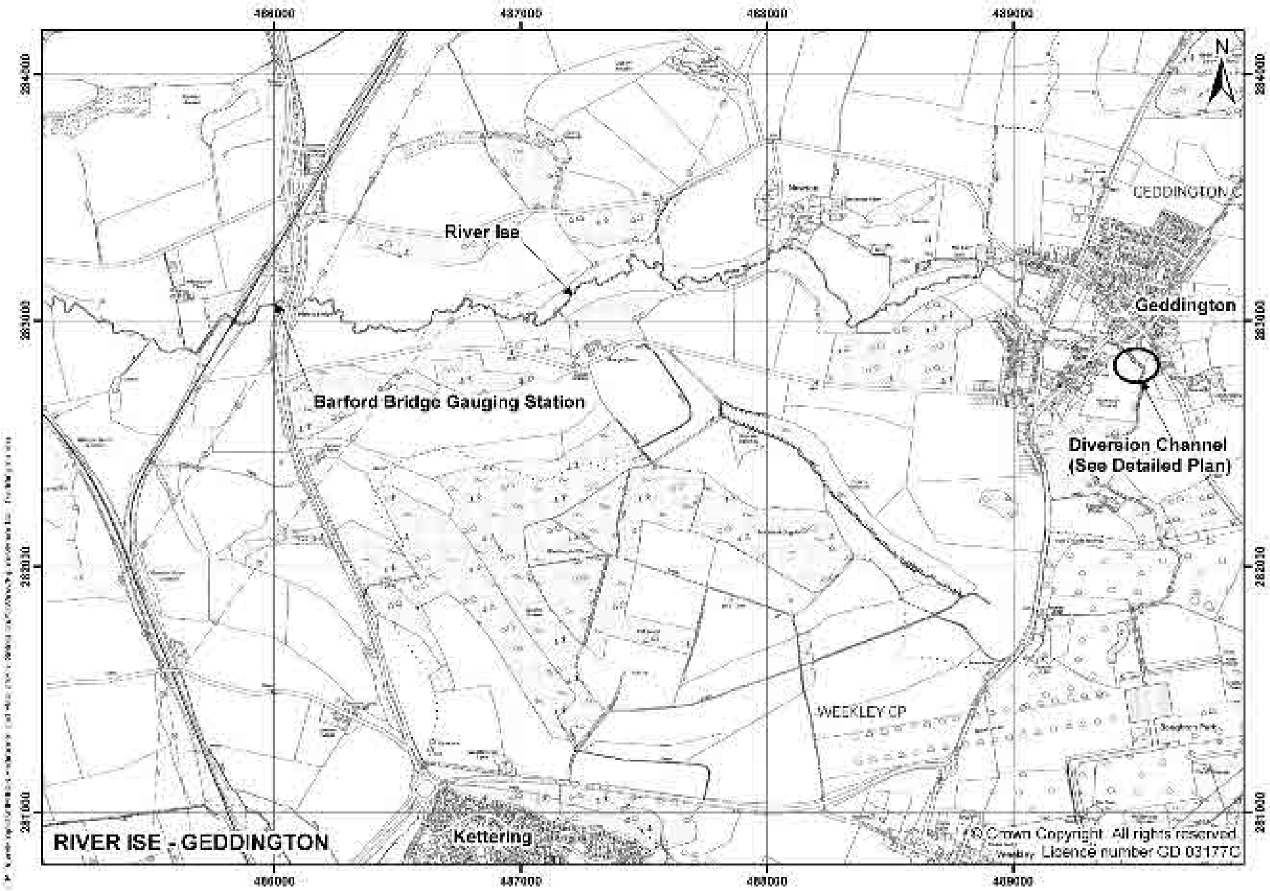

Figure 1 Location Map for River Ise, Northamptonshire

Plate 1 River Ise looking downstream

Plate 2 River Ise upstream from Geddington

Plate 3 River Ise looking upstream

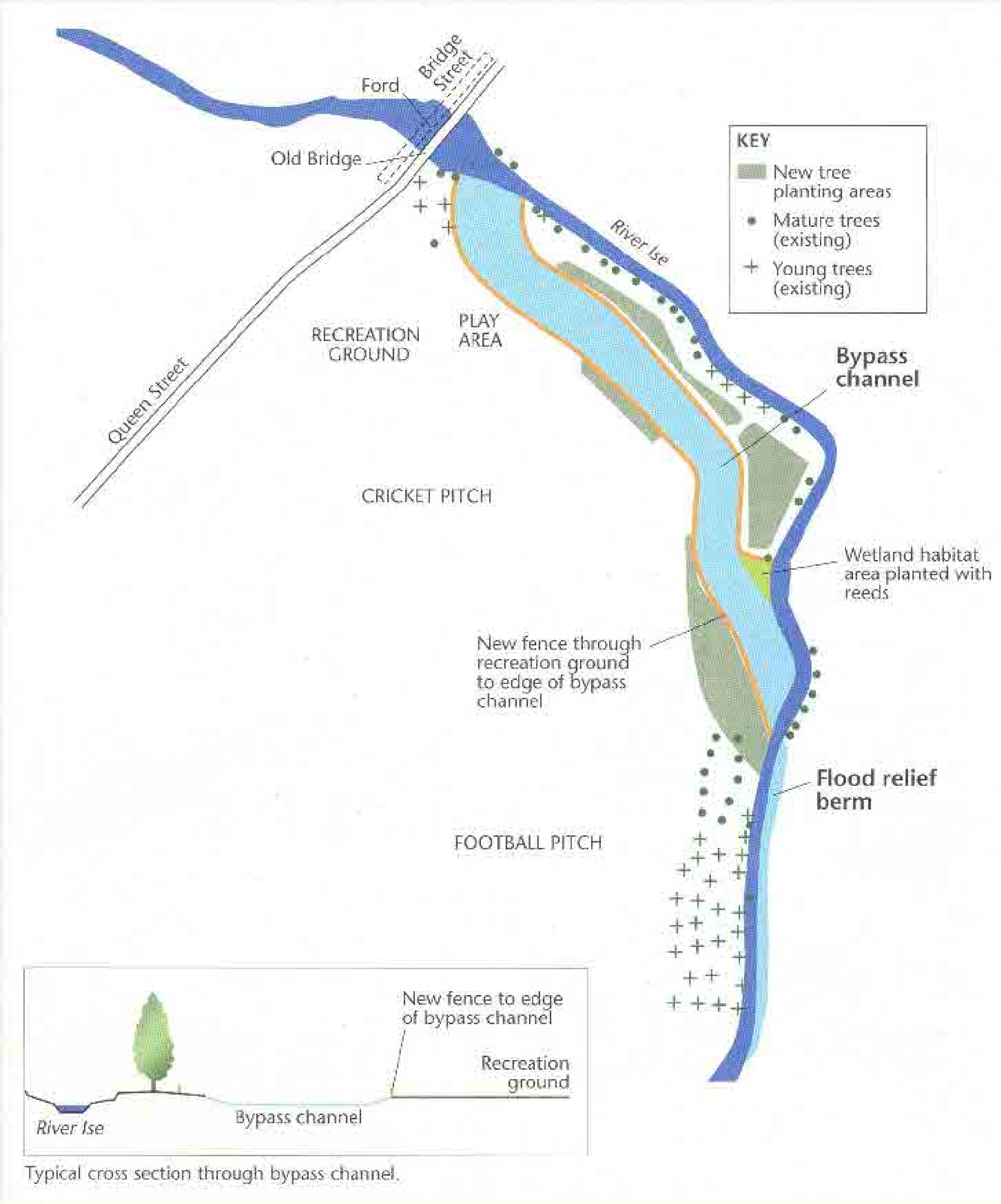

Figure 2 River Ise implemented management activities, including bypass channel

Contact details

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Details

Hydrology/soil/sediment information
The soils within the local area are predominantly clayey.

Description of river and character
The river channel is an upland rural meandering channel with little or no shading in new channel. The existing channel has overhanging trees and bushes which encourage shading. The watercourse is silty, but sediment dynamics are relatively unknown.

What parameters are gauged and where?
Weir at Barford Bridge monitoring water level and flow.

Land ownership/access issues
The land is privately owned with good pedestrian access.

Other environmental and water quality information
The site is used by anglers and there has also been otters spotted in the new channel.
Also upstream of the A43 lies an SSSI.
Some archaeological interests have occurred at Boughton Estates.

Summary pros and cons for site
The site has existing monitoring of water and flow levels and has extensive general information regarding the catchment and the new diversion channel. The diversion channel is a flood channel and is dry except during high flows.

However, the site has potential to be affected by local anglers, together with restrictions being implemented due to the otter populations within the local area.

Summary site information: River Piddle

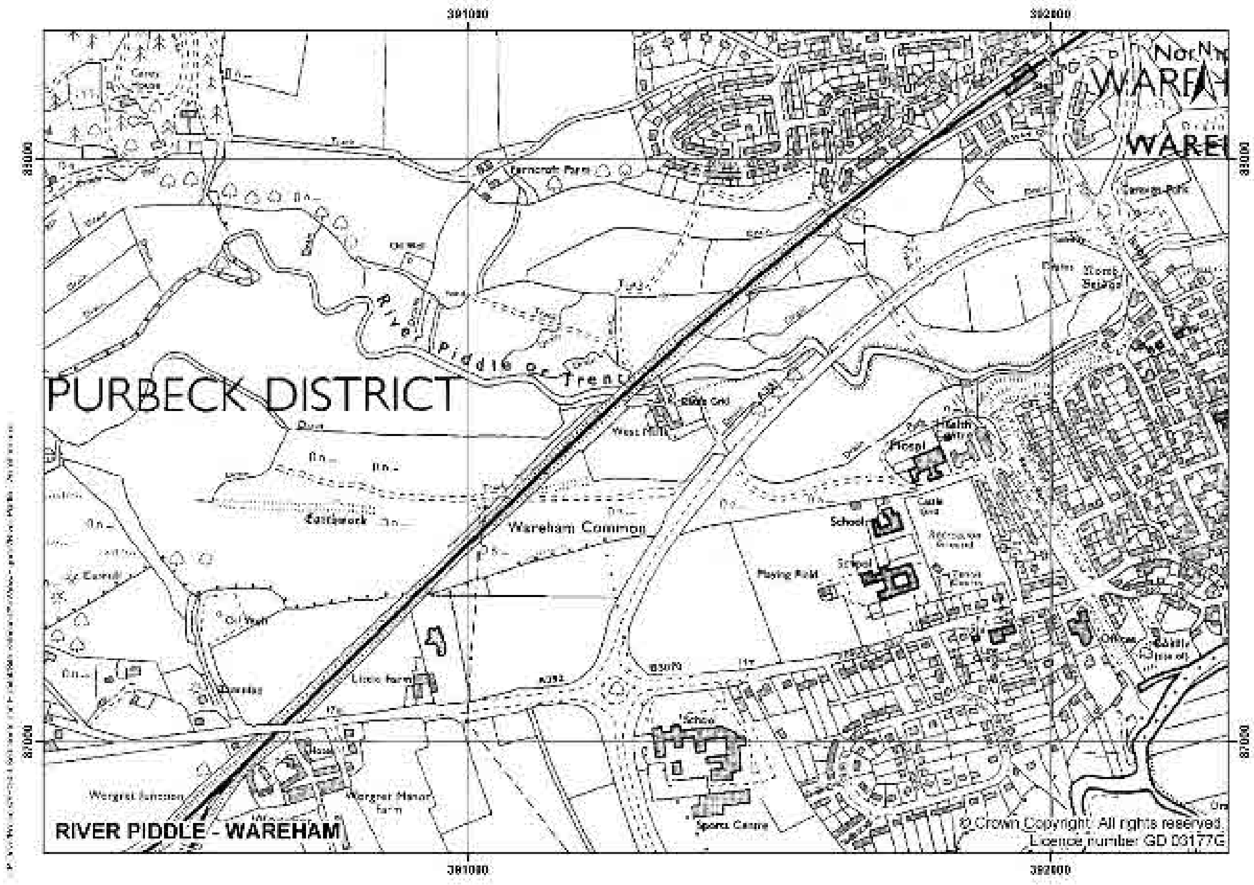
River Piddle is a main river within the Southwest region. It is a focus of current NERC-LOCAR project by CEH and University of Queen Mary's. There are varying levels of weed cutting within the channel, with the gauging areas cut more often.

Location

Name of Watercourse: River Piddle   *County:* Dorset

Upstream NGR: 39150875 (approximate site NGR)
Downstream NGR:

Management Intervention
Weedcutting in-channel at Wareham Common, once a year but also as and when required to prevent flooding. Area around the gauging station is cut more often.



Contact details

Contact Name: Brian Scott

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Email: B.Scott@environment-agency.gov.uk

EA Hydrometry – Geoff Hardwick
EA Environmental Management – Amanda Jenkins
EA Conservation – Denise Exton

Details

Hydrology/soil/sediment information
Velocity cross section measurements and sediment sampling have been conducted during the NERC-LOCAR project.

Description of river and character
The site has a meandering planform with occasional shading from overgrown bushes and trees.

What parameters are gauged and where?
Water level and flow gauge at Baggs Mill, with daily mean pre 1992 and 15 minute intervals for level and flow post 1992. Rainfall is also monitored at Trigon Farm, 80 years data post 1961, and daily data since 1961 to present.

Land ownership/access issues
Access to site is very good both vehicular and by foot.

Other environmental and water quality information
Sewage treatment works is located at Wareham, which is 50m downstream of the site. RHS information available for entire lengths (2002).

Summary pros and cons for site
No ecological designations within the reach specified and therefore no abnormal restrictions. The site already has a history of water level and flow and sediment monitoring as part of the long-term NERC-LOCAR project. If not used, results from ongoing CEH work should be monitored.

Summary site information: River Teise

Location: Over 2km of river upstream of the confluence with the Medway – TQ 688480 to TQ 690497.

FD Contact: Richard Harris, Tonbridge, Kent. 01732 703022.

Biodiversity: Edward Bradbrook 01732 223103.

Access & Services: Private land; good EA working relationships; heavy plant access been OK in past; no service details.

Maintenance: 'Desilting' with a minimum frequency of 10 years. Works proposed for Autumn 2004.

River character: EA report as lowland and rural; confirmed. Planform reported by EA as 'meandering'; not confirmed – the river is not meandering as the Eden is….there are bends, but it is improbably that the river now flows in its original course. EA report occasional trees and bushes; confirmed, but they are sparse.

Land-use: EA report mixed arable, pasture and grassland; confirmed.

Gauging on site: EA report level, flow, velocity gauged on site – there is, what is assumed to be, a flow gauge within 300m of the top of site 1.

Soils: EA report alluvial deposits and gravels over clay in the catchment, with silts over gravel as river sediments; confirmed.

Environmental: EA reports that otters have been recorded from the reach, and EA will have generic (if not site-specific) fishery data? The bridge in the centre of the site is a Scheduled Ancient Monument. The downstream end is connected to the Lees SNCI.

Site Assessment – 18th December 22, 2003 - River character

The target area can be conveniently divided into two reaches of broadly similar character, either side of Woodfalls Farm bridge. Both are similar in that they are very deeply incised (dredged) and with steep, often near vertical, banks. Being a river in a predominantly clay catchment, the banks are primarily cohesive clay soils, and the bed is dominated by gravel. Historic dredging means that the river is not only deeply incised, but much larger than it would be naturally.

Unlike the Eden, the river is virtually devoid of any fluvial features derived from sediment (see table below). Land-use varies, with a road running close to the river in part of the upper section, and grassland and orchards dominating the floodplain. There is also a 'yard' adjacent to the river on the left bank half way down the upstream section.

The bridge would appear to have less capacity than much of the river itself, and downstream of it is a major weir that is dissipating energy, and stopping headward recession undermining the bridge.

The bank mowing regime, best illustrated in the top section, is exemplary for banks that are assessed as requiring regular mowing; the top half of the bank is mown, leaving the lower half providing edge habitat and vegetation to support invertebrates, birds and other small mammals

Site Assessment – 18th December 22, 2003 - River processes

As elsewhere, the site assessment concentrated on looking for signs of fluvial activity. Effort concentrated on noting, very roughly, the extent and type of erosion and deposition features within the reaches; by assessing these it should be possible to gain a rudimentary understanding of the types and sources of sediments that are building habitats within the reaches (surrogate for fluvial audit).

The table shows a summary of the key features noted for the two sections (separated by the bridge) assessed – note reach 1 had just had maintenance carried out, and therefore some of the features previously present were either reduced in size (width or height) and extent (length along river bank) or may have been lost altogether (RCS and RHS data should help determine accurately).

Table Teise 1 (upstream of bridge) Fluvial Features

		<10m long	10-50m long	>50m long
Bank slips/slumps		1	3	
Stable cliffs		1 (due to slip)		
Unstable cliffs				
Shelves/berms		2	2	1
Vegetated side bars				
Vegetated point bars				
Unvegetated side bars				
Unvegetated point bars				
'Riffles'				
Pools				
Tree boughs				
Revetments				

Table Teise 2 (downstream of bridge) Fluvial Features

		<10m long	10-50m long	>50m long
Bank slips/slumps		3	1	
Stable cliffs				
Unstable cliffs			2	
Shelves/berms		8	2	
Vegetated side bars				
Vegetated point bars				
Unvegetated side bars				
Unvegetated point bars				
'Riffles'				
Pools				
Tree boughs	3			
Revetments				
Vegetated mid-channel bar	1			

Site observations, read in conjunction with the information in the table above suggest:

- Minimal sediment throughput and virtually no substantial fluvial features (i.e. the berms all very minor *cf.* Eden) and just one bar (see photo) in over 2km of river;
- Extremely low gradient results in NO pool or riffle habitats, and almost uniformly slow (smooth) flow;
- The berms are derived either from sediment washed into the reach from upstream, or from bank-slips;
- As water levels only fluctuate in relation to flow volumes, and banks are composed of cohesive clays, bank slips are not as common as on the Lesser Teise, but more apparent than on the Eden;
- No, or minimal, material is derived from *in-situ* bank erosion – slumps simply form berms;
- As the river is predominantly straight, few opportunities are afforded to the river to create habitat through erosion or deposition of sediment on meanders;
- Justification for planned de-silting not clearly apparent.

Site Assessment – 18th December 22, 2003 - Type of maintenance effecting sediments and habitats

De-silting is planned for autumn 2004; it is assumed this would take the form of spot-dredging. From a single site visit it is not clear what this would achieve. There is little evidence that sediment is reducing conveyance. As the bed is predominantly compacted gravel, it is unlikely that new gravel has been washed into the site since the previous dredging. Any reduction in conveyance has thus probably developed through berms being formed either by local bank slips, or silt accretion by marginal reeds (or a combination of the two).

Site Assessment – 18th December 22, 2003 – Suitability for R&D

The potential value of this site is limited due to the virtual absence of any sediment-derived habitats. The site has great potential if, and only if, work was done in conjunction with monitoring responses on the Eden and Lesser Teise. To be included within the R&D would extend the research to be able to provide guidance not only on the effects of different management practices, but guidance on when it should be carried out.

A fundamental requirement would be to assess what the existing channel dimensions (e.g. cross-sections) are, and what its conveyance performance is, compared with the design of the capital scheme. If the conveyance is less than the design standard, which is what it should be to require maintenance, then the R&D could advise on how the works could be carried out. This should aim to improve the potential for sediment-dependent habitats, and in-stream diversity, to be established in what is a very impoverished reach of lowland river, and also enhance self-sustaining conveyance within the channel.

Pros	Cons
Chance to link to complementary management on adjacent rivers of a broadly similar character	Minimal sediment-dependent habitats present
Good access and potentially landownership cooperation	Justification for doing works not clear
Lack of existing ability of the river to form sediment-related habitats provides opportunity to experiment with more radical approaches to maintenance to help the process	Potential for sediment-dependent habitats to develop is limited due to lack of building-block material

Recommendation: Take forward in combination with other local sites only. Potential to undertake invaluable assessment of conveyance and channel morphology 'status' in relation to capital design, and assessment procedures for determining when 'maintenance trigger should be pulled'. Potential to also recommend total new approach to maintenance on a featureless river that cannot develop sediment-dependent habitats form without help.


Teise upstream of weir…..Left: best practice mowing. Right: bank slump creating vertical bank (small cliff)

The one and only sediment feature in the reach – a tiny vegetated mid-channel bar

Cliff on outside of bend formed through erosion, rather than bank slumping (possible single example in whole reach)

Summary site information: Southwick Brook

Southwick Brook is a tributary of the River Nene within the Anglian Region. Annual dredging is carried out over a 50m concrete channel length of the Brook downstream of the Southwick town bridge. Bush clearing is carried out every 5 years, with no management intervention upstream of the village over the last 30 years. Weedcutting is carried out downstream of the village to Woodnewton Road (Wych Spinney Bridge) once a year. General channel clearance/improvement is planned upstream of the village.

Location

Name of Watercourse: Southwick Brook *County:* Northamptonshire
Upstream NGR:
Downstream NGR:

Management Intervention
Annual dredging; with bush clearing every 5 years. Weedcutting is also carried out twice a year through the village.

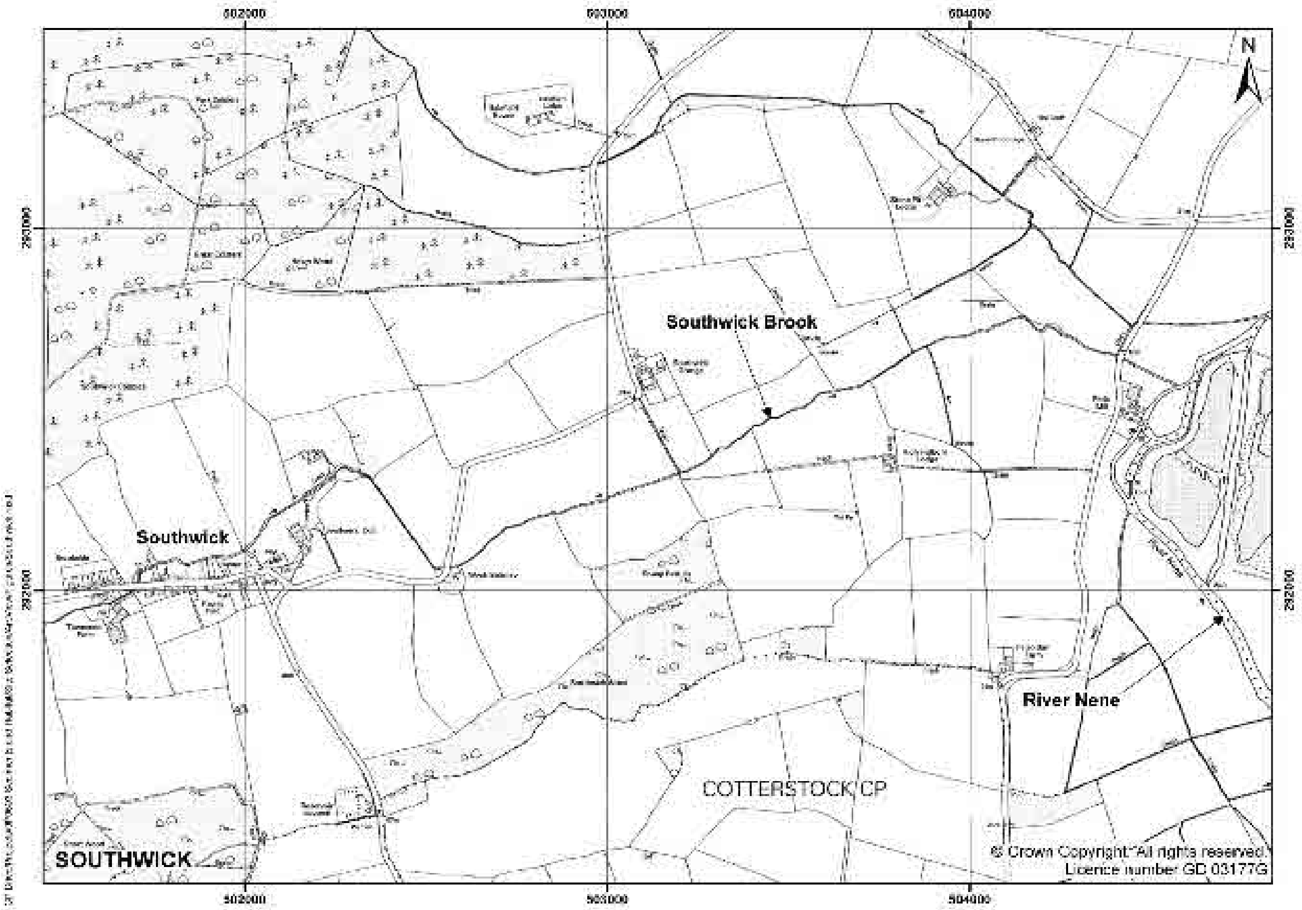

Figure 1 Location map of Southwick Brook

Plate 1 Southwick Brook looking upstream, left bank protection

Plate 2 Southwick Brook before weed cutting has been carried out

Contact details

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Details

Hydrology/soil/sediment information
Soils are predominantly clayey.

Description of river and character
The part of river channel around Southwick town bridge is concrete lined, although the majority of the channel is relatively sinuous and natural with significant point bars and medial gravel bar deposits. There is evidence of bank erosion in places. Overhanging trees and overgrown bushes heavily shade the river channel. Specific points within the Brook, the flow is restricted due to within-channel woody debris. The brook is usually dry except during high river flows.

What parameters are gauged and where?
No gauging station is present on the Southwick Brook.

Land ownership/access issues
Land is privately owned with good working relations. Access is mainly by foot however, vehicle access via the road bridge is possible.

Other environmental and water quality information
The water quality is generally good. The brook is an SSSI upstream of the A43, to beyond Barford Bridge. There are some archaeological interests near Boughton Estates. Otters are present in area. Fishing is carried out in watercourse.

Summary pros and cons for site
Part of the reach is designated SSSI, with otters present and the reach is a popular fishing location which could result in disturbance of potential trial site. No level or flow gauging is present on watercourse. Also the channel section where dredging occurs is concrete lined.

Appendix 3 Data Protocol for field studies

Introduction

The following is a draft of the Data Protocols to be used for collecting and storing data from Stage 2. The philosophy has been to use existing approaches and protocols as much as possible. This has been done for a number of reasons:

a) using methods that are already familiar will make the data collection easier and speedier
b) developing new protocols would involve unnecessary duplication of work.

There are, however, a number of disadvantages. One is aesthetic in that the completed protocols will look rather messy as a number of different styles and layouts will occur in one document. Another is that there will be some repetition of data at different locations in the protocol.

1 Name of River:

2 Location of field site (OS Grid Reference):

3 Description of catchment*:*
Catchment area to location (km^2):
Description of geology:
Maximum height of catchment (mOD)
Altitude of site (mOD)
River order:

4 Description of river at site

a) Hydrology
Q 5%ile (m^3/s):
Q 50%ile (m^3/s):
MAF (m^3/s):
Q5 (m^3/s):
Q10 (m^3/s):
Q20 (m^3/s):
Q50 (m^3/s):
Q100 (m^3/s):

b) Channel dimensions and slope
Channel width (m):
Width of right floodplain (m):
Width of left floodplain (m):
Maximum channel depth (m):
Average channel depth (m):
Bankfull area (m^2):
Hydraulic radius (m):

Channel slope:

5 Stream Reconnaissance Survey

STREAM RECONNAISSANCE RECORD SHEET

Developed by Colin R. Thorne
Depatment of Geography, University of Nottingham, NG7 2RD, UK

SECTION 1 - SCOPE AND PURPOSE

Brief Problem Statement:-

Purpose of Stream Reconnaissance:-

Logistics of Reconnaissance Trip:-

RIVER LOCATION DATE

PROJECT STUDY REACH From To

SHEET COMPLETED BY

RIVER STAGE TIME: START TIME: FINISH

General Notes and Comments on Reconnaissance Trip:-

SECTION 2 - REGION AND VALLEY DESCRIPTION

PART 1: AREA AROUND RIVER VALLEY

Mountains	Dendritic	**Surface Geology**	**Rock Type**	**Land Use**	**Vegetation**
Uplands	Parallel	Weathered Soils	Metamorphic	Managed	Temperate forest
Hills	Trellis	Glacial Moraine	Igneous	Cultivated	Boreal forest
Plains	Rectangular	Glacio/Fluvial	None	Urban	Woodland
Lowlands	Radial	Fluvial		Suburban	Savanna
	Annular	Lake Deposits			Temperate grassland
	Multi-Basin	Wind blown (loess)	**Specific Rock Types (if known)**		Desert scrub
	Contorted				Extreme Desert
					Tundra or Alpine
					Agricultural land

Notes and Comments:-

PART 2: RIVER VALLEY AND VALLEY SIDES

Location of River	**Height**	**Side Slope Angle**	**Valley Side Failures**	***Interpretative Observations*** *Material Type*	***Severity of Problems***
In Valley	< 5 m	< 5degrees	None	*Bedrock*	*Insignificant*
On Alluvial Fan	5 - 10 m	5-10 degrees	Occasional	*Soils*	*Mild*
On Alluvial Plain	10 - 30 m	10-20 degrees	Frequent	*Loose debris*	*Significant*
In a Delta	30 - 60 m	20-50 degrees	**Failure Locations**	***Failure Type***	*Serious*
In Old Lake Bed	60 - 100 m	>50 degrees	None	*(see Sketches in Manual)*	*Catastrophic*
Valley Shape	> 100 m		Away from river		
Symmetrical			Along river (Undercut)		
Asymmetrical					

Level of Confidence in answers (Circle one)
0 10 20 30 40 50 60 70 80 90 100 %

Notes and Comments:-

PART 3: FLOOD PLAIN (VALLEY FLOOR)

Valley Floor Type	**Valley Floor Data**	**Surface Geology**	**Land Use**	**Vegetation**	**Riparian Buffer Strip**
None	None	Bed rock	Natural	None	None
Indefinite	< 1 river width	Glacial Moraine	Managed	Unimproved Grass	Indefinite
Fragmentary	1 - 5 river widths	Glacio/Fluvial	Cultivated	Improved Pasture	Fragmentary
Continuous	5-10 river widths	Fluvial: Alluvium	Urban	Orchards	Continuous
	>10 river widths	Fluvial: Backswamp	Suburban	Arable Crops	**Strip Width**
	Flow Resistance*	Lake Deposits	Industrial	Shrubs	None
		Wind Blown (Loess)		Deciduous Forest	< 1 river width
				Coniferous Forest	1 - 5 river widths
				Mixed Forest	> 5 river widths

Left Overbank Manning n value ___
Right Overbank Manning n value ___ (* note: n value for channel is recorded in Part 6)

Notes and Comments:-

PART 4: VERTICAL RELATION OF CHANNEL TO VALLEY

Terraces	**Overbank Deposits**	**Levees**	**Levee Data**	***Interpretative Observations*** *Present Status*	***Problem Severity***
None	None	None	Height (m)	*Adjusted*	*Insignificant*
Indefinate	Silt	Natural	Side Slope (o)	*Incised*	*Moderate*
Fragmentary	Fine sand	Constructed		*Aggraded*	*Serious*
Continuous	Medium sand	**Levee Description**	**Levee Condition**		***Problem Extent***
Number of Terraces ___	Coarse sand	None	None	***Instability Status***	*None*
Trash Lines	Gravel	Indefinite	Intact	*Stable*	*Local*
Absent	Boulders	Fragmentary	Local Failures	*Degrading*	*General*
Present		Continuous	Frequent failures	*Aggrading*	*Reach scale*
Height above flood plain (m) ___		Left Bank			*System wide*
		Right Bank			*Regional*
		Both Banks			

Level of Confidence in answers (Circle one)
0 10 20 30 40 50 60 70 80 90 100 %

Notes and Comments:-

PART 5: LATERAL RELATION OF CHANNEL TO VALLEY

Planform	**Planform Data**	**Lateral Activity**	**Floodplain Features**	***Interpretative Observations*** *Present Status*	***Problem Severity***
Straight	Bend Radius ___	None	None	*Adjusted*	*Insignificant*
Sinuous	Meander belt width ___	Meander progression	Meander scars	*Over wide*	*Moderate*
Irregular	Wavelength ___	Increasing amplitude	Scroll bars+sloughs	*Too narrow*	*Serious*
Regular meanders	Meander Sinuosity ___	Progression+cut-offs	Oxbow lakes		***Problem Extent***
Irregular meanders		Irregular erosion	Irregular terrain	***Instability Status***	*None*
Tortuous meanders	**Location in Valley**	Avulsion	Abandoned channel	*Stable*	*Local*
Braided	Left	Braiding	Braided Deposits	*Widening*	*General*
Anastomosed	Middle			*Narrowing*	*Reach scale*
	Right				*System wide*
					Regional

Level of Confidence in percent (Circle one)
0 10 20 30 40 50 60 70 80 90 100 %

Notes and Comments:-

SECTION 3 - CHANNEL DESCRIPTION

PART 6: CHANNEL DESCRIPTION

Dimensions	**Flow Type**	**Bed Controls**	**Control Types**	**Width Controls**	**Control Types**
Av. top bank width (m) ___	None ☐	None ☐	None ☐	None ☐	None ☐
Av. channel depth (m) ___	Uniform/Tranquil ☐	Occasional ☐	Solid Bedrock ☐	Occasional ☐	Bedrock ☐
Av. water width (m) ___	Uniform/Rapid ☐	Frequent ☐	Weathered Bedrock ☐	Frequent ☐	Boulders ☐
Av. water depth (m) ___	Pool+Riffle ☐	Confined ☐	Boulders ☐	Confined ☐	Gravel armor ☐
Reach slope ___	Steep + Tumbling ☐	Number of controls ___	Gravel armor ☐	Number of controls ___	Revetments ☐
Mean velocity (m/s) ___	Steep + Step/pool ☐		Cohesive Materials ☐		Cohesive Materials ☐
Manning's n value ___	(Note: Flow type on day of observation)		Bridge protection ☐		Bridge abutments ☐
			Grade control structures ☐		Dykes or groynes ☐

Notes and Comments:-

PART 7: BED SEDIMENT DESCRIPTION

Bed Material	**Bed Armour**	**Surface Size Data**	**Bed Forms (Sand)**	**Bar Types**	**Bar Surface data**
Clay ☐	None ☐	D50 (mm) ___	Flat bed (None) ☐	None ☐	D50 (mm) ___
Silt ☐	Static-armour ☐	D84 (mm) ___	Ripples ☐	Pools and riffles ☐	D84 (mm) ___
Sand ☐	Mobile-armour ☐	D16 (mm) ___	Dunes ☐	Alternate bars ☐	D16 (mm) ___
Sand and gravel ☐			Bed form height (m) ___	Point bars ☐	
gravel and cobbles ☐	**Sediment Depth**	**Substrate Size Data**	**Island or Bars**	Mid-channel bars ☐	**Bar Substrate data**
cobbles + boulders ☐	Depth of loose	D50 (mm) ___	None ☐	Diagonal bars ☐	D50 (mm) ___
boulders + bedrock ☐	Sediment (cm) ___	D84 (mm) ___	Occasional ☐	Junction bars ☐	D84 (mm) ___
Bed rock ☐		D16 (mm) ___	Frequent ☐	Sand waves + dunes ☐	D16 (mm) ___

Notes and Comments:-

Channel Sketch Map

Map Symbols

Study reach limits	North point	Cut bank	Photo point
Cross-section	flow direction	exposed island/bar	Sediment sampling point
Bank profile	impinging flow	structure	Significant vegetation

Representative Cross-section

SECTION 4 - LEFT BANK SURVEY

PART 8: LEFT BANK CHARACTERISTICS

Type		**Bank Materials**		**Layer Thickness**		**Ave. Bank Height**		**Bank Profile Shape**	**Tension Cracks**	
Noncohesive	☐	Silt/clay	☐	Material 1 (m)	___	Average height (m)	___	(see sketches in manual)	None	☐
Cohesive	☐	Sand/silt/clay	☐	Material 2 (m)	___			☐	Occasional	☐
Composite	☐	Sand/silt	☐	Material 3 (m)	___	**Ave. Bank Slope**			Frequent	☐
Layered	☐	Sand	☐	Material 4 (m)	___	angle (degrees)	___		**Crack Depth**	
Even Layers	☐	Sand/gravel	☐						Proportion of	
Thick+thin layers	☐	Gravel	☐						bank height	___
Number of layers	___	Gravel/cobbles	☐							
		Cobbles	☐							
Protection Status		Cobbles/boulders	☐							
Unprotected	☐	Boulders/bedrock	☐							
Hard points	☐									
Toe protection	☐									
Revetments	☐									
Dyke Fields	☐									

Distribution and Description of Bank Materials in Bank Profile

Material Type 1		**Material Type 2**		**Material Type 3**		**Material Type 4**	
Toe	☐	Toe	☐	Toe	☐	Toe	☐
Mid-Bank	☐	Mid-Bank	☐	Mid-Bank	☐	Mid-Bank	☐
Upper Bank	☐	Upper Bank	☐	Upper Bank	☐	Upper Bank	☐
Whole Bank	☐	Whole Bank	☐	Whole Bank	☐	Whole Bank	☐
D50 (mm)	___	D50 (mm)	___	D50 (mm)	___	D50 (mm)	___
sorting coefficient	___	sorting coefficient	___	sorting coefficient	___	sorting coef.	___

Notes and Comments:-

PART 9: LEFT BANK-FACE VEGETATION

Vegetation		**Tree Types**		**Density + Spacing**		**Location**		**Health**		**Height**	
None/fallow	☐	None	☐	None	☐	Whole bank	☐	Healthy	☐	Short	☐
Artificially cleared	☐	Deciduous	☐	Sparse/clumps	☐	Upper bank	☐	Fair	☐	Medium	☐
Grass and flora	☐	Coniferous	☐	dense/clumps	☐	Mid-bank	☐	Poor	☐	Tall	☐
Reeds and sedges	☐	Mixed	☐	Sparce/continuous	☐	Lower bank	☐	Dead	☐	Height (m)	___
Shrubs	☐	**Tree species**		Dense/continuous	☐						
Saplings	☐	(if known)		**Roots**		**Diversity**		**Age**		**Lateral Extent**	
Trees	☐	☐		Normal	☐	Mono-stand	☐	Imature	☐	Wide belt	☐
Orientation		☐		Exposed	☐	Mixed stand	☐	Mature	☐	Narrow belt	☐
Angle of leaning (o)	___	☐		Adventitious	☐	Climax-vegetation	☐	Old	☐	Single row	☐

Notes and Comments:-

Bank Profile Sketches

Bank Top Edge	Failed debris	Engineered Structure
Bank Toe	Attached bar	Significant vegetation
Water's Edge	Undercutting	Vegetation Limit

PART 10: LEFT BANK EROSION

Erosion Location
- General
- Outside Meander
- Inside Meander
- Opposite a bar
- Behind a bar
- Opposite a structure
- Adjacent to structure
- Dstream of structure
- Ustream of structure
- Other (write in)

Present Status
- Intact
- Eroding:dormant
- Eroding:active
- Advancing:dormant
- Advancing:active

Rate of Retreat
m/yr (if applicable and known)

Rate of Advance
m/yr (if applicable and known)

Interpretative Observations

Severity of Erosion
- *Insignificant*
- *Mild*
- *Significant*
- *Serious*
- *Catastrophic*

Extent of Erosion
- *None*
- *Local*
- *General*
- *Reach Scale*
- *System Wide*

Processes
- *Parallel flow*
- *Impinging flow*
- *Piping*
- *Freeze/thaw*
- *Sheet erosion*
- *Rilling + gullying*
- *Wind waves*
- *Vessel Forces*
- *Ice rafting*
- *Other (write in)*

Distribution of Each Process on Bank

Process 1	***Process 2***
Toe (undercut)	*Toe (undercut)*
Lower bank	*Lower bank*
Upper bank	*Upper bank*
Whole bank	*Whole bank*
Process 3	***Process 4***
Toe (undercut)	*Toe (undercut)*
Lower bank	*Lower bank*
Upper bank	*Upper bank*
Whole bank	*Whole bank*

Level of Confidence in answers (Circle one)
0 10 20 30 40 50 60 70 80 90 100 %

Notes and Comments:-

PART 11: LEFT BANK GEOTECH FAILURES

Failure Location
- General
- Outside Meander
- Inside Meander
- Opposite a bar
- Behind a bar
- Opposite a structure
- Adjacent to structure
- Dstream of structure
- Ustream of structure
- Other (write in)

Present Status
- Stable
- Unreliable
- Unstable:dormant
- Unstable:active

Failure Scars+Blocks
- None
- Old
- Recent
- Fresh
- Contemporary

Interpretative Observations

Instability:Severity
- *Insignificant*
- *Mild*
- *Significant*
- *Serious*
- *Catastrophic*

Instability: Extent
- *None*
- *Local*
- *General*
- *Reach Scale*
- *System Wide*

Failure Mode
- *Soil/rock fall*
- *Shallow slide*
- *Rotational slip*
- *Slab-type block*
- *Cantilever failure*
- *Pop-out failure*
- *Piping failure*
- *Dry granular flow*
- *Wet earth flow*
- *Other (write in)*

Distribution of Each Mode on Bank

Mode 1	***Mode 2***
Toe	*Toe*
Lower bank	*Lower bank*
Upper bank	*Upper bank*
Whole bank	*Whole bank*
Mode 3	***Mode 4***
Toe	*Toe*
Lower bank	*Lower bank*
Upper bank	*Upper bank*
Whole bank	*Whole bank*

Level of Confidence in answers (Circle one)
0 10 20 30 40 50 60 70 80 90 100 %

Notes and Copmments:-

PART 12: LEFT BANK TOE SEDIMENT ACCUMULATION

Stored Bank Debris
- None
- Individual grains
- Aggregates+crumbs
- Root-bound clumps
- Small soil blocks
- Medium soil blocks
- Large soil blocks
- Cobbles/boulders
- Boulders

Vegetation
- None/fallow
- Artificially cleared
- Grass and flora
- Reeds and sedges
- Shrubs
- Saplings
- Trees

Age
- Immature
- Mature
- Old
- Age in Years

Tree species
(if known)

Health
- Healthy
- Unhealthy
- Dead

Roots
- Normal
- Adventitious
- Exposed

Interpretative Observations

Toe Bank Profile
- *Planar*
- *Concave upward*
- *Convex upward*

Sediment Balance
- *Accumulating*
- *Steady State*
- *Undercutting*
- *Unknown*

Present Debris Storage
- *No bank debris*
- *Little bank debris*
- *Some bank debris*
- *Lots of bank debris*

Level of Confidence in answers (Circle one)
0 10 20 30 40 50 60 70 80 90 100 %

Notes and Comments:-

SECTION 5 - RIGHT BANK SURVEY

PART 13: RIGHT BANK CHARACTERISTICS

Type	**Bank Materials**	**Layer Thickness**	**Ave. Bank Height**	**Bank Profile Shape**	**Tension Cracks**
Noncohesive ☐	Silt/clay ☐	Material 1 (m) ___	Average height (m) ___	(see sketches in manual)	None ☐
Cohesive ☐	Sand/silt/clay ☐	Material 2 (m) ___		☐	Occasional ☐
Composite ☐	Sand/silt ☐	Material 3 (m) ___	**Ave. Bank Slope**		Frequent ☐
Layered ☐	Sand ☐	Material 4 (m) ___	Average angle (o) ___		**Crack Depth**
Even Layers ☐	Sand/gravel ☐				Proportion of
Thick+thin layers ☐	Gravel ☐				bank height ___
Number of layers ___	Gravel/cobbles ☐				
	Cobbles ☐				
Protection Status	Cobbles/boulders ☐				
Unprotected ☐	Boulders/bedrock ☐				
Hard points ☐					
Toe protection ☐					
Revetments ☐					
Dyke Fields ☐					

Distribution and Description of Bank Materials in Bank Profile

Material Type 1	**Material Type 2**	**Material Type 3**	**Material Type 4**
Toe ☐	Toe ☐	Toe ☐	Toe ☐
Mid-Bank ☐	Mid-Bank ☐	Mid-Bank ☐	Mid-Bank ☐
Upper Bank ☐	Upper Bank ☐	Upper Bank ☐	Upper Bank ☐
Whole Bank ☐	Whole Bank ☐	Whole Bank ☐	Whole Bank ☐
D50 (mm) ___	D50 (mm) ___	D50 (mm) ___	D50 (mm) ___
sorting coefficient ___	sorting coefficient ___	sorting coefficient ___	sorting coef. ___

Notes and Comments:-

PART 14: RIGHT BANK-FACE VEGETATION

Vegetation	**Tree Types**	**Density + Spacing**	**Location**	**Health**	**Height**
None/fallow ☐	None ☐	None ☐	Whole bank ☐	Healthy ☐	Short ☐
Artificially cleared ☐	Deciduous ☐	Sparse/clumps ☐	Upper bank ☐	Fair ☐	Medium ☐
Grass and flora ☐	Coniferous ☐	dense/clumps ☐	Mid-bank ☐	Poor ☐	Tall ☐
Reeds and sedges ☐	Mixed ☐	Sparce/continuous ☐	Lower bank ☐	Dead ☐	Height (m) ___
Shrubs ☐	**Tree species**	Dense/continuous ☐			
Saplings ☐	(if known)	**Roots**	**Diversity**	**Age**	**Lateral Extent**
Trees ☐	☐	Normal ☐	Mono-stand ☐	Imature ☐	Wide belt ☐
Orientation	☐	Exposed ☐	Mixed stand ☐	Mature ☐	Narrow belt ☐
Angle of leaning (o) ___	☐	Adventitious ☐	Climax-vegetation ☐	Old ☐	Single row ☐

Notes and Comments:-

Bank Profile Sketches

Profile Symbols

Bank Top Edge	Failed debris	Engineered Structure
Bank Toe	Attached bar	Significant vegetation
Water's Edge	Undercutting	Vegetation Limit

PART 15: RIGHT BANK EROSION

Erosion Location	Present Status	Severity of Erosion	Processes	Process 1	Process 2
General	Intact	*Insignificant*	*Parallel flow*	*Toe (undercut)*	*Toe (undercut)*
Outside Meander	Eroding:dormant	*Mild*	*Impinging flow*	*Lower bank*	*Lower bank*
Inside Meander	Eroding:active	*Significant*	*Piping*	*Upper bank*	*Upper bank*
Opposite a bar	Advancing:dormant	*Serious*	*Freeze/thaw*	*Whole bank*	*Whole bank*
Behind a bar	Advancing:active	*Catastrophic*	*Sheet erosion*		
Opposite a structure			*Rilling + gullying*	***Process 3***	***Process 4***
Adjacent to structure	**Rate of Retreat**	***Extent of Erosion***	*Wind waves*	*Toe (undercut)*	*Toe (undercut)*
Dstream of structure	m/yr (if applicable	*None*	*Vessel Forces*	*Lower bank*	*Lower bank*
Ustream of structure	and known)	*Local*	*Ice rafting*	*Upper bank*	*Upper bank*
Other (write in)	**Rate of Advance**	*General*	*Other (write in)*	*Whole bank*	*Whole bank*
	m/yr (if applicable	*Reach Scale*			
	and known)	*System Wide*			

Interpretative Observations — *Distribution of Each Process on Bank*

Level of Confidence in answers (Circle one)
0 10 20 30 40 50 60 70 80 90 100 %

Notes and Comments:-

PART 16: RIGHT BANK GEOTECH FAILURES

Failure Location	Present Status	Instability:Severity	Failure Mode	Mode 1	Mode 2
General	Stable	*Insignificant*	*Soil/rock fall*	*Toe*	*Toe*
Outside Meander	Unreliable	*Mild*	*Shallow slide*	*Lower bank*	*Lower bank*
Inside Meander	Unstable:dormant	*Significant*	*Rotational slip*	*Upper bank*	*Upper bank*
Opposite a bar	Unstable:active	*Serious*	*Slab-type block*	*Whole bank*	*Whole bank*
Behind a bar		*Catastrophic*	*Cantilever failure*	***Mode 3***	***Mode 4***
Opposite a structure	**Failure Scars+Blocks**		*Pop-out failure*	*Toe*	*Toe*
Adjacent to structure	None	***Instability: Extent***	*Piping failure*	*Lower bank*	*Lower bank*
Dstream of structure	Old	*None*	*Dry granular flow*	*Upper bank*	*Upper bank*
Ustream of structure	Recent	*Local*	*Wet earth flow*	*Whole bank*	*Whole bank*
Other (write in)	Fresh	*General*	*Other (write in)*		
	Contemporary	*Reach Scale*			
		System Wide			

Interpretative Observations — *Distribution of Each Mode on Bank*

Level of Confidence in answers (Circle one)
0 10 20 30 40 50 60 70 80 90 100 %

Notes and Copmments:-

PART 17: RIGHT BANK TOE SEDIMENT ACCUMULATION

Stored Bank Debris	Vegetation	Age	Health	Toe Bank Profile	Sediment Balance
None	None/fallow	Immature	Healthy	*Planar*	*Accumulating*
Individual grains	Artificially cleared	Mature	Unhealthy	*Concave upward*	*Steady State*
Aggregates+crumbs	Grass and flora	Old	Dead	*Convex upward*	*Undercutting*
Root-bound clumps	Reeds and sedges	Age in Years		***Present Debris Storage***	*Unknown*
Small soil blocks	Shrubs		**Roots**	*No bank debris*	
Medium soil blocks	Saplings	**Tree species**	Normal	*Little bank debris*	
Large soil blocks	Trees	(if known)	Adventitious	*Some bank debris*	
Cobbles/boulders			Exposed	*Lots of bank debris*	
Boulders					

Interpretative Observations

Level of Confidence in answers (Circle one)
0 10 20 30 40 50 60 70 80 90 100 %

Notes and Comments:-

6 Catchment Baseline Survey

(*insert catchment baseline survey here*)

7 Detailed Geomorphic Survey

(*insert Detailed Geomorphic Survey here*)

8 Description of bed sediments

a) Surface sediment grading

D_5 (mm):
D_{16} (mm)
D_{35} (mm):
D_{50} (mm):

D_{84} (mm):
D_{90} (mm)

D_{84}/D_{16} (mm):

b) Sub-surface sediment grading
D_5 (mm):
D_{16} (mm)
D_{35} (mm):
D_{50} (mm):
D_{84} (mm):
D_{90} (mm)

D_{84}/D_{16} (mm):

9 Cross-sections

For each cross-section
Name
Location
XY coordinates

10 Derived velocity and depth information

This information should be aggregated over all the available cross-sections

a) 5%ile flow
Depths:
Depth exceeded at 5% of points
Depth exceeded at10% of points
Depth exceeded at 35% of points
Depth exceeded at 50% of points
Depth exceeded at 75% of points
Velocities
Velocity exceeded at 5% of points
Velocity exceeded at 10% of points
Velocity exceeded at 35% of points
Velocity exceeded at 50% of points
Velocity exceeded at 75% of points

b) 50%ile flow
Depths:
Depth exceeded at 5% of points
Depth exceeded at10% of points
Depth exceeded at 35% of points
Depth exceeded at 50% of points
Depth exceeded at 75% of points

Velocities
Velocity exceeded at 5% of points
Velocity exceeded at 10% of points
Velocity exceeded at 35% of points

Velocity exceeded at 50% of points
Velocity exceeded at 75% of points

c) MAF
Depths:
Depth exceeded at 5% of points
Depth exceeded at10% of points
Depth exceeded at 35% of points
Depth exceeded at 50% of points
Depth exceeded at 75% of points

Velocities
Velocity exceeded at 5% of points
Velocity exceeded at 10% of points
Velocity exceeded at 35% of points
Velocity exceeded at 50% of points
Velocity exceeded at 75% of points

11 Habitat data

11.1 River Habitat Survey
(*insert River Habitat Survey here*)

11.2 Biotic data
(*insert Biotic data here*)

12 Description of works/maintenance

12.1 Types of works/maintenance activity carried out

Type 1:
Method of carrying out work
Frequency
Timing
Extent: Length of reach over which work is carried out
Percentage of channel bed that is affected
Reason for work

Type 2:
Method of carrying out work
Frequency
Timing
Extent: Length of reach over which work is carried out
Percentage of channel bed that is affected
Reason for work

Type 3:
Method of carrying out work
Frequency
Timing
Extent: Length of reach over which work is carried out
Percentage of channel bed that is affected
Reason for work

12.2 Description of capital works

Description of work carried out
Channel dimensions and slope before and after the works
(include drawings and photographs if available)

12.3 Description of other operational works that might influence the reach

for example: flushing, local water level management, bushing, emergency works

13 Comparison of maintained reach with control reach

Channel dimensions

	Maintained reach	Control reach
Channel width (m):		
Width of right floodplain (m):		
Width of left floodplain (m):		
Maximum channel depth (m):		
Average channel depth (m):		
Bankfull area (m^2):		
Hydraulic radius (m):		
Channel slope:		

Sediments

	Maintained reach	Control reach
D_5		
D_{35}		
D_{50}		
D_{90}		
D_{84}/D_{16}		

Flow parameters

50%ile flow

Depths:	Maintained reach	Control reach
Depth exceeded at 5% of points		
Depth exceeded at10% of points		
Depth exceeded at 35% of points		
Depth exceeded at 50% of points		
Depth exceeded at 75% of points		

Velocities

Velocity exceeded at 5% of points
Velocity exceeded at 10% of points
Velocity exceeded at 35% of points
Velocity exceeded at 50% of points
Velocity exceeded at 75% of points

Habitats

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