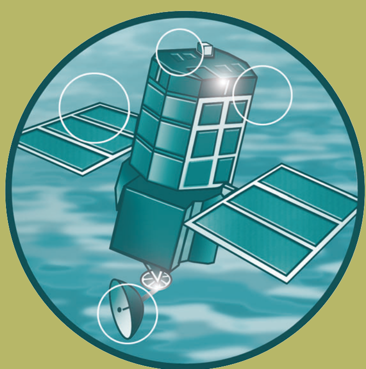
Joint Defra/EA Flood and Coastal Erosion Risk Management R&D Programme

Broad scale ecosystem assessment (BSEA)

BSEA Toolbox 1

R&D Technical Report FD2112/TR



Environment Agency

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Department for Environment Food and Rural Affairs

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Statement of use
This report is aimed at those involved in ecosystem assessment. It provides the current state of knowledge and science with respect to broad scale (i.e. river catchment or coastal cell) understanding of ecosystems impacted by flood management activities. It will be of benefit to those practitioners in the EA, local authorities and their consultants seeking to include ecological risk into flood risk management policy studies.

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Executive summary

Background

The scoping study on broad scale ecosystem impact modelling (BSEIM) identified a general lack of guidance on how to undertake broad scale ecosystem assessment, and a specific gap in guidance for ecosystem analysis of flood and coastal management plans (CFMPs and SMPs).

This Technical Report FD2112 has therefore been commissioned by the Department for the Environment, Food and Rural Affairs (Defra) and the Environment Agency to provide consolidated ecosystem assessment guidance for practitioners in flood management policy analysis. The work is a component part of a wider research initiative into broad scale modelling of flood and coastal defence activities. Outputs are in a format that allows integration within CFMP and SMP.

Objectives

The overall project objective of FD2112 is to establish and demonstrate, through use of case studies, good practice procedures for data collation/ interrogation and the assessment of ecosystem effects and risks resulting from river and coastal cell management policies/ options. The guidance has been developed in response to practitioners in England and Wales requiring a method for integrating ecology as part of broad-scale flood risk management.

Guidance

Broad Scale Ecosystem Assessment (BSEA) provides the framework for the assessment of the ecosystem effects and risks resulting from river catchment or coastal cell management policies/ options. BSEA is GIS-based and uses readily available, nationally consistent broad scale data.

The approach establishes ecosystem status, ecosystem drivers and the broad habitats supported, using information on hydrology, geomorphology and ecology. The primary objective is to maintain and improve broad scale ecosystem function.

The BSEA steps involve the following:

1. Establish catchment understanding (broad habitats & ecosystem drivers),
2. Define Broad scale Ecosystem Criteria (BEC),
3. Map & tabulate the BEC,
4. Expert consultation on catchment characteristics and suitability of BEC, and
5. Use of BEC in policy development and/ or policy appraisal.

Catchment or coastal cell understanding is developed using a set of seventeen tools/ methods that allow the presentation, interrogation and interpretation of information for:

- Freshwater catchments - channel condition, floodplain connectivity and channel continuity, and
- Coastal cells - shoreline migration, tidal inundation and coastal flooding, and mobile sediment availability.

Having established the condition and functioning of the catchment or coastal cell, BEC are defined that describe catchment opportunities and constraints. For example, this may include areas that require protection (e.g. ecologically sensitive, functionally important) combined with areas that could be improved (e.g. previously degraded river, historic flood banks limiting floodplain connectivity). These are not limited to the aquatic system, but may also include wider functional or non-functional wetlands. BEC are mapped to give spatial context to the opportunities and constraints.

BEC provide the yardstick against which policies or options can be assessed to give a relative assessment of positive, neutral or negative ecosystem impact. BEC integrate existing catchment objectives and can include emerging Water Framework Directive requirements. The initial BEC are used for expert stakeholder consultation. Once finalised the BEC form the framework for biodiversity inputs to policy/ option development and assessment.

The BSEA guidance and methods have been applied to three Case Study areas:

- River Ribble in north-west England: identifying ecosystem objectives which may affect or be affected by flood risk management (linked to management action, biodiversity benefit, flood management consequence, and possible cost). To provide input to CFMP policy development.
- River Derwent in Yorkshire: a relative assessment of the ecosystem consequences of alternative catchment-wide flood risk management policy. To provide input to the Strategic Environmental Assessment (SEA) of a CFMP.
- South Foreland to Beachy Head coastal cell in south-east England: identifying the ecological pressures and opportunities appropriate to flood risk management. To provide input to SMP policy development, as well as the SEA of a SMP.

Conclusions

The guidance is the first phase in the development of the broad scale ecosystem assessment toolbox. The guidance has been consolidated to use existing and available broad scale data, linked to established methods, which facilitate pragmatic analysis to support policy derivation and appraisal. As such the guidance represents a significant step forward for the consistent use of ecosystem assessment at a catchment or coastal cell scale.

However, there are currently a number of limitations to implementation of the guidance. Data availability and suitability at the broad scale are limited, as is the predictive capability of models for ecosystem impact assessment of flood management activities. Accepting these limitations, the guidance has been designed as a framework that should be updated as new information and methods become available.

Recommendations

The guidance can be used as the basis for all broad scale catchment and coastal cell ecosystem assessments, including CFMP and SMP. Further work is required to strengthen broad scale ecosystem monitoring, including data acquisition and interpretation methods, combined with development of better ecosystem impact models (that can integrate hydrology, geomorphology and ecological functioning). These are described in detail in the companion scoping document (FD 2108). There are also opportunities to integrate BSEA into the developing modelling and decision support framework (MDSF) that should be explored.

The BSEA studies should be implemented at project inception to ensure that the opportunities and constraints identified can be fully explored and incorporated. Further piloting of the guidance is recommended on a wider selection of catchments and coastal cells, to test against a wider spectrum of potential policy applications.

The guidance has also been developed so that it can be incorporated into Strategic Environmental Assessment and can be used as the basis of Water Framework Directive studies (spatial extent of pressures and impacts, programmes of measures, etc).

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Acronyms and abbreviations

BAP	Biodiversity Action Plan
BEC	Broad scale Ecosystem Criteria
BGS	British Geological Society
BSEA	Broad Scale Ecosystem Assessment
BSEIM	Broad Scale Ecosystem Impact Modelling
BSM	Broad Scale Modelling
CCW	Countryside Council for Wales
CEH	Centre for Ecology and Hydrology
CEN	European Committee for Standardisation
CFMP	Catchment Flood Management Plan
ChaMP	Coastal Habitat Management Plan
CroW	Countryside and Rights of Way Act, 2000
Defra	Department for the Environment, Food and Rural Affairs
EA	Environment Agency
EC	European Commission
EHS	Environment Heritage Service (Department of the Environment, Northern Ireland)
ELS	Entry Level Scheme (Environmental Stewardship)
EN	English Nature
EUNIS	European Nature Information Service
FCDPAG	Flood and Coastal Defence Project Appraisal Guidance
GIS	Geographic Information System
GQA	General Quality Assessment
HAP	Habitat Action Plan
HFA	Hill Farm Allowance
HLS	Higher Level Stewardship
HMI	Habitat Modification Index (River Habitat Survey)
HMS	Habitat Modification Score (River Habitat Survey)
HQA	Habitat Quality Assessment (River Habitat Survey)
IBO	Identifying Biodiversity Opportunities
ICFP	Indicative Coastal Floodplain Maps
ICH	Integrated Coastal Hydrography
ICZM	Integrated Coastal Zone Mapping
JNCC	Joint Nature Conservancy Committee
LCM2000	Land Cover Map, 2000
LFA	Less Favoured Area
MAFF	Ministry of Agricultural, Fisheries and Food
MarLIN	Marine Life Information Network for Britain and Ireland
MCA	Multi Criteria Analysis
MERMAID	Marine Environmental Resource Mapping and Information Database
MESH	Mapping European Seabed Habitats
MHWS	Mean High Water Spring Tide
MNCR	Marine Nature Conservation Review
NBN	National Biodiversity Network
NFCDD	National Flood and Coastal Defence Database
NMHC	National Marine Habitat Classification
NNR	National Nature Reserve

NVC	National Vegetation Classification
ODPM	Office of the Deputy Prime Minister
OS	Ordnance Survey
PAH	Poly-aromatic Hydrocarbon
PCB	Poly-chlorinated Biphenyl
PPS25	Planning Policy Statement 25 (Development and Flood Risk)
PSA	Public service agreement (target)
Q_{100}	Estimated '100-year' return period flood
Q_{MED}	Estimated '2-year' return period flood
RAMSAR site	site protected by the International Convention on Wetlands
RASP	Risk Assessment of Flood and Coastal Defence for Strategic Planning
RASP-HLM	RASP High Level Model
RBMP	River Basin Management Plan
RHO	River Habitat Objective
RHS	River Habitat Survey
RSLR	Relative Sea Level Rise
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SEA	Strategic Environmental Assessment
SEPA	Scottish Environment Protection Agency
SMP	Shoreline Management Plan
SNH	Scottish Natural Heritage
SNIFFER	Scotland and Northern Ireland Forum for Environmental Research
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
UKCIP	UK Climate Impacts Programme
UKHO	UK Hydrographic Office
WeBS	Wetland Bird Survey
WFD	Water Framework Directive
WLMP	Water Level Management Plan

1 Introduction

1.1 Objectives

Technical Report FD 2112 has been commissioned by the Department for the Environment, Food and Rural Affairs (Defra) and the Environment Agency (EA) to provide consolidated ecological assessment guidance for practitioners in flood management policy analysis. The overall project objective of FD2112 is to establish and demonstrate, through use of case studies, good practice procedures for data collation/ interrogation and the assessment of ecosystem effects and risks resulting from river and coastal cell management policies/ options. The methods adopt a “systems and evidence-based” approach for ecosystem assessment associated with both freshwater and coastal flood management plans.

The report summarises the guidance prepared by a consortium led by Cascade Consulting in association with HR Wallingford, the Institute of Estuarine and Coastal Studies at the University of Hull, Dr Helen Dangerfield of Haskoning UK, Dr Nigel Holmes of Alconbury Environmental Consultants and Professor Keith Richards of University of Cambridge Department of Geography.

This Technical Report has two functions: 1) a record of the project, and 2) guidance on BSEA methodology. For readers seeking to use the report as guidance only, it is recommended that the following sections are considered:

- Fluvial catchments in Sections 5 - 7,
- Coastal cells in Sections 10 and 11.

1.2 Linkages with Flood and Coastal Defence Research and Development Programme

The study follows a Scoping Study outlining future research and development to support Broad Scale Ecosystem Impact Modelling (BSEIM) (Cascade Consulting, 2002). The work is a component part of a wider flood and coastal defence research initiative resulting from the review of government-funded research and development reported by Professor Penning-Rowsell (1999). Six themes have been identified and adopted to form a joint Defra and EA research and development programme, as shown in Figure 1.1.

The Thematic structure seeks to cover all of the aquatic media that are of concern for flood management, ranging from fluvial systems to estuaries and coastal waters. During 2005 the programme underwent an external review resulting in the reduction of the number of research themes to four, and a new management structure. The four current themes are:

Theme 1: Strategy and Policy Development
Theme 2: Modelling and Risk
Theme 3: Sustainable Asset Management

Theme 4: Incident Management and Community.

This research was commissioned within the former framework. The Broad scale Modelling (BSM) theme was concerned with predicting large-scale, medium to long-term natural evolution and the influence that climate change and anthropogenic intervention may have. This will aid with the determination of regional and national economic impacts through to the optimum allocation of resources. A key element of broad scale modelling is to achieve an appropriate level of detail and associated data. Outcomes from the Theme will deliver tools to better assess the individual and cumulative impacts of alternative planning scenarios, floodplain policies and future catchment and coastal zone management practices that may result from future flood management initiatives. BSEIM, and through it this Broad Scale Ecosystem Assessment (BSEA) Toolbox 1, is an integral part of the BSM process, which will require the evaluation of the environmental and ecological implications of the variety of future flood management policies and practices. BSEA is a component part of BSEIM, as it is the first iteration of guidance on ecosystem assessment, but it does not include significant ecosystem modelling. It is likely that, subject to future successful research and development in this area, later iterations of the toolbox will include greater use of emerging ecosystem modelling technologies (as described for example in the BSEIM scoping report).

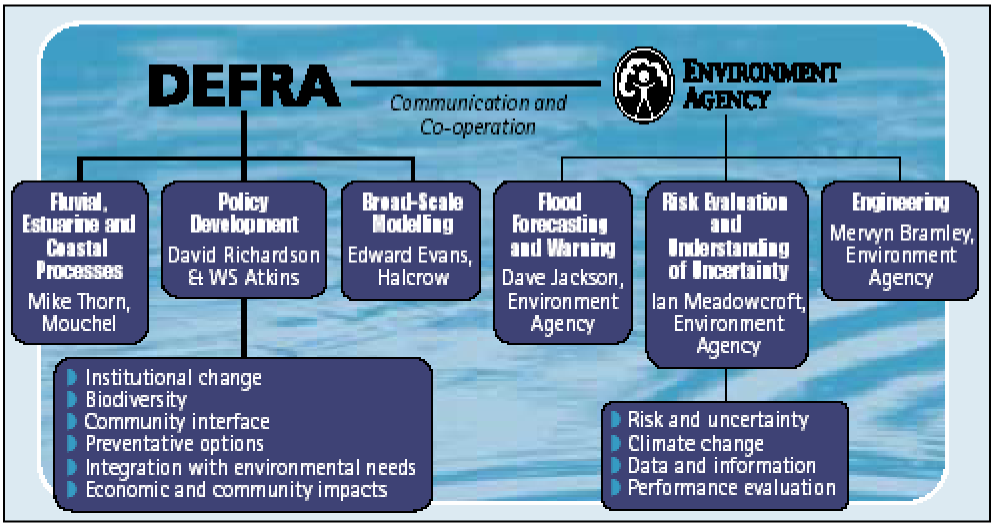


Figure 1.1 Thematic structure (1999) of the Defra and EA flood and coastal defence research and development programme

The former six main Themes were necessarily interlinked. BSEIM has strong ties with the Fluvial, Estuarine and Coastal Processes Theme, which seeks to describe and quantify all of the important processes that contribute to the evolution of river, estuarine and coastal systems. Similarly, the Engineering Theme has elements of river and catchment-related performance that incorporate for example projects to understand the flow over flood plains (includes the influence of vegetation) and the use of soft engineering solutions. Lastly, the Policy Theme has an overarching purpose to facilitate the adoption and implementation of policy measures which improve understanding, reduce risk and costs, and most importantly, improve decision making and result in better value for money. Each of the Themes therefore has a clear interaction with the inputs to and outputs from the BSEIM scoping study that have been considered throughout.

1.3 Flood management policy drivers

1.3.1 National flood management policies and strategies

A number of international and national policy initiatives have either direct implications for flood management or have an indirect effect that may influence flood management practices. Overall management actions in the freshwater and marine environments may be regarded as having to fulfil four ideals. They should be:

- Economically viable,
- Technically sound,
- Environmentally acceptable, and
- Sustainable.

It is important to recognise the complex matrix of policy drivers that may contribute to flood management practices, as these are likely to define the regulatory framework for ecosystem impact assessment and hence the requirement for broad scale ecosystem impact prediction. The following section analyses the range of drivers for flood management policy preparation and their potential implications.

Strategy for Flood and Coastal Defence in England and Wales

The strategy (MAFF, 1993) sets out the Government's policy aims and objectives for flood and coastal defence. It aims to reduce the risks to people and the developed and natural environment from flooding and erosion by encouraging the provision of technically, environmentally and economically sound and sustainable defence measures. Key objectives are:

1. Provision of adequate and cost-effective flood warning systems,
2. Provision of adequate, technically, environmentally and economically sound and sustainable flood and coastal defence measures, and
3. To discourage inappropriate development in areas at risk from flooding or coastal erosion.

The importance of this strategy is that it sets a broad policy context for flood management, to be supported by broad scale coastal and fluvial flood management planning established through Shoreline Management Plans (SMPs), Catchment Flood Management Plans (CFMPs) and Water Level Management Plans (WLMPs). The strategy states that flood management schemes should only be developed that are judged to be environmentally acceptable, with the potential impact on habitats and the environment generally to be a key consideration. Natural river and coastal processes should not be disrupted except where human life or important man-made or natural assets are at risk. This policy should continue and be elaborated upon in the subsequent planning stages. Recognition of the importance of the integrity of habitats and nature conservation more generally at this strategic level should dictate that subsequent plans incorporate a suitable level of impact assessment.

Making Space for Water: Response to consultation

Defra's Flood Management Strategy Unit is in the process of updating the Governments strategic direction on flood management (Defra, 2005a). The new approach is summarised in the report Making space for water – Taking forward a new Government strategy for flood management and coastal erosion risk management in England (March 2005). The new strategy will take a 20 year perspective and include the latest UKCIP 2002 predictions on climate change (Hulme *et al.*, 2002). The key aims are to:

- Reduce the threat to people and their property, and
- Deliver the greatest environmental, social and economic benefit, consistent with the Government's sustainable development principles.

The programme of action, with some of the potential measures identified in brackets, will include:

- A more holistic approach (whole catchment and whole shoreline analysis),
- Better management of risk (flood warning and greater resistance/resilience to flooding),
- Land use planning (emphasising flood risk assessment and new PPS25),
- Rural issues (greater use of wetlands, washlands and managed retreat; integration of rural land management techniques),
- Integrated urban drainage design (development of best practice), and
- Coastal issues (more strategic and integrated decision-making).

High Level Targets for flood and coastal erosion risk management

"High Level Targets" are templates to guide flood and coastal defence management authorities in preparing their plans (Defra, 2005b). Initial development of the Targets in 1999 was found to be necessary to ensure a more certain delivery of the Government's policy aims and objectives. Each operating authority (the EA, Internal Drainage Board and/ or local authority) was tasked with production of policy statements that establish the link between the Government's aims and objectives for flood and coastal defence and demonstrate how these are being implemented in the local area. The initial Targets have recently been revised and superseded, being replaced by new Targets from 1st April 2005. Although not statutory requirements, they are important for the delivery of Government policy. Of particular interest for BSEA are the following:

High Level Target 2 (Information of the National Flood and Coastal Defence Database) should improve the recording of flood and coastal defence structures, which is required as an input for BSEA.

High Level Target 4 (Biodiversity) is of key importance. The Target states that, in accordance with Government policies for the protection of the environment and biodiversity, any flood management works must be environmentally acceptable. However, it goes further, as operating authorities are positively encouraged to seek and consider opportunities for environmental enhancement when selecting flood and coastal defence options at a strategic level and in developing schemes. More specific Targets relate to:

- Ensure no net loss to habitats covered by Biodiversity Acton Plans (BAPs) and seek opportunities for environmental enhancement.
- Review all WLMPs for all priority SSSIs ….to identify flood management measures.
- Assess flood management measures to achieve PSA targets for SSSIs not covered by WLMPs to achieve favourable status.
- Report on flood management measures taken to contribute to PSA targets for SSSIs; and all losses and gains of habitats covered by UK BAP resulting from flood and erosion risk management operations.
- EA reporting to Defra of information from B to D.
- Create at least 200 hectares of new Biodiversity habitat per annum as a result of flood management activities, of which at least 100 ha should be saltmarsh or mudflat.

Of less direct relevance, Target 1 relates to policy delivery statements; Target 3 to production of second generation SMPs; Target 5 to working with planning authorities to ensure that development does not add to unnecessary flood risk; and Target 6 refers to changes to the arrangements for internal drainage boards.

The new High Level Targets are likely to have an influence on future flood and coastal risk management procedures, and should be considered carefully during the BSEA process. At a strategic level, it is likely that the broad Targets will be useful in helping to define the ecosystem constraints and opportunities available during policy appraisal.

Flood and Coastal Defence Project Appraisal Guidance (FCDPAG)

There are six Defra guidance documents (FCDPAG 1-6) that provide best practice advice to practitioners involved in the preparation of flood defence strategies and schemes. Ecosystem and ecological considerations are integral to the development of the strategic plans. For example, in FCPAG2 Strategic Planning and Appraisal Guidance (MAFF, 2001) the strategic approach for coastal and estuarine flooding should "desire" to maintain or enhance the environmental value of the beach and shoreline or "identify" opportunities for long term retention and enhancement of environmental features, respectively. Significantly, there is also guidance on flood alleviation taking into account internationally designated environmental sites, which relates the strategic approach to the Coastal Habitat Management Plan (CHaMP) process.

The key document that incorporates a requirement for consideration of ecosystem implications is FCDPAG5 Environmental appraisal (MAFF, 2000). It provides guidance for operating authorities to ensure proper account is taken of environmental considerations when preparing schemes for flood and coastal defence works. The document places specific emphasis on nature conservation, particularly sites of international importance, and requires detailed consideration of options that deliver environmental benefits or minimise damage.

1.3.2 Flood and coastal defence management plans

CFMP and SMP2 (designated 2 to identify second tranche of SMPs with revised input requirements) are top-level strategic planning documents through which the EA and local authorities will seek to work with other key decision-makers within a river catchment or coastal cell to identify and agree policies to secure the long term sustainable management of flood risk. The current relevant guidance for each is contained in:

- Catchment Flood Management Plans: Volume 1 Policy guidance. July 2004. Published by Environment Agency (2004a).
- Shoreline Management Plan guidance: Volume 1: Aims and requirements. March 2006. Published by Defra (2006).

1.3.3 Strategic Environmental Assessment Directive

The EC Strategic Environmental Assessment (SEA) Directive (2001/42/EC) has recently been established in England and Wales through the introduction of the Environmental Assessment of Plans and Programmes Regulations, 2004. Recent guidance from the Office of the Deputy Prime Minister (ODPM, 2005) has concluded, having taken legal advice, that there is no legal requirement to apply the Directive to CFMP, SMP2 or WLMP.

However, SMPs, CFMPs and Strategies clearly help to set the framework for future planning, have significant environmental implications, and require extensive consultation. Defra's view, therefore, is that adopting an SEA approach is appropriate. Furthermore, whilst these plans are not specifically required by Defra, they do strongly encourage their production to allow a strategic approach. Defra, therefore, strongly encourage the operating authorities to undertake SEA for such plans. Initial guidance on production of an SEA is given in:

- Guidance to Operating Authorities on the Application of Strategic Environmental Assessment to Flood Management Plans and Programmes (Defra, 2004).

1.3.4 Water Framework Directive

Recently introduced regulations in England and Wales provide a statutory framework to establish the requirements of the EC Water Framework Directive (WFD) (2000/60/EC) for the management of river systems through River Basin Management Plans (RBMPs). In particular, there is a requirement for all surface waters to achieve good ecological status or good ecological potential (for heavily modified or artificial water bodies).

Flood management activities will be included in the suite of impacts and consequent measures that will need to be addressed at a catchment scale. At present CFMPs and SMPs are seen as planning tools that will support the development of the RBMPs. The guidance contained in BSEA should therefore be compatible with and facilitate the assessment of ecological status and the potential impacts of future change. The approach advocated and described in the BSEA guidance is therefore designed to match the requirements of the WFD. Future development of the BSEA techniques could be widened to incorporate other (non flood management) activities to support WFD implementation.

2 Method development framework

2.1 Aspirations and philosophy

This first iteration of the BSEA provides a framework for the systematic assessment of the ecosystem effects that could result from a variety of flood and coastal erosion management policies. Outputs of the report are a clear suite of methods (tools) for prediction of broad scale ecosystem effects. These include the reporting format for inclusion into relevant SEA and CFMP/SMP multi-criteria evaluations. The guidance has been produced in response to calls from practitioners in flood and coastal management for clear procedures for undertaking broad scale catchment or coastal cell-scale ecosystem assessments. The assessment is based on environmental risk assessment principles contained in EA guidance (EA, 2003a).

The philosophy is based on a number of elements:

- The assessment of ecosystem effects must be evidence based. Suitable evidence at the broad scale includes spatial datasets (including GIS) and catchment/ coastal cell-specific texts.
- The framework must be modular and updateable as new evidence is identified.
- Environmental risk assessment techniques must be employed.
- Predicted effects must be compared to the specified objectives to identify relative suitability of policy drivers.
- Broad scale Ecosystem Criteria (BEC), based on a sound knowledge of the catchment or coastal cell, must be used to allow assessment of the relative effects of different policies.
- BEC must be clear and based on regulatory and/or broad scale criteria.
- The uncertainties and confidence with which relative effects can be predicted must be defined.

The methodology is designed to be pragmatic and will rely in this first iteration (BSEA Toolbox 1) on existing data and methods. There are few consolidated data (hydrological, geomorphological and/ or ecological) that can reliably be used across all catchment types in England and Wales. Equally, there is no method or suite of methods that can currently predict ecosystem risk for all of the ecosystem types that will be encountered. BSEA Toolbox 1 therefore uses existing datasets and methodologies, recognising and reporting potential limitations, with an emphasis on qualitative analysis (incorporating a significant element of professional judgement) for practical application.

The evidence base for many of the broad scale ecosystem impact predictive methodologies requires further strengthening, particularly as it relates to ecological process interactions, through scientific knowledge and case studies (summarised in Cascade Consulting, 2002). However, there are sufficient broad scale data and a number of existing predictive tools to begin to evaluate and assess broad scale ecosystem impacts from flood management initiatives. The methodology provided by BSEA Toolbox 1 seeks to provide the foundation for improved awareness and access to existing data and the encouragement of qualified professional judgement. In this context qualified means transparent, clear, based on contemporary understanding of ecological principles and, importantly, taken in consideration of documented uncertainties. From this position, future studies and research can contribute to a better fundamental understanding of ecosystem function and the effects of flood management interventions.

The methodology recognises that the ecosystem assessment will be at an appropriate broad scale and resolution, commensurate with the detail contained in the policy drivers. As the flood management policies (CFMP and SMP2) are high level, the studies and outputs required to evaluate their relative effects will have to mirror their over-arching nature.

Into the future, the aspiration is for methodological improvements that should allow development of deterministic modelling to represent ecosystem processes and dynamic change. The emerging requirements of the Water Framework and Habitats Directives, together with possible climate change modelling, should act as a stimulus to research that will be of direct relevance.

2.2 Over-arching approach to BSEA

The recommended approach is based on a generic and modular framework that is equally applicable to both freshwater and coastal ecosystems. The framework aims to define a set of key inputs to the assessment process that can act as the basis for the methodology and can subsequently be built on as scientific knowledge improves. The key components include:

1. Definition of policies and associated scenarios.
2. Description of baseline ecosystem characteristics, including hydrological, geomorphological and ecological condition.
3. Specification of Broad scale Ecosystem Criteria (BEC) based on condition of catchment or coastal cell.
4. Prediction of change in ecosystem characteristics with future policy drivers, through interpretation of available data (including GIS) and using evidence from previous research and operational experience.
5. Definition of ecosystem effects relative to the BEC.
6. Incorporation within decision-making framework (SEA, multi-criteria analysis (MCA) etc.).

Any BSEA tools that are developed under the auspices of the flood and coastal development research and development programme should be transferable and consistent with other research programmes and user needs. The Water Framework and Habitats Directives are specifically highlighted. With major drivers such as these Directives, ecosystem assessment is likely to focus in the near future more clearly on general ecosystem quality (e.g. “good” ecological status) rather than solely/ specifically the areas with nature conservation designations.

The project team together with the Project Management Group therefore considers that broad scale ecosystem assessment must consider the ecological components in a wider context (than as at present, incorporating only designated sites). The implications are that a fuller range of natural and impacted ecosystem types and geographical areas will require consideration, but will also include those identified under international and national nature conservation designations, and habitats and species listed in HAPs and BAPs. The approach focuses on the extent and quality of habitats and habitats for species (e.g. salmon, birds), but in most cases not the species themselves. In addition, the assessment undertaken should be able to establish the potential for ecological benefits (opportunities) and disbenefits (impacts) to meet the needs of catchment or shoreline management planning.

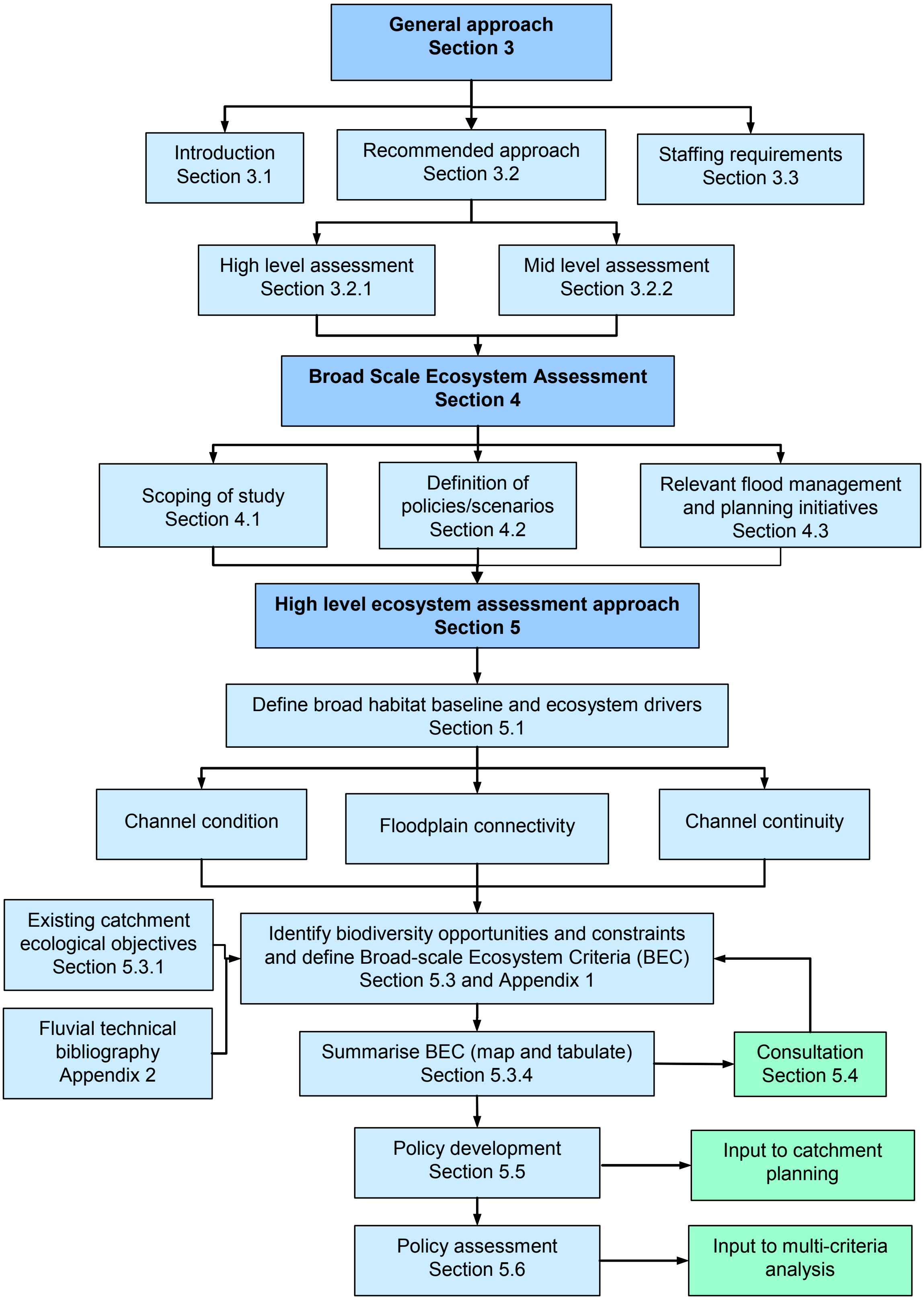
The recommended approach combines ecosystem indicators of both short-term impact and long-term dynamic change in the physical environment and translates the implications to broad scale changes in supported habitats through assessment of risk related to broad scale ecological criteria.

Prediction of ecosystem response will be evidence based, and will, initially at least, be reliant on interpretation of source-pathway-receptor conceptual models using qualified expert judgements to determine potential risks to ecosystem integrity. These relationships will be developed from existing field-based data and empirical relationships and conceptual process-based models (e.g. habitat evolution through changed inundation patterns, salmonid productivity models etc..).

Potential ecosystem impacts of policies and scenarios is supported by a technical bibliography. This will provide basic texts and research reports of relevance to BSEA and impact assessment – the bibliography will be the repository of relevant information/ data that describe, for flood and coastal erosion management activities, research and field evidence (where available) on the potential changes that could be expected as a result of defined policies and activities. The first iteration described in this guidance is necessarily limited to the research team's knowledge of existing reports. It is recommended that the library should be populated by emerging studies and data (as a dynamic database) as the CFMP and SMP processes move forward. Future research and development from the BSEIM programme should also help to inform the bibliography.

The outputs of the BSEA will have to fit within the wider SEA and/ or MCA for the CFMP or SMP. The findings of the BSEA will therefore have to be presented in a concise and relatively simple format. Guidance on these elements of the SEA/ MCA processes is not currently available. It is recommended at this time that the outputs of the BSEA should be couched in terms of policy analysis that determines a relative assessment of each policy identifying whether each BEC can be achieved.

Part A: Guidance for fluvial systems



For guidance on practical application of BSEA to fluvial systems go directly to Section 5.

3 General approach for fluvial systems

3.1 General principles

The guidance contained in this report is established on the policy requirement to seek to maintain and, where possible, enhance the ecosystem value of river systems in England and Wales. The general approach to river management should therefore be to allow to the river to continue in, or return to, its “natural” state where possible. However, in practice in many cases there will be constraints that limit the extent to which this is achievable. Nevertheless, management decisions should be undertaken recognising that rivers are in a constant state of dynamic evolution as they respond to climate variability and other changes.

Particular factors to be considered should include:

- Is the river natural or modified and if so what would the river be like naturally?
- How much has the river been disturbed from its natural state?
- What will proposed changes in flood management do to supported ecosystems?
- What are the opportunities to protect the natural features of rivers?
- What are the opportunities to enhance degraded rivers to provide a more natural setting?
- Where can flooding be allow to increase to beneficial effect?
- In the case of modified rivers, can the river recover naturally or is intervention needed?

In order to predict the type of effects described above, an approach is required that:

- Describes the historic and present condition,
- Predicts impacts of future changes including climate change and engineering work,
- Predicts the timescale over which the river will change in response to natural change and man-made interventions, and
- Provides guidance on recommended approaches to river management including protection, intervention and enhancement features.

There are a number of important considerations that must be represented in BSEA; these include:

- In-channel and riparian/ floodplain broad habitats and species migratory pathways,
- Importance of flood frequency: a floodplain must flood every 2 to 3 years to be ecologically active, and
- Extent to which a river can move in the floodplain.

The key processes in BSEA include hydrology (river flows), geomorphology (river form and sediment dynamics) and habitat formation and availability, and the links between these processes.

The way in which flows will be changed by climate change and engineering works are as follows:

- Climate change will affect the full range of flow conditions. It is expected that high flows will increase and low flows will reduce, leading to a change in the shape of the flow duration curve.
- Engineering works:
  - Works on the floodplain will only affect flows that exceed the bankfull capacity of the river. However this can change the in-bank characteristics of these flows, thus causing an impact on the complete channel cross-section.
  - In-channel works (including on-line and off-line flood) storage will impact on the full flow range.
- Other dynamic changes (e.g. from land use) may influence river function, either directly or in combination with flood management activities. Strategic studies should seek to understand any dependant forcing factors (e.g. changes to land use policy – Common Agricultural Policy reform) that may have equal or greater impact on the river system than the activities or measures being assessed. This would be undertaken in a wider policy context than within the guidance defined here, but should not be overlooked in the broad scale analysis.

It is possible to estimate changes in flows:

- Guidance is provided by Defra and others on the magnitude of changes in flow as a result of climate change that should be considered in strategic planning.
- The impacts of changes in flow caused by engineering works can be estimated by catchment flow modelling (that is often undertaken as part of the strategic studies).

The flows that have the most impact on channel morphology are the intermediate flows, those from about the 50-percentile flow to the 5-year flood. Thus the impacts of change on these flows must be determined in order to assess the impact on morphology. This is not undertaken routinely at present for policy appraisal, and may require modification to existing flood management appraisal methods to provide the data at suitable temporal resolutions. Some aspects of the impact of flow on channel morphology can be assessed, for example overall channel dimensions, but others aspects remain more difficult to predict at the broad scale, for example in-channel features.

The impacts on habitats and species arise from two causes:

- Direct impact of changes in flow frequency and potentially revised velocity profiles. The main interest is the complete flow range but with lesser interest for large return period events.

- Indirect impact from changes in river and floodplain morphology on habitat availability.

These impacts are more difficult to predict. Habitats are formed by local small-scale processes and the relationships between habitats and species are even more complex. It is proposed to use habitats as a surrogate for ecosystems, and to primarily assess impacts on habitats. The broad assumption is that if suitable habitats are available it is likely that supported species would also be provided for (this also assumes that recruitment and dynamic evolution are not inhibited).

Having established the philosophical approach and some of the practicable limitations of data and predictive methodologies at this time, the recommended approach for fluvial systems is presented below.

3.2 Recommended approach for fluvial systems

The recommended approach for fluvial systems is to have a two tier methodology, with the level of study complexity dependent on three factors:

- Analysis at a policy (broad scale) or strategic (sub-catchment or smaller) level,
- Ecosystem interest and relative sensitivity to change (given potential policy options) in the identified catchment, and
- Quality and quantity of input data, particularly on hydrology, geomorphology and ecology.

To obtain an initial catchment-wide understanding of the biodiversity opportunities and constraints that may arise from flood management policy or the likelihood of ecosystem change, a High Level analysis should be performed. This would include for example BSEA to support CFMP production.

The study could then be promoted to a more detailed Mid Level assessment where there are potentially significant ecosystem implications that need to be explored further by means of more complex assessment, for example for a particular strategy or scheme. However, where High Level assessment recognises that a more detailed approach may be beneficial, but too few data of reasonable quality exist to support the analysis, care must be taken to flag this as a significant issue to the appropriate project manager.

3.2.1 Approach to high level assessment

The understanding of catchment ecosystems will require definition using available data and techniques. Since the current inventory of catchment-scale habitats does not generally extend to in-channel habitats, the description of habitat availability, and the dynamic change in habitats over time, is dependent on the collation of a number of overlaid GIS-based datasets. In combination these give a broad approximation of the ecosystem function in the catchment. Key features of the High level approach are as follows:

- Whole catchment,
- Outputs intended to feed into Mid level (sub-catchment) approach,
- Based on spatially referenced (usually GIS) electronic data covering whole catchments,
- Uses existing, nationally available datasets, and
- Quick to implement, but needs specialist interpretation.

It is the intention that the High Level approach for fluvial systems, would form the main mechanism for addressing ecological issues within the CFMP process.

The High Level approach forms the basis for the fluvial guidance set out in this report, and which is presented in Section 5.

3.2.2 Approach to mid level assessment

It is anticipated that the general concepts and approach associated with BSEA set out in this guidance document would also be applicable for integrating ecology and habitats within more detailed strategic studies, such as flood management strategies. However, it is also recognised that a strategy would require a more data intensive approach using, where possible, semi-quantitative analysis and interpretation to reduce uncertainty that is inherent in the High Level approach. This strategic approach is termed the Mid Level BSEA approach, and key features differentiating it from the High level approach are as follows:

- Predictive impact of flows on morphology (as far as possible),
- Reliant mainly on existing fieldwork and analysis, and
- Semi-quantitative (limitations in process understanding are recognised).

This guidance document does not provide a full methodology for the Mid Level approach, which is outside the scope of work for this research project. However, when considering integration of BSEA at the strategic level, the following more detailed/semi-quantitative methods could be implemented:

- Draft Standard Protocol on Hydromorphology Quality for Flood Defence Assessment (CEN, 2004). A standard for survey and assessment, which provides guidance on integrating those riverine features of importance in Europe. The CEN approach includes collation of existing survey and management data, or collection of field survey data, and is therefore at a level of detail commensurate with the Mid level approach for BSEA. The CEN standard incorporates the following riverine features:
    - Channel geometry,
    - Substrates,
    - Vegetation and organic debris,
    - Erosion and deposition character,
    - Artificial structures and effect o flow and sediment,
    - Artificial structures and effect on biota migration,
    - Bank structure and modification,
    - Vegetation type/ structure on banks and adjacent land, and

    - Degree of lateral connectivity of river and floodplain, and lateral movement of channel.
- River regime (semi-quantitative method for predicting morphology of rivers). River regime predicts channel width, channel depth and channel slope based on flow equations.
- Broad scale flood inundations models, which allow prediction of inundation extent, frequency and duration. Models such as RASP and JFLOW are marketed as providing the required input floodplain data for a mid-level approach, but development of these models is still ongoing.

In addition, the following existing guidance documents should be read conjunctively and taken into consideration as part of any Mid Level assessment:

- Environment Agency, Guidance for Environmental Assessment (SEA) of Internal Plans and Programmes (Version 1, July 2004b).
- Defra, Flood and Coastal Defence Project Appraisal Guidance (FCDPAG2): Strategic Planning and Appraisal (April 2001).
- Defra, Flood and Coastal Defence Project Appraisal Guidance (FCDPAG5): Environmental Appraisal (March 2000).

No further discussion of the Mid Level approach is included in this guidance document. Application of the over-arching High Level approach, and embedding of later more detailed studies (including the Mid Level approach) should allow the benefits of a suitably tiered strategic analysis to be achieved. Benefits should include a more sustainable approach to catchment management, deriving cost savings for flood management activities and biodiversity gains from more suitably targeted management actions.

3.3 Staffing requirement for broad scale ecosystem assessment

BSEA involves an appreciation of catchment hydrological, hydraulic, morphological and ecological processes. Whilst guidelines will be provided on BSEA, it is important that BSEA is carried out by a team with appropriate training and experience and with suitable supervision. For example, staff undertaking BSEA should have an appreciation of the processes mentioned above and the ability to understand the linkages between them. Supervisors should have experience in broad scale work and river processes. Ideally staff undertaking BSEA should have access to specialists in catchment hydrology, geomorphology and ecology.

Whilst the staff requirements may appear onerous, investment in suitable training and the provision of suitable work experience to develop staff is strongly recommended. This is because the methods recommended in this report are often relatively simple but require judgement for effective application. There will therefore be considerable benefits in terms of work efficiency and quality of product if suitable staff are available to work on BSEA.

4 Fluvial broad scale ecosystem assessment

4.1 Scoping of study

The requirement for and level of detail necessary to undertake an ecosystem assessment is dependent on the study being undertaken. The guidance contained in this document is intended for use wherever assessment of risk to broad scale ecosystems is required in the context of sustainable flood management planning and its associated SEA requirements. Before undertaking any ecosystem assessment it is essential to define the requirements of the study, in terms of:

- Size of study area,
- Objectives of the study,
- Opportunity for influencing the development of the assessment scenarios (BSEA needs to be included at inception of study),
- Level of ecosystem assessment required, and
- Details of final decision-making process so that BSEA outputs are in a suitable format and at an appropriate level of detail.

These requirements will be specified in the procedural guidance or defining legislation for the study being undertaken (e.g. CFMP) and should be developed in collaboration with the project management team. An overview of the ecosystem assessment requirements for fluvial initiatives is presented below to assist in the definition of the policy or scenario framework.

4.2 Definition of potential policy directions

For flood management to be environmentally sensitive, a major consideration needs to be that the ecological quality of a river (and water-dependent habitats and species) should not be reduced. This may be a critical requirement when the ecology of a river is of good quality, but where the ecological value has been damaged by degraded habitat structure, there is a requirement to take advantage of opportunities to rehabilitate rivers so that they can take opportunities to recover their ecological potential, or reach good status.

This approach is required by:

- Internal EA policy (e.g. Environmental Vision, 2000; Corporate Plan 2005),
- UK legislation (e.g. Water Act, 1995; Wildlife & Countryside Act, 1981; Countryside and Rights of Way (CRoW) Act, 2002), and
- Transposed and emerging European legislation (e.g. Water Framework and Habitats Directives).

Note that the Environment Act (1995) requires the EA to:

- ‘Further conservation wherever possible, when carrying out water management functions’, and

- ‘Promote the conservation of natural beauty and amenity and the wildlife dependent on the aquatic environment’.

At the broad scale the general approach for fluvial systems seeks to identify flood risk management constraints to natural river ecosystem function and biodiversity opportunities that act at the catchment or sub-catchment level. These will tend to be system bottlenecks (e.g. flood embankments, channel modification, weirs) or broad scale pressures (e.g. land use and land management in the riparian zone and catchment gathering grounds).

4.3 Fluvial flood management planning initiatives

The particular fluvial flood management initiatives (see Table 4.1) where assessment of ecosystem risk is required include:

- CFMPs,
- Flood Management Strategy Plans, and
- Future integration with the WFD.

SEA is the systematic appraisal of the potential environmental consequences of high level decision-making. SEA will be applied throughout the development and implementation of a number of plans, programmes and modifications of plans and programmes (PPMs) proposed by the EA.

The guidance contained in this document is not designed to be a specific element of the CFMP process or its accompanying SEA, as it is designed to be applicable to a wider range of initiatives, including the analysis of activities of relevance to the WFD (e.g. water resources etc.). However, it is expected that the High Level BSEA approach should become the mechanism for integrating ecosystem assessment (including ecology and habitats) within CFMPs.

It is also generally recognised that the subsequent strategy plans and WFD assessments will also require an assessment procedure, and that in turn could be based on the BSEA framework, but with greater levels of detail in terms of river reach specific input data and process analysis (the Mid Level assessment).

The structural modifications/ interventions and management actions appropriate for development of a policy or scenario will typically be drawn-up as a feature of that policy or scenario (see also Constraints and Opportunities in Section 5.3.3 for opportunities to influence their development). The requirements for the appropriate level of assessment of risk to ecosystem change are established in the legislation or guidance for each initiative, and are summarised in Table 4.1.

In order to satisfy the requirements of these initiatives it is desirable that BSEA provides the following at catchment and sub-catchment scale:

- Broad scale understanding of ecosystems,
- Baseline description of ecosystems and indicators suitable for broad scale application,
- Assessment of the impacts of change, and

- Guidance on interventions including mitigation and enhancement measures.

Table 4.1 Broad scale ecosystem assessment requirements of fluvial flood management and other initiatives

Initiative	Ecosystem Assessment Required
CFMP	Appraisal of policies within CFMPs, carried out by MCA. One of the criteria is environmental acceptability, and there will be a need to assess the environmental impact of the policies. A major component of the environmental impact will be the impacts of proposals on ecosystems. BSEA is therefore required at catchment scale to: • Identify the impacts of change on ecosystems, • Identify whether the impacts will be positive or negative, and • Provide a qualitative assessment of impacts, suitable for use in MCA.
Flood Management Strategy Plans	The guidance contains the following requirements for environmental impacts: • Assessment of the environmental impacts of the options considered, • Impact of environmental considerations on option choice, and • Identification of any mitigation measures required together with recommendations for monitoring. The requirements for BSEA at Strategy Plan Level are therefore as follows: • Identify the impacts of options on ecosystems, • Impact assessment must be good enough to choose between options, and • Impact assessment must be good enough to identify mitigation measures.
WFD	The principle objectives of the Directive as set out in Article 4(1) include the following: • Prevent deterioration in the status of surface water bodies, • Protect, enhance and restore all bodies of surface water with the aim of achieving good surface water status by 2015, and • Achieve compliance with any relevant standards and objectives for protected areas. River Basin Management planning will be the main vehicle for protecting the water environment. The Directive sets out a planning cycle for river basin management which consists of three main parts: • Characterisation of River Basin Districts including an assessment of water bodies at risk of not achieving the Directive's objectives as a result of man-made pressures, • Establishing environmental monitoring informed by characterisation, and • River Basin Management Planning, which includes setting environmental objectives and designing a programme of measures. The requirements of BSEA for the WFD are as follows: • Identify the current ecosystem status of the catchment, • Identify the impacts from flood risk management activities on ecosystems in order to develop the measures needed to achieve good ecological status or good ecological potential, and • Develop a broad scale programme of measures relevant to flood risk management.

CFMP policies that can be tested in a given catchment include:

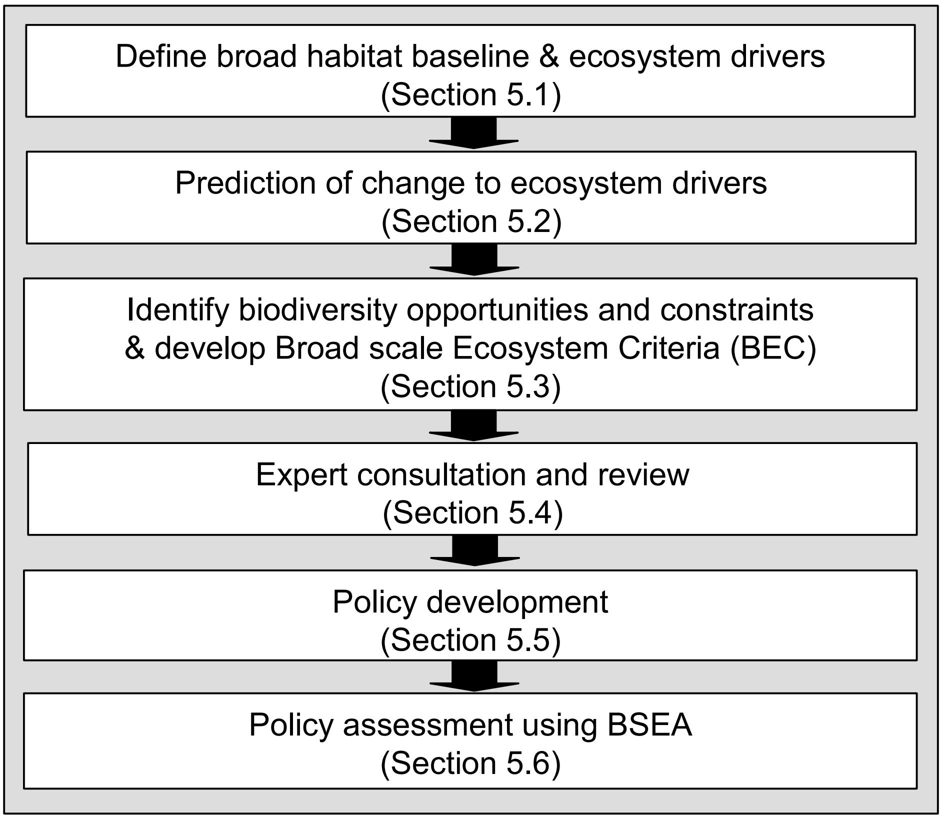
- No active intervention,
- Reduce flood risk,
- Maintain existing flood risk, and
- Increase flood risk.

The policy options to be considered should take account of the need to investigate:

- Range of floods to be considered (e.g. <1 in 5 year return) not just floods of longer return periods (for example, the ‘100-year’ flood), for the following reasons:
    - Frequent floods are important for channel formation and ecosystems,
    - Frequent floods are important in the assessment of economic and social impacts of flooding, as the majority of damages are caused by frequent floods in many cases, and
    - The EA’s Flood Management Strategy is aimed at reducing overall flood risk, and therefore all floods must be considered.
- Impacts of change, including:
    - Flood management interventions, including in-channel and out-of-channel solutions,
    - Climate change, where ecosystems will be affected by changes to both high and low flows, and
    - Land use and land management change, including further urban development.
- Long-term horizons. For example, CFMPs are intended to cover 50 to 100 years. It is recognised that there are large uncertainties in this process and CFMPs are intended to be updated at regular intervals.
- Overlap between fluvial and marine ecosystems.

5 Fluvial high level ecosystem assessment guidance

This Section contains the guidance for undertaking a High Level assessment of fluvial ecosystems, tailored to flood management policy at a catchment scale. To aid the reader in interpretation of the guidance, it is recommended that this section is read in conjunction with the following two Case Studies (Sections 6 and 7) that elaborate on the application of the approach and the detailed instructions for each Tool in Appendix 1. The following identifies the steps in the BSEA process.



The approach is GIS-based and driven by a qualitative review of current baseline and historic data for in-channel and floodplain habitats and the key drivers for their dynamic evolution, including the hydrology and geomorphological functioning of the catchment (Section 5.1).

Having described existing habitat availability and its driving ecosystem characteristics, the biodiversity opportunities and constraints in the catchment can be identified (Section 5.3). These will be based on the collective expert judgement of project team members, assisted by information and case studies contained in the technical bibliography (included in Appendix 2). These form the basis of the BEC for the catchment, relevant to flood management policy. The BEC are the key assessment criteria against which each of the catchment policy options are to be compared during the option assessment.

The evidence base for many of the broad scale ecosystem assessment methodologies requires further strengthening, particularly as it relates to ecological process interactions. Given that qualitative professional judgement is a key feature of the method, and that interpretation may therefore vary, expert consultation and review is strongly recommended to minimise inconsistent application. The consultation and review stage is also required to embrace the views and expertise of appropriate stakeholders within the catchment (Section 5.4). This is likely to contribute to a wider appreciation of the availability and quality of habitats in the catchment and the key factors governing its dynamic evolution. This will inform the suitability of the proposed BEC.

The BSEA methodology can then be used in the development of alternative flood management policies in the catchment, through early incorporation within the CFMP process. A range of potential flood management actions can be identified to achieve the potential biodiversity benefits of each BEC, and each of these actions will have a potential flood management consequence. These can be built into consideration of catchment flood management planning. Guidance is provided in Section 5.5, leading to the population of a policy development matrix.

The BSEA methodology can then be used for the appraisal of alternative flood management policies. This can be tailored to provide the ecological component of the SEA for a CFMP. Each alternative policy or option can be assessed in terms of achievement of each protection or enhancement BEC. Guidance is provided in Section 5.6.

Where the study area includes estuarine areas, the guidance provided in Section 10 should also be considered.

It should be noted that due to restrictions imposed by timescales and the choice of case studies, all of which had started and were in the process of public consultation, the full implementation of the BSEA methodology could not be tested. Clearly, introducing new concepts and potentially conflicting policy options at a critical stage of public involvement for CFMP consultation could be counter-productive and respective project managers deemed the risks to project delivery too great at the time. The key recommendation for future studies would therefore be to incorporate BSEA at the outset of any catchment scale policy appraisal, allowing input into policy development and subsequent direct alternative policies within the decision-making context.

5.1 Define broad habitat baseline and ecosystem drivers

Definition of the existing catchment characteristics, in terms of the available habitats and ecosystem drivers, is central to the successful application of the guidance. A range of tools and supporting methods have been developed to allow a systematic description of the catchment, based on existing datasets and expert interpretation. The purpose of this catchment characterisation is to identify and specify the key ecosystem drivers in terms of their current state and dynamic context, reflecting evolutionary change (potentially including anthropogenic influences) over time.

The fluvial High Level toolbox contents are presented in Table 5.1. Detailed guidance on each of the tools, including data sources, licensing, manipulation, presentation and interpretation, is described in Appendix 1. Appropriate data for each are readily available throughout England and Wales. The modular nature of the toolbox means that tools can be updated as new datasets or methods become available. Where surveys or more detailed modelling studies have been undertaken for a catchment, the output data from these can be used to supplement or replace the standard tool.

It will not be necessarily appropriate to apply all tools in all study catchments. Users discretion is required to scope those ecosystem drivers that are appropriate to the study catchment under investigation.

Table 5.1 Fluvial high level toolbox contents

Toolbox	Tool		
Toolbox A Channel condition			
Broad scale review of in-channel habitats and the development of an understanding of the ecosystem drivers that have shaped the current habitat diversity, availability, location, extent and quality. Channel condition addresses both in-channel benthic and water column habitat niches, fundamentally through flow and morphological regime; sediment type and availability; and extent of anthropogenic channel modification	Tool A1	Catchment hydrology	Catchment hydrology describes flows in the river system, which in turn provide the hydraulic regime for ecosystems. Hydrology is described using flow duration curves, to represent in-channel flows, and representative frequent and infrequent floods, together with an indication of flood duration.
	Tool A2	Surface runoff potential	Surface runoff potential provides an indication of the amount of water that runs off into the river system. This tool is used in combination with Tool A4 to assess the potential for sediment runoff into the river system.
	Tool A3	Channel gradient	Channel gradient provides an indication of stream power across the catchment. Stream power reflects the potential for sediment erosion, transport and deposition - morphological processes which influence habitat type and diversity. The process of mapping channel gradient also allows natural and artificial grade controls such as on-line lakes or artificial weirs to be identified. These influence channel morphology both upstream and downstream and impact upon the sediment regime.
	Tool A4	Catchment sediment sources	Sediment yield from catchments under different land use types affects the volume of sediment supply to river systems. The volume of sediment supplied to the river can determine the morphological response of river channels (erosion and deposition) throughout the river network affecting the diversity, quality and extent of habitat. This is particularly the case with fine sediment delivery which has the potential to cause rapid channel adjustment which can impact positively and/or negatively on in-channel habitat.
	Tool A5	Substrate erodibility	Erodibility of the channel boundary (bed and banks) contributes to potential for in-channel sediment sourcing in addition to catchment sediment sources (Tool A5). At the broad scale, boundary conditions are also indicative of the diversity habitats in the river system.
	Tool A6	Morphological continuity	Physical barriers to natural sediment movement both in a downstream direction and laterally across the floodplain affect river ecosystems by constraining the transport and storage of sediment. Tool A6 can be used in combination with Tools A3 and B1 to assess the potential for sediment to be moved and stored in the system and the potential for reinstating natural morphological functioning (e.g. flooding). Again this is particularly important for fine sediment which will be retained in channel where flood defences are present and can adversely affect significant lengths of otherwise functioning habitat..
	Tool A7	Channel modification	Channel modification directly impacts on ecological status by limiting natural features and processes. Channel morphology is also indirectly impacted by modification through a reduction in the potential for local sediment supply or storage. The impact of channel modification across the river network can be viewed by mapping the type and extent of modification.
	Tool A8	In-channel habitats and ecology	Continuous habitat mapping of river corridors is not undertaken routinely. Tool A8 is concerned with identifying trends in in-channel ecology through the use of summary reports and trend analysis from existing datasets. It does not seek to analyse raw ecological data. Datasets may include consolidated catchment scale biological general quality assessment (GQA) information, assessments from LEAPS, Salmon Action Plans etc. to arrive at an over-arching view of the health of the catchment and areas of particular value or concern.
	Tool A9	Chemical water quality	An understanding of general chemical water quality and in-stream nutrient quality can be used to assist in the interpretation of ecosystem pressures across a catchment. Pressures from point and diffuse source pollution, including eutrophication risk, are not typically associated with flood management policy.

Table 5.1 Fluvial high level toolbox contents (continued)

Toolbox	Tool		
Toolbox B Floodplain connectivity			
Floodplain connectivity enables the broad scale review of riparian habitats and the development of an understanding of the ecosystem drivers that have shaped the current habitat diversity, availability, location, extent and quality. Floodplain connectivity provides an indication of the extent of 'active' or 'potential' floodplain habitats and initiates an understanding of breaks in natural connectivity.	Tool B1	Floodplain areas and existing defences	Flood extent information is used to develop an understanding of the potential extent of floodplain. Information on flood defences assists the understanding of current and historic flood management policy, and provides information on areas benefiting from flood defences. Disconnection of the river from the floodplain from other linear barriers (e.g. railway embankments, canals) and management actions may also assist the understanding. Low return period flood extent outlines (e.g. 1 in 2 year, 1 in 5 year) provide information on areas of ecologically active floodplain
	Tool B2	Riparian zone and gathering grounds habitat mapping	The presence of water-dependent habitats in the riparian zone provides an indication of the current location of ecologically active floodplain (for protection and enhancement). In addition, areas for potential restoration to ecologically active floodplain through improved floodplain connectivity and suitable land management can be identified. The location of water-dependent habitats in the gathering grounds, particularly catchment headwaters, provides context to land management changes for runoff attenuation and reduction of sediment mobilisation.
	Tool B3	Land cover in potential floodplain areas	In association with Tool B2, the current land cover in areas at risk of flooding establishes the potential for management actions leading to the creation, restoration or enhancement of ecologically active floodplain.
Toolbox C Channel continuity			
Enables the broad scale review of channel continuity and the development of an understanding of the naturalness of mobile species movement.	Tool C1	Barriers to river continuity	River continuity is used to assess in-channel barriers to ecological migration, predominantly for fish (particularly salmon) migration, but also with respect to water-borne vegetative propagation and movement of fauna throughout the catchment.

5.2 Prediction of change to ecosystem drivers

Having described the dynamic evolution of the catchment in terms of hydrology, floodplain inundation and geomorphological processes, it may be necessary to predict the potential magnitude and significance of each in response to drivers other than flood management, e.g. land use and climate change.
In general it can be assumed that under the envisaged changes the river system would progress from one equilibrium to another over time. One issue relates to the timescale for this change to take place. In active, high energy systems this change is likely to take place rapidly but in low energy systems the timescale might be extremely long. The timescale for assessment of change is established for CFMPs as 50-100 years.

Predictive information on future change to ecosystem drivers are incorporated into Tools where appropriate and currently available. These are presented in Appendix 1 for the following Tools:

- Tool A1: Catchment hydrology
  Changes in flows arising from land use change, climate change and policy options can be represented by changes in the representative flow data calculated using Tool A1. Flow duration curves can be used to identify changes in the in-channel flow regime. Overlays of past, present and future (modelled) flow duration curves potentially help to identify trends in flow. Changes in flood flows provide an indication of the impacts of change on frequent floods (important for floodplain ecosystems) and large floods (important for floodplain extent).

- Tool A2: Surface runoff potential
  Changes in surface runoff potential will provide an indication of changes in the amount of sediment entering the river system under climate change. Increased winter rainfall and increased summer storminess could lead to an increase in the quantity of sediment entering the river.

- Tool A4: Catchment sediment sources
  Change in the catchment hydrology can impact the potential sediment yield from the catchment and thus the volume of sediment entering the river network. The nature of hydrological changes under climate change (duration, frequency of events and seasonal rainfall) will influence the sediment supply and the in-channel processes.

- Tool B1: Floodplain areas and existing defences
  Predicted future flood extents, from changes in rainfall and runoff, can be incorporated where available.

5.3 Derivation of appropriate fluvial broad scale ecosystem criteria

The BSEA approach is based on a modular framework that defines a set of key inputs to the assessment process. These can be replaced or built on as baseline data coverage increases and scientific knowledge improves. The recommended approach combines ecosystem indicators of both short-term impact and long-term dynamic change in the physical environment and translate the implications to broad scale changes in supported habitats through assessment of risk related to Broad scale Ecosystem Criteria (BEC). The key steps are as follows:

- Develop an overview of existing broad habitat types; where practicable to include their location, extent and status,
- Determine the appropriate ecosystem drivers for each broad habitat type,
- Develop an understanding of the broad habitat types through the appropriate ecosystems drivers,
- Define the context and objectives of the study (e.g. for flood management policy investigation, potential management actions will have consequences for flood management),
- Establish constraints (Protection BEC): geographical areas/ system functioning which must be protected as part of the study objectives,
- Establish opportunities (Enhancement BEC): geographical areas/ system functioning which can potentially be incorporated and enhanced as part of the study objectives,
- Map BEC to provide spatial context,
- Verify and, if required, supplement BEC through a key stakeholder forum,
- Use BEC to inform policy/ option development, and
- Use BEC to assess the relative merits of each policy/ option.

The starting point for the BEC is ecosystem function. If the ecosystem is considered to be functioning appropriately then it is assumed that physical habitats will also be in good condition. For the purposes of broad scale assessment, it is assumed that if habitats are in good condition then species/ assemblages will follow suit and any nature conservation designations will also be maintained/ improved accordingly. Species-targeted improvements are outside the scope of this catchment-scale assessment at this time.

BEC provide the yardstick against which policies or scenarios can be assessed to give a relative analysis of positive, neutral or negative ecosystem impact. Identifying and defining correct BEC is therefore essential in implementing BSEA as an assessment tool. When defining BEC the following factors must be taken into consideration:

- BEC must be appropriate for the type of study (linked to flood risk management),
- BEC must be at a broad scale (linked to ecosystem function/ broad habitat types),
- BEC must be tailored for the catchment (may involve re-casting data based on administrative or landscape boundaries), and
- BEC must be able to be assessed using the level of information and tools currently available.

The starting point for defining BEC is ecosystem function, as defined by channel condition, floodplain connectivity and channel continuity. If the ecosystem is considered to be functioning appropriately then it is assumed that physical habitats present within that ecosystem will also be in good condition. For the purposes of BSEA, it is also assumed that if habitats are in good condition then species/ assemblages will follow suit and any nature conservation designations will also be maintained/ improved accordingly.

In practice, BEC will be identified through interrogating the GIS outputs from the toolbox (Tools A1-A9, B1-B3 and C1) in isolation or, more usually, in combination. This process is very much reliant on the intuitive understanding of the status and functioning of the catchment, which will be developed by the project team. Different combinations of GIS layers will provide information to determine different BEC. Guidance on combining the GIS outputs is contained within the toolbox (see Appendix 1). However, some examples are presented below:

- Identifying areas of high potential sediment yield in the catchment can be undertaken by combining 'surface run-off potential (A2)' with 'catchment sediment sources (A4) and 'substrate erodibility (A5)',
- Identifying areas for floodplain wetland creation can be undertaken by combining 'floodplain areas (B1)' and 'habitat mapping (B2)', and
- Identifying potential for sediment deposition along a watercourse can be undertaken by combining 'morphological continuity (A6)' with 'channel gradient (A3)'.

BEC should also take into account the existing catchment targets, integrating these wherever possible and where relevant to the primary objective.

The initial list of catchment BEC will be defined using the collective expert judgement of the project team members, assisted by information and case studies contained in the fluvial technical bibliography (see Appendix 2). It is recommended that no more than 20 BEC are identified to ensure the assessment process is manageable.

Based on the input data (ecosystem drivers and existing catchment targets), BEC should be established for the three ecosystem components: channel condition, floodplain connectivity, and channel continuity. Each BEC should also be defined as either protection BEC or enhancement BEC. The definitions of each are given in Sections 5.3.2 and 5.3.3.

The following assumptions are made for this guidance:

- Sufficient core baseline data are available to undertake the assessment,
- The ecosystem function (status and change) can be modelled and assessed with a reasonable degree of certainty,
- The relationship between ecosystem function change and habitat change can be estimated, using evidence-based professional judgement, with a reasonable degree of certainty, and

- The relationship between habitat change and species/ assemblage change is less easily predicted (and requires further empirical analysis beyond the scope of this study).

The above assumptions may change in time as better cause-effect relationship information and understanding for ecosystem drivers, habitats and species/ assemblages is gained.

5.3.1 Existing ecosystem criteria

Complimenting the catchment characterisation should be a review of any ongoing catchment initiatives and programmes. This should provide an overview of current catchment issues, and establish relevant biodiversity or hydro-geomorphological targets which should be integrated within BSEA. The following list gives an indication of likely sources for catchment targets, but is by no means exhaustive:

- Nature conservation designation "conservation objectives":
  - Natura site (Special Area of Conservation (SAC), Special Protection Area (SPA)) and RAMSAR conservation objectives, and
  - SSSI favourable status.
- Defra High Level Target (HLT) 4: Biodiversity (ensure no net loss of BAP habitats and seek opportunities for environmental enhancements; create at least 200ha of new biodiversity habitat per annum),
- Biodiversity action plan objectives,
- Natural Area Targets for priority habitats,
- Salmon Action Plan,
- Catchment Management Plan,
- Water Level Management Plan,
- Hydromorphological improvement targets (being developed as part of WFD),
- Physical river features linked to EA physical quality objectives work,
- Flow objectives linked to "acceptable flow" studies, and
- Geomorphological objectives linked to general catchment aspirations
- WFD good ecological quality or potential status, to include objective for "no deterioration".

BEC should take into account the existing catchment targets, integrating these wherever possible and where relevant to the primary objective.

5.3.2 Protection BEC

Protection BEC are defined as constraints that <u>must</u> be protected as part of any policy/ option development. They include, for example, those parts of the river system that are deemed to be important for maintaining, or are themselves, in good ecological condition (e.g. active ecological floodplain, important morphological features (spawning gravels), important fish migration routes etc). Compliance with protection BEC is mandatory within the policy/ option development and assessment process. When the WFD is fully implemented there will also be identified constraints where “good ecological status” must be maintained, which has the potential to be more spatially integrated than current nature conservation sites (i.e. catchment-wide).

Protection BEC should therefore fulfil the requirements of: nature conservation legislation (to protect designated sites and habitats) and the WFD (no deterioration in ecological status).

5.3.3 Enhancement BEC

Enhancement BEC are defined as opportunities to enhance the ecology which can <u>wherever possible</u> be integrated as part of any policy/ option development. They include, for example, river restoration to remove channel modification, re-connection of the floodplain to create wetland habitat, or removal of barriers/ installation of passes to ease fish passage. It is also recognised that opportunities may be linked. For example, improving channel condition by increasing sediment inputs through reconnecting the floodplain, or reducing siltation through removal of downstream barriers.

Enhancement BEC that fulfil the requirements of legislation (for example nature conservation legislation, WFD objectives) should be considered critical enhancement criteria to be achieved wherever practicable through flood risk management activities. These include BEC that promote:

- Restoration of designated sites and habitats to a favourable condition if they are currently failing their conservation objectives.
- Meeting of good ecological status or potential in all waters.

For other enhancement BEC every effort should be made to incorporate these enhancements within the policy/ option development and assessment process. However, these non-statutory criteria may include objectives that are more aspirational in character which may need to be reconciled with other objectives.

The more aspirational ecosystem/ habitat enhancement BEC are framed as opportunities due to the lower level of confidence associated with predicting habitat change at this broad scale. Where opportunities are identified they will most likely form the basis for future studies, which can assess the opportunities in a greater level of detail. BSEA therefore provides the evidence-based identification of sub-catchment areas for more detailed study.

5.3.4 Mapping and tabulating BEC

Both protection BEC and enhancement BEC are mapped to give spatial context to the constraints and opportunities. The spatial limits of each BEC are determined by professional judgement taking into account factors such as geographical boundaries, natural or man-made barriers within the system, extent of habitat etc. Spatial limits, which form the boundaries for policy/option development, are verified through consultation with catchment specialists (see Section 5.4).

For each BEC, the potential flood management actions to realise the BEC are listed, together with the potential ecosystem benefits from realising the BEC. This can take the form of a table (see Table 5.2), with corresponding areas marked on a map of the catchment.

Table 5.2 Sample tabulation of broad scale ecosystem criteria

Broad scale Ecosystem Criteria		Potential flood management actions	Potential ecosystem benefit
BEC 1	State the BEC	List the potential flood management actions suitable for realising the BEC	List the potential ecosystem/ biodiversity benefits from realising the BEC

Tabulation enables the specification of potential biodiversity benefit from realising each BEC. This can be extended to include potential management activities, an indication of their cost, and the potential consequences for the study being undertaken (e.g. benefit to flood management).

The preliminary BEC should be used as a basis for the subsequent expert stakeholder forum. Having discussed and agreed the range of protection and enhancement BEC, they will form the framework for biodiversity inputs to policy derivation and, potentially, policy analysis, as required.

Further details of how BEC are defined and applied are given in the Case Studies (see Sections 6 and 7).

5.4 Expert consultation and review

Consultation within the BSEA process will focus on engaging key stakeholders in order to:

- Harness the views and expertise of appropriate catchment specialists and stakeholders,
- Confirm the understanding of the ecosystems present in the catchment - in terms of type, frequency, distribution and quality of habitats and the key drivers for maintenance and potential change, and
- Develop and finalise the protection and enhancement BEC.

BSEA consultation must integrate with existing consultation programmes and methods established as part of the overall flood risk management and SEA process to ensure and promote effective contact with the consultees and avoid consultee fatigue. Comprehensive guidance on consultation is provided in the following relevant documents:

- EA, CFMP Process and Procedures Guidance (Volume 2 Consultation Draft, August 2004c),
- Environment Agency, Guidance for Environmental Assessment (SEA) of Internal Plans and Programmes (Version 1, July 2004b), and
- Environment Agency, Guidelines for Planning and Managing National Consultations (2003b)

Key components of the existing guidance that is relevant to BSEA consultation is as follows:

- The CFMP consultation process integrates the requirements of the SEA Directive and SEA Regulations.
- The CFMP process is divided into six stages, of which Stage 3 (Scoping) is where BSEA requires integration.
- Stage 3 (Scoping) is the phase where 'initial catchment understanding' occurs, which includes identifying:
  - catchment characteristics, processes and management,
  - catchment opportunities and constraints,
  - future catchment scenarios, and
  - draft objectives for the CFMP.

Consultation must include Statutory Consultation Bodies, which for ecology include English Nature (EN)/ Countryside Council for Wales (CCW) and the EA

Consultation will also include a wider consultation group, which for ecology may include representatives from organisations including:

- Farming and Wildlife Advisory Group,
- Forestry Commission,
- National Park Authorities,
- National Trust,
- Natural England,
- RSPB,
- Wildfowl and Wetlands Trust, and
- Wildlife Trusts,

Consultation will be proactive and flexible, and for the needs of BSEA will most likely take the form of meetings and/or workshops.

BSEA consultation, as with the overall consultation as part of the wider flood risk management process, must:

- Ensure it is clear what stakeholders' involvement is and what it will achieve,
- Ensure tasks for the stakeholders are clearly defined, and
- Ensure consultation methods are appropriate for the target audience.

5.5 Policy development

To establish the most appropriate broad scale flood risk management policies it is essential that the catchment-wide ecological opportunities and constraints (the BEC) are taken into consideration at an early stage of the CFMP planning process. This allows those policies which address flood risk management but also provide multiple benefits to be identified and incorporated. This is the recommended proactive approach to embedding BEC within the overall flood risk management process.

Unless BEC are incorporated in this manner the potential ecological benefits of fluvial flood management assets and management will not be realised, and opportunities for sustainable development of the catchment could be missed or be sub-optimal. The BEC may also present opportunities for cross-sectoral benefits, for example for land use policy that could be simulated by the process.

However, since the main aim of flood risk management is to reduce flood risks, it is essential that BEC must be realistic and linked to flood risk management. An example of the stages in defining the BEC and their representation is provided in Table 5.3. Such an approach will enable efficient integration into the policy development framework.

Table 5.3 Example BEC for use within policy development

Broad scale Ecosystem Criteria			Potential management actions	Potential ecosystem benefit	Potential flood management consequences	Additional funding streams
Channel condition	1	Define BEC	State actions required to implement change	Identify expected change to ecosystem	State implications for flood risk management	Investigate potential availability of funding
	2	etc..				

Application of the methodology for policy development is demonstrated in the Ribble catchment case study (see Section 6).

5.6 Policy assessment

Within the current framework for broad scale flood risk management, policy appraisal will be based on a MCA within a sustainability appraisal (that should meet the requirements of SEA). CFMP Guidance Volume 2 (Policy and Procedures) provides more detail for the methodology, but in essence involves assessing policies against the catchment objectives (in the ecological context, BEC) for each policy unit. An example assessment matrix for BEC is provided in Table 5.4. The policy assessment mode of BSEA is demonstrated in the Yorkshire Derwent case study in Section 7.

Policy assessment is reactive, providing qualified judgement on the potential effect of a given flood risk policy. Therefore, as described above, the preferred and recommended approach to integrating ecosystem assessment is the proactive and early identification and incorporation of BEC at the policy development stage. With the recommended approach the risk of incorporating policies during the policy assessment phase that cause significant detrimental impact on ecology or which miss opportunities to benefit ecology is greatly reduced.

Given the High Level approach and uncertainties/unknowns inherent in the process (i.e. costs, specific measures required to deliver the policies) it will be necessary to define and describe any ecological risk and uncertainties, and the resultant confidence level within the policy assessment.

Table 5.4 Example BEC assessment matrix

Broad scale Ecosystem Criteria			Protection/ Enhancement	Draft preferred policy	
				Compliance	Note
Channel condition	1	State the BEC	Protection	Yes or no	Briefly describe reason for compliance assessment and associated risks
	2	Etc	Enhancement	Yes or no	Briefly describe reason and risks

Risks and uncertainties should form an important part of the decision-making process and should be reported within the CFMP documentation. For example, where there is a potentially significant effect on a sensitive ecosystem, but the outcome of the flood management policy or activity is poorly understood, this should be clearly stated in the assessment matrix notes and the precautionary approach adopted.

5.7 Application of methods to case studies

The procedural guidance has been applied to two fluvial case study areas. These are:

- River Ribble catchment in north-west England, which is part of the EA's pilot Ribble Basin Management Plan. The Ribble CFMP commenced in late 2004.
- River Derwent catchment in Yorkshire, which is the subject of an (ongoing) pilot CFMP.

5.7.1 Ribble catchment case study

For the River Ribble catchment in north-west England, the guidance methods have been applied to identify biodiversity objectives (opportunities and constraints) which may arise from flood management policy. Each objective is associated with potential flood management actions, potential biodiversity benefits, potential flood management consequences and an indication of available alternative funding streams. Such assessment could provide input to alternative flood management policy development in a CFMP.

The Ribble catchment fluvial case study is presented in Section 6.

5.7.2 Yorkshire Derwent case study

For the River Derwent catchment in Yorkshire, the guidance methods have been applied to provide a relative policy assessment of the ecosystem consequences of alternative catchment-wide flood management policy. Such assessment could provide input to the SEA of a CFMP.

The Derwent catchment fluvial case study is presented in Section 7.

It is important to note that the case studies could not fully implement the BSEA guidance at this time, as both CFMPs (on which the case studies were based) were entering very sensitive public consultation phases. The respective project management teams for the CFMPs considered that consulting on novel methods at this time could be counter-productive. It is recommended that future BSEA applications should be undertaken as an integrated part of the implementation process to ensure derivation of the maximum benefits.

6 Ribble catchment fluvial high level case study

6.1 Background

The River Ribble rises in the Western Pennines and flows 110 km before running into the Irish Sea, west of Preston. Two significant sub-catchments are included: the River Calder catchment (322 km^2) and the River Hodder catchment (260 km^2). The trial area includes the River Ribble catchment to the tidal limit on the eastern outskirts of Preston, upstream of the confluence with the Rivers Darwen and Douglas. A total land area of over 1,145 km^2 is drained by the rivers in the trial area.

Although the catchment is predominantly rural (90%), there are a number of urban and industrial areas in East Lancashire, including, Accrington, Burnley, Clitheroe, Nelson and Colne (see Figure 6.1). This urbanised area of the southern catchment has a population of around 220,000. The upper catchment is extensively managed for agriculture, dominated by improved grassland and some cereals, with sparse population. Flows in the rivers are largely natural, although Stocks Reservoir, used for public water supply, regulates the flow on the River Hodder. Other water supply abstractions also have an influence on flow in the Hodder sub-catchment.

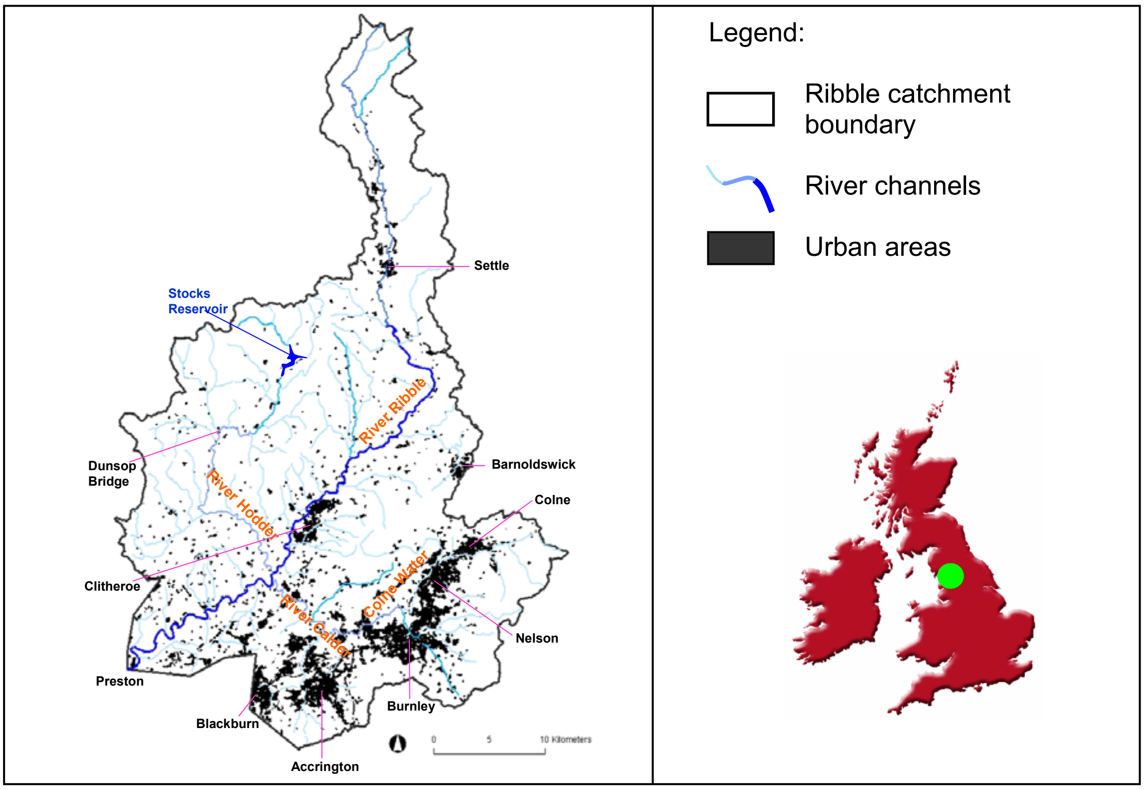


Figure 6.1 Ribble catchment: Background data

6.2 Flood management policy context

The Ribble case study has been undertaken against the backdrop of an emerging CFMP, which had already entered the consultation phase. As such, the work has been undertaken in parallel with, but not incorporated within, the CFMP planning framework. The consequence is that it has only been possible to implement the guidance by reference to the engineering project managers (JBA Consulting) and not the wider stakeholder groups. The understanding of the catchment, although advanced beyond previous methods, does not therefore benefit from the collective experience of local area expertise. It is recommended that this be incorporated once the guidance methodology is operational.

Guidance methods have been applied to identify biodiversity objectives (opportunities and constraints) which may arise from flood management policy. Each objective is associated with potential flood management actions, potential biodiversity benefits, potential flood management consequences and an indication of available alternative funding streams. Such assessment could provide input to alternative flood management policy development in a CFMP. Once policies for the catchment have been developed, the method could then extend to the policy assessment mode – no policies for the Ribble were available at the time of writing.

6.3 Licensing issues

Digital datasets used in the Ribble catchment case study are presented in Table 6.1, together with acknowledgement of the sources and license requirements.

Disclaimer

The maps used in this presentation are for illustrative purposes only. They are not being used for operational purposes by the EA nor should the maps be used in such a way by any other organisation. They are included here to demonstrate the guidance only and should not be viewed as constituting the views of the project sponsors.

Table 6.1 Data licenses used in the Ribble catchment case study

Digital dataset	Source	Data acknowledgement and source
CEH River catchment boundary, river channel network and Q_{MED}	Sub-licence of EA licence	Database uses Ordnance Survey data. Maps reproduced from Ordnance Survey material with the permission of Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office © Crown copyright. Unauthorised reproduction infringes Crown copyright and may lead to prosecution or civil proceedings. EA, 100026380 (2006)
CEH Land Cover Map (LCM2000)	Sub-licence of EA licence	EA sub-licence permits the production of paper maps from the data for use in reports and discussion documents.
Statutory nature conservation designations	Used with the permission of EN	EN are acknowledged as the owner of the information
Indicative floodplain outline and benefiting areas	Used with the permission of the EA	EA copyright and/or database rights 2006. All rights reserved.
UKBAP Priority habitats	Used with the permission of EN	EN are acknowledged as the owner of the information
British Geological Survey surface and drift geology	Sub-licence of EA licence number 2003/014WW	Reproduced from British Geological Survey Map data at the original scale of 1:50,000. British Geological Survey © NERC. All rights reserved.
Ordnance Survey contour data	Sub-licence of EA licence number 100026380	Maps reproduced from Ordnance Survey material with the permission of Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office © Crown copyright. Unauthorised reproduction infringes Crown copyright and may lead to prosecution or civil proceedings.
EA River Habitat Survey (RHS) data	Used with the permission of the EA	EA are acknowledged as the owner of the information

6.4 Review of broad habitat baseline and ecosystem drivers

This section uses the BSEA High Level fluvial methodology to develop an understanding of the drivers of fluvial ecosystems and their impacts on channel condition, floodplain connectivity and downstream continuity in the River Ribble catchment.

For demonstration purposes, Tools A1-8, B1-3 and C1 have been used (for guidance see Section 5 and Appendix 1). Figures in the text display the GIS datasets used to develop the catchment understanding. These individual figures are indicative only as they cannot be reproduced in paper copy at the various scales that they were used to interpret in GIS – GIS allows greater scrutiny of the data at a variety of scales (zooming in and out) that cannot be replicated in hard copy guidance. However, it is recommended that the GIS is used in this interactive mode when identifying drivers and their interactions/ implications for catchment function.

Following development of the catchment understanding, biodiversity opportunities and constraints in the catchment relevant to flood management policy have been developed through the identification of broad scale ecosystem criteria (BEC, see also Section 5.3). BEC are illustrated through the incorporation of overlay diagrams, for illustrative purposes (see Diagrams 6.1 to 6.15).

Where the BEC provide for the maintenance of ecosystem function, it is termed a protection BEC. Where biodiversity opportunities are identified which may arise from a change in flood management policy or activity, they are termed enhancement BEC. Areas identified as protection BEC may also provide opportunities for enhancement.

6.4.1 Channel condition

Channel condition can be described by the river's hydrological and morphological regime, linked to the establishment of characteristic habitats and their associated communities and species. The hydrological regime is described using summary data for the catchment and an assessment of surface runoff potential. The geomorphological regime is described using six data layers prepared in GIS. These layers are illustrated separately in Figure 6.2, as:

a. Substrate erodibility,
b. Channel gradient,
c. Catchment sediment sources,
d. Channel modification,
e. Morphological continuity, and
f. Surface runoff potential.

In addition, a fluvial audit and two smaller geodynamics assessments were identified in the catchment and were used to supplement the GIS assessment.

Ecological data at the broad scale are relatively limited, particularly as they relate to in-channel habitats and communities. Catchment-wide biological GQA data (for the macroinvertebrate community) supplied by the EA are awaited and will be introduced when the GIS layer is forwarded. Description of the broad scale ecology of the catchment would benefit from expert stakeholder consultation, although this has not been possible to date given the sensitivity of the catchment and the emerging consultation status of the CFMP.

Hydrological regime

The flow duration curves from key gauging stations show that the 50 percentile (Q_{50}) flow in the river system throughout the catchment is relatively high and consistent at about 0.013 to 0.015 m^3/km^2. Values on the River Darwen, a tributary in the southern extremity of the catchment, are slightly higher at about 0.019 m^3/km^2.

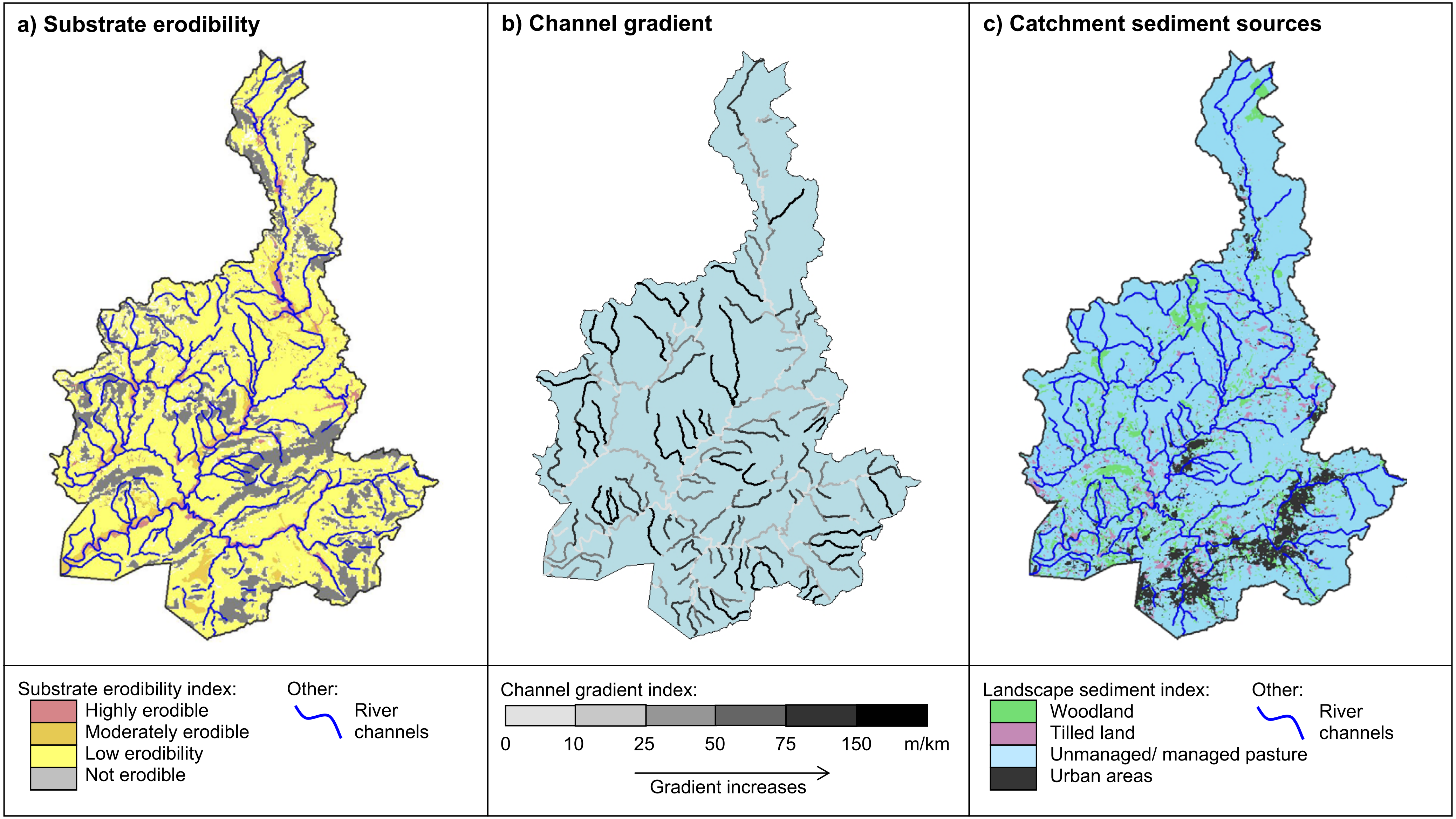


Figure 6.2 Ribble catchment: Channel condition

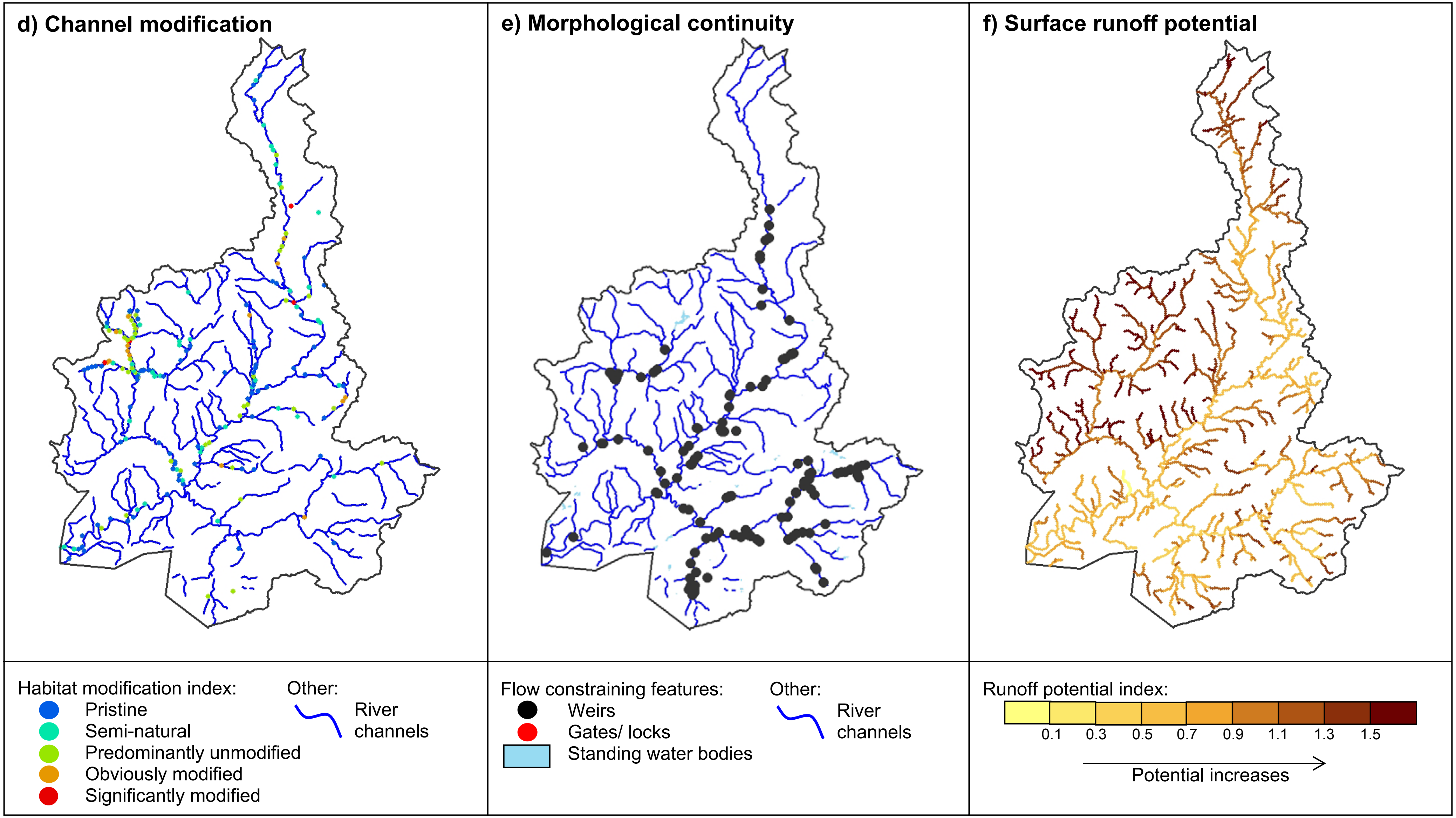


Figure 6.2 Ribble catchment: Channel condition (continued)

Low flows are also consistent throughout the catchment, indicating that there are no areas where there are likely to be significant stresses on ecosystems due to water shortages under normal conditions (except perhaps the Brennand and Whitendale). Values of low flow per unit area (defined using the Q_{95}) are slightly lower in the upper catchment reflecting the more flashy nature of the upper Ribble, where runoff is high and baseflow is relatively low.

Whilst flood risk is covered in CFMPs, it is important to include Q_{MED} in an ecosystem assessment as it the channel forming discharge and is representative of flows that sustain wetlands. The flood flow data shows that the Ribble has relatively high flood flows throughout the catchment, with values of Q_{MED}/A ranging from about 0.5 in the lower catchment to 1.5 in the upper tributaries. This reflects the relatively high annual average rainfall (in the range 1,200 to 1,800 mm) and mean annual runoff (800 to 1,200 mm), and the general steepness of the catchment. Thus surface runoff potential is high to very high throughout the catchment.

The impacts of climate change have the potential to cause an increase in the already high flood flows, leading to an increase in the frequency and magnitude of floodplain inundation. The expected reduction in summer rainfall will lead to lower base flows and, in particular, reductions in very low flows.

Geomorphological regime

The Ribble catchment is characterised by two sub-catchments, the Hodder and the Calder, in addition to the main River Ribble. The Ribble is a long narrow drainage system dominated by the single main channel compared with the Hodder and Calder which have a more dendritic drainage network. The Ribble and Hodder are largely unmodified with EA RHS habitat modification scores (HMS) indicating semi-natural river reaches. The Calder is urbanised through the central sections and is likely to be impacted by problems commonly associated with urban channels.

Sediment sources

The headwater tributaries of all three catchments are characterised by high gradients, thus they have potential for active natural erosion. Superficial geology is predominantly of low erodibility in the upper reaches and in the Calder and Hodder the drainage network flows over solid geology resulting in bedrock dominated rivers (or boulder bed). This will limit the rate of supply of sediment to the channel through in channel erosion. Local sourcing of sediment will be from active reworking of fluvial deposits as some of the upper reaches of the main channels are likely to be mobile gravel bed or from direct hillslope to channel supply. In addition, land cover is predominantly scrub, heath and woodland in the upper reaches thus supply will be reduced compared with managed grassland or tilled land found lower down in the catchment. There is a section of more erodible alluvium along the Ribble downstream of Settle which may be contributing fine sediment into this system. More extensive alluvial tracts are to be found along the floodplain sections of the Ribble and lower Calder and fine sediment is likely to be sourced locally from these sections. The central sections of the Calder are urbanised and will be impacted by direct supply of urban runoff.

Sediment transfer

The river system has the potential to transfer sediment although the gradient of the Ribble is low in parts of the upper catchment, due to the length in the system. Sediment transfer is therefore likely to be ‘pulsed’ during high flow events with temporary storage of sediment in-channel features (consistent with upland gravel bed rivers) providing diverse morphology and habitat. Downstream continuity of sediment transfer is limited on the Calder due to the number of in channel weirs and structures. The sediment system is relatively unmodified on the Hodder although there are several weirs on the main river which will disrupt sediment transfer to downstream reaches. On the Ribble there are several sections where there are several consecutive weirs limited sediment supply downstream.

Sediment storage

The largest sediment sink in the Ribble catchment is Stocks reservoir on the Hodder. The catchment above this point is relatively small and so the volume of sediment from the channel and surrounding catchment that is prevented from reaching the channel lower down will be small. Much of the coarse material in the Ribble catchment supplied from the hillslope and through natural bank erosion will be stored within the channel. It is unlikely given the land cover that there is a general pattern of accelerated (excessive) supply of fine sediment except locally where there is a specific cause (cattle poaching) and sedimentation is unlikely to be a widespread problem except at weirs. The number of weirs on sections of the Ribble (downstream of Settle) and through sections of the Calder will result in points of sediment accumulation and starvation which could be resulting in localised impacts of the sediment regime. Floodplain storage in the catchment is relatively limited until the lower reaches but the functional floodplain (resulting from limited extent of flood embankments) in the lower parts of the Calder and Ribble will allow transfer of sediment onto the floodplain out of the river system and floodplain should be preserved.

Summary of river form and function

The Ribble and Hodder are largely unmodified catchments where localised weirs and in-channel structures are likely to constitute the greatest impact on the sediment regime. The Calder has large urban areas resulting in issues affecting urban rivers including bank protection, re-sectioning and reprofiling. These directly affect the physical structure of the river (reflected in the Habitat Modification Scores) and impact upon sediment transfer to downstream floodplain sections.

Fine sediment supply is unlikely to be a major issue in the catchment although lower gradients in the central sections of the Ribble suggest that there is the potential for sedimentation locally and measures should be taken to prevent sourcing of fine material from poor land management practises which could accelerate sedimentation in areas where there is potential.

Sediment starvation may be an issue for river reaches downstream of urban areas particularly in the Calder where the urban area divides the upper catchment where sediment is likely to be supplied from the lower main river. Effects of this may be bed lowering or channel expansion. Where gravel is supplied into urban channels, maintenance removal of gravel could be causing a negative impact on channel morphology and diversity.

Nature conservation designations and ecological status

Figures 6.3 and 6.4 identify the international and national designations within the catchment as well as identifying which SSSIs EN consider to be in favourable condition. As can been seen the majority of SSSI in the catchment are considered to be in unfavourable condition.

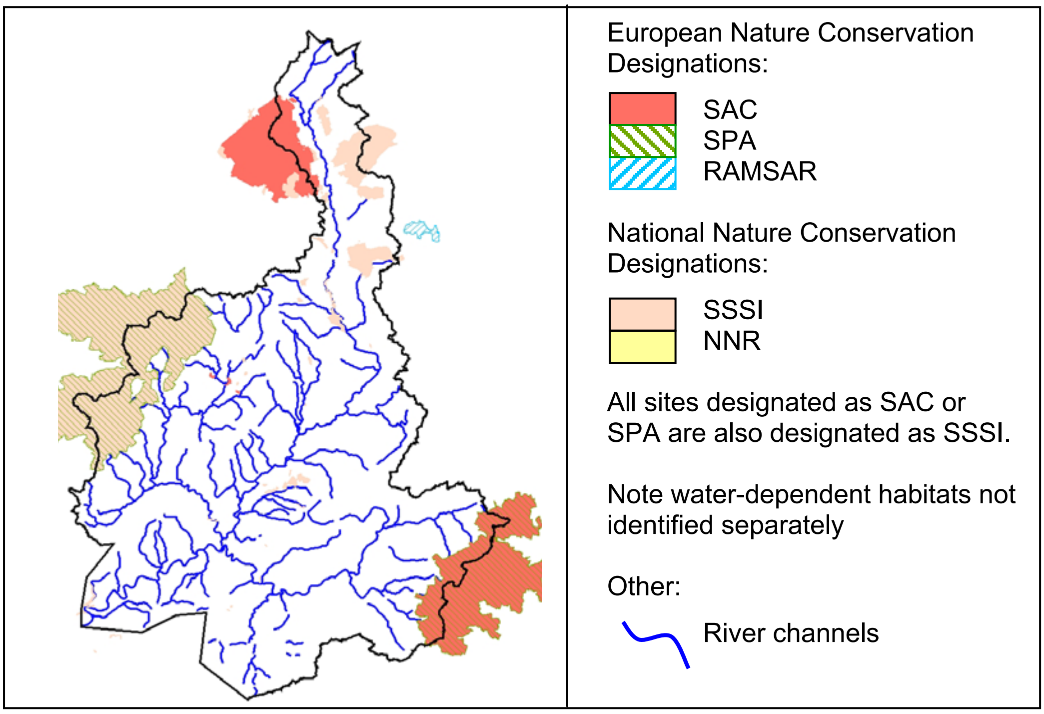


Figure 6.3 Ribble Catchment: Nature conservation designations

Information relating to SACs are provided in Table 6.2. Issues surrounding use of this information includes:

- Water-dependent protected areas are not identified separately from terrestrial habitats.
- Reasons for sites being in unfavourable condition is unknown

Table 6.2 Qualifying features for SAC in the Ribble catchment

Site Name	Qualifying features
Ingleborough Complex SAC	• Alkaline fens - Spring-fed flush fens. They are often species-rich communities rare or locally distributed species (black bog-rush *Schoenus nigricans*)
South Pennine Moors SAC	• Blanket bogs • Northern Atlantic wet heaths with *Erica tetralix* • Transition mires and quaking bogs

Gathering information on the structure, function and status of designated sites in order to better understand the catchment will form an important part of any subsequent consultation phase.

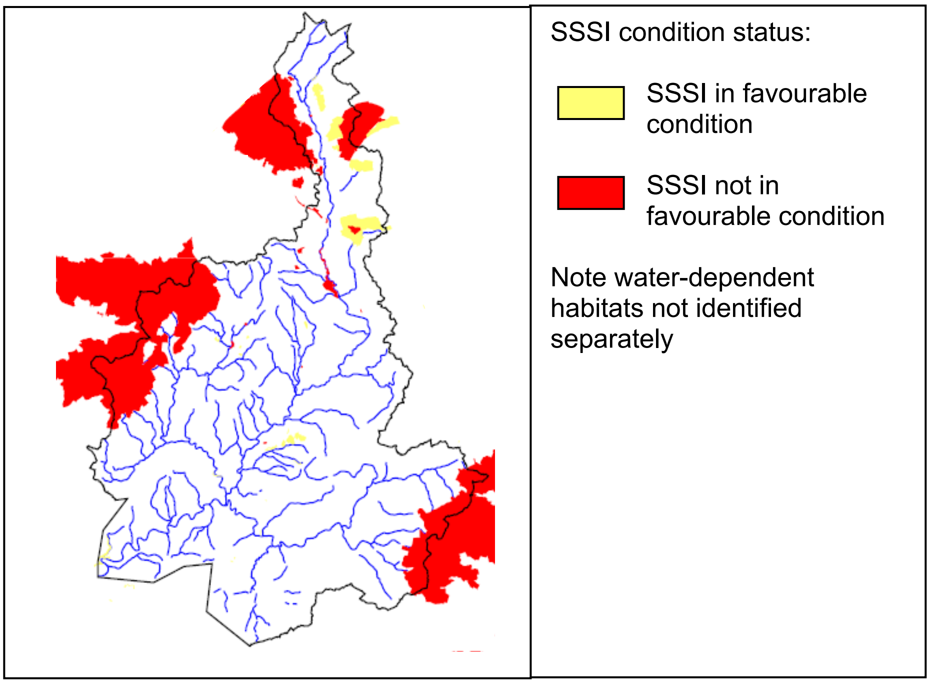


Figure 6.4 Ribble Catchment: SSSI condition status

Natural Area Targets data have been taken from EN's website. The Ribble catchment contains all or part of four Natural Areas as follows:

- Yorkshire Dales (Natural Area 8),
- Forest of Bowland (Natural Area No 12),
- Lancashire Plain and Valleys (Natural Area 13), and
- Southern Pennines (Natural Area 14).

From these areas, the range of potentially appropriate targets for freshwater UK BAP Priority Habitats include:

Protection
- Blanket bog,
- Fens,
- Purple moor grass and rush pastures, and
- Coastal and floodplain grazing

Enhancement
- Blanket bog,
- Lowland raised bog,
- Fens,
- Purple moor grass and rush pastures,

marsh.

- Coastal and floodplain grazing marsh, and
- Eutrophic standing water.

The Natural Area Targets will form the basis for refining BEC within the consultation phase. For example, although opportunities and areas for wetland habitat creation may have been identified, it will be the role of the consultation group to establish, where possible, the preferred habitat type to be created (i.e. floodplain grazing marsh, blanket bog, fen/ reedbed, rush pasture, standing water etc).

Further broad scale ecological data are scarce. The macroinvertebrate GQA results for 2004 are presented as Figure 6.5. Although the ecological data effectively synthesise all of the potential environmental pressures (including point and diffuse pollution effects, low flow problems etc.) they give a guide to the health of the in channel community and indicate areas that are in good condition or require improvement. Figure 6.5 indicates the main stem of the River Ribble is of generally good quality (Class B). Generally, the Hodder sub-catchment is of very good quality (Class A) and the Calder sub-catchment of fairly good quality (Class C). This reflects the urbanised nature of the Calder sub-catchment, and fewer water quality pressures on the Hodder sub-catchment and upper Ribble catchment.

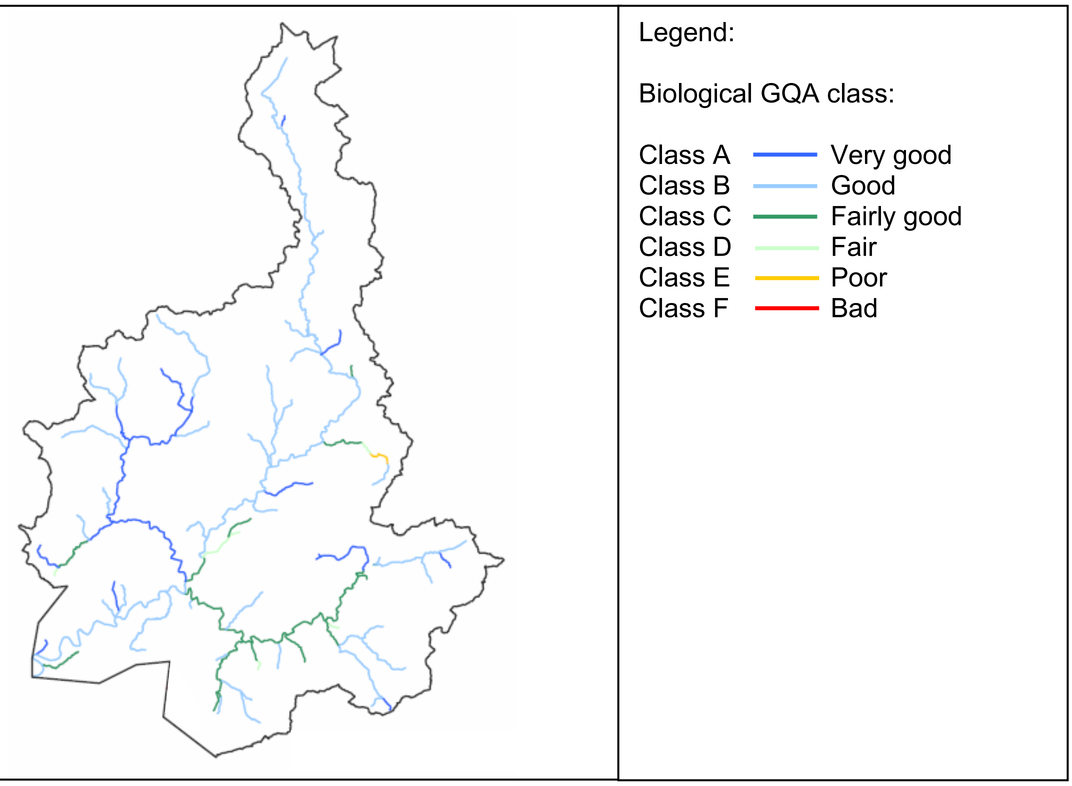


Figure 6.5 Ribble catchment: Biological general quality assessment

6.4.2 Floodplain connectivity

Three data layers have been prepared in GIS to develop an understanding of floodplain connectivity (see also Appendix 1, Toolbox B). These layers are illustrated separately in Figure 6.6, as:

a) Floodplain areas and existing defences
b) Active ecological floodplain and gathering grounds
c) Land cover in potential floodplain areas.

Figure 6.6a shows that the majority of significant floodplain is located along the middle/lower reaches of the River Ribble, and lower reaches of the River Calder. Existing flood defence protection is located, not surprisingly, around and within the main urban areas of Settle, Clitheroe, Blackburn, Accrington, Burnley, Nelson and Colne.

Figure 6.6b shows that the wetland priority (UK BAP) habitats are situated either in areas of functioning floodplain (floodplain grazing marsh in the middle and lower Ribble catchment) and within the upper reaches and gathering grounds (mainly blanket and lowland bogs located throughout the upper reaches of the whole catchment).

Figure 6.6c shows that the catchment is noticeably divided into three main land use types:

- The urban areas along the Ribble and Calder/ Colne Water,
- Agricultural grassland in the floodplain and lowland parts of the river network, and
- Semi-natural scrub/heath/woodland and grassland in the upland parts of the catchment.

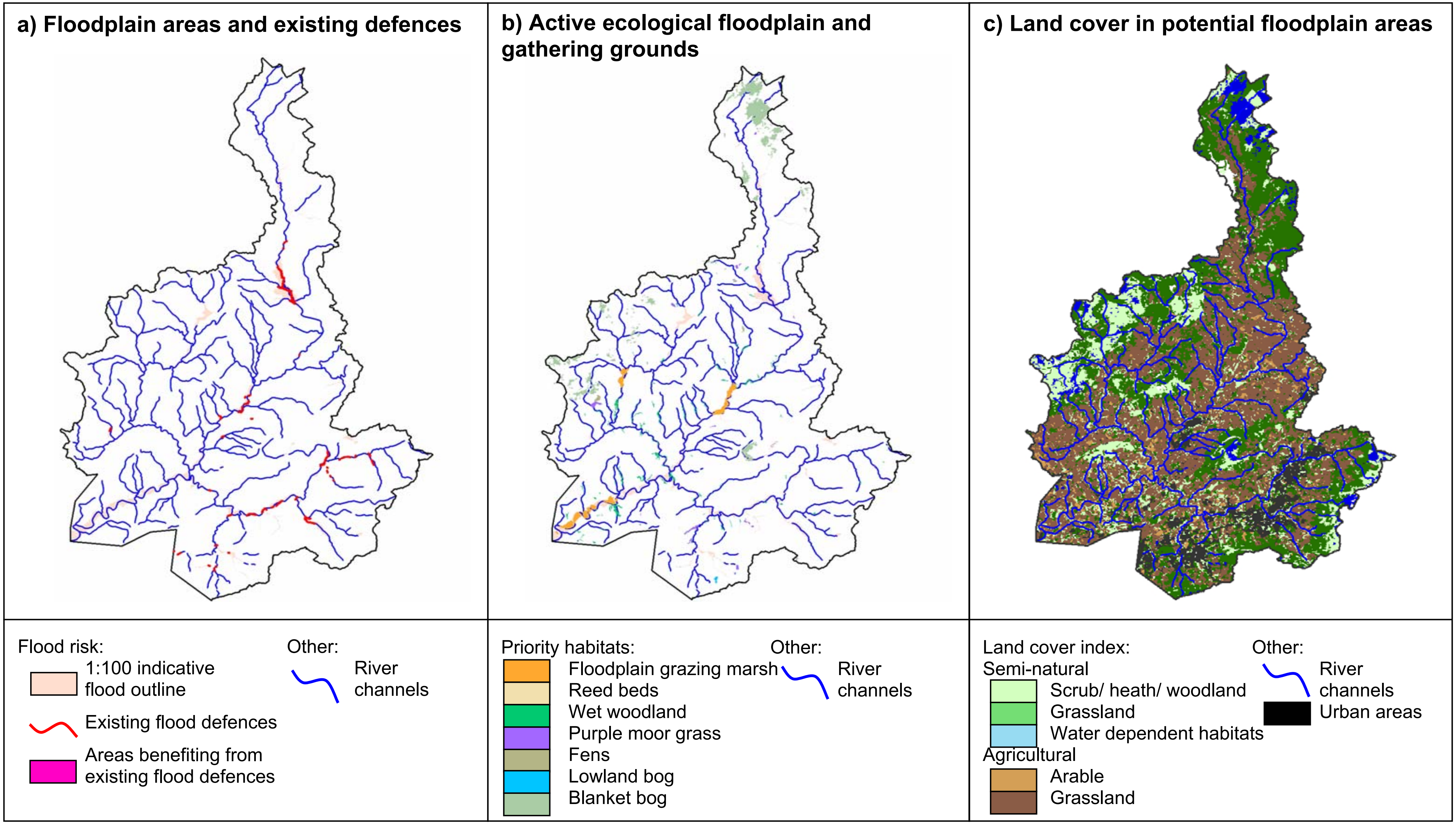


Figure 6.6 Ribble catchment: Floodplain connectivity

6.4.3 Channel continuity

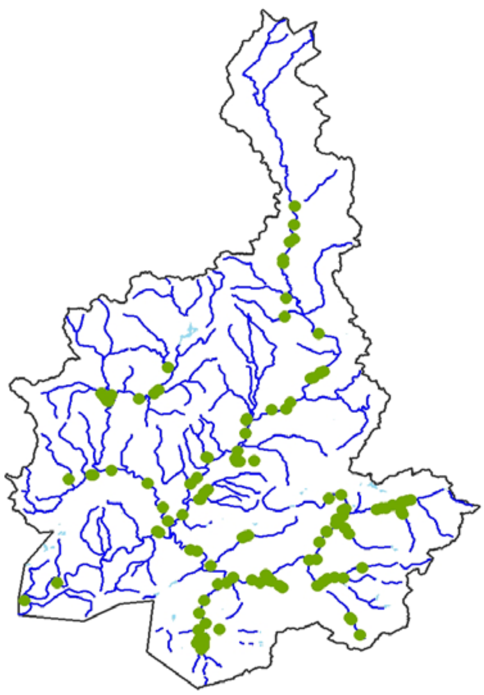
Figure 6.7 shows that the Ribble system is heavily managed and affected by numerous weir structures, which are located virtually all the way along the rivers Ribble, Calder and Hodder.

However, what is unknown at present is information relating to:

- Weir height and head difference, and
- Location of fish passes and bypass channels.

The above information is not contained within the NFCDD. Gathering additional information on structures would form an important component of the expert consultation phase.

In addition, what are also noticeable on Figure 6.7 are the on-line reservoirs in the upper Hodder catchment. They are water supply reservoirs and therefore outside the remit of flood risk management, although they form a barrier to migration. This does however, have implications for identifying BEC Opportunities (i.e. there is no point easing fish passage above an on-line reservoir (Stocks Reservoir) which is itself a barrier to migration).



Legend:

Features potentially constraining ecological movement:

- Weirs
- Standing water bodies

Other:

- River channels

Figure 6.7 Ribble catchment: River continuity

6.4.4 Broad scale ecosystem criteria (BEC) for channel condition

The understanding of channel condition in the Ribble catchment has provided one protection BEC and five enhancement BEC relevant to flood management policy. These are illustrated and described below and summarised in Table 6.4.

(see Section 5.3 for methods for BEC derivation). In each of the diagrams (below), the legend is consistent with the appropriate figure.

BEC 1: Maintain good morphological functioning

The upper Ribble is largely unmodified and is an active, diverse geomorphological system (see Diagram 6.1). The length and shape of the catchment means that much of the upper catchment is likely to be fed from direct hillslope supply rather than a large tributary network. Sediment transfer through the system is currently unimpeded until downstream of Settle and this should be preserved to allow the continued functioning of the sediment regime. Low gradients observed in some sections of the upper Ribble indicate a potential for sediment storage, possibly fine sediment storage in places. Accelerated fine sediment supply should therefore be limited where possible through good land and riverside management practises otherwise fine sedimentation over gravels may occur locally.

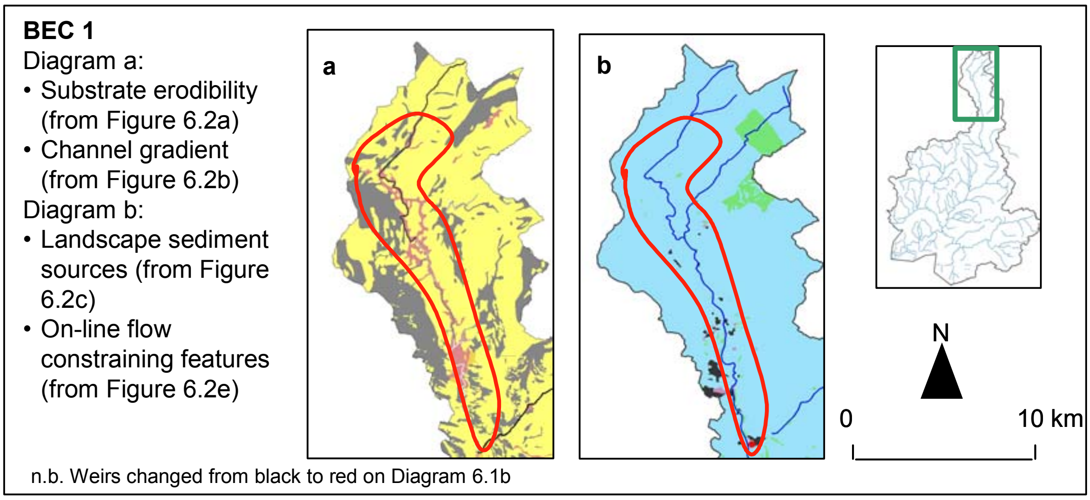


Diagram 6.1 Maintain status of sediment supply in upper Ribble catchment

BEC 2-4: Enhance channel to improve sediment regime and habitats

A series of weir structures downstream of Settle are reducing continuity of sediment transport through this section (see Diagram 6.2). It is recommended that the function of weirs and associated bank protection through these sections is reviewed as part of any flood risk management initiatives to identify opportunities for river enhancement. Similarly in the Hodder, weirs currently fall within an area of semi-natural HMSs and removal of structures could add additional benefit to sediment supply (see Diagram 6.3). Feasibility studies could identify whether or not this would bring positive benefit. Through the urbanised sections of the Calder opportunities for river restoration should be sought to improve the in-channel sediment regime (see Diagram 6.4). In all sections continuity of the sediment regime is disturbed and modification through structures will have had some direct level of impact on the physical structure of the channel.

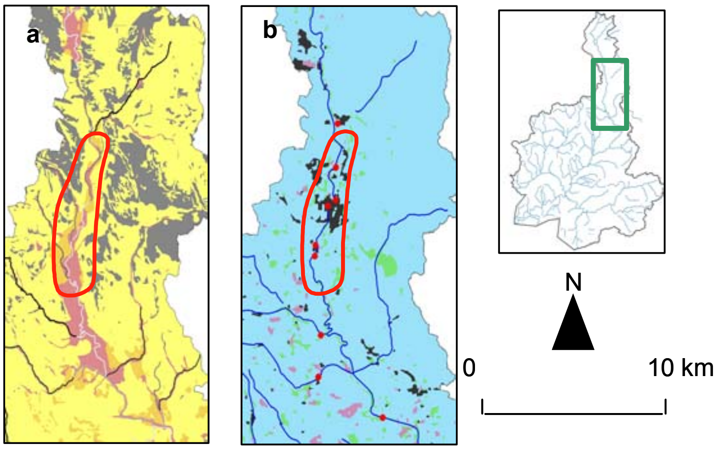
BEC 2

Diagram a:

- Substrate erodibility (from Figure 6.2a)
- Channel gradient (from Figure 6.2b)

Diagram b:

- Landscape sediment sources (from Figure 6.2c)
- On-line flow constraining features (from Figure 6.2e)



n.b. Weirs changed from black to red on Diagram 6.2b

Diagram 6.2 Enhance channel to maintain downstream continuity of sediment transfer in the upper Ribble

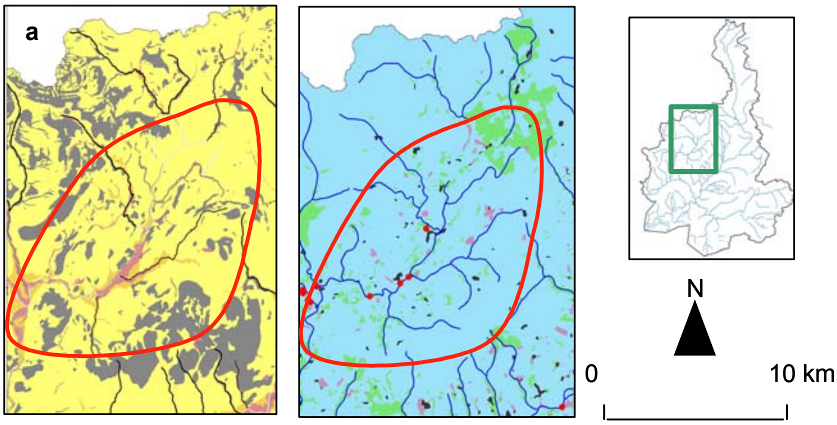
BEC 3

Diagram a:

- Substrate erodibility (from Figure 6.2a)
- Channel gradient (from Figure 6.2b)

Diagram b:

- Landscape sediment sources (from Figure 6.2c)
- On-line flow constraining features (from Figure 6.2e)



n.b. Weirs changed from black to red on Diagram 6.3b

Diagram 6.3 Enhance channel to maintain downstream continuity of sediment transfer in the upper Hodder catchment

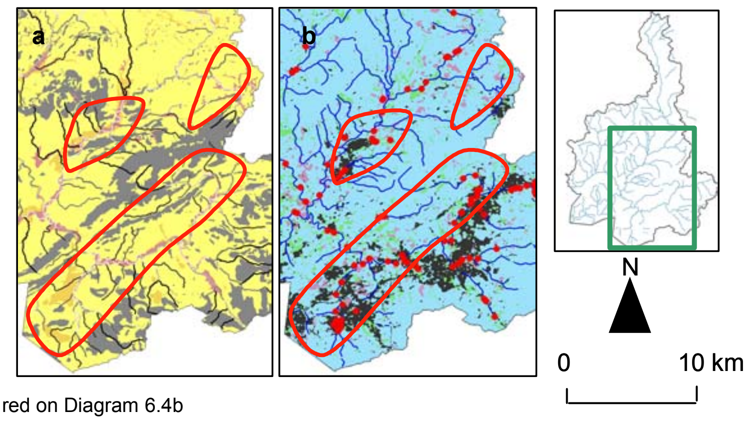
BEC 4

Diagram a:

- Substrate erodibility (from Figure 6.2a)
- Channel gradient (from Figure 6.2b)

Diagram b:

- Landscape sediment sources (from Figure 6.2c)
- On-line flow constraining features (from Figure 6.2e)



n.b. Weirs changed from black to red on Diagram 6.4b

Diagram 6.4 Enhance channel to physical structure and sediment regime in the Calder catchment

BEC 5: Attenuation of surface water runoff

Surface runoff potential in the upper Hodder catchment is classed as being high, which could lead to increased risk of flash flooding lower down the catchment (see Diagram 6.5). Land use in that part of the catchment is predominantly unmanaged or managed pasture. BEC5 therefore recognises that there is potential for land management changes which could reduce surface water runoff (i.e. flood storage areas, measures such as implementing buffer zones/ forestation, or altering soil management such as reducing/ changing livestock). Biodiversity opportunities exist through these management actions, including the potential to enhance and extend moorland habitat diversity and in-stream habitat quality.

BEC 5
- Landscape sediment sources (from Figure 6.2c)
- Surface run-off potential (from Figure 6.2f)

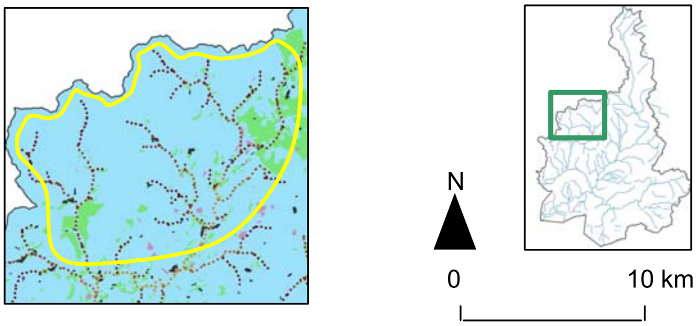


Diagram 6.5 Attenuate surface water runoff in the upper Hodder catchment

BEC 6: Promote land use change

Surface runoff potential in the top of the River Calder and Colne Water catchments is high, and sediment sources are such that sediment erosion could be an issue (see Diagram 6.6). Land use is semi-natural scrub/woodland and grassland in the upper parts of the catchment but turn to agricultural grassland lower down before the rivers enter the urban areas of Burnley, Nelson and Colne. BEC6 therefore recognises that there is potential for land use change (i.e. conversion of agricultural to semi-natural) or for land management change (implementation of buffer zones) which may not only attenuate water but importantly reduce sediment transport into the urban reaches.

BEC 6
Diagram a:
- Land cover in potential floodplain areas (from Figure 6.3b)
- Channel gradient (from Figure 6.2b)

Diagram b:
- Landscape sediment sources (from Figure 6.2c)
- Surface run-off potential (from Figure 6.2f)

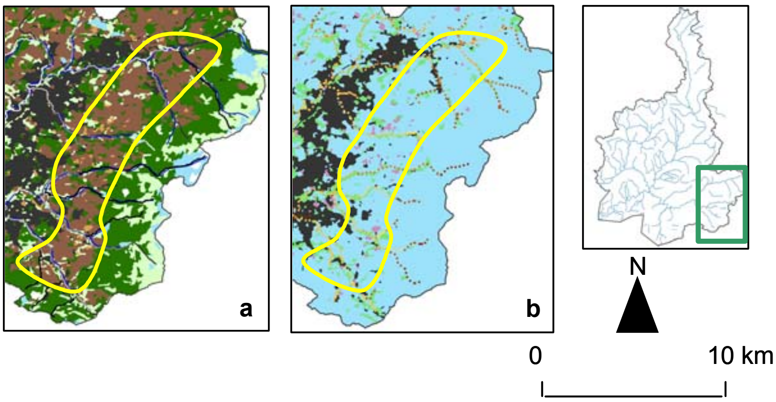


Diagram 6.6 Promote land use change/ changed land management in the upper Calder catchment

6.4.5 Broad scale ecosystem criteria (BEC) for floodplain connectivity

The understanding of floodplain connectivity in the Ribble catchment has provided 3 protection and 4 enhancement BEC relevant to flood management policy. These are illustrated and described below, as summarised in Table 6.4. In each of the diagrams(below), the legend is consistent with the appropriate figure (above) is used.

BEC 7-9: Protect floodplain connectivity

The presence of active ecological floodplain is demonstrated through the mapping of appropriate BAP priority habitats in Figure 6.6b. Active ecological floodplain habitat is well represented in the catchment, particularly in the middle Ribble (Diagram 6.7) and middle Hodder (Diagram 6.8), and throughout the lower Ribble catchment (Diagram 6.9). Flood management policy should ensure the protection of floodplain habitats in these locations, through maintenance of a suitable hydrological regime and appropriate bank modifications. The potential may exist for enhancement or expansion of floodplain habitat in these locations.

BEC 7
- Floodplain areas (from Figure 6.3a)
- Active ecological floodplain (from Figure 6.3b)

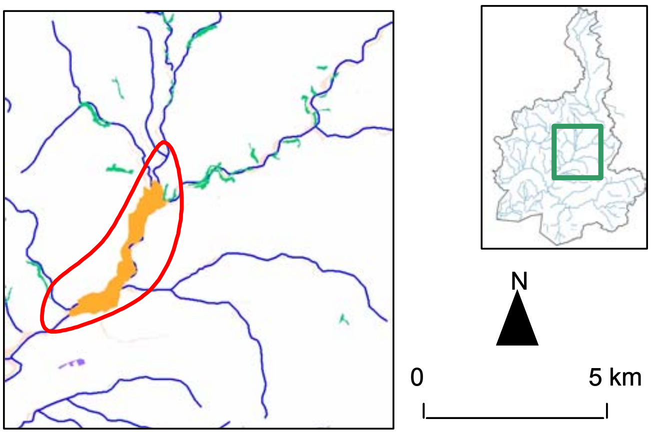


Diagram 6.7 Active ecological floodplain (middle Ribble catchment)

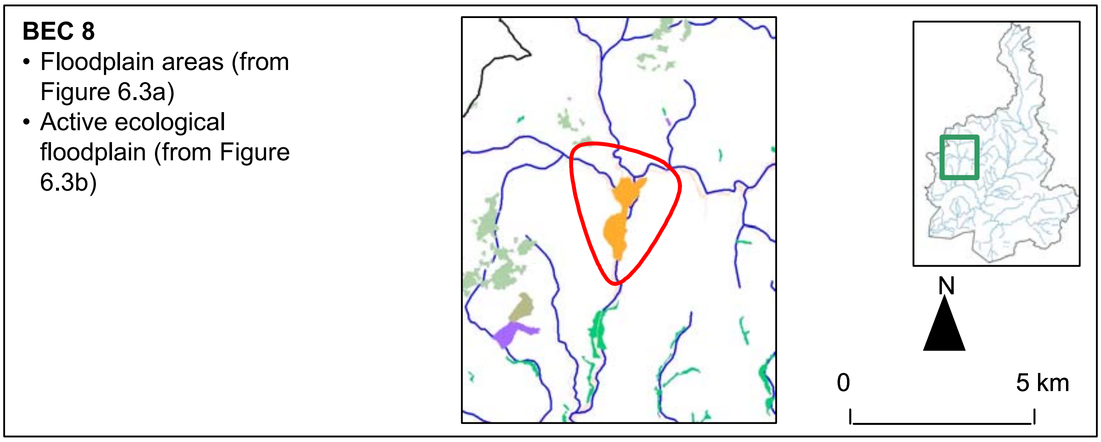


Diagram 6.8 Active ecological floodplain (middle Hodder catchment)

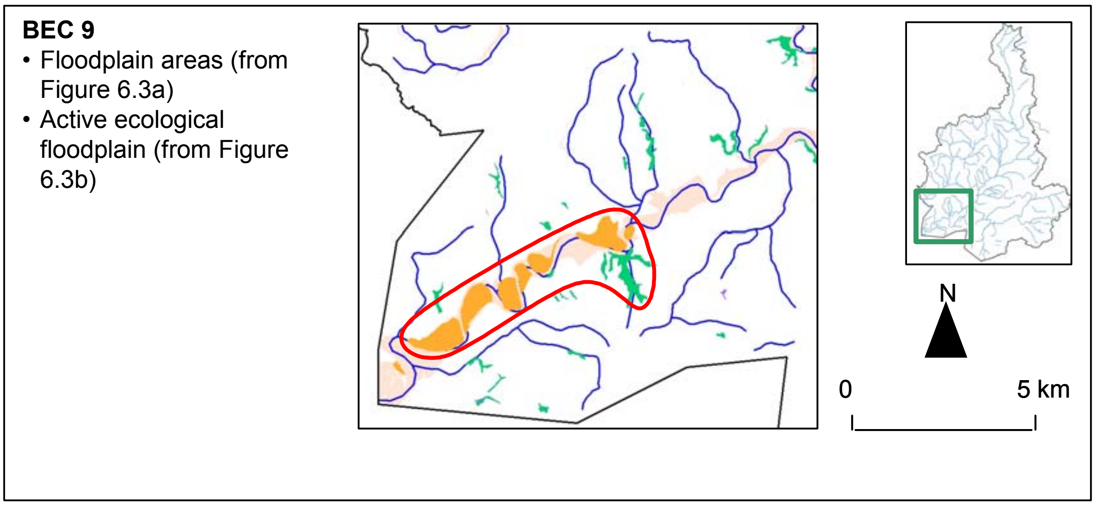


Diagram 6.9 Active ecological floodplain (lower Ribble catchment)

BEC 10-13: Re-connect floodplain

In floodplain areas without active ecological floodplain, the opportunity may exist for reconnection of the channel to the floodplain to enhance biodiversity. Potential areas are characterised by a 1:100 year return period flood outline (Figure 6.6a) but without riparian habitats (Figure 6.6b). The potential is low in urban areas, with the exception of parkland. The presence of flood embankments (Figure 6.6a) and the current land cover type (Figure 6.6c) assist in identifying suitable areas. Agricultural land (Figure 6.6c) benefiting from flood defences (Figure 6.6a) is potentially suitable, where abandonment of the defences and a change in land management practice would be required. Such areas exist in the upper Ribble catchment (Diagram 6.10) and the Calder Catchment (Diagram 6.11). Agricultural land (Figure 6.6c) within the 1:100 year return period flood outline is also potentially suitable, where a change in land management practice and potentially modification to the channel or floodplain would be required. Such areas exist in the lower Ribble catchment (Diagram 6.12) and throughout the indicative floodplain associated with the confluence of the Rivers Hodder and Ribble and the confluence of the Rivers Calder and Ribble 1km downstream (Diagram 6.13).

BEC 10

- Floodplain areas (from Figure 6.3a)
- Active ecological floodplain (from Figure 6.2b)
- Land cover in potential floodplain areas floodplain (from Figure 6.3c)

n.b. The land cover has been cut to display land cover within the 1:100 indicative flood outline

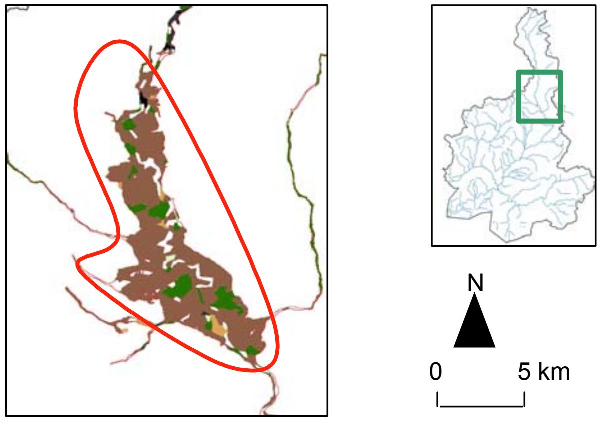


Diagram 6.10 Opportunity for ecological floodplain (upper Ribble catchment)

BEC 11

- Floodplain areas (from Figure 6.3a)
- Active ecological floodplain (from Figure 6.2b)
- Land cover in potential floodplain areas floodplain (from Figure 6.3c)

n.b. The land cover has been cut to display land cover within the 1:100 indicative flood outline

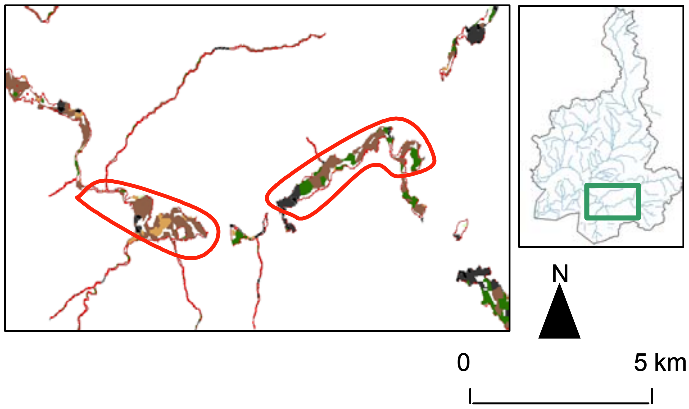


Diagram 6.11 Opportunity for ecological floodplain (Calder catchment)

BEC 12

- Floodplain areas (from Figure 6.3a)
- Active ecological floodplain (from Figure 6.2b)
- Land cover in potential floodplain areas floodplain (from Figure 6.3c)

n.b. The land cover has been cut to display land cover within the 1:100 indicative flood outline

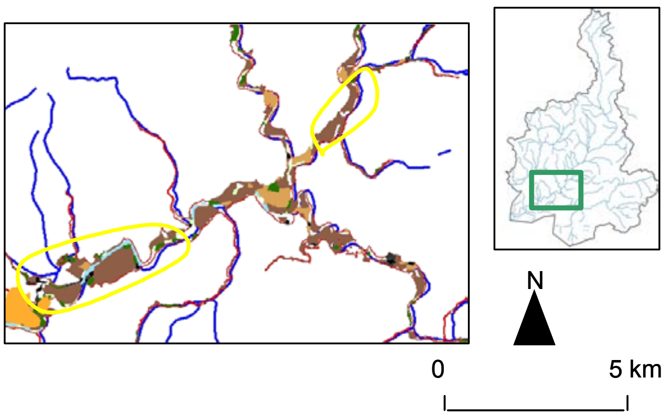


Diagram 6.12 Opportunity for ecological floodplain (lower Ribble catchment)

BEC 13

- Floodplain areas (from Figure 6.3a)
- Active ecological floodplain (from Figure 6.2b)
- Land cover in potential floodplain areas floodplain (from Figure 6.3c)

n.b. The land cover has been cut to display land cover within the 1:100 indicative flood outline

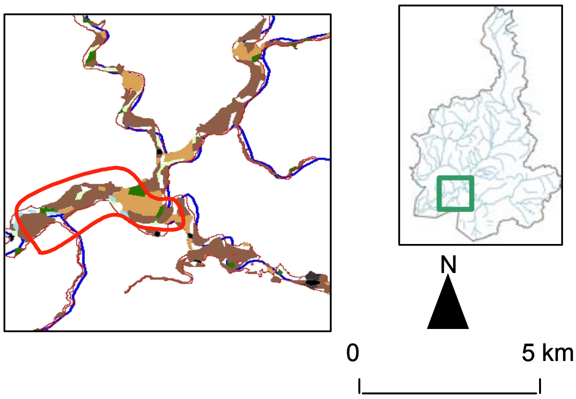


Diagram 6.13 Opportunity for ecological floodplain at the Ribble/ Hodder and Ribble/ Calder confluences

6.4.6 Broad scale ecosystem criteria for river continuity

The understanding of river continuity in the River Ribble catchment has provided 2 enhancement BEC relevant to flood management policy. These are illustrated and described below, summarised in Table 6.4. (see also Appendix 1, Toolbox C). In each of the diagrams below), the legend is consistent with the appropriate figure (above).

BEC 14-15: Overcome ecological barriers

The locations of in-channel barriers which may act as a barrier to ecological movement identified a number of weirs on the main channel and several clustered groups. Without local knowledge (e.g. from a site visit), the height of these weirs, their location on the main channel and the presence of fish passes cannot be confirmed. Attention is drawn to the cluster of 6 weirs in the middle Hodder catchment (Diagram 6.14) and the stretch of 8 weirs apparently on the main channel in the middle Calder catchment (Diagram 6.15).

BEC 14

- Features potentially constraining ecological movement (from Figure 6.4)

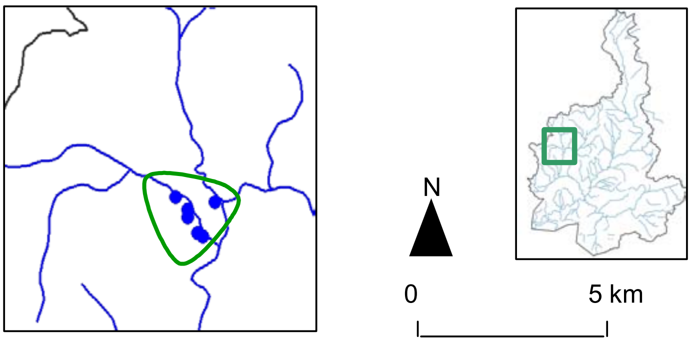


Diagram 6.14 Remove ecological barrier effect of weirs in the middle River Hodder

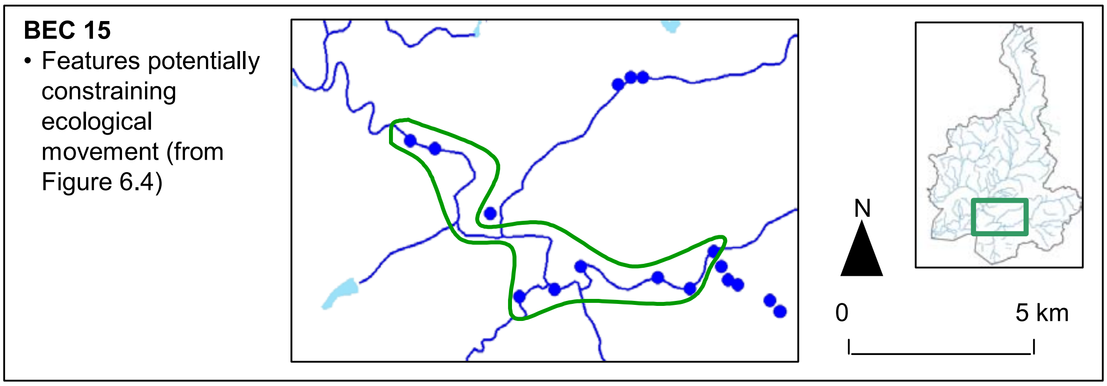


Diagram 6.15 Remove ecological barrier effect of weirs and culverts in the Calder catchment

6.5 Summary of broad scale ecosystem criteria in the Ribble catchment

The protection and enhancement BEC identified above have been summarised in Table 6.3. This includes identification of the BEC for each broad habitat type, listing the potential flood management actions to realise the BEC, together with the potential ecosystem benefits. Spatial context to the BEC is provided as Figure 6.8.

In developing the summary of BEC for use to inform policy development, Table 6.3 has been developed further to list, for each BEC, the potential flood management consequences and the potential cost of management actions. Further information on establishing the potential flood management actions and their cost is presented below.

Table 6.3 Broad scale ecosystem criteria in the Ribble catchment

Broad scale Ecosystem Criteria			Potential management actions	Potential ecosystem benefit	Potential flood management consequences	Additional funding streams
Channel condition	1	Maintain status of sediment supply in upper Ribble	No interruption of natural processes	Maintain downstream in-stream habitats through balance of coarse and fine sediment delivery	No upland storage in this area	Environmental stewardship scheme
	2	Enhance channel to maintain sediment supply and passage in the upper Ribble	Remove/ bypass in-stream obstructions and restore bank	Enhance downstream in-stream habitats through return to more natural sediment balance	Increase capacity for flood flow conveyance through flood risk areas. Reduce maintenance (fine sediment removal). Increase channel capacity.	Not identified
	3	Enhance channel through sediment supply control in upper Hodder catchment	Promote land use change/ changed land management to retain sediment on land (e.g. buffer strips)	Enhance in-stream habitats through reduction in fine sediment input	Increase landscape retention of water. Reduce maintenance (fine sediment removal).	Environmental stewardship scheme
	4	Enhance channel to maintain sediment supply and passage in urban areas	Remove/ bypass in-stream obstructions and restore bank	Enhance downstream in-stream habitats through return to more natural sediment balance	Increase capacity for flood flow conveyance through flood risk areas. Reduce maintenance (fine sediment removal). Increase channel capacity.	Not identified
	5	Attenuate surface water runoff in the upper Hodder catchment	Block moorland grips. Restore eroded gullies	Enhance and extend moorland habitat diversity (blanket bog, purple moor grass, lowland raised bog, wet woodland). Enhance in-stream habitats through reduction in fine sediment input.	Increase landscape retention of water. Reduce flood runoff. Reduce sediment transport	Environmental stewardship scheme
	6	Promote land use change/ changed land management in the upper Calder catchment	Promote land use change/ changed land management to retain sediment on land (e.g. afforestation)	Enhance in-stream habitats through reduction in fine sediment input	Increase landscape retention of water. Reduce maintenance (fine sediment removal).	Environmental stewardship scheme

Table 6.3 Broad scale ecosystem criteria in the Ribble catchment (continued)

Broad scale Ecosystem Criteria			Potential management actions	Potential ecosystem benefit	Potential flood management consequences	Additional funding streams
Floodplain connectivity	7	Protect connectivity of floodplain habitats in the middle Ribble	Maintain downstream in-stream habitats through balance of coarse and fine sediment delivery	Protect (or enhance) existing floodplain wetland habitat (floodplain grazing marsh, reedbed, wet woodland, ditch)	Maintain (or increase) flood flow attenuation (with benefit downstream)	Environmental stewardship scheme
	8	Protect connectivity of floodplain habitats in the middle Hodder catchment	No reduction in current flooding extent or pattern	Protect (or enhance) existing floodplain wetland habitat (floodplain grazing marsh, reedbed, wet woodland, ditch)	Maintain (or increase) flood flow attenuation (with benefit downstream)	Environmental stewardship scheme
	9	Protect connectivity of floodplain habitats in the lower Ribble	No reduction in current flooding extent or pattern	Protect (or enhance) existing floodplain wetland habitat (floodplain grazing marsh, reedbed, wet woodland, ditch)	Maintain (or increase) flood flow attenuation (with benefit downstream)	Environmental stewardship scheme
	10	Re-connect floodplain habitats in the upper Ribble	Channel, embankment or floodplain restoration	Restore or enhance/ extend floodplain wetland habitat (floodplain grazing marsh, reedbed, wet woodland, ditch). Also local in-stream habitat opportunities	Increase flood flow attenuation (with benefit downstream)	Environmental stewardship scheme
	11	Re-connect floodplain habitats in the Calder catchment	Channel, embankment or floodplain restoration. In urban areas, e.g. open culverts, utilise parkland for flood storage	Restore or enhance/ extend floodplain wetland habitat (floodplain grazing marsh, reedbed, wet woodland, ditch). Also local in-stream habitat opportunities	Increase flood flow attenuation (with benefit downstream)	Environmental stewardship scheme
	12	Re-connect floodplain habitats in the lower Ribble	Channel, embankment or floodplain restoration	Restore or enhance/ extend floodplain wetland habitat (floodplain grazing marsh, reedbed, wet woodland, ditch). Also local in-stream habitat opportunities	Increase flood flow attenuation (with benefit downstream)	Environmental stewardship scheme
	13	Re-connect floodplain habitats at the Ribble/Hodder and Ribble/Calder confluences	Channel, embankment or floodplain restoration	Restore or enhance/ extend floodplain wetland habitat (floodplain grazing marsh, reedbed, wet woodland, ditch). Also local in-stream habitat opportunities	Increase flood flow attenuation (with benefit downstream)	Environmental stewardship scheme

Table 6.3 Broad scale ecosystem criteria in the Ribble catchment (continued)

Broad scale Ecosystem Criteria			Potential management actions	Potential ecosystem benefit	Potential flood management consequences	Additional funding streams
River continuity	14	Remove/ bypass ecological barrier effect of weirs in the middle River Hodder	Remove/ bypass in-stream obstructions	Improve distribution of fish and mobile aquatic animals	Increase capacity for flood flow conveyance through flood risk areas. Reduce maintenance (fine sediment removal).	Not identified
	15	Remove/ bypass ecological barrier effect of weirs and culverts in the Calder catchment	Remove/ bypass in-stream obstructions and restore bank	Improve in distribution of fish and mobile aquatic animals. Local restoration of marginal in-stream vegetation	Increase capacity for flood flow conveyance through flood risk areas. Reduce maintenance (fine sediment removal).	Not identified

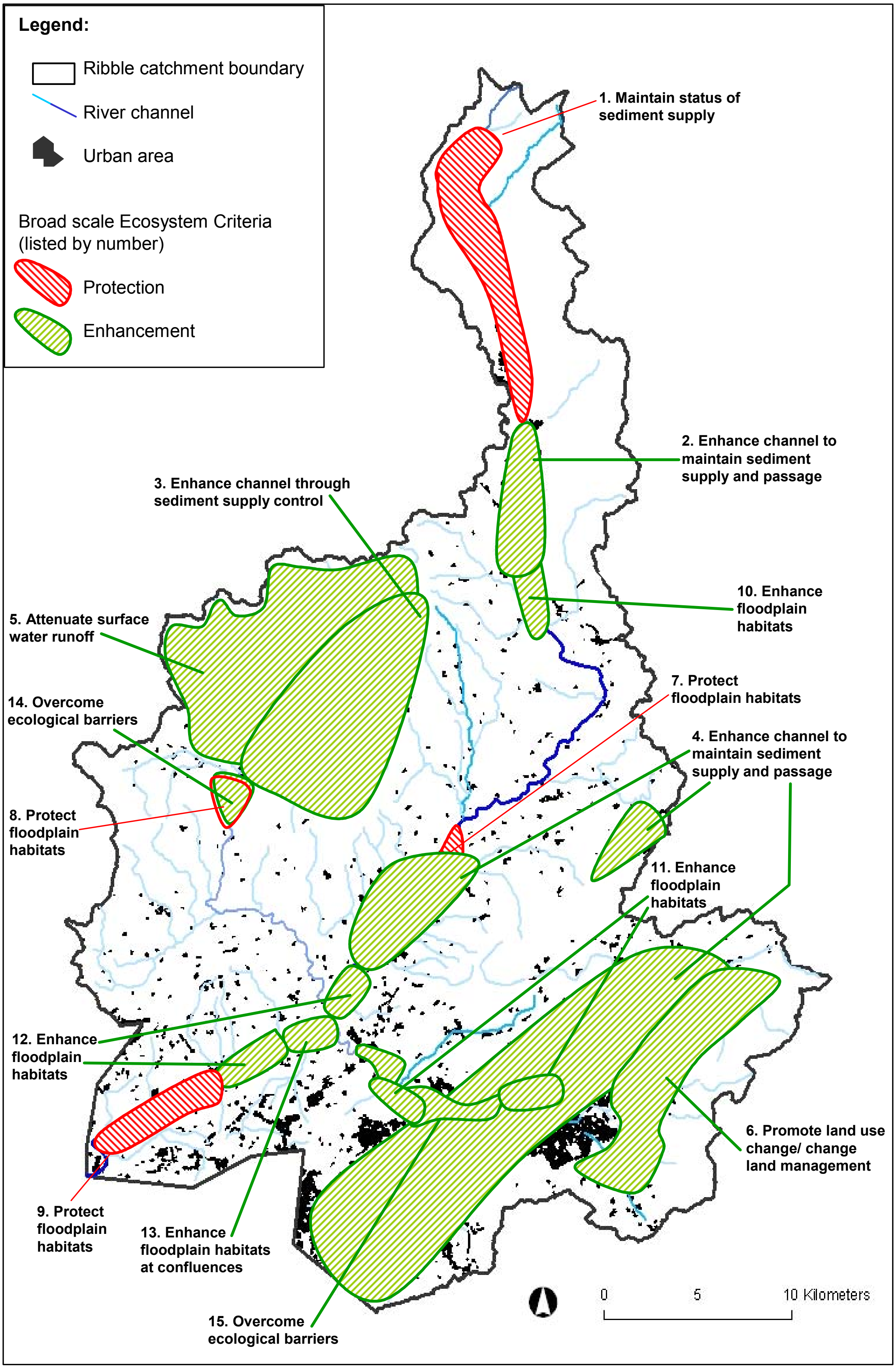


Figure 6.8 Ribble Catchment: Summary of broad scale ecosystem criteria

6.5.1 Potential management actions and funding streams

Land management

A number of the BEC would involve controls to be imposed on land management within the areas affected. Typically, this would mean less intensive agricultural production (e.g. by reducing stocking pressure and limiting land drainage efficiency) and the restoration of former natural and semi-natural habitats on the floodplains and moorland. The new Defra Environmental Stewardship scheme, launched in March 2005, provides opportunities for English farmers and land owners to receive annual payments for undertaking environmentally sympathetic farming operations to meet agreed environmental objectives for their particular location.

Entry Level Stewardship (ELS) is a 'whole farm scheme' open to all farmers and landowners which aims to secure widespread environmental benefits. Within ELS there are different payments for land parcels greater than 15ha in Less Favoured Areas (LFAs) and areas not in LFAs. LFAs are areas where the natural characteristics such as geology, altitude and climate make it more difficult for farmers to compete. In England the designated LFAs are mainly in upland areas. Most of the Ribble catchment (upstream of Clitheroe and including Longridge Fell), the Hodder catchment and the Calder catchment are located within the LFA designation (see Table 6.4). This means that the farmers are already entitled to additional farming subsidies, such as the Hill Farm Allowance (HFA). HFA is a scheme which provides dedicated support to beef and sheep producers who farm the LFAs. It recognises the difficulties that farmers face in these regions and the vital role that they play in maintaining the landscape and rural communities of the hills. The payment level for ELS within LFAs is £8/ha/year (for land parcels >15ha) for a five year agreement. Outside LFAs the ELS payment level is £30/ha/year for a five year agreement.

Table 6.4 Less Favourable Areas and BEC

BEC within LFA	BEC outside LFA	LFA not relevant to BEC
BEC1	BEC7	BEC2
BEC3	BEC9	BEC4
BEC5	BEC12	BEC14
BEC6	BEC13	BEC15
BEC8		
BEC10		
BEC11		

Within the Ribble catchment there are two land management options within the Higher Level Stewardship (HLS) which would help to meet the broad scale ecosystem criteria – moorland maintenance/ restoration in the uplands and wet grassland maintenance/restoration on the floodplains. HLS agreements usually last 10 years (with a possible break clause after 5 years); though in some cases a 20 year agreement may be more appropriate.

Moorland options

The moorland options aim to maintain and restore habitats contained within the moorland grazing units. They may also be used in the management of large enclosures such as allotments, intakes and newtakes. The options are targeted at land in LFAs which is predominantly above the moorland line. Management will include grazing the moorland following an agreed stocking calendar. In addition, items such as fencing and grip blocking may be funded by a Capital Works Plan.

Both the options to maintain and restore moorland attract a payment of £40/ha/year. The moorland options could be applied to BEC5 (Hodder headwaters) and BEC6 (Calder headwaters).

Wet grassland options

The wet grassland options aim to provide the required water and grass sward conditions for wading birds and wildfowl on river floodplains. When restoring or creating wet grasslands, the ability to control surface water will be required. In most situations land drainage consent (from the EA) and/ or a management plan will also be required. A range of capital items such as sluices, bunds, scrapes and ditch restoration may be funded by a Capital Works Plan.

Payments for the six wet grassland options range from £255/ha to £355/ha, with an average of around £300/ha. The wet grassland options could be applied to BECs7-13.

Other options

BEC3, in the Hodder headwaters, overlaps with BEC5. The lower slopes in BEC3 would probably benefit from the construction of buffer strips, to limit the sediment delivery to the watercourses in intensive grassland areas. Within HLS there is an option to construct buffer strips within intensive grasslands. A 2m buffer strip would attract a payment of £300/ha/year, whereas a 4m or 6m buffer strip would attract a payment of £400/ha/year.

BEC1 could usefully be brought under an ELS agreement for appropriate grassland management to maintain the natural sediment delivery process to the watercourses.

Removal of ecological barriers

The National Flood and Coastal Defence Database (NFCDD) has been interrogated to ascertain how many weirs exist in those BEC areas where removal of the ecological barrier (i.e. barrier to the potential migration/ movement routes for aquatic wildlife) would improve the existing environmental conditions. Unfortunately, the NFCDD dataset does not contain information on the type of weir, its size and condition, or whether it is an on-line weir or a side weir. The Calder catchment (BEC15) apparently contains 8 weirs along 10km of main channel. However, several of these may be side weirs and not particularly relevant to wildlife movement routes.

Weirs with a water drop in excess of 30cm are considered to provide a barrier to aquatic wildlife movement, especially for fish. In addition, many of the on-line weirs could have contaminated sediments (e.g. heavy metals, PCBs, PAHs) deposited immediately upstream of them, originating from the industrial legacy of the Calder catchment. The removal of these weirs would therefore have considerable environmental impacts unless the contaminated sediments are removed (dredged out) and disposed of appropriately beforehand. Dredging and disposal of contaminated sediments, followed by the removal of weir structure would represent a major expense.

A better way to remove the ecological barrier effect may be to construct suitable fish passes to bypass the existing weir structure. However, the cost of properly designed fish passes can be considerable, of the order of £250,000 capital cost each. The fish pass would also require an on-going maintenance schedule to maintain its effectiveness. The requirement to provide more than one of these fish passes would therefore represent a major expense. It has been assumed that where weirs have been identified in BECs 2 and 4 that more than one fish pass would be required to be constructed. Several may be needed in the Calder catchment. Funding streams for fish pass installation or weir removal could be discussed with nature conservation bodies during the consultation phase.

6.6 Further development of the Ribble case study

The Ribble case study has been progressed to the ‘Mapping and Tabulating BEC’ stage. When referring to the process as shown in the Part A flow diagram and described in Section 5, the next stages of the process would be to:

- Undertake expert stakeholder consultation (Section 5.4),
- Develop flood risk policies in conjunction with flood engineers (Section 5.5), and
- Assess flood management policies against the BEC (Section 5.6 to arrive at inputs to the multiple criterion evaluation of the various policy options, or for input into the SEA.

7 Yorkshire Derwent high level fluvial case study

7.1 Background

The River Derwent catchment includes the Rivers Rye, Seph, Dove, Seven, Hodge Beck and Costa Beck that rise in the North York Moors before joining the River Derwent near Malton. The River Derwent rises further east in the North York Moors, flowing through the Vale of Pickering where it is joined by the River Hertford. The main stem of the River Derwent then flows south for 60 km through a narrow catchment area including the Yorkshire Wolds and Vale of York. The channel downstream of Malton includes an area of managed water levels in the washlands of the lower Derwent prior to the tidal barrage at Barmby. The river then joins the tidal River Ouse prior to discharge into the Humber Estuary. A total land area of around 1,600 km^2 is drained by the rivers (See Figure 7.1).

The catchment area is predominantly rural and generally the population and industry are concentrated in and around the towns and villages of Malton, Pickering and Stamford Bridge. The catchment is extensively managed for agriculture, dominated by horticulture, improved grassland and cereals. There are numerous areas protected for their conservation value and many of the rivers provide good habitat for salmon. The lower Derwent is navigable as far upstream as Stamford Bridge, the Pocklington Canal branching off eastwards downstream of Stamford Bridge.

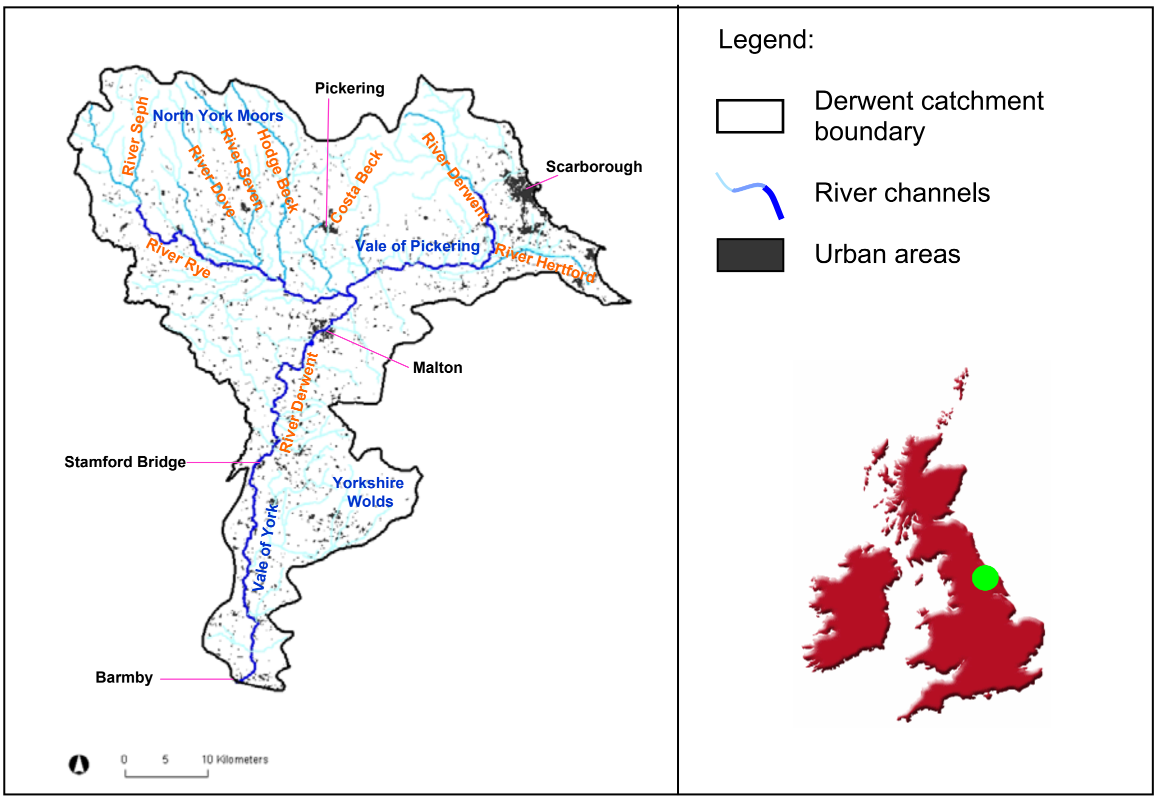


Figure 7.1 Yorkshire Derwent: Background data

7.2 Flood management policy context

The River Derwent case study has been undertaken against the backdrop of an emerging CFMP, which is going through the consultation phase for the preferred flood management options. The work has therefore been undertaken separately from the CFMP planning framework. The consequence is that it has only been possible to implement the guidance by reference to the potential policy outcomes, with no consultation or input from wider stakeholder groups. The understanding of the catchment, although advanced beyond previous methods, does not therefore benefit from the collective experience of local area expertise. It is recommended that this be incorporated once the guidance methodology is operational.

Draft policy options for the Derwent catchment have been published as part of the CFMP process. The guidance methods have been applied these to provide a relative policy assessment of the ecosystem consequences of the alternative “catchment-wide” flood management policy (in fact the policies would appear to be sub-catchment rather than catchment based). Such an assessment could provide input to the SEA of a CFMP.

Future development should include expert stakeholder consultation to develop the BECs and provide greater understanding of catchment-scale ecosystem processes and ecological dynamics.

7.3 Licensing issues

Digital datasets used in the Derwent catchment case study are detailed in Table 7.1, with an acknowledgement of the source and the license requirements.

Disclaimer

The maps used in this presentation are for illustrative purposes only. They are not being used for operational purposes by the EA nor should the maps be used in such a way by any other organisation. They are included here to demonstrate the guidance only and should not be viewed as constituting the views of the project sponsors.

Table 7.1 Data licenses used in the Yorkshire Derwent catchment case study

Digital dataset	Source	Data acknowledgement and source
CEH River catchment boundary, river channel network and Q_{MED}	Sub-licence of EA licence	Database uses Ordnance Survey data. Maps reproduced from Ordnance Survey material with the permission of Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office © Crown copyright. Unauthorised reproduction infringes Crown copyright and may lead to prosecution or civil proceedings. EA, 100026380 (2006)
CEH Land Cover Map (LCM2000)	Sub-licence of EA licence	EA sub-licence permits the production of paper maps from the data for use in reports and discussion documents.
Statutory nature conservation designations	Used with the permission of EN	EN are acknowledged as the owner of the information
Indicative floodplain outline and benefiting areas	Used with the permission of the EA	EA copyright and/or database rights 2006. All rights reserved.
UKBAP Priority habitats	Used with the permission of EN	EN are acknowledged as the owner of the information
British Geological Survey surface and drift geology	Sub-licence of EA licence number 2003/014WW	Reproduced from British Geological Survey Map data at the original scale of 1:50,000. British Geological Survey © NERC. All rights reserved.
Ordnance Survey contour data	Sub-licence of EA licence number 100026380	Maps reproduced from Ordnance Survey material with the permission of Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office © Crown copyright. Unauthorised reproduction infringes Crown copyright and may lead to prosecution or civil proceedings.
EA RHS data	Used with the permission of the EA	EA are acknowledged as the owner of the information

7.4 Review of broad habitat baseline and ecosystem drivers

This Section uses the BSEA High Level fluvial methodology to develop an understanding of the drivers of fluvial ecosystems and their impacts on channel condition, floodplain connectivity and downstream continuity, in the Yorkshire Derwent catchment.

For demonstration purposes, Tools A1-8, B1-3 and C1 were used. (for guidance see Section 5 and Appendix 1). Figures in the text display the GIS datasets used to develop the catchment understanding. These individual figures are indicative only as they cannot be reproduced in paper copy at the various scales that were used to interpret in GIS – GIS allows greater scrutiny of the data at the variety of scales (zooming in and out), that cannot be replicated in hard copy guidance. However, it is recommended that the GIS is used in this interactive mode when identifying drivers and their interactions/ implications for catchment function.

Following development of the catchment understanding, biodiversity opportunities and constraints in the catchment relevant to flood management policy through the identification of broad scale ecosystem criteria (BEC, see also Section 5.3). BEC are illustrated through the incorporation of overlay diagrams, for illustrative purposes (see Diagrams 1 to 13).

Where the BEC provides for the maintenance of good ecosystem function, it is termed a protection BEC. Where biodiversity opportunities are identified which may arise from a change in flood management, these are termed enhancement BEC. Areas identified as protection BEC may also provide opportunities for enhancement.

7.4.1 Channel condition

Channel condition can be described by the river's hydrological and morphological regime, linked to the establishment of characteristic habitats and their associated communities and species. The hydrological regime is described using summary data for the catchment and an assessment of surface runoff potential. The geomorphological regime is described using six data layers prepared in GIS. These layers are illustrated in Figures 7.2, as

a. Substrate erodibility,
b. Channel gradient,
c. Catchment sediment sources,
d. Channel modification,
e. Morphological continuity, and
f. Surface runoff potential.

In addition, a fluvial audit and two smaller geodynamics assessments were identified in the catchment and were used to supplement the GIS assessment.

Ecological data at the broad scale are relatively limited, particularly as they relate to in-channel habitats and communities. Catchment-wide biological GQA data (for the macroinvertebrate community) supplied by the EA are awaited and will be introduced when the GIS layer is forwarded. Description of the broad scale ecology of the catchment would benefit from expert stakeholder consultation, although this has not been possible to date given the sensitivity of the catchment and the emerging consultation status of the CFMP.

Hydrological regime

The flow duration curves from key gauging stations show that the Q_{50} flow in the river system is very variable and generally low, with values in the lower and middle catchment of the order of 0.005 m^3/km^2. This rises to values of about 0.010 to 0.013 m^3/km^2 in the upper reaches. This reflects the generally low rainfall and runoff in the catchment, particularly in the flat central and southern areas.

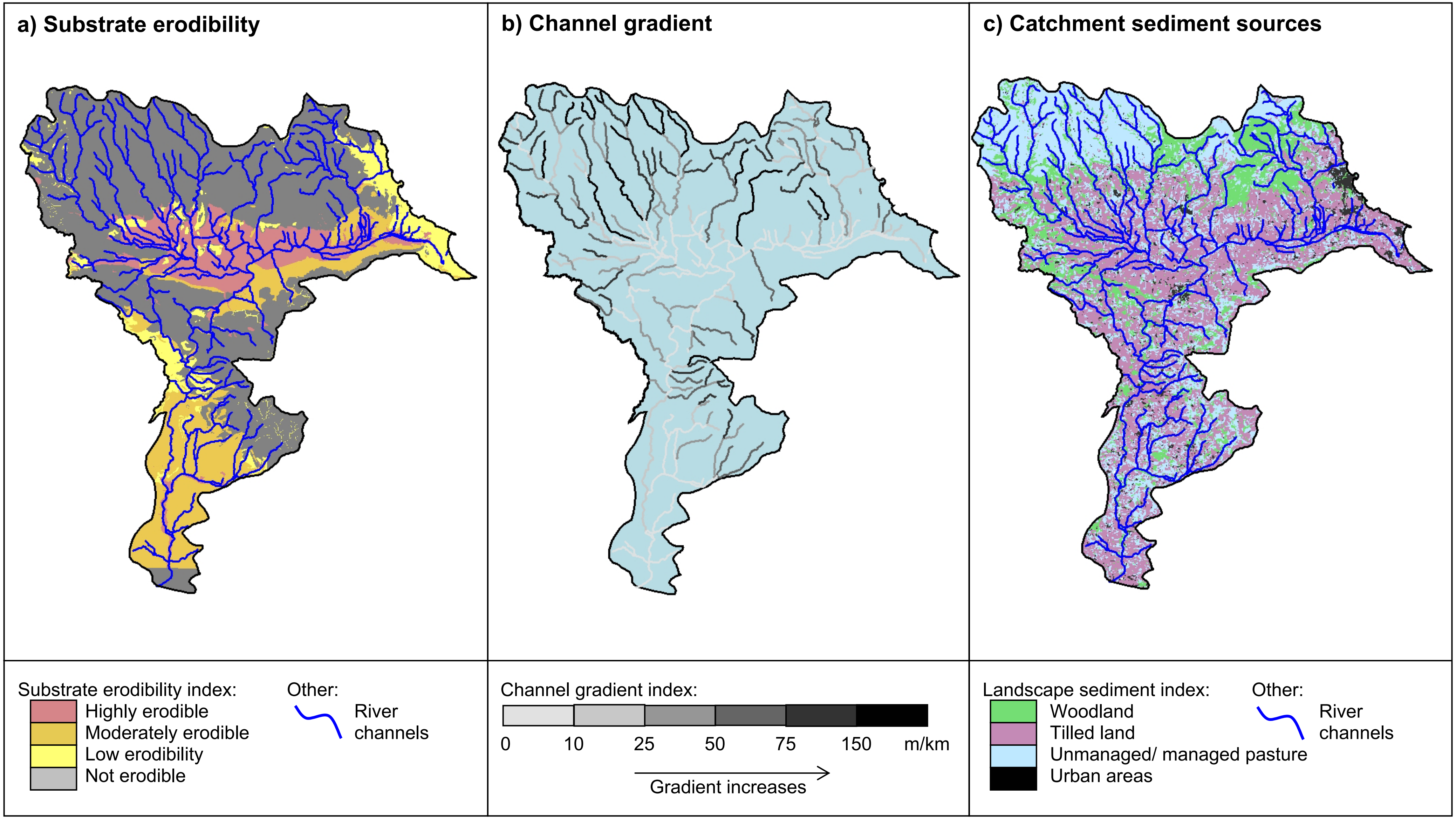


Figure 7.2 Yorkshire Derwent: Channel condition

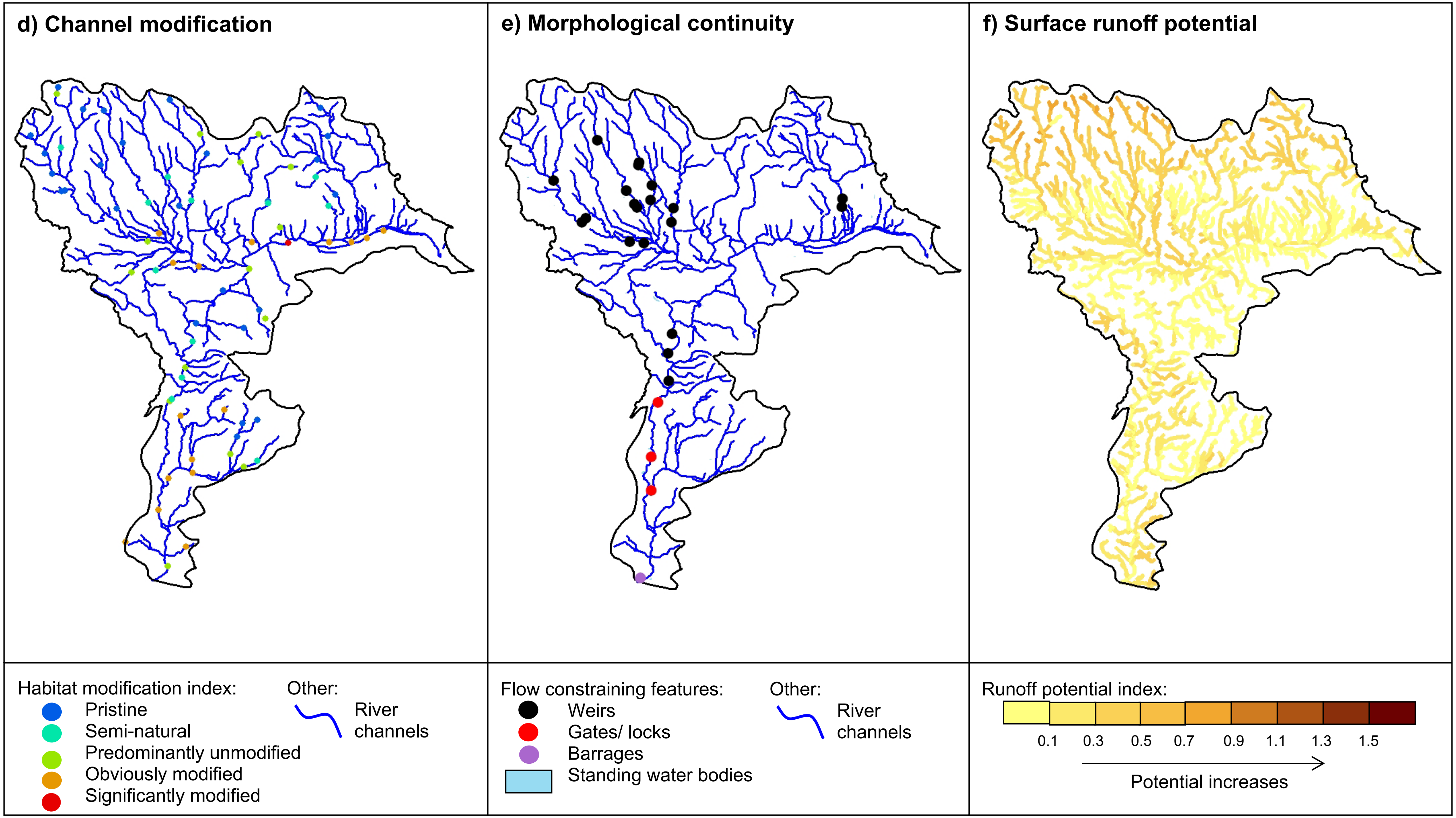


Figure 7.2 Yorkshire Derwent: Channel condition (continued)

Low flows are consistent for much of the catchment. The Q_{95} flow is about 0.002 to 0.004 m^3/km^2 at the majority of gauging stations but there are stations where the figure is much lower, particularly on tributaries which join the Derwent in the lower or southern part of the catchment. This indicates that there are areas where low flows are a problem and there could be significant stresses on ecosystems due to water shortages under normal conditions.

When assessing the impact of water shortages on ecosystems, the aquatic regime in areas of extreme low flow must also be considered. Where watercourses are flat there may be sufficient depth and quality of water to support ecosystems even though flows are low.

Whilst flood risk is covered in CFMPs, it is important to include Q_{MED} in an ecosystem assessment as it the channel forming discharge and is representative of flows that sustain wetlands.

The flood flow data shows that the Derwent has low to medium flood flows throughout the catchment, with values of Q_{MED}/A ranging from about 0.05 in the lower catchment to 0.2 in the middle catchment and 0.5 in the upper tributaries. Thus surface runoff potential will be low in the lower and middle catchment and medium in the upper catchment. This generally reflects the low to medium annual average rainfall (in the range 600 to 1,000 mm) and mean annual runoff (200 to 600 mm), and the fact that parts of the lower and middle catchment are flat.

The impacts of climate change have the potential to cause an increase in the flood flows, leading to an increase in the frequency and magnitude of floodplain inundation. The expected reduction in summer rainfall will lead to lower base flows and, in particular, reductions in very low flows. This will exacerbate any low flow problems that already exist in parts of catchment.

Morphological regime

The catchment can be broadly divided into four morphological units based on the broad scale mapping (Figure B.2):

- The Uplands – deeply incised valleys draining the North York Moors. A fluvial audit was undertaken in the Upper Derwent, the most easterly of the moorland sub-catchments.
- The Vale of Pickering – floodplain of the Derwent to the south of the North York Moors extending between Malton, Helmsley, Pickering and West Ayton.
- The Middle Derwent – an area known as the wolds splitting the Vale of Pickering from the tidal Lower Derwent characterised by unforested, undulating terrain.
- The Lower Derwent – Floodplain between Stamford Bridge and Barmby tidal barrage. Tidally driven at the lower end.

The sediment regime can be described within these broad landscape units according to sediment sources, transport and sinks.

Sediment sources

The upland tributaries are characterised by high stream powers indicating the potential for in-channel sourcing of sediment through erosion. Habitat modification is limited in the uplands (indicated by low HMS scores and limited flood defence infrastructure) suggesting that the channel is free to adjust. Catchment supply of sediment is limited by land use which is predominantly unmanaged and managed pasture and woodland. Whilst gradient is high, there is unlikely to be excessive diffuse sediment sourcing as the catchment is relatively unmodified and sediment yield is limited by land use and presence of bedrock in the channel.

Superficial geology is more erodible in the Vale of Pickering and combined with predominantly tilled agricultural land use results in a high potential for sediment sourcing. Mapping of channel modification shows a significant number of drains and outfalls directly transferring agricultural runoff into the river system. Gradients through the system are low indicating a reduced potential for active in-channel scour although increased channel capacity could increase erosive potential.

Headwater streams in the Middle Derwent reflect characteristics of the uplands and with limited catchment yield and low erodibility. However, pockets of highly erodible alluvium are combined with tilled land indicating potential for localised input of sediment to the river network. Modification is limited allowing natural adjustment possible with moderate gradients.

Sediment transfer

Transfer of sediment through the channel network is likely to occur in the Uplands, high to moderate gradients, bedrock sections and limited modification and through the Middle Derwent where in-channel structures are limited and gradients in the tributary network are sufficient to transfer sediment during high flow events. Gradients in the Vale of Pickering are limited and presence of embankments through this section indicates that fine sediments are likely to remain in the system. The high potential for sediment sourcing throughout the Vale of Pickering could result in overloading of fine sediments thus sediment is not transferred in low return period events. The presence of the Barmby Barrage impedes transfer of sediment out of the system. Sedimentation has been documented upstream of the barrage. Lack of sediment transfer onto the floodplain above Barmby as a result of flood embankments is also cited as a problem as land has degraded as a result.

Sediment sinks

There are several weirs in the Derwent system which act to store water and sediment during low flow conditions. Downstream continuity is generally good throughout the catchment. Storage of sediment on the floodplain through the main river Derwent on the Vale of Pickering and in the Lower Derwent as a result of embankments. Fine sediment is instead stored within the river system. Finger printing undertaken as part of Geodynamics Assessment indicated that the majority of fine sediment was sourced from field drains rather than from local bank erosion.

Summary of River Derwent form and function

- The upland rivers are supplying sediment from local bank erosion and hillslope supply but the land use and geology (bedrock) are unlikely to be resulting in accelerated (excessive) sediment sourcing. Runoff potential is reduced by extensive areas of woodland. Local farm management practises or land management may have the in combination effect of raising sediment supply above natural levels but this could be mitigated against.

- The main Derwent is subject to high sediment yield from agricultural land (alluvial sediments) and high densities of field drains and outfalls. High supply of sediment is combined with low gradients and presence of extensive and continuous embankments resulting the retention of sediments in-channel. Siltation through this section is a result of sediment supply through this section (rather than supply from the uplands) and from presence of embankments and associated increase in channel capacity.

- The middle Derwent has potential to locally supply sediment where there highly erodible sediments combined with high gradients. However, the land use is predominantly untilled and higher gradients also act to transfer sediment through the system. Flood embankments are isolated and Habitat Modification Scores indicate that the river and floodplain have potential to function naturally.

- The Lower Derwent floodplains are degraded by altered flow regime increasing the duration of flooding in winter months and causing loss of fines through soil piping. The channel continuity is disrupted by the barrage resulting in fine sediment storage upstream (sediment is prevented from reaching the floodplain by embankments).

Nature conservation designations and ecological status

Figures 7.3 and 7.4 identify the international and national designations within the catchment as well as identifying which SSSIs EN consider to be in favourable condition. As can been seen the majority of SSSIs in the North York Moors are considered to be in unfavourable condition.

Information relating to SACs, SPAs and RAMSAR convention sites is provided in Table 7.2. Issues surrounding use of this information includes:

- Water-dependent protected areas are not identified separately from terrestrial habitats, and
- Reasons for sites being in unfavourable conditions are unknown

Gathering information on the structure, function and status of designated sites in order to better understand the catchment will form an important part of the expert consultation phase.

Table 7.2 Qualifying features for SAC in the Yorkshire Derwent catchment

Site Name	Qualifying features
River Derwent SAC	• Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation. • River lamprey *Lampetra fluviatilis* • Sea lamprey *Petromyzon marinus* • Bullhead *Cottus gobio* • Otter *Lutra lutra*
North York Moors SAC	• Northern Atlantic wet heaths with *Erica tetralix*
Eller's Wood and Sand Dale SAC	• Petrifying springs with tufa formation (Cratoneurion) • Geyer's whorl snail *Vertigo geyeri*
Lower Derwent Valley SPA	The valley holds a series of neutral alluvial flood meadows, fens, swamps, valley mires, Alder *Alnus glutinosa* woodlands and other freshwater habitats lying adjacent to the River Derwent, Pocklington Canal and The Beck. The Lower Derwent Valley is one of the largest and most important examples of traditionally managed species-rich alluvial flood meadow habitat remaining in the UK.
Lower Derwent Valley RAMSAR	This site is one of the most important examples of traditionally managed species-rich alluvial flood meadow remaining in the UK. The river and these floodlands play a substantial role in the hydrological and ecological functioning of the internationally important Humber Basin.

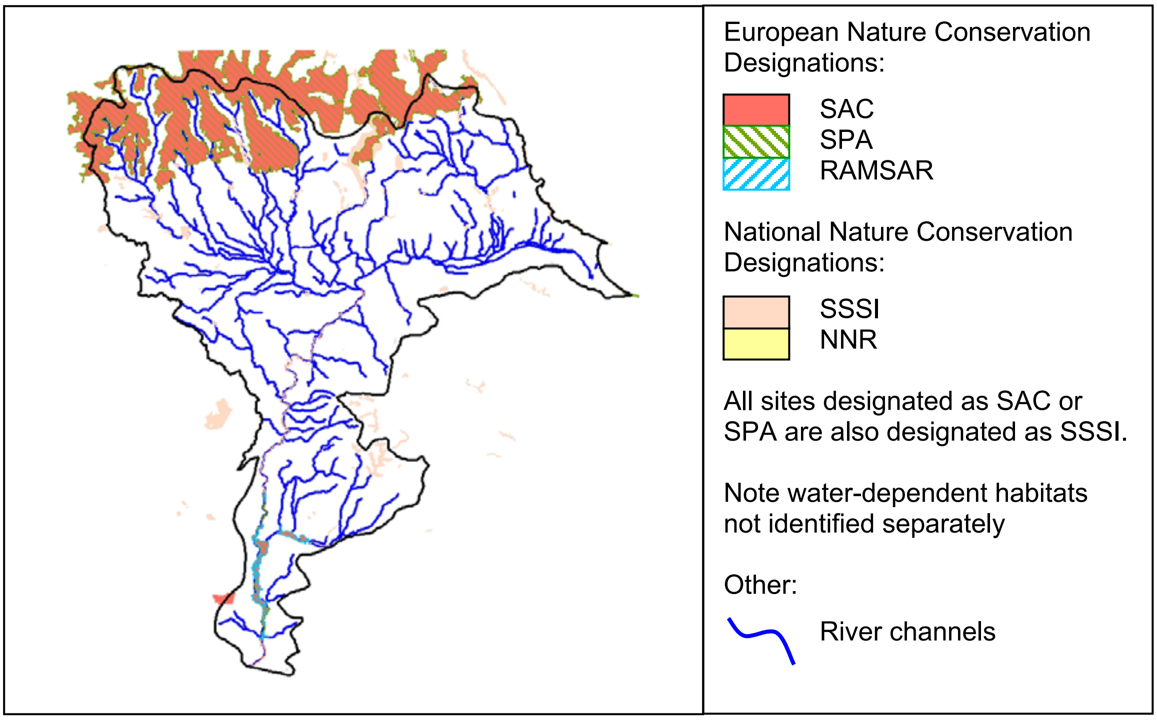


Figure 7.3 Yorkshire Derwent: Nature conservation designations

Natural Area Targets has been taken from EN's website. The Derwent catchment contains all or part of five Natural Areas as follows:

- Vale of York & Mowbray (Natural Area 16),
- North York Moors & Hills (Natural Area 17),
- Vale of Pickering (Natural Area 18),
- Yorkshire Wolds (Natural Area 19), and
- Humberhead Levels (Natural Area 22).

From these areas, the range of potentially appropriate targets for freshwater UK BAP Priority Habitats include:

Protection

- Coastal and floodplain grazing marsh,
- Purple moor grass and rush pastures,
- Reedbeds,
- Blanket bog,
- Fens, and
- Eutrophic standing waters.

Enhancement

- Coastal and floodplain grazing marsh,
- Purple moor grass and rush pastures,
- Reedbeds,
- Blanket bog,
- Fens,
- Eutrophic standing waters.

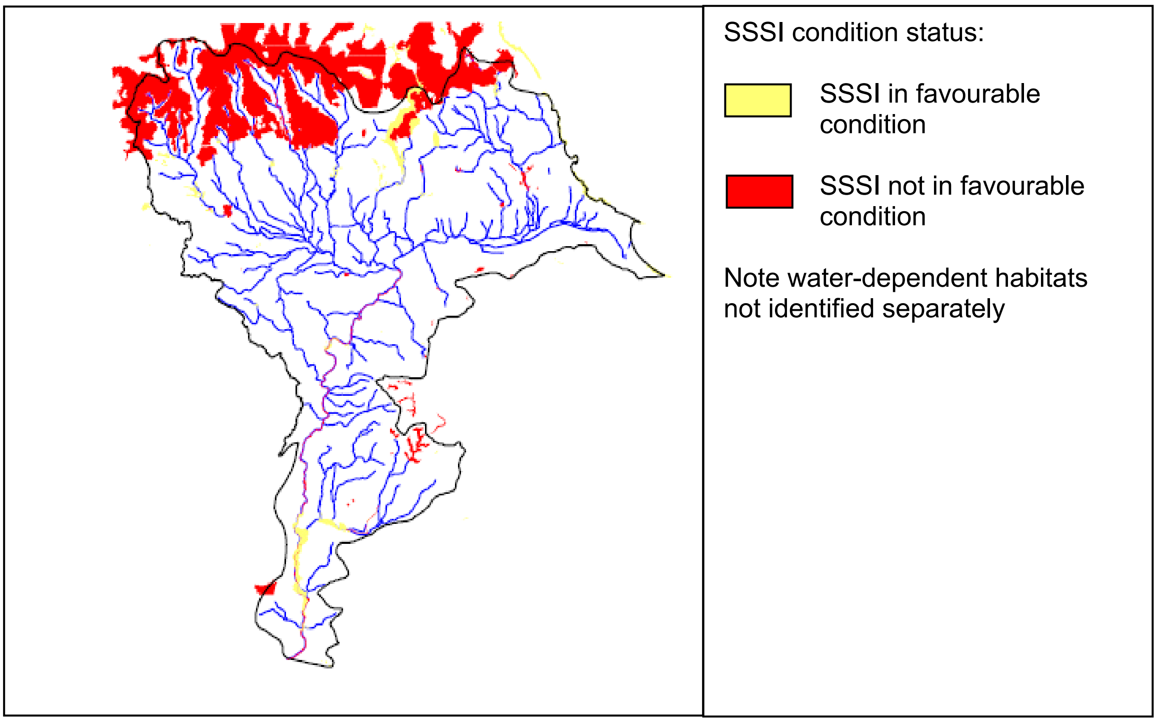
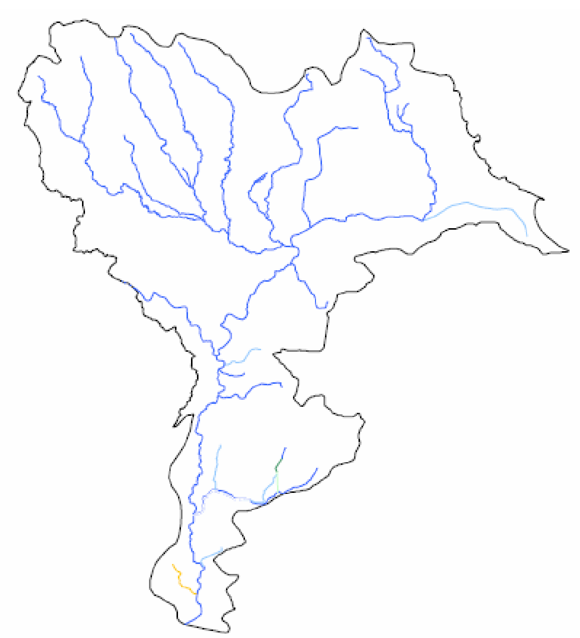


Figure 7.4 Yorkshire Derwent: SSSI condition status

The Natural Area Targets will form the basis for refining BEC within the consultation phase. For example, although opportunities and areas for wetland habitat creation may have been identified, it will be the role of the consultation group to establish, where possible, the preferred habitat type to be created (i.e. floodplain grazing marsh, blanket bog, fen/ reedbed, rush pasture, standing water etc).

Further broad scale ecological data are scarce. The macroinvertebrate GQA results for 2004 are presented as Figure 7.5. Although the ecological data effectively synthesise all of the potential environmental pressures (including point and diffuse pollution effects, low flow problems etc.) rather than those attributable to flood management activities, they give a guide to the health of the in-channel community and indicate areas that are in good condition or require improvement. Figure 7.5 indicates the main stem of the River Derwent and all headwater streams in the North York Moors are of very good (Class A) quality. Several of the lowland tributaries, including the River Hertford and tributaries of the lower Derwent are of reduced quality, generally classed as good (Class B), with sampling at only two reaches indicating a further reduction in quality.



Legend:

Biological GQA class:

Class A		Very good
Class B		Good
Class C		Fairly good
Class D		Fair
Class E		Poor
Class F		Bad

Figure 7.5 Yorkshire Derwent: Biological general quality assessment

7.4.2 Floodplain connectivity

Three GIS layers have been prepared to develop an understanding of floodplains connectivity. These layers are illustrated separately in Figure 7.6, as:

a. Floodplain areas and existing defences,
b. Active ecological floodplain and gathering grounds, and
c. Land cover in potential floodplain areas.

Figure 7.6a shows that the majority of significant floodplain is located along the River Derwent in the Vale of York and Vale of Pickering, as well as along the River Rye. Existing flood defence protection is located within the same three areas providing protection to the urban areas of Malton and Bamby, as well protecting arable lands in the river valleys, particularly the Vale of Pickering.

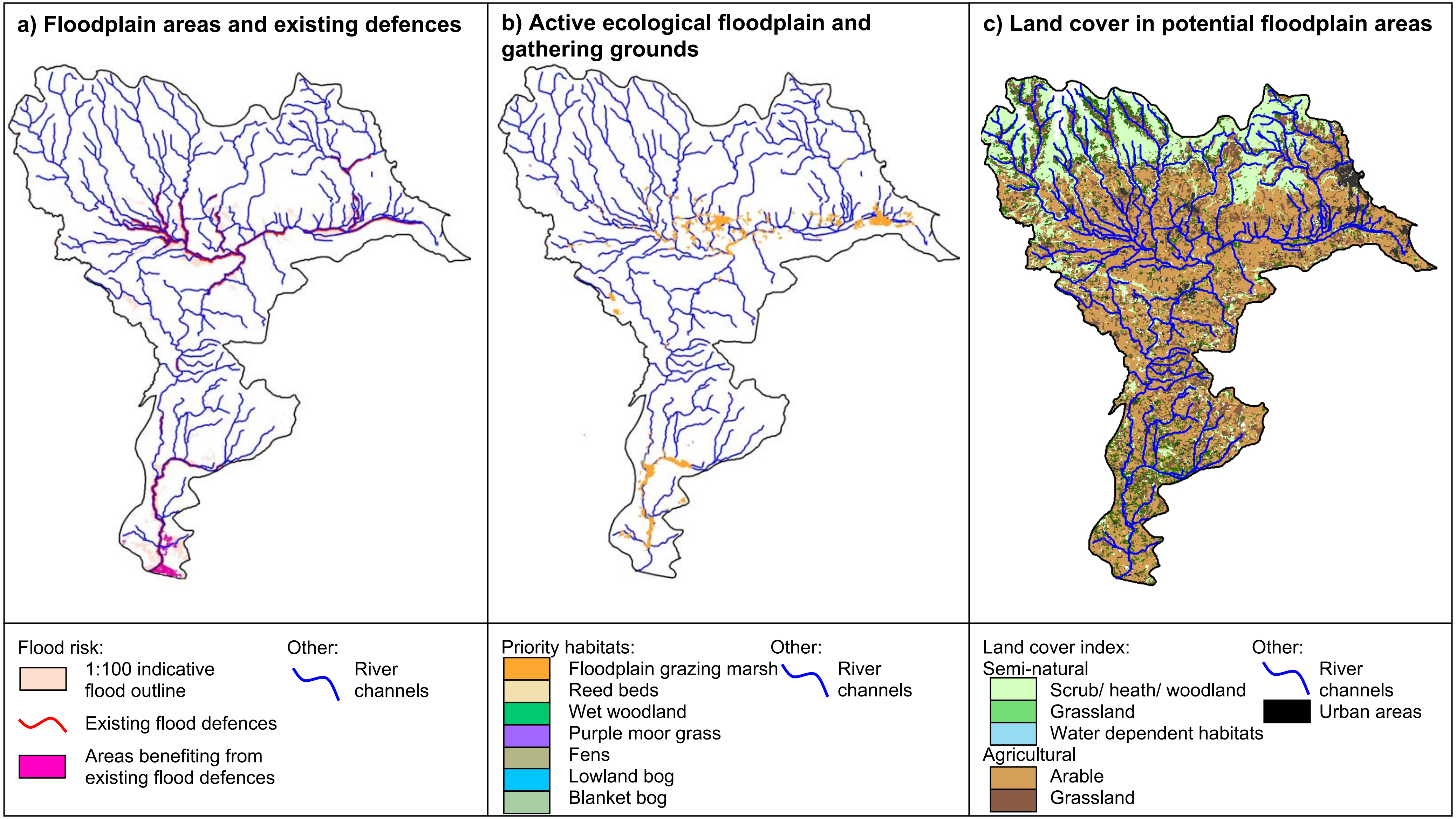


Figure 7.6 Yorkshire Derwent: Floodplain connectivity

Figure 7.6b shows that the main wetland priority (UK BAP) habitat is floodplain grazing marsh and this is situated in areas of functioning floodplain, again in the three main areas of the Vale of York, Vale of Pickering and River Rye. However, the extent of floodplain grazing marsh, especially in the Vale of Pickering, is fragmented due to the flood defences stopping natural floodplain function. In addition, where grazing marsh is identified the current status of its quality is unknown.

Figure 7.6c shows that the catchment is noticeably divided into three main land use types:

- Agricultural arable land covers the vast majority of the catchment,
- Semi-natural grassland covers the majority of the most upper part of the catchment, particularly in the North York Moors, and
- Semi-natural scrub/ heath/ woodland line some of the river valleys, again particularly noticeable in the North York Moors becks.

7.4.3 River continuity

Figure 7.7 demonstrates that the Derwent system has three significant (greater then 0.3m head loss) weir structures in the middle reaches, and four significant gate/lock structures in the lower reaches.

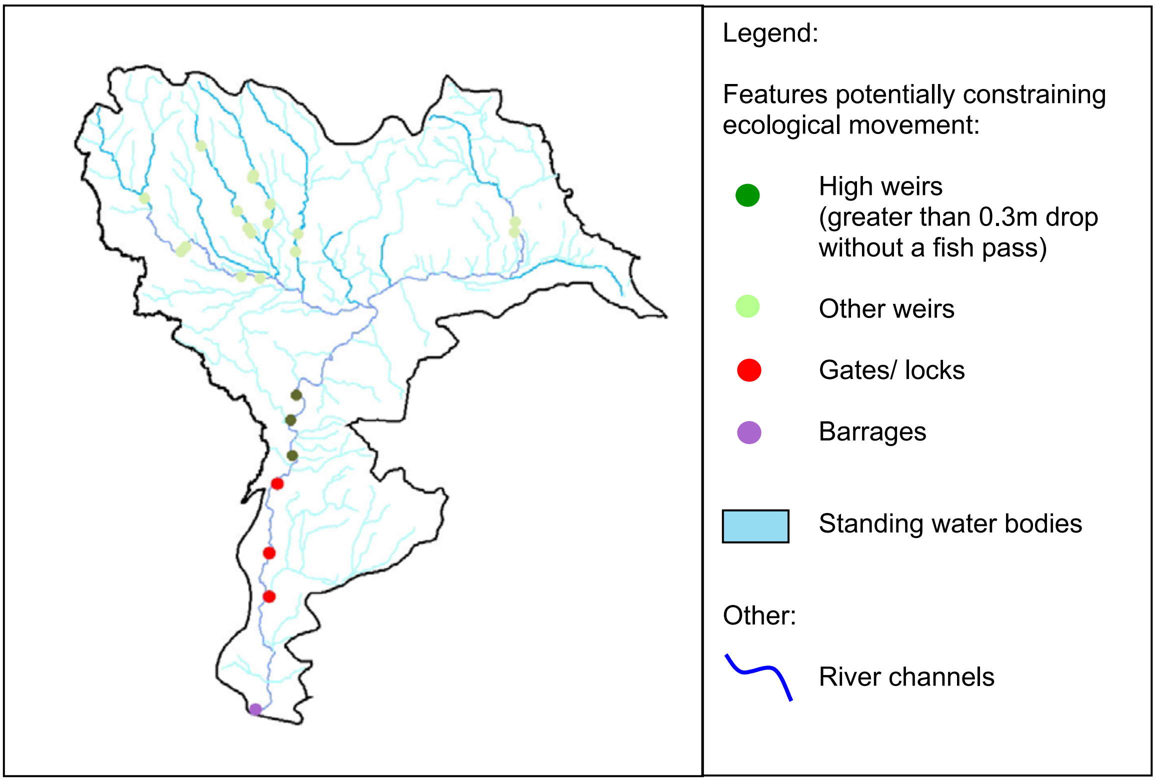


Figure 7.7 Yorkshire Derwent: River continuity

However, an important note is that this information was not obtained from the NFCDD - which showed no structures on the Derwent. Instead, this information was obtained from another recent Cascade Consulting project where significant detail of hydrologically-active structures was required for detailed full catchment hydrological modelling (using CAS-Hydro).

This is important as it clearly demonstrates a number of aspects of the BSEA methodology:

- Existing national datasets must be fully checked and not used as the definitive dataset,
- Available information from existing or previous schemes or strategies can usefully be incorporated within BSEA to bolster national datasets, and
- The need for consultation with regional expertise is paramount to establish a full understanding of the catchment and when identifying appropriate BEC.

7.4.4 Broad scale ecosystem criteria (BEC) for channel condition

The understanding of channel condition in the Yorkshire Derwent catchment has allowed development of one protection BEC and 3 enhancement BEC relevant to flood management policy. These are illustrated and described below and summarised in Table 7.3. In each of the diagrams (below), the legend is consistent with the appropriate figure (above).

BEC 1: Maintain unmodified channels of good diversity

Upland tributaries and sections of the middle Derwent are relatively unmodified (see Diagram 7.1). Sediment supply is likely to be typical of unmanaged, managed pasture or woodland (although localised practises may have individual or cumulative impact). Transfer of sediment through the system is unconstrained by artificial structures and mid-high gradients will allow entrainment and transport of sediment during flood events. HMSs are low (indicating minor modification to physical structure). A field-based fluvial audit of the upper Derwent confirmed these findings, recording good geomorphological diversity and active geomorphological processes. Where floodplain does exist, embankments are isolated so that rivers and floodplains are connected. This allows sediment to be transferred naturally out of the system. It is proposed that the morphological form and function of these rivers should be protected. Through doing this opportunities may be sought in the licensing and consents processes to protect and promote natural processes.

BEC 1
- Channel modification (from Figure 7.2d)
- Channel gradient (from Figure 7.2b)

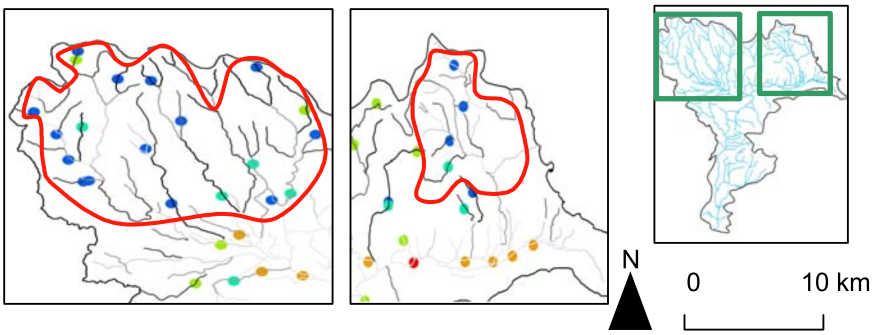


Diagram 7.1 Unmodified channels of good diversity in upland sub catchments in the North York Moors

BEC 2: Reduce channel capacity in the middle Derwent

Sedimentation in the channel upstream of Malton and Norton and sediment loading during flood events have resulted in a documented increase in channel dimensions (Sear, 1992). In order to achieve restoration of a natural flood regime as a result of low return period events and to reduce the effects of sedimentation on morphological and habitat diversity, opportunities for channel narrowing should be sought with managed set back of defences. There is likely to be sufficient sediment in the system for this to occur naturally but with current channel dimensions high flow events are likely to flush sediment downstream thus storage will be temporary. Investigation into low level intervention to reduce capacity in line with defence set back is therefore recommended. See Diagram 7.2.

BEC 2
- Channel modification (from Figure 7.2d)
- Channel gradient (from Figure 7.2b)

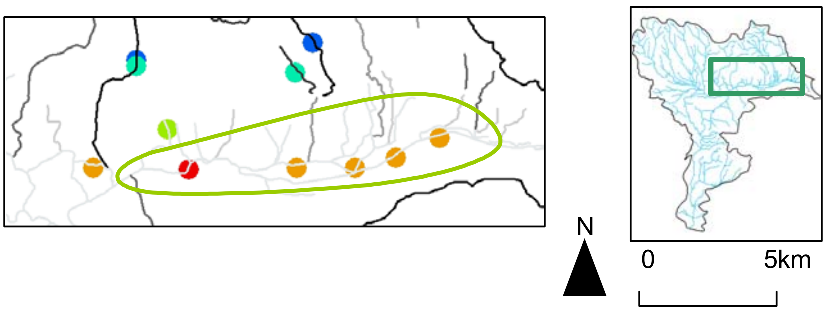


Diagram 7.2 Reduction of channel capacity in the middle Derwent

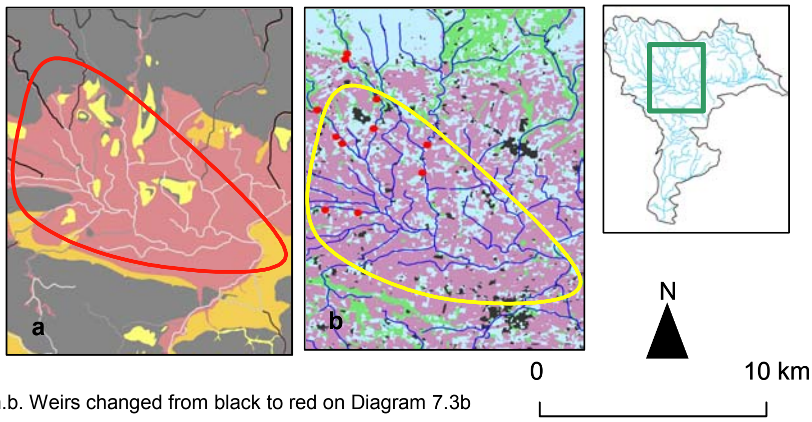
BEC 3: Enhance channel to improve river functioning and habitat

The lower Rye catchment has evidence of higher Habitat Modification Scores and a large number of weirs, floodbanks and drains and outfalls (Diagram 7.3). Reconnection of the floodplain has been identified under BEC 9 and this will help to restore a more natural functioning system. Opportunities should be sought to reduce further impacts through localised bank protection or land drainage and to enhance the river through removal of obsolete structures and/or failing bank protection. Improved land management practises to reduce fine sediment supply to the channel, for example use of buffer strips, fencing and best practise sediment management techniques should be implemented.

These measures will have benefits for habitat and also flood risk management by reducing fine sediment loading, an issue for flooding at Malton and Norton.

BEC 3
Diagram a:
- Substrate erodibility (from Figure 7.2a)
- Channel gradient (from Figure B.2b)

Diagram b:
- Landscape sediment sources (from Figure 7.2c)
- On-line flow constraining features (from Figure 7.2e)



n.b. Weirs changed from black to red on Diagram 7.3b

Diagram 7.3 Enhance channel to maintain sediment supply and passage in the Lower Rye catchment

7.4.5 Broad scale ecosystem criteria for floodplain connectivity

An understanding of floodplain connectivity in the Yorkshire Derwent catchment has allowed development of 3 protection and 4 enhancement BEC relevant to flood management policy. These are illustrated and described below and are summarised in Table 7.3. In each of the diagrams (below) the legend is consistent with the appropriate figure (above).

BEC 4-6: Protect floodplain connectivity

The presence of active ecological floodplain is demonstrated through the mapping of appropriate BAP priority habitats in Figure 7.6. Floodplain habitat is well represented in the catchment, particularly in the Costa Beck (BEC 4) (see Diagram 7.4) and River Hertford (BEC 5) (see Diagram 7.5), and throughout the lower Derwent catchment (BEC 6) (see Diagram 7.6). Flood management policy should ensure the protection of floodplain habitats in these locations, through maintenance of a suitable hydrological regime and appropriate bank modifications. The potential may exist for enhancement of floodplain habitat in these locations.

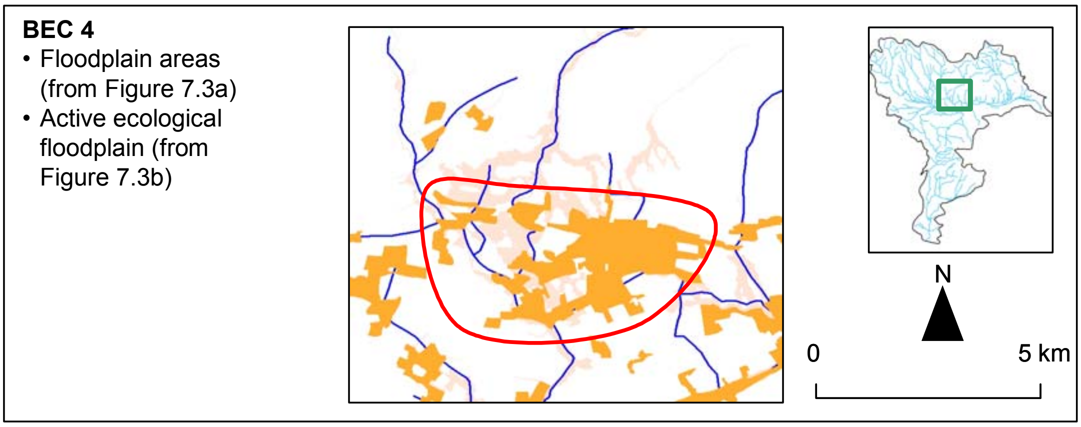


Diagram 7.4 Active ecological floodplain (Costa Beck)

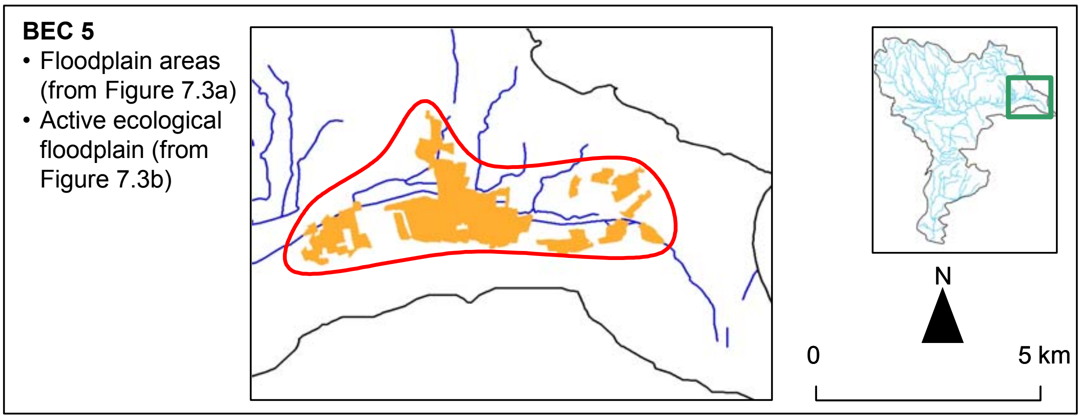


Diagram 7.5 Active ecological floodplain (River Hertford)

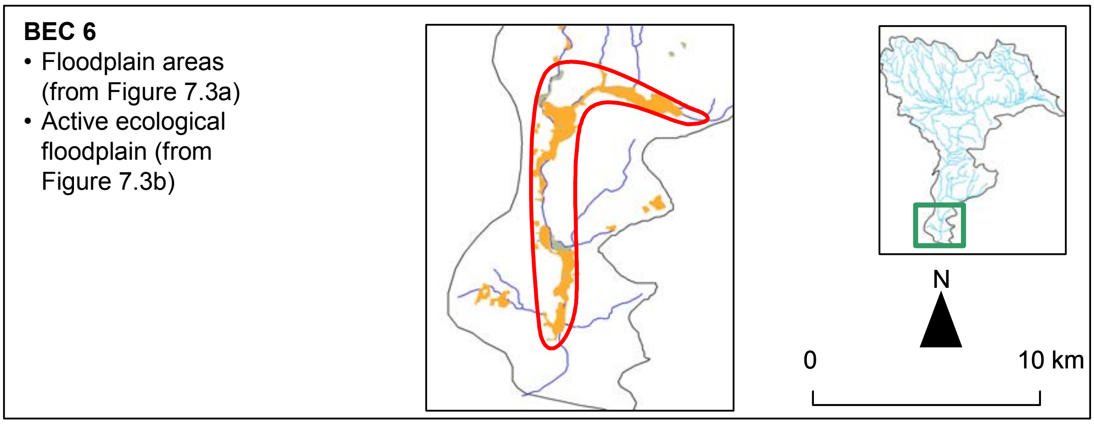


Diagram 7.6 Active ecological floodplain (lower catchment)

BEC 7: Enhance floodplain connectivity for sediment transfer

Opportunities to remove flood embankments in this part of the catchment should be sought to re-establish sediment transfer from the channel onto the floodplain. Sediment transfer in the lower part of the Derwent upstream of the barrage is limited both in a downstream direction and also laterally across the floodplain (see Diagram 7.7). This results in high potential for seasonal sediment storage upstream of the barrage, impacting on the channel but also impacting upon the floodplain by degrading the soil quality. By restoring a floodplain flows (as a result of overtopping rather than backing up of flows through naturally developed soil pipe systems) diffuse sediment sinks across the floodplain could be restored. This would begin to mitigate the impact on habitat quality, increase channel capacity and improve floodplain functionality.

BEC 7

- Channel modification (from Figure 7.2d)
- Channel gradient (from Figure 7.2b)
- Floodplain areas and existing defences (from Figure 7.3a)

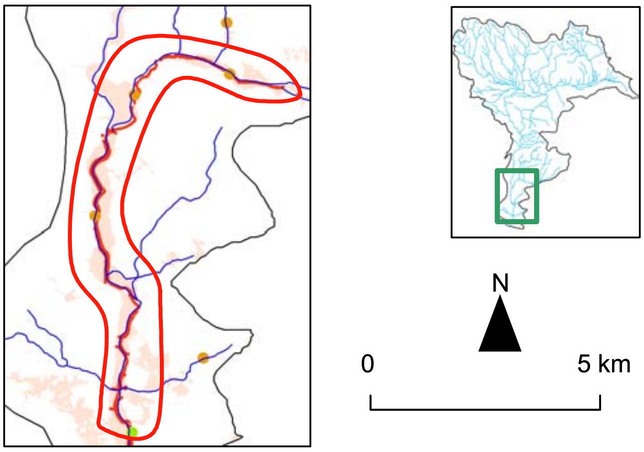


Diagram 7.7 Floodplain connectivity and sediment transfer in the lower Derwent

BEC 8-10: Re-connect floodplain

In floodplain areas without active ecological floodplain (Figure 7.6b) the opportunity may exist for reconnection of the channel to the floodplain to enhance biodiversity. Potential areas are characterised by a 1:100 year return period flood outline (Figure 7.6a). The potential is low in urban areas, with the exception of parkland. The presence of flood embankments (Figure 7.6a) and the current land cover type (Figure 7.6c) assist in identifying suitable areas. Agricultural land (Figure 7.6c) benefiting from flood defences (Figure 7.6a) is potentially suitable, where abandonment of the defences and a change in land management practice would be required. Such areas exist in the Vale of Pickering (BEC 8) (see Diagram 7.8)and the Lower Rye Catchment (BEC 9) (see Diagram 7.9). Agricultural land (Figure 7.6c) within the 1:100 year return period flood outline is also potentially suitable, where a change in land management practice and potentially modification to the channel or floodplain would be required. Such areas exist in the Ran Beck (BEC 10) (see Diagram 7.10).

BEC 8
- Floodplain areas (from Figure 7.3a)
- Active ecological floodplain (from Figure 7.2b)
- Land cover in potential floodplain areas floodplain (from Figure 7.3c)

n.b. The land cover has been cut to display land cover within the 1:100 indicative flood outline

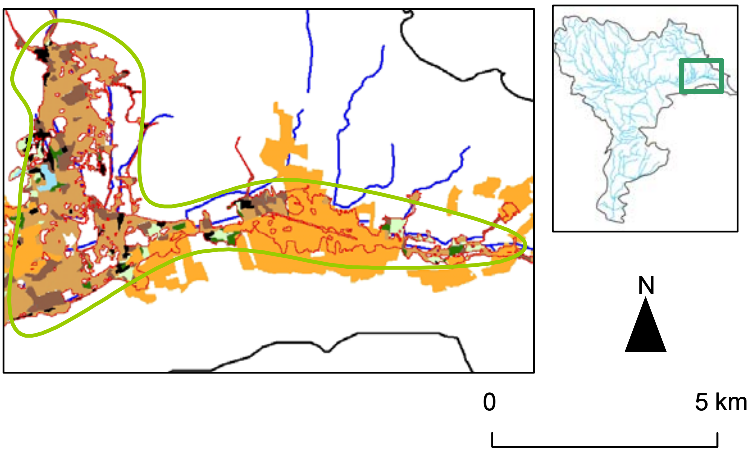


Diagram 7.8 Opportunity for ecological floodplain (Vale of Pickering)

BEC 9
- Floodplain areas (from Figure 7.3a)
- Active ecological floodplain (from Figure 7.2b)
- Land cover in potential floodplain areas floodplain (from Figure 7.3c)

n.b. The land cover has been cut to display land cover within the 1:100 indicative flood outline

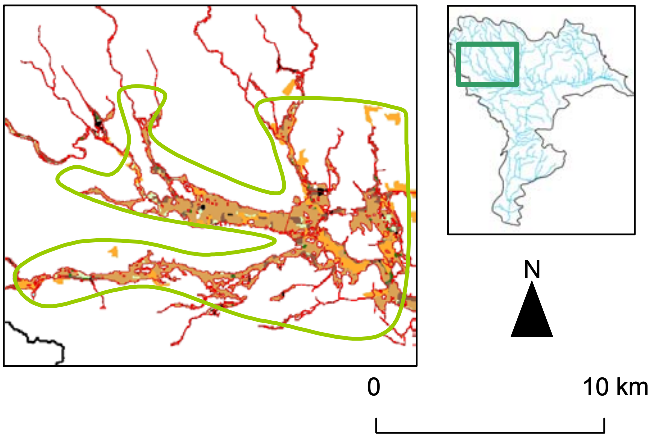


Diagram 7.9 Opportunity for ecological floodplain (lower Rye catchment)

BEC 10
- Floodplain areas (from Figure 7.3a)
- Active ecological floodplain (from Figure 7.2b)
- Land cover in potential floodplain areas floodplain (from Figure 7.3c)

n.b. The land cover has been cut to display land cover within the 1:100 indicative flood outline

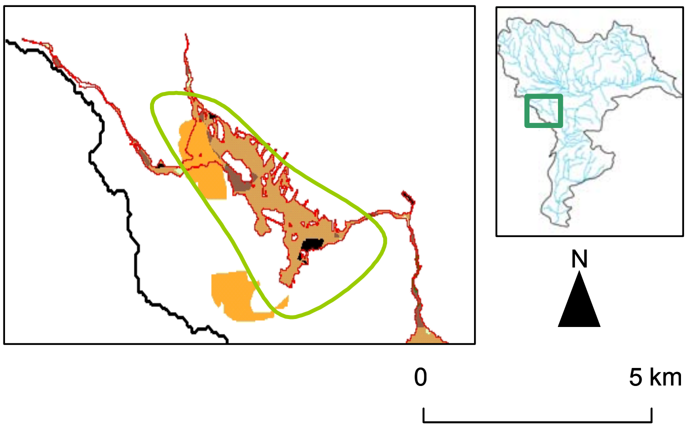


Diagram 7.10 Opportunity for ecological floodplain (Ran Beck)

7.4.6 Broad scale ecosystem criteria for channel continuity

The understanding of river continuity in the Yorkshire Derwent catchment has allow development of 2 enhancement BEC relevant to flood management policy. These are illustrated and described below and summarised in Table 7.3.

In each of the diagrams (below) the legend is consistent with the appropriate figure (above).

BEC 11-13: Overcome ecological barriers

Potential significant obstructions to migration have been located in the lower Derwent catchment (see Diagram 7.11). BEC11 recognises that large weirs can obstruct fish passage and installation of bypass channels or fish passes can ease or remove the problem. BEC12 recognises that large gates/locks can obstruct passage of fish and other aquatic life, and installation of bypass channels can ease or remove the problem. BEC13 recognises that the tidal barrage in the lower catchment may obstruct passage of fish and other aquatic life, and installation of bypass channels can ease or remove the problem.

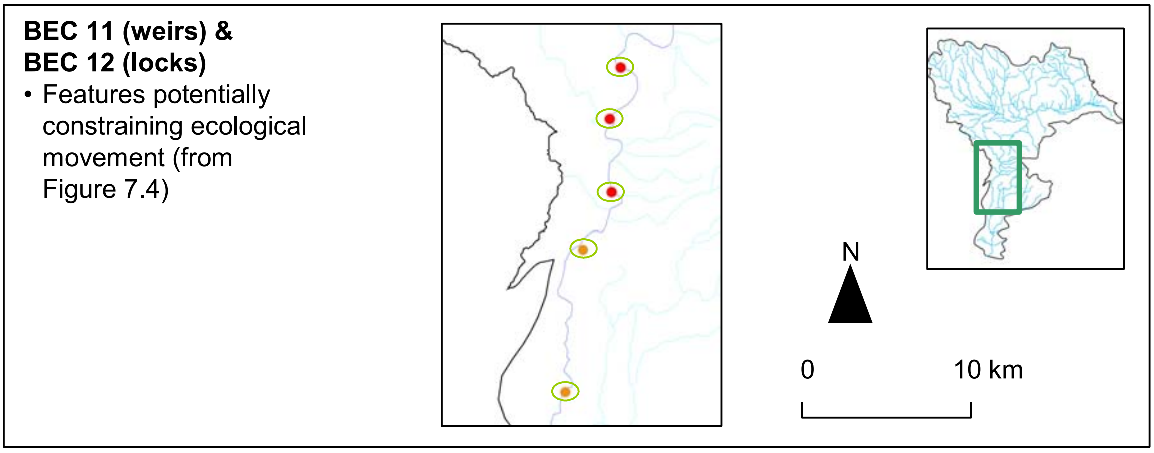


Diagram 7.11 Ecological barriers

7.5 Summary of broad scale ecosystem criteria in the Yorkshire Derwent catchment

The protection and enhancement BEC identified are summarised in Table 7.3. This includes identification of the BEC for each broad habitat type, listing the potential flood management actions to realise the BEC, together with the potential ecosystem benefits. Spatial context to the constraints and opportunities is presented on Figure 7.8.

Under normal circumstances it is hoped that after developing the first draft of BEC the BSEA team would follow the procedures described in Section 5, which would require expert consultation followed by pro-active flood risk management policy development, and then finally policy assessment against the BEC.

However, with this case study there has not been the opportunity to be part of the CFMP consultation process or policy development (CFMP consultation had progressed too far already). Therefore, the BEC that have been developed (shown in Table 7.3 and Figure 7.8) have been undertaken in relative isolation and have not been incorporated to inform policy development.

Table 7.3 Broad scale ecosystem criteria in the Yorkshire Derwent catchment

Broad scale Ecosystem Criteria			Potential flood management actions	Potential ecosystem benefit
Channel condition	1	Maintain unmodified channels of good diversity in upland sub-catchments	Avoid area	Protection of in-stream habitats and supply of sediment to downstream reaches
	2	Reduce channel capacity in the Vale of Pickering	Reduce cross-sectional profile of the channel	Enhance in-stream habitats and reconnect floodplain
	3	Enhance channel to maintain sediment supply and passage in the lower Rye catchment	Remove/ bypass in-stream obstructions and restore bank	Enhance downstream in-stream habitats through return to more natural sediment balance
Floodplain connectivity	4	Protect connectivity of floodplain habitats in the Costa Beck	No reduction in current flooding extent or pattern	Protect (or enhance) existing floodplain wetland habitat (floodplain grazing marsh, reedbed, wet woodland, ditch)
	5	Protect connectivity of floodplain habitats in the River Hertford	No reduction in current flooding extent or pattern	Protect (or enhance) existing floodplain wetland habitat (floodplain grazing marsh, reedbed, wet woodland, ditch)
	6	Protect connectivity of floodplain habitats in the lower catchment	No reduction in current flooding extent or pattern	Protect (or enhance) existing floodplain wetland habitat (floodplain grazing marsh, reedbed, wet woodland, ditch)
	7	Enhance floodplain connectivity for sediment transfer in the lower Derwent	Channel or floodplain restoration. Flood bank removal or alteration. Increased floodplain flooding	Restore or enhance/ extend floodplain wetland habitat (floodplain grazing marsh, reedbed, wet woodland, ditch). Also improve in-stream habitat downstream.
	8	Re-connect floodplain habitats in the Vale of Pickering	Channel or floodplain restoration. Flood bank removal or alteration. Increased floodplain flooding	Restore or enhance/ extend floodplain wetland habitat (floodplain grazing marsh, reedbed, wet woodland, ditch).
	9	Re-connect floodplain habitats in the lower Rye catchment	Channel or floodplain restoration. Flood bank removal or alteration. Increased floodplain flooding	Restore or enhance/ extend floodplain wetland habitat (floodplain grazing marsh, reedbed, wet woodland, ditch).
	10	Re-connect floodplain habitats in the Ran Beck	Channel or floodplain restoration. Flood bank removal or alteration. Increased floodplain flooding	Restore or enhance/ extend floodplain wetland habitat (floodplain grazing marsh, reedbed, wet woodland, ditch).
River continuity	11	Remove ecological barrier effect of weirs in middle catchment (3 no.)	Remove/ bypass in-stream obstructions	Improve distribution of fish and mobile aquatic animals
	12	Remove ecological barrier effect of locks in lower catchment (2 no.)	Remove/ bypass in-stream obstructions	Improve distribution of fish and mobile aquatic animals
	13	Remove ecological barrier effect of tidal barrage in lower catchment	Remove/ bypass in-stream obstructions	Improve in distribution of fish and mobile aquatic animals. Note: need to assess against potential loss of freshwater habitat

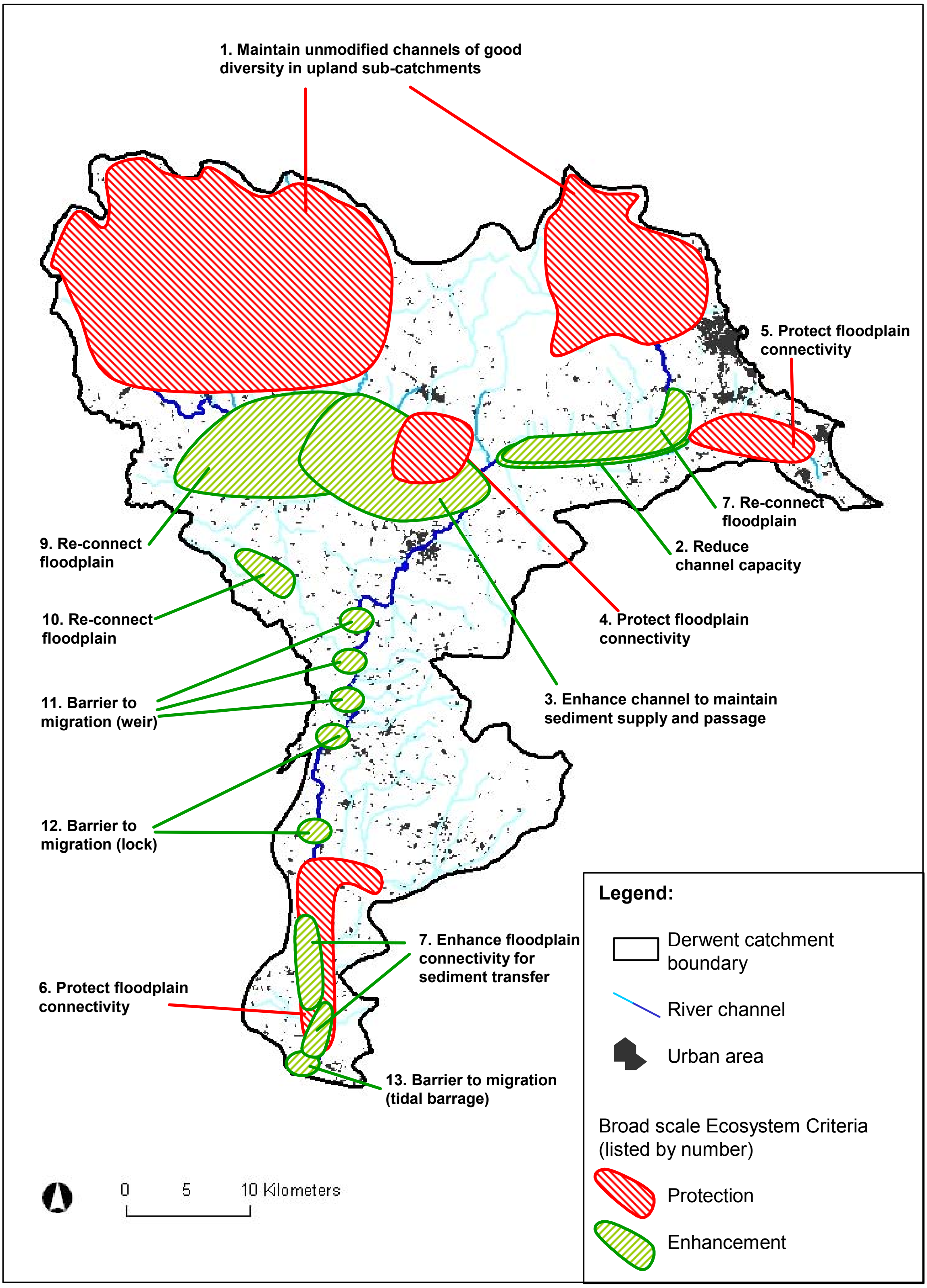


Figure 7.8 Yorkshire Derwent: Summary of broad scale ecosystem criteria

Therefore, this case study now provides a demonstration of the use of BEC to assess the preferred policy. This approach is reactive and would not usually be recommended – it is undertaken here to provide guidance on the possible methods of application (see Section 7.6). Due to the fact that the BEC are only being used to assess a given policy as opposed to informing the policy, Table 7.3 has been tailored and does not provide information on 'potential flood management benefit' or 'potential cost'.

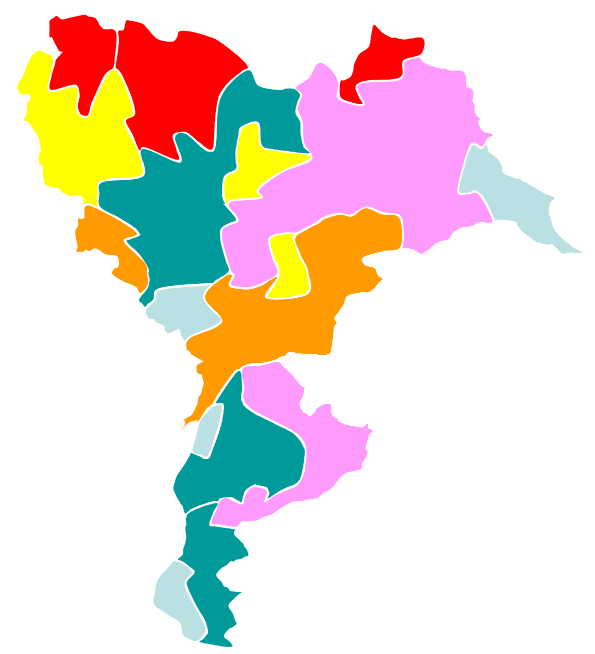
7.6 Definition of policy drivers and associated scenarios

The Yorkshire Derwent CFMP, one of the pilot CFMPs, is nearing a draft preferred sustainable flood management policy has been developed for the Yorkshire Derwent CFMP. However, due to the pilot nature of the CFMP, there are no catchment-wide alternative policies, as would be appropriate for SEA.

The relative assessment of alternative flood management policies cannot therefore be undertaken in the form envisaged by the guidance in BSEA Toolbox 1. In order to demonstrate the BSEA methodology, the draft preferred policy alone has been assessed against the BEC developed for the catchment (see Table 7.4).

It is noted that the BEC for the Yorkshire Derwent catchment have been developed in isolation from the CFMP pilot, and without stakeholder involvement. Section 7.6 is therefore theoretical, and strictly for methodology demonstration purposes only.

The draft preferred policy from the Yorkshire Derwent CFMP is established in Figure 7.9.



Policy option:

- **Policy 1**: No active intervention
- **Policy 2**: Reduce existing flood risk
- **Policy 3**: Continue with existing or alternative actions to manage flood risk at the current level
- **Policy 4**: Take further action to sustain the current level of flood risk into the future
- **Policy 5**: Take further action to reduce flood risk
- **Policy 6**: Take action to increase the frequency of flooding to deliver benefits locally or elsewhere

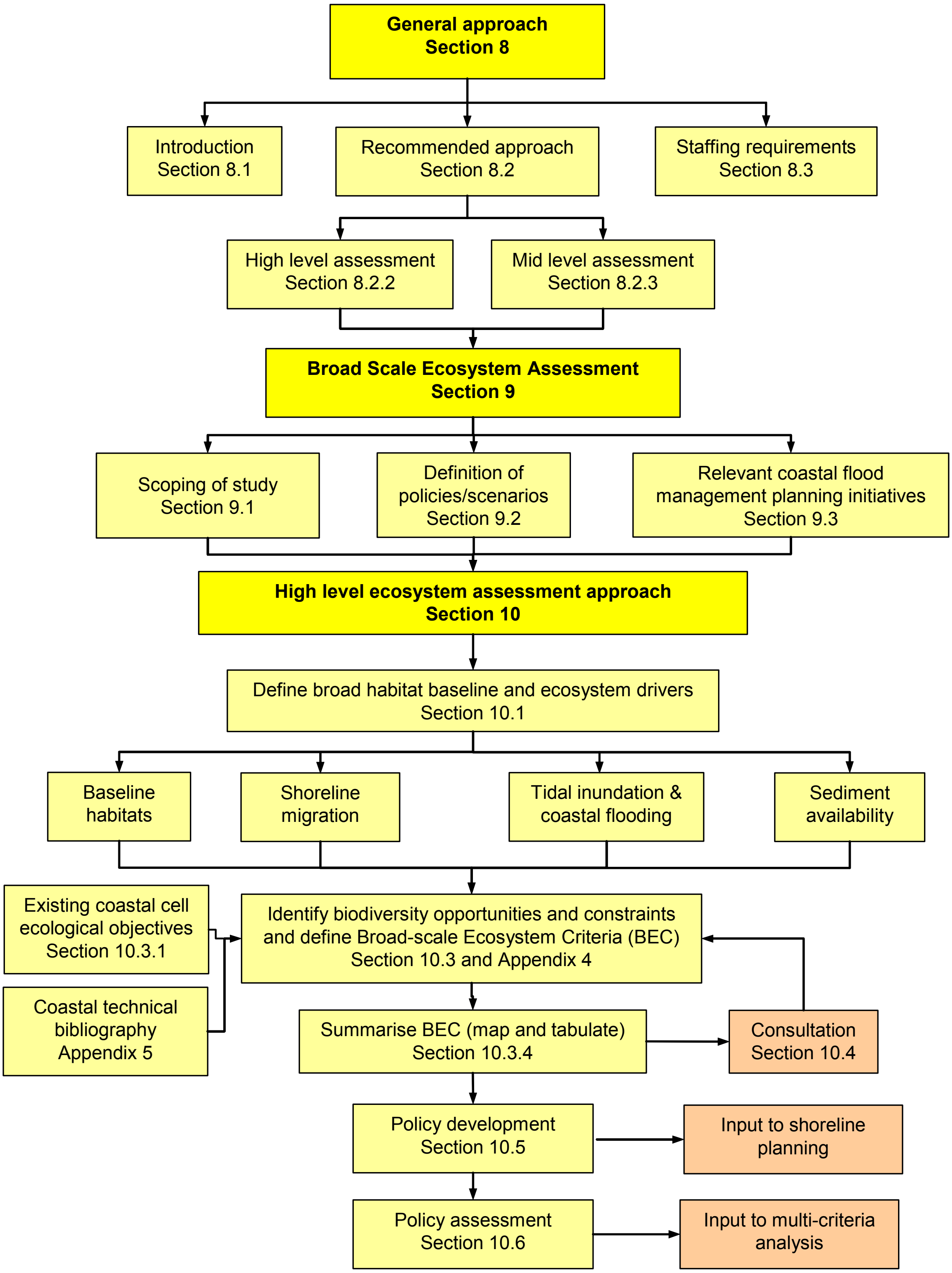
Note: The policy option units in the pilot Derwent CFMP have been identified as electoral wards, not on flood risk, hydrological or geomorphological criteria.

Figure 7.9 Yorkshire Derwent: Sustainable flood management policy options for the draft preferred policy

Table 7.4 Assessment of BEC in the Yorkshire Derwent catchment

Broad scale Ecosystem Criteria			Protection/ Enhancement	Draft preferred policy	
				Compliance	Note
Channel condition	1	Maintain unmodified channels of good diversity in upland sub-catchments	Protection	Y	Mainly no active intervention or maintaining current level of flood risk through investigating opportunities to create natural storage/runoff attenuation.
	2	Reduce channel capacity in the Vale of Pickering	Enhancement	Y	Potential actions include 'allowing the river to operate more naturally' and 'a reduction in river sediment levels'. Both actions could be achieved through re-sizing of the river channel.
	3	Enhance channel to maintain sediment supply and passage in the lower Rye catchment	Enhancement	Y / N	Potential actions include wetland creation, management of land drainage, small scale flood storage and reversion to pasture. However, no mention of removal of in-stream obstructions.
Floodplain connectivity	4	Protect connectivity of floodplain habitats in the Costa Beck	Protection	Y	Potential actions include abandoning or setting back defences, flood storage and wetland creation.
	5	Protect connectivity of floodplain habitats in the River Hertford	Protection	Y	Actively seeking to increase frequency of flooding.
	6	Protect connectivity of floodplain habitats in the lower catchment	Protection	Y	Actively seeking to increase frequency of flooding with potential actions including wetland creation, land drainage management and small scale flood storage.
	7	Enhance floodplain connectivity for sediment transfer in the lower Derwent	Enhancement	Y	Potential actions include abandoning or setting back defences, wetland creation, management of land drainage and small scale flood storage.
	8	Re-connect floodplain habitats in the Vale of Pickering	Enhancement	Y	Potential actions include 'allowing the river to operate more naturally' through abandoning or setting back defences, flood storage and wetland creation.
	9	Re-connect floodplain habitats in the lower Rye catchment	Enhancement	Y	Potential actions include wetland creation, management of land drainage, small scale flood storage and reversion to pasture.
	10	Re-connect floodplain habitats in the Ran Beck	Enhancement	Y	Actively seeking to increase frequency of flooding.
River continuity	11	Remove ecological barrier effect of weirs in middle catchment (3 no.)	Enhancement	N	No mention of removal or bypass of in-stream obstructions. However, potential reduction in sediment levels could include improving conveyance through removal of obstructions.

Part B: Guidance for coastal systems



For guidance on practical application of BSEA to coastal systems go directly to Section 10.

8 General approach for coastal systems

8.1 General principles

The BSEA toolbox project seeks to provide a user-friendly package of guidance, data sources and broad ecosystem impact modelling techniques to practitioners undertaking SMP/ CHaMP work within the coastal flood management field.

For the purposes of the project, the ecological resolution has been defined at the habitats scale. The assumption implicit in this decision is that if habitats are conserved in favourable condition the species assemblages associated with those habitats will also be conserved and the conservation status/designation of the site will be maintained. Although somewhat simplistic, this assumption is a necessary one given the broad-based nature of the approach and the difficulties involved in evaluating species-specific impacts at the broad scale at the current time. Hence, the task involves developing a toolbox to facilitate the assessment of the impact of flood management activities on coastal habitats.

A number of key factors associated with flooding and flood management will influence the nature and extent of the different habitats found around the coastline of England and Wales. They comprise:

- Coastal morphology and the sediment supply – In essence, the morphology of a stretch of coastline describes the form that it takes. It is defined by the sub-tidal bathymetry and inter-tidal and supra-tidal topography or surface elevation. Geomorphology is the study of change in form over time.

Morphological change arises as a result of erosion and accretion of sediment. Thus, erosion of material from one area leads to the movement of the eroded material to another area where it can deposit and accrete. This process has a direct effect on habitats over a variety of temporal and spatial timescales.

- Waves generated by the wind are governed by the strength of the wind and the fetch (distance) over which the wind blows. In the near-shore region, water depth (bed morphology) and the offshore wave climate also influence wave characteristics.

The energy residing in breaking waves has the potential to erode areas of shoreline thereby changing the morphology. It can also cause damage to sea defence structures leading to overtopping and/or breaching that may in turn give rise to flooding that produces further erosion.

- Surges are temporary changes in sea level that occur as a consequence of meteorological forcing factors. They may be positive or negative. In the context of potential flooding and erosion, positive surges can cause problems. They typically arise in periods of low atmospheric pressure (depressions).

- Relative Sea Level Rise (RSLR) – It is generally accepted by the scientific community that the level of the sea relative to the land is rising around many parts of the coast of England and Wales. Moreover, this increase in relative sea level is projected to continue throughout the 21st century. Clearly, the likelihood of coastal flooding and erosion will increase if this is indeed the case and nothing is done to combat the potential impacts.

All of the key factors described above have the potential to interact significantly with one another. Thus, for example increasing sea levels will allow waves to break closer inshore causing more wave energy to impact the shoreline in many areas. Positive surges are likely to produce most flooding and erosion when they coincide with an extreme high tide occurring during a period of severe wave action. Changes in coastal morphology and sediment supply will affect how much energy reaches the shoreline. Loss of fronting beaches or saltmarsh will dramatically increase the severity of damage arising from this impact.

8.2 Recommended approach for coastal systems

In order to predict coastal ecosystem impacts, an approach is required that:

- Identifies the location, nature, extent and significance of coastal habitats,
- Describes the current shoreline location/ configuration,
- Predicts the change in shoreline location/ configuration over time,
- Explains the reasons for the changes predicted,
- Predicts and evaluates the impacts of the changes identified, and
- Provides tools/ guidance for avoiding/ minimising adverse impacts and maximising beneficial outcomes.

The key question is how to provide and maintain a sustainable coastline, given current predictions for sea level rise, larger waves and increased storminess, while conserving and enhancing the ecological value of coastline features.

The general SMP philosophy is to compartmentalise the coastline into defined policy units for which the following options will be considered:

- Do nothing,
- Hold the line,
- Advance the line, and
- Retreat the line.

The recommended approach to coastal systems is to have a two tier methodology, with the level of study complexity dependent on two factors:

- Ecosystem interest and sensitivity to change (given potential policy options) in the identified coastal cell, and
- Quality and quantity of input data (hydrology, geomorphology and ecology).

Where there is little likelihood of ecosystem change, or where there are too few data to make a detailed analysis of ecosystem impact, a High Level analysis should be performed. The study can then be promoted to a mid level analysis where there are potentially significant ecosystem implications that need to be explored further by means of more complex assessment. The two tiered approach is analogous to environmental impact assessment (EIA), with the high level method similar to the Scoping phase in EIA. However, where initial studies recognise that a more detailed approach may be beneficial, but too few data of reasonable quality exist to support the analysis, care must be taken to flag this as a significant issue to the SMP project manager.

Having established the philosophical approach and some of the practicable limitations of data and predictive methodologies at this time, a framework is presented that defines the key stages and inputs for BSEA High Level toolbox for coastal systems.

8.2.1 Principal sources of data for the BSEA Toolbox

Data on the key factors highlighted is potentially available from a wide variety of sources such as European agencies, British government agencies, local authorities, academic institutions and consultancy organisations. There is, however, great variation in data availability and data quality in terms of attributes such as format, coverage and resolution. There are also significant deficiencies with regards to gaps in knowledge. For example, little geological data is available for shallow, inshore waters.

In recognition of the issues relating to the suitability of existing data sets, a number of initiatives have been implemented in an attempt to resolve them. Essentially, these efforts are seeking to develop networks of reputable data providers who can supply data along with the appropriate metadata that imparts confidence as to the provenance of the base data, its reliability and robustness. As a minimum, such metadata should comprise:

- Source(s), measurement technique, nature and spatial/temporal coverage of the base data,
- Accuracy and precision of the base data,
- The quality control procedures applied to the production of the base data, and
- The format (usability) of the base data – Increasingly the aim is to provide base data in a form suitable for immediate usage within a GIS package.

The present study seeks to make use of and complement current initiatives for providing reliable data more readily to potential end users. In doing this, however, it must accept, in good faith, that the stated objectives of on-going projects will be delivered as presently defined. With this proviso, the key data sources and data provision initiatives of relevance to the coastal aspect of BSEA are:

- The morphology and geology of the coastline –These attributes are described by bathymetry, topography and maps of sediment/rock characteristics. Currently, these data sets are derived from various sources such as the Hydrographic Office, Ordnance Survey, British Geological Survey, EA and local authorities.
- The Integrated Coastal Zone Mapping (ICZM) initiative seeks to provide a single portal for accessing this data in future. The ICZM project involves the Hydrographic Office, Ordnance Survey and British Geological Survey. These organisations have come together to bring their respective datasets to a common standard in order to provide a seamless integration of data for the coastal zone.

The ICZM project has successfully produced pilot data for three areas, the Firth of Forth, Milford Haven and the coast from Shoreham to Lyme Regis. Extension of this coverage will require further funds to be made available. The initial work was funded within the Treasury Invest to Save Budget programme.

- Tidal regime and wind and wave climate – These data are obtained from measuring devices situated around the coastline. It is collated and maintained by the British Oceanographic Data Centre. The Centre provides a focus for the Marine Environmental Data Network and is the UK partner in SEA-SEARCH, a project funded by the European Commission to provide a gateway to marine data, information, products and services in Europe. A commercial service, SeaZone, has also been set-up by Metoc to supply Admiralty and other marine data for immediate use within GIS.
- Information on sea defence structures – The EA maintain the National Flood and Coastal Defence Database (NFCDD). It contains a national data set of defence location, type and condition. Unfortunately, however, crest level and crest width, two crucial attributes of any defence structure, are not mandatory in this system and are, therefore, not available on a national basis.
- Predictions for relative sea level change – Predictions for relative sea level change are both numerous and varied. They differ in terms of the assumptions made in the calculation(s) and the location(s) and the timeframe over which they are applied. The most authoritative predictions are those produced by the UK Climate Change Impacts Programme. These are reviewed and updated to reflect developments in the understanding of key controlling processes.
- Coastal habitats – Various ecological datasets are available in the UK that may be of use for BSEA. Ecological data are not only available from more wide ranging sources than the physical data described above, it is also much more variable in terms of quality. For this reason sources of ecological data are described at some length below.

As habitats are being used as the ecological measure in this study, it seems appropriate to employ the UK National Marine Habitat Classification (NMHC) for Britain and Ireland as the basis for assessment. This system is both well developed and well understood. It is also currently being used to develop reference conditions for UK waters as part of the implementation of the WFD.

The NMHC defines marine habitats in terms of both physical (elevation, salinity, substratum etc) and biological characteristics (species abundance/coverage). The classification has been developed by a system of analysis of raw (survey) data in conjunction with the review of other classification systems and information from the scientific literature. It has recently been revised, and further details on the structure and rationale behind its development are available as an interactive web application at [www.jncc.gov.uk/marine/biotopes].

The NMHC contributes to a pan-European system (EUNIS) developed by the European EA in collaboration with other conservation bodies and scientists in Europe between 1996 and 2001. This classification describes both aquatic and terrestrial habitats and includes natural and man made habitats. The NMHC has been revised to be fully compatible with EUNIS and is widely used in the UK. Together these classification systems provide a consistent basis for the description and quantification of marine habitats.

The NMHC is a hierarchical system with the following divisions:

Level 1: Environment (marine)	A single unit is defined within EUNIS to separate the marine environment from terrestrial and freshwater habitats
Level 2: Broad habitat types	Broad habitat divisions applicable at a national and international level e.g. littoral rock, littoral sediment etc and are broadly equivalent to EC Habitats Directive Annex I habitats (e.g. reefs, mudflats and sandflats not covered by seawater at low tide).
Level 3: Habitat complexes	Broad divisions applicable at a national and international level which relate to major differences in community type e.g. Littoral mud. They are equivalent to the Sites of Special Scientific Interest (SSSI) selection units for intertidal areas and can be used as national mapping units.
Level 4: Biotope complexes	These are groups of biotopes with similar overall biological and physical character and provide better units for management and mapping than the component biotopes. They are relatively easy to identify, either by non-specialists or by low resolution methods of survey.
Levels 5 and 6: Biotopes and sub-biotopes	These describe in detail the main physical and biological characteristics of the communities within a habitat and are distinguished by their different dominant taxa or groups of conspicuous species and generally require more expertise or sampling effort to distinguish. These are equivalent to terrestrial classification schemes e.g. the UK National Vegetation Classification scheme (to which links are drawn where appropriate e.g. saltmarsh biotopes).

Habitats may be assigned or interpreted at various levels of resolution depending on the quality of the data and the scope of the study used to classify the habitat. In the context of BSEA it is likely that habitats will be assessed at level 3 (or possibly in some cases level 4) with further levels used as required.

The main sources of data are likely to emanate from a small number of sources:

- Marine Nature Conservation Review (MNCR),
- National Biodiversity Network (NBN),

- Marine Environmental Resource Mapping and Information Database MERMAID,
- Marine Life Information Network for Britain and Ireland (MarLIN), and
- Mapping European Seabed Habitats' (MESH).

Much of the data on which the classification is based comes from the Marine Nature Conservation Review (MNCR) which operated between 1987 to 1998 to identify sites/species of nature conservation importance and extend the level of knowledge on benthic marine habitats, communities and species in Great Britain. The MNCR dataset was based on survey data from conservation agencies and other sources e.g. commercial and academic studies. This data is currently held by the Joint Nature Conservancy Committee (JNCC) in the Marine Recorder database (previously Advanced Revelation).

Marine Recorder is an application designed to be compatible with the National Biodiversity Network (NBN) data model, enabling data to be contributed to the NBN Gateway. This is now the main database used by the conservation agencies (EN, Scottish Natural Heritage (SNH), CCW, and Northern Ireland Environment Heritage Service (EHS)) to hold marine monitoring habitat data for Special Areas of Conservation (SACs) and also holds the original MNCR marine dataset. In addition to describing the biotope classification code for each habitat the database holds a wide range of detailed quantitative and qualitative information on the physical and biological components of the habitat.

The NMHC dataset held by JNCC is linked to two additional information sources. The first is the JNCC's web based Marine Environmental Resource Mapping and Information Database MERMAID [www.jncc.gov.uk/mermaid/] and the second is the Marine Life Information Network for Britain and Ireland (MarLIN) developed by Marine Biological Association of the UK in collaboration with JNCC and other major bodies [www.marlin.ac.uk]. The information within MarLIN includes descriptions of where particular habitats, communities and species occur; descriptions of the features of those habitats, communities and species and, their sensitivity in relation to natural events and human activities. These portals together with the National Biodiversity Network [www.searchnbn.net] provide access to a huge amount of ecological data within the UK.

In addition to these datasets a large amount of spatial data in GIS format exists which are related to the national classification and linked to the habitat data held by JNCC. This data, comprising of biotope maps derived as part of the MNCR or more recently for SAC assessment by the conservation agencies provide a ready made source of ecological habitat data along many stretches of the UK coastal margins. Whilst no central portal currently exists to access this data at a national level, this will be addressed by the forthcoming MESH initiative (see below).

JNCC/ MNCR data have an extensive coverage of the UK covering many thousands of habitats recorded all around the UK coast. Data are available at a variety of levels ranging from broad scale spatial data over entire sections of coast or estuaries/ embayments to detailed quantitative point data sources.

Whilst coverage is more biased towards areas of conservation interest data are often available for other areas.

The primary drawback with MNCR/ JNCC data for BSEA are their variability in terms of coverage, scale and quality. Whilst data exist for much of the coast they are often at various levels of spatial (and temporal) resolution which may not always be appropriate for BSEA. As the data were obtained from a variety of sources using variable survey methods the data are not always directly compatible with some expert judgement. Furthermore the variability in survey effort means that data are often of variable quality and older data not always comparable with newer data sources. Older biotope surveys will relate to earlier version of the national habitat classification and will require adjustment to fit with the new version. Also many of the data are held as point data within recorder whilst the spatial datasets to which it pertains (e.g. biotope boundaries) are not fully implemented within the national database or available centrally.

Given that BSEA will use data at the habitat level, issues regarding data quality and compatibility are less severe. Furthermore, areas of missing data should be relatively easy to map at this level using existing data e.g. from aerial photographs, admiralty charts and Ordnance Survey/British Geological Survey maps. In addition, the current MESH project (see below) is likely to address many of these issues.

The JNCC are leading a 3 year EU Interreg-funded international marine habitat mapping programme entitled ‘Development of a framework for Mapping European Seabed Habitats’ (MESH). The project, which began in Spring 2004, involves 12 partners from across the UK, Ireland, the Netherlands, Belgium and France. The project aims to compile available seabed habitat mapping information from north-west Europe and integrate it with European habitat classification schemes (the EUNIS system and the EC Habitats Directive types). The output will comprise seabed habitat maps covering the marine waters of north-west Europe, together with the development of international standards for seabed mapping.

The MESH programme will collate existing seabed maps and harmonise them with existing classifications. Habitat modelling will be developed to predict habitat type for unsurveyed areas utilising available geophysical and hydrographic data. To assist end users the final maps will include an indication of data quality with regard to the degree of confidence and precision at different levels of resolution. A series of internationally agreed standards and protocols for habitat mapping, surveying, ground-truthing, data storage, analysis and interpretation will be formulated to assist the development of future mapping studies.

Habitat maps and accompanying mapping protocols will be accessible via an internet-based Geographical Information Systems (GIS) which will provide ready access to the information for a wide range of end-users at local, regional, national and international levels. A meta-database of seabed mapping projects for north-west Europe will also be developed which will hold details on the location of each study along with the techniques used and the data produced.

The project aims to map the INTERREG-IIIB Area of north west Europe including UK waters and the coasts of Belgium, Holland and northern France.

At this early stage of the project it is not known at which level of detail the mapping studies will be harmonised or developed and how these will integrate with the aims of BSEA. However, in the UK it is likely to incorporate existing information used for the UK national marine habitat classification outlined above and subject to the same problems.

Coastal habitat designations

Much of the coastal habitat described in the various datasets identified above is subject to designation in recognition of its nature conservation significance.

The principal designation in terms of UK conservation legislation is Site of Special Scientific Interest (SSSI). The SSSI citation defines site boundaries (from digitised maps), and provides an indication of the species and habitats present (sometimes including the BAP habitat assessment). The degree to which the data are presented in quantitative form depends on individual sites and citation/review dates, but in many cases, the data will only be in the form of a qualitative species list of key species of interest, and/or characteristic species.

In addition the citation includes an assessment of site condition (ranging from favourable to destroyed, and/or an indication of improvement or decline), together with a list of operations which will require EN's consent (formerly damaging operations). The citation will also provide some information on management activities for the site, and the responsible EN officer.

Special Protection Areas (SPAs) are designated under the Birds Directive (79/409/EEC), to give protection under EU law. They are generally based on SSSI boundaries, and provisions transposed into UK law through the Conservation (Natural Habitats &c) Regulations 1994 (the Habitats Regulations).

The site citation specifically addresses the importance of an area for species or assemblages of birds covered within the Directive, and as such covers breeding, migratory and over-wintering species included in the appropriate Annexes, together with assemblages of waterfowl or seabirds (over 20,000 in any season).

The citation also includes provision for other attributes such as usage as a severe weather refuge, and the designated sites are included within the Natura 2000 network. Sites with intertidal or marine habitats are known as European Marine Sites, and are treated slightly differently because of legal coverage below mean low water.

A designated site will have a Regulation 33 advice package for it, this advice (under the Habitats Regulations.) identifies the key species and assemblages of interest, as well as boundaries etc. The advice will also have some indication of numbers of key species, together with activities considered to be a threat to these features, and status assessments.

For estuarine sites there will be some bird data, at a site-specific level, this largely derived from high water WeBS survey work. In addition there may also be low water count data from the site. Such data are collected at a sectoral basis, usually with reaches around 5km in length. Coastal sites may also have WeBS data, depending on their location. In addition, some species-specific data may be available, for key species of migratory and over-wintering birds, with breeding species also being covered by some form of monitoring. Habitat extent/quality in relation to usage by bird species is also necessary to be checked in terms of condition, this potentially requiring data collection, possibly linked to SAC monitoring, but also including issue specific work, such as cockle stock assessments.

Data if available are only on a sectoral basis, and may be feature specific. Other information on habitat quality etc are possibly covered under other European Marine Sites designations.

Special Areas of Conservation (SACs) are designated under the Habitats Directive (92/43/EEC), to give protection under EU law. They are again generally based on SSSI boundaries, and provisions transposed into UK law through the Conservation (Natural Habitats &c) Regulations 1994 (the Habitats Regulations).

The site citation specifically addresses the importance of an area for key habitats and species (other than birds), these habitats and species are given in Annexes. Sites with intertidal or marine habitats are known as European Marine Sites, and are treated slightly differently because of legal coverage below mean low water.

In terms of assessment SACs are addressed in a similar way to SPAs, but all key habitats and species, not just bird assemblages, are considered.

A designated site will have Regulation 33 advice package for it, this advice (under the Habitats Regs.) identifying the key habitats and species of interest, as well as boundaries, status etc. The advice will also have some indication of activities considered to be a threat to these features, and status assessments based on condition. There will be boundaries available, and, as with SPAs), within the available data for the designation of the site, information on species numbers and habitat constituents and area.

For estuarine/coastal sites, it is likely that there will be habitat data in the form of NVC maps for saltmarsh, and some biotope maps utilising the national marine habitat classification (as outlined above) with species assemblage data for intertidal and sub-tidal areas. However, this may not always be the case, or data may be derived from documentary evidence rather than primary data. Maps will be in a digitised form, and it is likely that area/habitat information will also be present within the Regulation 33 package. Numbers of key species may also be available, together with an indication of area of key usage for some species. However, data may not be particularly up-to-date.

Data will only on a sectoral basis, and may be feature specific, with some potential data age/interpretation issues. The information relating to the designation is best aimed at a sectoral or holistic system approach, and may therefore not be at a useable scale.

The locations and boundaries of sites subject to designation, at whatever level, for nature conservation interest around the coast are obtainable, for immediate inclusion into a GIS format, from EN.

Data from the sources described above has already been employed to generate information of relevance to BSEA in various studies as follows:

FutureCOAST – This project was commissioned by Defra and the National Assembly for Wales. It involved a study of coastal processes and geomorphology for the entire open coastline of England and Wales. This work was undertaken to inform and guide the latest round of SMPs.

The most significant feature of FutureCOAST from the BSEIM perspective is that it provides a sound, scientific and nationally consistent basis for predicting coastal changes over the next 100 years. Outputs from the study include reports, guidance, data and mapping at various scales.

Foresight Flood and Coastal Defence Project – This study, sponsored by Defra, has produced a long term (30-100 years) vision for the future of flood and coastal defence in the whole of the United Kingdom. The vision takes account of recognised uncertainties, is robust and can be used to inform policy and its delivery.

The Foresight Flood and Coastal Defence Project employed a methodology (RASP – Risk Assessment for flood and coastal defence Strategic Planning) for national-scale flood risk assessment. This methodology makes use of data on the location and type of coastal floodplains and the standard and condition of sea defence structures to estimate the probability of flooding, to a range of depths, on grid scales up to 1.0km x 1.0km. It then combines this information with census data and commercial databases of location, population and property to derive information on the relationship between flood depth and economic damage.

The Foresight Flood and Coastal Defence Project employs this tool to investigate four different scenarios of social, economic and technical evolution in order to establish potential flood risks by the year 2080.

Indicative Floodplain Mapping – This work, undertaken by the EA, has generated maps that identify the potential extent of natural coastal floodplains. These features equate to the areas that would be flooded in the absence, or failure, of existing sea defences as a result of a 1 in 200 chance of occurrence.

The latest round of *Shoreline Management Plans*– A SMP provides a large-scale assessment of the risks associated with coastal evolution and presents a framework for addressing these issues in a sustainable manner. Thus, amongst other objectives, the SMP for any given stretch of coastline seeks to define flooding and erosion risks over the next century, to identify the preferred policy for managing those risks and the consequences of implementing preferred policies. Four shoreline management policies have been identified by Defra for consideration, viz. Hold the Line, Advance the Line, Managed Realignment and No Active Intervention. Not all of these are realistic in all cases, however.

A key output of the SMP studies in the context of BSEA is the predicted shoreline configuration, under the various management options considered, for 2025, 2055 and 2105. These have been developed as layers within a GIS format.

8.2.2 Approach to High Level ecosystem assessment

The base data required for high level assessment will include:

- General habitat types and areas designated for conservation interest (e.g. EN, CCW and SNH),
- Coastline topography down to mean low water (e.g. Ordnance Survey) and nearshore bathymetry from beyond mean low water (e.g. UK Hydrographic Office) to define surface elevations as height contours.
- Tidal levels (e.g. UKHO),
- Coastal sea/flood defences location, height, condition (National Flood and Coastal Defence Database-NFCDD), and
- Indicative Coastal Floodplain Maps (ICFP).

Two recent initiatives are of interest in this context.

The first is Integrated Coastal Hydrography (ICH) a partnership between OS, UKHO, EA and the Maritime and Coastguard Agency. This aims to produce an on-line database of hydrographic metadata and a shared methodology for definitive measurement of hydrographic data in UK coastal waters. This initiative defines the coastal zone as 5km inland to 20km offshore inclusive of tidal rivers.

The second is the development of a framework for Mapping European Seabed Habitats (MESH) which began in spring 2004 and is scheduled to last 3 years.

Output from these initiatives should be made available via internet based Geographical Information Systems so it is easy to envisage how it might be made use of for BSEA high level analysis in terms of identifying potential issues/impacts.

Also of interest in the MESH project is the intention to develop models for the prediction of habitat type based on physical and hydrographic information within different habitat areas and water depths. Clearly, BSEA should seek to take on board as much of this methodology as possible when it comes to developing the assessment methodologies.

Currently, the high level method is envisaged as a GIS-based system that merges geographically indexed data on coastal topography/bathymetry with information on sea defences from the NFCDD, output from ICFMs, general habitat types (MESH) and sites designated for their conservation interest (EN/CCW).

There are some deficiencies in this approach:

- Coastal topographic/bathymetric data are by no means comprehensive or, where they do exist, of adequate resolution to permit estimation of flood depth.
- Parameters like crest level and crest width are not mandatory within the NFCDD.
- The ICFMs indicate outlines of areas that would be inundated by a 1 : 200 year event. Current SMPs require consideration of coastline scenarios for 2025, 2055 and 2105.
- The MESH project was only initiated in Spring 2004.
- There are recognised difficulties when attempting to define the boundaries of designated sites when using information supplied by EN/CCW.

Nevertheless, the basic framework is more or less in place and it makes good sense to attempt to ensure that it develops with the needs of BSEA in mind.

The High Level approach is presented in Section 10.

This approach is relatively quick and straightforward seeking to highlight potential threats and/or opportunities on the broadest scale. Nevertheless, it will require a substantial degree of professional knowledge and judgement for proper interpretation.

It is readily apparent from the above account of key data sets and recent initiatives that the basis for the High Level assessment, in terms of data, information and tools, already exists. It remains, however, to translate the existing information on the risk of coastal flooding and erosion and the likely future configuration of the coastline under the various scenarios considered into likely changes in the habitats impacted by these events. This could be most simply achieved by superimposing GIS layers describing the various predictive scenarios on current baseline map layers showing existing habitats and shoreline configurations. Such an approach will provide an indication of the overall areas potentially subject to change, but will not reveal the magnitude and significance of the change as this will be governed by factors such as frequency and extent of tidal inundation.

The methodology employed in the Foresight study, however, does offer a means of quantifying potential impacts to some degree. Thus, coastal habitat data sets would be substituted for the location, population and property data sets that were coupled with the estimates of flooding probability generated by Foresight. It should then be possible to derive an indication of environmental (habitat) damage as opposed to economic damage at least in terms of low, moderate and high risk.

8.2.3 Approach to Mid Level assessment

The high level assessment as described above will serve to facilitate identify and prioritise areas for mid level analysis. This will involve more detailed assessment of specific areas over shorter timescales ideally using site-specific data on key variables Two basic approaches can be adopted:

- 'Top-down' methodologies, either wholly empirical or built around physical principles can be applied. One example is the use of historical trend analysis to identify directional trends and the rates of processes and morphological change over different time periods. Another approach might employ knowledge of how frequency and extent of tidal inundation influences the floristic diversity of saltmarsh communities to draw conclusion about potential impacts on this attribute arising as a result of changes in tidal regime.
- 'Bottom-up' methodologies are usually based around a process-based model of the coastal zone. Such models are widely available to investigate hydrodynamics, sediment transport, morphology, water quality and certain ecological features.

There is very little general guidance as to what constitutes a best practice approach to numerical modelling. Different practitioners, usually consultants, employ different modelling systems often in accordance with their own protocols. Some make extensive use of appropriate field measurements to calibrate and verify their model, others use the bare minimum in this regard. Consequently, some numerical modelling approaches are significantly better than others. A few leave much to be desired.

Because of the comparatively high cost of numerical studies, that should always include an adequate associated field data gathering programme if sufficient, appropriate data do not already exist, it is essential to select an approach that is fit for purpose. To this end some basic considerations are presented below.

There are various models currently available. The most sophisticated are modular systems built around a flow module that represents all of the significant mixing processes (e.g. tides, wind, inflows from rivers) to simulate flows in the area of interest and generate output comprising temporal and spatial variations in flow velocity and water level. This hydrodynamic database serves as input to drive associated modules simulating features such as sediment transport and morphodynamics. Other modules, such as wave models, water quality models and ecological feature models can also be incorporated

Depending on the morphology of the water body and the nature of the various water masses interacting within it, flows may vary in one, two or three dimensions (i.e. longitudinally, laterally and vertically). This fact is recognised in the construction of flow models.

One-dimensional models simulate longitudinal variations assuming that there is little or no variation across the width or through the depth. Generally, they are suitable for investigating conditions in long, narrow channels, or networks of such channels, that are vertically homogenous throughout the water column.

Two-dimensional models simulate variations in both horizontal dimensions, but still assume that there is little or no vertical variation through the water depth. They are suitable for relatively wide channels where significant lateral variations can be expected.

Three-dimensional models are the most complex and simulate conditions in water bodies where there are longitudinal, lateral and vertical variations. There are also a small number of two-dimensional in the vertical (2DV) models available that simulate longitudinal and vertical variations in long, narrow stratified channels where less dense brackish water overlays more saline water.

When selecting a model, it is essential that the correct dimensionality is chosen. The use of a one-dimensional or two-dimensional in-plan model for a stratified situation may provide an adequate simulation of water level, for example, but predictions of parameters such as water velocities and sediment transport will be totally unreliable because a major driving process (stratification) has been ignored. In some cases it may be possible to force an inappropriate model to fit a limited set of observations, but the predictions obtained from the model outside of the range of the observations employed in construction will not be reliable.

British coastal areas and estuaries are mostly characterised by rapidly fluctuating physico-chemical conditions that vary spatially over short, medium and long-term timescales. If the need arises to investigate such environments by numerical modelling on anything other than a very localised scale it is likely that a two or three-dimensional modelling system will be required. The ability to simulate situation over a variety of variable spatial and temporal scales is also highly desirable. Proven, well established modelling systems of this type include DELFT3D (Delft Hydraulics), MIKE21 (Danish Hydraulics Institute) and TELEMAC 2D/3D (Electricite de France/HR Wallingford)

In order to compare the merits of different models it is necessary to consider information on:

- The processes/ mechanisms (e.g. sediment transport, morphodynamics) included in the model and how these compare with the processes which occur within and adjacent to the area of interest.
- How these processes/ mechanisms are represented mathematically.
- How the model is used, e.g. the spatial resolution, period of simulation and the data used to drive the model.
- How the results are presented.

- The quality assurance procedures applied to the modelling approach. To verify coding, assess sensitivity and validate output, for example past usage of the model for similar studies that demonstrate an acceptable level of precision by comparing model predictions with observed field measurements of the parameters of interest.

As well as choosing the best model it is also very important to ensure that adequate, appropriate data are available to calibrate and verify it. Data are required for a range of conditions (e.g. neap and spring tides) covering a spatial area large enough to ensure that the variations in parameters like water velocities and sediment concentrations in the area of interest are known.

A model lacking information in any of the above areas should be treated with caution and only employed if there really is no alternative option. Such a situation might arise where information is sought that is on the limit of an existing model's capability to provide. In such a case the approach will be of necessity experimental. This fact should be clearly highlighted and detailed consideration should be given to defining the degree of uncertainty/variability associated with any predictions made.

No further discussion of the Mid Level approach is included in this guidance document. Application of the over-arching High Level approach, and embedding of later more detailed studies (including the Mid Level approach) should allow the benefits of a suitably tiered strategic analysis to be achieved. Benefits should include a more sustainable approach to coastal management, deriving cost savings for flood management activities and biodiversity gains from more suitably targeted management actions.

8.3 Staffing requirement for broad scale ecosystem assessment

BSEA involves an appreciation of coastal hydrological, hydraulic, morphological and ecological processes. Whilst guidelines will be provided on BSEA, it is important that BSEA is carried out by staff with appropriate training and experience and with suitable supervision. For example, staff undertaking BSEA should have an appreciation of the processes mentioned above and the ability to understand the linkages between them. Supervisors should have experience in broad scale work and relevant processes. Ideally staff undertaking BSEA should have access to specialists in coastal hydrology, morphology and ecology.

Whilst the staff requirements may appear onerous, investment in suitable training and the provision of suitable work experience to develop staff is strongly recommended. This is because the methods recommended in this report are often relatively simple but require judgement for effective application.

The following Section (9) defines the requirements of each of the key stages in the ecosystem assessment process.

9 Coastal broad scale ecosystem assessment

9.1 Scoping of Study

The requirement and level of detail necessary for an ecosystem assessment is dependent on the study being undertaken. The guidance contained in this document is intended for use wherever assessment of risk to broad scale ecosystems is required in the context of flood management and coastal defence initiatives and its associated SEA requirements. Before undertaking any ecosystem assessment it is essential to define the requirements of the study, in terms of:

- Size and boundaries of study area,
- Objectives of the study,
- Opportunity for influencing the development of the assessment scenarios (BSEA needs to be included at inception of study),
- Level of ecosystem assessment required, and
- Details of final decision-making process so that BSEA outputs are in a suitable format and at an appropriate level of detail.

The availability of staff with suitable experience in the disciplines required (e.g. ecologist, geomorphologist, GIS technician) should be confirmed within the delivery timescale of the assessment.

These requirements will be specified in the procedural guidance or defining legislation for the study being undertaken (SMP2) and should be developed in collaboration with the project management team. An overview of the ecosystem assessment requirements for coastal initiatives is presented below to assist in the definition of the policy or scenario.

9.2 Definition of potential policy directions

For flood management to be environmentally sensitive, a major consideration needs to be that the ecological health of a coastal cell (and water-dependent habitats and species) should not be reduced. This may be a critical requirement when the ecology of a system is of good quality, but where the ecological value has been damaged by degraded habitat structure, there is a requirement to take advantage of opportunities to rehabilitate the system so that it can take opportunities to recover its ecological potential, or reach good status.

This approach is supported by:

- Internal EA policy (e.g. Environmental Vision, 2000; Corporate Plan 2005),
- UK legislation (e.g. Water Act, 1995; Wildlife & Countryside Act, 1981; CRoW Act, 2002), and
- Transposed European legislation (e.g. Water Framework and Habitats Directives).

Note that the Environment Act (1995) requires the EA to:

- ‘Further conservation wherever possible, when carrying out water management functions’, and
- ‘Promote the conservation of natural beauty and amenity and the wildlife dependent on the aquatic environment’.

At the broad scale the general approach for coastal systems seeks to identify flood risk management constraints to natural coastal ecosystem function and biodiversity opportunities that act at the coastal cell or sub-cell level. These will tend to be system bottlenecks (e.g. artificial embankments, groynes) or broad scale pressures (e.g. mobile sediment availability, land use and land management in the coastal floodplain).

9.3 Coastal flood management planning initiatives

The particular coastal flood management and flood defence initiatives where assessment of ecosystem risk is required include:

- SMPs,
- CHaMPs,
- Future integration with WFD,
- SEA,
- Defra targets for no net loss for capital schemes,
- BAPs, and
- Provision of compensatory areas of habitat to mitigate losses attributed to “hold the line” policy.

At present the guidance contained in this document is not specifically aimed at SMPs or their SEAs. However, it is generally recognised that the subsequent plans for coastal management units, schemes and WFD assessments will require an assessment procedure that could be based on the framework contained here, but potentially with greater levels of detail in terms of site-specific input data and process analysis.

The structural modifications/ interventions and management actions appropriate for development of a policy or scenario will typically be drawn-up as a feature of that policy or scenario (see also Constraints and Opportunities in Section 10.3.3 for opportunities to influence their development). The requirements for the appropriate level of assessment of risk to ecosystem change are established in the legislation or guidance for each initiative, and are summarised in Table 9.1.

In order to satisfy the requirements of these initiatives it is desirable that BSEA provides the following at the SMP coastal cell and management unit scale:

- Broad scale understanding of ecosystems,
- Baseline description of ecosystems and indicators suitable for broad scale application,

- Predictive scenarios for future horizons: i.e. where will shoreline be, what will it look like, how will it have changed, what are the reasons for change, what are the impacts of change, and
- Guidance on measures to avoid/ mitigate adverse impacts and maximise enhancement opportunities.

Table 9.1 Ecosystem assessment requirements of coastal flood management and other initiatives

Initiative	Ecosystem Assessment Required
SMP	To be added when guidance completed.
CHaMP	The first round of CHaMPs is complete and it is currently understood that no revisions will be required. Should this situation change there may be a requirement for assessment of risk to ecosystems at the broad scale. The work included in ChaMPs should be internalised into the SMPs in the next round of SMPs
WFD	The principle objectives of the Directive as set out in Article 4(1) include the following: • Prevent deterioration in the status of surface water bodies, • Protect, enhance and restore all bodies of surface water with the aim of achieving good surface water status by 2015, and • Achieve compliance with any relevant standards and objectives for protected areas. River Basin Management planning will be the main vehicle for protecting the water environment. The Directive sets out a planning cycle for river basin management which consists of three main parts: • Characterisation of River Basin Districts including an assessment of water bodies at risk of not achieving the Directive's objectives as a result of man-made pressures, • Establishing environmental monitoring informed by characterisation, and • River Basin Management Planning, which includes setting environmental objectives and designing a programme of measures. The requirements of BSEA for the WFD are as follows: • Identify the current ecosystem status of the coastal cell, • Identify the impacts from flood risk management activities on ecosystems in order to develop the measures needed to achieve good ecological status or good ecological potential, and • Develop a broad scale programme of measures relevant to flood risk management.

SMP policies that can be tested in a given management unit include:

- Do nothing,
- Hold the line,
- Advance the line, and
- Retreat the line.

The policy/ scenario definition should take account of the requirements for investigating:

- Impacts of change include:

    - Climate change (sea level, wave heights, storminess),
    - Habitat change, and
    - Development (including sea defence works).
- Long-term horizons. For example, SMP2s are intended to cover 100 years with scenario predictions for 2025, 2055 and 2105. It is recognised that there are large uncertainties in this process and SMPs are intended to be updated at regular intervals.
- Overlap between estuarine and fluvial ecosystems.
- Impacts on brackish and inland ecosystems from modifications to existing coastal defences.

10 Coastal high level ecosystem assessment guidance

This Section contains the guidance for undertaking a High Level assessment of coastal ecosystems; tailored to flood management policy at a coastal sediment cell scale. To aid the reader in interpretation of the guidance, it is recommended that this section is read in conjunction with the following Case Study (Section 11) that elaborates on application of the approach and the detailed instructions for each Tool in Appendix 4. The following identifies the steps in the BSEA process.

Define broad habitat baseline & ecosystem drivers (Section 10.1)

↓

Prediction of change to ecosystem drivers (Section 10.2)

↓

Identify biodiversity opportunities and constraints & develop Broad scale Ecosystem Criteria (BEC) (Section 10.3)

↓

Expert consultation and review (Section 10.4)

↓

Policy development (Section 10.5)

↓

Policy assessment using BSEA (Section 10.6)

The approach is GIS-based and driven by a qualitative review of appropriate current baseline and historic data for coastal habitats and the key drivers for their dynamic evolution. This will include the hydrological and geomorphological functioning of the coastal cell (see Section 10.1).

Through use of expert judgement, assisted by information on causes and effects of flood management activities (bibliography included in Appendix 5) the biodiversity opportunities and constraints in the coastal unit of interest can be identified. These will be based on the collective expert judgement of the project team members and are central to the derivation of the BEC for the coastal unit. Guidance is provided in Section 10.3, leading to the mapping and tabulation of the BEC. The BEC are the key assessment criteria against which each of the coastal cell policy options are to be compared during option assessment.

An expert stakeholder consultation and review stage is included to enable an appropriate audience to discuss the understanding of ecosystem drivers in the coastal unit and the suitability of the proposed BEC. Guidance is provided in Section 10.4 for the consultation, which should lead, where necessary, to the modification and eventual confirmation of the BEC.

The BSEA methodology can then be used in the development of alternative sustainable flood management and coastal erosion policies in the coastal unit, through the SMP process. A range of potential flood management actions can be identified to achieve the potential biodiversity benefits of each BEC, and each of these actions will have a potential flood management consequence. These can be built into consideration of flood management planning in the coastal unit. Guidance is provided in Section 10.5.

The BSEA methodology can also be used in the appraisal of alternative sustainable flood management and coastal erosion policies. This can be tailored to provide the ecological component of the SEA for a SMP. Each alternative policy or option can be assessed in terms of performance against each protection or enhancement BEC. Guidance is provided in Section 10.6, leading to the population of a policy assessment matrix.

10.1 Define broad habitat baseline and ecosystem drivers

The purpose of this coastal cell broad scale characterisation is to identify and specify the key ecosystem drivers in terms of their current state and dynamic context, reflecting evolutionary change (potentially including anthropogenic influences) over time.

The coastal High Level toolbox contents are presented in Table 10.1. Appropriate data for each are readily available throughout England and Wales. Guidance on data sources, licensing, manipulation, presentation and interpretation are provided for each Tool in Appendix 4. The modular nature of the toolbox means that Tools can be updated as new datasets or methods become available. Where surveys or modelling studies have been undertaken for the coastal unit of interest, the output data from these can be used to supplement or replace the standard Tool.

It will not necessarily be appropriate to apply all of the Tools in all of the study areas. The discretion of the user will be required to scope those ecosystem drivers that are appropriate to the study of the specific coastal unit under investigation.

Table 10.1 Coastal high level toolbox contents

Tools	
Tool A	Baseline habitats
Tool B	Shoreline migration
Tool C	Tidal inundation and coastal flooding
Tool D	Mobile sediment availability

10.1.1 Tool A: Baseline habitats

As discussed earlier, the extent of the ecological resolution of the toolbox is the habitat type as identified by generally accepted criteria. Essentially, habitats are spatial complexes of communities composed of distinct assemblages of individual species that are determined by the prevailing physico-chemical conditions. Change in these conditions beyond the limits of tolerance of all/some of the species making up the existing community will give rise to change in community structure and habitat type. The basic premise applied here, therefore is that if habitats are maintained in favourable condition the species assemblages associated with them will also be conserved and the conservation designations of given sites will be maintained.

A number of GIS-based sources of data on coastal habitats in England and Wales are generally available at a national level. These are listed in Appendix 5. These data sources provide information on the location, and extent (area) of the different habitat types sufficient to define the occurrence and physical dimensions of each habitat type in any given study area. Additional information on aspects such as status and current condition are also required, however, in order to establish the baseline:

Although these additional attributes (potentially relating to the Ratcliffe criteria) require consideration, they cannot be integrated directly within a broad-scale assessment of risk to ecosystems because they are based on subjective interpretation of features such as:

- Habitat integrity/ fragmentation,
- Habitat diversity in the study area,
- Sensitivity of the habitat,
- Naturalness of the habitat, and
- Substitutability of a habitat (for development of mitigation or enhancement opportunities).

Habitat classification is not like species classification: there is no clearly agreed 'taxonomy' and many different systems have been developed, often independently of each other and for different purposes. The National Biodiversity Network (www.nbn.org.uk) habitats dictionary project brings those in current use in the United Kingdom together as a single publicly accessible information resource.

In order to develop an overview of the system, prior to consultation, the GIS layers for statutory nature conservation designations should be obtained and mapped. Supporting information on designation criteria and conservation objectives should be reviewed, where available. Overview documents of the coastal unit should be reviewed to obtain perspective on water-dependent habitat nature conservation in the study area, e.g. CHaMPs. It should be noted, however, that these may not represent the current status of nature conservation. The presence and potential significance of non-water dependent sites in proximity to the coastline should be determined and the presence of UK

Biodiversity Action Plan habitats and species should also be established to provide further context for the study of the area of interest.

The overview should provide an account of the spatial distribution, frequency and relative quality of the relevant habitats compatible with the requirements of the broad-scale assessment of risk to these habitats, in the context of the specified ecological quality objectives and nature conservation/ biodiversity opportunities.

10.1.2 Tool B: Shoreline migration

The current shoreline position at any given coastal location is governed by the surface elevation (topography) of the land mass and the tidal height at that location. In time this position may change. Thus, for example, the surface elevation of the land may diminish as a result of erosion and tidal heights may increase subsequent to sea level rise. The potential for shoreline migration varies according to different climate change scenarios as well as according to changes in flood management policy. Long term change and risk to vulnerable features (e.g. breaching of a sand bar) and associated habitats can be evaluated by reference to the predictive studies of future coastal evolution presented in the reports of the FutureCOAST project.

The basic methodology for investigating shoreline migration involves defining the current (baseline) position of mean high water spring (MHWS) tides at the desired location and then redefining this level under the chosen range of management/natural change scenarios to be examined all within a GIS framework that can readily manipulate/overlay the different layers generated to examine how and where shoreline migration encroaches on existing habitat boundaries.

10.1.3 Tool C: Inundation/ coastal flooding

Shoreline migration over time will bring with it changes in the location, extent, depth and frequency of coastal flooding. Understanding the pattern of change in this regard is essential if existing habitats are to be best protected and new habitats are to be encouraged to develop in suitable areas to compensate for those habitats unavoidably lost as a result of sea level rise for example. With sea level rise and increase in storminess predicted with climate change, the risk to saline-intolerant priority and designated habitats in flood risk areas becomes increasingly severe and some areas will be lost. Consequently, an effective means for exploring opportunities to create or enhance coastal priority habitats, including salt marsh and saline lagoons is required.

Consideration of the likely impact of flooding on those habitats open to the sea can be based upon examination of overlays of existing and projected tidal levels information and/ or reference to indicative floodplain maps. Consideration of the likely impact of flooding on those habitats currently protected from tidal inundation by sea defence structures will also require an evaluation of the likelihood of the failure of these structures such as can be obtained from application of the RASP methodology described for Tool C in Appendix 4.

10.1.4 Tool D: Mobile sediment availability and barriers to movement

In order to be self-sustaining a shoreline requires sufficient inputs of sediment to compensate for any losses arising. This need in turn requires an adequate sediment supply and the absence of any barriers to the natural pattern of sediment transport.

The coastal morphology review tool is used to provide an understanding of littoral and sub-littoral sediment type, the potential mobility of the sediment, the direction of movement of mobile sediment and the transfer rate. Identification of barriers to sediment transfer processes, such as physical barriers to longshore drift is a key component of this process.

This tool employs geological mapping information and the location of structures with the potential to disrupt natural sediment transport processes. For the most part this information will need to be translated into a suitable GIS format and subjected to interpretation that will require a high degree of professional knowledge and judgement. The base information for this approach has been drawn together in the SMP2 coastal morphology reviews.

10.2 Prediction of change to ecosystem drivers

The predictive component of the high level approach to changes in ecosystem drivers as described above relates to the use of general, nationally derived estimates of projected future change obtained from the application of various approaches. The prediction of change to ecosystem drivers may be necessary as part of an assessment of future policy options. This is addressed through specific Tools in Appendix 4. These include:

- Future trends in shoreline migration are derived from FutureCOAST which maps future shoreline positions for different management policies based on the integration of currently accepted rates of cliff erosion and sea level rise coupled with the presence/absence of sea defence works to identify potential changes in MHWS.
- Future trends in tidal inundation and flooding are derived from the DTi Foresight project. This employed the RASP high level methodology to establish flood risk within the indicative flood map flood outline for various projected conditions for the 2050s and 2080s.
- Future trends in sediment availability were derived from information on littoral/ sub-littoral sediment type, potential mobility, direction of transport and rate of transport, incorporated in the SMP2 coastal morphology review, coupled with the identification of physical structures on the coast that might eliminate/disrupt natural sediment transport processes.
- In each of these cases it is to be expected that the approaches employed can be further developed, refined and re-applied as more detailed information becomes available and tools, such as the RASP methodology, are improved. Moreover, scenarios other than those already examined could readily be investigated with the means already available.

In addition, however, it should be noted that a substantial number of other predictive tools, such as simulation models, have been applied to many areas of the coastline for a variety of purposes. While their general application in the context of BSEA will be, for the most part, in the Mid Level assessment as discussed in Section 8.2.3, it is clearly sensible to make use of any applications already undertaken to inform High Level assessments where this is possible.

10.3 Derivation of appropriate coastal broad scale ecosystem criteria

The BSEA approach is based on a modular framework that defines a set of key inputs to the assessment process. These can be replaced or built on as baseline data coverage increases and scientific knowledge improves. The recommended approach combines ecosystem indicators of both short-term impact and long-term dynamic change in the physical environment and translate the implications to broad scale changes in supported habitats through assessment of risk related to BEC. The key steps are as follows:

- Develop an overview of existing broad habitat types; where practicable to include their location, extent and status,
- Determine the appropriate ecosystem drivers for each broad habitat type
- Develop an understanding of the broad habitat types through the appropriate ecosystems drivers,
- Define the context and objectives of the study (e.g. for flood management policy investigation, potential management actions will have consequences for flood management),
- Establish constraints (Protection BEC): geographical areas/ system functioning which must be protected as part of the study objectives,
- Establish opportunities (Enhancement BEC): geographical areas/ system functioning which can potentially be incorporated and enhanced as part of the study objectives,
- Map BEC to provide spatial context,
- Verify and, if required, supplement BEC through a key stakeholder forum,
- Use BEC to inform policy/ option development, and
- Use BEC to assess the relative merits of each policy/ option.

The starting point for the BEC is ecosystem function. If the ecosystem is considered to be functioning appropriately then it is assumed that physical habitats will also be in good condition. For the purposes of broad scale assessment, it is assumed that if habitats are in good condition then species/ assemblages will follow suit and any nature conservation designations will also be maintained/ improved accordingly. Species-targeted improvements are outside the scope of catchment-scale assessment at this time.

BEC provide the yardstick against which policies or scenarios can be assessed to give a relative analysis of positive, neutral or negative ecosystem impact. Identifying and defining correct BEC is therefore essential in implementing

BSEA as an assessment tool. When defining BEC the following factors must be taken into consideration:

- BEC must be appropriate for the type of study,
- BEC must be commensurate with the detail of study,
- BEC must be tailored for the study area, and
- BEC must be able to be assessed using the tools available.

When addressing these factors at the broad scale, the following can be applied:

- BEC must be at a broad scale, which will be linked to ecosystem function/ broad habitat types. They are not linked to species or designation conservation objectives (which are generally species-led).
- BEC will be specific to the catchment cell being studied. This will involve taking existing data sets based on other landscape and/or administrative boundaries and adapting them.
- BEC must be able to be assessed using the available ecosystem assessment tools (i.e. for fluvial systems, understand changes in channel condition, channel continuity and floodplain connectivity).
- It is recommended that no more than 20 BEC are identified to ensure the assessment process is manageable.

The following assumptions are made for this guidance:

- Sufficient core baseline data are available to undertake the assessment,
- The ecosystem function (status and change) can be modelled and assessed with a reasonable degree of certainty,
- The relationship between ecosystem function change and habitat change can be estimated, using evidence-based professional judgement, with a reasonable degree of certainty, and
- The relationship between habitat change and species/ assemblage change is less easily predicted (and requires further empirical analysis beyond the scope of this study).

The above assumptions may change in time as better cause-effect relationship information and understanding for ecosystem drivers, habitats and species/ assemblages is gained.

10.3.1 Existing ecosystem criteria

The range of current initiatives that have established biodiversity, geomorphology or hydrology targets should be interrogated to establish integration with BSEA. The above list is not definitive. For a study coastal cell, the existence of the following should be investigated in the context of sustainable flood and coastal erosion management.

- Nature conservation designation “conservation objectives”:
    - Natura site (SAC, SPA) and RAMSAR conservation objectives, and
    - SSSI favourable status.

- Defra High Level Target (HLT) 4: Biodiversity (ensure no net loss of BAP habitats and seek opportunities for environmental enhancements; create at least 200 ha of new biodiversity habitat per annum),
- Biodiversity action plan objectives,
- Natural Area Targets for priority habitats,
- Physical coastal features,
- SMP recommendations,
- CHaMP recommendations,
- Provision of compensatory areas of habitat to mitigate losses attributed to “hold the line” policy,
- Hydromorphological improvement targets (being developed as part of WFD),
- Physical river features linked to EA physical quality objectives work
- Flow objectives linked to “acceptable flow” studies,
- Geomorphological objectives linked to general catchment aspirations, and
- WFD good ecological quality or potential status, to include objective for “no deterioration”.

BEC should take into account the existing catchment targets, integrating these wherever possible and where relevant to the primary objective.

10.3.2 Protection BEC

Protection BEC are defined as constraints that must be protected as part of any policy/ option development. They include, for example, those parts of the coastal system that are deemed to be important for maintaining, or are themselves, in good ecological condition (e.g. saltmarsh, active ecological floodplain, important morphological features, important fish migration routes etc). Compliance with protection BEC is mandatory within the policy/ option development and assessment process. When the WFD is fully implemented there will also be identified constraints where “good ecological status” must be maintained, which are likely to be more spatially integrated than current nature conservation sites (i.e. coastal-cell wide).

Protection BEC should therefore fulfil the requirements of: nature conservation legislation (to protect designated sites and habitats) and the WFD (no deterioration in ecological status).

10.3.3 Enhancement BEC

Enhancement BEC are defined as opportunities to enhance the ecology (or assist in restoring good ecological status), which can wherever possible be integrated as part of any policy/ option development. For example, re-connection of the coastal floodplain to create wetland habitat, or removal of barriers/ installation of passes to ease fish passage. It is also recognised that opportunities may be linked, for example, improving saltmarsh condition by increasing sediment inputs through reconnecting tidal inundation.

Enhancement BEC fulfil the requirements of: nature conservation legislation (to enhance designated sites and habitats) and the WFD (ensure all waters meet good ecological status or potential).

Although every effort is made to incorporate enhancement BEC within the policy/ option development and assessment process, they are considered to be more aspirational in character as there may be additional factors other than, for example, flood risk management that determine the success of restoration/ creation.

The ecosystem/habitat enhancement BEC are framed as opportunities due to the lower level of confidence associated with predicting habitat change at this broad scale. Where opportunities are identified they will most likely form the basis for future studies, which can assess the opportunities in a greater level of detail. This broad-brush approach therefore provides the evidence-based identification of sub-catchment areas for more detailed study.

10.3.4 Mapping and tabulating BEC

Both protection BEC and enhancement BEC are mapped to give spatial context to the constraints and opportunities. The spatial limits of each BEC are determined by professional judgement taking into account factors such as geographical boundaries, natural or man-made barriers within the system, extent of habitat etc. Spatial limits, which form the boundaries for policy/ option development, are verified through consultation with specialists (see Section 10.4).

For each BEC, the potential flood management actions to realise the BEC are listed, together with the potential ecosystem benefits from realising the BEC. This can take the form of a table (see Table 10.2), with corresponding areas marked on a map of the catchment.

Table 10.2 Sample tabulation of broad scale ecosystem criteria

Broad scale Ecosystem Criteria		Potential flood management actions	Potential ecosystem benefit
BEC 1	State the BEC	List the potential flood management actions suitable for realising the BEC	List the potential ecosystem/ biodiversity benefits from realising the BEC

Tabulation enables the specification of potential biodiversity benefit from realising each BEC. This can be extended to include potential management activities, an indication of their cost, and the potential consequences for the study being undertaken (e.g. benefit to flood management).

The preliminary BEC should be used as a basis for the subsequent expert stakeholder forum. Having discussed and agreed the range of protection and enhancement BEC, they will form the framework for biodiversity inputs to policy derivation and, potentially, policy analysis, as required.

Further details of how BEC are defined and applied are given in the case study (see Section 11).

10.4 Expert consultation and review

Consultation within the BSEA process will focus on engaging the correct expertise and key stakeholders in order to:

- Confirm the understanding of the ecosystems present in the coastal cell - in terms of type, frequency, distribution and quality of habitats and the key drivers for maintenance and potential change,
- Develop and finalise the protection and enhancement BEC, and
- BSEA consultation must integrate with existing consultation programmes and methods established as part of the overall flood risk management and SEA process to ensure and promote effective contact with the consultees and avoid consultee fatigue. Comprehensive guidance on consultation is provided in the following relevant documents:
    - Defra, SMP2 procedural guidance,
    - Environment Agency, Guidance for Environmental Assessment (SEA) of Internal Plans and Programmes (Version 1, July 2004b), and
    - Environment Agency, Guidelines for Planning and Managing National Consultations (2003b).

Consultation must include Statutory Consultation Bodies, which for ecology include EN/ CCW and the EA.

Consultation will also include a wider consultation group, which for ecology may include representatives from organisations including:

- Harbour authorities,
- Local authorities,
- National Park Authorities,
- National Trust,
- Natural England,
- RSPB,
- Wildfowl and Wetlands Trust, and
- Wildlife trusts.

Consultation will be proactive and flexible, and for the needs of BSEA will most likely take the form of meetings and/or workshops.

BSEA consultation, as with the overall consultation as part of the wider flood risk management process, must:

- Ensure it is clear what stakeholders' involvement is and what it will achieve,
- Ensure tasks for the stakeholders are clearly defined, and
- Ensure consultation methods are appropriate for the target audience.

10.5 Policy development

To establish the most appropriate broad scale flood risk management policies it is essential that the coastal cell ecological opportunities and constraints (the BEC) are taken into consideration at an early stage of the SMP2 planning process. This allows those policies which address flood risk management but also provide multiple benefits to be identified and incorporated. This is the recommended proactive approach to embedding BEC within the overall flood risk management process.

Unless BEC are incorporated in this manner the potential ecological benefits of coastal flood management assets and management will not be realised, and opportunities for sustainable development of the coastal zone could be missed or be sub-optimal. The BEC may also present opportunities for cross-sectoral benefits, for example for land use policy that could be simulated by the process.

However, since the main aim of flood risk management is to reduce flood risks to people and property, it is essential that BEC must be realistic and linked to flood risk management. An example of the stages in defining the BEC and their representation is provided in Table 10.3. Such an approach will enable efficient integration into the policy development framework.

Table 10.3 Example BEC for use within policy development

Broad scale Ecosystem Criteria			Potential management actions	Potential ecosystem benefit	Potential flood management consequences	Additional funding streams
Shoreline migration	1	Define BEC	State actions required to implement change	Identify expected change to ecosystem	State implications for flood risk management	Investigate potential availability of funding
	2	etc..				

Application of the methodology for BEC development is demonstrated in the Beachy Head case study (see Section 11).

10.6 Policy assessment

Within the current framework for broad scale flood risk management, policy appraisal will be based on a MCA within a sustainability appraisal (that should meet the requirements of SEA). SMP2 guidance provides more detail for the methodology, but in essence involves assessing policies against the objectives (in the ecological context, BEC) for each policy unit. An example assessment matrix for BEC is provided in Table 10.4.

Policy assessment is reactive, providing qualified judgement on the potential effect of a given flood risk policy. Therefore, as described above, the preferred and recommended approach to integrating ecosystem assessment is the proactive and early identification and incorporation of BEC at the policy development stage. With the recommended approach the risk of incorporating policies during the policy assessment phase that cause significant detrimental impact on ecology or which miss opportunities to benefit ecology is greatly reduced.

Table 10.4 Example BEC assessment matrix

Broad scale Ecosystem Criteria			Protection/ Enhancement	Draft preferred policy	
				Compliance	Note
Shoreline migration	1	State the BEC	Protection	Yes or no	Briefly describe reason for compliance assessment and associated risks
	2	Etc	Enhancement	Yes or no	Briefly describe reason and risks

Given the High Level approach and uncertainties/unknowns inherent in the process (i.e. costs, specific measures required to deliver the policies) it will be necessary to define and describe any ecological risk and uncertainties, and the resultant confidence level within the policy assessment.

Risks and uncertainties should form an important part of the decision-making process and should be reported within the SMP2 documentation. For example, where there is a potentially significant effect on a sensitive ecosystem, but the outcome of the flood management policy or activity is poorly understood, this should be clearly stated in the assessment matrix notes.

10.7 Application of methods to case studies

The procedural guidance has been applied to a coastal Case Study area:

- South-Foreland to Beachy Head coastline of south-east England, which is one of three demonstration areas for the revised SMP guidance.

For the coastal cell of South Foreland to Beachy Head in south-east England, the guidance methodology has been applied to provide an indication of the pressures and opportunities to ecosystems appropriate to alternative flood management policy development. Such assessment could be developed further to also provide input to the SEA of a SMP.

The South Foreland to Beachy Head coastal case study is presented in Section 11.

11 South Foreland to Beachy Head high level coastal case study

11.1 Background

The coastline covered by the trial area has a rich diversity in its physical form, human usage and natural environment. This includes the chalk cliffs of Beachy Head and South Foreland, the vegetated shingle lowlands of the Dungeness peninsula and the wetland systems of the Pett and Pevensey Levels, large urban areas fringing the coast (including Eastbourne, Bexhill, Hastings, Folkestone and Dover), extensive areas of agricultural land and many areas designated and protected for their heritage, landscape, geological and biological value. This combination of assets creates a coastline of great value, with a tourism economy of regional importance.

The South Foreland – Beachy Head high level coastal trial has been undertaken by a team comprising Cascade Consulting, HR Wallingford and Halcrow.

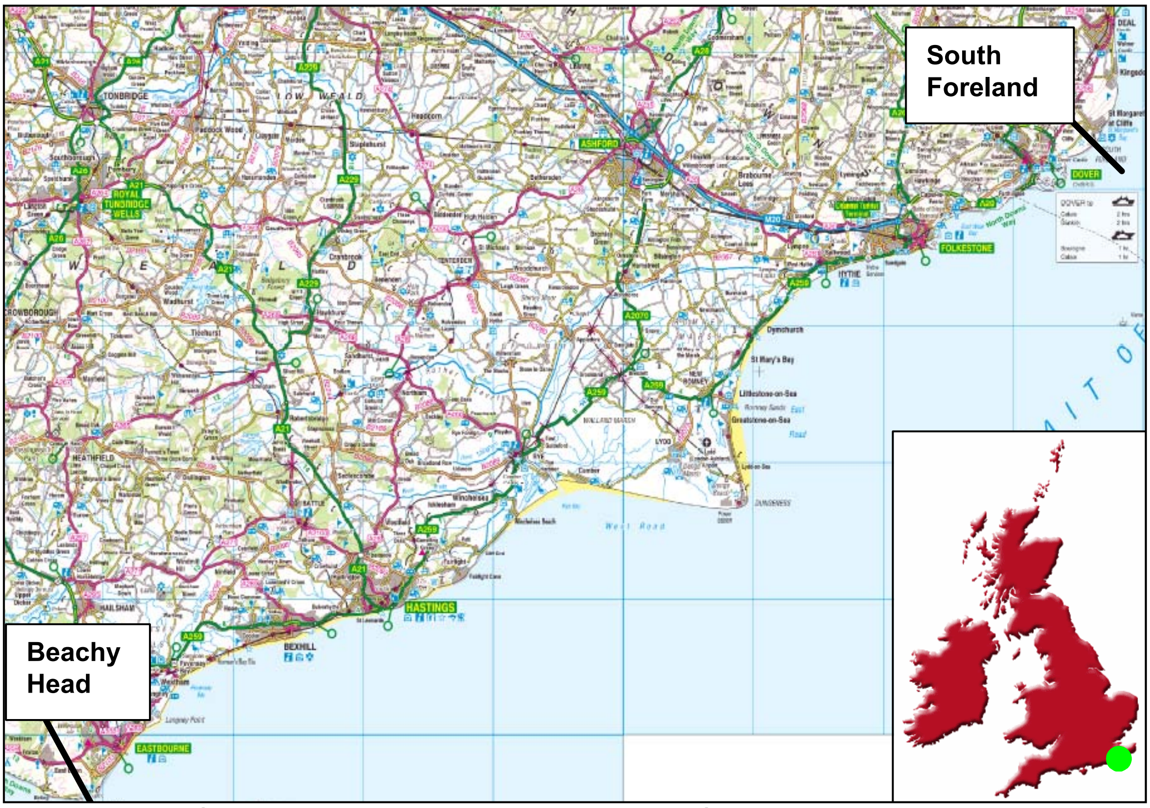


Figure 11.1 South Foreland to Beachy Head: Study area location

11.2 Flood management policy context

The Beachy Head case study has been undertaken against the backdrop of an emerging SMP2, which is going through the consultation phase for the preferred flood management policy options. The work has therefore been undertaken separately from the SMP2 planning framework. The consequence is that it has only been possible to implement the guidance by reference to the potential policy outcomes, with no consultation or input from wider stakeholder groups. The understanding of the coastal cell, although advanced beyond previous methods, does not therefore benefit from the collective experience of local area expertise. It is recommended that this be incorporated once the guidance methodology is operational.

Draft policy options for the Beachy Head coastal cell have been published as part of the SMP2 process. The guidance methods have been applied to provide a relative policy assessment of the ecosystem consequences of the alternative “area-wide” flood management policy (in fact the policies would appear to be sub-cell rather than cell based). Such an assessment could provide input to the SEA of a SMP.

The following gives a brief description of the current position with regard to broad scale policy development for the case study area.

11.2.1 South Foreland to Beachy Head SMP

The first review of the South Foreland to Beachy Head SMP (SMP2) has been prepared for the South East Coastal Group by Halcrow. The review was issued for consultation on 10 January 2005 . In summary the SMP2 includes 30 contiguous policy unit areas along the coastline, segmented on the basis of discrete flood management requirements and/or coastal processes. For each policy unit the current flood management policy was identified, with brief assessment of the suitability of the range of alternative policies, from the list:

- Hold the line,
- Advance the line,
- Managed realignment, and
- No active intervention.

Notwithstanding those policy units with specific policy requirements (e.g. hold the line for large urban areas at risk of coastal erosion/ flooding), three alternatives were compiled and described along the future timeline 2025, 2055 and 2105:

- With present management,
- No active intervention, and
- Preferred policy.

Although the BSEA high level methodology has not been developed to be directly incorporated into SMP guidance documentation, the synergies have been explored through data availability and output requirements. The BSEA high level trial has incorporated elements of the work undertaken in the preparation of the SMP2, including:

- GIS layers of the projected shoreline (mean high water spring, MHWS) for alternative flood management policies into the future,

- Understanding of coastal geomorphology processes and evolution in the SMP2 area, and
- EN's Identifying Biodiversity Opportunities (IBO) work incorporated into the development of preferred flood management policy for each policy unit.

11.2.2 Dungeness and Pett Levels CHaMP

CHaMPs have been produced to provide a way of fulfilling the UK Governments obligations under the Habitats and Birds Directives and the Ramsar Convention, to avoid damage and deterioration to Natura 2000 and Ramsar sites; particularly when developing SMPs and flood and coastal defence strategies, and planning maintenance and capital works. The primary functions of the CHaMP are:

- To offer a long-term (30-100 year) strategic view on the balance of losses and gains to habitats and species of European interest likely to result from sea-level rise and the flood and coastal defence response to it.
- To develop a response to these losses and gains by setting the strategic direction for the conservation measures that are necessary to offset predicted losses. They also identify suitable locations for new habitats that will need to be created and the flood and coastal defence works required to maintain protected habitats.
- Make recommendations to SMPs to ensure flood and coastal defence options address the requirements of the Habitats and Birds Directives.

The CHaMP area extends from Cliff End in the west to Littlestone-on-Sea in the east. This covers all of the European designated sites within an integrative "site complex" and defines the area within which the detailed assessments has been undertaken.

The geomorphological and ecological impacts of four alternative management policies were reviewed, with the purpose of informing the SMP planning process:

- Do nothing,
- Hold the Line: maintain existing management practices and alternative management practices,
- Managed retreat: removal of the Rye terminal groyne, and
- Managed retreat: retreat to 1800 coastline.

No preferred shoreline management alternative was proposed at the conclusion of the CHaMP.

11.3 Licensing

Digital datasets used in the South Foreland to Beachy Head case study are presented in Table 11.1, with an acknowledgement of the sources and respective license requirements.

Table 11.1 Data licenses used in the South Foreland to Beachy Head coastal case study

Digital dataset	Licence	Data acknowledgement and source
Ordnance Survey mapping at 1:50,000 and 1:250,000	Sub-licence of EA licence number 100026380	Maps reproduced from Ordnance Survey material with the permission of Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office © Crown copyright. Unauthorised reproduction infringes Crown copyright and may lead to prosecution or civil proceedings.
CEH Land Cover Map (LCM2000)	Sub-licence of EA licence	EA sub-licence permits the production of paper maps from the data for use in reports and discussion documents.
Statutory nature conservation designations	Used with the permission of EN	EN are acknowledged as the owner of the information
Coastal indicative flood outline	Used with the permission of the EA	EA copyright and/or database rights 2006. All rights reserved.
EA National Flood and Coastal Defence Database (NFCDD)	Used with the permission of the EA	Database uses Ordnance Survey data. Maps reproduced from Ordnance Survey material with the permission of Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office © Crown copyright. Unauthorised reproduction infringes Crown copyright and may lead to prosecution or civil proceedings. EA, 100026380 (2006)
UKBAP Priority habitats	Used with the permission of EN	EN are acknowledged as the owner of the information

Disclaimer

The maps used in this presentation are for illustrative purposes only. They are not being used for operational purposes by the EA nor should the maps be used in such a way by any other organisation. They are included here to demonstrate the guidance only and should not be viewed as constituting the views of the project sponsors.

11.4 Review of broad habitat baseline and ecosystem drivers

This section uses the BSEA High Level coastal methodology to develop an understanding of the broad coastal habitats present and the ecosystem drivers that maintain them – shoreline migration, inundation/coastal flooding and mobile sediment availability in the South Foreland to Beachy Head area.
For demonstration purposes, BSEA Tools A, B, C and D were used (for guidance see Section 10 and Appendix 4). Figures in the text display the GIS datasets used to develop the catchment understanding.

Following development of the coastal cell understanding, biodiversity opportunities and constraints relevant to flood management policy were identified.

The pressures and future risk to each ecosystem driver ware explored through available data and expert understanding. This has led to the summary of appropriate ecosystem pressures and associated biodiversity impact, together with identification of biodiversity opportunities in Section 11.5.

11.4.1 Baseline habitats and management

Three data layers have been prepared in GIS to develop an understanding of baseline habitats. These layers are illustrated separately in Figure 11.2, as:

a. Coastal sediment habitats,
b. Coastal rock habitats, and
c. Inland open water, marginal and water-dependent habitats.

The need to produce three separate habitat layers to maintain clarity when viewing them reflects the varied nature of the landforms and habitats along this section of the South East coastline. It is readily apparent from the layers presented in Figure 11.2 that shingle beaches are the dominant coastal form throughout the study area. Several distinct sections of maritime cliff and slope also occur and the area contains a substantial number of inland freshwater, brackish water and grazing marsh habitats in low lying areas along the frontage. There are also areas of littoral and sub-littoral chalk, which support important marine communities, along the frontage and areas of coastal dunes at Camber and Romney Sands.

All of these habitats are covered by Local and National BAPs which include targets for “no further net loss” and necessitate an approach that seeks to protect them in situ where possible or to mitigate the effects of unavoidable losses through the creation, elsewhere, of equivalent habitats to those lost. The implications that projected shoreline change and current management policies have for these BAP objectives is explored in the following sections.

11.4.2 Nature conservation management

Natural Area Targets have been taken from EN’s website. The South-Foreland to Beachy Head area contains all or part of two Natural Areas as follows:

- East Kent Coast (Natural Area 107), and
- Selsey Bill to Folkestone (Natural Area 108).

From these areas, the range of potentially appropriate targets for coastal UK BAP Priority Habitats include:

Protection

- Coastal sand dunes,
- Coastal vegetated shingle,
- Maritime cliff and slopes,
- Coastal saltmarsh,
- Mudflats,
- Saline lagoons,
- Coastal and floodplain grazing marsh, and
- Littoral and sub-littoral chalk.

Enhancement

- Coastal sand dunes,
- Coastal vegetated shingle,
- Maritime cliff and slopes,
- Coastal saltmarsh,
- Mudflats, and
- Saline lagoons.

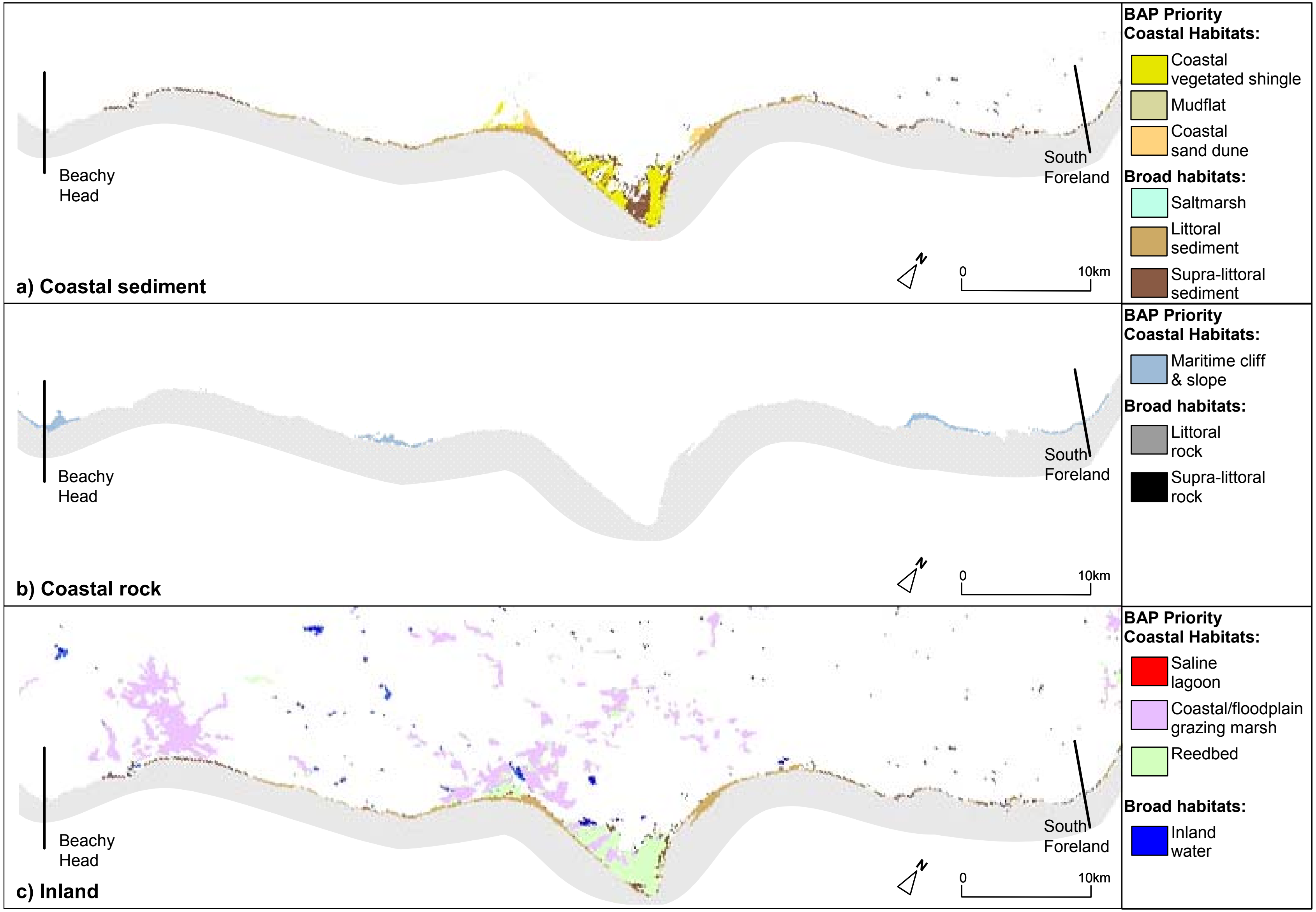


Figure 11.2 South Foreland to Beachy Head: Coastal habitat baseline

The Natural Area Targets will form the basis for refining BEC within the consultation phase.

11.4.3 Shoreline migration

Understanding of shoreline migration

In accordance with the methodology (see Section 10) a data summary (Figure 11.3) has been prepared in GIS to develop an understanding of shoreline migration. The figure clearly shows that extensive areas of the study area coastline are protected by hard engineering and naturally from cliffs. A hold the line policy is currently in place and is considered likely to remain in place for significant stretches of the coastline in the study area. There is considered to be limited potential for either “do nothing” or “managed realignment” which could result in significant variation in the shoreline position and potential changes in habitat, including biodiversity opportunities.

The current policy of holding the line for much of the SMP frontage reflects the heavily developed and urbanised nature of the area. This approach seeks to minimise loss of property and other assets along the coastline, but in the light of progressive sea level rise it will require improvements to existing sea defences and lead to the reduction and possible loss of shingle beaches in time. Moreover, the maintenance of sea defences along much of the frontage will greatly limit the area of shoreline that is free to erode and potentially exacerbate loss of beach building material from the system.

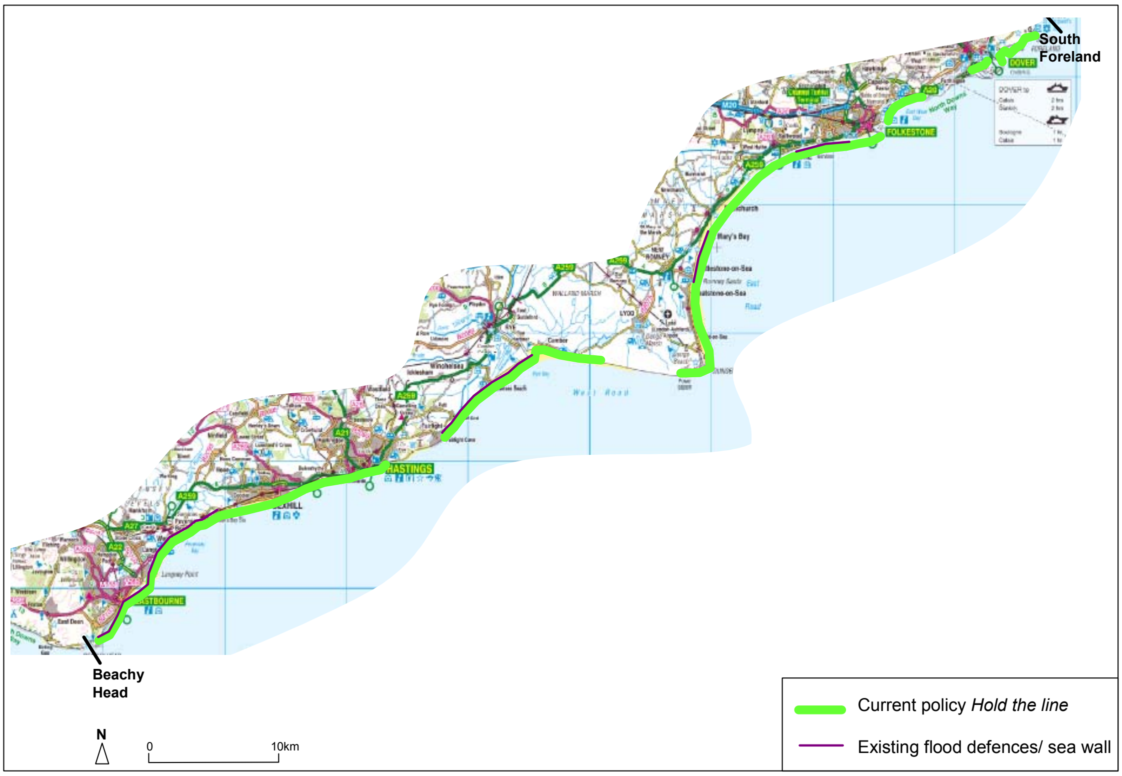


Figure 11.3 South Foreland - Beachy Head: Current shoreline position and management policy

11.4.4 Coastal flooding

A data summary (Figure 11.4) has been prepared in GIS to develop an understanding of coastal flooding. The summary shows that much of the frontage is potentially subject to coastal flooding. Especially noticeable is the extensive low lying area of the Dungeness Foreland. Indeed, the flood risk area in this region extends to over 20,000 hectares, penetrating far inland, and encompasses large areas of international nature conservation importance (plus a great deal of vital infrastructure).
The threat from coastal flooding along this frontage can only increase if sea levels rise as projected and the reality is that ultimately defending this long stretch of coastline will become unsustainable.

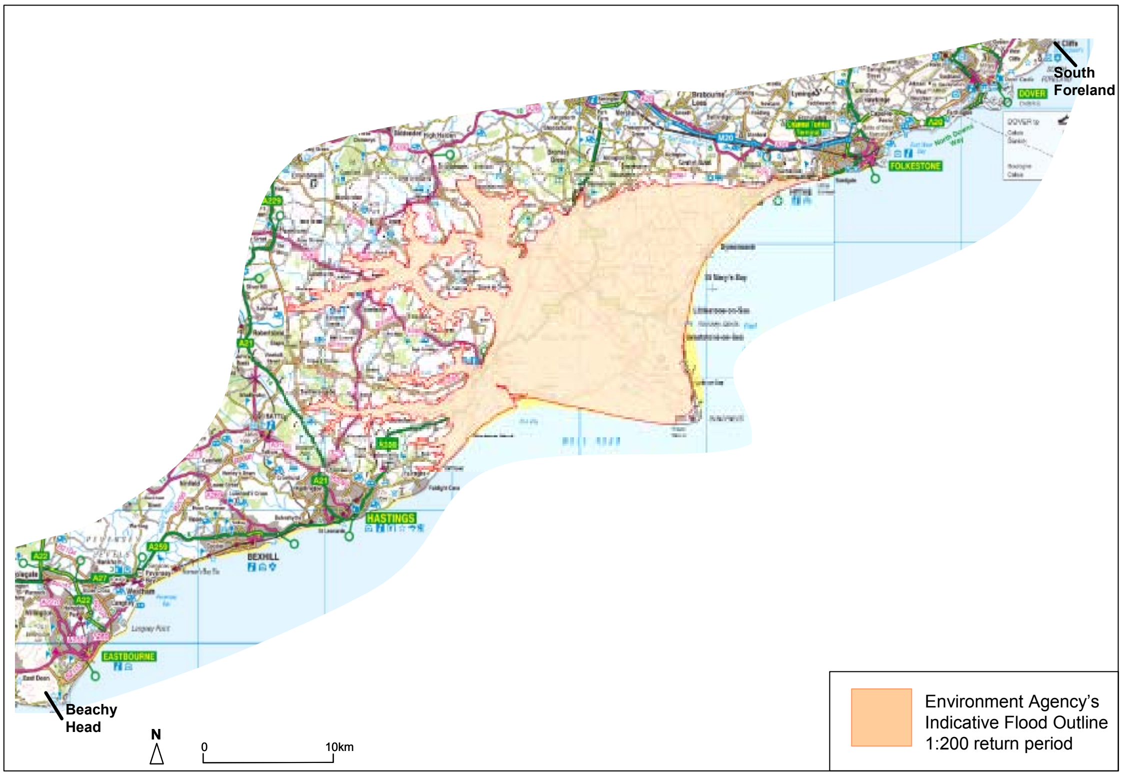


Figure 11.4 South Foreland to Beachy Head: Current coastal flooding risk

11.4.5 Mobile sediment availability and barriers to movement

Figure 11.5 develops an understanding of mobile sediment availability and the barriers to natural sediment migration. This GIS layer presents a clear picture of limited sediment availability and numerous barriers to natural sediment migration, arising as a result of the heavily developed nature of much of the frontage. Indeed, the situation has been so heavily influenced by the activities of man that the shoreline is mostly artificial with hardly any opportunity to employ natural coastal evolutionary processes as a means for the effective management of the coastline.

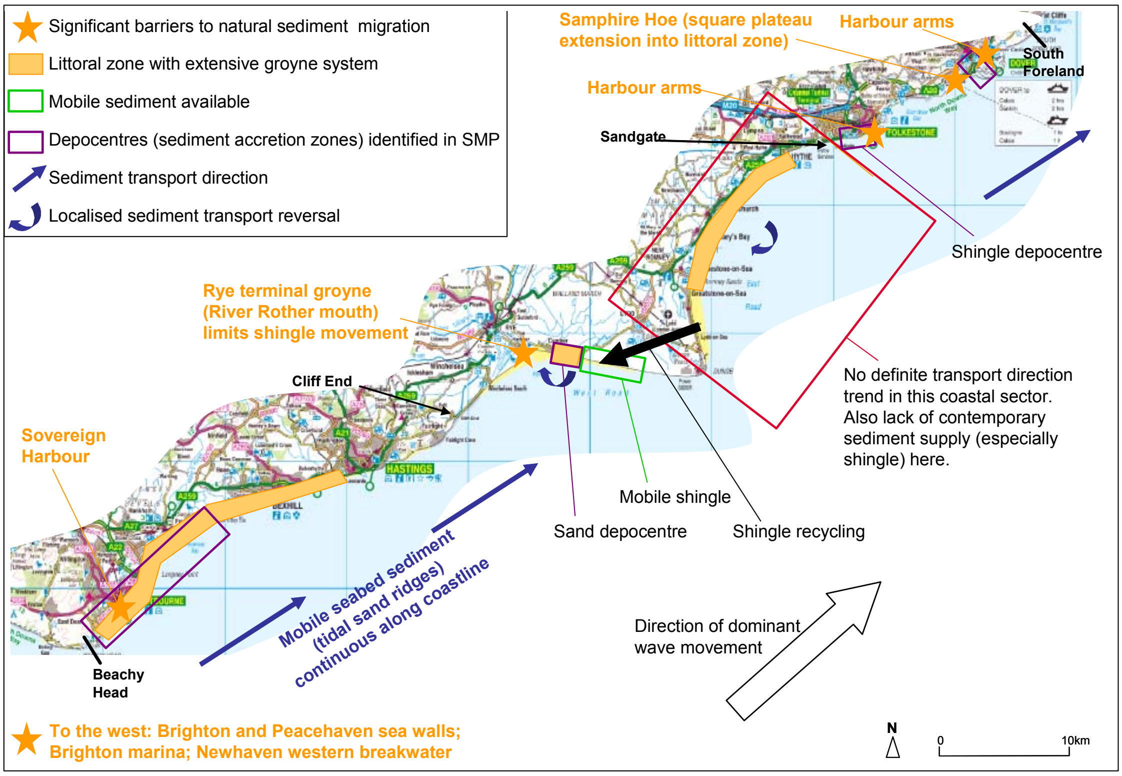


Figure 11.5 South Foreland to Beachy Head: Current sediment availability and barriers to sediment movement

11.5 Summary of broad scale ecosystem criteria in the South Foreland to Beachy Head area

Given the current status of the emerging SMP2, and the political difficulties in consultation on potential broad scale ecosystem criteria at such a sensitive time of study development, it has been decided that the full guidance will not be tested on for the coastal zone at present. It has not therefore been possible to engage in full consultation with the various authorities that hold key data and expertise on ecosystem function and biodiversity opportunity for the area.

For example, it could be possible through consultation to establish a BEC for Pett Level, which may a) allow adaptive management of those areas with highest saline flood risk (evolving towards brackish habitats) or b) maintain the existing freshwater habitats behind the shingle beaches. Clearly such discussions would not be appropriate at this stage.

Therefore, for this demonstration of the guidance the methodology has been developed to demonstrate areas with particular ecosystem pressures and threats, and put these in the context of potential flood management activities.

11.5.1 Pressures and future threats

Potential change in shoreline position is covered in the SMP based on data from modelling projected future shorelines for “no active intervention” and “with present management” in FutureCOAST. A detailed list of ecosystem pressures and biodiversity opportunities for the various component shoreline stretches of the study area is presented in Table 11.2 and some key issues are highlighted below. Current shoreline position, key habitats and present management policy are presented on Figure 11.6. Spatial context to the ecosystem pressures and biodiversity opportunities is presented on Figure 11.7.

As indicated in the analysis above, the shoreline of this frontage is an extremely artificial one, heavily influenced by the activities of man. Furthermore, given the extent of the development and the vast amount of infrastructure and essential assets located along this coastline, there is little option, at the present time, to a policy of "hold the line" along most of its length. Nevertheless, the critical pressure of projected sea level rise will necessitate ever bigger sea defences if "hold the line" is to be achieved and existing defences may have to be extended landward so that they are not outflanked by rising sea levels.

The "hold the line" policy seems destined, therefore, to lead to an even more fragmented coastline with extensive concrete frontages and very few beaches. Thus, it will not be possible to maintain this position indefinitely.

Several cliff areas are not considered as "hold the line" and natural erosion will result in slow changes to the shoreline position and hinterland. This approach is beneficial for maintaining the nature conservation significance of these areas as slope protection works and sea defence structures would limit/prevent the natural movements of these landforms and change their nature and visual appearance. Allowing Inland migration of cliff habitats (including maritime cliff and slope BAP priority habitat), will maintain their environmental quality and landscape value. Moreover, land above the cliffs has the potential to be managed for creation/ restoration of coastal habitats, where there is sufficient land and other land use pressures (e.g. agriculture, housing) can be overcome. In addition, progressive retreat of these cliff frontages should allow for the development of new sub-littoral rock platforms as sea level rises because nothing can be done to overcome the potential submergence of the existing platforms as a result of sea level rise.

The only low-lying area not considered subject to a "hold the line" policy is on the south side of the Dungeness peninsula; a section of coastline formed in shingle ridges that provide a slightly raised topography behind the current coastline which fronts a substantial low-lying hinterland of high flood. Returning this area to natural beach functioning will present a flooding risk to the low lying hinterland which contains important freshwater habitats. However, allowing the free operation of coastal processes in this area could produce a self-sustaining barrier beach which would facilitate the alongshore movement of shingle and enhance the conservation value of the internationally important shingle habitats. If this latter course is followed secondary embankments will be required if flood propagation is to be controlled and inland habitats protected.

Changes in shoreline position from either "do nothing" or "managed realignment" have been considered and mapped by the SMP process. However, although opportunities may exist in these areas, they are not integral to shoreline management for flood defence and coastal erosion. It is considered that the realisation of biodiversity opportunities in these areas would require funding from alternative streams to flood management.

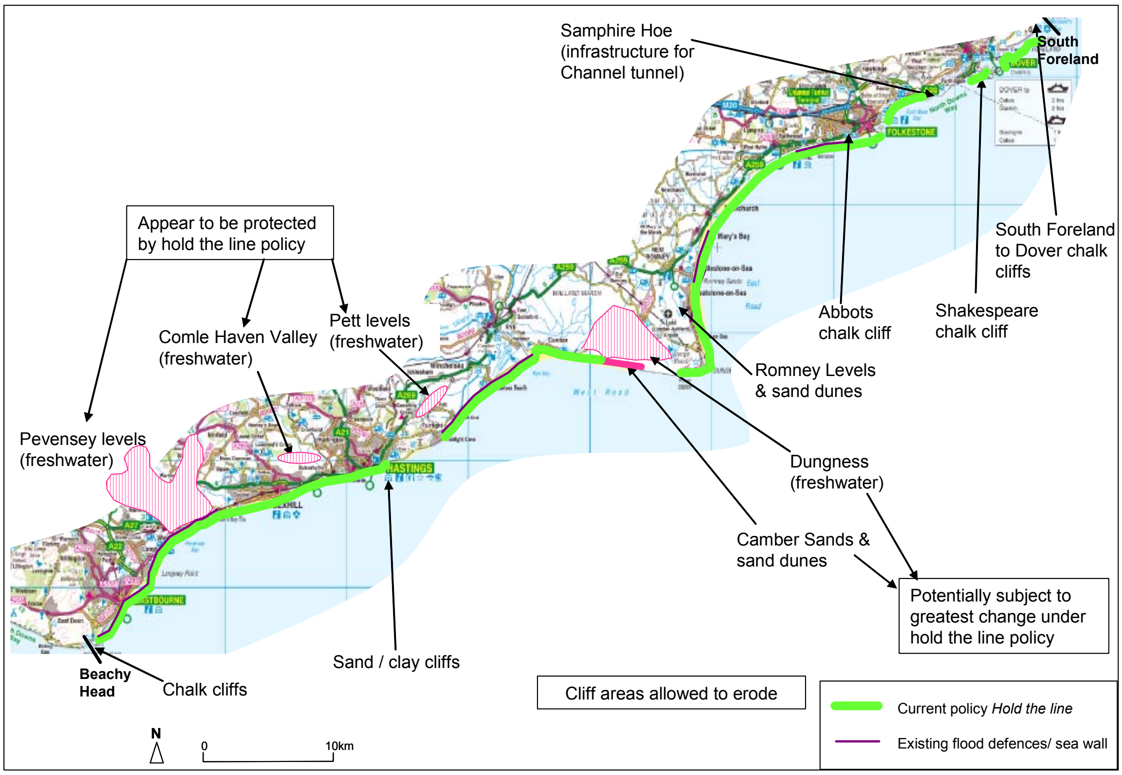


Figure 11.6 South Foreland to Beachy Head: Current shoreline position, key habitats and present management policy

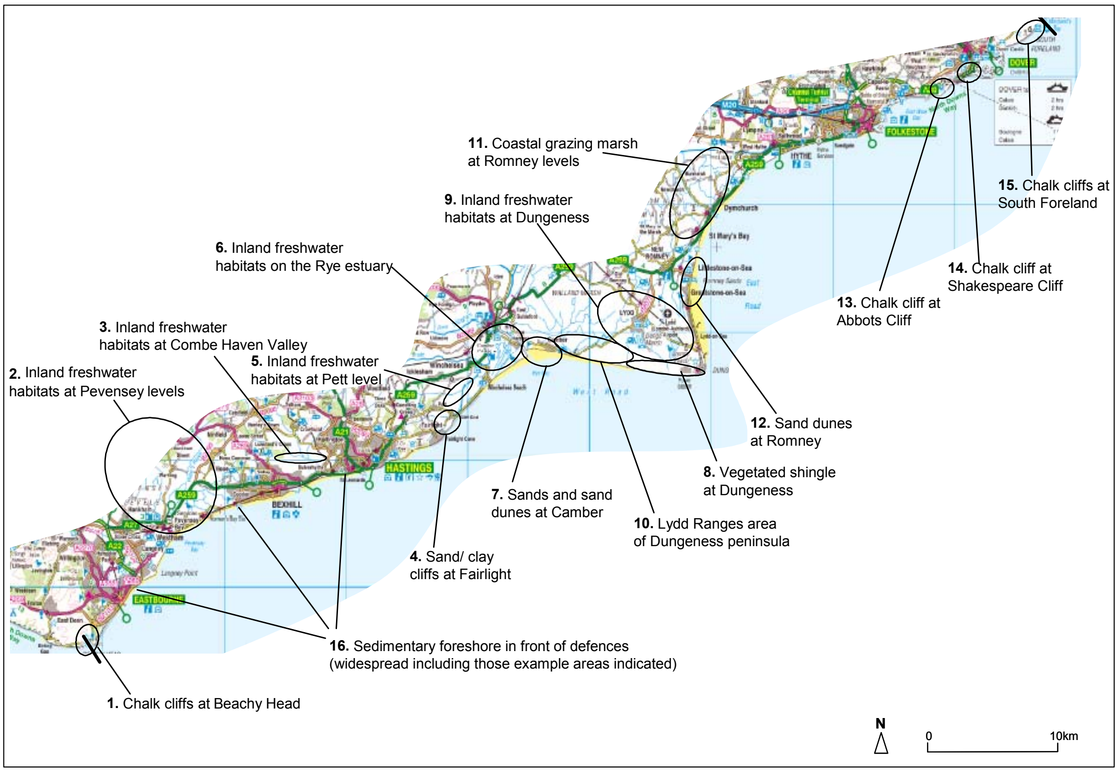


Figure 11.7 Location of Ecosystem pressures and biodiversity opportunities associated with flood management and coastal erosion policy in the South Foreland to Beachy Head area

Table 11.2 Ecosystem pressures and biodiversity opportunities associated with flood management and coastal erosion policy in the South Foreland to Beachy Head area

	Area	Pressures to ecosystem	Potential biodiversity impact	Biodiversity opportunity	Potential association with flood management and coastal erosion policy
1	Chalk cliffs at Beachy Head	Coastal erosion	Inland migration of existing maritime cliff and slope habitat	Management to enhance, and create maritime cliff and slope to rear	Major (1)
2	Inland freshwater habitats at Pevensey levels	Sea level rise, increase in coastal flooding risk, deviation from "hold the line" policy	Change to freshwater habitats and communities	Management of part of the area to brackish habitats	Major (2)
3	Inland freshwater habitats at Combe Haven Valley	Sea level rise, increase in coastal flooding risk, deviation from "hold the line" policy	Change to freshwater habitats and communities	Management of part of the area to brackish habitats	Major (2)
4	Sand/ clay cliffs at Fairlight	Coastal erosion	Inland migration of existing maritime cliff and slope habitat	Management to enhance, and create maritime cliff and slope to rear	Major (1)
5	Inland freshwater habitats at Pett level	Sea level rise, increase in coastal flooding risk	Change to freshwater habitats and communities	Management of part of the area to brackish habitats	Major (2)
6	Inland freshwater habitats on the Rye estuary	Sea level rise, increase in coastal flooding risk, deviation from "hold the line" policy	Minor quality habitats at present on estuarine floodplain	Management of estuarine floodplain to create and restore brackish habitats	Minor (3)
7	Sands and sand dunes at Camber	Sea level rise, mobile sediment supply	Reduction in extent of sand/ sand dune habitats	Limited	Minor (4)
8	Vegetated shingle at Dungeness	Sea level rise, mobile sediment supply and management	Reduction in extent of vegetated shingle habitat	Limited	Moderate (5)
9	Inland freshwater habitats at Dungeness	Sea level rise, increase in coastal flooding risk	Change to freshwater habitats and communities	Management to brackish habitats	Minor (6)
10	Lydd Ranges area of Dungeness peninsula	Coastal erosion, sea level rise, increase in coastal flooding risk	Minor quality habitats at present in hinterland	Management to create coastal habitats in hinterland	Moderate (7)
11	Coastal grazing marsh at Romney levels	Sea level rise, increase in coastal flooding risk	Change to current habitats and communities	Management to enhance and create appropriate habitats	Minor (8)

Table 11.2 Ecosystem pressures and biodiversity opportunities associated with flood management and coastal erosion policy in the South Foreland to Beachy Head area (continued)

Area		Pressures to ecosystem	Potential biodiversity impact	Biodiversity opportunity	Potential association with flood management and coastal erosion policy
12	Sand dunes at Romney	Sea level rise, mobile sediment supply	Reduction in extent of sand dune habitat	Limited	Minor (4)
13	Chalk cliff at Abbots Cliff	Coastal erosion	Inland migration of existing maritime cliff and slope habitat	Management to enhance, and create maritime cliff and slope to rear	Major (1)
14	Chalk cliff at Shakespeare Cliff	Coastal erosion	Inland migration of existing maritime cliff and slope habitat	Management to enhance, and create maritime cliff and slope to rear	Major (1)
15	Chalk cliffs at South Foreland	Coastal erosion	Inland migration of existing maritime cliff and slope habitat	Management to enhance, and create maritime cliff and slope to rear	Major (1)
16	Sedimentary foreshore in front of defences	Sea level rise, sediment migration	Reduction in extent of littoral sedimentary habitat	Limited	Major (9)

1 Coastal erosion policy will be consistent with appropriate management of the cliff top and rear to reduce the risk to property (e.g. through future planning control), and appropriate habitat management would be required to realise the biodiversity opportunities.
2 "Hold the line" policy appears to maintain the current habitat status. Deviation from this policy, would result in habitat modification and appropriate habitat management would be required to realise the biodiversity opportunities.
3 Management actions to increase coastal flooding of River Rye estuarine floodplain is not considered to provide a significant flood management benefit.
4 Management actions to maintain the sand/ sand dune system is not considered to provide a significant flood management or coastal erosion benefit.
5 Management actions to maintain the shingle system at Dungeness is considered to provide a potential medium-term solution to protection of assets at risk of coastal erosion (Dungeness power station).
6 Increased coastal flooding of the Dungeness area is not considered to provide a significant flood management benefit.
7 Abandonment of the current "hold the line" policy at Lydd Ranges would enable the development of biodiversity opportunities. However, these would not provide a significant flood management or coastal erosion benefit, and appropriate landscaping and habitat management would be required to realise the biodiversity opportunities.
8 Management actions to increase coastal flooding of Romney Levels is not considered to provide a significant flood management benefit.
9 Management actions to combat loss of littoral habitat and sediment include recycling sediment and/or allowing erosion in selected areas to generate additional natural sediment supply for other areas.

11.6 Further development of the South Foreland to Beachy Head case study

The continued use of the BSEA High Level methodology is limited in this case study due to the majority of the shoreline being defined as “hold the line” both currently and into the future. In these locations it is likely that there will be a thinning of the foreshore and reduction in the area of littoral sediment habitats (shingle and sand, few areas of mud), and maintenance of wave-cut platforms under the chalk cliffs.

Given that it is not possible to develop the high level BSEA further in this coastal cell, there remain a number of potential ecosystem benefits that could be derived as a result of the analysis. There are two areas where investigation of impacts and opportunities could be explored:

- Lydd Ranges on the southern shore of the Dungeness peninsula, and
- Eroding sand/ clay cliffs east of Cliff End.

It is recommended that a mid-level strategic assessment is recommended to assess the ecosystem impacts and potential opportunities at these sites arising from:

- Shoreline migration and future shoreline configurations under an alternative “managed realignment” policy.
- Change in risk from coastal flooding to include a range of flood frequencies (1:10, 1:20, 1:200 return periods).
- Changes to mobile sediment availability, including modification to existing barriers to movement.

12 Conclusions and recommendations

The guidance is the first phase in the development of the broad scale ecosystem assessment toolbox. The guidance has been consolidated to use existing and available broad scale data, linked to established methods, which facilitate pragmatic analysis to support policy derivation and appraisal. As such the guidance represents a significant step forward for the consistent use of ecosystem assessment at a catchment or coastal cell scale.

However, there are currently a number of limitations to implementation of the guidance. Data availability and suitability at the broad scale are limited, as is the predictive capability of models for ecosystem impact assessment of flood management activities. Accepting these limitations, the guidance has been designed as a framework that should be updated as new information and methods become available.

12.1 Policy context

Application of BSEA in the case studies have identified a number of issues that require resolution, particularly relating to policy appraisal.

12.1.1 Catchment Flood Management Plans

- Policy options are not currently easy to analyse as their hydrological consequences are not clearly defined,
- A catchment-scale policy context is required that considers hydrological boundaries before administrative boundaries,
- The lack of broad measures within the policy context restricts the usefulness of impact assessment methods,
- To establish the range of broad scale ecosystem opportunities and constraints there is a need to output shorter, ecologically significant, return period flooding events (e.g. 1 in 2 year) than are currently available, and
- It may be possible for CFMP to incorporate many of the lessons learnt from 10 years of SMP method derivation, including the application of broad scale policy analysis across significant spatial scales.

12.1.2 Shoreline Management Plans

- Dynamic evolution of coastal ecosystems and the apparent conflicts with protection of the static boundaries of designated habitats requires further clarification and guidance for practitioners,
- Prediction of the full range of potential future options on flooding potential is required rather than the "no active intervention" and "with present management" options currently available through, for example, FutureCOAST, and
- It is difficult to see how significant ecosystem opportunities can be delivered in the context of coastal flood management within the current funding rules, as opportunities tend to occur where no direct flood benefit

can be demonstrated. Further mitigation and compensation packages incorporating the BEC is recommended.

12.1.3 Water Framework Directive

- Given the ongoing application of WFD regulations, integration of the BSEA methodology is recommended to support analysis and implementation. This would be particularly beneficial to the identification of programmes of measures.

12.2 Science and evidence base

Many of the recommendations of the BSEIM Scoping Study (FD2108) remain relevant and are worthy of further consideration. It is noteworthy that BSEA Toolbox 1, which is reported here, is only one component of a significantly wider research and development programme that was recommended by the Scoping Report, which includes fundamental research into hydrological and geomorphological interactions resulting from flood management practices, and their consequences for the ecosystem. Improving knowledge of the evidence base could then be used to inform the next generation of ecosystem impact prediction models. Recommendations include:

- There is a need for consistent broad scale ecosystem data – this is likely to require remote data gathering at suitable spatial and temporal scales.
- The evidence base requires further definition to allow prediction of ecosystem impacts with confidence. This could focus initially on an empirical understanding of the causes and effects of in-channel and floodplain ecological impacts from the range of possible flood management activities, with a view to linking to predictive modelling approaches in the medium term.
- Linkages with other broad scale databases and applications requires attention. For example, many of the base layers for the GIS are compatible with MDSF and could be incorporated at relatively low cost.
- Consistent outputs for (for example) climate, land use and socio-economic change predictions are required to allow incorporation of consistent future hydrological predictions to feed into the impact assessment methodologies.

12.3 Suggested project team structure

At this early stage of guidance and toolbox implementation, there is a recognised lack of water industry expertise in the definition of the linkages between hydrology, geomorphology and ecosystem function. There is also an absence of fully functioning predictive ecosystem modelling capability.

In these circumstances, it is recommended that a multi-disciplinary environmental project team is used on the first generation of broad scale ecosystem assessments to accompany CFMP and SMP2. The team should include at least an hydrologist, geomorphologist and aquatic ecologist during the opportunities and constraints process and during the development of BEC.

Integration of catchment and coastal zone expertise for the specific catchments and coastal areas, through expert stakeholder consultation, is highly recommended.

12.4 Timing of broad scale ecosystem assessment

This guidance should be adopted at the CFMP or SMP inception phase and should be used to compliment both policy development and appraisal. Experience has shown that it is difficult to apply the guidance once the strategic decisions on policies or strategies have been made, as the outcomes may differ from or contradict earlier findings.

12.5 Further piloting

It is recommended that the guidance is piloted on a number of additional catchments and coastal/estuarine cells to ensure that the methodologies are robust. Case studies to date would suggest that this is the case. Engineering consultants undertaking the pilot CFMP and SMP2s who have been approached for inputs to the Case Studies have shown great interest and enthusiasm for the guidance to date.

Piloting would also allow a broader database of BEC to be developed that would aid in later applications of the guidance. A central database of exemplar BECs is recommended, that could be developed and stored centrally to help when more junior staff start to integrate into the project teams.

12.6 Integration with developing initiatives

There are a number of developing initiatives being progressed by UK environmental regulators at this time that should be recognised and where possible embraced as the guidance evolves. Equally, the methodologies being developed elsewhere, particularly concerning application of the WFD at the broad scale, have particular interest. The following highlights a number of initiative that should be considered:

- FD2114 Review of impacts of rural land use and management on flood generation (Defra and EA FCM research and development),
- Estuaries Research Programme (Defra and EA FCM research and development),
- WFD ecological indicators (EA, Scotland and Northern Ireland Forum for Environmental Research (SNIFFER)),
- WFD hydro-geomorphological characterisation and targets (SNIFFER),
- Habitat Catchment Visioning (EN),
- Ripon Project (Defra and EA), and
- EU 6th Framework research and development.

The guidance has also been developed so that it can be incorporated into Strategic Environmental Assessment and can be used as the basis of Water

Framework Directive studies (spatial extent of pressures and impacts, programmes of measures, etc).

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Appendix 1 Fluvial high level toolbox

The toolbox elements should be read in conjunction with the main methodology, which integrates the inputs from individual tools and guides the user to appropriate interpretation of the collated data.

Fluvial high level toolbox

This appendix contains a description of each of the Tools identified for undertaking the review of ecosystem drivers and broad habitat baseline (see Section 5.1). The Thirteen Tools are held within 3 toolboxes (see Table A1.1).

Table A1.1 Contents of the fluvial high level toolbox

Toolbox		Tool	
Toolbox A	Channel condition	Tool A1	Catchment hydrology
		Tool A2	Surface runoff potential
		Tool A3	Channel gradient
		Tool A4	Catchment sediment sources
		Tool A5	Substrate erodibility
		Tool A6	Morphological continuity
		Tool A7	Channel modification
		Tool A8	In-channel habitats and ecology
		Tool A9	Chemical water quality
Toolbox B	Floodplain connectivity	Tool B1	Floodplain areas and existing defences
		Tool B2	Riparian zone and gathering grounds habitat mapping
		Tool B3	Land cover in potential floodplain areas
Toolbox C	Channel continuity	Tool C1	Barriers to river continuity

Overview of tool combination

Identification and definition of Broad scale Ecosystem Criteria (BEC) will be undertaken by interrogating the GIS outputs from the toolbox (Tools A1-A9, B1-B3 and C1).

Some BEC will be identified from individual GIS layers, for example, identifying barriers to biological migration will only require a review of Tool C1. However, more usually the GIS layers will need to be viewed in varying combinations to provide the necessary information and understanding to identify those parts of the system that require protection (areas deemed to be functioning correctly, having high status etc) as well as those areas potentially requiring enhancement (areas deemed to be disconnected, not functioning correctly or carrying a high risk of detrimental impact to the system/habitats).

Determining the correct combinations of GIS outputs will be reliant on the intuitive understanding of the status and functioning of the catchment, which will be developed by the project team. However, as a guide the following list provides an overview of the potential combinations and comparisons that can be made from each tool.

The information provided here is not exhaustive as each catchment will require a bespoke assessment, which will be dependent on the catchment characteristics, status and function.

- Combining information on the surface water runoff potential (Tool A2) with catchment sediment sources (Tool A4) and substrate erodibility (Tool A5) provides an indication of the sediment yield /runoff potential from the catchment into the river system. For example, areas of high runoff potential combined with highly erodible soils could be potential areas to implement mitigating land management actions, such as changed land use, buffer strips etc.

- Combining information on the surface water runoff potential (Tool A2) with habitats/land cover in the gathering grounds (Tools B2 and B3) provides an indication of, firstly, the importance of existing upland water-dependent habitat (i.e. upland bog) in attenuating surface water runoff, and, secondly, identifies areas at risk from high surface runoff that could benefit from creation/re-instatement of preferred upland habitats such as bog.

- Combining information on channel gradient (Tool A3) with substrate erodibility (Tool A5) or morphological continuity (Tool A6) can give an indication of in-channel sediment supply and transport. For example, areas of high gradient and high erodibility are likely to be areas with a high risk of channel erosion and where sediments are sourced. Whereas areas of low gradient with in-channel flow constraining features are likely to be areas where sediment deposition occurs.

- Combining information on channel modification (Tool A7) and riparian habitats/land use (Tools B2 and B3) gives an overall indication of the quality of the river corridor, including the channel and bankside habitats. For example, restoring/enhancing areas of heavily modified channel through intensive agriculture may require a greater amount of resources than obtaining the same ecological gain for heavily modified channels through pasture.

- Combining information on floodplain areas (Tool B1) with riparian habitats (Tools B2 and B3) provide an indication of, firstly, ecologically active floodplain (areas which flood and support water-dependent habitats), and, secondly, identifies where management action could be implemented to expand, restore or create water-dependent riparian habitat.

- Combining information on sediment runoff potential (Tools A2, A4 and A5) with in-channel sediment sources (Tools A2 and A5) provides an indication of potential in-channel sediment loadings. For example, channel with high potential as sediment sources running through land with high sediment runoff potential are likely to be sites with a high risk of carrying high sediment loads.

- Combining information on sediment runoff potential (Tools A2, A4 and A5) with in-channel sediment sinks (Tools A3 and A6) provides an indication of potential in-channel sedimentation. For example, channel with high potential to collect sediment running through land with high sediment runoff potential are likely to be sites with a high risk of heavy sedimentation.

- Information on morphological continuity (Tool A6) and existing flood defences (Tool B1) can be used to supplement information on channel modification, and assist in the identifying reaches of channel that are deemed to be modified from the natural state.

- Information on in-channel habitats and ecology (Tool A8) can be used to support and supplement other GIS outputs, particularly those relating to hydrology, channel modification, water quality, and in-channel sediment loadings/sedimentation levels. For example, channels with heavy modification and high potential for sedimentation could be assumed to have poor in-stream habitats/ecology. The outputs from Tool A8 can help test this hypothesis.

- Information on water quality (Tool A9) can be used to support and supplement other GIS outputs, particularly those relating to hydrology, channel modification, in-channel habitats and ecology, and in-channel sediment loadings/sedimentation levels. For example, analysing in-channel ecology, water quality and habitat modification information may allow assumptions on cause of pressure/impact to be made (i.e. is primary driver physical habitat or water quality or both).

Tool A1 Catchment hydrology

A1.1 Purpose

Catchment hydrology (river flow) at the broad scale describes flow in the river system, which in turn provides the hydrological and hydraulic regime for ecosystems. This tool provides methods for calculating the following indicators of catchment hydrology:

- Flow duration curves. These show the proportion of time that flows are exceeded, and provide a description of the in-channel flow regime.
- Q_{MED} (the estimated ‘2-year’ return period flood). This is representative of frequent floods. It is important for wetland ecosystems and is also the ‘channel forming discharge’ used to calculate streampower.
- Q_{100} (the estimated ‘100-year’ return period flood). This is representative of large infrequent floods that are used to define the floodplain extent.

In addition, the tool provides guidance on the estimation of flood duration.

A2.2 Suitable data sources

Hydrometric data are available for specific locations in each catchment where flow gauging is undertaken. Flow duration data and flood flow data are available for these sites from a range of sources including:

- The ‘Hydrometric Register and Statistics’ produced by CEH Wallingford (the most recent volume covers 1996 – 2000), which includes the location of flow gauging stations (using National Grid References) and summary flow duration and flood flow data.
- The National River Flow Archive (www.nerc-wallingford.ac.uk/ih/nrfa), which holds information on the gauging station type, time series data and flow duration curves.
- The HiFlows UK website, which provides flood flow data. This requires permission from the EA to access the data.
- The relevant EA Regional hydrometry team.

Data from the HiFlows-UK database provides peak flood flow data for about 960 river gauging stations.

The Flood Estimation Handbook (FEH) can be used to estimate Q_{MED} and Q_{100}. In addition, a national Flow Grid has been produced by CEH Wallingford that provides data for Q_{MED} and Q_{100} (and other return periods) at 50m intervals for rivers throughout England, Wales and Scotland (using FEH methods). The EA and SEPA hold licences for this dataset.

The locations of all flow gauges in a catchment will be available from the EA. Hydrometric data for each of these will be held by the EA and time series data can be requested where a hydrologist considers them necessary to develop an understanding of catchment hydrology.

A summary of catchment hydrology may be available from review of EA documents: such as CAMS or LEAPS.

A1.3 Methodology

Identify the location of significant river flow gauging stations in the catchment and prepare historic flow duration curves for each. Overlaying curves for annual, summer (April-September) and winter (October – March) flow should be prepared.

A figure should be prepared overlaying the catchment boundary and the river channel network with the locations of significant flow gauging stations in GIS. Flow duration curves should be overlaid adjacent to the relevant flow gauging station.

Values of Q_{MED} and Q_{100} should also be obtained for each gauging station. These data can also be obtained for other locations in the catchment if required, potentially including areas of floodplain interest.

An indication of the duration of flooding can be obtained from Table A1.2

Table A1.2 Indication of the duration of flooding

Factor	Duration:		
	Short	➠ ➠ ➠ ➠ ➠ ➠ ➠ ➠ ➠	Long
River length	Short	➠ ➠ ➠ ➠ ➠ ➠ ➠ ➠ ➠	Long
Average river slope	Steep	➠ ➠ ➠ ➠ ➠ ➠ ➠ ➠ ➠	Flat
Proportion of urban area	High	➠ ➠ ➠ ➠ ➠ ➠ ➠ ➠ ➠	Low
Annual Average Rainfall	High	➠ ➠ ➠ ➠ ➠ ➠ ➠ ➠ ➠	Low
Typical values	< 4 hours	➠ ➠ ➠ ➠ ➠ ➠ ➠ ➠ ➠	several days

A1.4 Interpretation

Flow duration data describe the flow regime in the river channel and identifies, for example, the duration of very low flows when ecosystems may be stressed. They can also be used to show differences between the winter and summer flow regime. Overlays of past, present and future (modelled) flow duration curves could help to identify trends in flow at both high and low flows.

Q_{MED} approximately corresponds to the 'bank-full' flood flow and has an approximate frequency of occurrence of once in two years on average. It is representative of the type of flood that sustains wetlands, as these require regular inundation every few years. It is also used as the 'channel forming' discharge, that is, the discharge which has greatest influence over channel geometry (particularly width).

Q_{100} represents a large flood and is typically used for flood defence design and definition of floodplain limits. Large infrequent floods inundate large areas and produce high flow velocities. Such flood can dramatically change aspects of the ecosystem, for example by removing vegetation and sediment from the river channel and depositing them on floodplains.

Duration provides an indication of how long floodplains will be inundated during a flood.

Tool A1 links with Tool A2, which provides runoff potential based on Q_{MED}. Tool A1 can also provide input information for Tools A5 (substrate erodibility) and A7 (channel modification).

Tool A1 should be used by a hydrologist, who will be familiar with the data and methods, and the uses of the outputs.

A1.5 Prediction of change

Flow duration curves provide a useful tool through the identification of changes to channel flows across the catchment caused by climate change, land use change, and various policy options. In particular, flow duration curves identify the durations of very low flows when ecosystems become stressed.

The impact of climate change could initially be assessed using information from the regionalised annual and seasonal rainfall change predictions in UKCIP 2002. These should be applied on a seasonal basis to identify likely impacts at different stages of ecosystem development. Climate change predictions are regularly being updated, and a check of the latest updates to either rainfall or flow predictions should be made.

Changes in Q_{MED} would affect wetland sustainability and also have an impact on river morphology. Increases in Q_{MED} would result in more floodplain inundation and increases in natural channel size. Decreases in Q_{MED} would have the opposite effect.

Present climate change predictions suggest that Q_{MED} could increase by 20% by the year 2050. Q_{MED} could also be affected by land use change and implementation of policy options.

Changes in Q_{100} would affect extreme flood flow conditions. Q_{100} is subject to the same climate change predictions as Q_{MED} (i.e. 20% increase by 2050). The proportional impact of land use change on Q_{100} is likely to be less that on Q_{MED}. Q_{100} can be significantly changed by the implementation of policy options. Flood storage could reduce Q_{100} significantly whereas 'channelling' of rivers will increase it.

A1.6 Further development

The main variable missing from the hydrology analysis described above is flow velocity, which affects the potential for erosion and deposition. It also affects other aspects of ecosystems not covered by this method, such as the ability of fish to swim against the current. Velocity could be estimated where river and floodplain cross-section data are available, including gauging stations and locations where surveys have been carried out for modelling.

More detailed analysis of data (including hydrographs) for gauging stations near significant floodplain areas could be carried out to explore the frequency, duration and seasonality of high flow events. This would provide a loose correlation with floodplain inundation and season.

Tool A2 Surface runoff potential

A2.1 Purpose

The surface runoff potential provides an indication of the amount of water that runs into the river system. It can be combined with Tool A4 to provide an indication of the sediment yield from the catchment into the river system.

A2.2 Suitable data sources

The surface runoff potential could be expressed in terms of the total annual runoff, which is recorded at gauging stations, or using a representative flood flow. The latter is selected on the assumption that a high proportion of the sediment load that enters the river system occurs during floods.

The surface runoff potential is represented by Q_{MED}/A, where Q_{MED} is the estimated 2-year return period flood and A is the catchment area upstream of the point where Q_{MED}/A is calculated.

Q_{MED}/A can have values from about 0.5 in upland rivers in 'wet' areas, for example the Tyne or the Tees in north-east England, to less than 0.05 for lowland rivers in 'dry' areas, for example the Cherwell or the Thames in central southern England.

Q_{MED}/A can be obtained from gauging station data or calculated at any point in a river system using the Flood Estimation Handbook (FEH). In addition, a national Flow Grid has been produced by CEH that provides data for Q_{MED} and A at 50m intervals for rivers throughout England, Wales and Scotland (using FEH methods). The EA holds licences for this dataset. This approach was adopted in the case studies to show how Q_{MED}/A varied within catchments and also for comparison between catchments.

Q_{MED}/A provides an indicator of runoff during flood events. As an indicator of surface runoff potential (and sediment runoff), it assumes that the important runoff for ecosystems is the storm runoff. Low flow issues are dealt with using flow duration data in Tool A1.

A2.3 Methodology

Q_{MED} and Area can be obtained using the FEH, which is the standard method for predicting flood flows in England and Wales. A typical reach length of 5km should be adequate to identify changes in Q_{MED}/A across the catchment. Reaches should not extend across significant confluences. These should be at the end of reaches as they will have a significant change in flow. In the case studies, the continuous 50m data from the Flow Grid referred to above was used.

Values of Q_{MED}/A can quickly be obtained for gauging stations using gauging station data. Data currently published by CEH Wallingford in the 'Hydrometric Register and Statistics' (latest edition, 1996 – 2000) gives Mean Annual Flood at most (but not all) gauging stations. This is slightly higher than Q_{MED}, with a return period of 2.33 years.

A range of Q_{MED}/A values will be generated across the catchment. These cannot be attributed to a unit scale of increasing surface runoff potential. Therefore the use of a national 9 point scale, a runoff potential index, is recommended regardless of the minimum and maximum in the catchment. A recommended index is presented in Table A1.3.

Table A1.3 Runoff potential index

Runoff potential	Low → High							
Scale	<0.1	0.1-0.3	0.3-0.5	0.5-0.7	0.7-0.9	0.9-1.1	1.1-1.3	1.3-1.5	>1.55

A figure should be prepared overlaying the catchment boundary with the runoff potential index dataset in GIS.

A2.4 Interpretation

High values of Q_{MED}/A show the areas in the catchment where the surface runoff potential is high. It also provides an indication of where sediment runoff is likely to be highest. Combining these data with the landscape sediment sources from Tool A4 (catchment sediment sources) will provide a qualitative assessment of sediment runoff potential.

An important factor in assessing the sediment runoff potential is the slope of the land, which affects the ability of runoff to erode sediment and wash it into the river system. This is one of the factors that is implicitly taken into account in the calculation of Q_{MED}/A. Other factors such as drainage density, watercourse maintenance and land management (assessed under Tools A3, A4 and A7) are also significant.

The calculation of surface runoff potential should be undertaken by a hydrologist, who will be familiar with the data requirements and outputs.

A2.5 Prediction of change

This tool together with Tool A4 can be used to identify whether the catchment sediment yield to the river system could change under climate and/ or land use change. Current climate change predictions indicate that winter rainfall and summer storm rainfall intensity will increase, and Defra advise that a 20% increase in river flows should be used in flood defence design.

When considering climate change, Q_{MED} should be increased by 20%. This figure should be used to develop a future set of Q_{MED} values. The same runoff potential index scale as that referred to in Table A1.3 above could then be used to provide comparison between present day and future runoff potential.

Tool A4 can be used to identify the impact of future land use change on catchment sediment sources. Tools A2 and A4 can then be used together to provide an indication of future change in sediment runoff caused by changes in the climate and the land use.

A2.6 Further development

Q_{MED}/A provides an indication of storm runoff potential. It would also be possible to estimate runoff potential based on the full flow range using annual (or seasonal) runoff data from gauging sites. Runoff potential should be used in combination with catchment land use to estimate the potential for high sediment yield. Sediment yield methods are currently being assessed as part of EA/ Defra funded research and it is recommended that the findings from the research are used to develop methods for estimating sediment yield in the future.

Tool A3 Channel gradient

A3.1 Purpose

Channel gradient can be used to assess the energy within the river network and likely effect on the sediment regime (erosion, transport and deposition of sediment). Specifically, bed slope is one of the parameters used to calculate streampower, and can be used with Q_{MED} to provide an indication of stream power across the catchment.

A3.2 Suitable data sources

There are several sources of topographic data that could be used to define the gradient of the watercourse:

- Ordnance Survey 5m profile contours including spot heights (GIS vector),
- NextMap digital terrain model (airborne Synthetic Aperture Radar, GIS vector), and
- LiDAR (airborne Light Detection and Ranging, GIS vector).

Ordnance Survey profile data can be used directly to plot slope by measuring the distance between contours and plotting level against distance. Ordnance Survey profile contours are available under sub-license from the EA Twerton data centre. NextMap data are held by the EA, but the license agreement currently precludes its use as a tool in this methodology. The EA hold limited England and Wales LiDAR coverage and for this reason its value in the high level methodology has not been explored, although it should not be precluded at project Scoping stage.

A3.3 Methodology

It is recognised that at the broad scale localised controls on bed gradient will not be represented but major structures and waterbodies can be represented (see Tool A6 for more detail).

From the OS profile spot height dataset a height raster for the catchment can be created by interpolation. A dataset of node points of the segmented river network can be used as basis for extracting spot heights from this raster layer. Gradients for each segment can then be derived using the difference in height at each node point over the length of the segment.

Gradient can be classified according to high, medium and low. By classifying according to a national dataset, comparisons between catchments can be made. The recommended index is presented in Table A1.4.

Table A1.4 Channel gradient index

Channel gradient	→ → → → Low → →→ → → Medium → → → →→ → High→ → → → → →				
Scale m/km	0-10	10-25	25-50	50-75	75-150	>150

A figure should be prepared overlaying the catchment boundary with the channel gradient index in GIS.

A3.4 Interpretation

Stream power provides an essential tool in the characterisation of the propensity of the river to source, transfer and store sediment. This is undertaken in combination with Tools A4, A5 and A6. Each layer can be analysed separately; overlaying the layers in GIS builds the understanding of sediment sourcing or storage.

Sediment sourcing is associated with:

- High gradient,
- Highly erodible substrate (substrate erodibility index, Tool A5), and
- Presence of tilled land (landscape sediment index, Tool A4).

Sediment sinking is associated with:

- Low gradient, and
- On-line flow constraining features (Tool A6).

These provide the extremes of dynamic behaviour. Zones of transfer can be identified as intermediate zones.

Channel gradient should be used to gain an overview of energy within the system. It can be used to calculate stream power;

Streampower = 9,810 Q_d S / W

Where:	Q_d	Dominant discharge (approximately Q_{MED})
	S	Slope
	W	Width

Streampower provides an indication of how active a river is, and the potential rates of morphological response. Steep rivers with high flows have high streampower and are likely to be active, whereas low gradient rivers with relatively low discharges per unit catchment area have low streampower and are likely to respond more slowly. Streampower also provides an indication of how rapidly a river might change during large floods.

Channel width is not included in the high level toolbox. It is possible to estimate width using regime equations for natural rivers but there is significant scatter in the results. As many rivers in England and Wales are modified, the uncertainty in width estimation would be even greater.

However an initial indication of streampower and therefore the susceptibility of the river to change can be obtained from the product Q_{MED} * S.

It is recommended that a summary of morphological behaviour be prepared to summarise spatial variability, to support the understanding of channel condition baseline. Interpretation of the data will require analysis by an experienced geomorphologist.

A3.5 Further development

The factor missing in the streampower calculation at present is channel width (A3.2 above). In addition, information on velocity would strengthen the approaches to ecosystem impact including erosion potential and direct impacts on habitat.

Further to high level review of the desk based information a more detailed assessment of morphological form and processes should be undertaken to support the baseline characterisation. This exercise should not aim to provide a long literature review of all relevant data for geomorphology. The objective is to provide an assessment of the spatial variability of morphological processes and character of the river and floodplain and to flag up key geomorphological issues. The high level assessment should have involved a selection of relevant information. This review is therefore focused on key data, for example:

- Fluvial Audits,
- Geomorphological Dynamics Assessment, and
- Sediment related studies e.g. bank erosion reports.

It is suggested that a method is developed for assessing channel width and depth, based on regime theory but with scope for modification using local data. Where available, topographic survey used in numerical modelling of river flows can be used to plot long profiles and assess the influence of gradient on the sediment regime. This is likely to be more useful at the mid-level assessment where modelling is being undertaken and the range of tools available to assess changes in water levels and velocities downstream is increased. Topographic data are likely to be more useful than LiDAR data at the medium scale to compute an accurate long profile bed levels are required. It is likely that if modelling is being undertaken, topographic data or at least some ground-truthing data will be available for part or all of the catchment.

Topographic and possibly LiDAR data could also be used to derive channel width for use in stream power calculations. Sources of local data include velocity-area gauging station (natural) cross-sections, channel survey and model data, and field data. Approximate cross-sections could quickly be obtained by measuring channel width and depth at sites with suitable access (for example, clear-span bridges or wadeable sections).

Tool A4 Catchment sediment sources

A4.1 Purpose

The sediment yield from catchments under different land cover and land management types affects the volume of sediment supply to river systems. The volume of sediment supplied to the river can determine the morphological response of river channels (erosion and deposition) throughout the river network affecting the diversity, quality and extent of habitat. This is particularly the case with fine sediment delivery which has the potential to cause rapid channel adjustment which can impact positively and/or negatively on in-channel habitat.

This tool identifies at the broad level the types of land cover and associate potential as sediment sources, for input into the mid level analysis.

A4.2 Suitable data sources

The determination of catchment sediment sources requires spatial data on land cover and land management across the catchment. Tilled land is potentially the most significant source of fine sediment across the catchment, where a pathway exists for its transfer from field to watercourse. In simple terms the pathway is enhanced by high slope and high rainfall runoff potential; reduced by the presence of buffer strips or alternative land cover prior to connectivity with the watercourse.

The land cover type can be identified from the CEH Land Cover Map (LCM) 2000, prepared by Landsat TM satellite imagery at a spatial resolution of 25m on a national basis. LCM2000 raster GIS data are available under sub-license from the EA Twerton data centre. Other potentially suitable soil-type databases, including hydrology of soil types (HOST) are not available from the EA Twerton data centre.

No spatial datasets are currently available which identify buffer strips.

A4.3 Methodology

A land cover classification based on potential sediment yield can be prepared from re-sampling the LCM2000 dataset. Re-sampling is presented in Table A1.5.

Table A1.5 Re-sampling of LCM2000 to prepare a landscape sediment index

Landscape sediment index	LCM2000 land cover subclasses (and target codes)
Woodland	Broad-leaved/mixed woodland (1.1), coniferous woodland (2.1)
Tilled land	Cereals (4.1), horticulture/non cereal or unknown (4.2), not an annual crop (4.3)
Unmanaged/ managed pasture	Improved grassland (5.1), setaside grass (5.2), rough grass (6.1), managed neutral grass (6.2), calcareous grass (7.1), acid grassland (8.1), bracken (9.1), dwarf shrub heath (10.1), open shrub heath (10.2)
Urban areas	Suburban/ rural developed (17.1), continuous urban (17.2)

The river network can be split according to land cover type adjacent to the channel boundary. This method does not take into account land cover type of the contributing area but this could be undertaken if combined with a DTM.

A figure should be prepared overlaying the catchment boundary and river channel network with the landscape sediment index dataset in GIS.

A4.4 Interpretation

Catchment land cover provides an indication of the likely sources and nature of sediment supply. Whilst it is not possible to quantify the contributions of sediment source areas, Table A1.5 ranks land cover in terms of likely relative contribution. This can be combined with potential surface runoff to identify key areas of sediment supply. However, it is important that the land cover classification is not considered only in terms of volumes of sediment yield but also in terms of the nature of supply, for example the number of drainage outfalls indicates high levels of artificial urban or agricultural drainage. This indicates direct sediment supply into the river system. The absence of a floodplain can be indicative of direct hillslope supply of sediment, important in terms of provision of natural substrate. Urban areas may provide high levels of sediment through urban runoff through the artificial drainage network.

Combining of land cover data with Tools (A2 to A7) should provide an overview of likely impact of changing land cover in the catchment in question. For example, in heavily urbanised catchments the potential for land cover change will be more limited thus there will be a different impact than in catchments where significant change from one land cover class to another is identified. Use of local plans or other planning documents such as forestry management plans (which plan over similar timescales to a CFMP) are useful in considering impacts of land cover change.

Interpretation would require a GIS technician and geomorphologist.

A4.5 Further development

It is possible to address catchment sediment supply for the areas contributing to each river segment by combining land cover data with a DEM or by assigning an area of land either side of the river network. This would still require some data classification and could not be quantified without incorporation of existing research on sediment yield. However combination with surface potential runoff would go some way towards better establishing relative contribution of sediment from the catchment.

Tool A5 Substrate erodibility

A5.1 Purpose

Variation in river bed and bank materials (their “boundary conditions”) reflects the diversity, location and extent of broad habitat types. An assessment of the erodibility of the bed and bank materials can be made based on superficial geology to identify the likely potential for local sediment sourcing due to erosion. Local sediment sourcing can be combined with the catchment sediment sources identified in Tool A4 to identify areas of high potential sediment supply. For example, where erodible boundary conditions are combined with tilled agricultural land there is high potential for sediment supply to the channel. The sediment supply is important when considering the overall sediment regime in terms of habitat quality. This tool provides a broad assessment of river erodibility based on the variation in drift geology within the catchment.

A5.2 Suitable data sources

The erodibility of boundary conditions can be determined from the superficial drift geology of the catchment. Superficial deposits (drift) geology data are available from the British Geological Survey (BGS) at a scale of 1:10,000 on a national basis. Digital geological map raster GIS data are available under sub-license from the EA Twerton data centre.

A5.3 Methodology

A index of erodibility of channel boundary conditions should be prepared from re-classifying the BGS superficial deposits dataset. The categories used to classify the data are presented in Table A1.6.

Table A1.6 Re-sampling of BGS superficial deposits dataset to prepare a substrate erodibility index

Substrate erodibility index	Superficial deposits classification
Least erodible	Absent (solid strata only) Glacial Till – Lowland
Low erodibility	Glacial Till – Upland Glacial Soils (lateral and terminal moraines) Head deposits/alluvial fans Recent alluvium (peat)
Moderately erodible	River terrace deposits Glacial sand and gravel
Highly erodible	Recent Alluvium

A figure should be prepared overlaying the catchment boundary and river channel network with the substrate erodibility index dataset in GIS.

A5.4 Interpretation

Substrate erodibility provides an essential tool in the characterisation of the propensity of the river to source, transfer and store sediment. The boundary conditions GIS layer should first be analysed in terms of likely capacity to supply sediment (for example, bedrock channels will have little sediment yield). It is useful to view this in combination with the topography of the catchment as particular features may have potential to supply considerable volumes of sediment, for example upland floodplains. The erodibility of boundary conditions can then be analysed in combination with Tools A3, A4 and A6 to identify the likely supply of sediment.

A5.5 Further development

Where available, soil mapping may also be useful to identify the changes in sedimentary characteristics across the catchment. The boundary conditions of the river affect the degree of sediment sourcing and lateral mobility of a river. This affects the downstream sediment regime, the planform configuration and the activity of the river, which may have an influence on habitat type.

Tool A6 Morphological continuity

A6.1 Purpose

Physical barriers to natural sediment movement patterns through a river system can influence in-channel ecosystems. The interruption of natural flow is explored through this Tool.

Physical barriers (e.g. Weirs,…lakes) to natural sediment movement both in a downstream direction and laterally across the floodplain affect river ecosystems by constraining the transport and storage of sediment. Tool A6 can be used in combination with Tools A3 (and B1) to assess the potential for sediment to be moved and stored in the system and the potential for reinstating natural morphological functioning (e.g. flooding). This is particularly important for fine sediment which will be retained in channel where flood defences are present and can adversely affect significant lengths of otherwise functioning habitat.

A6.2 Suitable data sources

On-line flow constraining features potentially include any significant natural or artificial constrictions to the flow of water and sediment in the channel or across the floodplain. A list of potential features includes:

- in-channel structures, such as dams, locks (e.g. on navigable rivers), tidal barrages, gates and weirs,
- channel constraining structures, such as bridges and culverts,
- natural flow-reducing features, such as on-line lakes, and
- embankment or floodwalls.

National spatial datasets are not available for all of these features. Certain data are available from the EA's National Flood and Coastal Defence Database (NFCDD), notably in-channel structures. However coverage is intermittent and many features are omitted. Interrogation of Ordnance Survey 1:25,000 mapping is therefore recommended to confirm the presence of any significant features.

The potential significance of bridges is not considered in the high level methodology, and no datasets are available on the location or effect of culverts.

The presence of on-line lakes can be identified from the CEH Land Cover Map 2000 (see Tool A4).

A6.3 Methodology

NFCDD data should be interrogated to display, separately, dams, locks, tidal barrages, gates and weirs.

Ordnance Survey 1:25,000 mapping should be interrogated to obtain the X,Y co-ordinates for all weirs, dams, locks and tidal barrages. These can then be digitised and used to supplement the NFCDD dataset.

LCM2000 should be interpreted to display the land cover class *inland water* only.

A figure should be prepared in GIS overlaying the catchment boundary and river channel network with each of the flow constraining features.

A6.4 Interpretation

The river network can be segmented using the drainage network structure (watercourse confluences), on-line storage (lakes, reservoirs) and in-channel structures (e.g. weirs, dams). This segmentation of the river network should be viewed in terms of the movement of sediment downstream. Ponded sections of river upstream of major in-channel structures result in sediment sinks, sometimes extending a considerable length upstream. Fine sediment deposition can reduce access of species to underlying gravels and reduce diversity of flow depths. Coarse sediment deposition can result in a requirement to extract gravel for maintenance reasons, disrupting habitat and causing potential instability of channel bed and banks both upstream and downstream of the structure. The locking up of sediment in artificial sediment sinks can result in downstream sediment starvation; this has potential to cause further erosion of channel bed and banks, additional sediment supply and lack of habitat diversity downstream. The extent to which the channel is segmented reflects the extent to which habitat is likely to have been impacted. Structures which are infrequently overtopped are likely to cause greatest impact.

The reduction in connectivity between rivers and floodplains is also important in terms of the sediment regime (see Toolbox B). Floodplains may be cut-off through linear flood defence structures and sediment retained within the river system. This has two impacts; first the likelihood of sediment storage within the channel is increased, often with negative impacts; secondly, floodplain accretion is prevented so that the floodplain changes in relation to any changes in bed level of the channel. In addition, soils on the floodplain are often degraded as a result of lack of fine sediment deposition.

Consideration of both downstream continuity and floodplain connectivity in terms of sediment regime is important as impacts on the sediment regime are likely to be highest where both have been reduced. These impacts may not be limited to the reach where the channel has been modified but also upstream and downstream.

An expert in engineering and a geomorphologist would be required to interpret the data.

A7.1 Purpose

Morphological naturalness of a river system will strongly influence the ecological status of the river compared to its ecological potential. Channel modification has a direct influence on habitat diversity, provision of shelter, shading and suitable flow types. Indirectly, the disruption to the in-channel sediment regime through bank and bed protection can exacerbate the above factors relating to habitat status. The purpose of this tool is to describe the relative level of channel modification across the catchment against a pristine, unmodified state.

A7.2 Suitable data sources

River Habitat Surveys are the only nationally available data for assessing morphological characteristics throughout the river network. These data are point data i.e. only short/ reprehensive river reaches, rather than continuous and must therefore be used to identify indicative trends.

The Habitat Modification Score (HMS) is used to assess artificial modification of the physical structure of a river channel. It uses a simple point scoring technique when recording types of channel modification to allow a cumulative score to be calculated for each RHS site. The cumulative score can be used to summarise the severity of alteration to the channel. Using the scoring system, zero describes a pristine channel while most heavily and extensively modified channels score 45 points or more. The system relies on the description of physical features and structures; ecological factors such as presence of non-native plant species are not included in the scoring system.

RHS data are held by the EA's RHS team.

A7.3 Methodology

A figure should be prepared overlaying the catchment boundary and river channel network with the habitat modification scores dataset in GIS.

Classification of the RHS habitat modification index is presented in Table A1.7.

Table A1.7 Classification of the RHS habitat modification index

Habitat modification index	RHS habitat modification score
Pristine	0
Semi-natural	1-16
Predominantly unmodified	17-199
Obviously modified	200-499
Significantly modified	500-1,399
Severely modified	1,400+

A7.4 Interpretation

RHS data are primarily of use where there is sufficient coverage of the catchment to identify spatial trends. If this is the case, trends in the level of physical habitat alteration can be identified and combined to support findings from using Tool A5. Otherwise, single site data can be used to support other assessments as even isolated information is of some value when combined with other data sets or outcomes from consultation. It is often the case that RHS is done in places where there is a proposed project or development to establish a baseline condition.

A7.5 Further development

As part of ongoing EA research into setting River Habitat Objectives (RHOs), the development of which is largely driven by the Water Framework Directive, a new methodology for characterising channel morphology is being developed.

This new method will characterise the river according to a fuller range of morphological parameters, and is thus a more robust tool for identifying morphological diversity The characterisation process uses not only HMI but also Habitat Quality Assessment (HQA) scores, which give an indication of the habitat diversity.

HQA has not been included within the existing BSEA process as it is river-type specific, and thus first requires river types to be grouped before relative scores can be compared and assessed. Given the broad-brush nature of the BSEA method it is not considered appropriate or necessary to investigate the RHS data in that amount of detail, and therefore HMI is only used as an indication of habitat quality.

However, in the RHO methodology the river type grouping is based on slope, distance from source, height of source and site altitude. For each group of river types (known as a Principal Component Analysis (PCA) Group) a General Habitat Quality (GHQ) score is established. The GHQ is a combination of HMI and HQA, and gives a score of A (excellent) – E (extremely poor).

A similar approach to combining HMI and HQA to provide an overall River Habitat Quality (RHQ) score was adopted by the EA's RHS team when they undertook a geomorphological evaluation of Goldrill Beck, a feeder stream for Ullswater in 2003.

Once this method becomes standardised and nationally accepted, it is recommended that it should be considered for incorporation into the toolbox, and used for characterising river morphology as part of future strategic flood risk management studies.

Tool A8 In-channel habitats and ecology

A8.1 Purpose

The collation and analysis of readily available in-channel habitat and ecology data will, especially if spatially presented as a GIS layer, provide additional information to assist in defining and interpreting river processes, constraints and opportunities, as well as providing a reference to additional, more detailed information which would be available to investigate and use in more detailed phases of the flood study (i.e. strategy or scheme level).

However, standardised and digitised mapping of in-channel habitats is not undertaken routinely and other ecological data are generally species- or taxa-specific and collected intermittently (both temporally and spatially) throughout most catchments. These discontinuous data may be of use for the analysis of trends in ecological status (i.e. good fisheries/macroinvertebrate community structure at a given site) providing that the detailed survey-specific data have been suitably analysed, to allow broad scale evaluation of overall trends. Detailed site and/or survey specific data should not be analysed for BSEA. Tool A8 provides support to the core suite of channel condition tools used in the BSEA methodology (Tools A1-A7) to aid setting appropriate BECs.

A8.2 Suitable data sources

Although the BSEA methodology does not advocate collecting bespoke in-channel information, local habitat and ecology data should be incorporated where they are available and in a digital format or in a format that can be easily digitised. Potential data sources which may exist include:

- EA routine sampling sites for fish, aquatic invertebrates and macrophytes: locations of sites are likely to be presented in existing documents including Local Environment Agency Plans or River Basin Management Plans. These should be accompanied by trend description of fisheries etc. Statuses of such information (e.g. where in the catchment there are good/poor ecological communities).
- Biological General Quality Assessment (BioGQA): maps of the most recent biological GQA (status of water quality based on routine EA macroinvertebrate monitoring). Provides a snapshot of ecological health at the time of survey on a grade from A (very good) to F (bad). Obtained from the EA.
- Salmonid Waters (SW) and Cyprinid Waters (CW): maps and schedules which provide an indication of the ecological condition (or target) of specific rivers based on the water quality requirements for both salmonid and cyprinid fish. Maps and schedules are available from the Defra website.
- Aerial photography: high resolution digital photography covering the whole of England and Wales was collected as part of the Millennium Project, and is available from the EA.
- Nature conservation designations: international and national designations (maps and citations) can provide an indication of high value

river sites and reason for designation. Information can be obtained from EN and JNCC websites.
- Surveys as part of bespoke projects: could include surveys undertaken as part of river condition assessment, river restoration/enhancement, flood risk management strategies/schemes etc. Could provide information on habitats, substrate/deposition features as well as locations of species/taxa-specific surveys etc. Should only be included if the information support the scale, high level catchment analysis.

A8.3 Methodology

In some instances information could be incorporated within existing GIS layers. For example, RHS/RCS may identify in-stream structures/barriers to migration, which could be added to the river continuity layer.

However, the more likely approach will be to use existing maps (i.e. Biological GQA, salmonid waters, designations) and aerial photographs, or to generate bespoke GIS layers (i.e. showing locations of survey sites and data type). This information will be used off-line to supplement the standard GIS layers and will be used to help understand the system and develop BEC Opportunities and Constraints, whilst also informing recommendations for further more detailed studies.

A8.4 Interpretation

Available information on habitats and ecology may be used in the following manner:

- Assisting with the general understanding of catchment characteristics, functioning and pressures/ impacts,
- Assisting with the interpretation of nature conservation designations,
- Identifying constraints (areas of good habitat) and opportunities (areas in need of improvement),
- Assisting in the interpretation of fluvial geomorphological data (i.e. identifying areas of sediment deposition and erosion), and
- Assisting in setting BEC within an appropriate spatial context (i.e. try to ensure Enhancement BEC are within areas of low habitat/ecology status, and Protection BEC within areas of high habitat/ecology status)

Aerial photography could be used to:

- Assist in interpretation of land cover data (i.e. differentiation between floodplain grassland habitats), particularly relevant if habitat mapping is unavailable,
- Identify in-stream features such as gravel/earth bars and islands, riffles, areas of siltation, pools etc that would be of ecological significance,
- Identify bankside features such as bank erosion, bank reinforcement, and
- Assist in identifying and interpreting effect of in-stream structures such as weirs, sluices and dams.

The analysis of the broad scale data and information should be undertaken by an experienced aquatic ecologist with a focus on expertise in catchment-scale strategic analysis.

A8.5 Further development

One of the major weaknesses in catchment-scale ecosystem assessment at this time is the lack of a consistent, consolidate dataset that describes both floodplain and particularly in-channel habitats and communities. This area is receiving considerable attention as a result of development of methods to support WFD implementation. The toolbox will require updating to reflect advances in this area in the coming years (review in 2008 recommended).

The National Biodiversity Network (www.nbn.org.uk) habitats dictionary project brings habitat data in current use in the United Kingdom together as a single publicly accessible information resource. This should be inspected periodically to assess the usability of the data contained for BSEA.

Ongoing research by Durham University and the Eden Rivers Trust is assessing the use of aerial photography to quantify in-stream habitat availability for salmonid fish and assess condition of the riparian zone. The research is also investigating use of unsupervised classification and reclassification techniques in GIS to identify depth variations (deep, medium, shallow, exposed) within the channel. This research is focusing on the River Eden and its tributaries. The research output would definitely provide valuable support to the main suite of tools within BSEA, and could develop into a GIS layer in its own right to support the in-channel condition assessment.

Tool A9 Chemical water quality

A9.1 Purpose

An understanding of general chemical water quality and in-stream nutrient quality can be used to assist in the interpretation of ecosystem pressures across a catchment. Although pressures from point and diffuse source pollution, including eutrophication risk, are not typically associated with flood management policy, the solution may in certain circumstances by increasing implemented as part of flood risk management (i.e. changed land use, changed land management). This tool provides a description of chemical water quality within the catchment.

A9.2 Suitable data sources

The EA at present classifies water quality based on the River Ecosystem (RE) Classification and the General Quality Assessment (GQA).

The RE defines the statutory river quality objective, which is a river-reach specific target for quality. The targets are currently based on the requirements of the Freshwater Fisheries Directive. RE range from RE1 (highest quality objective) to RE5 (lowest quality objective).

The GQA is based upon the EA's 3-yearly results for routine water quality monitoring, which covers chemical, biological and nutrient status of waters. This information is available on-line or via the relevant EA region. The GQA provides a snap-shot in time of the overall river water quality, and is then compared to the RE target to assess whether the current water quality is meeting or otherwise the RE target.

A9.3 Methodology

Two maps for water quality should be produced as follows:

- The river network divided into its RE classes, with the GQA compliance based on the most recent GQA data also shown (i.e. RE2, compliant; RE1, non-compliant).
- The river network divided into its GQA classes, with separate bars for chemical, biological and nutrient status

A9.4 Interpretation

The chemical water quality data are not a core part of the BSEA methodology in terms of understanding the functioning of the system. However, it does provide valuable information on current catchment pressures and potential sources of impact (including water quality-mediated ecosystem impairment).

Water quality information should be investigated off-line from the main GIS layers. As part of flood risk management the water quality information should be used to identify pressures on the system and guide potential BEC which may assist in addressing any identified problems (i.e. catchment land use change).

A9.5 Further development

It is unlikely within the remit of flood risk management that additional water quality information would be required.

If BSEA is applied to alternative catchment initiatives, such as WFD, it is recommended that water quality information could be embedded within the main GIS framework and linked and supplemented with additional information such as land use, landscape sediment sources, substrate erodibility and livestock census to build up a more detailed picture of catchment pressures.

Tool B1 Floodplain areas and existing defences

B1.1 Purpose

Flood extent information is used to develop an understanding of the potential extent of floodplain. Information on flood defences assists the understanding of current and historic flood management policy, providing information on areas benefiting from flood defences. Disconnection of the river from the floodplain from other linear barriers (e.g. railway embankments, canals) and management actions may also assist the understanding. Low return period flood extent outlines (e.g. 1 in 2 year, 1 in 5 year) provide information on areas of ecologically active floodplain.

B1.2 Suitable data sources

Data are required on flood extent outlines for different flood risks and structures which disconnect the floodplain from the river channel. [No nationally available dataset is currently available for low return period flood events (e.g. 1 in 2 year, 1 in 5 year)].

The flood extent outlines used in this project used the “EA Flood Map for England and Wales”. These digital databases contain the fluvial flood outlines for 1 in 100 years and 1 in 1,000 year return periods. The dataset also includes flood defence structures (cross-check with the NFCDD) and spatial representation of areas benefiting from flood defences within the flood outline. Use of 1 in 100 year return period flood extent is currently the best solution as it uses a consistent methodology nationally and can be easily obtained. The flood extent flood line is extracted in ESRI ArcView shapefile format (shp), for manipulated using a GIS.

Other linear barriers to floodplain connectivity, such as railway and road embankments and canals can be identified from Ordnance Survey 1:25,000 mapping.

B1.3 Methodology

The flood extent outline GIS shapefiles are imported as a new layer file in conjunction with the catchment boundary layer file. By using the selection tools in the GIS package, all flood extent outline data contained within the catchment boundary is selected and a separate layer file created.

NFCDD data should be interrogated to display flood defence assets.

Ordnance Survey 1:25,000 mapping should be interrogated to obtain the locations of embankments and canals in floodplains. These can then be digitised and added as a separate layer in GIS.

A figure should be prepared overlaying the catchment boundary and river channel network with the 1 in 100 years indicative flood outline, existing flood defences and areas benefiting from existing flood defences in GIS.

B1.4 Interpretation

Floodplain area provides an essential tool in the characterisation of the propensity of the river to interact hydrologically with the riparian zone. This is undertaken in combination with Tools (B2) and (B3). Each layer can be analysed separately; overlaying the layers in GIS builds the understanding of riparian habitat risk and potential.

Tool B1 effectively maps the natural floodplain area. Use of 1 in 100 year flood extent outlines provide an indication of those areas at risk of flooding, and through appropriate management intervention, could be realised as active ecological floodplain. 1 in 100 year flood extent outlines do not provide an indication of which areas could be considered as active ecological floodplain under current flood and land management.

Tool B2 provides spatial data on riparian habitats. These would be anticipated to be a subset of the 1 in 100 year flood extent outline and do not include areas benefiting from flood defences. In the first instance, riparian priority habitats should be protected from flood management policy interventions, which would adversely impact on their current connectivity with the river.

In addition, areas can be identified from combination of Tools B1 and B2 where management action could expand, restore or create riparian habitat. Potential areas are not restricted to those areas benefiting from flood defences, which could be removed (e.g. certain embankment for protection of agricultural land). Potential areas may have suitable or unsuitable (e.g. urban) land cover (Tool B3). The reconnection or enhancement of hydrological connectivity between river and floodplain may not provide a flood management benefit but could be considered where mitigation +/or compensation needed to promote wider flood management policy, or strategy or schemes. Consideration of local land ownership issues (i.e. return of land to floodplain) is not included in this broad scale review.

Interpretation of the data should be undertaken by an hydrologist and aquatic ecologist, or if available a hydro-ecologist.

B1.5 Prediction of change

Predicted future flood extents, from changes in rainfall and runoff, can be incorporated where available. The EA has started to provide flood outlines which show the ‘100-year + 20% flow’ outline in addition to the 100-year outline, to take future climate change into account.

In addition, there is scope for predicting flood extents for a range of return periods with and without climate change by constructing rating curves (plots of flow against water level) at selected locations where large floodplains exist. There are a variety of ways of doing this by hydrological and hydraulic calculation, but the main data requirement is a reasonably accurate cross-section survey of the floodplain.

Water levels would be estimated for flows with and without climate change, and the levels projected across the floodplain to determine the floodplain width in each case. The ratio of the floodplain width compared with the 100-year floodplain width could then be used to estimate floodplain widths for different return periods elsewhere in the floodplain, thus building up a flood outline.

It may be possible to do this quickly using the results from hydraulic river models where they exist.

Flood outlines of particular relevance include:

- The 100-year flood outline with and without climate change, and
- The 5-year flood outline with and without climate change, to provide an indication of the extent of areas that flood frequently, which could potentially be wetlands.

The climate change flow would be assumed to be the present day flow plus 20%.

B1.6 Further development

There is currently some debate between hydrological modellers as to which modelling software is the most appropriate for modelling flood inundation. A specification for the modelling output data is required to inform the debate and ensure that it will be possible to arrive at hydrological driver data for input to the ecosystem assessment. At present the requirement is for floodplain inundation data that describe:

- Flooding extent (for a variety of return periods from 1:1 to 1:100),
- Flood seasonality, and
- Flood duration.

Possible approaches include:

- Catchment models based on flow routing and rating curves, which provide a simple and quick (but not very accurate) initial estimate of floodplain inundation,
- Conventional '1-Dimensional' hydraulic models,
- Flood spreading models such as JFLOW, which provide flood outlines based on '2-dimensional' spreading of floodwater,
- Fully dynamic '2-dimensional' models, such as TUFLOW, and
- In addition, the RASP (Risk Assessment for Strategic Planning) methodology provides an approach for taking the performance of flood defences into account when estimating flood extent.

All of the above models could achieve the requirements if suitable seasonal flow data are used.

Topographic input data is critical for such modelling, particularly for low return periods. Given the difficulties of obtaining LiDAR data for the whole catchment and the work required to process model output data effectively, this cannot be currently proposed as a high level BSEA tool. Sustainable flood risk management is currently focusing on high return period events; however where modelling of other flood events (including with climate change) has been undertaken for sustainable flood risk management, these data could be incorporated into Tool B1.

Tool B2 Riparian zone and gathering grounds habitat mapping

B2.1 Purpose

The presence of water-dependent habitats in the riparian zone provides an indication of the current location of ecologically active floodplain (for protection or possible enhancement). In addition, areas for potential restoration to ecologically active floodplain through improved floodplain connectivity and suitable land management can be identified. The location of water-dependent habitats in the gathering grounds, particularly catchment headwaters, provides context to land management changes for runoff attenuation and reduction of sediment mobilisation.

B2.2 Suitable data sources

Mapping and digitising of UK Biodiversity Action Plan (BAP) Priority Habitats has been undertaken in England for EN. This includes relevant aquatic and riparian habitats. The spatial resolution and survey date differs between datasets, (for further information, see Appendix 3).

Water-dependent habitats selected from the digitised datasets held by EN for the purposes of this project include blanket bog, coastal floodplain and grazing marsh, coastal sand dunes, coastal vegetated shingle, fens, lowland raised bog, maritime cliff, mudflats, purple moor grass, reedbeds, saline bog and wet woodlands. These digitised datasets show the UK coverage of each water-dependent habitat type and should be extracted in shapefile format (shp), in order for it to be manipulated using a GIS.

Mapping and digitising of international and national nature conservation designations has been undertaken in England and Wales by EN and CCW respectively.

Regional *opportunity maps* for landscape-scale conservation of biodiversity may have been prepared through the EN research initiative (English Nature, 2005).

B2.3 Methodology

GIS Shapefiles for each water-dependent habitat type for the catchment are imported as a new layer file in conjunction with the catchment boundary layer file. By using the selection tools in the GIS package, each water-dependent habitat should be manipulated to show only the coverage contained within the catchment boundary. From this, a separate layer file is created. This layer file is specific to each water-dependent habitat type.

A figure should be prepared overlaying the catchment boundary and river channel network with the priority habitats dataset in GIS.

Sites designated for nature conservation importance can also be mapped across the catchment to provide an indication of habitat quality.

B2.4 Interpretation

Riparian zone habitat mapping provides an essential tool in the characterisation of the propensity of the river to interact hydrologically with the riparian zone, and thus forms a surrogate for establishing good ecological function and status of the floodplain. This is undertaken in combination with Tools B1 and B3. Each layer can be analysed separately; overlaying the layers in GIS builds the understanding of riparian habitat risk and potential. The combined approach is presented in Tool B1.

Mapping habitats within the gathering grounds provides a tool to assist in understanding the current status of those areas, with emphasis on human impact, particularly agriculture. The presence of important or priority habitats is an indication that the areas are functioning appropriately, and should not be affected. Presence of degraded (i.e. improved/ semi-improved grassland) or agricultural land/commercial forestry, provide indications that ecological gains could be achieved through land management whilst assisting flood management through attenuation of surface water runoff.

Supporting data for these sites could be interrogated to identify those with aquatic ecology interest and those in favourable ecological status. However, as nature conservation designation is generally species-led, not habitat-led, these data sit alongside, not within BSEA. Designated site boundaries are available from a range of sources, including downloads from the JNCC website (www.jncc.gov.uk):

- Internationally designated sites of nature conservation importance:
  - Natura 2000 sites:
    - Special Protection Areas (SPA), and
    - Special Areas of Conservation (SAC).
  - RAMSAR convention sites.
- Nationally designated sites of nature conservation importance:
  - Sites of Special Scientific Interest (SSSI), and
  - National Nature Reserves (NNR).

Interpretation should be undertaken by an experienced aquatic ecologist.

B2.5 Further development

EN is currently undertaking research into mapping of biodiversity opportunities at the landscape scale, which is based upon the premise of identifying where BAP habitat could and should be restored, re-created and created. The research is due to be published in 2005. Findings and conclusions from this research should be incorporated into the BSEA methodology.

Tool B3 Land cover in potential floodplain areas

B3.1 Purpose

Tool B3 investigates the potential for management actions leading to the creation, restoration or enhancement of ecologically active floodplain. This tool reclassifies broad scale land cover data to identity the current land cover in areas at risk of flooding and, with Tool B2, establish areas with the potential for ecological improvement.

B3.2 Suitable data sources

Floodplain areas that are not currently active ecological floodplain may have the potential for intervention and management action to develop riparian priority habitats. This potential is dependent on a number of features, cause of reduced hydrological connectivity from the river, current land cover, historic land management, current land management.

The cause of reduced hydrological connectivity from the river is investigated by Tool B1.

Land cover in potential floodplain areas can be identified from the CEH Land Cover Map (LCM) 2000, prepared by Landsat TM satellite imagery at a spatial resolution of 25m on a national basis. LCM2000 raster GIS data is available under sub-license from the EA Twerton data centre.

Historic and current land management cannot be readily interpreted from overview data.

B3.3 Methodology

The LCM2000 data for the catchment are supplied in GIS shapefile format and can be cut to the catchment boundary. In order to distinguish between the different landcover index types, the LCM 2000 layer is re-sampled by categorising the data into common broad habitats within the categories semi-natural land cover and agricultural land cover. Re-sampling is presented in Table A1.8.

Table A1.8 Re-sampling of LCM2000 to prepare a land cover index

Land cover index	LCM2000 land cover subclasses (and target codes)
Semi natural	
Scrub/ heath/ woodland	Broad-leaved/mixed woodland (1.1), coniferous woodland (2.1), dwarf shrub heath (10.1), open shrub heath (10.2), bracken (9.1)
Grassland	Setaside grass (5.2), rough grass (6.1), managed neutral grass (6.2), calcareous grass (7.1), acid grassland (8.1)
Water dependent habitats	Standing water/ canals, (13.1), bog (12.1), fen/ marsh/ swamp (12.1)
Agricultural	
Arable	Cereals (4.1), horticulture/non cereal or unknown (4.2), not an annual crop (4.3)
Grassland	Improved grassland (5.1),
Urban areas	Built-up areas/gardens (17.1 and 17.2)

A figure should be prepared overlaying the catchment boundary and river channel network with the land cover index in GIS.

B3.4 Interpretation

Land cover in potential floodplain areas provides an essential tool in the characterisation of the propensity of the river to interact hydrologically with the riparian zone. This is undertaken in combination with Tools B1 and B2. Each layer can be analysed separately; overlaying the layers in GIS builds the understanding of riparian habitat risk and potential. The combined approach is presented in Tool B1.

Semi-natural broad habitats within the flood outline, particularly grassland and water dependent habitats provide the highest potential for managed succession to riparian habitats through enhanced floodplain connectivity. Agricultural broad habitats, particularly improved grasslands, have the potential to be removed from agricultural production, and riparian habitats restored or created through appropriate hydrological intervention and changed land management. Urban areas provide low potential, except where parkland can be identified.

B3.6 Further development

Hydrology of Soil Types (HOST) can provide spatial information on soil drainage potential (but not drainage infrastructure or water table height)

Ongoing research is currently assessing vegetation habitat type and change based on hydrological regime (*Morris et al (2004). Integrated Washland Management for Flood Defence and Biodiversity. Report to Defra and English Nature).* Three water related characteristics of washlands determine their vegetation habitat potential, namely duration of flooding, seasonality of flooding and soil water regime. The three components have been chosen to form the basis of a classification matrix because they can be readily estimated for an existing or potential washland.

A typology matrix has been produced which focuses on habitats whose composition is largely determined by the prevailing water regime (see Table A1.9). The assumption within the matrix is that the flood frequency of sites is greater than once every three years.

The current matrix is illustrative rather than definitive in terms of its assignment of NVC types to particular cells. The majority of the cells in the matrix have more than one vegetation type. The communities listed represent the vegetation which could develop on the site over a long period of consistent management. Such communities may not be achievable in the short (1-10 years) or even medium term (10-50 years), but they may be used to represent either future goals or as a guide to the appropriate management of the land, even though it may be recognised that the full community is unlikely to assemble at a site within the time-frame of a specific project.

Table A1.9 Typology Matrix Showing Classification of Washlands by Flood and Soil Water Regimes and Related Habitat Types

	Winter flooding only			Flooding at any time of year		
	Rapid soil drainage	Moderate soil drainage	Slow soil drainage	Rapid soil drainage	Moderate soil drainage	Slow soil drainage
Short duration flooding	**1** Arable Pasture Hay meadow Woodland	**2** Pasture Hay meadow Woodland	**3** Pasture Woodland	**4** Hay Meadow Pasture Woodland	**5** Woodland Pasture	**6** Swamp Pasture Woodland
Medium duration flooding	**7** Hay meadow Pasture Woodland	**8** Pasture Woodland	**9** Pasture Swamp Woodland	**10** Pasture Woodland	**11** Pasture Woodland Swamp	**12** Swamp Pasture
Long duration flooding	**13** Pasture Woodland	**14** Pasture Woodland	**15** Swamp Pasture Woodland	**16** Swamp Woodland	**17** Swamp	**18** Swamp

Notes:

Soil drainage is a function both of soil conductivity and drainage infrastructure
Rapid soil drainage = Following inundation, water table typically falls by > 30 cm in < 10 days in winter
Moderate soil drainage = Following inundation, water table typically falls by > 30 cm in < 30 days in winter
Slow soil drainage = Water table does not fall below 30 cm following an inundation event in winter until late April
Short duration of surface water: typically 3 days per event.
Medium: typically less than 2 weeks per event.
Long: typically more than two weeks per event

Discussions are ongoing as to the most suitable modelling approach that will provide appropriate flood inundation data (refer to Tool B1)
Local topographic modifications and changed land drainage patterns (including field drains, storm flaps) can be addressed through LiDAR data (see also Tool B1), field survey and consultation with land owners. This would be suitable for the mid level methodology.

Tool C1 Barriers to river continuity

C1.1 Purpose

River continuity is used to assess in-channel barriers to ecological migration, predominantly for fish migration (particularly salmon), but also with respect to movement of fauna (upstream/downstream movement of particular species lifestages at keytimes) throughout the catchment.

C1.2 Suitable data sources

Unlike Tool A6, only in-channel structures which present a physical barrier to river continuity should be considered here. These are dams, locks, tidal barrages, gates/ sluices and weirs. Although the datasets used are a sub-set of Tool A6, the interpretation is for a different purpose.

Data are available from the EA's National Flood and Coastal Defence Database (NFCDD). However coverage is intermittent and many features may be omitted. Interrogation of Ordnance Survey 1:25,000 mapping is recommended, and if available other information sources such as channel condition surveys and aerial photography.

C1.3 Methodology

NFCDD data should be interrogated to display separately dams, locks, tidal barrages, gates/sluices and weirs.

Ordnance Survey 1:25,000 mapping (or other sources) should be interrogated to obtain the X,Y co-ordinates for all structures. These can then be digitised and used to supplement the NFCDD dataset.

A figure should be prepared overlaying the catchment boundary and river channel network with each of the barrier features in GIS.

C1.4 Interpretation

Where possible those features which include by-passes and fish passes should be identified and flagged on the GIS layer.

Factors such as fish swimming performance and behaviour will govern which structures certain species and size of fish can overcome. However, in general terms the EA Fish Pass Manual recommends to keep head loss between pools ≤ 0.3m for high swimming performance fish such as chub and barbel, while low swimming performance fish (most other cyprinids) require head loss between pools to be kept to between 0.1-0.2m.

Therefore, at the broad scale level identification of those in-channel features which present a head loss greater than 0.3m should be flagged as being potentially a significant barrier to migration. It is expected that this information will be acquired through local knowledge during consultation.

C1.5 Further development

Further assessment of obstructions to migration will require detailed site-specific information such as structure design, operation/settings, water level and flows. Information would need to be obtained through site inspection and collation of reports/ drawings etc for the structure in question.

Design and operational information would be coupled with additional knowledge on fish communities and target species before meaningful conclusions could be drawn on the effect of the structure and likely solutions.

This is outside the scope of the High level BSEA approach but could be incorporated at a strategic or scheme level.

Appendix 2 Fluvial technical bibliography

The prediction of change to ecosystems from flood management activities is undertaken by expert judgement, supported by a technical bibliography. It is recommended that this process be undertaken by a team with suitable experience in the disciplines of ecology, hydrology, geomorphology, and flood management.

This technical bibliography establishes a range of potential flood management actions and likely ecosystem consequences. It is neither exhaustive in terms of potentially suitable flood management actions, nor definitive in terms of potential impacts on ecosystems. The identified texts are given to allow users to explore potential flood management issues and activities, and to assess the currently state of knowledge of the ecosystem pressures and impacts, and consequences for flood management application.

Potential management actions	Bibliography
Channel condition	
Fine sediment supply control	Morgan, R.P.C. (2004) *Soil Erosion and Conservation Third Edition*. Blackwell
	Morgan, R.P.C and Rickson, R.J. (1995) Slope Stabilization and Erosion Control. Spon Press (UK), London
	Morgan, R.P.C, Quinton, J.N., Smith, R.E., Govers, G., Poesen, J.W.A., Auerswald, K., Chisci, G., Torri, D. and Styczen, M.E. (1998) The European soil erosion model (EUROSEM): a process-based approach for predicting sediment transport from fields and small catchments. Earth Surface Processes and Landforms 23, 527-544 http://www.silsoe.cranfield.ac.uk/nsri/research/erosion/eurosem.htm
Fine sediment transfer/ deposition control	Thorne, C.R., Allen, R.G. and Simon, A. 1996 Geomorphological river channel reconnaissance for river analysis, engineering and management. Transactions, Institute of British Geographers 21, 469-83
Bank modification/ restoration	Hey, R.D. 1996 Environmentally sensitive river engineering. In River Restoration, eds G Petts and P Calow, Blackwell, Oxford, 80-10
	River Restoration Centre (n.d.) Manual of River Restoration Techniques. Revetting and supporting river banks 4.1 Willow spiling (329k) 4.2 Willow mattress revetment (376k) 4.3 Log toe and geotextile revetment with willow slips (423k) 4.4 Plant roll revetment (423k) 4.5 Supporting bank slips and exposed tree roots (705k) 4.6 Short term bank revetments (705k) 4.7 Bank revetment using low steel sheet piling and coir rolls (1.3Mb)
	Simons, J., and Boeters, R. (1998) A systematic approach to ecologically sound river bank management. In L. C. de Waal, A. R. G. Large, and P. M. Wade, editors. Rehabilitation of rivers: principles and implementation. Wiley, Chichester, UK, 57-85
Bedload Management	Leeks, G.J., Lewin, J. and Newson, M.D. (1988) Channel change, fluvial geomorphology and river engineering: the case of the Afon Trannon, Mid-Wales. Earth Surface Processes and Landforms 13, 207-23
	Sear, D.A., Newson, M.D. and Brookes, A. (1995) Sediment-related river maintenance: the role of fluvial geomorphology. Earth Surface Processes and Landforms, 20, 629-47

Potential management actions	Bibliography
Managing channel pattern	River Restoration Centre (n.d.) Manual of River Restoration Techniques. Restoring meanders to straightened rivers 1.1 New meandering channel upstream of mill (658k) 1.2 New meandering channel downstream of mill (893k) 1.3 Single meander in Mill Leat (376k) 1.4 New meanders to one side of existing channel (576k) 1.5 New meandering channel replacing concrete weirs (1.1Mb) 1.6 New meandering channel downstream of mill (940k) 1.7 Reconnecting remnant meanders (1Mb)
Floodplain connectivity	
Maintain/ enhance flooding of active ecological floodplain	Morris *etal.* 2004: Description of potential management actions for increasing the frequency and/or duration of floodplain inundation: • Decreased channel maintenance leading to increasing in river and bank vegetation, • Increased pumping/ siphoning into washland, • Reduced pumping/ restricted gravity outflow from washland, and • Increased vegetation height on floodplain.
	Hill, M. and Platts, W. S. (1991) Ecological and geomorphological concepts for in-stream and out-of-channel flow requirements. Rivers, 2, 319-343
	Hughes, F.M.R. et al. (eds.) (2003) The Flooded Forest: Guidance for policy makers and river managers in Europe on the restoration of floodplain forests. FLOBAR2, Department of Geography, University of Cambridge, UK. 96pp.
	Hughes, F.M.R. and Rood, S.B. (2001) Floodplains. In Warren, A. and French, J.R. (eds.) Habitat Conservation: Managing the Physical Environment, John Wiley and Sons Ltd., Chichester, UK, 105-121.
	River Restoration Centre (n.d.) Manual of River Restoration Techniques. Enhancing redundant river channels 2.1 New backwaters in redundant river channels River Skerne (564k) 2.2 New backwaters in redundant river channels River Cole (752k)
	Zöckler, C. (2000) Wise Use of Floodplains – LIFE Environment Project: A Review of 12 WWF River Restoration Projects Across Europe. WWF European Freshwater Programme, Copenhagen
Restore/ create floodplain (hydrology)	Morris *etal.* 2004: Description of potential management actions for increasing the frequency of floodplain inundation: • Set-back of embankments, • Removal of embankments, • Introducing/ lowering spillways in banks, and • Creation of in-line dams/ sluices.
	River Restoration Centre (n.d.) Manual of River Restoration Techniques. Managing overland floods 6.1 Floodplain spillways (705k) 6.2 Re-profiling of land within meanders (282k) 6.3 Removing and setting back flood banks (752k)
	WWF (2004) Living with Floods: Achieving ecologically sustainable flood management in Europe. Report, June 2004
Restore/ create floodplain (land management)	Morris *etal.* 2004: Description of potential management actions for increasing the frequency and duration of floodplain inundation • Lowering of floodplain.
	Adger, W.N. and Luttrell, C. (2000) Property rights and the utilisation of wetlands. Ecological Economics 35, 75-89
	River Restoration Centre (n.d.) Manual of River Restoration Techniques. Creating floodplain wetland features 7.1 Floodplain scrapes (376k) 7.2 Floodplain wetland mosaic (2.1Mb)
	Ward, J.V., Tockner, K., Arscott, D.B. and Claret, C. (2002) Riverine Landscape Diversity. Freshwater Biology 47, 517-539

Potential management actions	Bibliography
Enhance sediment supply to floodplain	Morris *etal.* 2004: Description of potential management actions for increasing the ecological area of the floodplain: • Decreased channel maintenance leading to increasing in river and bank vegetation, • Removal of embankments, and • Creation of in-line dams/ sluices.
River continuity	
Remove barrier effect	Brookes, A.M. (1990) Restoration and enhancement of engineered river channels: some European experiences. Regulated rivers: research and management 5, 45-56
	Petts, G. E., Gurnell, A. M., Gerrard, A. J., Hannah, D. M., Hansford, B., Morrissey, I., Edwards, P. J., Kollman, J., Ward, J.V., Tockner, K. and Smith, B. P. G. (2000) Longitudinal variations in exposed riverine sediments; a context for the ecology of the Fiume Tagliamento, Italy. Aquatic Conservation: Marine and Freshwater Ecosystems 10, 249-266
	Ward, J V and Stanford, J A (1995) Ecological connectivity in alluvial river ecosystems and its disruption by flow regulation. Regulated Rivers: Research and Management 11, 105-119
	World Commission on Dams (2000) Dams and Development: A new framework for decision-making. Earthscan Publications Ltd. London, UK.

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Boon, P., Calow, P. and Petts, G. (eds) (1992) River conservation and management. Wiley, Chichester
Brierley, G.J., and Fryirs, K.A. (2005) Geomorphology and River Management, Applications of the River Styles Framework, Blackwell Publishing
Brookes, A. 1987 Channelized rivers: perspectives for environmental management. Wiley, Chichester
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Calow, P. and Petts, G.E. (1992) The Rivers Handbook: hydrological and ecological principles (2Volumes). Blackwell, Oxford
Downs, P. and Gregory, K.J. (2004) River channel management: towards sustainable catchment management Downs, P. W., Skinner, K. S. and Kondolf, G. M. (2002) Rivers and Streams. In M. R. Perrow and A. J. Davy. Handbook of Ecological Restoration, Volume 2 Restoration in Practice. Cambridge University Press, Cambridge, UK, 267-296
Gardiner, J.L. (ed.) (1991) River projects and conservation: a manual for holistic appraisal. Wiley, Chichester
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Petts, G.E. (1984) Impounded rivers: perspectives for ecological management. Wiley, Chichester
Petts, G.E. and Calow, P. (eds) (1997) River Restoration
Postel, S. and B. Richter. 2003. Rivers for life: managing water for people and nature. Island Press, Washington, D. C., USA
Raven, P.J., Holmes, N.T.H., Dawson, F.H., Fox, P.J.A., Everard, M., Fozzard, I.R. and Rouen, K.J. (1998) River Habitat Quality: The Physical Character of Rivers and Streams in the UK and Isle of Man. River Habitat Survey, Report No. 2. • Environment Agency, Bristol, U.K.
River Restoration Centre (1999) River Restoration – Manual of Techniques. River Restoration Centre, Silsoe. (www.therrc.co.uk/manual.php)
Rosgen, D., ed. (1996) Applied river morphology. Woldland Hydrology, Pagosa Springs
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Stream Corridor Working Group. 1998. Stream corridor restoration: principles, processes and practices. Federal Stream Interagency Stream Restoration Working Group, USA
Thorne, C. R. (1998) Stream Reconnaissance Handbook.
Thorne, C.R., Hey, R.D. and Newson, M.D. (eds) (1997) Applied fluvial geomorphology: a guidebook for river engineering and management. Wiley, Chichester
UK TAG (2004) Guidance on Morphological Alterations And the Pressures and Impacts Analyses. UK

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Ward, D., Holmes, N. and José, P. (1994) The New Rivers and Wildlife Handbook. RSPB, Sandy

WFD CIS Guidance (2003) Analysis of Pressures and Impacts. Document No. 3, Common Implementation Strategy for the Water Framework Directive Working Group 2.1 - IMPRESS

Appendix 3 Fluvial metadatabase

Data layer	Source of data *(Accurate Name)*	Available From	Data Included	Scale	Extent	Date	Updatability	Digitized	Toolbox Number	Comments
Catchment Boundary	OS *(1:250,k)*	EA Twerton	Topographical maps to define catchment boundary	1:250k	UK	May 2004	Annually updated by EA	✓	Not specific	
River Channel Network	OS *(Strategi 1:250,k)*	EA Twerton	Topographical maps used to differentiate all lower, main middle, main source, minor secondary lower and secondary source channels within the catchment.	1:250k	UK	May 2004	Annually updated by EA	✓	Not specific	
Catchment OS Layer	OS *(1:50 scale colour raster)*	EA Twerton	Continuous map base providing details including woodland, water features, urban areas, contour lines as well as weirs, lock, tidal barrages and dams.	50k x 50k	England & Wales	2004	Annually updated by EA	✓	Not specific	
Water Level Management Plan	EA	EA regional office	Outline of Water Level Management Plan sites within the catchments	NA	England	NA	NA	✓	Not specific	Information only available on site with WLMP
Q_{MED} and Q_{100}	CEH *(Electronic version of the Flood Estimation Handbook)*	CEH	Q_{MED} and Q_{100} generated from the FEH – data provided as a grid for each parameter and acquired in ascii format as grid and tables	50m x 50m	UK	2004	Updated as better information becomes available	✓	A1, A2	Provide good estimates of Q_{100} discharges at 50m intervals for all rivers in the UK
Hydro-geology	BGS *(Hydro-geology)*	EA Twerton	Information relating to the occurrence and properties of water on and within the catchment, including its distribution, composition, quality, origins, availability and abundance.	1:625k	UK	2003/2004	Updated as better information becomes available	✓	A1, A5	
Contour data	OS (Profile data)	EA Twerton		1:50k	UK	2005	No	✓	A3	

Data layer	Source of data *(Accurate Name)*	Available From	Data Included	Scale	Extent	Date	Updatability	Digitized	Toolbox Number	Comments
Terrain and Surface Model	EA *(NEXTMAP)*	EA		NA	UK	2005	Updated as better information becomes available	✓	A3	EA do not hold the license
Land Cover Map 2000	CEH *(LCM2000)*	EA Twerton	National coverage of habitat types, produced from analysis of satellite imagery	25m x 25m	UK	2000	Last updated in 1992	✓	A4, B3	Difficult to identify linear features e.g. river corridors
Hydrology of Soil Types	CEH *(HOST)*	CEH	Information on the Hydrology of Soil types.	Based on 1: 250k	UK	2004	Updated as better information becomes available	✓	A4	EA do not hold the license
Drift Geology	BGS *(Drift Geology)*	EA Twerton		1:625k	UK	2003/2004	Updated as better information becomes available	✓	A5	
In-channel Structures	NFCDD *(In-channel Structure database)*	EA regional office	MapInfo shapes associated with access database of defence information.	Various	England & Wales	Mar 2004	Continuous updates following each annual review	✓	A6, C1	
EA River Habitat Survey (RHS) Habitat Modification Index (HMI)	EA *(HMI dataset)*	EA regional office	HMI – five point classification of habitat modification of physical character of river habitats from field hydromorphology data	NA	UK	2005	RHS database extended by additional (including repeat) field survey	×	A7	

Data layer	Source of data *(Accurate Name)*	Available From	Data Included	Scale	Extent	Date	Updatability	Digitized	Toolbox Number	Comments
Nature Conservation Designations	JNCC *(Digital Boundary Data for Designated Sites)*	EN and CCW regional office	All sites (SSSI, RAMSAR, SPA and SAC) notified under the Wildlife and Countryside act including: a) *SSSI* – land notified under the 1949 act b) *RAMSAR* – land listed as wetland of international importance under the convention on Wetlands of International Importance (RAMSAR convention 1973) c) *SPA* – land classified under Directive 79/04 on the Conservation of Wild Birds d) *SAC* - land designated under Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora	1:2500	England & Wales	2002	No definitive programme however updates integrated as new sites added.	✓	A8	
Important Bird Areas	RSPB *(Important bird areas in the UK and Isle of Man – excluding Channel islands)*	RSPB online	Data Source from Heath, M.F and Evans, MI (2000) Important Bird Areas in Europe: priority sites for conservation (2 volumes), Birdlife International, Cambridge	UK	NA	2000	Updated as better information becomes available	✓	A8	Data has not been updated for 5 years
EA Routine Monitoring Sites	EA *(datasets)*	EA online	Information on fish, macrophytes and macroinvertebrates plus the biological river quality and chemical river quality	NA	England	2005	Updated as better information becomes available	×	A8, A9	

Data layer	Source of data *(Accurate Name)*	Available From	Data Included	Scale	Extent	Date	Updatability	Digitized	Toolbox Number	Comments
Indicative Floodplain	EA *(Flood Zone 3 and Benefiting Areas from the Flood Map of England & Wales)*	EA Twerton	Outlines of the fluvial floodplain based upon natural floodplain and projection models superimposed on NEXTMAP DTM. Information required: 1) Flood zone 3 – areas at high risk (a 1% chance of flooding from rivers and 0.5% chance from the sea) 2) Benefited areas – locations that benefit from flood defences	1:10k	England & Wales	2005	Updated as better information becomes available	✓	B1	
Priority Habitat	EN *(Blanket Bog)*	EN online	Digital NVC Surveys, ENSIS data (contains phase 1 info, CEH Land Cover 2000 Maps	Land Cover 25m x 25m.	England	Sept 2003	Current data 1st version	✓	B2	The quality of the data set was influenced mainly by the accepted integrity of the data capture methodology of CFPGM capture. Validation can only come from better aerial photography interpretation, local knowledge and the use in the field.

Data layer	Source of data *(Accurate Name)*	Available From	Data Included	Scale	Extent	Date	Updatability	Digitized	Toolbox Number	Comments
Priority Habitat	EN *(Coastal Floodplain and Grazing Marsh)*	EN online	EN inventory of Lowland Wet Grassland in England after Dargie (1993), Ordnance Survey (OS) Profile elevation data and OS 10K raster base maps.	Based on OS 1:10k raster maps.	England	1993	Current data 1st version	✓	B2	
Priority Habitat	EN *(Fens)*	EN online	FenBASE, a point based inventory of fen habitat location (EN). Aerial photography where available. SSSI unit info. EN Wetland Habitats Pilot Project work. OS Landline or OS 10K raster tiles.	Data polygons held at 0.25ha.	England	Mid - late 1990s	Current data 1st version	✓	B2	
Priority Habitat	EN *(Lowland Raised Bog)*	EN online	EN BogBASE, a point based inventory of Lowland Raised Bog habitats location. SSSI unit info. OS 10K raster tiles. Aerial photography where available.	Minimum mappable Data polygons held equal 0.1ha.	England	Mid - late 1990s	Current data 1st version	✓	B2	An inclusion rather than exclusion policy was applied, where there was uncertainty over the presence of cliff and slope therefore some degree of overestimation may have occurred.

Data layer	Source of data *(Accurate Name)*	Available From	Data Included	Scale	Extent	Date	Updatability	Digitized	Toolbox Number	Comments
Priority Habitat	EN *(Purple Moor Grass and Rush Pastures)*	EN online	VEGAN (a database storing community information). EN Site Information System (ENSIS) Level 2 feature information. Somerset Environmental Records Centre County Wildlife Site Surveys. Exmoor Grasslands Survey. Blackdown Hills Grasslands Survey. 1999 Audit of Culm Grasslands Survey in Cornwall. Inventory of Fen Habitats in Dorset' (DERC / Dorset Biodiversity Initiative, 2000). Phase 1 information from Dorset SNCI surveys. Culm grassland of Devon GIS. Bristol Regional Environmental Records Centre data. UK Perspectives aerial photographs.	NA	England	1994	Current data 1st version	✓	B2	
Priority Habitat	EN *(Reedbeds)*	EN online	Inventory compiled at the EA's National Centre for Environment Data and Survey, includes: RSPB Reedbed Inventory. OS 10K Raster. EN Wetland Habitat Pilot Project work. OS Landline data.	Data polygons held at 0.25ha.	England	1993	Current data 1st version	✓	B2	

Appendix 4 Coastal high level toolbox

Contents

This appendix contains methodological detail for undertaking a coastal High Level ecosystem assessment, as described in Section 10.
This appendix contains a description of each of the Tools identified for undertaking the review of broad habitat baseline and ecosystem drivers (see Section 5.1). These Tools are held within one Toolbox (see Table A4.1).

Table A4.1 Contents of the coastal high level toolbox

Tool A	Baseline habitats
Tool B	Shoreline migration
Tool C	Tidal Inundation and coastal flooding
Tool D	Sediment availability

Tool A Baseline habitats

A1.1 Purpose

To identify the location, nature, extent and significance of the range of coastal habitats in any given area of interest.

A1.2 Suitable data sources

Topic	Data layer	Data source
Coastal broad habitats	Supra-littoral sediment, littoral rock, littoral sediment, saltmarsh	CEH LCM2000
Coastal priority habitats	Coastal grazing marsh, sand dune, vegetated shingle, maritime cliff and slope, mudflat, saline lagoon, reed bed	EN “Nature on the Map”
On-shore priority habitats	All additional priority habitats within an appropriate area	EN “Nature on the Map”
Important bird areas	RSPB Important bird areas	RSPB
Indication of habitat quality	European designated site boundaries (SAC, SPA, RAMSAR)	EA data centre
	Nationally designated site boundaries (NNR, SSSI)	EA data centre
Freshwater systems	Standing water	CEH LCM2000

A1.3 Methodology

The key data sources identified above provide information in a GIS based format. Thus, the methodology employed involves accessing the appropriate GIS layers as required and overlaying them to build-up a picture of the habitats in the study area.

A1.4 Interpretation

The GIS based data will provide information on the location, nature and extent of the different habitats highlighting the boundaries and enabling the calculation of the total area covered by a given habitat.

In order to provide a basis for evaluating the significance of the habitats under investigation an assessment of their sensitivity to natural or management induced change is required. This ultimately involves the application of professional knowledge and judgement based upon consideration of their historical behaviour and present status and application of accepted measures of habitat condition (e.g. Radcliffe criteria). Consultation with the appropriate regulatory agencies (e.g. EN, CCW and SNH) is an essential part of this process

A1.5 Further development

As noted in Section 5, the EU Interreg funded MESH programme includes a module for the development of habitat modelling to predict habitat type for unsurveyed areas utilising available geophysical and hydrographic data. This work is scheduled to conclude in 2007. The availability of such a tool would facilitate improved classification of existing habitats and prediction of changes to these habitats arising as a result of changing physical conditions.

Tool B Shoreline migration

B1.1 Purpose

To provide information on current shoreline positions and projected shoreline positions under a range of different natural change scenarios and different management options over various timescales.

B1.2 Suitable data sources

The elevation of the nearshore zone and adjacent land are defined by the bathymetry and topography respectively. The Hydrographic Office is the principal source of data on the former and the Ordnance Survey is the principal source for data on the latter.

Predictions for relative sea level change are produced by the UK Climate Change Impacts Programme. They are updated from time to time in the light of increasing knowledge and improved understanding.

Information on sea defence structures that protect areas of coastline is held in the National Flood and Coastal Defence Database maintained by the EA.

A detailed account of both the current understanding of coastal behaviour and predictions of future coastal evolution at both the large-scale and local-scale for the coast of England and Wales is presented in the reports on the FutureCOAST study. FutureCOAST includes mapping of future shoreline positions (MHWS) for policies of “no active intervention” and “with present management” based on the integration of currently accepted rates of cliff erosion and sea level rise coupled with the presence/absence of sea defence works to identify potential changes in the level of MHWS.

B1.3 Methodology

The methodology involves the manipulation of GIS layers containing bathymetric/ topographic information to produce a seamless integration of seabed, intertidal zone and land elevations in the coastal zone so that the position of the MHWS level can be defined. The level of MHWS is then redefined under the selected range of natural change and management option scenarios so that each scenario can be overlaid onto the base layer of present shoreline position to identify and evaluate the extent of change.

B1.4 Interpretation

Having identified the extent of shoreline change under a given scenario as described above, the significance of that change in terms of impact on existing coastal habitats is evaluated at the High Level by overlaying the redefined shoreline on the base GIS layer of existing habitats to determine the magnitude of habitat change (i.e. sum of gains and losses) with respect to the present case, the location of the changes and the timescale of the changes

B1.5 Further development

An initiative of relevance to the better determination of shoreline migration is the Integrated Coastal Zone Mapping project which brings together the Hydrographic Office, Ordnance Survey and British Geological Survey. These organisations are seeking to bring together their respective datasets to provide a seamless representation of the coastal zone. So far, however, only pilot data for three areas has been produced. Comprehensive coverage of the coast will require further funding.

Tool C Tidal Inundation and coastal flooding

C1.1 Purpose

To identify the location and extent of those coastal areas subject to tidal inundation and coastal flooding under various natural change scenarios and different management options.

C1.2 Suitable data sources

Data on tidal regime is collated and maintained by the British Oceanographic Data Centre. The potential extent of coastal flooding in England and Wales is revealed in the Indicative Coastal Floodplain Maps produced by the EA. These originated from the DTi Foresight project. Foresight employed the RASP High Level Methodology to establish flood risk, within the EA Indicative Flood Map flood outline, for different socio-economic and environmental conditions projected for the 2050s and 2080s. The RASP methodology incorporates land topography and sea defence data and represents coastal flooding processes over linear flood defence systems at a level of detail that permits the testing of alternative flood management strategies and natural change scenarios. Flood outlines and depths are generated and potential socio-economic effects evaluated against national databases of flood plain properties and demography.

C1.3 Methodology

Both existing and projected tidal levels information and the EA Indicative Floodplain Maps can be readily overlaid on the GIS base layer of existing coastal habitats to identify the location and extent of those habitats currently/ potentially subject to tidal inundation or coastal flooding under different natural change scenarios. Consideration of the likely impact of flooding on those habitats currently protected behind sea defence works will require an evaluation of the likelihood of defence failure. This can be undertaken by RASP which, at the simplest level, generates probabilities of defence failure based on condition assessment and crest freeboard. More sophisticated applications of RASP can employ reliability analysis to define probabilities of defence failure and the most detailed level employs simulation-based reliability analysis of defence systems and simulation modelling of inundation.

C1.4 Interpretation

Overlaying tidal levels information and/ or the indicative coastal floodplain map upon the coastal habitats base map will reveal the location and extent of the potential incursion of tidal flows and/ or floodwater into areas of habitat interest.

C1.5 Further development

Although work in this area is, as far as we are aware, not currently in progress, it appears possible to incorporate detailed information from habitats databases into the RASP framework. This already contains base data on surface levels and sea defence works. These could all then interact with the simulation and predictive tools as appropriate to generate flood outlines and depths at different locations for different scenarios for direct evaluation in terms of potential impact on habitats.

Tool D Sediment availability

D1.1 Purpose

To identify present/future sources and sinks of sediment and disruption to natural patterns of sediment transport in order to better understand the impact of geomorphological processes (sediment erosion and accretion) and the activities of man on the evolution of coastal habitats over space and time.

D1.2 Suitable data sources

The morphology and geology of the coastline are the key attributes in a consideration of sediment availability. These features are described by bathymetry, topography and maps of sediment/rock characteristics. The Hydrographic Survey Office, Ordnance Survey and the British Geological Society are the principal sources of information for these data.

FutureCOAST describes both the current understanding of coastal behaviour and predictions of future coastal evolution at both the large-scale and local-scale. This analysis is based upon consideration of littoral and sub-littoral sediment type, potential mobility, direction of transport and rate of transport. This information has been incorporated into the SMP2 coastal morphology review.

Sea defences prevent the erosion of many sections of shoreline and, thereby, restrict the natural sediment supply while structures such as jetties, piers and groynes disrupt alongshore and cross-shore sediment transport. Information on these features is available from the National Flood and Coastal Defence Database and the Ordnance Survey.

D1.3 Methodology

Present/ future sources and sinks of sediment, as inferred from SMP2, should be identified in terms of location and extent and translated into a GIS layer for integration with the other GIS layers described above. Any structures with the potential to restrict erosion and or disrupt natural patterns of sediment transport should be identified and included in the layer.

D1.4 Interpretation

A naturally sustainable shoreline requires adequate inputs of sediment into local beaches without any alongshore and cross-shore disruption to the natural patterns of sediment transport. Unfortunately, however, in many areas the construction of defence structures and other developments have resulted in only very limited areas of shoreline being free to erode and have created numerous obstacles/ barriers to nearshore sediment transport. Thus, sediment is often in short supply and the amounts that are available are often prevented from reaching those areas where they would be of most benefit. The outputs of this tool should be interpreted in terms of the location and extent of present/ future sediment sources and sinks and the various obstacles and barriers to natural patterns of sediment transport as discussed in the case study presented in Section 11.

D1.5 Further development

This tool employs geographic data only, i.e. geological mapping information and the location of structures with the potential to disrupt natural processes of sediment cycling. Consequently, while in its present format, further development would need to be confined to more precise mapping of these features.

Appendix 5 Coastal technical bibliography

The prediction of change to ecosystems from flood and coastal erosion management activities is undertaken by expert judgement, supported by a technical bibliography. It is recommended that this process be undertaken by a team with suitable experience in the disciplines of ecology, coastal morphology, and flood management.

This technical bibliography establishes a range of potential flood and coastal erosion management actions and likely ecosystem consequences. It is neither exhaustive in terms of potentially suitable flood management actions, nor definitive in terms of potential impacts on ecosystems.

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Cundy, A.B., Long, A.J., Hill, C.T., Spencer, C., Croudace, I.W., 2002. Sedimentary response of Pagham Harbour, southern England to barrier breaching in AD 1910. Geomorphology 1156.
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salt marshes: Field evidence from north Norfolk. Journal of the Chartered Institution of Water and Environmental Management, 15, 109-116.
Scottish Natural Heritage, 1997. Coastal erosion and defence. III. Coastal defences and the natural heritage. Information and Advisory Note Number: 73 http://www.snh.org.uk/pdfs/publications/earthscience/CoastalErosionDefence3.pdf

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Appendix 6 Coastal metadatabase

Data layer	Source of data *(Accurate Name)*	Available from	Data included	Scale	Extent	Date	Updatability	Digitized	Toolbox number	Comments
Coastal cell OS Layer	OS *(1:50 scale colour raster)*	EA Twerton	Continuous map base providing details including woodland, water features, urban areas, contour lines as well as weirs, lock, tidal barrages and dams.	50k x 50k	England & Wales	2004	Annually updated by EA	✓	Not specific	
Nature Conservation Designations	JNCC *(Digital Boundary Data for Designated Sites)*	EN and CCW regional office	All sites (SSSI, RAMSAR, SPA and SAC) notified under the Wildlife and Countryside act including: e) *SSSI* – land notified under the 1949 act f) *RAMSAR* – land listed as wetland of international importance under the convention on Wetlands of International Importance (RAMSAR convention 1973) g) *SPA* – land classified under Directive 79/04 on the Conservation of Wild Birds h) *SAC* - land designated under Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora	1:2500	England & Wales	2002	No definitive programme however updates integrated as new sites added.	✓	A	
Important Bird Areas	RSPB *(Important bird areas in the UK and Isle of Man – excluding Channel islands)*	RSPB online	Data Source from Heath, M.F and Evans, MI (2000) Important Bird Areas in Europe: priority sites for conservation (2 volumes), Birdlife International, Cambridge	UK	NA	2000	Updated as better information becomes available	✓	A	Data has not been updated for 6 years

Data layer	Source of data *(Accurate Name)*	Available from	Data included	Scale	Extent	Date	Updatability	Digitized	Toolbox number	Comments
Priority Habitat – Coastal Floodplain and Grazing Marsh	EN *(Coastal Floodplain and Grazing marsh)*	EN online	EN inventory of Lowland Wet Grassland in England after Dargie (1993), Ordnance Survey (OS) Profile elevation data and OS 10K raster base maps.	Based on OS 10K Raster maps.	England	1993	Current data 1st version	✓	A	The quality of the data set was influenced mainly by the accepted integrity of the data capture methodology of CFPGM capture. Validation can only come from better aerial photography interpretation, local knowledge and the use in the field.
Priority Habitat – Coastal Sand Dunes	EN *(Coastal Sand Dunes)*	EN online	Data based upon: Original paper inventory Sand Dune Vegetation Survey of Great Britain – Part 1 England; Radley G.P. 1994, and is a collation of survey data, the majority carried out between 1987 and 1990. . Site selected by identification on series of 1:50000 Ordnance Survey maps. Cornwall data digitised by the Environmental Records Centre for Cornwall and the Isles if Scilly (ERCCIS). In addition National Survey, 1995 Aerial Photography were used.	Sites were selected principally by identification on a series of 1:50000 Ordnance Survey maps.	England	1987 - 1990	Current data 1st version	✓	A	The quality of the data set was influenced mainly by the accepted integrity of the data capture methodology of CFPGM capture. Validation can only come from better aerial photography interpretation, local knowledge and the use in the field.

Data layer	Source of data *(Accurate Name)*	Available from	Data included	Scale	Extent	Date	Updatability	Digitized	Toolbox number	Comments
Priority Habitat – Coastal Vegetated Shingle	EN *(Coastal Vegetated Shingle)*	EN online	F Sneddon and Randall, (1994), Coastal Vegetated shingle structures of Great Britain: Appendix 3. Shingle sites in England. Antonini and Bennat (1996) Title unknown (Pagham Harbour). Williams and Cooke (1993), Vegetated shingle survey of the Sussex Coast. Ferry, Lodge and Waters (1990), Dungeness: A vegetation survey of a shingle beach including maps by Fuller (1989). Ferry and Waters (1985), Dungeness Ecology and Conservation. Sneddon and Randall (1993), Coastal Vegetated Shingle Structures of Great Britain: Main Report. Younghusband (2003), Environmental Monitoring of Vegetated Shingle Habitats in East Sussex.	Sneddon and Randall and Williams ad Cooke 1:110000 , Fuller 1:2500.	England	1987 - 1994	Current data 1st version	✓	A	

Data layer	Source of data *(Accurate Name)*	Available from	Data included	Scale	Extent	Date	Updatability	Digitized	Toolbox number	Comments
Priority Habitat – Maritime Cliff and Slope	EN *(Maritime Cliff and Slope)*	EN online	EN's Site information System (ENSIS), (June 2002 version). National Maritime Cliff Database. Ordnance Survey 10k Raster tiles and Landline polylines. UKPerspective.com digital aerial photographs. National Trust property boundary data. EA Light Detection And Ranging (LiDAR) data.	NA	England	1984 - 1989	Current data 1st version	✓	A	An inclusion rather than exclusion policy was applied , therefore it is probable that there is an overestimate of the resource due to other habitats such as saltmarsh, etc being present.
Priority Habitat - Mudflats	EN *(Mudflats)*	EN online	EA R&D Technical Report E2A: Biodiversity Key Resource Inventory (2002). OS Mastermap (Oct 2003). OS10k Raster land maps. Aerial photography where available.	Minimum mappable Data polygons held equal 0.1ha.	England	2004	Current data 1st version	✓	A	An inclusion rather than exclusion policy was applied; therefore it is probable that there is an overestimate of the resource due to other habitats such as saltmarsh, etc being present.
Priority Habitat – Saline Lagoon	EN *(Saline Lagoon)*	EN online	Smith, BP and Laffoley, D (1992) Saline lagoons and lagoon-like habitats in England. 1st edition. EN, Peterborough (EN Science, No. 6) . OS Landline data.	NA	England	1992	Current data 1st version	✓	A	
Land Cover Map 2000	CEH *(LCM2000)*	EA Twerton	National coverage of habitat types, produced from analysis of satellite imagery	25m x 25m	UK	2000	Last updated in 1992	✓	A,C	Difficult to identify linear features e.g. river corridors
Contour Data	OS (Profile data)	EA Twerton		1:50k	UK	2005	No	✓	B, C	

Data layer	Source of data *(Accurate Name)*	Available from	Data included	Scale	Extent	Date	Updatability	Digitized	Toolbox number	Comments
In-channel Structures	NFCDD *(In-channel Structure database)*	EA regional office	MapInfo shapes associated with access database of defence information.	Various	England & Wales	Mar 2004			B,C	
Shoreline Behaviour Statement	FutureCOAST *(Shoreline Behaviour Statement)*	EA regional office	Prediction of future coastal evolution for SMP review. Defra project FD2002, prepared by Halcrow Group. Supplemental text reviewing local studies of coastal morphology.	NA	England & Wales	2002	One-off study	×	B, D	
Projected Future Shoreline Positions	FutureCOAST *(Projected Future Shoreline Positions)*	EA regional office	Prediction of future coastal evolution for SMP review. Defra project FD2002, prepared by Halcrow Group. Polylines of predicted future shorelines (mean high water spring) for a "do nothing" and "maintain current policy" policy context.	NA	England & Wales	2002	One-off study	✓	B, D	
Coastal Inundation	EA *(Coastal Indicative Floodplain Outline and Benefiting Areas)*	EA Twerton	Outlines of the coastal floodplain boundary based upon model output from historic events.	1:10k	England & Wales	2000	Data superseded by Flood Zones	✓	C	Dataset currently being updated.
Hydrology of Soil Types	CEH *(HOST)*	CEH	Information on the Hydrology of Soil types	Based on 1: 250k	UK	2004	Updated as better information becomes available	✓	C	EA do not hold the license

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