ComCoast

Work Package 2: Socio-Economic Evaluation ComCoast

The Roach and Crouch Flood Management Strategy: A Case Study for the Economic Assessment and Valuation of Multifunctional Flood Management Projects

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This report has been prepared by Halcrow Group Ltd in co-operation with the Environment Agency

The ComCoast project is carried out in co-operation with ten partners.
- Rijkswaterstaat (NL - leading partner)
- Province of Zeeland (NL)
- Province of Groningen (NL)
- University of Oldenburg (D)
- Environmental Agency (UK)
- Ministry of the Flemish Community (B)
- Danish Coastal Authority (DK)
- Municipality of Hulst (NL)
- Waterboard Zeeuwse Eilanden (NL)
- Waterboard Zeeuws Vlaanderen (NL)

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Work package 2 Socio-Economic Evaluation

The Roach and Crouch Flood Management Strategy: A Case Study for the Economic Assessment and Valuation of Multifunctional Flood Management Projects

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This report is a deliverable of WP2: Socio-Economic Valuation
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1. Preface

1.1 Mission statement ComCoast

MISSION OF COMCOAST (= COMbined functions in COASTal defence zones)
ComCoast is a European project which develops and demonstrates innovative solutions for flood protection in coastal areas.

ComCoast creates and applies new methodologies to evaluate multifunctional flood defence zones from an economical and social point of view. A more gradual transition from sea to land creates benefits for a wider coastal community and environment whilst offering economically and socially sound options. The aim of ComCoast is to explore the spatial potentials for coastal defence strategies for current and future sites in the North Sea Interreg IIIb region.

ComCoast Goals:
- developing innovative technical flood defence solutions to incorporate the environment and the people and to guarantee the required safety level;
- improving and applying stakeholder engagement strategies with emphasis on public participation;
- applying best practice multifunctional flood management solutions to the ComCoast pilot sites;
- sharing knowledge across the Interreg IIIb North Sea region.

ComCoast Solutions:
Depending on the regional demands, ComCoast develops tailor-made solutions:
- to cope with the future increase of wave overtopping of the embankments;
- to improve the wave breaking effect of the fore shore e.g. by using recharge schemes;
- to create salty wetland conditions with tidal exchange in the primary sea defence using culvert constructions or by realigning the coastal defence system;
- to cope with the increasing salt intrusion
- to influence policy, spatial planning and people
- to gain public support of multifunctional coastal zones.

ComCoast runs from April 1, 2004 to December 31, 2007. The European Union Community Initiative Programme Interreg IIIB North Sea Region and the project partners jointly finance the project costs of 5,8 million.

1.1.2 Information

Information on the ComCoast project can be obtained through the Project Management, located at the Rijkswaterstaat in the Netherlands.

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2. Introduction

2.1 Comcoast

ComCoast (COMbined function in COASTal defence zones) is an international project that aims to promote and implement an integrated approach to improving coastal defence systems. ComCoast is funded by the Interreg IIIB Community Initiative Programme in which Holland (lead partner), the United Kingdom, Germany, Belgium and Denmark are participating.

The Interreg programme covers the North Sea region for community initiatives concerning trans-European co-operation and is intended to encourage harmonious and balanced sustainable development of the European territories.

The ComCoast project deals with the identification and understanding of social, economic and technical opportunities and constraints of innovative coastal and flood risk management techniques and the delivery of a more sustainable environment. The over-arching objective of ComCoast is to share knowledge and expertise on:

- Improvement of coastal defence infrastructure and on sustainable development;
- Stakeholder participation; and
- Set up, implementation, monitoring and evaluation of Pilot Projects.

ComCoast also fits into the Environment Agency's development of a more strategic approach to flood risk and Shoreline Management Plans. The principle objective being to make recommendations on the economic valuation of innovative techniques involving the constructive use of coastal and estuarial wetlands using the EU Habitats and Water Framework Directives as the main legislative drivers.

The project contributes towards the Agency's *Making It Happen* targets under the themes of:

- Reducing Flood Risk;
- Limiting and Adapting to Climate Change;
- Improved and Protected Inland and Coastal Waters; and
- Enhanced Environment for Wildlife.

There are several themes within the ComCoast project which are divided into 6 work packages:

- Work Package 1 - Spatial Sensing
- Work Package 2 – Socio-Economic Evaluation

- Work Package 3 - Civil Engineering
- Work Package 4 - Participatory Action
- Work Package 5 - Pilot Project
- Work Package 6 - Project Management and Knowledge Dissemination

This report covers the themes that will be addressed under Work Package 2, using one the Environment Agency's estuary flood risk management strategy studies as a case study (see Section 2.2).

2.2 *Work Package 2*

The aims of Work Package 2 are to:

- offer alternative methods of evaluating potential schemes by providing holistic evaluation methods and future guidance in the form of a handbook; and
- influence policy, planning and people by providing methodologies that are both economically and environmentally sound.

This work package is led by the UK and comprises three PhDs, which will examine:

i) nutrient capture capabilities of managed realignment sites;

ii) fish utilisation of managed realignment sites; and

iii) the economic case for a more integrated approach to estuary management in collaboration with the two other PhDs.

A more detailed description of the PhDs is given in Section 2.3.

The PhDs aim to provide a bottom-up valuation method and demonstrate the value of new managed realignment schemes in terms of the wider coastal or estuary benefits e.g. nutrient storage, local fisheries, flood protection and carbon tax, and therefore assists in attracting additional funding to these schemes. It is anticipated that the knowledge gained through these PhDs will be disseminated as practical guidance and information for regulatory bodies and those organisations that are involved in the design, implementation and management of managed realignment schemes. The guidance will assist in improving the environmental performance of the scheme at the scheme design stage and in particular enhance the value of the scheme in terms of fish utilisation and nutrient capture.

Work package 2 will also provide a link with existing estuarine and coastal strategies, build on current research and development, and link with other Interreg projects, where the UK is a partner.

2.3 *PhD's Being Developed Under Work Package 2*

(a) Nutrients PhD

The aim of the nutrients PhD is to quantify the biogeochemical processes that occur in newly created mudflats and salt marsh as a result of managed realignment schemes at various locations along the Essex coast.

The buffer zone that is created by a managed realignment scheme can help protect the coast from severe flooding and can lead to the recreation of new intertidal habitat. It is also recognised that the new intertidal zone could accrete sediment in the long term, and probably store organic carbon, while microbial activity and organic matter storage in the sediments will help reduce nutrient (nitrogen and phosphorus) loading to downstream coastal waters.

(b) Fisheries PhD

The main objective of the fisheries PhD is to assess the related benefits of creating managed realignments to associated commercial and recreational fisheries. Through the PhD, methods will be explored for quantifying the fish utilisation of recreated intertidal areas. This will allow for observations to be made to help inform how sites are used over tidal cycles to make recommendations for further site design. The study will help to inform predictions of a time frame for ecological establishment of restored salt marsh contributing to understanding the functioning of salt marsh areas as nursery sites or fish fry.

Features of habitat structure, such as heterogeneity, creek profiles, semi-permanent water bodies and vegetation, will be assessed to determine their effects on roundfish and flatfish behaviour by influencing prey abundance, refugia availability, and access. To gauge temporal and spatial effects on foraging success and fish abundance, temperature, salinity, dissolved oxygen, pH, turbidity, velocity, depth, wind speed and light will be measured. This will be complimented with secondary data relating to the hydrological, climatic, and chemical nature of the Blackwater Estuary and Salcott Channel.

(c) Economics PhD

The aim of the economics PhD is to analyse the case for a more integrated approach to the management of the Blackwater estuary. This PhD will operate in collaboration with the two others described above.

The PhD will investigate the following ecosystem functions, which are valued by human society:

- nutrient storage in the inter-tidal zone and the subsequent links to water quality changes and amenity gains;
- fisheries;
- carbon sequestration;
- recreation and amenity; and

- flood protection.

The management actions and strategies for the Blackwater estuary will be appraised and evaluated via the economic cost-benefit approach (in its extended form) and if necessary via multi-criteria analysis (using monetary and non-monetary decision criteria). The aim will be to investigate the social costs and benefits associated with the management strategy. In particular, managed realignment, as a component of a coastal protection or sea defence policy will be appraised.

2.4 The Roach and Crouch Flood Management Strategy

Within the Essex shoreline (England), the Roach and Crouch estuary complex drains into the Outer Thames Estuary between two areas of reclaimed marshes; the Dengie Peninsula to the north and the islands of Foulness, Potton, and Wallasea to the south. Changes to the estuarine complex due to human intervention have resulted in the Roach and Crouch estuaries forming into a single system that flows into the sea between the Thames and the Blackwater estuaries

Within the 12,100 ha of coastal floodplain surrounding the Roach and Crouch estuary complex, there are a significant number of assets at risk of flood damage, including over 2,700 properties, 9,560ha of typically high-grade agricultural land and 168km of flood defences. The risks to the loss of life vary throughout the study area. The total cash value of these assets in a Do Nothing case (the economic base case) is £652M. The flood risk to these assets is likely to increase due to predicted sea level rise of 6mm per year in this region of England

The Roach and Crouch Flood Management Strategy (RCFMS) includes an assessment of the existing condition of the Roach and Crouch estuaries in terms of flood risk and the hydrodynamic stresses exerted on the estuaries and the flood defences. The Strategy also explores how the estuaries would behave in response to predicted sea level rise in order to establish the most economically, environmentally, socially and hydrodynamically acceptable methods of managing flood risk for the next 5, 20 and 50 years (subsequently referred to as the short, medium and long-term). This approach is based on the latest Government guidance. The Strategy has also been developed so that it can be fully integrated into the Shoreline Management Plan (SMP) review process.

The RCFMS is being used as a case study on Work Package 2 to gain an understanding of the strategic economic appraisal procedures that were applied during the development of the Strategy. The RCFMS will also be used to identify opportunities for applying the knowledge gained through the work packages to sites within the RCFMS study area. The RCFMS has been selected because it considers the economic consequences of implementing flood management options in individual flood compartments in accordance with Government guidance, and on an estuary-wide scale. It is anticipated that the work undertaken on the RCFMS and PhDs will compliment one another and assist the Environment Agency in implementing multifunctional flood management schemes in areas where there are significant benefits to the sustainability of the wider estuary, that are not currently recognised within Defra's Priority Scoring System. Consequently, it is anticipated that this approach will assist in identifying additional economic and environmental benefits that could be accrued to increase the Defra priority score.

2.5 Content of this Report

The main focus of this report is to describe the economic appraisal techniques applied to the RCFMS. The majority of the discussions on policies and procedures are specific to England. An overview of the differing funding processes and procedures in the rest of the UK (Wales, Scotland and Northern Ireland) is provided in Appendix A.

In addition, this report presents the following information:

- summary of the existing economic appraisal best practice;
- economic appraisal techniques that were developed for the RCFMS;
- opportunities for further development of these techniques;
- the key economic opportunities and constraints to the implementation of flood management schemes in the Roach and Crouch Estuaries;
- the potential estuary-wide economic, flood management and environmental losses and benefits of implementing low Defra Priority Score schemes at constrained estuary channel locations (i.e. pinch-points);
- how the environmental element for the Defra Priority Score could be increased by improving the methodology for evaluating sites; and
- how the findings of the PhDs may benefit the scheme implementation process.

3. Economic Appraisal Best Practice

3.1 Introduction

This section summarises the industry recognised best practice for the economic appraisal of flood and coastal defence projects in England.

3.2 Purpose

The main purpose of undertaking an economic appraisal for a flood or erosion risk management project is to demonstrate whether there is a robust economic case for each of the flood or coastal management options being considered; to assess the relative economic benefits of a series options; and to secure funding to implement the option.

The majority of flood and erosion risk management schemes in England are funded using public money and therefore it is essential to ensure that the proposed scheme represents the best value for money and that the scheme is economically viable. In addition to meeting these targets, an economic appraisal will also promote the selection of the most economically sustainable flood and erosion risk management schemes for the appraisal period, and will provide accountability and quality assurance for Government spending.

The Government Department for Environment, Food and Rural Affairs (Defra) has overall policy responsibility for flood and erosion risk in England. Defra funds most of the Environment Agency's flood management activities in England through the provision of block grant. The Environment Agency manages the block grant funds and allocates funding on a project by project basis. Defra does not build flood defences.

The Environment Agency (EA) is the principal flood defence operating authority in England (and Wales) and is empowered to manage flood risk from designated 'main' rivers and from the sea. The EA is also responsible for flood forecasting and disseminating flood warning information. It should be noted that flood and coastal defence legislation in England and Wales is permissive and does not confer a right to protection, except in very limited circumstances.

Defra has established a priority scoring system for the funding of flood management and coastal defence projects. Under this system, the economic score has the biggest influence to the funding decision (based on the weighting of the score), compared to the other two elements, namely people and environment scores. This is further discussed in Section 2.9.

3.3 Guidance Documents

The Ministry of Agriculture, Fisheries and Food (MAFF, subsequently replaced by Defra) published a series of guidance documents, Flood and Coastal Defence Project Appraisal Guidance (FCDPAG), in 1999. This series of guidance documents are designed to provide advice on best practice for the appraisal of flood and coastal defence projects.

The FCDPAG document that covers economic appraisal is known as FCDPAG3, and this document identifies methods for valuing costs and impacts in monetary terms and also sets out a recommended decision process, based on economic value. The economic appraisal principles set out in FCDPAG3 should be used in undertaking economic appraisals for nationally-funded projects for river and coastal flood alleviation, coast protection and other related purposes. Tools and worked example including sample spreadsheets are given in the FCDPAG3.

The FCDPAG Environmental Appraisal, FCDPAG5, provides guidance in evaluating the nature conservation assets, archaeological and heritage assets, landscape and habitat replacement costs.

HM Treasury published a revised version of their publication Appraisal and Evaluation in Central Government (the "Green Book") in January 2003. To reflect the new Green Book, Defra published a supplementary note to Operating Authorities, titled Revisions to Economic Appraisal Procedures arising from the New HM Treasury "Green Book", in March 2003. A supplementary note to the FCDPAG series of documents on Climate Change considerations was published in April 2003.

In the UK, Multi-coloured Manual (MCM) is widely used as a guidance document in assessing benefits of flood and coastal schemes. Published in 2003, it was written for Defra by the Flood Hazard Research Centre (FHRC) at Middlesex University. It presents a range of techniques and data that can be used to assess the benefits of policies, plans and projects relating to fluvial and coastal flood alleviation, and coastal erosion. It also updates the techniques and data contained in its previous volumes; and explains limitations and complications of cost-benefit analysis, so that it can be used in a thoughtful and critical way. There are also other guidance documents on economic appraisal. Some of them are specific to the flood defence/coast protection option such as managed realignment.

During the development of the Roach and Crouch Flood Management Strategy, the Environment Agency identified that further guidance would be required from Defra and English Nature regarding the short-term management of uneconomic sea flood defences in order to meet the Environment Agency's requirements under the Conservation (Natural Habitats, &c.) Regulations 1994 (Habitats Regulations). The guidance (Defra, 2004) sets out a clear approach to the classification of sea flood defences and where future Environment Agency maintenance cannot be justified, the development of an Exit Strategy.

The four categories of sea defence are:

1. Defences for which there is a clear economic case to continue maintenance;

2. Defences that are uneconomic to maintain although there is justification to protect internationally designated environmental features from the damaging effect of tidal flooding;

3. Defences that are uneconomic to maintain although there is justification due to the uncertain and unacceptable risk associated with withdrawal of maintenance (e.g. hydrodynamic, contamination, fisheries); and

4. Defences that are uneconomic to maintain and protect low risk flood compartments.

In July 2004, Defra published another supplementary note to Operating Authorities covering Defra's policy on socio-economic equity and appraisal of human related intangible impacts of flooding.

The Multi-coloured Manual (MCM) is another widely used guidance document. Published in 2003, it was written for Defra by the Flood Hazard Research Centre (FHRC) at Middlesex University. It presents a range of techniques and data that can be used to assess the benefits of policies, plans and projects relating to fluvial and coastal flood alleviation, and coastal erosion. It also updates the techniques and data contained in its previous volumes; and explains limitations and complications of cost-benefit analysis, so that it can be used in a thoughtful and critical way.

There are also other guidance documents on economic appraisal. Some of them are specific to the flood defence/coast protection option such as managed realignment.

3.4 Cost

The best estimate of the total costs for each flood or erosion risk management option are developed by considering a range of cost elements including the capital works, operating and maintenance, risk, fees, engineering and management. The capital works costs are based on an outline design of the flood or coast protection options. Operating and maintenance works costs estimates are based on the design and if available, historical maintenance expenditure records. Engineering, management and fees are estimated based on the scale and nature of the works. It is recommended that the cost estimates are validated by contractors and/or third parties with local knowledge or experience of similar works.

The costs are calculated for each year of the appraisal period and reduced to present day prices by multiplying the 'cash' costs by a 'discount factor', which varies between 1.00 in Year 0 up to approximately 0.05 in Year 99 (i.e. costs that occur later in the appraisal period are discounted more). The sums of the discounted costs are known as the Present Value (PV) costs.

The PAG3 supplementary note issued in March 2004 (see Section 3.3) recommends that the appraisal period should reflect the physical life (with maintenance) of the longest-lived asset under consideration of a scheme. It recommends that *"for most conventional schemes, involving major earthworks, concrete or masonry structures a 100-year timeframe will be appropriate"*. The recommended discount factor is 3.5% for years 0 to 30, 3.0% for years 31 to 75 and 2.5% thereafter. Project risks can be quantified an presented as Optimism Bias by either undertaking a 'Monte-Carlo' type risk valuation approach and calculating the 95% confidence level estimate or by adopting an Optimism Bias value of 60% of the total PV costs at the strategy (pre-feasibility) appraisal stage or 30% at the scheme (detailed design) appraisal stage.

3.5 Benefits

In general, the economic benefit arising from a flood or erosion risk management option is the reduction in risk of flooding or coastal erosion over the appraisal period. The benefits are derived by calculating the flood and erosion damages associated with existing situation with no further maintenance works, normally termed as the Do Nothing scenario, and then subtracting the flood and erosion damages associated with the Do Something options. Coast protection schemes typically delay coastal erosion, and in some cases reduce risks of flooding. It should be noted that *"No scheme can remove the risks of flooding or coast erosion and there can be no certainty about the standard of protection (SoP) provided by the option"*, as stated in FCDPAG3.

Annual average damages (AADs) are used in the economic appraisal analysis to take account of the probability of a range of extreme flooding and/or erosion events, and the corresponding damages to assets, people and the environment for each event. The Present Value (PV) damages are calculated by applying discount factors (see Section 3.4) to the AADs over the appraisal period. The damages considered in the benefit analysis are economic losses to the UK public, instead of financial losses to individuals.

For flood risk management options, frequently flooded assets (generally up to a probability of 20%, depending on the type of asset) are considered to be written-off at the beginning of the appraisal period and therefore the write-off values are used to calculate PV damages instead of the AAD. The write-off value is generally the market value of the asset. For erosion risk management options, the write-off values are generally taken as the market value of the assets under threat of permanent loss due to erosion. The PV damages are limited (capped) to the write-off values of the assets.

The PV cost and PV benefit of each option is used to calculate the benefit cost ratio (i.e. the PV benefits divided by the PV costs) and the net present value (NPV), i.e. PV benefits minus PV costs. There may also be intangible benefits arising from the implementation of the scheme. These could include reduced physical and mental health/stress effects, improved tourism, local business and recreation, and an enhanced physical and natural environment.

It is important to ensure that there is consistency in the assumptions in both the cost and benefit estimates. This applies to the base date of the estimates, the years in which the scheme and any maintenance works are implemented, the discount factors, the appraisal period and the year in which assets are written off.

3.6 Evaluation of Environmental Benefits

In the appraisal of flood and erosion risk management options, there is no readily available market price for the valuation of environmental or recreational assets and therefore the calculation of these benefits is often more time consuming and complex. The inclusion of environmental and recreational benefits in the economic appraisal will depend on a number of factors including: i) whether the option is being appraised at a strategy or scheme appraisal stage; ii) the relative value of environmental and recreational assets compared to residential, commercial and agricultural assets; and iii) the economic viability of the option.

In addition to the economic value derived from the direct use of an un-priced asset, such as a beach, there are other components of economic value, which might arise in some cases:

- a functional value - where an asset serves a number of functions and yields benefits other than those deriving from its direct use by 'consumers'; for example, where wetlands provide the function of flood storage and wastewater treatment in addition to other values, such as for recreation.

- an option value – someone may not actually use it but may choose to use it in future.

- an existence value – value of knowing that an asset is present, even if they don't use it.

Due to the lack of research in evaluating the environment benefits in current best practice, the following needs should be addressed in order to develop high level confidence in the estimated project-specific environmental benefits:

- to demonstrate the validity of the results in terms of cost-benefit analysis;

- to consider the relative benefits of functional value compared to other assets and whether their inclusion will affect the results of a cost benefit analysis;

- to consider whether qualitative (comparison of quality of items) versus quantitative (comparison of quantities) data; and

- to consider geographical variations in quality and quantity in relation to value

A summary of the environmental benefits evaluation methods undertaken in the UK is contained in Appendix B.

3.7 Climate Change Considerations

It is recognised that some aspects of anticipated climate change will have an impact on flood and erosion risk management. FCDPAG Overview, or FCDPAG1, sets out the basis of climate change consideration. The expected impacts of climate change include sea level rise and an increase in peak river flow (sensitivity test). Higher sea levels will result in larger waves reaching the shoreline and consequently, greater damage to beaches and

coastal defences. Higher peak flow in rivers will result in higher flood levels and potentially affect erosion and accretion rates. It is therefore critical that impacts of climate change are taken into account in the development of a sustainable flood or erosion risk management strategy. FCDPAG1 states that a sensitivity test for assessing the impact of increased river peak flow should be undertaken by increasing the flow rates by 20% by the end of a 50 year appraisal period.

Sea level rise can be defined as the increase in mean sea level in response to global climate change and local land movements. FCDPAG3 provides details the expected rate of relative sea level rise for the Environment Agency regions.

For Anglian, Thames, Southern and North East (south of Flamborough Head), the allowance is 6mm/year. This is derived by adding 4.5mm/year sea level rise and 1.5mm/year of isostatic adjustment (sinking of the land brought about by local geological processes). This average takes into account the future accelerated effects of climate change. The evidence for this was provided by UKCIP (UK Climate Impacts Programme) and IPCC (Inter-governmental Panel on Climate Change). It is the result of work by several hundred scientists and represents a balanced body of opinion, tested in the normal manner by peer review.

The Proudman Oceanographic Laboratory (POL) has also studied sea level rise in East Anglia, and their work shows results for the period up to 2075 as "reasonably consistent with the FCDPAG3 expected rate in East Anglia of 6 mm per year". (www.suffolkestuaries.co.uk).

The relative sea level rise allowance for the North West and North East (north of Flamborough Head) is 4mm/year and 5mm/year for the South West and Wales.

The supplementary note on climate change considerations issued in April 2003 (see Section 3.3) states that the expected rate of sea level rise is unchanged. However, sensitivity tests of impacts of increased storminess as a result of climate change should be undertaken, along with the sensitivity test of increased river peak flow level for river flood defence schemes and studies. The increased storminess includes a 10% increase in wind speed and wave height, and 5% increase in wave length.

3.8 Option Selection

The FCDPAG3 sets out a decision making process for the selection of the economically preferred option. The process is based on the land use class of the protected area hence the indicative standard of protection and the robustness of the benefit cost ratio and the incremental benefit cost ratio.

This decision making process, however, does not include any consideration of any environmental, hydrodynamic, estuarine processes and technical constraints and opportunities. Therefore, it is recognised that the economic appraisal is one tool available to aid decision making of the overall preferred option.

A clear decision making process has been developed for the RCFMS, which comprises a staged approach to the selection of the most economically, environmentally, technically robust flood management options, whilst taking account of estuary processes and the Defra guidance on uneconomic sea walls.

3.9 Defra Priority Scoring System

The purpose of the Defra priority system is to ensure that the most worthwhile projects are carried out first and to allow authorities to devote resources to those projects. The system is based on three criteria:

(d) Economics

Economic risk (economic damage resulting from flooding or erosion multiplied by the probability of the events causing the damage) compared with the whole life cost of providing the proposed defences. Only those benefits and costs that can be assigned a monetary value are included in the benefit/cost ratio.

(e) People

The people score recognises that there are often impacts on those living in risk areas that are not reflected in the economic assessment. The focus is on impacts on people as a result of flood or erosion risk at their places of residence, rather than at their places of work. The score is further adjusted to reflect the degree of vulnerability within the population at risk.

(f) Environment

The environmental score is included to give greater priority to those projects that are expected to provide additional benefits to the natural environment. This includes the recognition that government is committed to the promotion of Biodiversity Action plan (BAP) targets, which include habitats such as grazing marsh, reed bed and salt marsh that may be created through schemes. An additional score is given to include protection afforded to heritage sites afforded a national heritage classification.

Proposed projects must achieve the score threshold in order to be eligible for funding. The threshold is set annually.

By only considering the above Defra criteria, many benefits of an option could be excluded unless a holistic evaluation method is adopted. These methods could include an assessment of the changes in hydrodynamic stresses and subsequent flood defence maintenance costs, and habitat creation benefits. As a result, schemes that should be prioritised, for example, due to hydrodynamic benefits and subsequent flood risk benefits to the whole of an estuary could be rejected.

The Defra priority score is heavily biased towards on the economic score, which accounts for up to 46% of the highest possible score of 44. However, the people and environmental scores only account for up to 27% of the highest possible score each.

In addition, the people and environment scores are also functions of the estimated project cost. This further increases the weighting of the economic element in the priority score such that the additional points score attained from, for instance, the environment benefits of additional BAP habitats are counteracted by the increase in scheme cost of creating this. In the case of larger projects with a higher benefit cost ratio, the overall point score actually reduces with the creation of additional environmental benefits.

3.10 Broad Scale Economic Appraisal

When benefit-cost analysis is undertaken for a flood compartment or length of coast, the estimated benefits might not necessarily reflect the overall economic benefit (not financial benefits) to the public. A broad scale economic appraisal would therefore be preferred in order to evaluate the option holistically.

For example, benefit-cost analysis for a flood cell within an estuary should involve consideration of opportunities and constraints of the options to other flood cells within the estuary. Estuarine processes are complex and any

changes at one location could result in changes elsewhere the estuary. Therefore, implementation of a scheme would results in constraints or benefits to other flood cells. For instance, implementing a managed realignment scheme to turn a flood cell into wash land might not be economically justifiable if it is only the benefits arising from the flood cell itself that are taken into consideration. However, the scheme could contribute to the reduction hydrodynamic stresses elsewhere in the estuary, reduce extreme tide levels by accommodating storm flood water, result in habitat creation to compensate the estuary-wide habitat loss due to coastal squeeze.

Although it is recognised that broad scale economic appraisal represents a better way of evaluating the economic benefits of flood and coastal defence projects, there are constraints in the broad scale economic appraisal process. Broad scale benefit-cost analysis can be a complex process since the study areas are often large and a good understanding of the interaction of the complex estuary or coastal processes is required.

A range of method of assessing the broad scale economic benefits of flood or erosion risk management options have been adopted on individual projects, and vary due to several factors including the length and shape of the estuary or coast, the numerical or physical modelling capabilities, and the baseline and model calibration data. Each of these factors will affect the accuracy and level of confidence in the quantification of broad scale economic benefits.

As discussed in Section 3.6, the use of flood depth - damage curves in MCM is the current best practice in quantification of flood damages given the flood depths. However, the flood depth-damage information available in the MCM is limited to information gathered from survey results of previous flood events. Therefore, for the broad scale economic appraisal covering a large area containing a wide variety of asset types, there is a higher chance that further investigation would be required for asset types of which the flood depth-damage information is not included in the MCM flood depth-damage database. The difficulty in evaluating environmental benefits in Section 3.9 is also considered as one of the constraints.

In the RCFMS, a broad scale economic appraisal has been undertaken to evaluate the benefits and costs of the possible engineering options in order to achieve a more sustainable estuary form, and also to meet the strategic objectives. The details of the RCFMS economic appraisal are discussed in more detail in Section 4.

4. Economic Appraisal Techniques used in the Roach and Crouch Flood Management Strategy

4.1 Introduction

This section discusses the economic appraisal undertaken in the RCFMS, including background information, the purpose of the study, the strategy objectives and general economic approach that was adopted. This is followed by discussions on how the economic appraisal has been used in the decision making process for the preferred flood management options.

The economic appraisal methodology covers the background economic appraisal data and the methods used to calculate the flood risk management option costs, flood damages and benefit cost analysis using FCDPAG3.

4.1.1 Purpose of the study

The Essex Shoreline Management Plan (SMP; Mouchel, 1997) recommended a Hold the Line policy for the Roach and Crouch estuary in the short-term until a monitoring and modelling programme was completed to consider the physical impacts of various defence policies within the estuary as a whole. Following the SMP, the Essex Sea Wall Management Study (ESWMS; Halcrow, 1998) was produced and specifically assessed the economic viability of maintenance and improvement works. It concluded that a better understanding of coastal processes was needed before firm decisions on sections of seawall could be made.

The RCFMS represents the culmination of the studies recommended in the SMP and ESWMS. These studies include a detailed assessment of physical processes, flood risk, environmental issues and economic justification.

The primary strategic objectives of RCFMS are:

- Provide a flood management strategy which supports the long-term objectives of providing effective flood management schemes for the protection of people's lives and property, whilst developing towards a more sustainable estuary shape;
- Enhance salt marsh generation through managed realignment, foreshore recharge or other soft defence measures;
- Avoid pollution of controlled water from release of landfill material or other sources of contamination;
- Ensure compliance with the Conservation Regulations with respect to the integrity of internationally designated sites, or, where this is not possible, undertake appropriate compensatory measures to ensure the overall coherence of the Natura 2000 series;
- Maintain or enhance environmentally designated sites and Biodiversity Action Plan habitats and species, where environmentally sustainable, technically possible and economically feasible; and
- Maintain access to the sea for commercial, recreational and safety vessels.

The RCFMS also aims to achieve the following secondary strategic objectives, which have been established to enhance the flood management strategy, depending upon their feasibility.

- Maintain the extent and distribution of habitats that support the fish and shellfish populations;
- Re-route and create Public Rights of Way;
- Enhance or protect socio-economic assets, significant visitor attractions and recreational resources, where environmentally, economically and technically viable;
- Protect Scheduled Ancient Monuments (SAMs) and listed buildings where possible and provide mitigation in the form of excavation and recording at sites of non-scheduled known archaeological sites and undiscovered archaeology; and
- Maintain or enhance the existing landscape character and physical appearance, features of historic, archaeological and environmental importance, and Special Landscape Areas,

4.1.2 Flood Management Units

The study area covers the estuary and land at risk from tidal flooding under a 1 in 300 year return period event, which was initially defined as the hinterland up to the +5mOD contour. The characteristics of the land protected vary from the urban settlements of Burnham-on-Crouch, South Woodham Ferrers, Great Wakering and Battlesbridge to unpopulated poor quality agricultural land.

In order to assess flood risk management options for different land uses and different levels of flood risk, the study area was divided into distinct flood compartments, which were called Flood Management Units (FMUs). These were defined by analysing the topographic data using Geographical Information Systems (GIS). The boundaries of the FMU were taken as distinctive topographic features, which were expected (by observation) to limit the flow of flood waters into neighbouring units. The definition of FMUs did not take account of the distribution of assets within the flood risk area, as their purpose was to identify largely independent flood compartments.

The economic analysis addresses FMUs as if the flood risks are entirely independent but it was noted that adopting a 'No Active Intervention' policy (i.e. no further active intervention in the management of the flood defences by the Environment Agency) in some FMUs would lead to extensive flooding of neighbouring FMUs across the landward boundary in a few cases. These FMUs are considered as an extended flood compartment, of which the combined benefits and costs for a range of flood management options were analysed.

4.2 The Approach

The approach that has been adopted for the economic analysis of RCFMS followed the recommendations defined in the FCDPAG3. This guidance, as detailed in Section 3.3, sets out the principles that should be used in undertaking the economic appraisal for river and coastal flood alleviation and coast protection projects.

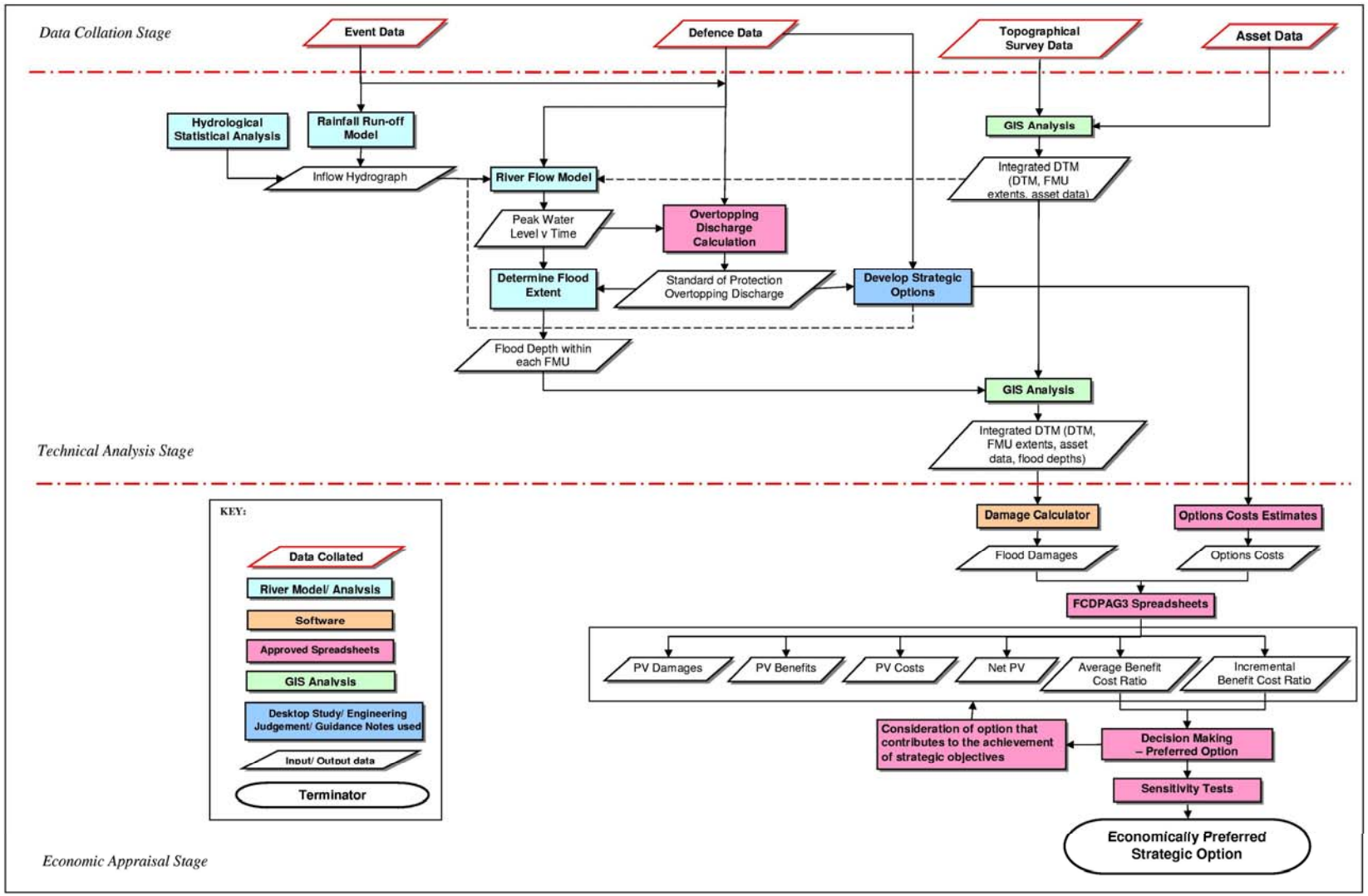

Figure 4.1 Principal steps in assessing scheme benefits and selecting the preferred option

Economic appraisal was undertaken on an individual FMU basis (or group of FMUs for the reason given in Section 4.1) using a broad scale estuary-wide approach, to assess the economic viability of the strategic flood management options. The analysis was undertaken by using an automated and integrated appraisal process using a variety of numerical modelling software packages, GIS analysis and visualisation and the use of approved Defra spreadsheets.

The appraisal process is detailed in Figure 4.1

4.3 Strategic Flood Management Options

Common strategic flood management options are considered across all FMUs in the Roach and Crouch estuary complex. The flood management strategic options are identified based on their achievability of the primary strategic objectives, and to a lesser extent the secondary strategic objectives. These options are:

Option 1: Do nothing

This is a baseline option and is included for comparison purposes and to evaluate the benefit of all other options.

Do something options:

Option 2: Maintain

Maintenance of existing flood defences throughout the FMU area.

Option 3: Sustain

Sustain the existing standard of protection (SoP) to account for climate change throughout the FMU area.

Option 4 Improve

Improve the SoP of the existing defence to the indicative standard of protection based on the land uses of the FMU.

Option 5: Cease maintenance (No active intervention) of all uneconomic FMUs

This option adopts a No Active Intervention policy for the defences in FMUs that are economically unviable to maintain, irrespective of the potential impacts on adjacent frontages, the potential for harm to freshwater and terrestrial environmental sites, and the potential for loss of inter-tidal habitats.

Option 6: Achieve the strategic objectives

This option comprises the implementation of one or a combination of maintain, sustain, improve, cease maintenance and/or managed realignment options to achieve the strategic objectives. This option could be

applied in FMUs that are economically unviable to protect as the benefit area would be extended to include other FMUs, of which the combined benefits should be considered. For instance, implementation of a managed realignment option to address the needs of compensatory flood storage or inter-tidal habitats could provide estuary-wide benefits.

4.4 Flood Risk Management Scheme Unit Cost Rates

4.4.1 Introduction

The best estimates of costs for each flood risk management option were determined with reference to a range of flood defence schemes and studies in Essex. In addition, there were discussions with the Environment Agency engineers on current maintenance and site supervision costs. A contractor with relevant experience of constructing flood management schemes was also consulted with regard to the unit cost rates that were used. These unit cost rates were later reviewed by the Environment Agency.

Project risks were identified as Optimism bias, which was taken as 60% of the total Prevent Value (PV) option costs as recommended in Defra guidelines (FCDPAG3 supplementary note, March 2003). The appraisal period is taken as 50 years, which is the physical life (with maintenance) of the longest-lived flood defence asset within the study area.

4.4.2 Methodology

For maintenance works, the average flood defence dimensions in each FMU, including crest width, crest height, toe level and landward/seaward slopes, were used to calculate the quantities of the work items. This data was extracted from existing survey data and the Essex Seawall Management Strategy (Halcrow, 1998).

For capital works in the Sustain and Improve options, design crest levels were calculated based on wave and water overtopping analysis, which included climate change allowances. The impact of climate change on the costs is considered to be minimal in comparison with the Optimism Bias.

The estimated base costs excluded contractor's profit, mobilisation, running costs and the Environment Agency site supervision costs. The sum of these additional costs is estimated to be 10% of the base costs.

The principal steps to estimating the option costs is presented in Figure 4-2

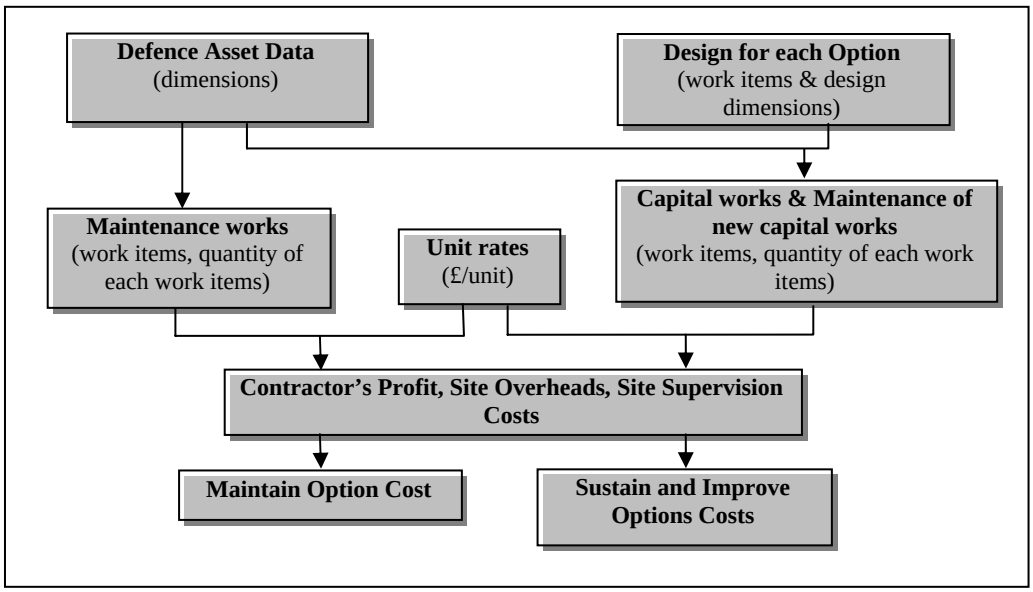

Figure 4-2 Principal steps in estimating options costs.

4.4.3 Annual Flood Defence Maintenance

For the purposes of this cost analysis, it was assumed that annual flood defence maintenance comprises the general annual maintenance of the flood defences but not proactive breach repairs.

Annual flood defence maintenance comprises grass cutting, weed control, vermin control, concrete patchwork, reinstatement of rock protection. It is not anticipated that these works will be necessary along the full length of the defences and therefore the unit rates used per km assumed works on a proportion of a 1km length of defence.

4.4.4 Breach Repair Maintenance

The cost of repairing breaches in the flood defences comprised reactive (post breach) and proactive (prior to breaching) maintenance costs. In the RCFMS, reactive breach maintenance costs were included in the economic analysis as losses associated with the Do Something options, since they are incurred after a breach in the flood defences. Proactive maintenance costs were incorporated into the flood management options costs, since they occur prior to a breach.

An assessment has been undertaken to develop costs for the proactive repair to sections of seawall as their condition deteriorates over the appraisal period. Capital works will be undertaken at a point where substantial repair works are required.

The data was obtained on the condition and the residual life of the defences for discrete flood defence lengths, with residual life bands of less than 5 years, 5 to 10 years or greater than 10 years. This data was used in conjunction with photographic evidence enabled a detailed assessment of the works required to reinstate the integrity of the existing flood defences at the end of its residual life within each FMU.

The proactive breach repair costs were applied in the PV cost calculation in the middle of the residual life bands for flood defences with a residual life of less than 10 years. For flood defences with a residual life of greater than

10 years, 50% of the cost for these works has been applied in Year 15 and the remainder is discretely distributed over the rest of the appraisal period.

4.4.5 Costs for Options to Improve Defence Standards

Improvements to the flood defences are economically justifiable in some FMUs, in order to raise the SoP within the life of the Strategy. Proposals for these improvements comprise raising the crest level of the flood defences to reduce the overtopping discharge to acceptable design levels and additional slope protection (concrete block work or open stone asphalt) and toe protection (toe beams, toe piles or rock armouring) to all areas where improvement works are required. The improvements will comprise sustaining the existing standard of protection or raising the SoP such that it falls within the FCDPAG3 SoP range for the remaining life of the Strategy.

Improvements to the existing flood defences has been considered for each defence length separately in order assess the extent of construction required and to develop an understanding for the built up costs.

For each defence length within the study area, a percentage of the three forms of slope protection (open stone asphalt, Essex blocks and interlocking concrete block revetment) has been assumed for the raised flood defences, based on knowledge of the existing slope protection developed from photographic evidence. Where no information was available, the percentages were assumed to the same as for adjacent defences.

In line with the methods employed for the maintenance works, the capital improvement works costs have been determined for defence lengths with the residual life bands described above. The improvement works costs have therefore been applied in the FDCPAG3 cost spreadsheets in the middle of the residual life bands and Year 15 for flood defences with a residual life of less than 10 years and greater than 10 years respectively. Consequently, any improvement works will be undertaken at the same time as proactive breach repair works, resulting in a more time and cost effective construction process.

It has been assumed for the improve options that 100% of the capital maintenance works for flood defences with a residual life of greater than 10 years will be completed in Year 15, as part of the overall scheme.

Where it has been identified that all of the agricultural assets within an FMU could be written off within the residual life of the weakest defences, it has been assumed that the improvement works would be undertaken in Year 0.

4.4.6 Managed Realignment Costs

Managed Realignment costs have been estimated for some FMUs, to cover realignment to higher ground or to a newly constructed secondary defence. Managed Realignment has only been considered as a potential option where there is an economic case to do so, where there is a requirement for Managed Realignment in order to address estuary-wide technical, environmental or hydrodynamic issues, or where there are adverse impacts associated with adopting a No Active Intervention policy.

For the purpose of the RCFMS, it has been assumed that the construction of a secondary flood defence, landward of the existing defences, will incur costs for earthworks, slope protection and breaching the existing defences, whereas realignment to higher ground would only incur breaching costs.

It has been assumed that secondary defence construction works comprise construction of earth embankments using locally sourced material; and that the existing flood defences would be actively breached but not completely removed. It has also been assumed that any secondary defences constructed within a FMU that is

not situated on the coastline or main river channel will only experience limited wave action and therefore these secondary defences will only be provided with grass slope protection.

Breach costs have been calculated per metre length of breach based on an assumed breach length of 20m every 0.5km, which is similar to the smaller breaches created for other managed realignment schemes in East Anglia. The cost consists of plant mobilisation, removal of embankment material, a lump sum for dismantling the existing slope and crest protection, and an allowance for sub-contractor's profit.

4.4.7 Other costs

A number of other costs have been highlighted for inclusion in the development of the 'Do Something' flood defence options.

a) Management costs

For the majority of the strategic flood defence options, long-term management commitments will be required for their successful implementation. Costs have been identified for project construction management by the Environment Agency as well as the costs incurred by a consultant for management of the Strategy Review and implementation.

The Environment Agency management costs cover the management during the RCFMS and the capital/maintenance works identified in the RCFMS. The consultancy costs estimates assumed review of the current Strategy every five years and design and management costs for the capital and/or maintenance works of the scheme recommended by the RCFMS. These costs have been ratified against actual costs for preparing other strategy reviews and implementing other schemes.

The total Agency and consultancy costs over the life of the Strategy have been calculated as a percentage of the capital and maintenance costs for each of the flood management options (maintain, sustain and improve to indicative standard) in the FCDPAG3 spreadsheets. The Agency and consultancy costs equate to an average percentage of 3% and 6% of the option costs respectively.

b) Monitoring

Monitoring is an integral part of the proposal for the preferred scheme as it provides data for the assessment and evaluation of the scheme's performance.

The Environment Agency has undertaken some monitoring within the estuary in the past including bathymetric and beach surveys, aerial photography, wave and water level monitoring and flow velocity monitoring, although not on a regular basis. In order to monitor geomorphological change within the estuary and the future sustainability of the estuary complex, it is recommended that further monitoring is undertaken in line with the outline specifications in the Essex Estuaries Monitoring Programme Specifications (Halcrow, 2003a), which include inshore wave heights, water level, current flow, suspended particle matter, salinity and bathymetry. This data will assist the construction, calibration and verification of hydrodynamic and sediment transport models, leading to greater confidence in the potential long term impacts of scheme implementation.

In the implementation of any Managed Realignment or No Active Intervention policy, it is recommended that an environmental monitoring programme is established.

An allowance of a nominal percentage of 1% has been included to cover additional monitoring that is not undertaken as part of the Environment Agency's regional monitoring programme.

4.4.8 Risk Allowance

In accordance with Defra guidelines (FCDPAG3 supplementary note dated March 2003), an optimism bias of 60% of the total PV base costs has been included.

4.5 Option Costs

Scheme costs have been developed for the strategic flood management options of Maintain, Sustain and Improve to the Indicative Standard of Protection throughout the estuary. The format of these costs has been determined using the FCDPAG3 spreadsheets for economic assessment of the preferred option, but excluding any contingency. This breaks down the total cost into components for capital works, maintenance works and other associated costs. Consideration has been given to the timing of expenditure over the time horizon of the strategy period.

For the purpose of the RCFMS, the scheme costs estimated only cover the direct costs of maintaining, sustaining, improving (to the indicative standard), realigning or ceasing maintenance of the existing flood defences for an individual FMU. The costs do not include the additional costs that may be required to raise the flood defences in a neighbouring FMU if a No Active Intervention policy or low standard of protection option is identified as the preferred option. Once the costs and benefits of providing the most economically robust standard of protection to each FMU have been calculated, the combined effects of the options will be considered in terms of providing a consistent standard of protection. In addition, the intangible costs associated with the hydrodynamic consequences of No Active Intervention and future sustainability will be considered.

4.5.1 Do Nothing (Option 1)

Under the Do Nothing option, no costs have been allowed for. This is the 'walk away' option allows the flood defences to be eroded, gradually deteriorate and fail, leading to tidal inundation of the flood risk areas behind the defences.

4.5.2 Maintain (Option 2)

This option comprises proactive maintenance repairs to the existing flood defences as they deteriorate and the standard of protection reduces with increasing sea level and wave climate.

Management costs would include for Environment Agency management and consultancy costs during the Strategy reviews. Some additional costs would be incurred to cover monitoring that is not undertaken as part of the Environment Agency's standard monitoring programme.

4.5.3 Sustain (Option 3)

This option comprises annual maintenance, proactive maintenance repairs and raising the crest level of the existing flood defences in order to sustain the current standard of protection in the face of climate change.

Proactive breach repair costs have not been included for work on the crest and rear slope of the flood defences, including earth works and concrete patch work to the crest protection. This is because it has been assumed that the crest and rear slope will be repaired as part of the ground preparation works for the capital works to raise the crest level.

Management costs would include for EA management and consultancy costs during the Strategy reviews and the implementation phase. Monitoring costs would also be incurred.

4.5.4 Improve to Indicative Standard (Option 4)

The total option costs under this scheme are comparable to the costs detailed in the Sustain option. This option comprises annual maintenance, proactive breach repairs and raising the crest level of the existing flood defences in order to achieve the indicative SoP for the remaining life of the Strategy.

Proactive breach repair costs have not been included for work on the crest and rear slope of the flood defences, including earth works and concrete patch work to the crest protection. This is because it has been assumed that the crest and rear slope will be repaired as part of the ground preparation works for the capital works to raise the crest level.

Management costs would include for the Environment Agency management and consultancy costs during the Strategy reviews and the implementation phase. Monitoring costs would also be incurred.

4.5.5 Cease Maintenance of Uneconomic Flood Defences (Option 5)

Under this option, each FMU that is not economically viable to maintain (i.e. the benefit cost ratio for maintenance is less than unity) would be left to deteriorate and fail.

The economic justification for intervention within each FMU was determined using the Decision Rule (FCDPAG3). This option does not take account of the Defra guidance on uneconomic sea walls.

This option would be undertaken in conjunction with maintaining, sustaining or improving (to the indicative standard) all FMUs that are economically viable to maintain. Whilst it is possible to estimate the direct costs of adopting this option throughout the Roach and Crouch estuary complex, the indirect costs associated the potential hydrodynamic, environmental and social consequences of adopting this option cannot be readily quantified.

For example, the potential consequences of adopting a No Active Intervention policy for the uneconomic sea walls include dramatic long-term changes in the estuary form, significant widening of the estuary mouth, undermining of the existing flood defences, the release of significant quantities of suspended sediment into the estuary system, the release of potentially contaminated material and the loss of significant areas of existing salt marsh.

This option could not be recommended because of the significant detrimental environmental, hydrodynamic and intangible economic consequences. However, it forms a useful basis for developing Option 6, in which practical measures are included to mitigate impacts by monitoring and by facilitating changes in asset management practice over periods of decades, to reduce the potential for damage.

4.5.6 Achieve the Strategic Objectives (Option 6)

This option was established in order to achieve the strategic objectives through the implementation of one or more of the following options in each FMU: maintain, sustain, improve, cease maintenance and/or managed realignment. As discussed in Section 4.5.5, allowing all uneconomic flood defences to fail could have a significant impact on the sustainability of the estuary shape, leading to excessive maintenance costs on those flood defences that are maintained and severe environmental impacts.

The costs and benefits of providing the most economically robust standard of protection to each FMU have been calculated and the combined effects of the options have been considered in terms of providing a consistent standard of protection. A technical and environmental appraisal of the most economically viable options has been undertaken. A desktop study of the hydrodynamic consequences of the most economically robust options has been undertaken. In addition, a desktop study of the environmental impacts of the most economically robust option has been undertaken, with particular reference to the environmental consequences of adopting a No Active Intervention policy in FMUs that protect or contain potentially contaminated or land fill material and those that protect freshwater Special Protection Areas (SPA). Where considerable indirect costs are identified, consideration has been given to the next most economically robust option for that FMU or until the consequences have been reduced to what is considered to be a reasonable level.

For the FMUs that were identified as economically unviable to maintain, the prioritisation of implementation of these sites has been based on a salt marsh regeneration site matrix, a form of multi-criteria analysis for the prioritisation of managed realignment sites for salt marsh regeneration.

Management costs would include for EA management and consultancy costs during the Strategy reviews and the implementation phase. Monitoring costs would also be incurred.

4.6 Benefits Assessment

4.6.1 Introduction

Appraisal of the benefits of flood management has been undertaken for each FMU or group of FMUs. The PV benefits were calculated as the expected PV of flood damage avoided, i.e. the expected PV of flood damage in the 'Do Nothing' (Option 1) scenario minus the expected PV of flood damage of the Do Something options (Options 2 to 6).

The PV flood damage with each option was calculated by discounting the expected annual flood damage by an annual discount rate of 3.5%, in line with the PV costs calculation, over an appraisal period of 50 years. As floods are deemed to be random events, the expected annual flood damage with each option was quantified by multiplying the probability of a range of flood events (or return periods) by the flood damage that such an event would incur.

The flood damage was calculated from the flood depth curves from the MCM. The flood depths were calculated within an integrated Digital Terrain Model (DTM) containing topographical data, hydrodynamic modelling outputs and assets data within the Roach & Crouch estuary complex. These assets consist of residential properties, commercial and industrial properties, agricultural land and caravans.

The above steps in assessing benefits are summarised in Figure 4.3, a simplified and RCFMS-specific version of Figure 4.1 on benefits assessment.

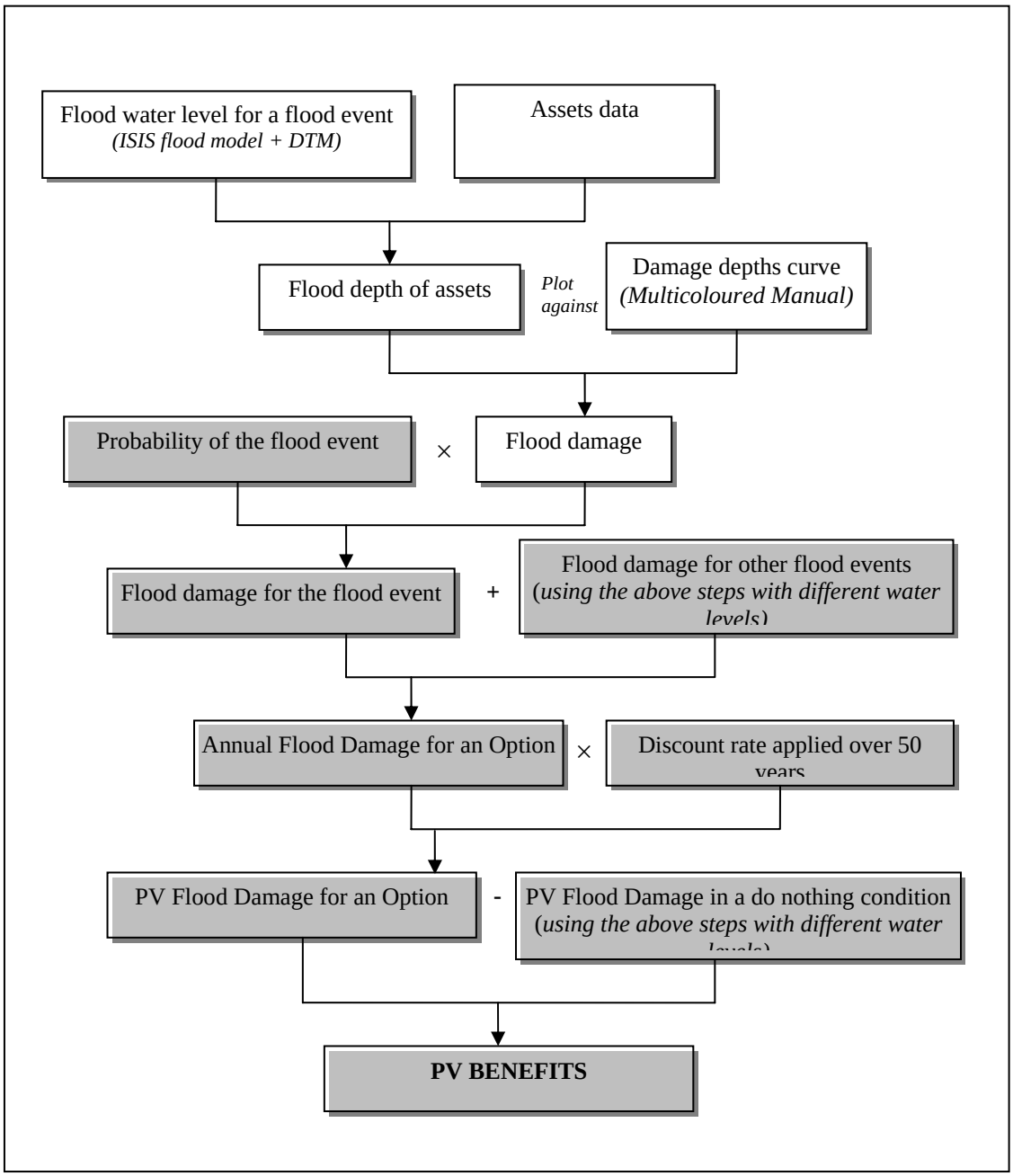

Figure 4.3 Principle steps in benefit assessment.

4.6.2 Asset data

Asset data for residential, commercial and industrial, agricultural land and caravan sites has been obtained for all assets within the Roach and Crouch study area. This data was imported into the DTM together with ISIS output data of water surface elevation in order to determine ground and water levels at each asset location. A value of 150mm was added to the elevation of each residential, commercial and industrial property to allow for standard building regulation threshold requirements. This provided flood depth information to be used in the calculation of asset damages.

(a) Residential Properties

The location of residential properties (eastings and northings) was obtained from Ordnance Survey Address Point data, provided by the Environment Agency. This data contains a record of each postal mailing address in the

study area. To enable the use of damage depth curves in the Multicoloured Manual (FHRC, 2003), which was established by property type basis, the following approach has been used.

For the purpose of RCFMS benefits assessment, it was considered acceptable to relate the property types with Council Tax bands. Council Tax band information was obtained for all residential properties from the Valuation Office website. Within the RCFMS study area, between five and ten properties were randomly selected from each Council Tax band for the determination of their property type by the Valuation Office. This data was used to derive the percentages of each property type associated with each Council Tax band. The percentages were randomly applied to all residential properties within the study area to give a reasonable estimation of property type distribution.

The Address Point data and Council Tax band (with property type) data sets were combined based on the address and postcode fields (which are common in both data sets). The combined dataset was then imported into the DTM. Duplicate entries (in terms of eastings and northings) were removed from the dataset, as were those properties classed as flats that were assumed to be on the first floor of properties or higher (as these would not be directly affected by flooding). The Council Tax band of properties not listed on the Valuation Office website was assumed to be the same band as their neighbours.

The data collation process for the residential properties is summarised in Figure 4.4.

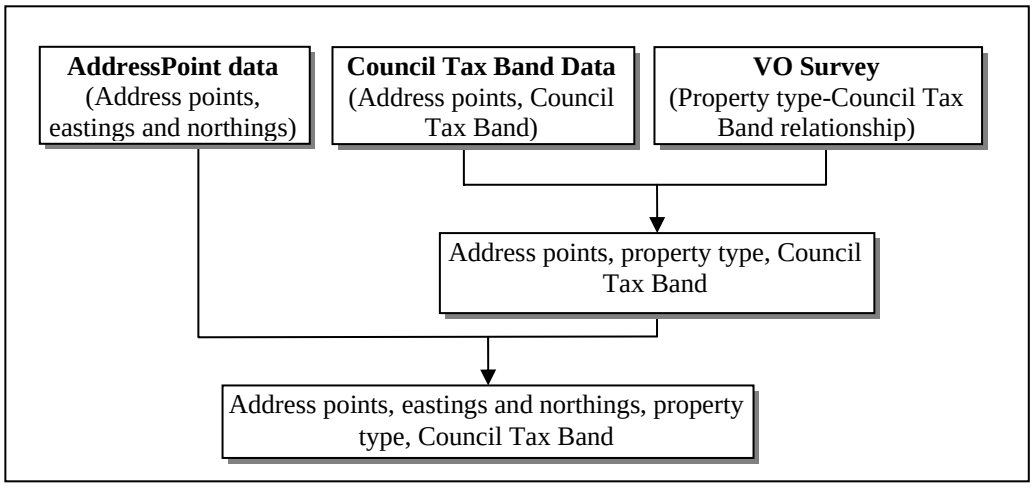

Figure 4.4 Residential properties data collation process.

(b) Commercial/Industrial Properties

Address Point data provided by the Environment Agency also includes information on the location (eastings and northings) and address/postcode of each commercial/industrial property. It consists of address/postcode, type of commercial/industrial properties and rateable values. This database is compiled and maintained by the Valuation Office Agency and is updated every 5 years. The two data sets, Address Point and FOCUS, were joined, based on the address and postcode fields.

The floor area of each property was determined using standard values from the Multicolour Manual (FHRC, 2003). The standard floor area for each commercial or industrial property type is based on a database of floor areas that were surveyed for the Multicoloured Manual. The suitability of these values varies since floor area can be based on one or many surveyed properties. It was considered acceptable not to determine the actual floor area of each commercial or industrial property in the study area at a strategic level.

The data collation process for the commercial properties is summarised in Figure 4.5.

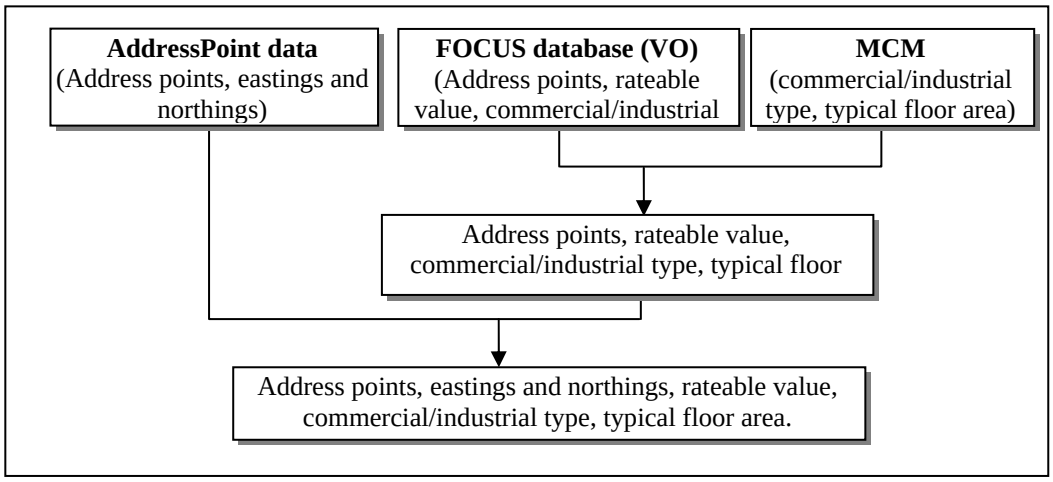

Figure 4.5 Commercial/industrial properties data collation process.

(c) Agricultural Land

Flood damages to agricultural land have been determined based on a new agricultural land classification that was developed specifically for the Roach and Crouch Flood Management Strategy.

A local chartered surveying and valuation consultant was commissioned to undertake a field survey in the winter of 2002 to reclassify all agricultural land within the Roach and Crouch study area. The results of the reclassification, termed as W&N land classification hereafter, has been used in preference to the Defra Agricultural Land Classification (ALC) data because the W&N land classification data reflects changes in farming practice and technology that have occurred since the introduction of Defra ALC system.

The W&N land classification was divided into the following categories:

- Good easy working arable land
- Good heavy arable land
- Medium or poor arable land
- Good grass land
- Medium grass land
- Poor grass land

The majority of the land within the study area is good arable land.

The W&N land classification was compared with the Defra ALC system within the Roach and Crouch study area. Table 4.1 shows that there is a strong correlation between W&N and Defra ALC land classification grades, with the percentage of good arable land reducing and grassland increasing with the reducing Defra ALC grade. In many locations, the Defra ALC Grade 5 land coincided with existing salt marsh, with the exception of the head of the River Crouch, where Grade 5 land was identified in an area that Whirledge and Nott had classified as Arable Good (81%) and Grass Good-Medium (19%). It was assumed that the Defra ALC map was incorrect at this location since the results did not correspond with the observed relationship between Grade 5 land and salt marsh.

W&N Land Classification	Defra Agricultural Land Classification				
	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
1 (Arable Good, Easy-Working)	60%	36%	4%	5%	Salt marsh
2 (Arable Good, Heavy-Working)	5%	29%	39%	29%	Salt marsh
3 (Arable Medium-Poor)	-	-	-	1%	Salt marsh
4 (Grass Good-Medium)	35%	35%	52%	60%	Salt marsh
5 (Grass Poor)	-	-	5%	5%	Salt marsh

Table 4.1 Percentage of Whirledge and Nott agricultural land classification within Defra ALC boundaries

(d) Caravans

Caravan site locations were identified from Address Point Data. Numbers of static caravans, tourer pitches and fixed facilities were provided directly by caravan site owners. This information was incorporated within the DTM, with the coordinates and site areas provided. It was assumed that only static caravans would attract flood alleviation benefits.

(e) Contaminated Land

The Strategic Environmental Assessment (SEA) of the RCFMS identifies locations within the Roach and Crouch study area that comprise landfill, refuse-filled seawalls or potentially contaminative former land use.

A cost estimate has been developed to determine an approximate cost for the removal of each of the contaminated land types described above. Information has been obtained on the history and previous land use of the sites from historical Ordnance Survey maps and records, information obtained from provisional enquires with Local Authorities and through data collated from Environment Agency consultation. These sites (both former and existing) are likely to require further investigation if a scheme is to be implemented and especially if managed realignment or No Active Intervention is proposed.

All flood defences are likely to include a short length of breach within the 50 year life of the Strategy under the Do Nothing option and therefore all contaminated land within the 1 in 300 year flood extent would prudently need to be removed in order to avoid contamination of the Roach and Crouch estuary complex.

Quotations have been obtained from a contaminated land removal specialist for the haulage and disposal of either inert/non-hazardous and hazardous contaminated material.

The quantity of contaminated refuse filled seawall material has been estimated based on the assumption that 50% of the seawall cross-sectional area would be removed and the wall length has been scaled off the figures presented in the SEA. The quantity of potentially contaminated land and landfill has been estimated based on the calculated plan area of the contaminated land site using GIS applications and the assumption that the material would be excavated to a depth of 2m. The type and degree of contamination has been determined from information presented in the SEA.

In order to determine whether contaminated land would need to be removed prior to the implementation of any scheme and the true cost of these works, it is recommended that a comprehensive ground investigation is undertaken at scheme appraisal stage.

It has been assumed that there is no justification for the removal of landfill sites, refuse filled seawalls or potentially contaminative former land use sites within the 1 in 300 year flood plain, unless the FMU has been identified as a potential realignment or No Active Intervention site, which could result in a significant contamination event.

4.6.3 Damages

Flood damages have been considered for residential properties, industrial, commercial properties, agricultural land, caravans, emergency services and traffic disruption based on the output of numerical flood modelling studies for a range of extreme events ranging in frequency from 1 in 1 year to 1 in 300 years.

Damage costs for properties have been predicted using the damage curves for residential, commercial and industrial properties provided in the draft Multicolour Manual (Middlesex University, 2003) with a minor Retail Price Index (RPI) adjustment. The saltwater damage curves have not been used as, through communication with the Flood Hazard Research Centre (FHRC), they are suggested to be unreliable due to limited number of samples. In order to reflect the fact that saltwater causes more damage than freshwater, the damage curves with longer flood duration (more than 12 hours) have been used. This information is not available for commercial/industrial properties; hence data for flood disruptions less than 12 hours have been used. Saltwater damages have been taken into account in the agricultural land damages.

This methodology was directly applied to residential, commercial/industrial and caravan damages. However, agricultural damages are calculated by multiplying the area of flooded land by the agricultural damage rate which is highly dependent on the frequency of occurrence. Therefore, the agricultural damages for the 'Do Something' options were calculated by transferring the plan area of flooded agricultural land (rather than the damages) to the relevant return period, from which the agricultural damage were calculated.

The Do Nothing present damages have been used to derive the flood damages for all 'Do Something' options using the method described above, with the exception of the sustain option, where the Do Nothing present damages are assumed to be the same as the Sustain future damages.

(a) Residential Properties

Flood depth damage curves for residential properties have been taken directly from the Multicolour Manual.

(b) Commercial/Industrial Properties

Flood depth damage curves for commercial/industrial properties have been taken directly from the Multicolour Manual.

(c) Agricultural Land

Analysis of the agricultural benefits associated with each defence option gives consideration to the total loss of yield to crop production, costs for reinstatement of the land and depreciation in land value land under each of the flood events. The crop loss and land reinstatement costs were derived from Nix Farm Management Pocket Book (Nix, 2003), the Soil Survey of East England, anecdotal evidence following the 1953 and 1978 floods and a field investigation /desk study into land fertility, accessibility, field size, topography and climate.

Land use was assumed to comprise 60% winter wheat, 30% oilseed rape, and 10% fallow for the remaining time. Land depreciation has been calculated for return periods less than or equal to a 1 in 5 year flood event as the difference between the write off values and market values. For flood events with higher return periods, depreciation has been based on a percentage of the land purchase costs, which are the Agency's standard allowances for land value depreciation. The damages incurred are taken as the combination of crop loss and land value depreciation.

A local chartered surveying and valuation consultant undertook a consultation exercise to obtain anecdotal evidence of the duration of the impact of salt water inundation. The questionnaire requested a variety of information including the type of flood event (breach or overtopping), flood duration, the impact on drains and ditches, the impacts on arable and grass land, a description of the reinstatement works, and the period of land recovery. The survey result shows that the typical time taken for arable and grass land to fully recover following a flood event was approximately 6 and 5 years respectively, although the land was partially productive after 4 and 3 years respectively.

For the Do Nothing option, it is assumed that the agricultural damages will only occur once after the flood defences have breached and therefore the damages only comprise land value depreciation. For the 'Do Something' options, these damages may be incurred more than once during the 50 year life of the Strategy, since the flood defences are repaired after the breach event, and therefore the flood damages comprise crop loss and land value depreciation.

The Do Nothing agricultural damages are calculated using the Do Nothing Linear (DNL) FCDPAG3 spreadsheets. Up to the year of failure of the flood defences (assumed to be the residual life), the damages are calculated by

taking account of the probability of breach occurrence due to overtopping and the future (Year 50) agricultural damages. From the year of failure to Year 50, only Average Annual Damages (AAD) apply, which are assumed to incrementally increase with sea level rise.

For the Maintain option, the damages are calculated by assuming that all agricultural land flooded within the 1 in 5 year return period storm event is written off in Year 0. For damages due to the 1 in 10 to 1 in 300 year return period events, these are incurred as AADs and incremental write-off damages.

For the Sustain and Improve options, the damages are calculated using the same methodology as for the maintain option up to the year of improvement (i.e. at the mid-point of the residual life band) and thereafter the AADs remain constant.

For the purpose of the RCFMS, a sensitivity analysis was undertaken to identify the economic consequences of either assuming one year of crop loss (as considered in FCDPAG3) or up to 6 years of full or partial crop loss, as described above. The result is discussed in Section 4.7.4.

(d) Caravans

The depth damage curve for caravans has been developed from curves provided in the Flair 90 manual for prefabricated housing (land use code 17) since the relevant curves in the Multicolour Manual were found to grossly over-estimate damage values for caravans. The Flair 90 values were then multiplied by a factor of 1.474 to bring them up to 2003 prices. The values for damage per square metre (£/m2) have been used for an assumed typical caravan floor area.

(e) Emergency Services

The damage costs for emergency services are calculated in accordance with the guideline in Section 7.4.5 of the MCM with costs per FMU based on a 10.7 percent of the residential property losses in each FMU.

(f) Traffic Disruption

Traffic disruption during flood events in parts of the study area would be expected. Quantification of traffic disruption in cash monetary terms is extremely difficult and likely to be very small in relation to damage to properties. In addition, there are no major roads or motorways linking major cities in the study area and the predicted flood levels are not high enough to pose a threat to the rail connection in the north of the flood risk area. Considering the small scale of impacts of the traffic disruption assessment to the overall economic appraisal, it was decided not to include these potential damages.

(g) Reactive Breach Repair Costs

Assessment has been undertaken to develop costs for the reactive breach repair to sections of seawall following a severe storm event where a breach in the seawall has occurred i.e. when the overtopping threshold has been exceeded. These costs are based on estimated site-specific rates for the removal of the damaged sections of the wall and replacement with a similar structure in the Roach and Crouch study area. These works would be undertaken at short notice and would therefore be subject to a degree of cost increase due to the emergency nature of the works. Breach lengths have not been taken into consideration, although it has been assumed for the purpose of this costing that the breach repair cost be will be applied to each kilometre length of flood defence affording a different SoP within each FMU. The cost rate for reactive breach repair is £40,000 per km length of flood defence and is consistent throughout the study area. This cost includes emergency mobilisation of plant and an emergency works factor.

The reactive breach repair cost incurred as flood damage per year is calculated by multiplying the reactive breach repair cost by the breach probability. As the probability of breaching increases with time, the reactive breach repair cost per year increases accordingly.

Under the Maintain option, the existing probability of breaching was used to calculate the breach repair cost. Until capital works are undertaken at the mid-point of the residual life band to improve the defence level or the probability of breaching under the Sustain and Improve options, the existing probability of breaching was applied. Although the improved probability of breaching under the Sustain and Improve options were taken from the analysis for Year 50, it is considered acceptable for the purpose of RCFMS economic appraisal to use this probability as soon as the defence level is improved. This will give a more conservative estimate of the cost.

(h) Removal of contaminated land costs

As described in Section 0 (e), estimated costs have been obtained from a contaminated land removal specialist in order to calculate an approximate benefit against which the 'Do Something' options can be justified.

In some cases, the potentially contaminative land may prove on inspection to be inert. It is highly recommended that accurate contaminated land removal costs are obtained following a comprehensive site investigation, prior to the implementation of any scheme that could impact on contaminated land.

It has been assumed that all the contaminated material is suitable for landfill and there is no excavation bulking effect, and the bulk density of the material is similar to the typical bulk density of soil.

4.6.4 Near and Far-Field Economic Benefits of Managed Realignment

Adopting a Hold the Line or Managed Realignment policy in any FMU within this sensitive estuary complex may have hydrodynamic impacts to neighbouring FMUs (near-field effects) or to other reaches of the estuary (far-field effects). The near and far-field effects may be particularly evident where there is high confidence that the estuary would like to naturally realign landwards, applying higher hydrodynamic stresses to the existing defence.

Consequently, by implementing a Managed Realignment option at these locations may relieve the hydrodynamic stresses leading to reduced flood defence capital maintenance costs in neighbouring FMUs (near-field economic benefits) or in other reaches of the estuary (far-field economic benefits).

Following consultation with Defra in January 2004, a preliminary economic appraisal technique was developed to provide a best estimate of the near-field economic benefits associated with the preferred and provisional Managed Realignment options identified in the short, medium and long-term plans.

The economic appraisal technique applies the capital maintenance costs presented earlier in this report, contemporary bed shear stress values from hydrodynamic modelling studies and the results of analysis of the hydrodynamic sustainability of the estuary. This data has been used to identify the potential reduction in flood defence present value capital maintenance costs that may be achieved through implementing Managed Realignment options at locations where there is high confidence (greater than 50%) that the estuary would like to naturally realign landwards. The results of this analysis indicate that the total present value capital maintenance costs presented in the Strategy could be reduced by approximately £6m if the existing stresses on the flood defences are reduced to acceptable values through the implementation of Managed Realignment options, where the estuary would like to naturally realign landwards.

In some FMUs it may appear to be uneconomic to implement a Do Something option although there is indication of a high confidence that the estuary would like to naturally realign landwards. In these FMUs, it is considered the near and far-field benefits of a holistic realignment strategy should be taken into consideration for the justification of implementing Managed Realignment option. This achieves the RCFMS's primary objective of promoting the progressive development of a more sustainable estuary shape and contributes to salt marsh generation.

These benefits have been assigned to flood defence lengths where the estuary would like to naturally realign landwards and the FMU has been identified as Defra Sea Wall Classification category 3 (uneconomic to maintain although there is justification due to the uncertain and unacceptable risk associated with withdrawal of maintenance). This approach may provide the necessary economic justification to realign higher risk uneconomic FMUs in the medium to long-term and therefore satisfy:

(i) the strategic objectives; and

(ii) the aim of the latest Defra guidance for the production of Shoreline Management Plans (SMP2, Halcrow 2003), to "promote sustainable management policies for the coastline into the 22nd Century, which achieve long-term objectives without committing to unsustainable defences".

Whist this technique deviates from the standard Defra Project Appraisal Guidance economic appraisal, it is critical that the near and far-field benefits of a holistic realignment strategy are quantified and considered. It is recommended that the technique developed for the Roach and Crouch Flood Management Strategy is developed further as part of the remaining Essex Estuary Strategies and future Strategy Reviews. This could be achieved by comparing historical and future maintenance expenditure at specific sites and hydrodynamic monitoring at realignment sites.

4.6.5 Write-off values

An asset is assumed to be written off economically once the accrual PV damages exceed the write off value of that asset, although it may be not physically written off. For all residential, commercial/industrial and caravans, the write-off (capping) value is the current capital value of the property. For agricultural land the write-off value is taken as 45 percent of the current capital value of the land in accordance with FCDPAG3 recommendation.

For the purpose of RCFMS economic appraisal, the sum of the write-off values of all the assets within the 1 in 300 year flood plain in each FMU was used to limit the PV flood damages incurred within each FMU. Contaminated material/land removal costs were not included in the FMU's write-off value. They are added to the final capped/uncapped flood damages value.

(a) Residential properties

The write-off value for residential properties has been derived from the council tax band information. This tax band information was related to the property type as discussed in Section 0 (a). Each tax band covers a range of estimated values of the residential property at 1st April 1991. The average value of that property type was inflated to 2003 prices using the housing price index provided by the Nationwide Building Society website for the East Anglian region.

(b) Commercial/Industrial

Rateable values were obtained from the FOCUS database for commercial and industrial properties. This value has been converted into a capital value for the property by applying a multiplier as stated in the Waveney District Council Coastal Strategy Study (Valuation Office, 2000). This multiplier has been taken as the average value in the RCFMS, which is 10.

(c) Agricultural Land

Land purchase costs for all grades of agricultural land in the Roach and Crouch study area were provided by Whirledge and Nott, based on land values given in the Nix Farm Management Pocket Book (Nix, 2003) and direct experience of land prices within the study area. It was assumed that all agricultural land is written off if flooded more frequently than every 5 years. It was estimated that the write-off values for total loss of arable land are lower than that of grassland, on the basis that grassland would be generally more resistant to saline conditions and therefore could be purchased for immediate non-agricultural use, whereas arable land would eventually become non-productive grassland.

These write-off values have been taken in preference to 45% of the value of the land purchase costs in accordance FCDPAG3, because the detailed data provided is considered more representative of the likely damage costs to be incurred.

(d) Caravans

The economic value for temporary structures such as caravans is deemed to be the equivalent cost of moving it and establishing a new site, not the value of the unit itself, which could be retained if it were to be moved elsewhere. The economic loss is therefore limited to the cost of removing the caravans together with the loss of installed infrastructure and this in turn limits the flood damage contribution made by caravans to the overall flood damages.

Cost information for relocation of caravan sites has been developed through discussions with an independent caravan site developer and ratified against information provided by Defra for the Lincshore Strategy Review (Halcrow, 2003b). This cost includes for provision of a new site assuming Grade 5 agricultural land, infrastructure to include provision of services, hard standing, access roads etc. and transport costs for removal of the caravan.

4.6.6 Flood Depth Damages Calculations

Flood depth damages have been calculated using Halcrow's Damage Calculator v1.0.1 (see Figure 4.6). This application calculates damages due to flooding at properties for multiple return periods. The total costs are expressed as the total of the damages to residential properties, commercial and industrial properties and caravans. The application only provides damage values for properties, with damages to other items requiring separate consideration (e.g. agricultural land, emergency services, and traffic disruption).

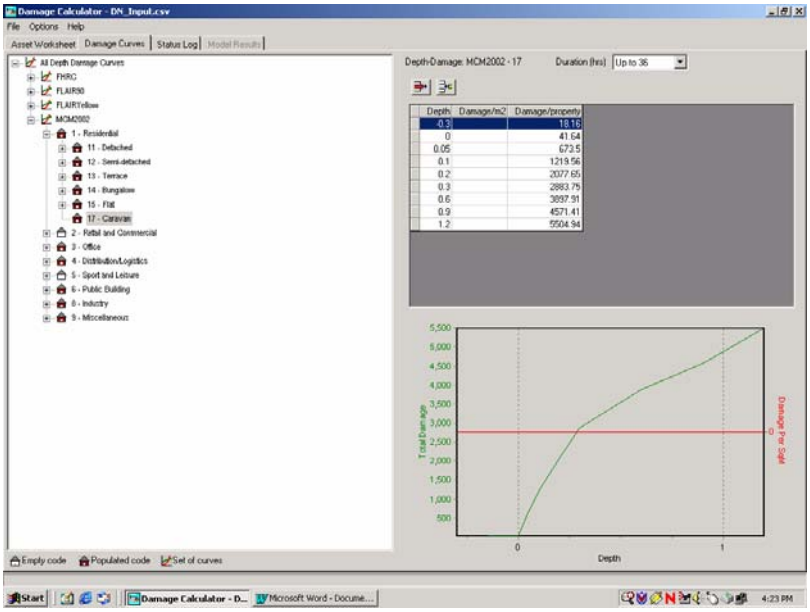

Figure 4.6 Example damage curves used in flood damage calculation.

The total flood damages have been compiled from flood damage values for residential properties, industrial/commercial properties, caravans, emergency services and agricultural land, for the quantative assessment of the benefits for each strategic option.

4.7 FCDPAG3 Economic Appraisal

4.7.1 Introduction

The FCDPAG3 guidance and spreadsheets were used to carry out the economic appraisal of strategic options for each FMU.

As discussed in Section 4.4.1, the base PV costs (without contingency) for the options have been increased by 60% to reflect the optimism bias appropriate to a project at strategy stage. There is a high degree of confidence that the overall costs at this strategy stage are adequate for the determination of whether the hold the line policy could be justified, or whether the Agency should cease maintenance of the defences.

More detailed studies will be required to progress the recommendations for the first five years, with early framework contractor involvement in the preparation of cost estimates.

4.7.2 Benefit Cost ratios

The benefit cost ratios for each option within each FMU is calculated in the FCDPAG3 spreadsheets. The RCFMS demonstrated that it would not be economically viable to achieve strategic flood defence options 2, 3, 4 or 5 by maintaining, sustaining or improving all of the flood defences within the Roach and Crouch study area, or ceasing Environment Agency maintenance of all uneconomic FMUs.

4.7.3 Choice of Preferred Option

The FCDPAG3 decision process has been followed for the selection of the most economically robust option within each FMU.

The selection of the most economically viable options does not take account of any environmental, hydrodynamic, estuarine processes and technical constraints. The basis for selection of the preferred option for each FMU is based on the following five stage decision making process:

Stage 1: An assessment of flood management policies (No Active Intervention, Hold the Line, Managed Realignment and Advance the Line) against each of the strategy objectives. This stage is a coarse filter that has been undertaken to identify the preferred policies that should be taken forward for the whole FMU in order to meet the strategy objectives;

Stage 2: Identify the flood management option(s) that would successfully implement the preferred policies;

Stage 3: Appraisal of each of the flood management option(s) against key economic, technical, hydrodynamic, social and environmental issues. This stage also comprises the identification of the most economically viable, environmentally acceptable and hydrodynamically sustainable options;

Stage 4: Apply the Defra Sea Wall Classification (Defra, 2004) to all flood defences that are uneconomic to maintain over the strategy appraisal period;

Stage 5: Identify economically viable, environmentally acceptable and hydrodynamically sustainable preferred flood management option(s) for the short (0-5 years), medium (5-20 years) and long-term (20-50 years) to reflect the first five years of planned work and the first two SMP epochs.

Within the decision making process, opportunities have been identified for the implementation of other flood management options in the short, medium and long-term in order to meet the strategic objectives. These are referred to as provisional options and will be assessed through a more detailed feasibility assessment in conjunction with the scheme specific studies for the preferred options. The feasibility of the provisional option(s) will be assessed in terms of the long-term economic, environmental and hydrodynamic benefits or losses (e.g. estuary wide economic benefits, leaching of contaminants). This process is summarised in Figure 4.7.

In recognition of the very real implications of No Active Intervention and Managed Realignment policies, this pragmatic approach to changing flood management policies over time is adopted in this strategy plan. In particular, uncertainties over the response of a vast and complex estuarine system to radical, short-term changes has led to the prudent decision to continue to maintain some uneconomic defences until later epochs. This wills not only enable increased understanding of physical response to be gained through monitoring and observation, but it will facilitate changes in asset management practices (including land management) in future potential flood risk areas, to minimise the potential for damage and disruption.

In most cases, the need for environmental mitigation will be identified and implemented as part of scheme implementation. The cost profile for implementing the prioritised options includes for 60% contingency on base estimates, to reflect Optimism Bias.

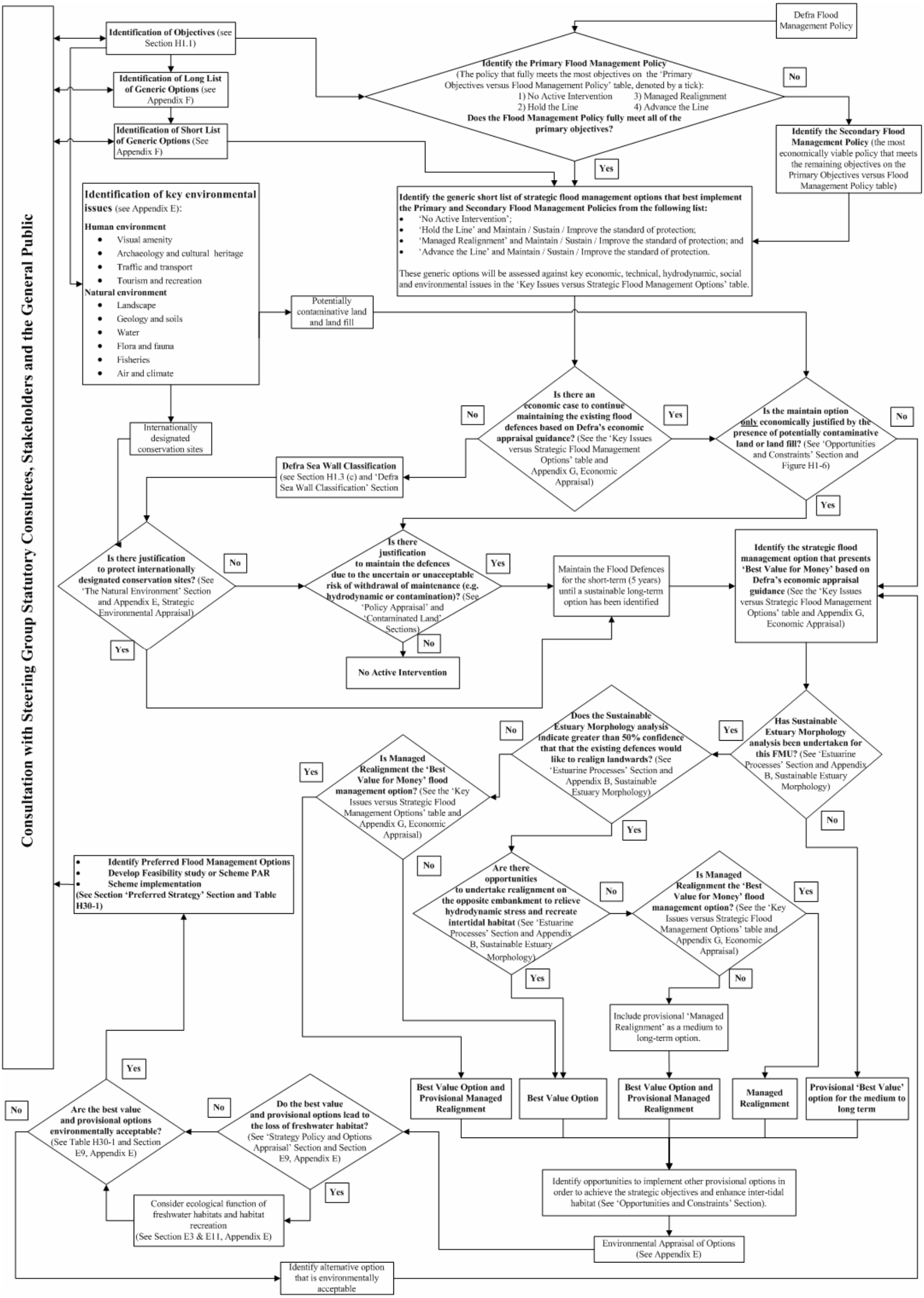

Figure 4.7 – The Decision Making Process

4.7.4 Economic Sensitivity Tests

Economic sensitivity tests of the preferred option have been undertaken in order to address the following questions. The results of the sensitivity analyses are provided below.

(i) What are the economic implications of assuming that flood defence maintenance and capital works will be constructed using in-situ material?

Ans: Discussions have been held with Environment Agency Area engineers regarding current practice for flood embankment maintenance and capital works. Where suitable, material for embankment reconstruction is locally gained from areas landward of the existing flood defences and therefore this approach has been assumed for the purpose of this economic analysis. However, if the fill material was imported (i.e. local material is not suitable/available), a unit rate of £10/m^3 for embankment construction would be assumed, based on other earthworks schemes.

A sensitivity analysis of the proactive breach repair costs indicated that increasing the embankment construction cost rate from £5/m^3 to £10/m^3 would increase the total proactive breach repair capital cost per FMU comprising earthworks by an average of 20%.

The sensitivity analysis was repeated for the sustain, improve to low indicative standard and improve to high indicative standard throughout the estuary complex (i.e. Options 3, 4a and 4b). This analysis showed increases of 6.7%, 7.2% and 11.6% in the capital costs respectively.

(ii) What are the economic implications of assuming that crop loss and agricultural land reinstatement costs will be incurred over 4-5 years, rather than a single year?

Ans: A sensitivity analysis has been undertaken to identify the economic consequences of applying either 1 year of crop loss damages per flood event (as recommended in FCDPAG3) or 4 - 5 years of crop loss and agricultural land reinstatement costs per flood event, as identified during the Whirledge and Nott consultation exercise. More specifically, attention was paid to whether the use of the one year flood damage data set would result in the selection of different strategy options to those identified using the 4 to 5 year flood damage data set.

The average PV damages increased by the percentages shown in Table 4.2, when calculated using the 1 year and 4 to 5 years of crop loss data sets (i.e. the percentage of 1 year data set damages).

Option	Option 2 (Maintain)	Option 3 (Sustain)	Option 4a (Improve to	Option 4b (Improve to
% increase	6%	13%	13%	16%

Table 4.2: Percentage increase in strategy option PV damages

The economic analysis was undertaken using both agricultural flood damage data sets and showed that the only FMUs for which the most economically viable option changed were FMUs 15 and 16. The most economically viable option for FMU 15 was identified as Improve to a 1 in 100 year indicative SoP, using the 4 to 5 years of

crop loss data and Improve to a 1 in 10 year indicative SoP, using the 1 year of crop loss data. FMU 16 was identified as Improve to a 1 in 100 year indicative SoP, using the 4 to 5 years of crop loss data and Maintain, using the 1 year of crop loss data. This sensitivity analysis therefore demonstrates that using the 4 to 5 years of crop loss dataset only has a minor impact on option selection.

(iii) What would be the economic implications if site investigations identified that the potentially contaminative land is inert and would not need to be removed under a Do Nothing scenario?

Ans: A sensitivity analysis has also been undertaken to determine whether the preferred flood management policy for each FMU would change if: i) further site investigation results identifies that potentially contaminative material, refuse-filled sea wall or land fill is non-hazardous and inert or ii) funding for the removal of potentially contaminative material is provided by an external organisation. The results of this analysis are presented in Appendix H and show that the preferred flood management policy would change for six FMUs located within the River Roach and River Crouch.

4.8 Defra Scheme Prioritisation

4.8.1 Introduction

The aim of the Defra scheme prioritisation system is to "*ensure the equitable distribution of funding supporting the provision of flood and coastal defence solutions"* and to "*ensure that the most worthwhile schemes are carried out first and to allow authorities to devote resources to those projects*".

However, based on estuarine processes analysis for the Strategy, it is recommended that consideration should be given to adopting an alternative mechanism for deciding on the timing for realignment schemes. It is proposed that "*managed realignment schemes should be implemented progressively from the middle reaches of an estuary in pairs, the first of each pair should be downstream of the planned second of the pair (which will be upstream of the first); ideally the pairs would be on opposite sides of the estuary. Once the first pair has been established a second pair, surrounding the first pair, can be implemented in the same manner, and so forth"*. Some of the possible advantages of this management option are summarised below, although it is recommended that research be undertaken into the merits of this approach. The full list of potential advantages is given below:

- realignment of only inner estuary sites can result in major channel widening throughout the estuary to its mouth involving the loss of salt marsh;

- realignment of only outer estuary sites results in sediment release which may result in increased sub-tidal deposition and impacts on water quality, navigation etc. Furthermore, it is possible that the impacts of restoring sites in a landward direction starting at the mouth of the estuary may have irreversible consequences upstream;

- the location of the switch point from outer estuary erosion to inner estuary accretion is unknown, but likely to be somewhere in the middle reaches of an estuary. It would therefore seem prudent to try and work with this low energy location in terms of minimising the wider estuary impacts of realignment; and

- it is speculated that implementing managed realignment schemes via pairs of locations starting at the middle estuary reaches may minimize the potential for rapid large-scale changes in estuary dynamics.

Consequently, careful consideration will need to be given to the prioritisation sequence in which managed realignment schemes are implemented based on the above proposal, whilst taking account of the Defra scheme prioritisation system.

4.8.2 Summary of Defra Priority Score Parameters

It has been identified that several of the preferred Managed Realignment options do not achieve the Defra Priority Score threshold.

Therefore, it is recommended in the Strategy that further consideration is given to the mechanisms for prioritising and implementing Managed Realignment options within the Roach and crouch estuary Complex in the short term where economically, technically and environmentally feasible. This may be achieved through the development of partnerships with conservation groups and Countryside Stewardship funding, which would enable the process of breaching and managing the site to be undertaken in controlled conditions. These site management partnerships would be subject to the existing land owner's consent.

5. Future Economic Appraisal Development Opportunities

5.1 Introduction

This section discusses the development in economic appraisal after the complement of the RCFMS in 2003 and future development opportunities to improve the quality of the appraisal results and to optimise the investment of time and effort in the appraisal process.

5.2 The Process

A transparent, integrated benefit cost analysis process (see Figure 5.1) involving modelling software packages, GIS analysis and approved spreadsheets was established in the RCFMS. However, the process required manual conversion of the outputs of these analytical tools in order to produce results in formats compatible to other tools. This could be achieved by developing an 'over-arching' tool, such as a software package that links to other software packages (including GIS software) and approved spreadsheets.

5.3 Data Collation

Data collation in economic appraisal is a complicated and involved process. The data required for the economic appraisal of flood and coastal defence projects includes cost data, hydrodynamic data, wave data, rainfall data, topographical data, defence data, asset data, etc. It is preferred that the historical changes of the data are available to aid the prediction of future scenarios and economic appraisal.

Although there are not many development opportunities in the data collation technique, but it would be useful if the flood and coastal defence projects could include a plan to monitor and record the above data following implementation of the defence option, in particular for managed realignment as it is a relatively new defence option, for future strategy development and studies.

5.4 Modelling Techniques

It is recognised in the RCFMS of the need of suitable modelling techniques for the prediction of estuarine processes, in particular the impact of implementing managed realignment schemes. This will improve the level of confidence of the modelling results, and also identify potential saving in time and effort. The application of the modelling output for carrying out defence risk assessments should be considered in the development of the modelling tools.

5.5 Cost Estimates

As discussed in Section 4.4, the cost estimates for each flood management option were determined with reference to a range of flood defence schemes and studies in Essex and the input of the Agency Area engineers on current maintenance together with a framework contractor to advise on unit rates to be used. Generic costs rates were used in the RCFMS in all FMUs. This was considered acceptable at this stage of development.

The RCFMS cost estimates could have been refined to FMU-specific rates. The haulage and mobilisation/demobilisation costs could vary considerably with the Roach and Crouch estuary.

5.6 Benefit Assessment

A majority of the current best practice for flood and coastal defence projects economic appraisal are for the assessment of tangible losses. There is relatively less guidance and tools developed for the quantification of intangible losses including physical and mental health/stress effects, loss of confidence in the authority, loss of community, loss of irreplaceable items such as photos/memorabilia and impacts to environment.

The RCFMS economic appraisal covered a majority of tangible benefits but very few intangible benefits due to data, time and financial constraints. Apart from using the current best practice in evaluating the tangible benefits, the RCFMS has improved the evaluation of agricultural land benefits by incorporating local knowledge and experience in the Roach and Crouch estuary with input from a local surveying and valuation consultant. Local farmers have been approached by the consultant to collate data by means of questionnaires. This has attributed to a more realistic economic appraisal as the agricultural land is one of the major assets with the study area.

In July 2004, Defra published a supplementary note to Operating Authorities covering Defra's policy on socio-economic equity and appraisal of human related intangible impacts of flooding. The distribution index is introduced to reflect the impacts of flooding for different social classes. The method of quantifying human related intangible impacts including increased stress, health effects and loss of memorabilia has been detailed in the supplementary note. Both the socio-economic equity and appraisal of human related intangible impacts of flooding were not considered in the RCFMS as they were introduced by Defra after the completion of the RCFMS.

For the environmental related benefits, there have been a few studies undertaken on the benefit evaluation methods for a wide variety of environmental opportunities (see Section 6). These methods are very likely to have been employed in flood and coastal projects in the UK. As discussed in Section 3.9, there is relatively limited contribution of environmental enhancement benefits to the overall Defra priority score, unless economic value of these benefits could be quantified. Therefore, there is a need to develop a widely accepted environmental benefits evaluation tool or guidance based on the experience of using current valuation methods, together with further research.

In the RCFMS, contribution to a sustainable estuary shape has been identified as an intangible benefit associated with the development of the flood defence options. As the estuarine processes are complex. Any changes in the processes would have impacts elsewhere with the estuary. The RCFMS economic appraisal considered the reduction in hydrodynamic stress within the Roach and Crouch estuary as one of the benefits of the managed realignment option. It is divided into near field (neighbouring FMUs) and far field (other reaches) benefits. The economic value of the reduction in hydrodynamic stress benefits is quantified in monetary terms, based on the capital maintenance costs of the defences near and far fields, contemporary bed shear stress values from hydrodynamic modelling studies and the results of the estuary processes analysis.

This is a preliminary approach and has uncertainties due to lack of detailed data on potentially contaminated land which restricts the selection of the alignment of the set back defence, and due to the lack of historical physical process data. Further research into this approach will not only improve the benefit evaluation but also contribute to the sustainable development of the estuary.

There are also opportunities to develop methods to assess benefits arising from other functions associated with flood and coastal defence options, such as improvement to navigation, fisheries, amenity, etc

6. Environmental Flood Management Benefits

6.1 Introduction

This section covers the environmental benefits arising from managed realignment schemes compared to other options such as no active intervention or hold the line. The current environmental benefits evaluation methods are discussed. An introduction to Managed Realignment is also given.

6.2 Introduction to Managed Realignment

Realignment is the process of re-introducing tidal regimes to previously protected or reclaimed land. This realignment can be undertaken with varying degrees of management. Managed and unmanaged realignment are defined, in the context of RCFMS, as follows:

- Managed realignment is a fully managed process and involves deliberately breaching or entirely removing an existing flood defence having identified and quantified the likely consequences.

- Unmanaged realignment is the systematic identification of areas where realignment is an option, quantifying the likely consequences and then ceasing to maintain the defences in a planned fashion, accepting that over time the flood defences are likely to breach without intervention.

The key functions of a realignment site may include biological, physical, chemical, social and economic issues.

A significant number of managed realignment schemes have been undertaken in relation to sea defence issues in the UK. Such schemes can reduce the maintenance costs of extensive lengths of older defences and provide reductions in water levels and flood risk within estuarine environments.

There are a number of different approaches to managed realignment. These all involve the reintroduction of tidal waters to areas, but differ in the method of achieving this:

- Regulated tidal exchange using tidal flaps, valves and weirs/spillways;

- The removal of a section of seawall to create a breach (breached retreat);

- The removal of the entire seawall (banked retreat).

Regulated tidal exchange can be used to adjust the tidal inundation to favour a particular habitat type.

6.3 Comparison between Economic Appraisal of Managed Realignment and No Active Intervention

Compared to No Active Intervention option, the benefits of Managed Realignment might include a higher value of habitat created and/or benefits from the recreated habitat occurring earlier. This added value will be compared against the cost of whether new defences need to be set up inland or not, depending on whether:

- the topography of the site requires it;
- the value of the assets to be protected; and
- the costs of building the defence.

6.4 Comparison between Economic Appraisal of Managed Realignment and Hold the Line

The main economic cost of Managed Realignment is the opportunity cost of the land that was originally protected by the existing defence (this is equivalent to saying that the benefits of holding the line are the avoided damage costs of flooding). The net benefits of Managed Realignment can be considered as the opportunity cost of Hold the Line and vice versa. Benefits in this case will be measured on the monetary value of:

- Value of property assets in built up areas.
- Value of agricultural land (financial compensation was negotiated above the market price, to take into account possible decrease in farm profitability, and emotional value of the land).
- Value of natural ecosystems (range of values). If they have high ecological value for wildlife, they are likely to have been designated in the context of the Habitats Directive. If creation of replacement habitat is required by the Regulations then it is an integral part of the scheme, and its costs and benefits must be included in the analysis.

Additional economic benefits of Managed Realignment were identified by Bryan et al (1994) in the context of the East Anglian coast:

- Potential market goods and services from recreated inter-tidal habitats, e.g. shellfish, samphire, wildfowl, mooring etc. (examples of revenues from Essex sites which will be included in the final report).
- Potential non-market goods, on which value can be placed: wildlife habitat, pollution assimilation (nutrient and contaminant recycling), recreational and amenity value, option and existence value.

6.5 Preference-Base Value System

The following text has been extracted from Defra/EA, 2001: "*Defra/Environment Agency Flood ad Coastal Defence R & D Programme. Managed Realignment Review. Project FD2008. Halcrow Group Ltd; CSERGE; and Cambridge Coastal Research Unit. August 2002*".

"In an individual preference-based value system, the benefits of environmental gain (or the damages from environmental loss) are measured by social opportunity cost (i.e. cost of foregone options) or total economic value. To fill these gaps the non-marketed gaps must first be identified and then where possible monetised. The mainstream economic approach to valuation takes an instrumental (usage-based) approach (as opposed to an intrinsic value which resides in the object itself), and seeks to combine various components of value into an aggregate measure of resource value labelled total economic value (TEV). This total economic value (TEV) can be usefully broken down into a number of categories as shown in Table 6.1 The initial distinction is between use (direct and indirect) value and non-use value.

A use value is a value derived from the utilisation of a productive function of a natural system and has several subcomponents. Direct use value refers to the gain from the actual use which may be consumptive (e.g. fishing) or not (e.g. aesthetic enjoyment). Indirect use value refers to the benefits individuals derive from the various ecosystem functions (e.g. storm buffering, species nursery and breeding grounds.). Option value relates to the value an individual might place on perceived future benefits from the conservation of a resource or one of its components. A number of environmental economists include an additional sub-division of option value, the quasi-option value which is the value of information gained by delaying a decision to proceed with use of a resource which may result in an irreversible loss.

Non-use values, in essence, are associated with benefits derived simply from the knowledge that a resource, such as an individual species or an entire ecosystem, is maintained. It is, by definition, not associated with any use of the resource or any tangible benefit derived from it, although users of a resource might also attribute non-use value to it. Such values will be motivated by a number of different ethical and other motivations. Non-use values can be sub-classified into three main components:

- Economists have developed a range of valuation. Existence value is the satisfaction value an individual derives by simply knowing that a feature of the environment continues to exist, whether or not it brings benefits to others.

- Bequest value relates to the knowledge that a resource will be maintained for future generations so protecting the opportunity for them to enjoy it.

- Philanthropic value is associated with the satisfaction an individual derives from ensuring that a resource is maintained and available for contemporaries of his or her generation.

Which method should be used depends on the type of impact considered (Table 6.2). As a general rule, any study whose objective is to measure total economic value must use Contingent Valuation, as this is the only method that can measure non-use value as well as use value."

Valuation Method	Description	Direct Use Values	Indirect Use Values[1]	Non-use Values
Market Analysis	Where market prices of outputs (and inputs) are available. Marginal productivity net of human effort/cost. Could approximate with market price of close substitute. Requires shadow pricing	√	√	
(Productivity Losses)	Change in net return from marketed goods: a form of (does-response) market analysis.	√	√	
(Production Functions)	Wetland treated as one input into the production of other goods: based on ecological linkages and market analysis.		√	
(Public Pricing)	Public investment, for instance via land purchase or monetary incentives, as a surrogate for market transactions.	√	√	√[2]
Hedonic Price Method (HPM)	Derive an implicit price for an environmental good from analysis of goods for which markets exist and which incorporate particular environmental characteristics.	√	√	
Travel Cost Method (TCM)	Cost incurred in reaching a recreation site as a proxy for the value of recreation. Expenses differ between sites (or for the same site over time) with different environmental attributes.	√	√	
Contingent Valuation (CVM)	Construction of a hypothetical market by direct surveying of a sample of individuals and aggregation to encompass the relevant population. Problems of potential biases.	√	√	√
Damage Costs Avoided	The costs that would be incurred if the wetland function were not present; e.g. flood prevention.		√	
Defensive Expenditures	Costs incurred in mitigating the effects of reduced environmental quality. Represents a minimum value for the environmental function		√	
(Relocation Costs)	Expenditures involved in relocation of affected agents or facilities: a particular form of defensive expenditure.		√	
Replacement/ Substitute Costs	Potential expenditures incurred in replacing the function that is lost; for instance by the use of substitute facilities or 'shadow projects'.	√	√	√[3]
Restoration Costs	Costs of returning the degraded wetland to its original state. A total value approach; important ecological, temporal and cultural dimensions.	√	√	√[3]

Table 6.1: Valuation Methodologies Relating to Ecosystem Functions: e.g. wetlands (*Source: Turner et al, 2001)*

Notes to Table 6.1:

[1] Indirect use values associated with functions performed by a wetland will generally be associated with benefits derived off-site. Thus, methodologies such as hedonic pricing and travel cost analysis, which necessarily involve direct contact with a feature of the environment, can be used to assess the value of indirect benefits downstream from the wetland.

[2] Investment by public bodies in conserving wetlands (most often for maintaining biodiversity) can be interpreted as the total value attributed to the wetland by society. This could therefore encapsulate potential non-use values, although such a valuation technique is an extremely rough approximation of the theoretically-correct economic measure of social value, which is the sum of individual willingnesses to pay.

[3] Perfect restoration of the wetland or creation of a perfectly substitutable 'shadow project' wetland, which maintains key features of the original, might have the potential to provide the same non-use benefits as the original. However, cultural and historical aspects as well as a desire for 'authenticity' may limit the extent to which non-use values can be

'transferred' in this manner to newer versions of the original. This is in addition to spatial and temporal complexities involved in the physical location of the new wetland or the time frame for restoration.

Effects Categories	Valuation Method Options
PRODUCTIVITY	Market valuation via prices or surrogates
e.g. primary productivity, fisheries, agriculture, tourism, flood control, storm buffering and coastal protection	Preventive expenditure
	Replacement cost/shadow projects
	Defensive expenditure
HEALTH	Human capital or cost of illness
	Contingent valuation
	Preventive expenditure
	Defensive expenditure
AMENITY Coastal and freshwater wetlands, landscapes including cultural assets and structures	Contingent valuation/ranking
	Travel cost
	Hedonic pricing
EXISTENCE VALUES	Contingent valuation
Ecosystems; cultural assets	

Table 6.2 Environmental impacts of Managed Realignment and valuation methods (*Source: adapted from Turner et al, 2001)*

6.6 Contingent Valuation

Contingent Valuation (CV) is a collective term for various survey-based environmental valuation methods and is the most widely used economic analysis for the purpose of measuring indirect/tangible benefits. CV is based on survey results, which itself is based upon a persons perceived environmental benefit is compared to the cost of carrying out another activity.

Drawbacks to this approach include:

- Different cultural views on social relations are assumed to give rise to different preferences towards decision-making procedures for different kinds of issues, including environmental ones.

- Burgess et al., (1998) seriously questioned the role of CV in environmental decision-making by arguing that people come up with a monetary amount because of the coercive interview situation, or people's trust in the expertise held by those asking the questions. Burgess et al., (1998) concluded that decisions about the environment should be based on social consensus about appropriate standards and acceptable choices rather than on the individual WTP amounts elicited in CV surveys.

- The key message is that all the methods and approaches must be anchored to a proper testing protocol to yield information on the "reliability" and "validity" of the results.

The MCM provides guidance on the CV Method and the different ways of evaluating benefits, however the focus is placed on the measurement of Willingness to Pay and recreation benefit assessment. It also presents ways of measuring environmental gains and losses in coastal defence. The manual suggests using the following methods to assess recreation benefits under different options:

- Costs associated with a visit to that site in its present condition (use these costs as a measure of enjoyment when using the site).

- Present a drawing of that option, i.e. do-nothing and ask if you get more or less enjoyment from visiting that site when compared to the existing site – quantify this by asking how much enjoyment a person would get from a visit. This method could be applied to Managed Realignment.

- Convenience of travelling to another site.

- The manual highlights the need for public support of the realignment site.

- Comparison of predicted and actual habitat creation and management costs.

Monetary methods; preference methods; approximate monetary methods; avertive expenditure; and replacement costs.

7. How does this work complement what is being undertaken on the PhD's

There is a clear link between strategic objectives to enhance salt marsh habitat regeneration and to maintain the extent and distribution of habitats that support the fish and shellfish populations, and the two Work Package 2 PhDs on nutrient storage in newly created mudflat and salt marsh habitats, and fish utilisation of recreated intertidal areas. Consequently, it may be possible to use the findings of the two PhDs to provide additional economic benefits to support the promotion of managed realignment options with the multi-functions of flood risk management, habitat creation, recreation and fisheries.

It has also been demonstrated that through the Roach and Crouch Flood Management Strategy option appraisal that whilst there are estuary-wide benefits to realigning flood defences at key locations within the estuary complex, the may be insufficient economic justification to do so. Consequently additional research is required in order to provide a robust valuation of the intangible benefits of managed realignment schemes. It is possible that these Managed Realignment schemes may be economically viable if the findings of the PhDs are incorporated into the economic appraisal. However, there are many other potential intangible benefits that could be used to justify these schemes and if developed in conjunction with a multi-criteria analysis approach to options selection and justification, it may be possible to implement more softer flood risk management options, whilst complying with the Defra Priority Score System.

8 Recommendations

Since the current flood and coastal defence project appraisal guidance focuses on economic benefits rather than environmental or social benefits, it is recommended that the economic value of other benefits of multi-functional flood management scheme is assessed and robustly valued so that the true 'value' of the preferred scheme is recognised for the best use of public money.

However, most of these other benefits are intangible and since there is limited current best practice for assessing them, the promotion of low direct economic benefit options, e.g. managed realignment, in predominantly rural areas is limited by economic justification and the Defra Priority Score system.

Broad scale economic appraisal has been shown to offer significant additional benefits to justify the implementation of managed realignment schemes, and it is recognised that the method should be promoted for assessing flood management options holistically. In the context of an estuary flood management strategy, it identifies works that benefit the estuary complex as a whole and more importantly works that contribute to a more sustainable estuary shape. This includes managed realignment works that can reduce the hydrodynamic stress within the estuary complex. An outline approach has been developed in the RCFMS and it would require further development to benefit other studies of its kind.

Multi-criteria analysis is currently being promoted as one method for driving forward the promotion of holistic options appraisal and this approach should be developed further with the support of the Work Package 2 PhD and other research in order to provide a robust argument for the implementation of sustainable long-term strategic options.

9 References

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Appendix A Rest of UK Flood & Coastal Defence Funding Procedures

Appendix A Wales, Scotland and Northern Ireland Flood & Coastal Defence Funding Procedures

Wales

Flood defence services are delivered in Wales by the Environment Agency (EA), local authorities (LAs) and Internal Drainage Boards (IDBs). The EA is the main operating authority in respect of flood defence. It has powers to construct and maintain defences against flooding on watercourses designated as "Main Rivers" and the sea and to implement flood warning schemes. It also advises local planning authorities on flood defence matters and provides general supervision over all drainage matters. LAs have permissive powers to carry out flood defence works on non-main watercourses albeit outside those areas covered by IDBs. LAs also have powers to undertake coastal defence measures including both sea defence to prevent flooding and coast protection to protect the land against erosion. IDBs are local committees which operate in specific areas known as internal drainage districts.

There is no general statutory responsibility on public bodies to provide new flood defences, though existing defences do have to be maintained. Local authorities and the Environment Agency can seek assistance from the Welsh Assembly Government towards the cost of schemes which meet relevant criteria designed to ensure that benefits justify the expenditure.

At present, WAG does not use priority scoring in the assessment of a scheme's eligibility.

Scotland

The Scottish Executive has responsibility for national policy on flood prevention and provides grants to Local Authorities for the construction of flood prevention schemes.

In Scotland primary responsibility for protecting land from flooding lies with the landowner. However under the Flood Prevention (Scotland) Act 1961 Local Authorities have wide powers to mitigate flooding of non-agricultural land in their areas. In addition, the Flood Prevention and Land Drainage (Scotland) Act 1997 imposed duties on Councils requiring them to maintain watercourses where it appears to the local authority that any watercourse in their area is in a condition which is likely to cause flooding of non-agricultural land. Local Authorities are also responsible for planning control.

The Scottish Environmental Protection Agency (SEPA) has responsibility for dissemination of flood warnings, providing flood risk and flood mitigation information, assisting Local Authorities by providing flood risk information and advising in the preparation of flood defence schemes.

Priority scoring is not applied in Scotland. Generally a scheme with a benefit cost ration of unity or greater will attract funding at a level of 80%.

Northern Ireland

The Rivers Agency (RA) is an Executive Agency within the Department for Agriculture and Rural Development (DARD) and is the statutory drainage and flood defence authority for Northern Ireland. The RA is not responsible for the prevention of

flooding. Under the terms of the Drainage (Northern Ireland) Order 1973, the RA has discretionary powers to construct and maintain drainage and flood defence structures to reduce the risk of life and damage to from flooding. The RA can also maintain watercourses and sea defences that have been designated by the Drainage Council which protect land and property from flooding from the sea. The RA also has responsibility for an extensive network of culverts throughout Northern Ireland.

The Drainage Council is an independent advisory body with 18 members who are appointed by the Minister with responsibility for agriculture and rural development to oversee the programme of publicly funded drainage and flood defences in Northern Ireland.

The RA will generally follow the lead from Defra and use the guidance laid out in the FCDPAG suite of documents, although priority scoring is not used.