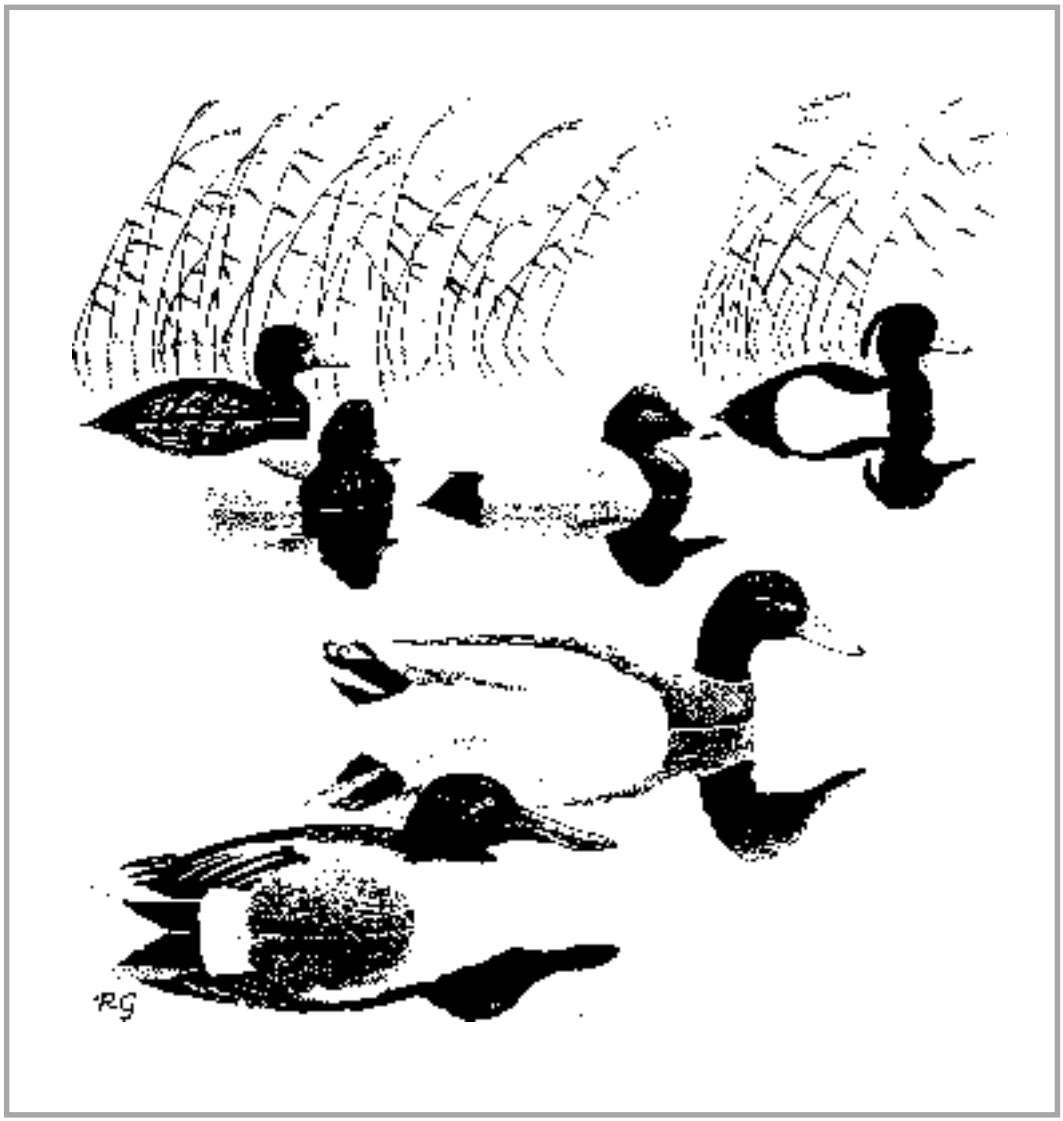
ENGLISH NATURE

Sustainable flood defence

The case for washlands

No. 406 - English Nature Research Reports



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Number 406

Sustainable Flood Defence: The Case for Washlands

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RPA REPORT - ASSURED QUALITY	
Project: Ref/Title	J345/Washlands
Approach:	As set out in RPA proposal and taking account of associated discussions.
Report Status:	Final
Report prepared by:	Matthew Hickman, Consultant John Ash, Technical Director Teresa Fenn, Consultant
Report approved for issue by:	John Ash, Technical Director
Date:	9 February 2001

ISSN 0967-876X

Summary

The extent to which natural floodplains form an integral part of river systems has been well demonstrated in the recent fluvial floods in England and Wales (throughout October/November 2000 and into 2001). Aerial photographs have vividly shown the limits of floodplains and commentators have remarked on the need to work with these natural systems to reduce flooding to areas where people and the built environment are at risk.

The service provided by floodplains can include washlands, which are flood storage areas used during times of high flow to reduce flooding in other parts of the catchment. If floodplains, and in particular washlands, can be managed in such a way as to reduce risk to people and the built environment, and at the same time provide additional habitat and other benefits, then there will be increased benefits to society from this integrated approach.

Not only will flood risk be managed in a more natural way, but there are real opportunities across the country to enhance biodiversity, delivering BAP targets and providing an environmental resource that can be enjoyed by all. An actively managed washland can provide benefits covering conservation, recreation and productive uses (such as the production of reed/sedge or biofuel). This approach to managing flood risk, therefore, is a fully integrated, living and sustainable water system rather than relying on hard engineering options such as embankments or flood relief channels, that require large amounts of public money to construct and manage.

Washlands provide a real opportunity to take a catchment-based approach to managing flood risk. This type of approach is set out in the Water Framework Directive, together with the preparation of catchment plans. The Environment Agency is taking steps in achieving this type of approach via its development of flood risk catchment strategies across the country.

This report, therefore, sets out the case for washlands as a viable flood defence option. It is vital to point out that washlands provide flood defence benefits that are the same as any other flood risk management option i.e. the reduction in flood damages to the built environment. Consideration is given to the wide range of services and functions, in addition to their flood defence function, provided by both washlands and wetlands more generally. A short review of the approach to the economic valuation of such sites is presented before a suggested methodology for the valuation is developed. A number of case studies show that washlands can provide an environmentally sustainable, technically feasible and economically robust method to managing flood risk.

It is recommended that English Nature work together with MAFF and the operating authorities in taking a pro-active role in encouraging washlands to be considered as a viable flood defence option, together with investigating the appropriate compensatory payments (such as a washland agri-environment scheme) that may be paid to land owners in order to accrue the wide range of benefits that washlands provide. This would not only be a cost-effective solution, but the management of flood risk in this way offers a much more sustainable and holistic approach that will benefit society (both now and in the future) as a whole.

Contents

1. Introduction

"In England when we see flooded fields we see it as a sign of failure. In Holland it is a feature of a working water management system"[1]

1.1 Background to the study

The straightening and deepening of rivers as a method of providing increased protection against flooding and improving land drainage has had two main consequences:

- it has aided the destruction of floodplain environments, causing a loss of important habitats; and
- it has resulted in the need for unsustainable flood defence expenditure.

The service that floodplains provide as an alternative method of flood defence is now being recognised. The extent to which natural floodplains form an integral part of river systems has been well demonstrated in the recent fluvial floods in England and Wales (in October and November 2000 and into 2001). Aerial photographs have vividly shown the limits of floodplains and commentators have remarked on the need to work with these natural systems to reduce flooding to areas where people and property are at risk.

The service provided by floodplains can include washlands, which are flood storage areas used during times of high flow to reduce the flooding in other parts of the catchment.

The last 20-30 years has seen the general trend towards using floodplains for arable agricultural production and urban development. This means that lower water tables are required, leading to a river management system of striving to reduce water levels during all months of the year. The use of floodplains for intensive grazing has also driven the need for lower water levels. The changed use of the floodplain for agricultural production rather than extensive grazing or the historic use as water meadows has resulted, in many cases, in the agricultural community calling for increased protection of their land from floods to reduce the risk of damage to crops. The recent floods have been a dramatic reminder of the need for a catchment management approach to flood defence with the use of floodplains, and in particular washlands, as an integral part of any sustainable flood defence measure. The flood waters must go somewhere. If floodplains, and in particular washlands, can be managed in such a way as to reduce risk to people and the built environment, and at the same time provide additional habitat and other benefits, then there will be increased benefits to society from this integrated approach.

[1] Quote by John Prescott (Deputy Prime Minister) on a visit to view newly developed flood defences in Holland.

1.2 Objectives of the study

The objectives of the study, taken from the Project Specification, are to:

1. Develop the policy case that washlands provide services to other parts of the floodplain, and as such these flood defence and water resource benefits should be recognised in financial terms.

2. Develop ways of valuing the flood control contribution of these habitats e.g. 'avertive cost' estimates, other methods, and perhaps non-monetary indicators where monetary valuation is difficult.

3. Develop different scenarios, and especially consider situations where (a) there is likely to be a good economic case for habitat protection on these grounds, and (b) situations where the economic case is less strong. The scenarios should include; a) natural floodplain washlands, either with little or no flood defence infrastructure, b) long established washland with spillways and walls, including scenarios where flooding frequency and duration might be deliberately modified, and c) where defended land will now intentionally become a washland. Consideration should also be given as to how the benefit from numerous small washland or managed retreat schemes might be allotted. Using case studies examine the sensitivity of the methodology and the range of values for such.

4. Identify any potential institutional constraints, for example the fact that one would be paying for the service on an ongoing revenue basis as opposed to a one-off MAFF funded capital project (albeit with some revenue consequences).

5. Provide an indication of the range of values per hectare that might be attributable to washlands. Consider the interaction between such payments, and their justification, with other payments regimes such as the ESA payments and Countryside Stewardship.

It should be noted that this study is very much a small scoping study and should not be read as an in-depth investigation as to the valuation of washlands.

1.3 What is a washland?

The definition[2] of a washland is an area of land 'periodically flooded by a stream', whereas a wetland is defined as a 'swamp or other damp area of land'. Within the context of this report, a washland is an area of land adjoining a river or stream that floods from the positive act of directing floodwaters onto it as part of a flood defence measure (such as a flood storage reservoir). Washlands could be a wetlands, or include wetlands, where water is retained at a high level, naturally or artificially, for the benefit of flora and fauna associated with that type of habitat.

Within the report, therefore, the use of the word washland may or may not include wetland habitat. Where there are specific requirements for set water levels to achieve certain wet habitat objectives, then that is described as a wetland. This project investigates the services and values associated with these wetter environments and therefore has concentrated on the intrinsic benefit of wetlands (where these can be generated by a 'wet' washland).

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[2] Definitions from The Concise Oxford Dictionary.

1.4 Institutional background

The Ministry of Agriculture, Fisheries and Food (MAFF) has responsibility in England for policy in respect of flood defence and coast protection. The National Assembly for Wales (NAW) has equivalent responsibility in Wales. Jointly, they administer the Land Drainage Act and the flood defence provisions of the Water Resources Act, the Environment Act and the Coast Protection Act. These acts empower the relevant authorities (referred to as 'operating authorities', and include the Environment Agency, local authorities and internal drainage boards) to undertake flood and coast protection measures. They also enable Ministers to offer financial support to the operating authorities for those measures that qualify as capital works (such as the construction of an embankment).

It is the responsibility of the appropriate operating authority to identify the need for defence measures and to decide which projects should be promoted. MAFF and the NAW may offer grant-aid for new or improved flood warning systems and flood and coastal defence capital improvements which are technically sound, economically viable and environmentally sustainable. For any project to be eligible for grant-aid it must be a capital improvement scheme and satisfy criteria laid down by MAFF and the NAW. This includes a detailed appraisal to ensure that the chosen option is the 'best' solution both economically and environmentally. Maintenance works are carried out by the operating authorities from revenue budgets and are not subject to such a rigorous appraisal.

Washlands, within the context of this report, will be part of a flood defence improvement scheme, and as such, they will constitute capital works and be subject to detailed appraisal (and also attract grant-aid). However, the continual maintenance of washlands will be deemed maintenance works, under revenue budgets, and will not attract grant-aid.

Over the years, MAFF has introduced a number of agri-environment initiatives aimed at improving and/or maintaining the natural environment, with the ESA and Countryside Stewardship schemes being most relevant to the management of flood defences in general and washlands in particular. ESA schemes provide payments to manage 'wet' grassland and although this is primarily for preserving landscape there is the potential for a similar type of scheme for managing wetlands for flood defence and, at the time, maximising environmental benefits. The Countryside Stewardship Scheme includes management of waterside land and may be a vehicle for providing suitable management for washlands deigned to be flood defences.

The Habitat Creation (Saltmarsh) Scheme (now within the Countryside Stewardship Scheme) has been successfully used in conjunction with coastal defence schemes by providing the ongoing payments for managing newly created saltmarsh on land which was previously in arable production. The scheme in this instance provides the necessary incentive for the owner to change land use. There are parallels, therefore, between this scheme and the requirements for the use of washlands as a flood defence option.

1.5 Current appraisal requirements

Flood and coastal defence expenditure (be it on fluvial or sea defence or coast protection) is allocated from public funds. Such funds are limited by their very nature and there are many competing uses (such as health, education, defence, and so on). In order to decide where such funds should be spent, analysis is required to determine whether the costs of projects and policies are outstripped by their associated benefits over time.

Guidance on the appraisal of flood and coastal defences is given in MAFF's Project Appraisal Guidance series. This covers essential subject areas such as economic appraisal, risk and the environment. The aim of the series is to encourage a holistic approach to the appraisal of flood and coastal defences. The appraisal process consists of a number of steps:

- setting objectives;
- identifying options;
- assessing the costs and benefits of options;
- choosing the best option;
- conducting sensitivity tests on the appraisal; and
- selecting the preferred option.

In essence, this process weighs up the relative merits of different options in order to choose the one that should benefit society the most. MAFF set three criteria for which each scheme should be:

- technically sound;
- economically viable; and
- environmentally acceptable.

It is stated in MAFF's strategy for flood and coastal defence (MAFF, 1993) that "...schemes should be based on an understanding of natural processes and, as far as possible, work with these processes...". The nature of washlands would clearly be suitable for this purpose, however, their full appraisal may be problematic given the wide range of services they provide. A full valuation is, therefore, required in order for washlands to be considered as a viable option. This is the case put forward in this report.

1.6 Organisation of the report

This report has been organised to address the set objectives (stated above). Section 2 describes the services that can be provided by washlands/wetlands and economic valuations are provided in Section 3. A suggested valuation methodology is given in Section 4. A number of case studies (scenarios) are described in Section 5 and finally, conclusions are drawn as to developing a case for washlands as a flood defence option in Section 6.

2. Services Provided by Washlands

2.1 Introduction

This section considers the range of services provided by washlands in both the ecological and wider sense. It must be stressed that a washland can be developed into a wetland habitat when water levels remain at a high enough level. It is highly unlikely that a washland that is only very occasionally flooded will develop any sort of wetland habitat and, therefore, will not provide the beneficial services discussed in this section. However, there still may be indirect benefits, such as a reduction in fertiliser use, from this wetter environment. Hence, the 'wetter' the washland, then the greater the chances are at accruing benefits from the 'wetland'.

The section begins by setting out the more detailed definitions, moving onto the 'traditional' services afforded by wetlands. Wider services are then considered (in a washlands context), followed by a consideration of the flood defence perspective.

2.2 Definitions

There is a wide range of definitions as to what actually constitutes a 'wetland'. Dugan (1990) notes that there are in excess of 50 definitions in use. The Ramsar Convention defines wetlands as:

> "...areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres..."

Clearly this is a relatively wide definition for our purposes. Barbier *et al* (1997) set out five broad wetland systems for classification purposes:

- estuaries - where rivers meet the sea and salinity is intermediate between salt and freshwater (e.g. deltas, mudflats, salt marshes);
- marine - not influenced by river flows (e.g. shorelines and coral reefs);
- riverine - land periodically inundated by river overtopping (e.g. water meadows, flooded forests, oxbow lakes);
- palustrine - where there is more or less permanent water (e.g. papyrus swamp, marshes, fen); and
- lacustrine - areas of permanent water with little flow (e.g. ponds, kettle lakes, volcanic crater lakes).

On the other hand, Mannion & Bowlby (1992) classify wetlands into seven types:

- estuaries;
- open coasts;
- floodplains;
- freshwater marshes;
- peatlands;
- lakes; and
- swamp forest.

For the purposes of this study, we are clearly focusing upon the riverine/floodplain aspect of wetlands, with primary focus on the management of flood waters and the additional benefits that may accrue. As is stated in Barbier *et al*, op. cit., "...as flood water flows out over a floodplain wetland, the water is temporarily stored; this reduces the peak river level and delays the time of the peak, which can be a benefit to riparian dwellers downstream...".

2.3 What services do they provide?

It should come as no surprise to the reader that wetlands provide a wide range of services, and only by understanding this will their 'true' value be taken into account in decision-making. Of course, the more washlands that are introduced for flood defence purposes then the more opportunity there is to study the wider interactions of the washland and its environ.

A large amount of literature is available on this subject, however, we have been careful to focus the search on practitioners that discuss the flood defence aspects of wetlands. Three examples are given below.

Turner *et al* (1998) states that UK wetlands provide all of the following services:

- flood storage;
- flood protection;
- important wildlife habitats;
- nutrient cycling/storage and related pollution control;
- landscape and amenity benefits;
- recreational services;
- non-use benefits (existence and bequest values);
- agricultural output;
- other commercial output (e.g. reeds);
- shoreline protection; and
- extended food web control.

With reference to floodplains specifically, Dugan (1990) sets out a number of functions that are either 'present' or 'common and important':

- groundwater recharge;
- groundwater discharge;
- flood control;
- shoreline stabilisation erosion control;
- sediment/toxicant retention;
- nutrition retention;
- biomass export;
- micro-climate stabilisation;
- water transport; and
- recreation/tourism.

European research entitled the 'Functional Analysis of European Wetland Ecosystems' (FAEWE) has produced a breakdown of the functions of wetlands into three key areas:

- hydrological;
- biogeochemical; and
- ecological.

A summary of these functions is provided in Table 2.1 (source: Maltby *et al*, 1996).

Table 2.1: Functions covered by the FAEWE research

Function	Process maintaining function
Hydrological functions	
Flood water retention	Short term storage of overbank flood water due to backwatering or velocity reduction Long term storage of overbank flood water due to impeded outflow Detention of surface runoff from surrounding slopes
Groundwater recharge	Infiltration of flood water into the wetland surface followed by percolation to a significant aquifer
Groundwater discharge	Upward seepage of groundwater through the wetland surface
Sediment retention	Net storage of fine sediments carried in suspension by river water during overbank flooding events Net storage of fine sediments carried in suspension by surface runoff from other from other wetland units or the contributory area
Biogeochemical functions	
Nutrient retention	Plant uptake of nutrients (nitrogen and potassium) Storage of nutrients (nitrogen and potassium) in soil organic matter Absorption of nitrogen as ammonium Absorption and precipitation of potassium in the soil Retention of particulate nutrients
Nutrient export	Gaseous export of nitrogen Nutrient (nitrogen and potassium) export through land use management Export of nutrients (nitrogen and potassium) through physical processes
Peat accumulation	In situ carbon retention
Ecological functions	
Ecosystem maintenance	Provision of overall habitat structural diversity Provision of microsites for: - macro-invertebrates - fish - herpetiles - birds - mammals Provision of plant and habitat diversity
Food web support	Biomass production Biomass import via physical processes Biomass import via biological processes Biomass export via physical processes Biomass export via biological processes

In summary, the flood storage function provides many additional services ranging from the ecological to the economic.

2.4 The flood defence perspective

In the context of this report, an area set aside for flood storage is viewed as a viable option in the management of flood risk. The traditional flood defence benefits that such options may accrue are no different to the benefits from other flood risk management options (such as building embankments or flood diversion channels). In flood defence parlance, if a scheme achieves a 1 in 50 year standard (a probability of flooding of 0.02 per annum), then it is of no concern how this standard is achieved when assessing the traditional benefits (usually in the form of the protection of assets from flooding).

As such, a flood defence benefit is a flood defence benefit regardless of the engineering approach adopted to provide a certain level of protection. As long as a washland is technically feasible, environmentally sustainable and economic then it should be considered a valid option. In simple terms, flood defence benefits accruing via the use of washlands will be no different than those derived from other engineering options.

Perhaps the greatest threat to the consideration of washlands as a viable option is a lack of imagination of the behalf of operating authorities and consultants undertaking the appraisals. English Nature should work with MAFF and all operating authorities to ensure that washlands are given due consideration, especially given the additional benefits that they may provide, which is discussed in more details below.

2.5 Additional services

It is useful to split the services (and products) derived from wetlands into two main categories:

- direct use: which are those derived from the economic uses made of a wetland's resources and services, such as transport, fishing, wildfowling, tourism, water supply, biofuel and agriculture (in the case of reed/sedge production); and

- indirect use: which are those derived from the indirect support and protection provided by the wetland's natural function. Hydrological uses in this case could include groundwater recharge and discharge, flood storage, sediment trapping and so on, whilst ecological uses include food chain support, habitat for fisheries and wildlife and nutrient retention.

The approach to washlands tends to be counter-intuitive in terms of this traditional breakdown of services (and products) that wetlands provide. The direct use is for flood defence purposes and the additional benefits that can accrue add to their case. For example, the creation of a washland on a floodplain near to an urban centre can result in the creation a valuable asset in terms of environmental, economic and social benefits. Table 2.2 breaks down the services offered by washlands with this in mind.

Table 2.2: Services offered and uses for washlands

Primary use	Secondary uses
Flood water storage	Habitat creation 'New' flora and fauna Bird watching Walking Some formal recreation (depending on frequency of flooding) Change in agricultural practice and type Water quality improvements downstream Water quantity improvements New commercial opportunities (e.g. reed, willow, biofuel)

As can be seen from the table above, a number of secondary benefits can be added to the traditional flood defence 'protection of assets' benefits. The implication of this could well mean that washlands offer a much wider range of benefits than are currently being considered in appraisals. This means that washlands could be an attractive alternative when compared against hard engineering options. However, it is worth considering the change in flood risk that may be a result of the creation and use of washlands. For example, there may be a trade-off between increased (and improved) habitat and an increased flood risk to tangible assets. The US Army Corps of Engineers (1995) note that the longer water is detained as it moves through the wetland, the greater the potential for the wetland to perform its function and to support other wetland functions. In effect, this means that in order to accrue as many of the secondary benefits as possible, the washland area should be inundated for long periods (possibly reducing its effectiveness as a flood defence).

Clearly, the period of inundation will drive the type of habitat. It is true that some habitats may be 'too wet' or 'too dry' for certain species, but perfectly suitable for others. It is a difficult decision to determine which is the 'best' habitat, particularly when balancing flood risk on the other side of the equation. Another factor to consider will be the speed of evacuation of the water, for example, a scheme that evacuates water quickly from an area may accrue greater flood defence benefits potentially at the expense of environmental gains. However, the general principle of re-wetting floodplains and encouraging a more naturally functioning riverine system are moves in a positive direction.

The next section considers how such additional benefits should be valued in economic terms. This issue has been approached with the background of the use of washlands for flood defence purposes and how appraisals (or indeed, the system) can be improved.

3. Economic Valuation of Wetlands

3.1 Overview

This section examines the concepts and methods behind the economic valuation of wetlands. There is, currently, limited literature available for wetlands in the UK. It is true that the majority of valuation studies have been focused on the US, however, there are an increasing number of studies examining the European context (supported by EU funding) with the UK playing a full role in these and other valuation studies.

The concept of total economic value is first introduced, followed by a description of the key valuation methodologies. A summary of valuation studies identified in the literature review are then set out. Finally, conclusions are drawn regarding the relevance to washlands where flood defence is their primary use.

3.2 Total economic value

Environmental economists have developed a holistic valuation concept referred to as 'total economic value', with the aim of ensuring that all aspects of the value held towards environmental goods and services are taken into account.

The 'total economic value' (TEV) of an environmental asset is broken down into two elements, namely 'use values' and 'non-use values'. Use values are those associated with the benefits gained from actual use (now or at some point in the future) of the environment and may include private sector uses, recreational uses, education, science, amenity, and so on. Non-use values (also known as 'passive use values') can be separated into two key types: 'bequest' and 'existence' values:

- **bequest values** relate to the desire of an individual to preserve environmental (and other) assets so that future generations may have use of them; and

- **existence values** are defined as those values which result from an individual's altruistic desire that an environmental asset is preserved and continues to exist into the future.

These non-use values are not associated with actual or potential use of the environment, but solely with the knowledge that the asset is being protected. Figure 3.1 sets out the breakdown of use and non-use values in diagrammatic form.

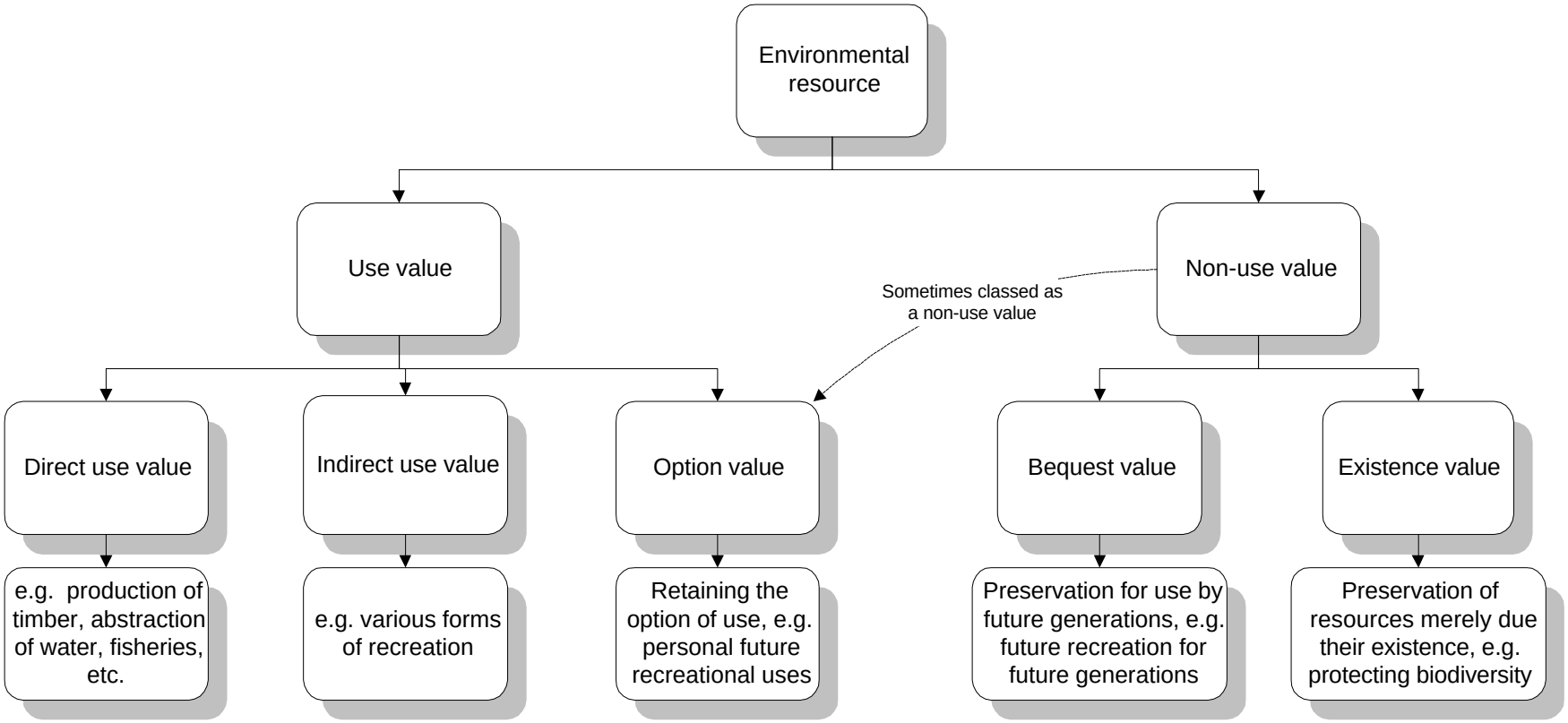

Figure 3.1: Representation of total economic value

3.3 Valuation methodologies

A range of economic valuation techniques has been developed to assist in imputing the monetary value attached to environmental goods and services. These techniques attempt to derive an individual's willingness to pay (WTP) for an environmental improvement [or willingness to be compensated for (willingness to accept - WTA) an environmental loss] as revealed in the marketplace through individuals' actions, or as directly expressed through surveys. The general aim of these is to determine the trade-offs that individuals would make either directly or, as is often the case, indirectly in labour, housing and other markets.

The techniques which are most commonly used are:

- conventional market price or effect on production approaches;
- household production function approaches;
- hedonic pricing methods; and
- experimental markets.

The basic principles are summarised in Annex 1 together with the manner in which they are applied. It should be borne in mind, as the Annex states, that these approaches can be resource intensive in terms of both time and cost.

3.4 Summary of valuation studies

3.4.1 Caveat

It should be noted that given the size of this study, a full in-depth literature review has not been possible. This summary, therefore, is not intended to be comprehensive but should provide a 'feel' for the types of values that have been derived. Values quoted have been converted and inflated to year 2000 prices as far as possible.

The focus here has been on the UK and wider European studies, given the differences in wetland types and valuation culture in the US. However, a summary of a variety of wetland valuation studies is given in Annex 2.

3.4.2 UK valuations

As stated above, there is not a wealth of UK-based studies examining the value of wetlands. However, one study, in particular, does consider washlands explicitly - a study on the Hundred Foot Washes (Finney, 1988).

Most of the washlands area is used for wildfowling in the winter months. More frequent summer flooding has led to dominance of reed-type vegetation and low quality grasses at the expense of better quality grasses, and a severe reduction in stock grazing, due primarily to the boggy condition and the disruption caused by sudden summer floods. Shooting rents in the Washes do not vary greatly, generally being between £49 and £62 per hectare (although up to £74/ha may be obtainable for washes with easy access). These rents are for shooting only and do not include grazing or hay cutting rights. There is more variation in land prices than rent, with washlands generally fetching £2,960 to £3,700 per hectare, usually nearer the top than the bottom end. Again, the more accessible areas have gone for up to £6,175/ha, although £4,940/ha may be more commonplace. The total number of wildfowling visits to the Washes has been estimated as 4,005 per season over the available area, made up of wildfowling clubs,

commercial day ticket shooting and syndicates and private shooting. Total wildfowling expenditure is estimated as £467 per hectare for the Hundred Foot Washes.

Ecotec (1993) undertook a contingent valuation study for aquatic ecosystems in upland areas in the UK and the benefits of rectifying all current damage to these ecosystems, where this damage related mainly to the decline in the number of plant and animal species due to acidification. The mean annual willingness to pay for an improvement of the quality of the ecosystem and to reverse the damage to biodiversity was estimated as about £35 for the total sample. For users, the value was higher at £43, while the mean annual household willingness to pay for those who said they do not visit upland water at all was estimated at about £23.

Hanley & Craig (1991) also used a contingent valuation study to assign a value to the flow country of Scotland (an area of peat bogs). The mean once-for-all willingness to pay was estimated as £23 per household. Annualisation using a discount rate of 6% gave a total willingness to pay of £28/ha/yr (based on the aggregated value across the population of Scotland). The difference between users and non-users was also investigated, with users found to have a willingness to pay of £36/person and non-users at £17/person.

Perhaps the most comprehensive analysis is a study by Brouwer *et al* (1997) which undertook a meta-analysis of wetland contingent valuation studies. Table 3.1 summarises the findings. It should be noted that the original valuations were presented in the IMF's Special Drawing Rights (SDRs) and have been converted using an exchange rate of $1.45 to the pound. However, care must be taken when examining these figures, the different categories are not intended to be additive, but seek to highlight the types of values that are derived depending upon wetland types.

As can be seen, households are willing to pay a considerable amount for wetlands that provide a flood storage function, with a mean value of £83.65/household/year. Given that there are around 1.3 million households at risk from flooding, a rough calculation equates to a 'value' of over £100 million per annum. Using an overall (truncated) value for the UK results in a value of around £20/household/year.

Table 3.1: Summary of findings of meta-analysis

	Average WTP per household per year		
	Mean value (SDRs)	**Mean value ($)**	**Mean value (£)**
Wetland class			
Salt water	56.2	$73.81	£50.77
Marine	22.7	$29.81	£20.51
Lagoonal	136.6	$179.40	£123.39
Lake	42.8	$56.21	£38.66
Fresh water	58.9	$77.36	£53.21
Riverine	71.7	$94.17	£64.77
Lacustrine	36.8	$48.33	£33.24
Palustrine	36.9	$48.46	£33.33
Groundwater	125.7	$165.09	£113.55
Unknown	71.2	$93.51	£64.32
Wetland function			
Flood control	92.6	$121.62	£83.65
Water generation	21.5	$28.24	£19.42
Water quality	52.5	$68.95	£47.42
Biodiversity	76.1	$99.95	£68.74
Wetland size			
Very large	86.9	$114.13	£78.50
Large	70.3	$92.33	£63.50
Medium	67	$87.99	£60.52
Small	29.5	$38.74	£26.65
Very small	53.4	$70.13	£48.24
Value type			
Use	68.1	$89.44	£61.52
Non-use	35.5	$46.62	£32.07
Use and non-use	63.8	$83.79	£57.63
Region			
Illinois, Iowa, Wisconsin, Kentucky	28.6	$37.56	£25.83
Montana, Alberta	70.6	$92.72	£63.77
Colorado, New Mexico	35.4	$46.49	£31.98
New Hampshire, Mass, Pennsylvania	43.9	$57.66	£39.66
Washington, Oregon	52.7	$69.21	£47.60
California	164.3	$215.78	£148.42
Georgia, Louisiana	187	$245.60	£168.92
UK	34.9	$45.84	£31.53
UK (truncated)	22	$28.89	£19.87
Netherlands	25.9	$34.02	£23.40
Austria	17.6	$23.11	£15.90
Sweden	55.6	$73.02	£50.22

With regards to flood risk specifically, mean willingness to pay for conserving the Broads via a protection strategy designed to mitigate the increased risk of flooding was estimated by Bateman *et al* (1993) as £90 to £188 per household per year. The lower bound is similar to that found in the above meta-analysis.

An attempt has been made to bring together a number of wetland studies to provide generic figures for the total economic value by site type (RPA, 1998). Table 3.2 provides a summary.

Table 3.2: Summary of TEV for wetlands*

Site type	Bound	Capital value per ha	Equivalent annual value per ha (6% over 50 years)
High conservation quality: important ecologically; recreation does take place	Upper	£32,000	£1,920
Good conservation quality: county or local designations; some or no recreational usage	Central	£10,000	£600
No designations, little recreational activity	Lower	£5,000	£300

* these values were originally developed to be related to groundwater abstraction that may affect wetlands and reflect the total (full) value of the site

3.4.3 European studies

The value of the life-support functions and environmental goods provided by the Martebo mire in Sweden were estimated using the costs of replacing them with feasible human-made technologies. These functions included: peat accumulation, maintenance of drinking water quality, maintenance of ground and surface water levels, processing of sewage and cleansing of chemicals, provision of food for humans and domestic animals, habitat for fish species, wetland dependent flora and fauna, recreation area for birdwatching, sport fishing and boating. These values were estimated in biophysical, energy and monetary terms. The estimate of monetary replacement costs indicates that the annual cost of replacing the wetlands functions is about £5 million or £199/ha. The major part of this relates to technical substitutes for the biogeochemical processes, such as those related to flows of nitrogen and phosphorus, followed by substitutes for the services associated with the hydrological cycle. Not more than 10% are related to the biological part of the system, which might reflect the lower priority and difficulty of substituting for the loss of species diversity and genetic variability (Gren & Söderqvist, 1994).

An Austrian study (Kosz *et al*, 1992) estimated the value of wetlands based on the environmental services provided, where these include forests, hunting, grazing for cattle, fish and recreation. The input resources were valued at their market price, which amounts to £101/ha/year. Recreation values were estimated using the travel cost method at £332/ha/year, increasing to £1,250/ha/year when all other expenses (hotels, food, etc.) were included.

The loss in value from floodplains destroyed following the construction of a dam in the Czech Republic was based on the loss in wood production, yield on agricultural land and hunting. The results showed that the annual value of the floodplains amounted to £240/ha (a value which exceeded the maintenance cost of the dams by about 40%) (Gren & Söderqvist, 1994).

Traditional sustainable activities such as hunting and fishing in the Po Delta region in Italy have been progressively replaced by extensive farming, tourism and industrial activities (Tomasin, 1991). The values were calculated as the associated regional incomes from these activities. According to these results, the total net benefits from fishing, fish farms and hunting amount to about £1,080/ha/year. The tourist flows provide additional benefit of at least £160/ha/yr.

The Danube floodplains were valued based on the forest supply of wood, grassland supply of food for cattle and the permanent water supply of fish. These were valued at their market price. Recreation value was estimated using the travel cost method. The potential value of the floodplains as nitrogen sinks was calculated as cost savings obtained by the replacement of more expensive nitrogen abatement measures. The total annual value was £380/ha, with the value of nitrogen sinks accounting for 56% and recreational value for 29% of the total. However, these estimates included a number of simplifying assumptions which may affect the validity of the results (Gren & Söderqvist, 1994).

3.5 Valuation in the washlands context

As stated in the previous section, care should be taken regarding the definition and valuation of washlands, as opposed to generic wetlands. Given that washlands' primary function is to store flood waters and any secondary benefits (such as habitat creation, sediment storage, and so on) are in addition to this, then any choice of value should be treated with caution. With reference to high water levels, the current flood defence appraisal guidance (FCDPAG3, MAFF (1999)) states:

> "In 1999, a figure of £175/ha/year was agreed as a conservative economic measure of the environmental benefits of retaining high water levels ... In particular circumstances ... a sum of up to £300/ha/year might be considered." [FCDPAG3, page 30]

A fair question to be asked when considering these values is 'what is being valued?'. Although the value refers to the "environmental benefits" it is unclear as to whether these cover the full range of services offered by a maintaining high water levels. Given that these values were based on ESA payments, then the values themselves refer to 'landscape' rather than the detailed services and functions performed by a 'wetter' area. Of course, the recreational (and other) elements should also be a consideration in order to evaluate the TEV of the site.

The value of a site may be looked at simply in terms of the lost productivity of land that is to be developed into a washland, however, this is a very narrow view and may only account for the loss of land owners income. It is worth mentioning the expected losses caused by poor agricultural drainage as highlighted in Environment Agency (1998). Economic losses associated with land use change can be summarised as being:

- for a move from intensive pasture to extensive pasture: £401/ha; and
- for a move from extensive arable to extensive pasture: £378/ha.

It could be argued, therefore, that a move to extensive pasture (as may be likely for a well managed washland scheme) will result in, as a minimum, lost productivity of £378/ha. This infers, given that this represents income foregone to develop the washland, a minimum value of £378/ha (this value closely converges with the Danube study detailed above). This value is also close to the lower bound shown in Table 3.2 and MAFF's higher value for maintaining high water levels. It should be remembered, however, that flood defence benefits are in addition to these values.

The next section develops a valuation methodology for assessing the benefits of developing a washland. This will focus on methods for the inclusion of washlands as a viable option in appraisals.

4. Suggested Valuation Methodology

4.1 Overview of approach

The valuation methodology presented in this section focuses on the valuation of washlands to feed into the economic appraisal for the management of flood risk. This methodology is intended to provide the benefits that washlands may accrue **in addition** to their flood defence benefits, which are calculated in the usual way in accordance with MAFF's current guidance FCDPAG3 (MAFF, 1999).

A summary of the proposed approach is set out in Figure 4.1 overleaf. This breaks down the valuation process into three distinct parts:

- the determination of the type of washland to be created;
- the benefits that are expected to accrue from this washland; and
- the valuation of such benefits.

This section discusses these elements in more depth below. It is also considered whether economic valuation is required or necessary in order to offer washlands as a viable flood defence option.

4.2 The types of washland

The first element to consider is the type of washland that is to be created. For simplicity, we have classified the types of washland into three scenarios:

- occasional flooding of agricultural land, with little environmental improvement;
- high water levels for some of the year; and
- greatly increased water levels for much of the year, with potential increase in number of BAP species.

Clearly, there may be some points between these scenarios, however, for this approach to valuation, the three scenarios seem suitable.

In the case of the former, it is likely that this type of land will be arable land, with potentially high value crops grown. The washland in this case, therefore, will only come into use on relatively rare occasions. The primary use of the land, therefore, remains agricultural with very few opportunities for habitat creation or recreational activities.

The central case may be likened to the type of land currently gaining payments under the ESA scheme or water fringe areas, i.e. probable agricultural land (grazing and possibly arable) that maintains high water levels for part of the year. The opportunities are much more enhanced, therefore, to create habitat and increase the recreational potential of a site.

The latter case will be what many would refer to as a 'full wetland', i.e. high water levels all year round. This category, by far, offers the greatest opportunities for habitat creation and recreational enhancement.

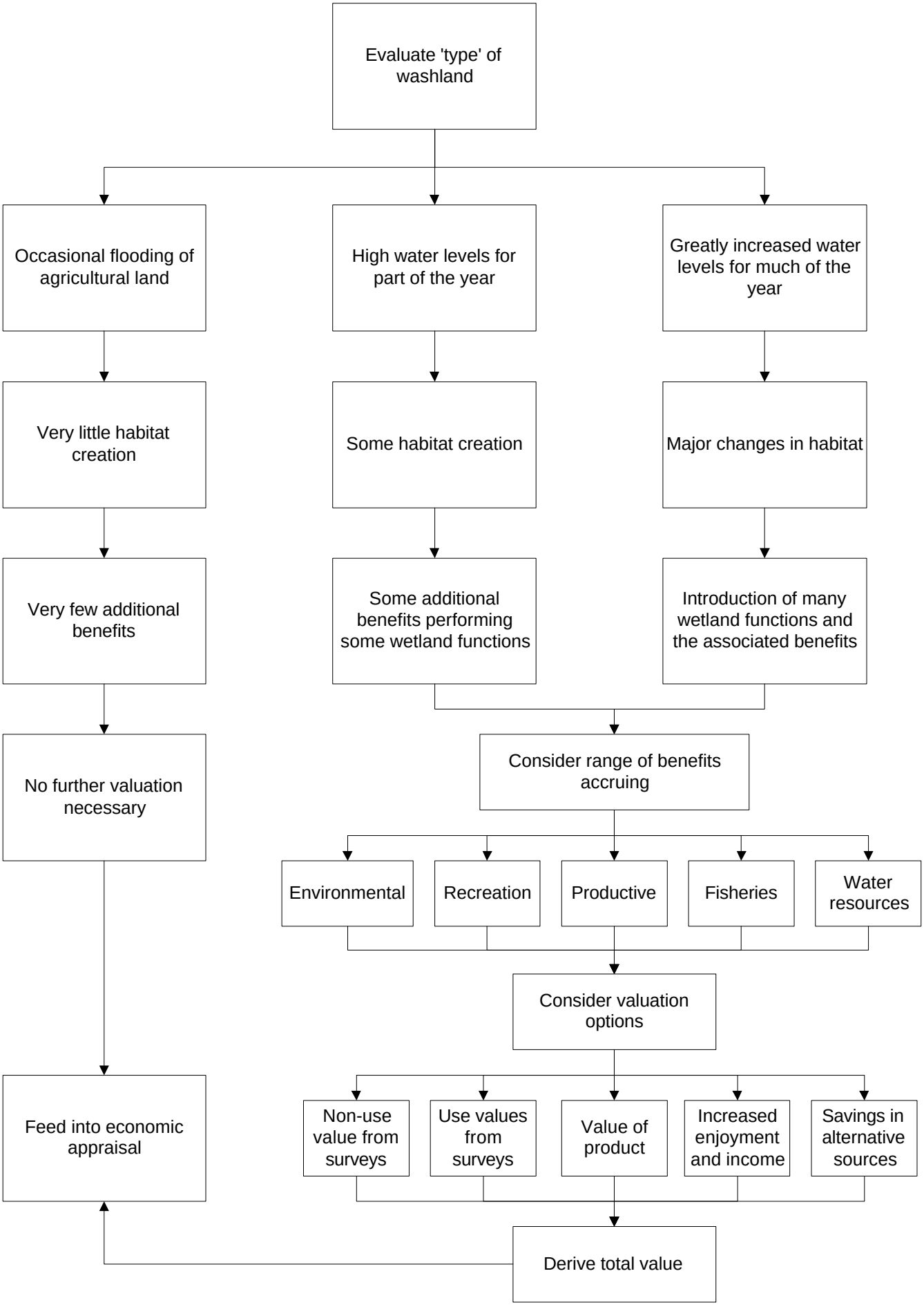

Figure 4.1: Overview of valuation methodology for additional benefits of washlands

4.3 The differing range of benefits

Given that it has been recognised that there are different types of washland, it also follows that there will be different levels of benefits associated with each type. In order to present a simplified approach, the agricultural washland, given its inability to significantly create habitat or enhance recreation, is assumed to accrue no additional benefits. Of course, these additional benefits are over and above the primary objective of flood defence.

The second and third scenarios, however, will accrue additional benefits. Following Section 2, it can be seen that wetlands in general offer a wide range of services and functions, many of which cannot be valued as separate entities. With this in mind, we suggest considering benefits under the following headings (flood defence is included to emphasise that these benefits should be included as well):

- **flood defence**: where this refers to the protection of assets (such as residential or industrial property);

- **environmental**: where this covers habitat creation and the flora and fauna that are a result of this. The 'importance' in environmental terms may be measured in terms of, for example, the number of BAP species or migratory birds over-wintering;

- **recreational**: this examines the extent of recreational enhancement that is possible. Recreation may range from the informal (such as walking), through to bird watching and to more formal sporting activities (such as canoeing or boating). Such opportunities could well be defined by the size and management of the washland, together with the type of facilities provided (interpretation boards, toilets, visitor centres and so on);

- **productive services**: these cover the direct productive capacity of the washland. For example, it may be possible to harvest reed or willow for sale;

- **fisheries**: given the sediment holding function of wetlands, downstream fisheries may benefit greatly from improved water quality. It is likely that such benefits will be experienced in urban areas (the probable reason behind the management of flood risk in the first place) and hence value may be considerable in both rents and angler enjoyment; and

- **water resources**: wetlands provide opportunity for both recharge and discharge in relation to water quantity. This, in turn, may benefit society in terms of less over-abstraction and a lessened need to investigate new sources.

Obviously each case will be different, but the above should act as a guide for the types of benefits that may be associated with the development of washlands.

4.4 Valuation of benefits

Once benefits have been identified, the next stage is to place a suitable value on those benefits for inclusion in appraisals. The reason why this methodology currently focuses on monetary valuation is that under current appraisal procedures, there is an emphasis on the monetary valuation of all impacts as far as possible. This tends to mean that those impacts that remain unvalued are given less weight in the appraisal and hence in the decision-making process.

Monetary valuation, in some form, ensures that decisions are being made that take into account as many aspects as possible.

As has been stated Section 3, there are still very few UK-based studies on the value of wetlands and their numerous services and functions. However, it is possible to use the values that are available for wetlands and, using benefit transfer, adapt them to the needs of any specific case.

It may be possible to value the washland as a whole (in terms of its total economic value in a single number) or to break down the approach to value each component separately. Care must be taken, however, with this latter approach to avoid double counting. Suggested valuation approaches are given below (again, flood defence is included to emphasise that these benefits should be included as well):

- **flood defence**: assessed as set out in the current guidance (see MAFF, 1999);

- **environmental**: ideally a contingent valuation survey should be undertaken to determine the non-use value of the site in question. However, the careful transference of values is possible (even given the sparse selection of UK-based studies);

- **recreational**: many methods exist for the derivation of recreation values (ranging from contingent valuation to travel costs). A wide range of values are also available for transfer purposes;

- **productive services**: these outputs can be valued in terms of market prices;

- **fisheries**: a number of reliable studies have been undertaken for the valuation of anglers enjoyment. Perhaps the best source for transfer values is the FWR Manual (FWR, 1996) which has values based on fishery type and quality. It is worth noting that a multiplier of 1.5 can be used to account for anglers consumer surplus above their actual expenditure; and

- **water resources**: benefits in terms of this category may be valued in terms of the avoidance of abstraction costs or the cost of developing new sources. The Environment Agency use a standard value of £1million/megalitre/day as the cost of developing new sources.

A range of values are presented in Annex 1, however, this represents a small selection of studies. Recommended sources include the FWR Manual and a variety of publications by CSERGE (UEA and UCL), Newcastle University and Middlesex University.

It should be noted, however, that if the monetary valuation route is accepted, we recommend work be commissioned on an economic valuation study in order to ensure that robust and defensible values are consistently used in appraisals. As highlighted previously, however, such an option can be time and cost intensive.

4.5 To value or not to value?

Even though the monetary valuation route is recommended above, it is still worth emphasising that this is not the only route that can be adopted. A scoring and weighting approach is

equally feasible. The disadvantage in this context though is that the majority of other impacts in the flood defence appraisal will be valued in monetary terms and hence, as outlined above, the 'value' of the washland may be given less weight in the analysis.

A scoring and weighting approach may also face difficulties in deciding which habitat is 'better' (or more important) than another. Clearly, it is difficult to be objective about such a judgement and the designed scores and weights may have to rely upon expert judgement. It is interesting to note, however, that a policy paper has been agreed at the Environment Agency Regional level which discusses the concept of 'habitat trading' which accepts losses of one type of habitat for gains in another as long as there is a net wildlife gain (Environment Agency, 1999).

On the whole, given that the primary aim of washlands in the context of this study is to provide a method for managing flood risk, the most appropriate method is to attempt monetary valuation as far as possible.

4.6 Summary

This section has set out a preliminary methodology for valuing washlands in the context of managing flood risk. This means that the value derived following the above approach will be classed as a 'benefit' in the flood defence economic appraisal. It should also be borne in mind, however, that there may be additional 'damages' to be considered depending on the type of land. For example, the semi-regular flooding of agricultural land will result in crop losses and reduced productivity which should be taken into account.

The values presented in this report, therefore, should not be viewed as net values, but rather as values associated with the creation of the washland. Additional flood damage will still need to be taken into account in the economic appraisal.

5. Case Studies

5.1 Introduction

In order to explore the current assessment of washlands as options for flood defence a number of case studies have been identified. The study brief included details of a number of possible case studies and these have been reviewed for information available and their applicability. In addition, discussions have been undertaken with staff of the Environment Agency for other suitable case studies. Where information was available in the form of a report at either feasibility study, strategy study or scheme specific level and, at some stage washlands had been considered as an option, then that project was used. The information presented in this report centres around washlands as options and any benefits associated with them.

Nine projects have been identified and these are listed in Table 5.1.

Table 5.1: Washland projects

Name	Location	Brief description
River Calder	Wakefield, Yorkshire	Washlands are an integral part of the preferred flood defence option being progressed to construction.
Haddiscoe Island	Norfolk	Saline washlands considered as part of Broadland Flood Alleviation Strategy but not taken forward as preferred option.
River Witham	Lincolnshire	Agreed flood alleviation strategy included four washlands.
Ouse Washes	Cambridgeshire	Existing Ouse Washes suffering from summer flooding which affects the flood carrying capacity. Additional washlands being explored as an option to attenuate summer flood flows.
River Ancholme	Lincolnshire	Washlands considered as an option but was not the preferred option as provision of hard defences was considered more cost effective.
Melton Mowbray Flood Alleviation Scheme	Leicestershire	Washlands part of the agreed flood alleviation scheme to be implemented shortly.
Lincoln Flood Alleviation Scheme	Lincolnshire	Washlands to protect the city of Lincoln have been in operation for 17 years.
River Trent Beckingham Marshes	Gainsborough, Lincolnshire	Washlands as part of flood defences have been in operation since 1960.
River Nar	Norfolk	Washland option considered in long list of flood defence options but not taken to detailed assessment due to high cost and technical concerns.

A fuller description of all the above projects together with an indication of the benefits considered at the time they were appraised is included on the data sheets in the following section.

5.2 Case study data sheets

Case Study 1: River Calder

Reference	Environment Agency (2000): **River Calder, Wakefield Flood Alleviation Scheme** National Review Group Report March 2000.
Factor	**Details**
Were washlands considered as an option?	A significant number of options and sub-options (42) were identified for providing flood protection to Wakefield. These included upstream flood storage washlands for both partial and maximum storage.
How far were washlands taken as an option?	Washlands were taken through to detailed appraisal.
Description of the washlands option(s)	The washland option was based on the use of five storage sites operating above the 1:25 year return period event. The five storage areas are: • Horbury Sailing Lake (increased storage); • Wildlife Pond (increased storage); • Grange Farm (new storage area following gravel extraction); • West Riding Quarry (new storage area following gravel extraction); and • Pugneys Lake (modifications to existing washland).
Are reasons given as to why washlands were/were not appropriate?	Limited use of washlands was already part of the existing flood defence system and the extension of washlands incorporating areas at present used for gravel extraction was an obvious option.
What benefits were considered?	The main benefits were to the built environment including residential and commercial properties. Intangible benefits such as recreation, amenity and conservation were also mentioned but not described in the report.
Which benefits were quantified?	The 1,200 mixed industrial, commercial and residential properties were quantified.
What were the estimated benefits?	The total benefits amounted to £27m (PV). The report also stated that £6.7m was attributed to environmental benefits but no details given.
What problems were envisaged?	One of the washland areas depended on receiving planning permission for gravel extraction.
Were washlands selected?	Yes.
What reasons were given for selection/non-selection?	Most cost effective solution.
Was any detail given on funding of the scheme?	Normal funding with MAFF grant-aid.
Further information	

Case Study 2: Broadland Flood Alleviation Strategy - Haddiscoe Island

Reference	National Rivers Authority (1992): **A Flood Alleviation Strategy for Broadland, Haddiscoe Island Washland Outline Design,** report prepared by Binnie & Partners June 1992.
Factor	**Details**
Were washlands considered as an option?	The use of washlands were considered in conjunction with other engineering options including bank strengthening and barriers. The washlands would receive saline water in this tidal environment.
How far were washlands taken as an option?	Haddiscoe Island washland was investigated in detail including outline design and costings. However, it was not taken forward as a preferred option for more detailed appraisal due to high costs and concerns over the Bure Barrier which was an integral part of the Haddiscoe Island washland.
Description of the washlands option(s)	The design of the washland included overflow weirs and pumping stations to evacuate the flood water. The aim was to allow flooding up to three times per year with a maximum duration of six days. The washland was to allow two stage flooding with part of the area flooded on a less regular basis to enable traditional grazing to carry on. The ecology of the washland on the part subject to more regular flooding would be left to adapt naturally to saline conditions. It was expected to eventually establish itself into upper saltmarsh.
Are reasons given as to why washlands were/were not appropriate?	The historic practice of raising embankments along the tidal rivers and draining the land for agricultural use has lost what used to be natural floodplains. The reintroduction of areas to flood at times of high tide and/or fluvial flows was seen as a real flood defence option.
What benefits were considered?	Benefits from the washland were maintenance of the summer grazing regime and improved wetland habitat for birds.
Which benefits were quantified?	No conservation benefits separately quantified.
What were the estimated benefits?	n/a
What problems were envisaged?	Problems identified included the created saltmarsh being uncharacteristic of the Broads area, protection or compensation for the few properties on the Island and the method of leasing/purchasing the land.
Were washlands selected?	No.
What reasons were given for selection/non-selection?	The bank strengthening was considered the most cost effective option for the whole of Broadland.
Was any detail given on funding of the scheme?	n/a
Further information	

Case Study 3: River Witham

Reference	Environment Agency (1997): **Lower Witham Strategy Study**, report prepared by Bullen Consultants, May 1997.
Factor	**Details**
Were washlands considered as an option?	Washlands were considered in association with improvements to flood embankments.
How far were washlands taken as an option?	Washlands were taken to final appraisal in the strategy.
Description of the washlands option(s)	The washlands were to be located at four sites within the river system to provide maximum flood defence benefit.
Are reasons given as to why washlands were/were not appropriate?	Washlands were considered appropriate as they were cost effective in reducing flood levels and in addition gave the potential for environmental enhancement and wetland creation which it was stated would help meet UK BAP targets.
What benefits were considered?	The only benefits considered were associated with damages to property, agriculture, traffic disruption, emergency costs and utilities.
Which benefits were quantified?	All the above were quantified.
What were the estimated benefits?	The tangible benefits for the preferred option amounted to £533m.
What problems were envisaged?	There was concern expressed by the NFU that only 'dry' washlands would be acceptable to farmers to allow them to carry on their normal agricultural practice. EN stated that the land needed to be kept damp if it is to be environmentally useful.
Were washlands selected?	Washlands were selected as the preferred option taken together with embankment strengthening and would provide a standard against flooding of 1:25 years.
What reasons were given for selection/non-selection?	The option including washlands was the most cost effective option and also environmentally acceptable. The preferred option had a very high b/c ratio of 7.55.
Was any detail given on funding of the scheme?	MAFF grant-aided capital scheme.
Further information	The strategy was agreed by MAFF and is now being taken forward to implementation. However, MAFF has insisted that the Agency look at each individual section of defence and discrete benefit area and justify each one separately. It is unclear how washlands fit into this approach where they provide benefit to the whole system for flood defence and environmental gain.

Case Study 4: Ouse Washes

Reference	Posford Duvivier (2000): **Overview of Measures to Alleviate Summer Flooding**, report prepared for the Ouse Washes Habitat Protection and Funding Group, July 2000.
Factor	**Details**
Were washlands considered as an option?	The Ouse Washes are currently used to contain and convey floodwater from the Bedford Ouse. Residential properties, farms and more than 74,000 ha Grade I agricultural land are protected from flooding by the Ouse Washes. The approximate value of assets protected is £500 million. The options were designed to minimise summer water flooding on the washlands. These options included improving drainage and/or attempting to prevent water entering the Washes. Most of the options allowed opportunities for marginal habitats to be created. One option was to attenuate summer flood flows by temporarily storing water upstream in the floodplain.
How far were washlands taken as an option?	All options were considered.
Description of the washlands option(s)	Water would be stored temporarily upstream in the floodplain of the Great Ouse. The water would then be released in a controlled manner after the flood peak has passed. The potential risk of exacerbating flooding of properties near to the storage areas would be removed by establishing a predetermined flow, above which a control structure would be opened and the floodplain storage released downstream. The total storage capacity utilising existing control structures is 1.08 Mm^3 for floodplain storage depth at the structures of 0.5m. (A complex hydrological model will need to be developed). The cost of modifying each sluice and providing a dam across the floodplain to retain an additional 0.5m would be approx. £200,000 per sluice. To provide a total storage volume of 9.5 Mm^3 would cost approx. £50m.
Are reasons given as to why washlands were/were not appropriate?	In order to completely eliminate summer flooding in the Ouse Washes, storage for approximately 86 Mm^3 would need to be found. There are insufficient locations within the floodplain to store this quantity of water without major adverse impacts. However, when considered in conjunction with other options, this figure is greatly reduced and the option appears more realistic.

What benefits were considered?	Flood storage areas along the River Ouse upstream of Earith would provide significant opportunities for the creation of wetland habitats. In addition, the sites could provide improved opportunities for flood storage in winter, with consequential benefits to flood protection of the neighbouring towns and villages. The benefits include: • additional flood benefits could be gained by finding other measures to reduce summer flooding since a reduction in summer flooding on the Washes would reduce the growth of scrub and carr and hence raise the flood defence standard of the Washes to its original level for use during winter flooding; • the Washes have been put forward to the Montreux List, which could place additional political pressure on the requirement to find an alternative flood defence option, and to allow the Washes to regain their conservation status (in this scenario a complete re-evaluation of the benefit-cost of alternatives would be required); • recreational opportunities could be included within some of the options; and • navigation improvements could be derived from some of the options.
Which benefits were quantified?	None quantified in money terms.
What were the estimated benefits?	n/a

What problems were envisaged?	The success of the option is dependent on the timing with which the storage areas are filled. The scheme will not work if the storage areas are filled too early since there will be no additional capacity to remove flow from the flood peak. The sequence of storage will depend upon the location of rainfall within the catchment. If the majority of the rain falls in the upstream reaches of the catchment, there will be a greater potential for storage along the entire length of the Ouse, and all storage areas can be utilised. If rain is predominantly in the south-east of the catchment, the structures upstream of the Ouse confluence will be less able to contribute. In such situations, all storage areas upstream of the Ouse confluence could be filled to minimise flow downstream. The biggest disadvantage is the increase in flood risk to land and properties. In order to maintain the existing standard of flood defence, a 'trigger' point must be calculated above which the stored water would be released and the control structures opened fully. Flood storage areas would have to be carefully designed to minimise potential adverse impacts on navigation during their operation due to temporary loss of channel definition, rise in water levels, reduced access to marinas and potential height restrictions under bridges. Construction of the areas could also disrupt river users, ecology and the local community. Operation of the storage areas would impede boat movements for the proposed Bedford-Milton Keynes navigation. There could be a potential adverse effect on Felmersham Gravel Pits SSSI and other sites of nature conservation interest. The potential impact on sites such as Portholme cSAC/SPA would also need to be established and minimised. Summer flooding would disrupt existing land use such as summer grazing and may result in the loss of arable land. A sudden rise in water levels may affect summer drainage pumping regimes at mineral extraction sites adjacent to two flood storage areas. It is also unknown as to how close waste disposal sites are to the river and how these may be impacted by high water levels in the flood storage areas.
Were washlands selected?	All options failed to meet the objectives, but the attenuation of floodwaters (flood storage areas) options came the closest. However, this report is only an overview, with a technical appraisal required to consider the options in more detail.
What reasons were given for selection/non-selection?	n/a
Was any detail given on funding of the scheme?	Key sources were identified as: Heritage Lottery Fund, European LIFE Nature, European Regional Development Fund Objective 2 and the Rural Development Regulations.
Further information	The Ouse Washes were constructed as washlands in 17th Century. They have proved to be effective in reducing flooding and in providing a wet grazing habitat. The increased summer flooding is reducing the viability of cattle grazing but in addition is threatening the breeding of ground nesting birds.

Case Study 5: River Ancholme, Lincolnshire

Reference	Environment Agency (1999): **River Ancholme Flood Storage Area Progression**, Report E3475/01/001 prepared by Posford Duvivier Environment, October 1999.
Factor	**Details**
Were washlands considered as an option?	Both on-line and off-line storage upstream of Brigg were considered feasible options together with defences in Brigg.
How far were washlands taken as an option?	Both the off-line and on-line options were considered feasible and were investigated further.
Description of the washlands option(s)	Offline storage: this option involved the deliberate creation of a separate flood area (or areas) adjacent to the River Ancholme, linked to the river through a sluice, weir or other control mechanism. Existing banks along the river and the adjacent tributaries bound the area with no supplementary embankments required. All or part of the flood storage area may be maintained for grazing or arable (depending on the frequency of flooding), or parts could be designed for wildlife or environmental benefits. Different standards were assessed, from a 1 in 10 year scheme to a 1 in 200 year scheme.
	On-line: in this option, the river and storage areas are directly connected by removing the embankments. This creates a permanently wet area that fills further during flood events. On-line areas flood more frequently and in a loss controlled manner than off-line storage, this means they are less efficient and consequently a larger area is required for the same return period.
Are reasons given as to why washlands were/were not appropriate?	The off-line storage option was considered to be the preferred option from an environmental perspective, but it was not as economic as 'raise banks in Brigg only'.
What benefits were considered?	In addition to the tangible benefits from protecting the urban area the following were discussed: • control of flooding providing farmers with additional security; • (re)creation of valuable ecological habitats to meet targets (e.g. UK BAP) and offset losses in the Humber SPA; • flood storage areas could be used to provide a form of winter storage, thus reducing the need for direct summer abstraction; • development of a sustainable strategy which will have value as a model for flood defence schemes elsewhere; and • there are likely to be a number of other environmental, recreational, sustainability and land diversification benefits for landowners, and the whole Ancholme valley, arising from a well designed flood storage scheme.
Which benefits were quantified?	The benefit estimates include agricultural and urban damage costs avoided to estimate present value benefits but not any environmental benefits.
What were the estimated benefits?	In the assessment, the benefits to the urban and rural area amounted to: • £34.983 million for the 1 in 10 year scheme; and • £36.537 million for the 1 in 200 year scheme.

What problems were envisaged?	Even with a storage option, flood events with a return period greater than approximately 1 in 10 years will still lead to flooding of agricultural land. It was anticipated that the Environment Agency was unlikely to consider compulsory land purchase, therefore, any storage scheme, including compensation or other packages associated with it, must be acceptable to all landowners within the proposed storage area. MAFF funding will not be available until all the affected landowners have accepted the package on offer which may take considerable time. Farmers will wish to see some guarantee of income and long-term stability from any flood storage scheme. A 1 in 10 year return period may be too short to offer landowners the stability they require. As a result of its current use for intensive agriculture, the soil properties (e.g. nutrient content) in any flood storage area may lengthen the process of habitat enhancement. There may be knock-on impacts on drainage of the land surrounding a flood storage area (e.g. backing up of water in drains).
Were washlands selected?	Raise banks in Brigg only had an average benefit cost ratio of 7.54 and satisfied the 1 in 100 year indicative standard. Off-line storage had an average benefit cost ratio of 6.76. Therefore, the preferred option was raise banks in Brigg only.
What reasons were given for selection/non-selection?	The option was chosen on economic grounds. Environmental opportunities were not given a monetary value.

Was any detail given on funding of the scheme?	The only direct source of funding for flood defence schemes comes from MAFF and the Environment Agency and many organisations will not provide funding for projects that fall within the government's functions. A range of other sources of funding were investigated different aspects of the flood storage scheme: • organisation, feasibility and implementation of projects: DETR Environmental Action Fund; European LIFE Nature, European LIFE Environment, Heritage Lottery Funding, Landfill Tax Credits, MAFF Countryside Stewardship Grants; • habitat creation enhancement (species specific): British Association for Shooting and Conservation (loan), Countryside Agency (coasts and forests), National Trust and Environmental Action Fund - none of these may be suitable, however; • encouragement of sustainable farming: BASC (loan), European LIFE Environment, Forestry Authority Woodland Grant Scheme, MAFF Countryside Stewardship Scheme, Lincolnshire Trust for Nature Conservation; • encouragement and support for sustainable leisure activities: BASC (loan), Countryside Agency (increased access), Forestry Authority Woodland Grant Scheme, MAFF Countryside Stewardship; • improvement of the countryside around towns: Countryside Agency, European Regional Development Fund (incorporating the DETR Rural Development Programme), Forestry Authority Woodland Grant Scheme, MAFF Countryside Stewardship, Landfill Tax Credits, Heritage Lottery Fund, DETR Environmental Action Fund; and • land purchase: Countryside Agency, English Nature, European LIFE Nature (designated sites), National Trust (heritage coast), Landfill Tax Credits, World Wide Fund for Nature, Heritage Lottery Fund.
Further information	

Case Study 6: Melton Mowbray Flood Alleviation Scheme

Reference	Environment Agency Midlands Region (June 2000): **Melton Mowbray Flood Alleviation Scheme, Project Appraisal Report**.
Factor	**Details**
Were washlands considered as an option?	Yes. A long list of 23 options was reduced to six for detailed appraisal of which three were washlands (although in reality this was one washland designed to three standards).
How far were washlands taken as an option?	Taken through to final appraisal.
Description of the washlands option(s)	The washland option is on-line storage incorporating an earth dam with associated control structure. The washland covers an agricultural area of mixed arable and grazing. The dam is within an SSSI.
Are reasons given as to why washlands were/were not appropriate?	The washland option achieved the objective of reducing the risk to the urban population and in addition gave improvements to water quality, including silt reduction which benefited the gravel spawning beds.
What benefits were considered?	The tangible benefits included the reduction of flood damage to properties and industrial premises. Additional benefits included the water quality improvements gained by careful design of the works incorporating silt traps.
Which benefits were quantified?	Within the economic appraisal only tangible benefits were quantified.
What were the estimated benefits?	Tangible benefits of £14m (PV).
What problems were envisaged?	Problems envisaged included concerns regarding constructing the earth dam in the SSSI and mitigation measures, including the provision of wet woodland and grassland, were an integral part of the project.
Were washlands selected?	Washland to provide a standard of protection of 1 in 100 years is the preferred option being put forward for approval for grant-aid.
What reasons were given for selection/non-selection?	The washland was the most cost effective solution and provided environmental gain as it would help reverse the decline to the SSSI caused by changing farming practices.
Was any detail given on funding of the scheme?	Compensation to landowners to account for increased flooding amounts to £240,000 within the scheme costs. In addition £173,000, associated with the environmental enhancements including wet woodland, reedbeds and grassland, were included as scheme costs.
Further information	

Case Study 7: Lincoln Flood Alleviation Scheme

Reference	Anglian Water (1982): **River Witham System Scheme, Lincoln Flood Alleviation**, Engineers Report.
Factor	**Details**
Were washlands considered as an option?	Washlands were one of 200 options identified.
How far were washlands taken as an option?	Controlled washlands were identified as the preferred option.
Description of the washlands option(s)	The sites of the washlands are within the river floodplain upstream of Lincoln. The option was for the construction of two washlands, on the River Witham and River Till, comprising 8.24km^2 and 2.98km^2 respectively. The land to be flooded on an irregular basis is mainly arable. Properties within the washland are protected by flood embankments and access roads are raised. Control sluices were constructed on the rivers for the controlled filling and emptying of the washlands.
Are reasons given as to why washlands were/were not appropriate?	Washlands were considered appropriate due to the excessive costs of providing defences through the ancient city of Lincoln (including listed bridges) or inbank storage within the river system.
What benefits were considered?	Only damages to residential, commercial and industrial properties were considered.
Which benefits were quantified?	The above were quantified using standard damage data.
What were the estimated benefits?	NPV benefits of £15.5m (discounted over 30 years at 5% in 1982).
What problems were envisaged?	Need for planning permission and impounding licences and CPO or Act of Parliament.
Were washlands selected?	Yes and are in operation.
What reasons were given for selection/non-selection?	Economically advantageous. Benefits of £15.5m against costs of £9.4m.
Was any detail given on funding of the scheme?	A compulsory purchase order was made for compensation to the farmers which included the level of payment and operating procedures. A Public Inquiry took place which confirmed the Order.
Further information	Used for the first time in November 2000 although the operating procedures indicated their use every 10 years on average.

Case Study 8: River Trent, Beckingham Marshes

Reference	Discussions with Environment Agency
Factor	**Details**
Were washlands considered as an option?	Washlands were an integral part of the Gainsborough Flood Alleviation Scheme being promoted in the 1950s.
How far were washlands taken as an option?	The land on the opposite bank of the River Trent, which was originally floodplain before being embanked for agricultural purposes, was identified as a suitable area. The land had been purchased by the River Board in 1930's and 40's. The flood defence scheme was completed in 1960.
Description of the washlands option(s)	The washlands extend to 566ha. The majority of this area is in agricultural production either as arable or intensive grassland. In addition, there are a number of production oil wells, a factory (raised above flood level) and a fishing lake. The washlands begin to flood in a 1 in 3 year event with the whole area flooded in a 1 in 20 year event.
Are reasons given as to why washlands were/were not appropriate?	It is assumed that washlands were considered appropriate at this location due to its history as a floodplain.
What benefits were considered?	It is assumed that the only benefits considered were tangible benefits realised from protecting the urban area of Gainsborough and surrounding villages.
Which benefits were quantified?	n/a
What were the estimated benefits?	Not known.
What problems were envisaged?	From the decision made by the River Board to purchase the land, the future control and management of the washland may have been considered as a problem.
Were washlands selected?	As above, an integral part of the scheme.
What reasons were given for selection/non-selection?	n/a
Was any detail given on funding of the scheme?	Land purchased for the scheme. Subsequently the agricultural land was then rented to three farmers with a tenancy agreement including a clause that the area floods and there would be no claim by the owners. Since the purchase of the land, 66ha has been sold for agricultural use.
Further information	The Agency as owners of the majority of the washlands, manage them through their estates section with the objective of maximising financial return. As part of a project for the Royal Institution of Chartered Surveyors the management of the Beckingham Estate to provide conservation benefits has been explored. A number of actions have been identified and costed in respect of conservation and recreation 'improvements' and in economic terms the benefits outweigh the costs with the benefit-cost ratio being 1.7.

Case Study 9: River Nar

Reference	Environment Agency (2000): **River Nar Improvement Scheme,** draft Engineers Report prepared by Posford Duvivier March 2000; and Environment Agency (1998): **River Nar Improvement Scheme Review of Option 6**, report prepared by Posford Duvivier July 1998.
Factor	**Details**
Were washlands considered as an option?	A washland incorporating a wetland was included at feasibility study stage.
How far were washlands taken as an option?	The washland option was not taken to detailed appraisal.
Description of the washlands option(s)	The washland would be contained by an earth embankment with associated inlet and outlet structures. It would be designed to provide a standard of protection of 1 in 25 years. The washland was also promoted on the basis that it would be managed as a wetland to complement the River Nar SSSI.
Are reasons given as to why washlands were/were not appropriate?	The washland was not taken forward for detailed appraisal on the grounds that: it was more costly than the relief channel option and: • colonisation of the wetland would be slow due to remoteness of similar habitat; • the ground conditions would give rise to excessive seepage from the wetland; • water to keep the wetland wet during the summer would be limited; and • the existing arable use of the site would delay any colonisation of wetland species due to high nutrient levels.
What benefits were considered?	The conservation benefits were identified as wet grassland and reedbeds which would help towards UK BAP targets.
Which benefits were quantified?	The above benefits were not quantified and it was stated that it would not be so great as to increase the NPV so that the reservoir scheme was economically viable.
What were the estimated benefits?	The benefits associated with protecting the at risk area from flooding was estimated as £6.172m (PV).
What problems were envisaged?	Problems envisaged included construction and maintenance of the wetland environment.
Were washlands selected?	No.
What reasons were given for selection/non-selection?	It was stated that the economic benefit of any possible wetland creation would be insufficient in economic terms to switch from the lower cost relief channel option.
Was any detail given on funding of the scheme?	MAFF grant-aid funding for relief channel option. It was also suggested that the higher cost washland option would not attract grant-aid for the extra cost but if additional contributions could be found for this option then they would be classed as windfalls (therefore not decreasing the grant-aid amount).
Further information	

5.3 General comments on the case studies

5.3.1 Locations

From the discussions held with Agency staff the consideration of washlands as part of flood defence options is generally widespread throughout the country. However, they are not generally appropriate in steeper catchments where there may be only limited space for their construction. As can be seen from the case studies chosen, all the washlands are in lowland areas and in that respect are associated with floodplains.

5.3.2 Construction

All the washlands have costs associated with their construction. The types of structures required to impound flood waters include earth embankments and dams and their associated spillways, sluices, culverts, etc. The costs of construction can form a significant part of the overall costs. A number of the case studies required the embankments and dams to be constructed and managed in accordance with the Reservoirs Act 1975 as they impound over 25,000m^3 of water above the surrounding natural ground level. The cost of construction and maintenance to comply with the Act may, in certain circumstances, be high.

Where river embankments contain the washland, a good example being the Ouse Washes, then the case is not so clear cut and the designation depends on a number of factors. At present tidal river embankments, coastal defences, navigable watercourses and natural washland areas are outside the scope of the Act.

It should be borne in mind that developing a washland is a 'real' flood defence option and does involve active design and management. It may be perfectly feasible to allow a breach to go unrepaired to allow formation of a washland. However, this approach may not maximise the flood defence benefits of the washland whilst maximising environmental benefits. There may be some degree of trade-off, therefore, between flood defence and environmental functions. A washland may be achieved under options such as 'do-nothing' or 'managed retreat', however, more active management of the storage capacity may result in greater flood defence and environmental benefits. Hence, a washland should be treated as a fully viable option and managed as such.

The key point to bear in mind is that there should be a catchment driven approach to managing flood risk. This ensures that benefits are maximised (flood defence, environmental, etc.) at a catchment level, negating the need to be concerned as to whether one particular washland achieves the 'correct' balance between flood defence and environmental benefits. Different catchments and geographical areas will, therefore, have different requirements and provides the opportunity to have different approaches for each catchment. This will ensure a move to a diverse living environment that achieves the management of flood risk whilst providing environmental and much wider benefits.

5.3.3 Habitat creation

In general the creation of wetland habitat was not pursued in detail for any of the studies and there has been no attempt to place a value on the habitat or indeed many of the other wider benefits. The River Nar identified a site for wetland habitat but then it was stated that it would be difficult to maintain wet conditions due to the underlying geology and competing demand for water during dry periods. The proposed Melton Mowbray Washland will provide a wetland within the washland but not of any great size and it will compensate for loss of part of

the SSSI when the embankment is constructed. The washland benefits associated with the River Calder were not quantified but statements were made that there would be benefits arising from recreation, conservation and amenity.

An observation from the case studies is that it appears that there was generally a clear cut case for the preferred option, be it washland or structural solutions, and the non-quantification of conservation benefits has not had a material effect on the outcome. This, however, may not be the case for all washlands (as shown in the next section) and within the present appraisal methodology required by MAFF there are distinct advantages to be gained from maximising the benefit-cost ratio[1]. The inclusion of habitat benefits will assist in this.

The Ouse Washes is an interesting case where, it is assumed, the original design of the washland did not envisage the internationally important wetland that has been created as a result. Flooding during spring and summer months can damage the habitat (which also has an effect on the flood retention capacity) and further washlands are being explored to provide additional storage.

In the Haddiscoe Island case, there were concerns expressed by landscape interests that although the 'new' upper saltmarsh habitat would be an important addition it was not typical of the broadland landscape. This may be the case in other situations although if washlands are within floodplains there should be little conflict over landscape issues.

An interesting point raised by all the case studies is that encouragement of their use reverts the floodplain back to a more natural state. However, given that the landscape across the country has been changed and adapted over generations, it is difficult to determine what actually is 'natural'. As an example, the lower valleys of the Broads in a fully functioning state would be saltmarsh - an element that is now seen as alien. The creation of washlands, therefore, should be seen as the first steps to altering the landscape, which will change over time (probably decades or centuries).

5.3.4 Payments

The case studies where washlands have been constructed have varied in the methods used for compensating the landowner for flooding land. In the case of Beckingham, the land was purchased and rented to farmers on the agreement that there would be no compensation for flooding. The farmer therefore carries the risk. The Lincoln Scheme compensated the landowners for loss of agricultural output based on an estimated frequency of flooding. It was decided to try and agree levels of compensation with all the landowners rather than go for a Compulsory Purchase Order (CPO). However, as there were many issues causing concern a CPO was made, the alternative being an Act of Parliament which would have caused considerable delay. The level of compensation was part of the public inquiry and was paid as a one-off payment. However, as part of the agreement a review of the frequency of flooding and the need for additional compensation payments would take place after 20 years of operation. The Melton Mowbray Flood Alleviation Scheme is paying compensation to all the affected landowners, with the level of payment related to future agricultural losses from increased flooding.

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[1] Under the current scoring system, the higher the benefit-cost ratio then the higher the score, which means there is a greater chance of acquiring MAFF grant-aid.

With capital schemes attracting grant-aid there are advantages for the promoters of making one-off payments which can be included in the grant-aided costs. A method by which landowners were compensated on an annual basis would be more difficult to argue as a grant eligible cost as it could be seen as an operating cost and therefore not grant-aidable. It is worth noting here that for the Orplands managed retreat option on the Essex coast the compensation payments were achieved through the habitat creation scheme then in operation, and these costs, therefore, did not fall on the operating authority. This method of payment may be worth exploring in the future, although care will be needed to ensure the correct economic costs appear in the economic appraisal.

The inclusion of compensation costs for washland landowners in the economic appraisal was investigated in the River Witham Scheme and guidance from MAFF was that it should be excluded from the economic costs. This could make washlands a more attractive option economically although they will have to be included in the financial costs of the scheme. This is an area that requires further clarification.

The case studies have identified a number of different routes that can be taken to secure land to be used as washlands. The different methods are either through voluntary agreements or compulsory purchase. They all require significant negotiation with land owners regarding possible change of use of the land, compensation for loss of crop and/or changes within the farming practice and costs associated with future management. At the very basic level this will be the purchase of the 'right' to flood the land. However, in order to maximise environmental benefits, there may need to be a component that specifies water level management practices and this could be either capital or annual payments linked to an agreed management plan. There could be difficulties with flood defence monies being used to provide environmental benefits over and above the flood defence benefits. The most appropriate method appears to be where the flood defence budget provides the capital cost to construct the washland (which is for flood defence purposes) and the management of the washland after its creation is funded through agri-environment payments aimed specifically at optimising environmental benefits.

This is an important point to stress, there needs to be more encouragement of 'joined-up thinking' in terms of managing flood risk in a sustainable manner. At present, funds are very much ring-fenced for specific uses; a much more open approach is required in order to encourage the development of washlands. In effect, the MAFF funding for development of the washland (i.e. its capital cost) must be supported by a commitment to on-going revenue funding (i.e. for maintenance) to ensure that the washland fully operates in respect of its flood defence function in order to develop the wider benefits of the washland. The development of a washland agri-environment scheme could be crucial to the realisation of the many benefits washlands provide.

At present, however, the agri-environment schemes and flood defence capital grants are all under the MAFF umbrella but administered by different sections. There needs to be further dialogue to ensure joint objectives of sustainable flood defence and maximum environmental gain are fully realised.

5.3.5 Catchment planning

An observation from all the case studies is that washlands were considered as an option to address localised flood risk. The location of washlands does not have to be in the immediate vicinity of the at risk area as is the case with hard defences. There is therefore more scope for imaginative use of washlands within a river catchment but this will only take place if flood risk

is addressed on a catchment basis. (Catchment could related to a whole river system or divided up into smaller sub-catchment units depending on the geography). However, there will be limitations as to where washlands can be located to be effective. For example, a washland at the head of a catchment will provide only limited flood relief benefit as it will only be able to intercept a small part of the rainfall falling on the catchment. The use of a number of smaller washlands within a catchment may be appropriate in some cases although there could be increased construction costs from physically working on a number of sites. There may also be a need to flood areas at present defended or a lower standard may result to some areas following development of a washland. In relation to habitat creation, there may be more suitable areas for washlands within the catchment rather than close to the flood risk site, for example, areas adjacent to existing wetlands or where wetland areas have been drained in the past.

These points link in with recommendations contained in the English Nature report on *The Effectiveness of the Floodplain ESA Schemes in the Maintenance and Enhancement of Biodiversity* (2000), which sets out the need for an overall 'vision' for each floodplain ESA involving the identification of areas of biodiversity importance to:

- maintain, and where necessary enhance, conservation activities at existing key sites;
- identify areas which require restoration or rehabilitation;
- key areas where restoration would result in optimum conservation returns; and
- identify areas for habitat creation.

In the development of washland proposals, therefore, great care should be made to ensure that options are developed that maximise benefits. Hence, there is an opportunity to situate washlands where they not only provide the flood defence benefit, but are also able to maximise other benefits, particularly biodiversity.

Catchment planning is very much part of the Water Framework Directive (or river basin districts as they are referred) with an emphasis on "...taking into account the natural flow conditions of water within the hydrological cycle...". Article 1 of the directive aims to "...prevent further deterioration and to protect and enhance the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems...". Washlands could not only provide viable flood defences, but also help the UK in meeting EU requirements under this directive.

With reference to national policy, MAFF currently encourages the development of river catchment plans (MAFF, 1993) and states that where possible schemes should be designed and managed to enhance the environment. The Environment Agency has recently embarked on the production of Catchment Flood Management Plans. These will provide a large-scale strategic planning framework for integrated management of flood risks to people and the developed and natural environment in a sustainable manner. Guidelines are at present under development (as at February 2001) which state that such plans provide an opportunity to contribute to delivering biodiversity targets.

This catchment approach is clearly vital in linking together the management of flood risk with the achievement of BAP targets and the development of a vision for their future sustainable management.

5.4 How the valuation of washlands can alter appraisals

5.4.1 Overview

This section takes two of the case studies discussed above and re-examines the appraisal, which is modified to include the valuation of the wider benefits of washlands (in addition to the traditional flood defence benefits). For the purposes of this exercise, we are using the values as presented in RPA (1998) and summarised in Table 3.2, which reflect the total economic value of wetlands.

5.4.2 River Ancholme

The costs and benefits for the options considered have been taken from Environment Agency (1999). There are, effectively, five main options:

- do-nothing;
- do-minimum;
- off-line storage with no road raising;
- off-line storage with road raising; and
- bank raising.

The original appraisal calculated that the preferred option was to raise banks to a 1 in 100 standard. However, no explicit value was carried out with regards to the additional benefits that may accrue from the development of the washland.

The washland is expected to be 800ha and using values from Table 3.2 generates present value benefits of:

- upper: £25.66m/annum;
- central: £8.02m/annum; and
- lower: £4.01m/annum.

Given the nature of the area, the lower bound estimate has been taken forward into the updated appraisal. The updated costs and benefits are shown in Table 5.2 (the full spreadsheet can be found in Annex 3).

Table 5.2: Summary of updated Ancholme appraisal (ranked in terms of cost)

Option	Benefits (£k)	Costs (£k)	NPV* (£k)	B/C**	Inc. B/C***
Do-nothing	N/A	N/A	N/A	N/A	N/A
Do-minimum	29,392	4,091	25,301	7.18	N/A
Bank raising	35,097	4,654	30,443	7.54	10.13
Off-line B	40,541	5,376	35,165	7.54	7.54
Off-line A	40,541	5,883	34,658	6.89	0.00

* net present value (benefits minus costs)
** benefit-cost ratio (benefits divided by costs)
*** incremental benefit-cost ratio (change in benefits divided by change in costs)

The above table shows that, in this case, the preferred option does change from bank raising to that of developing a washland (being the option with the highest net present value and benefit-cost ratio).

It is also interesting to see how far the analysis 'can go' in terms of the values and assumptions underlying the valuation of washlands. For example, the following questions highlight some interesting findings:

- how low can they go to not change the decision: **£55/ha/annum**;
- what does the area have to reduce to not change the decision: **150 ha**; and
- does a halving in value and area still change the decision: **no**.

For this case, therefore, there is a very good case for the development of a washland.

5.4.3 River Nar

The assessment of the River Nar is slightly more complicated. The option of the washland was dropped at a fairly early stage for technical, environmental and economic reasons. However, it is of interest to highlight how the appraisal may have looked if a washland had been included. Given that this option had been discarded, the benefits had not been updated in line with the other options. We have updated these benefits based on an interpolation (using a log function) of standards of defence and damage incurred.

The options in this case can be summarised as being:

- do-nothing;
- do-minimum;
- improve to 1 in 50 (with varying standards of spillways); and
- washland.

The original appraisal concluded that the improve to 1 in 50 (with a 1 in 5 spillway) should be the preferred option.

The washland is expected to be 150ha and using values from Table 3.2 generates present value benefits of:

- upper: £4.81m/annum;
- central: £1.50m/annum; and
- lower: £0.75m/annum.

For this appraisal, both the lower and central estimates have been taken forward into the updated appraisal. The updated costs and benefits are shown in Table 5.3(the full spreadsheet can be found in Annex 3) for both cases.

Table 5.3: Updated River Nar appraisal (ranked in terms of cost)

Appraisal using lower estimate					
Option	**Benefits (£k)**	**Costs (£k)**	**NPV* (£k)**	**B/C****	**Inc. B/C*****
Do-nothing	N/A	N/A	N/A	N/A	N/A
Improve	25,449	4,954	20,495	5.14	N/A
Washland	25,764	5,140	20,624	5.01	1.69
Do-minimum	23,674	5,543	18,131	4.27	-5.19
Appraisal using central estimate					
Option	**Benefits (£k)**	**Costs (£k)**	**NPV* (£k)**	**B/C****	**Inc. B/C*****
Do-nothing	N/A	N/A	N/A	N/A	N/A
Improve	25,449	4,954	20,495	5.14	N/A
Washland	26,516	5,140	21,376	5.16	5.74
Do-minimum	23,674	5,543	18,131	4.27	-7.05

* net present value (benefits minus costs)
** benefit-cost ratio (benefits divided by costs)
*** incremental benefit-cost ratio (change in benefits divided by change in costs)

The above shows that the case is much less clear cut and marginal. The preferred option remains as in the original appraisal when the lower value estimate is used (following the current MAFF decision rule, which can be found in MAFF, 1999). However, when the central estimate is used, the decision does change. There may be a case for the use of the central estimate given that the relative locality of Kings Lynn means there may be many recreational users.

As above, it is also interesting to see how far the analysis 'can go' in terms of the values and assumptions underlying the valuation of washlands. For example, the following questions highlight some interesting findings:

- how low can the value go before the option doesn't change: **£400/ha/annum**;
- using the lower estimate, what area is required to change to a washland: **200 ha**;
- using the central estimate, what area is required for there to be a change back to the 'improve' option: **100 ha**.

For this case, therefore, there is a less strong case for the development of a washland.

5.4.4 Conclusions

These small tests on two case studies show that the appropriate valuation of washlands may be vital to their consideration within flood defence appraisals. Clearly, from the case studies, washlands may be discounted as a viable option at a very early stage due to the non-inclusion of the additional benefits that may accrue.

6. Conclusions: Developing a Case for Washlands

6.1 Overview

This report has set out:

- the valuable function and services that are provided by wetlands in general;
- a review of the approach to the economic valuation of wetlands;
- an approach to the valuation of washlands specifically;
- a number of case studies where washlands may have been given more serious consideration in the analyses; and
- two cases where the inclusion of the economic valuation of the additional services that washlands provide may have altered the choice of the preferred option for managing flood risk.

6.2 The importance of washlands

Washlands not only have the capability to improve biodiversity whilst providing flood defence benefits, but in a wider context, they may be crucial for the UK in achieving national and international regulatory requirements. A co-ordinated approach to the consideration and use of washlands not only ensures a more sustainable approach to flood defence but also provides opportunities for delivering BAP targets, improving the condition of SSSI's and developing a more naturally functioning floodplain.

Clearly, the catchment-focused approach emphasised in the Water Framework Directive, provides a real opportunity for washlands to be a widely considered flood defence option.

6.3 Validity of washlands as a flood defence option

Washlands do indeed provide a viable alternative for the management of flood risk. In fact, given the additional benefits that washlands provide, their use should be actively encouraged (where technically, environmentally and economically feasible).

We recommend that English Nature work together with MAFF and operating authorities in taking a pro-active role in encouraging washlands to be considered a flood defence option, together with investigating the appropriate compensatory payments that may be paid to land owners in order to accrue the wide range of benefits that washlands provide. This would not only be a cost-effective solution, but the management of flood risk in this way offers a much more sustainable and holistic approach that will benefit society (both now and in the future) as a whole.

We also encourage MAFF to produce guidance on the opportunities for the use of washlands in flood defence schemes. This will encourage operating authorities and their consultants to consider washlands as a viable option.

6.4 Appraisal of washland benefits

In order to fully appraise the benefits from washlands, both the flood defence and wider benefits need to be included in flood defence appraisals. In the case of the former, guidance is available from MAFF in its Project Appraisal Guidance series. In the case of the latter, a methodology has been put forward in this report. However, agreement is required as to the appropriate values to be used for these wider benefits within appraisals in order to ensure a

consistent approach. This will involve interaction between English Nature, MAFF, DETR and the Treasury. Ideally, a joint research project may be commissioned in order to derive robust and defensible values that could be applied nationally. This would ensure that each English Nature Region approaches (and encourages) washlands in the same manner.

In the interim, however, the use of standard values is feasible and if applied correctly will provide robust and defensible results. This report has shown that a value of £300/ha/annum provides a reasonable minimum value that reflects the additional value of wetlands to their flood defence function. In fact, the major hurdle that English Nature may face is being able to encourage the consideration of washlands/wetlands as a viable option in the first place. As a number of the case studies have shown, washlands are often considered and dismissed at a very early stage of the analysis, without a full consideration of their benefits.

We recommend that English Nature, in its role as a statutory consultee, strongly encourages operating authorities and their consultants to at least consider washlands as an option in the early stages of an appraisal and ensure such options are not dismissed prematurely. If washlands have not been considered, then reasons should be given as to why not.

6.5 Institutional/payment issues

The use of washlands as an integral part of flood defence requires co-operation between MAFF, the Agency and English Nature. MAFF encourages the strategic approach to flood defences which should guide the Agency to look at flood defence on a catchment-wide basis. The Agency has made the first steps with Catchment Flood Management Plans, currently in development. To satisfy the objectives of economic soundness and environmental acceptability requires a commitment from all parties and a willingness to work together

The method of payment for land either through purchase, compensation or management agreements is vital to the success of washlands. Given the environmental and social benefits that may accrue, a compensatory partnership approach is probably the most appropriate way forward (involving organisations such as MAFF, English Nature, the Environment Agency, Internal Drainage Boards and local authorities).

We therefore recommend the use of a washland agri-environment scheme to compensate and encourage land owners to allow their land to be used in the development of a washland and hence a catchment-based approach to flood risk management.

6.6 Recommendations for future work

We recommend the following work be undertaken in order to enhance the case for washlands:

- a robust valuation study examining the use and non-use benefits in relation to washlands primarily used as flood defences;
- a detailed consultation exercise undertaken covering land owners whose land could be suitable areas for washland development. This will illustrate the willingness (or not) to allow land to be flooded;
- a study should be commissioned to examine the level of payments that would be required to encourage land owners to opt into a washland creation scheme; and
- following outputs from these studies, a robust case could then be put forward to MAFF and the Treasury regarding the valuation and use of washlands and the potential development of a washlands agri-environment scheme.

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Annex 1: Environmental economics valuation techniques

A1. Valuation techniques

A1.1 Market price/effect on production approaches

These approaches rely on the use of market prices to value the costs/benefits associated with changes in environmental quality. One approach in this category is the **dose-response technique**, which determines the economic value of changes in environmental quality by estimating the market value of the impact which these have on the changes in output of an associated good. For example, changes in crop yield are linked to changes in atmospheric pollutant concentrations and deposition.

A second related technique is calculation of the costs of replacing or restoring an environmental asset after it has been impacted. The **replacement costs** approach does not provide an economic value, but a minimum figure indicating only the engineering and other costs of re-creation (and assumes that the economic value would be higher as the site would not be re-created if it were not 'valued' more than such costs).

A1.2 Household production function approaches

In these approaches, expenditure on activities or goods which are substitutes for, or complements to, an environmental good are used to value changes in the level of the environmental related good.

The **avertive expenditure** (or averting behaviour) approach relies on estimation of expenditure on substitute goods. It attempts to infer individuals' willingness to pay to reduce or prevent damages by observing and placing a value on the behaviour used to avoid that damage. In the case of environmental effects, it is based on determining the amount which people are willing to spend on measures which mitigate impacts. So, for example, the installation of double glazing on windows is a substitute for reduced noise impacts, and expenditure on this provides an indication of individuals' willingness to pay for policies aimed at reducing noise levels.

One of the key difficulties in applying this method, however, is decomposing the reason for the expenditure (for example, is the purchase to reduce the risk to one or many individuals?). Other problems include: individuals not understanding the level of environmental protection that they are getting for their money; the proportion of expenditure aimed at reducing impacts; and the degree to which purchase of the item is considered a 'second' best option.

The **travel cost method** (TCM) is based on the concept that people spend time and money travelling to a recreational site and that these expenditures, or costs, can be treated as revealing the demand for the site. Surveys of site visitors are undertaken to determine the demand for a site, where visit rates are a function of travel expenditure, leisure time, income, any entry fees, environmental characteristics and the availability of substitute sites. In practice, a number of issues surround the application of this approach which are related to, for example: the inclusion of costs associated with the actual time spent travelling; trips which may involve visits to more than one site; difficulties in accounting for varying qualities of alternative sites and thus their affect on the demand for a given site; and accounting for visitors who travel to the site by modes other than private car.

A1.3 Hedonic pricing methods

The hedonic pricing method (HPM) is based on the concept that the price paid for a complementary good implicitly reflects the buyer's willingness to pay for a particular environmental attribute (e.g. a high quality river), or his willingness to accept an increased risk. These methods determine an implicit price for a good by examining the 'real' markets in which the asset is effectively traded.

Hedonic property (land) prices have been used in the valuation of characteristics such as air quality, noise, fishery quality and other amenity characteristics associated to residential and other properties. It is still commonly used to assess amenity effects, although many analysts have argued that the technique is not reliable in the valuation of environmental effects which are not readily perceptible in physical terms. A number of studies, for example, have found no relationship between increases in property values and differing standards of chemical water quality.

A1.4 Experimental (hypothetical) markets

The two key techniques which involve the use of experimental or hypothetical markets are the contingent valuation method and the contingent ranking method. Under the **contingent valuation method** (CVM), individuals are surveyed to determine their willingness to pay for a specified change in the quality or quantity of an environmental good (or how much compensation they would expect for an increase in risk or in environmental damages). The mean willingness to pay value across all valid bids is then used to provide an indication of the economic value of the specified change. Difficulties with this approach include: problems in understanding the concept of risk and in particular marginal changes in risk, and individuals acting strategically when responding to questions (or indeed respondents giving random answers in that numbers are pulled out of the air).

The **contingent ranking (or stated preferences method)** involves the elicitation of individuals' ranking of preferences amongst a bundle or 'basket' of different environmental outcomes. Values for changes in environmental goods are derived by 'anchoring' preferences to either a money sum or the real market price of one of the goods included in the bundle/basket of outcomes.

A1.5 Use of environmental 'benefit transfer' approaches

As it stands, one of the biggest constraints to the valuation of environmental effects as part of any one cost-benefit analysis is the financial costs of undertaking a valuation exercise and the time required to do so. Clearly, it is not feasible to estimate all environmental benefits to damages for each location and time specific situation for each case. Much of the work required is extremely time consuming and expensive, making the transfer of estimates from one study to another an important part of the exercise. As a result, economists are increasingly adopting benefit transfer approaches as a cost-effective alternative to the commissioning of issue specific valuation studies. Benefit transfer eliminates the need to design and implement a new and potentially expensive valuation exercise for different sites or for different policies. The difficult issue, indeed a key issue, is to know when a value is transferable and what modifications, if any, need to be made before it can be used in its new context.

Benefit transfer can be defined as the process of taking a value or benefit estimate developed for a previous project or policy decision and transferring it to a proposed project or policy

decision. In other words, estimates of the value of a recreational user-day for one specific site and environmental quality change are assumed to provide a reasonable approximation of the value of a recreational day for another site given a similar type of environmental improvement.

There are three different approaches which might be adopted in benefit transfer:

- the transference of mean unit values;
- the transference of adjusted unit values; and
- the transference of a demand function.

The use of mean unit values is obviously the simplest approach that can be adopted. A range of factors may affect, however, the validity or reliability of such an approach. For example, the environmental change measured in the original study may differ significantly in one or more key attributes from the problem currently under consideration; or, indeed, measurement may have been undertaken for a different purpose and some factors relevant to the current decision may not have been considered. At a project level, there may be substitute sites or other opportunities which could affect individuals' valuations.

The second approach, the adoption of an adjusted unit value involves the analyst adjusting past estimates to correct for biases incorporated in the original study, or to take into account differences in socio-economic characteristics, project/problem components, levels of damage reduction, site characteristics and the availability of substitute goods. This approach is open to many of the same questions concerning validity and reliability as the use of unadjusted mean values.

The third approach is preferable and involves taking the demand function from a previous study, inputting new data relevant to the project in question and re-running the analysis. The advantages of this type of approach are that calculated benefits are based on information on use and unit values which are derived from the same data set. Adoption of this type of approach, however, is likely to be constrained by there being insufficient information for developing a transferable demand function.

Where several studies report a similar final estimate of environmental benefits or damage, and where there are significant differences between them in terms of the background variables, a procedure known as *meta-analysis* has been developed to transfer the results from one study across to other applications. What such an analysis does is to take the estimated damages from a range of studies of, for example, coal fired plants and see how they vary systematically, according to affected population, building areas, crops, level of income of the population, etc. The analysis is carried out using econometric techniques, which yield estimates of the responsiveness of damages to the various factors that render them more transferable across situations. This can then be used to derive a simple formula relating environmental costs to per capita income, which could then be employed to calculate damages in countries where no relevant studies were available.

A formal meta-analysis is difficult to carry out, and will not prove possible for most projects. However, some of the 'expert' adjustments can make an informal meta analysis. For example, adjusting estimates of damages for size of population to obtain a per capita estimate and transferring that to the new study implicitly assumes that damages are proportional to population. Such adjustments are frequently made.

At a general level, therefore, a number of potential difficulties arise in transferring values from one study to another. The first of these concerns a lack of previous studies which have examined the same environmental quality change under consideration. For example, difficulties occur in benefit transfer when considering new policies as these will not have been considered by past valuation exercises. Extensions of current policies may also be difficult to value using benefit transfer methods. Water or air quality changes, for example, are unlikely to be linearly related to benefits, so a policy which is more stringent than any previously may not justify the extrapolation of previous benefits.

There are also problems in transferring estimates developed for one country with particular cultural and socio-economic characteristics (e.g. the US) to other countries (e.g. EU countries). Cultural factors may be significantly different, as may be perceptions of relative damage levels and risk, and these may invalidate the straight transfer of benefit estimates. In addition, WTP measures will depend upon income and care must be taken to consider how these values should be adjusted in moving between countries with different income levels. Several different approaches have been suggested, such as adjustments according to relative income, according to purchasing power and/or environmental awareness. However, using such approaches assumes that WTP for environmental quality varies proportionately with income; but damage costs are not necessarily constant across countries in terms of income.

In addition, with regard to the transfer of single mean values, it must be remembered that no one model will provide the all embracing or an unassailably valid estimate of the value of environmental benefits or damage. Individual studies and their results are specific to particular issues and situations, in both space and time, and their applicability to other cases is questionable. As a result of people's perceptions of risk and environmental quality, some forms of impact may be viewed more seriously than others. As a result, people may be prepared to pay more to reduce or avoid some types of effects (e.g. loss of a 'charismatic' species or particular habitat type - e.g. rainforest versus mudflats) than others. The accuracy and quality of the original value is, therefore, crucial to the use of benefit transfer. To ensure robustness, Box A1.1 sets out a number of criteria for assessing the quality of values chosen for transfer (after Desvouges *et al*, 1998).

Box A1.1: Assessing the quality of values for benefit transfer

Scientific soundness

The transfer estimates are only as good as the methodology and assumptions employed in the original studies. Specific criteria may include:

- data collection procedures;
- sound empirical practices;
- consistency with scientific and economic theory; and
- appropriate and rigorous statistical methods.

Relevance

The original studies should be similar and applicable to the new context. Specific criteria may include:

- magnitude of impacts should be similar;
- baseline levels of environmental quality should be comparable;
- affected goods or services should be similar;
- affected sites should also be similar;
- the duration and timing of the impact should be similar;
- the socio-economic characteristics of the affected populations should be similar; and
- the property rights should reside with the same party in both contexts.

Richness of information

The existing studies should provide a 'rich' dataset and accompanying information. Specific criteria may include:

- inclusion of full specification of original valuation equations as well as mean values;
- explanation of how substitute commodities were treated;
- data on participation rates and extent of aggregation employed; and
- provision of standard errors and other statistical measures of dispersion.

Annex 2: Summary of valuation studies

Table A2: The Services Offered by Wetlands and a Selection of Economic Values for these Services			
Service	**Author(s)**	**Value and units**	**Details**
Flood storage/control	Gupta & Foster (1975) in Gren & Söderqvist (1994)	$25 to $183 per hectare	
	Thibodeau & Ostro (1981)	$480 per wetland acre	Based on land contributing 25% to the value of the home and based on the damages that would occur if wetlands were developed.
Flood protection	Owens (1980) in Shabman & Batie (1988)	$905.16 (case study)	The estimated value of wetlands as setback, based on property values.
Wildlife habitats	Gupta & Foster (1975) in Gren & Söderqvist (1994)	$50 to $365 per hectare	
	Hanley & Craig (1991) in Gren & Söderqvist (1994)	$34 per hectare per year	Based on a CV study to assign a value to the flow country of Scotland (an area of peat bogs). The mean once-and-for-all wtp was $28 per household. The per hectare per year value is based on annualisation at 6% of the aggregated value across the population of Scotland. Users value of $43/person and non-users $21/person.
	Kosz *et al* (1992) in Gren & Söderqvist (1994)	$122 per hectare per year	Estimated value of wetlands based on the environmental services provided. Input resources were valued at their market price. Austrian study.
Pollution control/reduction	Thibodeau & Ostro (1981)	$3,552 per hectare	Based on the additional costs associated with tertiary treatment (over secondary treatment to wetland).
	Gren (1994) in Gren & Söderqvist (1994)	$256 per hectare	Based on the potential value of the Danube floodplains as nitrogen sinks. Value estimated as the cost savings obtained by the replacement of more expensive nitrogen abatement measures.

Table A2: The Services Offered by Wetlands and a Selection of Economic Values for these Services			
Service	**Author(s)**	**Value and units**	**Details**
Landscape and amenity benefits	Gupta & Foster (1973, 1976) in Shabman & Batie (1988)	$5,000 per acre (yearly return of $270 per acre)	Best estimate of the value of wetlands in terms of visual-cultural benefits (historical, educational, artistic, aesthetic and research values). Considered to represent a maximum wtp measure for high quality visual-cultural values.
Recreational benefits (general)	Gupta (1972) in Shabman & Batie (1988)	$70 per acre	Based on the purchase price of land and the estimated public cost of producing wildlife benefits, where the only value is purchased in associated with recreational use of the wetland.
	Gupta & Foster (1975) in Gren & Söderqvist (1994)	$176 to $1,280 per hectare	
	Farber (1987) in Gren & Söderqvist (1994)	$22 per hectare	Using the travel cost method.
	Thibodeau & Ostro (1981)	$102 to $1,833 per hectare	Based on the value of 'nature study'. Low value relates to recreational activity levels as estimated by the US Fish and Wildlife Service. High value relates to the recreationists' own evaluation (wta).
	Bateman *et al* (1993)	$108 to $226 per household per year	Mean wtp for conserving the Broads via a protection strategy designed to mitigate the increased risk of flooding; measures the recreation value of the Broads
	Kosz *et al* (1992) in Gren & Söderqvist (1994)	$400 to $1,500 per hectare per year	Based on the travel cost method (Austria), where the higher value includes all expenses (hotels, food, etc.).
	Gren (1994) in Gren & Söderqvist (1994)	$133 per hectare	Based on the travel cost method for the Danube floodplains.
	Sappideen (1992)	$146 per hectare per year	Based on a CV study to estimate the recreational value of the Sale wetlands in the Lake Wellington area of eastern Victoria (deep freshwater wetlands covering an area of 3,600ha). The mean wtp per person was $1.77.
	Stone (1992)	$21 per person	Based on a CV study of the Barmah wetlands along the Victorian border of the Murray River (wetlands listed under the Ramsar Convention which include temporary and permanent wetlands and are important habitats for a variety of species). Includes both use and non-use values.

Table A2: The Services Offered by Wetlands and a Selection of Economic Values for these Services			
Service	**Author(s)**	**Value and units**	**Details**
Recreational benefits - fishing and game	Raphael & Jaworski (1979) in Shabman & Batie (1988)	$286 per wetland acre per year	Based on estimates of the economic value of average annual expenditure by those involved in fishing plus the carcass values of the fish. This does not take the presence of alternative sites into consideration.
	Raphael & Jaworski (1979) in Shabman & Batie (1988)	$31.23 per wetland acre per year	Based on estimates of the economic value of average annual expenditure by those involved in hunting plus the carcass values of the waterfowl. This does not take the presence of alternative sites into consideration.
	Millar & Hay (1981) in Shabman & Batie (1988)	$82 per acre of habitat	Using a logit analysis, the average value of duck hunting following a 10% loss in habitat. Based on hunter participation and travel costs.
	Farber (1987) in Gren & Söderqvist (1994)	$132 per hectare	Using the travel cost method.
	Thibodeau & Ostro (1981)	$8 to $613 per hectare	Low value relates to recreational activity levels as estimated by the US Fish and Wildlife Service. High value relates to the recreationists' own evaluation (wta). Small game hunting ($32 and $576), waterfowl hunting ($32 and $613), trout fishing ($13 to $216) and warmwater fishing ($8 to $128).
	Finney (1988)	£467 per hectare	Value of wildfowling on the Hundred Foot Washes, based on wildfowling expenditure.
Non-use	Lant (1988) in Gren & Söderqvist (1994)	$393 to $871 per hectare per year	Possibly also includes some use values.
Agriculture	Ungerman (1994) in Gren & Söderqvist (1994)	$290 per hectare	Based on the loss in value from floodplains destroyed following the construction of a dam in the Czech Republic. The value is based on loss of wood production, yield on agricultural land and hunting.
Commercial output (e.g. reeds)	Johnston (1979) in Shabman & Batie (1988)	$250 per acre	Rough estimate of the value of standing trees (stumpage) based on best guesses about stumpage prices and average yields.

Table A2: The Services Offered by Wetlands and a Selection of Economic Values for these Services			
Service	**Author(s)**	**Value and units**	**Details**
	Raphael & Jaworski (1979) in Shabman & Batie (1988)	$3.78 per wetland acre per year	Based on the market value of commercial fish species
	Tomasin (1991) in Gren & Söderqvist (1994)	$1,300 per hectare per year	Based on the value of fishing, fish farms and hunting in the Po Delta region of Italy.
Water supply	Gupta & Foster (1975) in Shabman & Batie (1988)	$0.0713 per 1,000 gallons	Comparison between providing additional community water from wells (presumably from wetlands) with the next most expensive means of acquiring additional water.
	Gupta & Foster (1975) in Gren & Söderqvist (1994)	$2,260 to $16,440 per hectare	
	Thibodeau & Ostro (1981) in Gren & Söderqvist (1994)	$21,087 per hectare	Based on the difference between water supplied from wells in a wetland to the cost of wells from the District Commission.
Biodiversity	Ecotec (1993) in Gren & Söderqvist (1994)	$42 per household per year	Based on a CV study for aquatic ecosystems in upland areas in the UK and the benefits of rectifying all current damage to these ecosystems, where this damage relates mainly to the decline in the number of plant and animal species due to acidification. $42 is the mean annual wtp; for users this was higher at $52 whilst for non-users it was $28 per household per year.
Notes: on average, wetland functions are valued more than twice as high in the USA than in Europe			

Annex 3: Appraisal spreadsheets

(£000's)

	Option																
	Do-nothing	**Do-minimum**	**Off-line storage (A) (road raising)**					**Off-line storage (B) (no road raising)**					**Bank raising in Brigg**				
			10	**20**	**50**	**100**	**200**	**10**	**20**	**50**	**100**	**200**	**10**	**20**	**50**	**100**	**200**
Costs		£4,091	£5,883	£5,883	£5,883	£5,883	£5,883	£5,376	£5,376	£5,376	£5,376	£5,376	£4,654			£4,654	
Damage (agr)	£12,992	£1,200	£277	£277	£277	£277	£277	£277	£277	£277	£277	£277	£1,200			£1,200	
Damage (Brigg)	£24,000	£6,400	£1,649	£1,052	£583	£347	£184	£1,649	£1,052	£583	£347	£184	£4,271			£695	
Damage (total)	£36,992	£7,600	£2,015	£1,329	£860	£624	£461	£2,015	£1,329	£860	£624	£461	£5,471			£1,895	
Benefits		£29,392	£34,977	£35,663	£36,132	£36,368	£36,531	£34,977	£35,663	£36,132	£36,368	£36,531	£31,521			£35,097	
NPV		£25,301	£29,094	£29,780	£30,249	£30,485	£30,648	£29,601	£30,287	£30,756	£30,992	£31,155	£26,867			£30,443	
B/C		7.18	5.95	6.06	6.14	6.18	6.21	6.51	6.63	6.72	6.76	6.80	6.77			7.54	

Taking best option from each group and ranked in order of cost

Option	Bens	Costs	NPV	B/C	Inc. B/C	(standard)
Do-nothing	NA	NA	NA	NA	NA	
Do-minimum	£29,392	£4,091	£25,301	7.18	NA	1 in 5
Bank raising	£35,097	£4,654	£30,443	7.54	10.13	1 in 100
Off-line B	£36,531	£5,376	£31,155	6.80	1.99	1 in 200
Off-line A	£36,531	£5,883	£30,648	6.21	0.00	1 in 200

Area of washland for 1 in 200 scheme 800 ha (from Table B4.13)

Using values per ha from RPA (1998)

	Value per ha/annum	Total area	Total value per annum	PV Value (£m)
Upper	£1,920	800	£1,536,000	£25.66
Central	£600	800	£480,000	£8.02
Lower	£300	800	£240,000	£4.01

Using lower bound as additional benefit for both off-line options

Option	Bens	Costs	NPV	B/C	Inc. B/C
Do-nothing	NA	NA	NA	NA	NA
Do-minimum	29,392	4,091	25,301	7.18	NA
Bank raising	35,097	4,654	30,443	7.54	10.13
Off-line B	40,541	5,376	35,165	7.54	7.54
Off-line A	40,541	5,883	34,658	6.89	0.00

How low can the value go to not change the decision?
£55

What does the area have to reduce by to not to change the decision?
150 ha

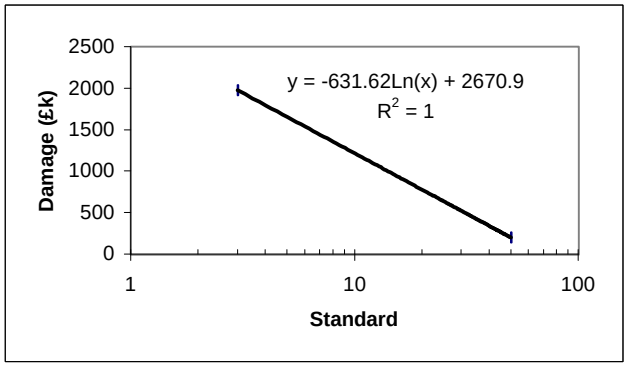
Does a halving in value and area still change the decision?
Yes

£000's		Option					
	Do-nothing	Do-minimum	Improve to 1 in 50 with spillway at:				Washland
		1 in 3	1 in 5	1 in 10	1 in 25	1 in 50	1 in 25
Costs		£5,543	£4,954	£5,471	£6,153	£6,298	£5,140
Damage	£25,650	£1,977	£201	£192	£186	£185	
Benefits		£23,674	£25,449	£25,458	£25,464	£25,465	£6,172
NPV		£18,131	£20,495	£19,987	£19,311	£19,167	£1,032
B/C		4.27	5.14	4.65	4.14	4.04	1.20

Update of washland benefits

Clearly, benefits have been updated for the other options, but not the washland (which was not taken forward)

Standard	Damages (£k)
3	1977
50	200
So,	
25	638



Taking best improve option and ranking by cost

Option	Bens	Costs	NPV	B/C	Inc. B/C
Do-nothing	NA	NA	NA	NA	NA
Improve	£25,449	£4,954	£20,495	5.14	NA
Washland	£25,012	£5,140	£19,872	4.87	-2.35
Do-minimum	£23,674	£5,543	£18,131	4.27	-3.32

Area of washland 150 ha

Using values from RPA (1998)

	Value per ha/annum	Total area	Total value per annum	PV Value (£m)
Upper	£1,920	150	£288,000	£4.81
Central	£600	150	£90,000	£1.50
Lower	£300	150	£45,000	£0.75

Appraisal using lower washland estimate

Option	Bens	Costs	NPV	B/C	Inc. B/C
Do-nothing	NA	NA	NA	NA	NA
Improve	25,449	4,954	20,495	5.14	NA
Washland	25,764	5,140	20,624	5.01	1.69
Do-minimum	23,674	5,543	18,131	4.27	-5.19

Appraisal using central estimate

Option	Bens	Costs	NPV	B/C	Inc. B/C
Do-nothing	NA	NA	NA	NA	NA
Improve	25,449	4,954	20,495	5.14	NA
Washland	26,516	5,140	21,376	5.16	5.74
Do-minimum	23,674	5,543	18,131	4.27	-7.05

How low can the value go before the decision doesn't change?
£400 to stay with the 'improve' option

What is the area that changes the decision?
Lower **200 ha** to change to the washland
Central **100 ha** to drop back to 'improve'