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Integrated washland management for flood defence and biodiversity

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Abstract*

In the context of growing interest in finding sustainable solutions to flood management in England and Wales, this study set out to determine the extent to which benefits to flood management and biodiversity can be achieved through an integrated approach to the creation and management of ‘washlands’. For the purpose of the study, a washland is defined as “an area of the floodplain that is allowed to flood or is deliberately flooded by a river or stream for flood management purposes, with potential to form a wetland habitat”.

Following a questionnaire survey of engineers and conservationists, a review of selected sites, and a workshop of key stakeholders, it was concluded that there is both scope and willingness to exploit potential synergy. It appears, however, that until now most washlands have either been used mainly for flood storage or for wetland habitat, and there has been only a limited attempt to integrate the two objectives.

In many respects, the opportunity for integrating biodiversity depends on the ability to maintain wet conditions on the washland beyond the period of the flood event, and this largely depends on the dominant land use. The scope is greatest where the washland is under grass or woodland, and actions can be taken to ‘engineer’ or manage soil wetness regimes which serve biodiversity interests. Such water management plans and related biodiversity targets are best designed into washland management from the outset, rather than as an afterthought, when conflicts of interest are likely to arise.

While there is much interest in pursuing an integrated approach, lack of funding for biodiversity on washlands and the relative complexity of preparing the washland case for appraisal appear to constrain washland development. Nevertheless, washlands are perceived by engineers and conservationists alike to offer potentially sustainable solutions to flooding, enabling biodiversity targets to be met within an integrated approach to catchment flood management.

Recommendations were made to:

- improve, through the use of guidance and training, understanding between engineers and conservationists of how flood management and biodiversity objectives can be simultaneously achieved;
- consider the establishment of a biodiversity fund to support the biodiversity components of washland schemes;
- develop practical guidance on the formulation of washland management plans that exploit biodiversity potential by managing wetness conditions in washlands beyond the flood-event period;
- review how washland creation and management can be integrated and help to deliver the objectives of Biodiversity Action Plans and Catchment Flood Management Plans.

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Executive summary

S1 Context

A combination of agricultural policy reform, changing priorities in the countryside, growing commitment to protect and enhance biodiversity and concerns about increased flood risk in lowland areas have drawn attention to the potential benefits of managed washlands. In this context, this study set out to determine how, and under what conditions, washlands might be developed to deliver both flood management and biodiversity benefits. The study also considered the extent to which improvements in habitats might be achieved within a predominantly flood defence framework.

S2 Definition of a washland

The study defines a washland as “an area of the floodplain that is allowed to flood or is deliberately flooded by a river or stream for flood management purposes, with potential to form a wetland habitat". This broad definition includes areas which provide natural storage as well as artificial storage and is justified because, in the context of England and Wales, virtually all river systems are managed in some way, and the retention or creation of natural storage is itself a management decision. Furthermore, the definition incorporates the setback of agricultural defences which restore natural floodplain.

S3 Approach

The approach to the study included the following activities:

- a review of research literature;
- an exploratory enquiry with key informants;
- a survey of flood defence engineers and conservationists within the Environment Agency and Non-governmental Conservation Organisations to ascertain perceived synergy between flood defence and biodiversity, and how this might be achieved in practice;
- site surveys and interviews with relevant personnel on five selected washland sites in England;
- a review of selected experience elsewhere in Europe;
- the development of a framework to classify washlands according to flooding and groundwater regimes, land use and habitat potential;
- compilation of a ‘menu’ of engineering and management interventions to enhance the habitat value of washlands;
- a one-day participatory workshop, attended by 35 representatives of key stakeholder groups, including personnel from Defra, English Nature, the Environment Agency and a range of Non-Government Organisations. Participants discussed the preliminary outcomes of the study, confirmed the main issues which define the feasibility of integrated washland development, and made recommendations for action.

S4 Washland classification

Washlands take a variety of forms and demonstrate a variety of characteristics. For management, washlands can be classified according to:

- flood regime;
- soil wetness (beyond the flood period); and
- land use and related habitats.

Given the purpose of defining the scope for integrating flood management and biodiversity, it is important that these defining characteristics are accommodated within a framework which can guide appropriate management strategies.

A two-stage approach was developed. The first, referred to as the Hydraulic Matrix, (Table S1) classifies washlands according to degree of hydraulic control of the inflow and outflow of flood waters, reflecting a mainly engineering and flood management perspective. Generally, the greater is the degree of engineering intervention, the greater is the degree of control.

Table S 1 Hydraulic Matrix: washland classification by degree of hydraulic control

		Inflow		
		Uncontrolled inflow	Fixed controlled inflow	Variable controlled inflow
Outflow	Uncontrolled gravity return	**1**	**2**	**3**
	Fixed controlled gravity return	**4**	**5**	**6**
	Controlled return (sluices/pumps)	**7**	**8**	**9**

The second stage, referred to as the Habitat Matrix (Table S2), captures those attributes of washland hydrology that critically define the type and quality of the habitat that exists or can be created. From a flora viewpoint, habitat type and quality depend on the duration and seasonality of flooding and, in many ways more critically, on the relative wetness of washland soils during the post-flooding periods. Any one cell in the Habitat Matrix can have up to ten variants in habitats depending on the detail of water regimes and site conditions. The habitat potential for fauna also depends on non-hydraulic features such as size, connectivity and freedom from human disturbance.

Although there is no direct link between the Hydraulic and the Habitat matrices, it is possible to adopt interventions to engineer and manage particular flooding and soil wetness regimes and thereby exploit habitat potential. These are listed in a ‘Menu of Interventions’ (Table S3).

The typology provides a logical framework for classifying washlands in terms of flood management and biodiversity. The classification is output rather than input driven, perceiving engineering and management options as the means by which flood management and biodiversity objectives can be met. The classification method can be used in two ways: to show the habitat potential of a given water regime, or to show the changes in water regimes needed to achieve a desired change in habitat. The choice of most appropriate intervention method to achieve this change will depend on site conditions.

Table S 2 Habitat Matrix: washland classification by flood and soil water regimes and related habitat types

	Winter flooding only			Flooding at any time of year		
	Rapid soil drainage	Moderate soil drainage	Slow soil drainage	Rapid soil drainage	Moderate soil drainage	Slow soil drainage
Short duration flooding	**1** Arable Hay meadow Pasture Alder Woodland	**2** Flood meadow Pasture Alder Woodland	**3** Flood meadow Inundation pasture Alder Woodland	**4** Water Meadow Pasture Alder Woodland	**5** Inundation pasture Alder Woodland	**6** Inundation pasture Rush pasture Swamp Willow carr
Medium duration flooding	**7** Hay meadow Pasture Alder Woodland	**8** Flood meadow Pasture Alder Woodland	**9** Flood meadow Inundation pasture Willow carr Swamp	**10** Pasture Rush pasture Willow carr	**11** Inundation pasture Rush pasture Swamp Willow carr	**12** Inundation pasture Rush pasture Swamp Willow carr
Long duration flooding	**13** Flood meadow Pasture Willow carr	**14** Inundation pasture Rush pasture Swamp Willow carr	**15** Inundation pasture Rush pasture Swamp Willow carr	**16** Swamp Willow carr	**17** Swamp Reedbed	**18** Swamp Reedbed

Table S 3 Menu of Interventions to modify flooding and soil drainage

Actions to modify frequency/duration of washland flooding and the downstream hydrograph	**Actions to modify washland soil drainage conditions**
Set-back/removal of embankments	Vegetation management to facilitate natural retention
Introducing/lowering spillways in banks	Control outflow sluices
Decreased channel maintenance leading to increased in-river and bank vegetation	Changes in pumping regime
Creation of on-line dams/sluices	Introduce hydrological compartments
Increased pumping/siphoning into washland	Create scrapes
Reduced pumping/restricted gravity outflow from washland	Modify ditches
Increased vegetation height on floodplain	Introduce subsurface pipes
Lowering of floodplain	Increase ditch ‘roughness’
Ecological flooding: retention and evacuation just in time for next flood	

S5 Conclusions

The following conclusions are drawn:

Defining washlands

For the purpose of integrating flood defence and biodiversity objectives, it is considered appropriate to adopt a broad, inclusive definition of washlands which includes areas which provide natural as well as artificial storage.

Classification framework for washland water regimes and habitats

The classification framework confirmed that flood duration, flood seasonality and wetness conditions in the washland are the key factors that determine the potential type and quality of washland habitat. The retention of surface and soil wetness beyond the flood event period is a particularly critical determinant of habitat quality. The study showed that habitat potential on washlands mainly depends on land and water management practices beyond the flooding period, especially the management of groundwater levels.

Scope for synergy between flood management and biodiversity

With respect to a key objective of this study, whether biodiversity objectives can be met within a predominantly flood defence framework, the answer appears to rest on whether the dominant land use requires flood and land drainage regimes which are not conducive to habitat creation. Most parts of the flood plain have the potential to be maintained in a wet condition, but whether they are or not depends on the drainage requirements of the dominant land use and the expectations of land managers. Where the washland is given to arable cropping (implying infrequent flooding and rapidly drained soils), the scope for habitat enhancement is often limited. Where washlands are given to grassland or woodland (often implying more frequent flooding and wetter ground conditions), there is more scope for habitat improvement. Some species-rich grassland, however, requires short duration flooding followed by rapid soil drainage which is fully compatible with flood defence preferences. This confirms that even within a predominantly flood defence framework there can be scope for synergy, but much depends on dominant land use.

The main source of conflict between flood management and biodiversity objectives on washlands arises with respect to the duration and seasonality of flooding. Flood management generally requires the storage of flood water during the period of peak flows followed by evacuation of flood water as soon as possible in order to secure the storage facility for re-use. Biodiversity objectives, however, usually require some retention of water beyond the flood period. Opportunities for synergy rest on the ability to reconcile these interests, for example, by over-designing flood storage capacity so that the wetness of the washland beyond the flood event period is retained without compromising flood storage capacity when it is needed. In many respects, the potential to exploit biodiversity rests on the ability to separate out the management of flood events and non-flood water regimes.

The study showed that it is possible to create a range of land uses and related habitat types in a given washland through intervention measures which modify flooding and soil drainage. The scope for habitat creation, and the suitability of engineering and management interventions, will however vary amongst sites. Large washlands in particular could support a diverse mosaic of habitat types involving a range of management interventions creating variations in flooding and soil water conditions.

Evidence of integration

Although flood defence managers and conservation officers perceive potential synergy between flood management and biodiversity in washlands, the English and European case studies show that there has been limited achievement of this in practice. Older, established washlands appear to have been developed primarily for flood defence where agriculture has developed within the prevailing flood regimes. Little attention was paid to biodiversity. However, more recently, in the light of reduced viability of conventional farming, biodiversity options have sometimes been taken up through agri-environment schemes independent of any changes in flood management.

Initial design

For new washland schemes, potential synergy is best exploited if it is included at the design stage. For example, species rich grassland and breeding waders require or can tolerate short duration flooding followed by relative quick drainage of the land, which is the regime best suited to flood storage. This can be engineered by creating a microtopography to give good drainage in general whilst maintaining wet features in scrapes and foot drains. In this respect, there is scope for compatibility of flood defence and biodiversity objectives. Biodiversity has been a more explicit aspect of scheme design for more recently completed schemes, and synergy has been achieved. The key to successful washland biodiversity is a site specific water level management plan targeted at specific outcomes, with appropriate interventions in place to deliver this.

Washland types

The study concludes that is valid and useful to distinguish three types of washlands according to priority, namely:

Flood management washlands where flood management is the main concern and biodiversity is a secondary consideration;

Integrated washlands where flood management and biodiversity are given equal importance; and

Conservation washlands where biodiversity is the main concern and flood management is secondary.

Such a framework can help to promote understanding and agreement about what a particular washland can reasonably be expected to deliver, as well as the identification of appropriate management and funding arrangements. It was generally felt, by flood managers and conservation managers alike, that flood management objectives should take precedence where there is serious risk to human welfare, such as during a major flood event.

Funding and administration

During discussions with flood managers and conservation managers, there appeared to be agreement that, although flood defence budgets cannot be expected to be a major source of funds for biodiversity enhancement, some limited allocation of funding for biodiversity within flood defence budgets was possible. Strong arguments were made, however, for designated funds for biodiversity to be channelled through Defra and the Environment Agency. This, it was argued, is required if the development of integrated washlands is going to happen on the scale possible or desirable. Such designated biodiversity funds would be a key source for integrated washlands. Proposals for integrated washlands should focus on BAP targets, for it is these that will determine access to funds for biodiversity in future.

Administrative arrangements

Of the options for the administration of washlands, land purchase was commonly perceived by flood and conservation managers to be the best arrangement for securing integrated washland development, because this gave the greatest degree of control over water regime and habitat management. This has implications for funding.

Appraisal

Strong views were expressed by both flood managers and conservation officers that the current priority scoring and benefit:cost appraisal methods used to judge the viability of schemes do not adequately recognise and value the environmental and other benefits associated with the washland option. This may be due to a shortcoming in the policy and appraisal process, or it could be that existing guidance is misunderstood or not properly applied. This identifies a need to consider how guidance is currently used, whether it is suitable in its present form, and whether there are needs for training to equip users with the appropriate knowledge and skills to prepare and present integrated schemes.

Awareness creation and stakeholder interaction

There is a general feeling that a lack of awareness and understanding between engineers and conservationists means that opportunity for synergy is not identified or taken up. The study revealed a bias towards conventional rather than sustainable solutions to flooding problems. The perceived relative complexity of the washland option, involving multiple objectives and stakeholders and more complicated appraisal methodology and funding mechanisms, presents particular challenges. There appears to be a need for guidance, experience-based learning and case study material to support washland development, targeting the needs of various stakeholder groups.

Catchment scale

It is perceived that the search for synergy must be considered at the catchment level, recognising that different sites will have potential to serve different needs. There is a strong call to integrate CFMPs and BAPs as a means of actively searching out opportunities for compatibility of flood management and biodiversity.

Policy review

There is a general feeling that lack of integration of policy and related funding mechanisms currently acts as a barrier to integrated washland management. Overall, it is apparent that, in spite of the commonly held view that integrated washlands are feasible, desirable, and potentially offer good value for money, they are unlikely to make a significant contribution to BAP targets without a major shift in policy, administration and funding regimes.

S6 Recommendations

The following recommendations are made.

Guidance to support the creation and management of washlands

Consideration should be given to undertaking a review of existing guidance to determine whether it is fit for purpose and accessible for those who need it. There is a clear need to develop a better understanding between engineers and conservationists of the extent to which flood defence and biodiversity objectives can be achieved through integrated washlands. There is also a call for guidance on how engineers and conservationist can work together to find sustainable solutions that serve multiple purposes, rather than, as has been the case to date, having one or other added on as an afterthought. Such guidance, will help clarify, justify and gain acceptance of the balance of priority given to flood management and biodiversity on a given site or within a given catchment.

Assessment of training needs, and design and delivery of training

There is a clear need for training to facilitate an improved understanding between the flood management and conservation functions, and practical methods of integration. There is specific need to improve knowledge of the principles and competency in the practice of the design, preparation and appraisal of projects which can integrate flood management and biodiversity. Practical, case-study based training materials demonstrating the application of guidance should be prepared accordingly. These should be delivered through a series of participatory short courses to relevant personnel within Defra, Environment Agency and other organisations as appropriate.

Policy guidance

Defra, English Nature and the Environment Agency should consider the production of a policy note on washland creation and management which states the purpose and rationale of an integrated approach to washland management and, in broad terms, how, under what circumstances and through what mechanisms this might be achieved in practice.

Funding for washlands

Consideration needs to be given to funding mechanisms for washlands, especially given the clear preference by engineers and conservationists for land purchase. Three types of washland schemes were identified in terms of the balance of priority. It is recommended that funding sources are identified for each of these scenarios.

Consideration should be given to establishing a biodiversity fund operated by the Environment Agency on behalf of Defra which could finance the biodiversity component of washland schemes. This would be a major source of funds for integrated washlands and possibly for some predominantly conservation washlands, although the latter would most likely continue to draw funds from other sources as they do now.

Where the additional cost of achieving environmental enhancement within flood storage schemes is small, it may be possible to fund this from existing flood defence budgets. It is recommended that those responsible for preparing schemes are made aware of the scope for such funding and that guidance is provided on how to make the case for using funds in this way.

Development of Washland Management Plans

There is a need to develop Water Level Management Plans specifically for washlands which address the flood event and the management of water levels beyond the flood period. These water management plans will focus on intervention methods to supply and retain water on the surface, in the drainage network and/or in the soil profile as required, while at the same time securing the flood storage facility. Although it is recognised that practical recommendations must be site specific, this review, drawing on examples and existing knowledge, would help provide guidance on sources of information and the selection of appropriate management interventions.

Washland strategy

It is recommended that the Environment Agency seeks better ways of integrating Biodiversity Action Plan targets into flood defence schemes, possibly by drawing up specific biodiversity targets for the river basin or catchment. It is strongly recommended that a review of washland potential in the context of BAP and CFMP is undertaken for selected pilot catchments, in order to inform a washland strategy.

Contents

1. Introduction

1.1 Background

A combination of agricultural policy review and reorientation, changing priorities in the countryside, growing commitment to protect and enhance biodiversity, and concerns about increased flood risk in lowland areas have drawn attention to the potential contribution that managed washlands can make to deliver diverse benefits to biodiversity, flood management and sustainable rural livelihoods. Reviews of flood defence standards of service in rural areas are promoting a re-appraisal of land management options and policies. This is taking place in the broad context of the development of Catchment Flood Management Plans (CFMP), as well as policy drivers in the form of the European Directives such as the Habitats Directive and the Water Framework Directive, and the Agenda 2000 Reforms of the Common Agricultural Policy.

Many of these issues come together in managed floodplains where in the past priority may have been given to agriculture in terms of land drainage and flood defence, but where now other benefits are apparent (RPA 2001, Morris and others 2002). Such benefits include the potential to store flood-waters to take pressure off flood defences elsewhere and to enhance biodiversity through the creation of washlands. Simultaneously, it may be possible to devise land management and farming regimes which provide a basis for sustainable rural livelihoods. Indeed, given that flood defence, environment and agricultural support are already the subject of policy and funding mechanisms, it seems reasonable to expect that these could be joined up to provide a solid basis for integrated washland creation and management. A washland creation programme could be an important feature of measures to deliver some of the detail of the Water Framework Directive, though this is as yet speculative.

In this context English Nature and the Department for Environment and Rural Affairs (Defra) identified the need to explore ways in which washlands can be created and managed to deliver flood management, biodiversity and other potential benefits.

1.2 Aim and objectives

In accordance with the terms of reference, the broad aim of the project is to review the options for washland creation and from this to provide guidance on how, and under what conditions, washlands might be developed to deliver benefits for biodiversity and/or flood management. The output from the study can also help inform a number of key policy areas pertaining to CFMP, habitat management, agri-environment schemes, and interventions that might be made under the Water Framework Directive. The study also reviews the general suitability of alternative funding mechanisms for integrated washland management.

1.3 Approach

In accordance with the terms of reference, the study comprised two phases. The first involved a review of the potential synergy between flood management and biodiversity objectives in washlands and how, if at all, his might be achieved in practice. The second involved a review workshop to assess the validity of the research output as a basis for progressing washland development which can integrate these multiple objectives.

The study involved a review of research literature and guidance on good practice with respect to washland management in UK and other parts of northern and central Europe. Following an exploratory enquiry with key informants, a survey of relevant staff within the Environment Agency and non-governmental conservation organisations was carried out to ascertain perceived synergy between flood defence and biodiversity, and how this might be achieved in practice. This information was combined with that derived from visits to five selected washland sites in England to construct a typology for washlands. This typology classifies washlands by flood duration and seasonality and by the soil wetness characteristics of the washland during non-flood periods. From this, the potential for biodiversity can be determined, together with the range of actions that can be undertaken to enhance the habitat value of washlands while simultaneously meeting flood management objectives. A review of management options to administer and fund washland development was also carried out.

A workshop was held in June 2003, attended by 35 representatives from Defra, English Nature, the Environment Agency (flood and conservation managers), Countryside Agency, Association of Drainage of Authorities, RSPB and Wildlife Trusts and the research community. The workshop critically reviewed the outputs of the project at that time, and identified and appraised selected issues pertaining to integrated washland development. A paper on the preliminary findings of the study was presented at the Defra Annual Conference of River and Coastal Engineers, Keele, July 2003.

1.4 Structure of report

Following this introduction, Chapter 2 defines washlands and presents a typology of washlands based on flooding, soil wetness and habitat characteristics. Chapter 3 reviews selected case study experience in the UK and Europe, drawing out existing and potential synergy between flood defence and biodiversity, and issues arising. Chapter 4 identifies engineering and management interventions that can be adopted, where suitable conditions allow, to deliver flood management and biodiversity objectives simultaneously. Chapter 5 reports on a questionnaire survey of engineers and conservations on perceptions of the scope for synergy between flood management and biodiversity. Issues relating to the administration and funding of washlands are dealt with in Chapter 6, followed in Chapter 7 by the findings of a participatory stakeholder workshop. Chapter 8 contains the main conclusions and recommendations. Appendices contain detailed information in support of the main report.

2. Washland typology

This chapter provides a definition of washlands and explains the role of washlands with particular reference to flood management and biodiversity. The chapter also develops a typology which classifies washlands for the purpose of integrating flood management and biodiversity functions. This provides a basis for management interventions which can help to enhance biodiversity for given washland circumstances.

2.1 Definition of washlands

There are numerous definitions of washland in the literature, with many different descriptions. The Oxford English Dictionary (2001) defines a washland as:

"Land that is periodically flooded by a river or stream".

This definition does not distinguish a washland from a floodplain, but in some cases it is difficult to differentiate the two, especially where the washland is natural. Defra describes washlands as:

> "Usually man-made and typically an area of floodplain surrounded by banks that provide a low level of flood protection so that in a flood event higher than the (river) banks the land fills with water and then provides capacity for both temporary storage of floodwater and flow. Washlands may have agriculture, amenity or recreational use".
>
> (English Nature, the Environment Agency and the Flood Management Division, of the Department for Environment, Food and Rural Affairs 2002)

In Europe, a washland site has often been described as a water-retention area or polder. The term polder is derived from coastal water-engineering methods, whereby banks are constructed to prevent flooding by the sea. Inland flood-defence polders are areas surrounded by a bank system used to store floodwater when exceptional floods occur. Polders reduce the flood peaks by filling the embanked areas according to highly-regulated inflow regimes based on hydrological models (Rast 2003 pers. comm.).

Both the Defra and European descriptions define a washland as a man-made landscape feature. However, some washlands comprise natural unmanaged areas, which have hitherto not been subject to engineering works but nevertheless provide many of the same functions of a managed one. Indeed, in the context of England and Wales, virtually all floodplains are managed in some way. The retention or restoration of the natural functions of the floodplain, for example, also reflect decisions to manage hydrological processes.

The Defra description tends to focus on the separation of the floodplain from the channel by structures in order to separate storage and conveyance functions. This is similar to the distinction made by engineers between on-line and off-line storage. However, the critical factor determining the functionality of washlands rests on the degree of hydraulic control, and this can be achieved by a variety of means according to site and hydrological characteristics.

For the purpose of this report, with its focus on the integration of flood management and biodiversity objectives, the following inclusive definition is used.

> "A washland is an area of the floodplain that is allowed to flood or is deliberately flooded by a river or stream for flood management purposes, with potential to form a wetland habitat."

This definition includes washlands created as a consequence of the setback of agricultural defences, which previously gave a relatively high standard of flood protection.

2.2 Role and benefits of washlands

Washlands can provide multiple benefits. The effective and purposeful storage of flood-waters on washlands can reduce damage to property that might otherwise be flooded. It may also offer a more cost-effective solution than conventional engineered flood defences in the immediate vicinity of property that would suffer high damage costs in the event of flooding. Washlands also have potential to provide significant biodiversity benefits associated with open-water and wetland habitats, and the hydrological, ecological and regulatory processes implicit in these environmental features. The deposition of silt, which can occur as a result of holding back floodwaters laden with sediment, can enrich and improve the agricultural productivity of the washland post-inundation. This practice, undertaken in the past, is known as 'warping' of flood or water meadows.

Washlands can also deliver benefits associated with landscape and amenity, in many cases providing a basis for recreation and tourism activities, sometimes associated with nature reserves and visitor centres. These potential benefits are often particularly valuable in areas which are otherwise generally intensively farmed. Depending on priorities given to flood management and biodiversity objectives, washlands may also support agricultural activities, usually grassland, but also cereal production where flooding is relatively infrequent. In this respect, washlands, especially where land managers are sponsored to deliver wetland habitat objectives, can help to support sustainable rural livelihoods.

The benefits of washland creation or restoration can be diverse and significant. They are associated with the functions that washlands perform, the potential usefulness of these to society, and the values or benefits that are generated as a result. Whereas some benefits, such as flood defence to avoid property damage can be assessed reasonably well in monetary terms, others cannot. Biodiversity, for example, is predominantly an 'unpriced', 'untraded' but nonetheless valuable public good, especially if it is scarce. The assessment reported here focuses on two main washland functions, namely that of flood defence and biodiversity, and in general terms their associated 'uses' and 'values'. In particular the assessment considers whether and how it is possible to achieve synergy between these two functions, and how the resultant outcomes are useful (in that they serve purposes) and valuable.

To date, the dominant focus has been on the potential contribution of washlands to flood management, mainly because these comprise value in 'use' benefits which can be monetised. However there is increasing interest in the intrinsic ecological 'non-use' values of washlands, although these are much more difficult to express in monetary terms. The current context appears to be one of defining the extent to which these biodiversity benefits can be delivered within a predominantly flood management framework: that is enhancing biodiversity without compromising flood defence objectives, or requiring significant increases in expenditure to do so. The scope for synergy, and the extent to which this can be achieved in practice, is a key focus of this study.

2.2.1 Flood defence functions and strategy

With around 5 million people at risk of flooding in England and Wales, Defra and the Environment Agency have adopted a strategy (Environment Agency 2003) for flood defence which, amongst other things, seeks to encourage the provision of adequate, economically, technically and environmentally sound and sustainable flood and coastal defence measures (National Audit Office 2001). As part of this strategy the Environment Agency has identified that the designation of strategic floodplain storage areas can offer a viable solution to flood defence (Environment Agency 2001a). Furthermore, Defra and the Environment Agency are drawing up long-term, strategic Catchment Flood Management Plans (CFMP) for fluvial flood management. These, in consultation with key stakeholders, aim to provide 'integrated, technically, environmentally and economically sound and sustainable flood risk management strategies' at catchment level for the next 50 years (Environment Agency 2002). The European Water Framework Directive which seeks to achieve good water quality status includes reference to the role of flood defence. The relationship between CFMPs and the Water Framework Directive, however, has not yet been firmly established and it remains uncertain how the Directive will impact upon washland construction and management.

CFMPs will identify options for flood risk management including strategic storage, local protection and, where appropriate, large-scale changes in land use or alternative development locations (English Nature, the Environment Agency and the Flood Management Division, Defra 2002). The incorporation of biodiversity targets and habitat restoration opportunities into the catchment flood management plans (English Nature 2001) will be an important driver to promote the creation and use of washlands for floodwater storage, whilst simultaneously seeking to enhance creation the biodiversity of the floodplain.

2.2.2 Biodiversity functions and strategy

For given regional climatic and ecological conditions, the biodiversity, that is the numbers of different species of plants and animals generated within a washland depends on flooding and wetness regimes and the dominant forms of land use and management. In some cases, where washlands are used infrequently for flood storage, land may be down to extensive arable cropping such as cereals. In this farmed environment, species numbers and composition may be limited although such fields can be valuable grazing and roosting sites for birds, such as geese and swans. Even infrequently inundated washlands can support biodiversity in the form of farmland birds if appropriately sited, designed and managed. Where flooding and wetness are greater, however, river and floodplain wildlife can benefit because land within the storage area is dominated by uses which are tolerant of flood risk, mostly extensive grassland management. Traditionally this entails low intensity management practices such as grazing and hay cutting (Joyce & Wade 1991). Additionally, it may involve purposely managed wetland habitats, for example as parts of Sites of Special Scientific Interest (SSSI). These sites are designed to provide stable, protected habitats relatively undisturbed by human activity other than those intended to secure their ecological integrity (Ward and others 1994).

The main factors that influence the washlands habitat are wetness regime, substrate, vegetation structure, grassland management and freedom of disturbance (Joyce & Wade 1991). The richness of the biodiversity of a washland depends on these factors, and variations in these factors can result in a mosaic of habitats even within a given washland, further enhancing diversity.

Birds are among the most conspicuous of wetland animals and it is often for this reason that many washlands are specifically managed to attract birds. Water conditions are one of the main factors affecting the composition and abundance of bird communities on washlands. For example, water level fluctuations influence the physical structure of habitats, the availability and accessibility of food and the presence of safe roosting or breeding sites.

Washlands can provide an important mechanism to deliver the habitats contained within the targets of the UK Biodiversity Action Plan (BAP). Coastal and floodplain grazing marsh, lowland meadows, reedbeds and wet woodland are of particular interest. BAPs identify protected species which are associated with these habitats, such as water vole, otter, bittern, mash warbler and many plants and invertebrates. Furthermore, as referred to above, the protection and creation of these habitats will provide a variety of functional benefits. For example, in situations where washlands are kept permanently wet, the hydrological and ecological processes associated with reedbeds can serve to improve water quality (Tyler and others 1998).

2.3 A Typology of washlands

Washlands take a variety of forms and demonstrate a variety of characteristics. For management purposes these can be classified broadly into:

- flood regime characteristics,
- washland soil wetness characteristics (once flooding is over), and,
- land use and related habitats.

Given the purpose of defining the scope for integrating flood management and biodiversity, it is important that these defining characteristics are accommodated within a framework which can guide appropriate management strategies.

A two staged approach has been developed. The first, referred to as the Hydraulic Matrix, classifies washlands according to degree of hydraulic control, reflecting a mainly engineering and flood management perspective. Generally the greater the degree of engineering intervention, the greater the degree of control with respect to inflow onto the washland from the source channel and outflow from the washland as water returns to the source channel (or in some cases some other part of the river system). Degree of hydraulic control is seen by flood managers (as discussed later) to be the critical characteristic that determines the usefulness of a washland as a flood management facility.

The second stage, referred to as the Habitat Matrix, captures those attributes of washland hydrology that critically define the type and quality of the habitat that exists or can be created. From a vegetation viewpoint, habitat type and quality depend on the duration and seasonality of flooding, and the relative wetness of washland soils during the post flooding periods. Some habitats, such as species rich grassland favour short duration, winter flooding. Some habitats, such as swamps, prefer longer duration flooding with retained high water table levels. In this way, the Habitat Matrix makes the link between flood and soil water regimes and resultant habitat characteristics.

While there is no direct link between the Hydraulic and the Habitat matrices, it is possible to adopt interventions to 'engineer' or manage particular flooding and soil wetness regimes and thereby better exploit habitat potential. For example, modifications to the duration of flooding where outflows from the washland can be controlled, or the retention of ditch levels within the washland area itself, could help to enhance habitat potential.

Figure 2.1 shows the two elements of the typology and the linkage that can be achieved through management interventions. The components in the figure are explained in subsequent sections of this report.

Hydraulic matrix
Classifies washlands according to degree of hydraulic control. Generally the greater is the degree of engineering intervention, the greater the degree of control with respect to inflow onto the washland from the source channel and outflow from the washland.
(See Table 2.1)

Menu of Interventions
Interventions to 'engineer' or manage particular flooding and soil wetness regimes and thereby better exploit habitat potential.
(See Tables 2.4 & 2.5)

Habitat
Captures attributes of washland hydrology that define the type and quality of existing or potential habitats. From a vegetation viewpoint, habitat type and quality depend on:

- duration of flooding;
- seasonality of flooding;
- relative wetness of washland soils.

(See Table 2.2)

Figure 2.1 Hydraulic and Habitat Matrices and associated Menu of Interventions

The two matrices allow the user to classify a washland site in terms of both engineering and biodiversity. The typology can be used in two ways:

i. Estimating the biodiversity potential of an existing washland
ii. Identifying appropriate washland management for a specific biodiversity target.

The Hydraulic and Habitat Matrices are discussed in turn.

2.4 Hydraulic Matrix

Engineering and flood management interventions by their nature affect the hydraulic regime of the washland, in turn affecting land use and biodiversity. They are therefore an essential element in the classification of washlands. However a classification based on engineering and management solutions is problematic due to the considerable number and combination of techniques used. It is therefore considered more appropriate to classify washlands by their hydraulic characteristics rather than by the interventions themselves: that is, to classify on the basis of degree of hydraulic control achieved (the output of interventions) rather than the detail of the control methods. This recognises that a given hydraulic outcome can be achieved by a variety of methods, depending on site circumstances. This definition is a main justification for taking the broad definition of washlands used the study.

Washlands and flood storage areas are sometimes described as being ‘on-line’ - in that they are contiguous with the river system - or ‘off-line’ - where flood water is diverted from the system into a storage area. The differentiation between on-line and off-line storage can be ambiguous – for example, a riparian area separated from the river by a flood bank that overtops with moderately high flows could be considered on-line, but if the water cannot flow back into the channel it may be considered off-line. The value of a washland to flood control does not depend on whether it is on- or off-line. Such a classification is therefore of little value in this study. It is more useful to consider the way in which inflow to, and outflow from, the washland can be controlled.

Washlands provide a flood management function by creating additional storage at strategic locations in the river system. By manipulating the storage during the passage of the flood, the flood hydrograph can be translated (in time) and attenuated (in discharge) to reduce the downstream flood peak (Figure 2.2).

The degree of attenuation is determined by the difference between the rate of flow into a flood storage area (inflow) and flow out (outflow) and how these change with the stage of the river. Therefore engineering works to manipulate the impact of washlands on the flood hydrograph involve modifying the inflow and outflow.

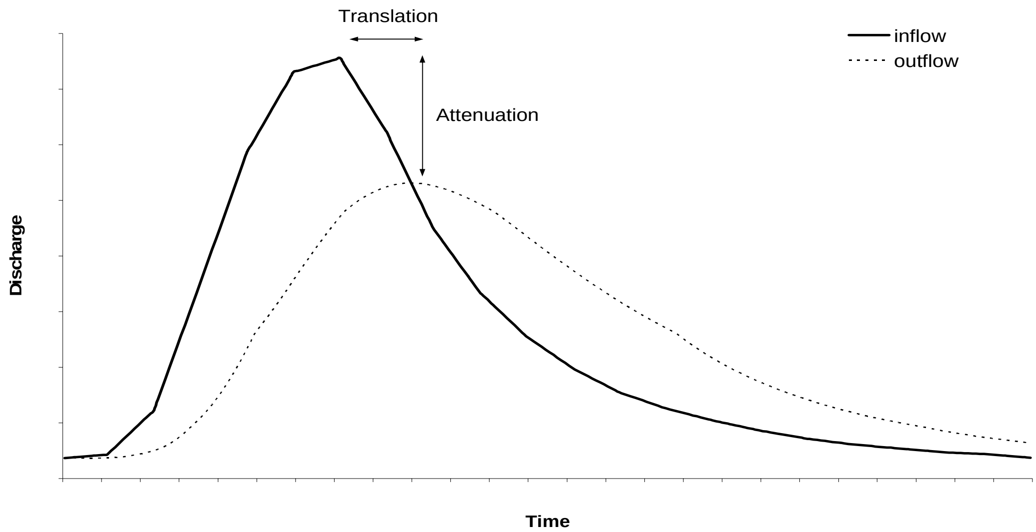

Figure 2.2 Flood hydrograph showing how translation (in time) and attenuation (in discharge) can reduce downstream flood peaks

2.4.1 Inflow

The way in which water flows into a washland site can be classified into: uncontrolled, fixed controlled and variable controlled overtopping.

Uncontrolled inflow: As the river stage rises, out-of-bank flow increases, water flows into the washland unimpeded without the use of any engineering solutions. This is most common in the upper and middle reaches of river systems where the natural flood plain slopes towards the river (Figure 2.3). In these situations it may be difficult to differentiate “washlands” from “flood plains”. Such a situation may not be entirely free of human intervention as the stage-discharge relationship may be deliberately influenced by downstream controls. For example, an engineered constriction in the channel may cause a backwater effect resulting in increased channel storage and out of bank flow at a lower discharge.

Figure 2.3 Twyford Brook, Derbyshire

(Photo T.M. Hess)

Fixed controlled inflow: Out of bank flow occurs once an engineered threshold stage has been exceeded. Overtopping may be confined to a particular stretch of flood bank where a low point has been engineered, or may be along the entire reach. The important factor differentiating this case from the above is that the level of the embankments has been engineered to overtop at a particular stage (and therefore discharge), but this stage cannot be varied. The rate of inflow will depend on the length of the flood bank overtopped and stage in the river channel.

In the Coombe Hill washland overtopping occurs almost every year due to the embankments being low relative to mean water level (refer to Appendix 4). At the Beckingham Marsh washland (Figure 2.4) overtopping is less frequent partly because the embankments are higher relative to mean water level.

Figure 2.4 River Trent overtopping flood banks at Beckingham Marshes, Gainsborough

(Photo Environment Agency).

Variable controlled inflow: The stage at which water enters the washland may be manipulated by use of variable height structures (eg sluices and adjustable weirs), pumping or controlled 'backing-up'. This provides the opportunity to maximise the storage capacity at higher stages by not allowing the washland to flood at lower stages.

The Harbertonford case study (refer to Appendix 4) provides an example of variable controlled out of bank inflow. A downstream constriction (sluice) can be manipulated to cause a variable backwater effect. When the water rises in the River Harbourne it flows onto the washland unimpeded.

At the Saundby Beck (part of the Beckingham Marshes washland, refer to Appendix 4) a sluice gate in the embankment can be opened or closed to regulate the flow into the Beckingham Marsh when the stage is below the embankment height (Figure 2.5).
These categories form the horizontal axis on the Hydraulic Matrix (Table 2.1).

Figure 2.5 Controlled inlet. Saundby Beck (Beckingham Marsh)

(Photo T.M. Hess)

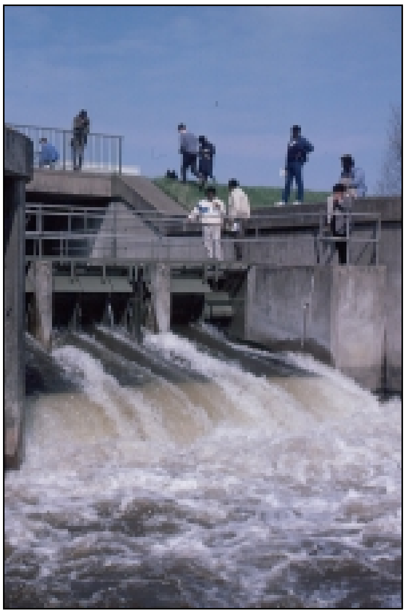

Figure 2.6 Neyrpic gate at Denver Sluice. Controlled rate of discharge

(Photo T.M. Hess)

2.4.2 Outflow

Water flowing out of a washland and returning to the main channel can again be classified in three ways; uncontrolled gravity return, downstream uncontrolled gravity return and controlled return.

Uncontrolled gravity return flow: As the river stage falls, floodwater returns by gravity to the main river channel. This may occur along the entire reach, or more likely, at discrete points (natural or engineered low spots). Manipulating these low spots influences the duration of flood storage.

The Harbertonford washland has no engineered return flow structures incorporated into the site and return flow returns to the river by natural processes. At the Long Eau setback site

(Appendix 4) a low point has been excavated in the river bank which links the flood storage area to the river channel.

Fixed controlled gravity return flow: As the river stage falls, flood waters return to the channel until retained by embankments, after which remaining water may find another route to the main channel downstream via a ditch network or ‘back drain’ often through a flapped outfall to prevent backflow (Figure 2.7). Many natural and embanked flood plains slope away from the main channel.

This method of outflow control occurs in the Coombe Hill washland site (Appendix 4).

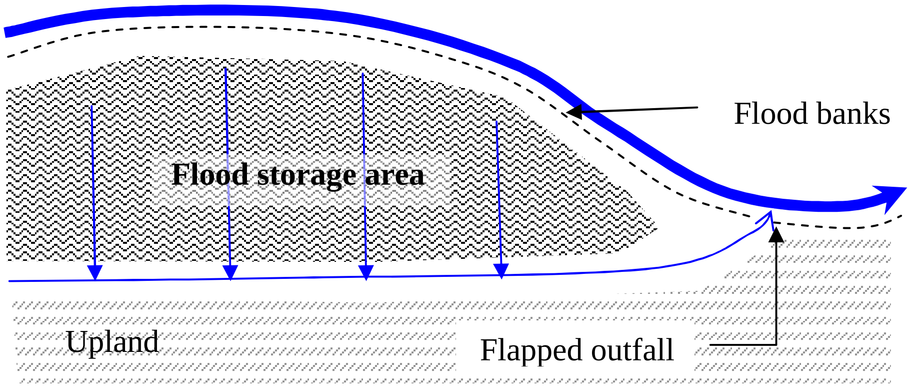

Figure 2.7 Downstream uncontrolled gravity return flow

Variable controlled return flow: Return flow may be controlled via sluices and/or pumping. Control of the opening of sluices and rate of pumps allows control of the rate of return flow.

In the Beckingham Marsh case study (Appendix 4) return flow is controlled first by sluices and later by pumping (when the water level in the washland falls below the water level in the main river, Figure 2.8).

Figure 2.8 Beckingham Pumping Station

(Photo T.M. Hess)

These categories form the vertical axis on the Hydraulic Matrix (Table 2.1).

2.4.3 Matrix

From the above, the Hydraulic Matrix (Table 2.1) classifies washlands into nine combinations of hydraulic control of the inflow and outflow of water onto and off a washland site. Generally, the greater the degree of control, the greater is the degree of engineering intervention. It may appear that sites could contain elements of more than one classification. For example, a site may be envisaged where outflow may take place by gravity via a downstream flapped outfall (type 5) or by pumping (type 8). However, the site is best classified at type 8 as there is the option to control the outflow, whether or not it is used, providing greater flexibility to the flood management function.

The Hydraulic Matrix was used to classify and select a number of case study sites for investigation. The classification by hydraulic characteristics of these sites is shown in Table 2.1. The case studies themselves are reported in Chapter 3 and Appendix 4.

Table 2.1 Hydraulic Matrix classifying washlands by degree of hydraulic control

(for case studies, see Appendix 4)

		Inflow		
		Uncontrolled inflow	**Fixed controlled inflow**	**Variable controlled inflow**
Outflow	**Uncontrolled gravity return**	**1** As river stage rises, water flows onto the washland and returns to the channel when the stage falls. This situation is akin to a natural flood plain and is the best example of on-line storage. Examples include the Long Eau and Steenwaard (Netherlands).	**2** Water flows into the washland once a flood bank is overtopped, and returns to the channel in the same vicinity via a flapped outfall when the stage falls	**3** Water is let into the washland via a sluice gate at the discretion of the flood manager, and returns to the channel via a flapped outfall when the stage falls.
	Fixed controlled gravity return	**4** This situation is unlikely to occur as if water flow into the washland is unimpeded return flow should also be unimpeded.	**5** Water flows into the washland once a flood bank or spillway is overtopped. Water returns to the channel back over the embankment /spillway or via a flapped outfall some distance downstream where there is sufficient head difference for gravity flow. Examples include Coombe Hill.	**6** Water is let into the washland via a sluice gate at the discretion of the flood manager, and returns to the channel via a flapped outfall some distance downstream where there is sufficient head difference for gravity flow. Examples include the Alterheim Polders (Germany).
	Variable controlled return (sluices/pumps)	**7** This situation is unlikely to occur as if water flow into the washland is unimpeded return flow should also be unimpeded. It could be conceived that water could enter via a flapped gate that prevents return flow and is then pumped back into the river, but this example was not found.	**8** Water flows into the washland once a flood bank is overtopped, and is then pumped back into the river. Examples include Beckingham Marsh.	**9** Water flows into the washland when a control on the river is closed (at the discretion of the flood manager), and returns to the channel once the control is re-opened. Examples include Harbertonford and the Leigh Barrier.

2.5 Habitat matrix

As previously mentioned, three water related characteristics of washlands determine their vegetation habitat potential, namely duration of flooding, seasonality of flooding and soil water regime. These are explained in more detail below:

- **Duration** of flooding (short/medium/long). The presence of surface water following a flood event is important from a vegetation perspective because it will limit soil aeration and may also prevent plants of short stature obtaining oxygen from the atmosphere.
- **Seasonality** of flooding (winter only or year round). This is relevant because many plant communities are able to tolerate flooding and waterlogged soils in winter but not summer.
- **Soil water regime** as determined by the drainage characteristics of the soil profile. This is important because, following the recession of the flood, some washlands may drain freely, re-aerating their soils and allowing non-wetland specialist vegetation to persist. Soils that have no subsurface drainage or drainage management may only support species adapted to anoxic rooting environments.

The matrix focuses on habitats and vegetation types whose composition is largely determined by the prevailing water regime. The assumption within the matrix is that the flood frequency of sites is greater than once every three years. The vegetation of sites with lower flood frequencies is unlikely to be primarily determined by the flooding regime. The only arable land use in the matrix is that associated with short duration flooding in winter on soils with rapid drainage, and this would be confined to extensive arable such as cereals, possibly spring sown.

Rarely flooded land is likely to be committed to relatively high value cropping, and there are likely to be measures in place to evacuate water quickly in order to minimise the duration of inundation and waterlogging. Thus, sites subject to medium and long duration flooding in the matrix are those that are likely to experience relatively frequent flooding, of at least once every three years or so. Of course, measures which otherwise are used to evacuate flood water to avoid long duration flooding can be modified or immobilised to help create a desired washland habitat.

The three components listed above were chosen to form the basis of a classification matrix because they can be readily estimated for an existing or potential washland. They also summarise the flooding and soil water regime requirements of a habitat in a way which is clear to both flood and environmental managers. The degree to which they are determined by flood management, other sources of water such as that draining from higher land or drainage infrastructure will be a site-specific issue. It is important to distinguish between a flood event and water level management beyond a flood event – the latter relying on stored floodwater or another source of water where one exists. It is the management of field water levels which arguably will have the greatest effect on the water related biodiversity interest of a washland.

2.5.1 Flood duration and seasonality

Table 2.2 contains the Habitat Matrix which classifies washlands by flood duration, seasonality of flooding and soil water regime. The rows of the matrix classify washlands according to the typical duration of flood events, namely short (less than 3 days), medium (3 days to 14 days) and long term (more than 14 days). The matrix is divided vertically into two sections which denote the seasonality of flood occurrence, namely; winter flooding only, and winter and summer flooding. These seasonality categories are further classified according to the rapidity of soil drainage after the flood event, namely rapid, medium and slow soil drainage. The body of the Habitat Matrix contains cells which denote the habitats associated with given flood duration, seasonality and soil wetness regimes. It is noted that the wetness of soils in the period following a flood event is a key determinant of habitat potential.

2.5.2 Habitat types

Each cell in the matrix can be described in terms of detailed habitat types reflecting variation in other site factors such as soils, topography and habitat management practices such as grazing or hay making. Decision trees can be developed for each cell in the matrix to indicate which National Vegetation Classification (NVC) type is compatible with the given washland characteristics and management regimes. The current matrix is illustrative rather than definitive in terms of its assignment of NVC types to particular cells. The majority of the cells in the matrix have more than one vegetation type. The communities listed represent the vegetation which could develop on the site over a long period of consistent management. Such communities may not be achievable in the short (1-10 years) or even medium term (10-50 years), but they may be used to represent either future goals or as a guide to the appropriate management of the land, even though it may be recognised that the full community is unlikely to assemble at a site within the time-frame of a specific project. For the purpose of illustration, decision trees have been completed for five cells in the Habitat Matrix as shown in Appendix 1.

The decision trees are derived from a purely vegetation perspective. Broader biodiversity qualities including fauna could be added. These latter qualities depend, however, on site specific features, many of which relate to aspects which are not primarily hydrological, such as the size of the washland, its relationship with other wetlands and its position on migratory pathways for wildfowl. These factors need to be assessed on a case by case basis. For this reason it is not possible to predict which species will be attracted to a particular washland type. Vegetation communities are very useful for prescribing the basis of habitats which are suitable for given fauna and faunal communities. A matrix describing the types of vegetation compatible with flood and wetness regimes gives the foundation for defining habitat potential. The supporting decision trees of the type shown in Appendix 1 also show management requirements for the creation of particular vegetation communities and habitats.

The range of factors which determine the suitability of any given washland in relation to fauna and related community dynamics are described briefly below and in more detail in the Appendix 2, namely:

Area: This is a critical characteristic and typically encompasses a number of factors described below. Generally the larger the area, the greater is the potential for diversity.

Isolation: Increased isolation of washlands reduces the movement between sites and consequently reduces rates of colonisation.

Diversity of habitats: A washland has the potential to contain a variety of habitats as demonstrated in part the habitat matrix. The diversity of habitats leads to significant biodiversity on washland sites.

Ecotones[1] and gradients: Washlands present a number of ecotones typically associated with wetness. Ecotones contribute to the diversity of habitats on a site.

Carrying capacity and home range: Different species require different sized areas to feed, breed and maintain a viable population. This is predominantly a function of the area of the washland and of neighbouring habitats.

Drainage regime: Drainage is a critical aspect of the condition of a washland, cutting across a number of the factors previously described. Generally a drainage pattern which produces flooding in the winter with floodwaters receding in spring/summer is most beneficial.

Dominant land management regimes: The management regime practised across a washland will have a significant effect on the biodiversity in place. Land management can be divided into agricultural, woodland, wildlife/nature conservation, amenity and drainage. Each of these will create different site conditions and therefore impact on composition of species.

Historical geography: It is important to understand past management in order to either maintain the wetland or to restore it to its former condition(s).

[1] Ecotone: a narrow and clearly defined transitional zone between two communities or habitats; an edge habitat (Osborne 2000).

Table 2.2 Habitat Matrix showing classification of washlands by flooding and soil water regimes and related habitat types

	Winter flooding only			Flooding at any time of year		
	Rapid soil drainage	Moderate soil drainage	Slow soil drainage	Rapid soil drainage	Moderate soil drainage	Slow soil drainage
Short duration flooding	**1** Arable Hay meadow Pasture Alder Woodland	**2** Flood meadow Pasture Alder Woodland	**3** Flood meadow Inundation pasture Alder Woodland	**4** Water Meadow Pasture Alder Woodland	**5** Inundation pasture Alder Woodland	**6** Inundation pasture Rush pasture Swamp Willow carr
Medium duration flooding	**7** Hay meadow Pasture Alder Woodland	**8** Flood meadow Pasture Alder Woodland	**9** Flood meadow Inundation pasture Willow carr Swamp	**10** Pasture Rush pasture Willow carr	**11** Inundation pasture Rush pasture Swamp Willow carr	**12** Inundation pasture Rush pasture Swamp Willow carr
Long duration flooding	**13** Flood meadow Pasture Willow carr	**14** Inundation pasture Rush pasture Swamp Willow carr	**15** Inundation pasture Rush pasture Swamp Willow carr	**16** Swamp Willow carr	**17** Swamp Reedbed	**18** Swamp Reedbed

Note:
Soil drainage is a function both of soil conductivity and drainage infrastructure
Rapid soil drainage = Following inundation, water table typically falls by > 30 cm in < 10 days in winter
Moderate soil drainage = Following inundation, water table typically falls by > 30 cm in < 30 days in winter
Slow soil drainage = Water table does not fall below 30 cm following an inundation event in winter until late April
Short duration of surface water: typically 3 days per event.
Medium: typically less than 2 weeks per event.
Long: typically more than two weeks per event

While the Habitat Matrix broadly classifies washlands in terms of flood management and biodiversity, in practice many washlands consist of mosaics of flood regimes and habitats, often associated with variations in boundary conditions and internal topographical. It is likely that large washlands in particular will have variable localised hydrological characteristics which will produce different habitats. This detail is not accounted for within the existing matrix because it requires site-specific details. Observations at a generic level are not useful for the purpose of site-specific assessment and management recommendations. An expert system could be a useful means of organising the gathering and processing of such site-specific details. If this degree of precision were required, such a system could provide detailed classification of sites and more targeted management specifications to help create or maintain a site. This goes beyond the terms of the existing study, but is worthy of further consideration as a basis for guidance.

2.5.3 Wetness regimes

The Habitat Matrix also describes the soil wetness regimes within the washland area which are a function of natural conditions and management interventions. The latter includes engineering solutions in the form of drainage infrastructure such as subsurface drainage, ditch systems, water level control mechanisms and possibly pumping regimes. The wetness of soils post inundation can be linked to the rapidity of drainage as follows:

Rapid soil drainage: The soil is likely to be highly permeable (probably a sandy or well structured soil) with adequate freeboard to allow rapid percolation of water. The topography of the washland site will allow rapid surface drainage to occur, with few depressions or ridges to hold surface water.

Rapid soil drainage can also be assisted by intense drainage management with subsurface drainage, pumps or ditches being used to rapidly lower the water table, with a typical fall of 300mm in less than 10 days in winter.

Moderate soil drainage: soil is likely to have a slower percolation rate than in the category above. The soil is likely to be a less structured clay loam or silty loam or have insufficient freeboard to allow gravity drainage. The site will have some depressions or ridges to reduce the surface water runoff rate.

Drainage management could be associated with the site but not to the same intensity as the rapid soil drainage regime. If ditches are present, they may be narrow and have a much reduced carrying capacity. The drainage management will not be as efficient at reducing the soil water table, with a typical fall of 300mm in less than 30 days in winter.

Slow soil drainage: the soil is likely to have a low percolation rate, probably consisting of poorly structured heavy clay or restricted freeboard. The soil type could be highly permeable but if there is no outflow for the soil water to drain to, the water table will remain high. The topography of the site may hinder surface water drainage, with ridges and depressions present to hold water. There will probably be low intensity drainage management with low pumping rates. Typically soil water tables will not fall below 300 mm following an inundation event, until net evapotranspiration begins to dry the site in spring.

2.6 Washlands and agricultural land use

The flooding and wetness regimes of washlands critically affect their potential for agriculture. Generally the greater the flood risk and wetness, the less suited a washland is for intensive farming. It is possible to prescribe the water regime standards required to deliver given types of farming activities and practices, and thereby the tolerance to regime change associated with washland creation or modification for either flood management or biodiversity purposes. Furthermore, agricultural land use, especially in the form of extensive grassland is often used to provide a basis for habitat management in washland areas, supported by 'stewardship' agreements.

Based on observed land use (Morris and others 1984; Morris and Sunderland 1993; Dunderdale and Morris 1996, 1997a, b) Table 2.3 shows the common standards of flood defence associated with, and therefore implicitly required to support, given types of agricultural land use and productivity. With respect to flooding (Table 2.3(a)), over the year as a whole, for example, cropping systems such as cereals would probably not be financially viable if flood risk on washlands was on average more frequent than once in 5 years; and once in 10 years in the case of root crops such as sugar beet and potatoes. The tolerable risk of summer flooding on cereals and potatoes is about once in 10 years and 25 years respectively, reflecting the significantly greater damage associated with summer floods on these crops.

Grassland, as evidence bears out, has a much greater tolerance to flooding. Intensive grassland systems will tolerate relatively frequent flooding (once every 2 or 3 years) providing this is not long duration and does not occur in summer when tolerance is lower (once every 5 years or so). Extensive wet grassland is commonly associated with multiple winter flooding, but summer flooding is less acceptable because of the impact on grassland use.

With respect to waterlogging (Table 2.3(b)), experimental and empirical research in Britain and the Netherlands (Hess and Morris 1988, Dunderdale and Morris 1997a, b) has shown that the productivity of agriculture is critically dependent on water table levels as they determine crop growth conditions and field access. High water tables within 0.3m of the surface usually indicate 'very bad' agricultural drainage resulting in 'very low' levels of agricultural productivity. Such conditions would not support arable cropping and would mainly be confined to extensive grassland.

Of course the development of washlands to promote biodiversity objectives is likely to preclude intensive agriculture. The dominant agricultural use is likely to be wet grassland which will need some degree of flood and water table control to be practically feasible.

Table 2.3 Flood and drainage standards for agriculture

(a)Common minimum acceptable flood risk by land use (return period in years)

Land use	Whole year	Summer April-October
Horticulture	20	100
Roots crops	10	25
Cereals	5	10
Intensive Grass	2	5
Extensive Grass	<1	3

(b) Field water table levels, drainage conditions and freeboard in watercourses

Water table height from surface	Agricultural drainage condition	Agricultural productivity	Spring time freeboards in watercourses (no field drains)	Spring time freeboards in watercourse (field drains)
0.5m or more	Good,	Normal, no impediment	1m (sands) to 2.1m (clays)	1.2m (clays) to 1.6m sands
0.3m to 0.49m	Bad,	Low reduced yields, reduced field access	0.7m (sands) to 1.9m (clays)	Temporarily submerged pipe outfalls
Less than 0.3m	Very Bad,	Very low, severe constraints on land use, reduced yields, reduced field access, mainly wet grassland	0.4m (sands) to 1m (clays)	Permanently submerged pipe outfalls

Source: Morris and others 1984, Dunderdale and Morris 1997a

2.7 Interface between Hydraulic Matrix and Habitat Matrix

There is no direct link between the Hydraulic Matrix and the Habitat Matrix because the type of hydraulic control does not directly influence the vegetation community of the washland. It is the flood and soil water regimes that determine habitat conditions for vegetation communities. The nature of these elements can only be identified with site specific information from an individual washland. Information on the types of hydraulic control in place will not in themselves allow habitat classification.

An indirect link between the Hydraulic and Habitat Matrices can however be developed in the form of a lists or Menus of Possible Interventions which can be taken to change the hydrological conditions of the site and therefore potential habitat types. The first Menu of Interventions (Table 2.4) illustrates by way of examples the types of actions that can be taken to manipulate the inflow and outflow of water from the washland as this defines the frequency and duration of flooding. Table 2.4 is indicative rather than exhaustive of the possible interventions that can be taken for biodiversity benefit. The actions are further classified in terms of their hydraulic impacts, washland impacts and in-channel impacts. The link between actions and the Hydraulic Matrix is also given. Some actions are applicable in all cases, but others may be applicable only to particular cells in the Hydraulic Matrix. For example, decreased channel maintenance will have an impact on all washlands whereas some, such as changes to pumping regimes, only apply to cases with a relatively high degree of hydraulic control.

Table 2.4 Menu of possible interventions to modify the frequency/duration of washland flooding and the downstream hydrograph for the benefit of biodiversity

Action	**Hydraulic impact**	**Washland impact**	**In-channel impact**
Set-back/removal of embankments	Increased on-line storage	Increased area	Reduced peak stage
Introducing/lowering spillways in banks	Increased frequency of off-line storage	Increased frequency of inundation	Reduced peak stage
Decreased channel maintenance leading to increased river and bank vegetation	Change in stage-discharge relationship	Increased frequency of inundation	Increased stage at all discharges, depending on the extent of vegetation
Creation of in-line dams/sluices	Increased back-water effect.	Increased frequency of inundation	Increased peak stage
Increased pumping/siphoning into washland	Variable	Increased frequency and duration of inundation	Reduced in-channel discharge (up to capacity of washland)
Reduced pumping/restricted gravity outflow from washland	Variable	Increased duration of inundation	Changed (reduced) in-channel discharge linked to the event frequency
Increased vegetation height on floodplain	Reduced rate of inflow and outflow	Change in duration of flooding	Increased floodplain roughness. Vegetation on washland may allow rapid run-on but slow runoff
Lowering of floodplain	Increased off-line storage	Increased frequency and duration of inundation	None upstream
Ecological flooding: retention and evacuation just in time for next flood	Increased off-line storage	Controlled duration of inundation for specific habitats	Reduced peak stage

A distinction is made between washland drainage and catchment drainage. The drainage channel in catchment terms is the river. In the washland drainage channels are introduced to allow control of the inflow and, importantly, the outflow of water. In the case of a washland taking water from a flood event in the river, water may be distributed in a controlled way through the washland by introducing a network of ditches (referred to as drainage channels in the tables). Such ditches have the function of linking intermediate structures such as bunded compartments and/or scrapes, directing water to controlled outflow points and providing a water source for sub-irrigation or a soil drainage outfall for subsurface pipe systems.

The second Menu of Possible Interventions (Table 2.5) illustrates by way of examples the actions that can be taken to <u>manipulate the duration of soil water</u> (including some surface water retention) once the main floodwaters have receded or have been evacuated. Table 2.5 is indicative rather than exhaustive of the possible interventions that can be taken in order to achieve biodiversity benefit. The table also shows the hydrological impact of the interventions, the impact on washland characteristics, and the impact on washland drainage channel. These interventions can for the most part be carried out independently of the management of flood defence. The retention of ground, surface and ditch water levels for biodiversity may have an impact on flood storage capacity, but much depends on site conditions and time of year (as discussed in section 4.1.1).

Together these menus show the range of engineering and operational interventions that can be drawn on to deliver specific flood and wetness regimes. It is not possible to be prescriptive about the suitability of particular methods to achieve regime objectives without knowing the site conditions, such as existing hydraulic characteristics and control methods, soil types, and washland topography.

It is possible to change the position of a washland in the Hydraulic Matrix by implementing an action in the menu. For example, the action to set back the embankments on the Long Eau River, moved the washland from one with a threshold inflow control (cell 2 in Table 2.1) to one reliant on natural inflow control (cell 1). If the pumping regime at Beckingham Marshes is stopped entirely as proposed by RSPB, then the site would shift from one of 'fixed control inflow' and 'pump out' (cell 8) to one of 'fixed control inflow' and 'fixed control gravity out' (cell 5). This demonstrates how the Menu of Interventions allows washland managers to change the washland type in the Hydraulic Matrix by changing the degree of hydraulic control. The cell in the Hydraulic matrix does not in itself determine the habitat that is achievable nor the effectiveness of the flood management. Generally, the greater is the degree of hydraulic control, the greater is the potential to 'manage' flooding and wetness regimes in accordance with objectives.

Table 2.5 Menu of possible interventions to modify washland soil drainage conditions for the benefit of biodiversity

Action	Hydraulic impact	Washland impact	Drainage channel impact in the washland
Vegetation management to facilitate natural retention	Longer retention, decreased peak outflow	Increased wetness	Increased storage capacity of channels within the washland drainage network.
Raise outflow sluices	Water retained, reduction in storage capacity	Wetter soil, higher water tables possible	Water levels raised
Changes in pumping regime	Controlled outflow, effect on storage capacity	Wetter soil, higher water tables possible	Water levels maintained
Introduce hydrological compartments	Water retained, possible reduction of storage capacity for subsequent floods	Hydrologically isolated areas, retained wet areas	Re-routed drainage channels to connect hydrological compartments in the washland
Create scrapes, hollows and ponds	Holds water on the floodplain, impact on flood storage capacity.	Soil removed to create hollows, maintained wetness of site in localized areas	Scrapes and ditches connected to the drainage channel system to integrate whole drainage system
Modify ditches, including control structures	Control drainage of surface water, possibly increased storage	Controlled water table levels	Changed water regimes in washland soils, possibly increased ditch network
Introduce subsurface pipes	Water drained through soil profile via pipes or provision of sub-irrigation.	Controlled water table levels	Water levels in washland channels lowered or raised to provide drainage or sub-irrigation respectively
Increase ditch roughness, possibly through reduced maintenance	Flow rate reduced and increased water held on washland	Water table levels raised	Increased vegetation in channels as part of a natural outflow control system

The position of the washland within the Habitat Matrix can also be changed by selecting from the Menu of Interventions. For example, the creation of scrapes at Harbertonford reduced soil drainage, increased the duration of surface water on the site by increasing ponding, thereby producing permanently wet areas within the washland. These actions increased the wetness of the washland by moving it from rapid soil drainage to moderate soil drainage, thereby changing the potential habitat from pasture (cell 10 in Table 2.2) to wet grassland/swamp (cell 11).

As well as moving the position of a washland within the Habitat Matrix, interventions can change the detailed characteristics of the habitat within a particular cell. This is apparent through the use of the detailed decision trees that support the Matrix. For example, a washland classified as type in cell 18 in the Habitat Matrix would be associated with swamp conditions. Addition of a sluice could facilitate an increase in the depth of water retained on the washland. If water depth increases from 200 mm to 500 mm, the composition of the swamp vegetation community would change, perhaps from sedge bed to reedbed, as shown by working through the appropriate pathway in the decision tree (Appendix 1, Figure 4).

These examples demonstrate how the Menu of Interventions can, for given site conditions, help determine actions to modify flooding and wetness regimes in order to create or change the position of a washland within the Habitat Matrix, and thereby desired outputs in terms of bio-diversity.

2.8 Summary and preliminary conclusions

This chapter has defined and classified washlands for the purpose of integrating flood defence and biodiversity. A number of preliminary conclusions are reached at this stage which are carried forward for further analysis, namely:

- A broad, inclusive definition of washlands is used to incorporate areas of floodplain that are allowed to flood or are deliberately flooded for management purposes, with potential to form a wetland habitat. This definition includes areas which provide natural storage as well as artificial storage, and is considered justified because in, the context England and Wales, virtually all river systems are managed in some way, and the retention or creation of natural storage is itself a management decision. Furthermore, the setback of agricultural defences which restore natural floodplain can facilitate the recreation of a washland.
- The proposed classification of washlands enables the integration of engineering and water regime management. The typology provides a logical framework for classifying washlands in terms of flood management and biodiversity.
- The proposed classification system can help to determine the types and qualities of habitats that might be achieved for a given flood and water regime, or the degree of change in these regimes that are required to deliver a given change in habitat.
- The classification is output rather than input driven, perceiving engineering and management options as the means by which flood management and biodiversity objectives can be met. This approach recognises that given flooding and water level regimes, designed to deliver required flood management or biodiversity objectives, can be achieved by a variety of engineering and management interventions. The choice of intervention depends on site specific circumstances.
- Flood duration, flood seasonality and wetness conditions in the washland are the key factors that determine the potential type and quality of washland habitat. The retention of soil wetness beyond the flood event period is a particularly critical determinant of habitat quality. Thus, habitat potential on washlands mainly depends on land and water management practices beyond the flooding period, especially the management of soil water levels.
- In many respects, the scope for habitat improvement on the washland will depend on the dominant land use, itself determined by flood and soil drainage conditions. Where the washland is under arable land (implying infrequent flooding and rapidly drained soils) the scope for habitat enhancement will be limited. Where washlands are under grassland or woodland (often implying more frequent flooding and wetter ground conditions), there is more scope for habitat improvement.
- Given reductions in the profitability of arable farming due to changes in agricultural policy, and reduced justification for flood defence for agriculture, there appears to

be scope to promote land use change on washlands which can provide opportunity for wetland habitats. Such conversions are, and can be, further promoted under agri-environmental schemes.

- With respect to a key objective of this study, whether biodiversity objectives can be met within a predominantly flood defence framework, the answer appears to rest on whether the dominant land use requires flood and land drainage regimes which are not conducive to habitat creation. Most parts of the flood plain have the potential to be maintained in a wet condition, but whether they are or not depends on the drainage requirements of the dominant land use and the expectations of land managers. Where arable land is used to store infrequent flood waters, scope for habitat creation will be limited. There is much more scope for habitat improvement on washlands under extensive grassland which is compatible with wet conditions beyond the flood event.

3. Washland case study examples

This Chapter reports on the use of selected case studies to illustrate and confirm the validity of the washland typology. These include five case study examples of washlands in England and four elsewhere in Europe. The sites were selected to provide examples of the range of types according to the hydraulic matrix, the diversity of engineering interventions in place on washlands and the various opportunities for biodiversity.

3.1 English case studies

In collaboration with Defra, English Nature, and other members of the project steering group, over 20 sites were identified for potential case study enquiry. The purpose was to select sites which already demonstrated some integration of flood management and bio-diversity, and for which information was readily available. This proved difficult. Most identified sites were either predominantly flood storage sites or wetland nature reserves. It appeared that very few sites had been designed, or were currently operated with integration in mind, although this is not to say this could not be achieved. Large scale schemes such as the Ouse washes and sites within the Somerset Levels and Moors were not selected because these were the regarded as 'special cases' and were also the subject of other enquiries. Within the resources available, five washlands were selected for study on the basis that they covered the range of characteristics of washlands with respect to flooding and wetness regimes, habitat types and dominant benefits, whether flood management or bio-diversity. These were:

Mainly flood management washlands

Beckingham Marshes, Nottinghamshire
Leigh Barrier, Kent

Mainly conservation washlands

Long Eau, Lincolnshire
Coombe Hill, Gloucestershire

Integrated flood management and conservation washlands

Harbertonford, Devon

The characteristics of the sites are summarised in Table 3.1 with more detailed descriptions in Appendix 4. All five English washlands were predominantly on clay soils, which have relatively low hydraulic conductivity and associated poor natural drainage. The sites have similar average flood duration periods of between 2 and 4 days, with all sites except Harbertonford flooding only in winter.

There is variation in frequency of flooding between sites, from frequent flooding of 3 to 4 times a year on average on the Long Eau set-back scheme, to infrequent flooding on Beckingham Marshes at 1 in 10 years. This variation in flood frequency is reflected in the vegetation found on sites. Consistent with observed agricultural tolerance, high frequency of flooding is associated with grassland, while low frequency flooding is associated with relatively extensive arable land use such as cereals.

The case studies also demonstrate the array of engineering solutions used to modify the flood regime, although all except the reinstated natural washland of Long Eau (with its setback of agricultural defences) exhibit a relatively high degree of hydraulic control. The resultant habitats are associated with a mix of wet grassland and woodland, except for Beckingham Marshes which retains predominantly cereal land use. Habitat targets are difficult to ascertain except for the most recent schemes such as Harbertonford, and most appear to be managed for general enhancement within a mainly flood management lead regime. Indeed, it is only the most recent washland schemes (such as Harbertonford) which appear to be engineered and operated with specific biodiversity outcomes in mind, partly in response to the impetus provided by Biodiversity Action Plans.

3.2 European washlands

In continental Europe, countries such as Germany, Denmark, Belgium and the Netherlands are restoring natural floodplains which provide a mix of managed wetland habitat and flood defence benefits, and in this respect involve aspects of washland creation and management. The techniques used serve to illustrate the washland typology and challenges of washland creation. Published information on washland creation in Europe mostly concerns the River Rhine.

The European experience demonstrates the first steps along a route towards sustainable flood management programme. This action has been encouraged by the desire to reverse the damage of historical river re-profiling, canalisation and floodplain development (Zegers and others 2001). In the Netherlands public debates have taken place in which communities at risk articulate their views on options for flood protection. This has allowed the Dutch Government to gain public support for large integrated flood management and floodplain restoration operations. It remains the case, however, that most washland-type development in continental Europe has either been for flood management or for biodiversity purposes For example, the projects contained within the Rhine Action Plan have been largely driven by flood storage objectives, whereas the innovative Danish Stern river restoration project was designed predominantly for biodiversity. Opportunities for achieving multiple purposes have largely been explored subsequently. Although there is much interest in exploiting potential synergy, there has been limited achievement to date (Eco-flood 2003).[2]

It has to be emphasised that international co-operation is essential for flood management and bio-diversity in Europe, especially along the Rhine, and this is being encouraged within existing EU frameworks and international actions such as the Rhine Action Plan (World Wide Fund for Nature 2001; International Commission for the Protection of the Rhine website 2003).

3.2.1 European techniques and outcomes

The policies adopted by European countries, especially the Netherlands, require the development of sustainable flood defences which integrate the principles of flood management and nature enhancement, moving away from the traditional structural response of heightening embankments. Table 3.1 summarises the main techniques used in Europe to restore washlands while maintaining flood defence services. The techniques have been variously combined with river re-profiling, widening and deepening the channel, in some cases creating a so called ‘green river’.

[2] Subsequent to the completion of this report, the 7th Intecol Conference in Utrecht, July 2004, reviewed some recent international approaches to promote the integration of flood management and biodiversity. www.bio.uu.nl/intecol

The efficiency of washland techniques for flood defence purposes has been reported by Klijin (2001). Large scale setting back of dykes, river re-profiling and lowering of groynes produced the greatest flood defence benefits per million Euros invested. The removal of hydraulic restriction gives moderate value for money, whereas floodplain lowering has proved less cost-effective, although the latter has been associated with significant benefits for biodiversity.

The European experience shows the importance of establishing a monitoring programme to assess the success of attempts to enhance biodiversity on washlands. Such a programme requires a multidisciplinary approach considering hydrology, vegetation, macro-invertebrates, fish and waterfowl (Buijse and others 2002), some of which have been acknowledged as biological indicators in the EU Water Framework Directive. Monitoring is expensive however, and needs to be incorporated into the budget of projects from the onset. A monitoring programme on the Altenheim Polders (Case Study 1, Appendix 3) reported the steady return of the flora and fauna to wetland species associated with washlands. In this way it was possible to confirm the success of the project in restoring the floodplain to its natural habitat, and to use this information for subsequent washland development initiatives.

3.3 Confirmation of typology

The UK and continental European case studies provide information on washlands which have been used to evaluate the typology. The case studies appear to fit well into the proposed typology. They demonstrate different washland conditions and represent a range of types within the Hydraulic and Habitat Matrices.

The case studies confirm that washlands can provide important flood defence benefits. Washlands and associated benefits can be on a small scale as in the case of the Long Eau set-back scheme, or on a large scale as demonstrated by the Leigh Barrier. The European case studies provide examples of techniques that could potentially be used to create or enhance washlands in England, such as flood plain lowering or managed ‘ecological-flooding’. These can be included in the Menu of Interventions.

The case studies provide an overview of the varying habitats that washlands contain and demonstrate the usefulness of the Habitat Matrix. Case study habitats range from arable at Beckingham Marshes to wet woodland at Harbertonford. The case studies also provide information on land use and habitat management which has been used to confirm the decision trees which support the Habitat Matrix. The case studies do, however, confirm the difficulty of classifying washlands by a single habitat type. Each site is composed of a mosaic of habitats, such that describing sites in terms of any one cell in the habitat matrix may fail to report the diversity of habitats contained within any one washland site.

Alongside the detailed case studies, a questionnaire survey of conservation officers and flood managers (see Chapter 5 below) provided details of washlands in their areas. (Table A4.1, Appendix 4). This information from across the regions confirmed the general relevance of the issues raised by the five English case studies.

3.4 Priority-based washland classification

The case studies show that the priority given to flood defence and biodiversity varies amongst washland sites, reflecting a mix site of characteristics, historical origins, needs and opportunities, and the dominance of a particular interest to be served, whether flood defence or biodiversity. In this respect, it is possible to classify washland sites, and the case studies that were examined, into three types according to priority. These are:

Flood Management Washlands, where flood management is the most important consideration and biodiversity is a secondary consideration. It is here that public safety and the protection of the built environment are the overriding priorities in the original design and subsequent management of washlands. Biodiversity objectives will be met as long as they do not significantly compromise flood management purposes. In these situations, discussion with conservation officers confirmed acceptance that flood management took precedence. The cases showed that it was possible to exploit biodiversity opportunities in a flood management oriented washland, but more often than not there was scope for further enhancement. The Beckingham Marshes provide an example of biodiversity enhancement within a predominantly flood management oriented regime, including more recent creation of wetland features. The Leigh Barrier represents a case which offers biodiversity potential, although to date little has been done to exploit this. As referred to above, the very fact that sites are used for flood storage of some kind, with land uses that will accommodate this flooding, means that there is usually some potential for habitat enhancement.

Integrated Washlands, where flood management and biodiversity have equal consideration and management regimes are sought which optimise potential synergy. Particular attention is paid to the retention of some surface water and soil wetness beyond the flood event period. The scope for full integration of flood management and biodiversity functions needs to be identified at initial project identification and design, with water regimes and intervention measures built in and managed accordingly. The Harbertonford Project, albeit on a small scale, is an example of this purposeful integration.

Conservation Washlands, where biodiversity is the most important consideration and flood management is a secondary consideration. Here, the creation and management of wetland habitats are the key objectives and flooding regimes, and the flood storage facility offered by the site, are managed to support habitat quality. Flooding frequencies, depths and timings which might damage important plants and animals are avoided where possible. The Coombe Hill case study is an example of a site which has been developed primarily as a wetland nature reserve but which offers some flood storage benefits during peak flow periods. In such cases, wetland sites may individually offer limited contribution to flood management. However, taken in aggregate over a whole catchment, the contribution of many individual sites can be substantial.

It is possible that the classification of a given washland may vary over time with changing driving forces and circumstances, whether these relate to increased flood risk or changes in land use policy as they affect agricultural or environmental objectives. The Long Eau set-back scheme, which results in more frequent flooding of the washland, thereby delivering an enhanced mix of flood management and biodiversity benefits, is an example of a transition from a conservation to an integrated washland. This transition has been facilitated by agri-environment payments to land managers. Local flood defence managers perceive that such set back schemes could deliver significant dual benefits when aggregated at catchment scale.

The Ouse Washes, designed primarily as a flood management washland scheme, has been increasingly managed as an integrated scheme in recent years. However, greater incidence of flooding in the last few years has in the view of some conservation organisations compromised biodiversity benefits.

If priorities change away from intensive agriculture in floodplains, there appears to be much greater scope for enhancing the biodiversity component of flood management washlands, in some cases moving them towards integrated washlands. This may be associated with changes in the frequency and duration of flooding in order to further enhance biodiversity. The purposeful shallow flooding of selected wetland sites in the Parrett Catchment, Somerset is such an example.

The priority-based classification may also reflect the relative importance of flood management and biodiversity drivers at different scales of influence, whether very local, catchment, regional or national. There may be an urgency to address a local urban flooding problem, but the biodiversity components, as they incorporate BAPS and agri-environment objectives, may be driven by regional and national priorities. This points to the challenge of lining up objectives that are defined, promoted and funded at different levels.

3.5 Funding and administration

The case study enquiries identified a number of funding and administrative issues. These are discussed in Chapter 6. The case study evidence on these issues was consistent with that derived from the survey of flood defence and conservation officers (Chapter 5) and from the stakeholder workshop (Chapter 7). In particular, flood managers and conservation officers drew attention to the need to provide long term funding streams to support washland creation and management within an overall integrated approach to catchment management.

3.6 Summary and preliminary conclusions

This chapter has drawn on evidence from visits to five case study sites in England and from secondary sources for experience elsewhere in continental Europe. The following conclusions can be made at this stage.

- The case studies appear to confirm the suitability and relevance of the typology for washland classification based on hydraulic and habitat characteristics. The classification would merit validation by extending its application to other cases.
- The importance of land use and the management of wetness regimes beyond the flooding period is confirmed as a key determinant of habitat potential.
- The cases demonstrate the type of interventions that have been used to integrate flood defence and biodiversity objectives. They involve a mixture of actions to affect flooding regimes and post-flood water levels in the soil and drainage systems.
- It is valid and useful to distinguish washlands by the dominant purposes to be served, namely Flood Washlands, Integrated Washlands and Conservation Washlands. It is possible that, overtime and in response to changing priorities, the main purpose and hence classification of a given washland may change.
- For the most part in England, and also elsewhere in Europe, washland development has tended to be single rather than multi-purpose, mainly driven by flood defence requirements. There are few examples of an integrated approach, although more

recently action has been taken to enhance biodiversity on existing, mainly flood defence, schemes.

The priority based classification has important implications for funding. To date, Flood Washlands have mainly been funded under the flood defence budget, and Conservation Washlands have been funded mainly by conservation organisations. Funding for Integrated Washlands is not readily available at present.

At present, an integrated approach requires the assembly of funding from different sources, and this, together with perceptions by of limited longevity of funding from sources such as agri-environment schemes, can act as key barriers to implementation

Table 3.1 Summary of five English washland case studies

(see Appendix 4)

Site and year of development	Size (ha) and Soil type	Engineering solutions & Hydraulic Matrix type.	Average flood duration (days), frequency (per year) and seasonality	Vegetation	Biodiversity and Habitat Matrix type
Beckingham Marshes (Nottinghamshire) early 1970s	1000 Clay	Pumps, Sluice gate, drainage ditches, embankments. **Type 8**	2-3 days, 1in 10 years Winter	Arable	Enhancements aimed at waterfowl **Habitat Matrix Cell: 1**
Leigh Barrier (Kent) 1970s	278 Clay	Embankments, radial gates, scrapes. **Type 9**	3-4 days, twice per year Winter	Pasture and small areas of woodland.	Increase general biodiversity via excavation of scrapes. **Habitat Matrix Cell: 8**
Coombe Hill (Gloucestershire) 1970s and extensions	650 Silty-clay	Non return valve, embankments, ditches. **Type 5**	Highly variable duration, every year Winter	Pasture/ hay meadow	Enhancements aimed at waterfowl **Habitat Matrix Cell: 14**
Long Eau (Lincolnshire) 1996/7	15 Clay	Setback embankments. **Type 1**	3-4 days, 3-4 times per year Winter	Pasture	Increase general biodiversity via grassland management. **Habitat Matrix Cell: 8**
Harbertonford (Devon) 2000	3.5 Clay	Dam, sluices, scrapes, vegetation planting **Type 9**	2-3 days. 1 in 10 years, but with some annual retention. Winter and Summer	Woodland and lowland wet grassland	Increase general biodiversity by recreating natural washland, with retained water **Habitat Matrix Cell: 11**

Table 3.2 European techniques for the creation of washlands and illustrative examples

Technique	Outputs	Example
Polder reconnection: Connecting the floodplain behind the embankments with the main river body via inlet and outlet structures.	• Polder retains flood-water and reduces flood peak (G. Rast per coms 2003). • Polders produce excellent wetland habitats	Altenheim Polders, Germany (case study 1) River Dijle Restoration Project, Belgium (case study 3)
Set-back of embankments: Removal and relocation of embankments further back from the river channel.	• Creates more floodplain habitat. • Create room for the river to flood, increased storage.	Dyke setback where the Lower Rhine and the River Ijeel meet, Netherlands.
Weir construction : Control structures to manage the flow the water in the main channel and including flood water retention	• Retained in-channel levels and impoundment , controlled downstream flows	The Kulturwehr weir between Kehl and Strasburg, Germany.
River water retention: The diversion of floodwaters into the natural river channels in a multi-channelled river.	• Managed wetland inundation. • Diversion of flooding from urban areas.	River Retention Scheme at Strasburg, Germany (case study 4)
Removal of flow restrictions to alleviate unwanted flooding in some areas and purposefully relocate this to designated areas.	• Reduced channel resistance or restrictions reduces unwanted flooding up. • Increased river flows downstream with managed storage areas used for habitat creation.	The construction of a railway bridge at Oosterbeek flood plain (Arnhem), to replace the existing embankment which carried the railway and which caused the bottleneck, Netherlands.
Construction of side channels to increase storage capacity.	• Creates range of aquatic and wetland habitats. • Increases the total flow and storage capacities	River Retention Scheme at Strasburg, Germany (case study 4)
Lowering the floodplain: lowering land levels adjacent to the river. Often a preferred option for habitat restoration	• Extends the river channel and floodplain • Reduces risk of unwanted flooding.	Steenwaard Water Meadow Restoration Project, The Netherlands (case study 2)

Klijin and others 2001; Pruijssen and others 2000; Oudendammer 2003; The Belgium Federal Department of the Environment Website 2003; The Integrated Rhine Programme, Bavaria website 2003).

4. Washland management

Management of the washland is essential for effective flood defence and wildlife conservation. This section describes washland management for flood defence and biodiversity purposes. Particular attention is given to soil water management and to the management of vegetation and fauna regimes.

4.1 Managing for flood defence

The role of washlands in flood defence is to provide storage for floodwater. The main challenge of washland management, in terms of flood defence, is maintaining the ability to control the inflow and outflow of water and storage of water on the site. If the storage capacity of a washland is reduced the effectiveness of the site as a flood defence facility is decreased. The importance of flood storage capacity has been emphasised in the consultation with flood managers and in the case studies.

Effective flood management requires floodwater to be removed from the site as rapidly as possible after the peak flow has passed, allowing the storage area to be ready for the next flood event. In this respect, conflict may arise between flood management and biodiversity objectives (see following section). Conservationists may want to retain surface water in the washlands for periods beyond the flood event in order to enhance biodiversity. This could reduce overall flood storage capacity. Compromises can be reached, however, by intervention measures such as at Coombe Hill (Appendix 4), where ditches water levels are raised in the summer period and lowered in the winter when most flooding occurs. This is common practice in many grazing marshes. Providing some water is retained in the ditches over winter, the ditch communities themselves are not too severely compromised. A solution to the apparent conflict could be reached by providing excess storage capacity in the washland, thereby allowing some of it to remain water-filled throughout the year without compromising flood defence capacity.

When a new washland site is proposed, flooding for ecological benefit and flood storage will need to be considered from the start of the project. Ditch or scrape water levels which benefit biodiversity can be incorporated into the washland design so as not to hinder flood water storage. It is essential that flood storage and wildlife objectives are reconciled at an early stage in the development and planning process. Of course, the scope for this will depend on local circumstances and priorities. This can be achieved by using Catchment Flood Management Plans (CFMPs) and Water Level Management Plans. CFMPs will allow discussions between flood managers and conservationist about broad options and actions which can help reconcile flood management and biodiversity objectives. This can help to identify whether integrated washland creation is practically feasible, to be followed by more detailed design if it is shown to be so.

4.1.1 Soil and water management in washlands

While the input and output of water from washlands may be subject to managed control, the fate of the water in the washland maybe subject to natural processes such as evaporation, infiltration and seepage which depend on the type of soil, climatic area and underlying geology. For this reason drainage is a key factor in classifying washlands in the typology and, for a given flood regime, a key determinant of habitat potential.

It can be shown that in the majority of cases, the surface flow of water off the washland is at least an order of magnitude faster than the subsurface flow of water that occurs within the soil due to drainage. In these circumstances the management of soil and water within the soil is relevant only at those times when there is little or no inundation.

Maintaining suitable conditions in the washland after surface inundation has been removed is likely to be an ecological goal and has been the subject of considerable research. Pezeshki (2001) discusses the responses of vegetation to flooding and Lessmann (1997), Gowing and Youngs (1997) and Gowing and others (1998) have shown how water table control affects vegetation community dynamics. In addition Wells and Sheail (1988) classified the change in agricultural practices that can bring about increased lowland grassland diversity, confirming the importance of water management in low lying lands where particular regimes may provide enhanced ecological interest. In Somerset, land is deliberately flooded in winter for just this purpose (ADAS 1996).

In order to manage water within the washland to meet environmental objectives various management options are available. These include direct soil management through tillage operations, re-profiling of the soil surface, field drainage and water table control. Of these, it is unlikely that tillage would be a viable option in most circumstances because the soil disturbance that might occur would be likely to adversely affect the target ecosystem.

Re-profiling of the soil surface involving the creation of scrapes and hollows may in some circumstances provide the topographic changes that are needed to ensure that during flood times, niche environments remain above water level. This might be particularly important for invertebrates for instance. Plant communities however will alter their composition in response to the water regime. Some control over the soil water regime is possible using water table control systems. In these situations, there may be ditches alone or combined ditch and subsurface pipe systems which allow the control of the water table.

Water-table management is the operation and management of a ground water table to maintain adequate soil moisture for optimum plant growth, to sustain or improve water quality, and to conserve water. Water table control systems may be categorized as shown in Figure 4.1. Here the water table is controlled, in most cases, by controlling the ditch water level, as demonstrated in the Beckingham Marshes case study (Appendix 4).

The following definitions, (North Carolina State University, unpublished data, Skaggs *pers. comm.*) have been used to distinguish between various possibilities for ditch water level management combined with water table control (Figure 4.1).

- **Surface drainage** - refers to the removal of water from a field by water movement across the soil surface to an open ditch or other drainage outlet (Figure 4.la).
- **Subsurface drainage** - refers to removal of water from a field by water movement within the soil profile (below the land surface) to underground drainage tubing or open ditches (Figure 4.lb).
- **Controlled drainage** - when a structure is placed in the ditch or tile outlet to manage the subsurface drainage outflow (Figure 4.1c).
- **Subirrigation** - when water is pumped into the ditch containing the control structure and moves into the field through the underground pipes or field ditches (Figure 4.1d).

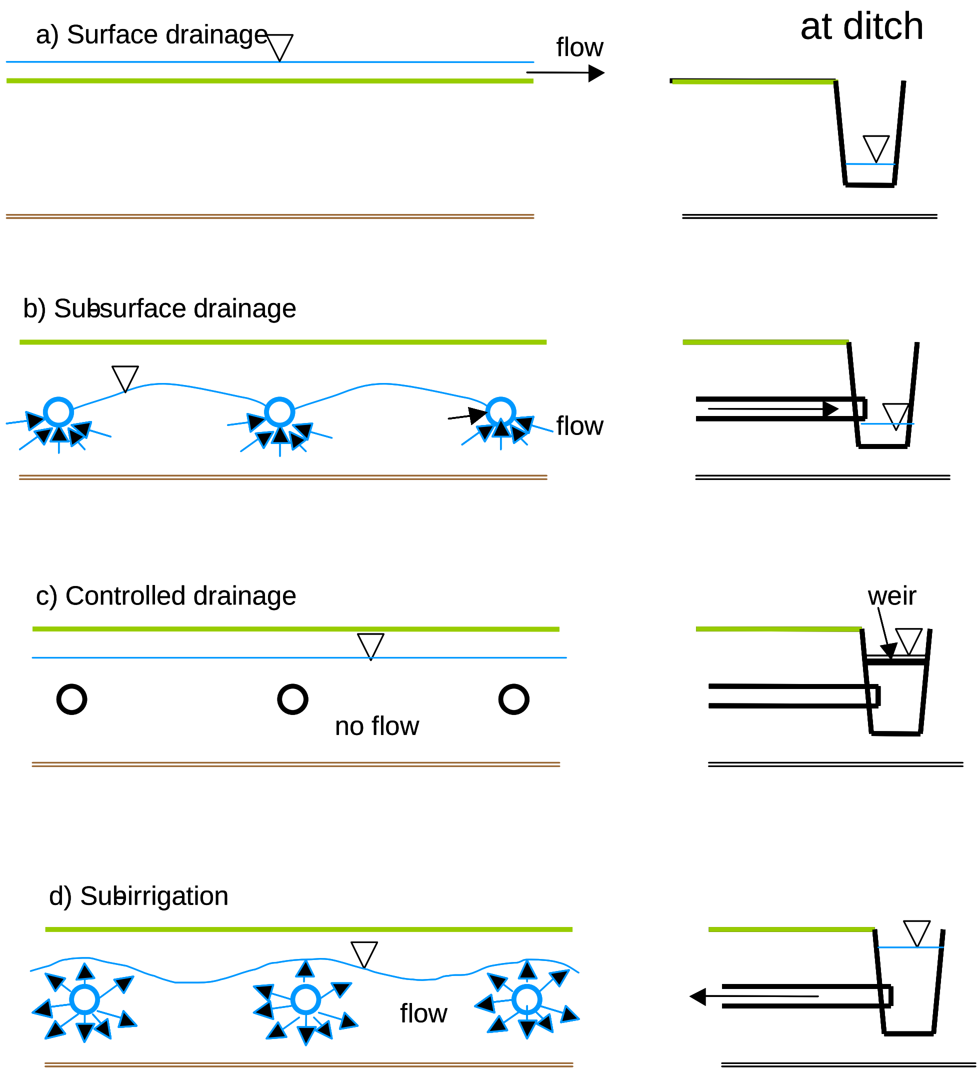

Figure 4.1 Water level control scenarios in washlands

The operation of the system in one or more of the modes, described in Figure 4.1, is such that the water table is controlled so that a suitable root zone environment exists during wet periods (drainage), raising levels during dry periods (subirrigation) and maintaining levels during transition (controlled drainage).

The control of the water regime in the washland requires that the inundation from flood water be removed. If removed by surface drainage, as shown in Figure 4.1a then the ditch network needs to be connected to the outfall system - which may be a gravity flow outlet, controlled by an outfall sluice or a pump. Such control may have implications for the storage capability of the washland during a flood because there will be no or reduced soil storage capacity for water. However, with the exception of very sandy soils, the volume of water that could be stored in soil, compared to surface stored water is relatively small. Typically, the additional storage available in a soil at field capacity, compared to the same soil when it is saturated, may be 15% of the soil depth - 500 mm of soil at field capacity could only store an additional

75 mm of water - so the loss of such storage due to the maintenance of high water tables is also small.

Water table control may be by ditches alone or by pipe systems as shown in Figure 4.1. The key parameters which determine the control position of the water table are the soil properties, in particular the hydraulic conductivity[3] and specific yield of the soil, the spacing of the ditches or pipes and the control level of the water in the ditch system. Closer spaced drains provide more control on the water table than wider spaced ones. Youngs and others (1989) have shown that the interaction of these parameters can be modelled to provide a risk assessment tool for washlands. In their work they showed that ditch water levels were usually the most critical factor in determining water regime in the peat soil washlands of Somerset. Such models can be used to evaluate the drainage and water level management plans for a washland area.

Thus the checklist of factors to be considered in a washland subjected to intermittent flooding when considering environment enhancement includes:

- The depth and duration of the water on the site. The longer the inundation period and the deeper the water, the more impact (possibly detrimental) there will the on vegetation
- The soil properties, particularly hydraulic properties of the soil. This is linked to the fluctuation rate of the water table. High permeability soil with low specific yields responds quickly to inputs and outputs of water.
- Ditch or pipe spacing. Closely spaced ditches give more rapid water table response in any given soil compared to widely spaced ones. Also the variation in water table height across the area will be less with closer spaced systems.
- Water level management in the ditches after inundation is removed. The water regime is dependent on the boundary flow conditions imposed by the water in the ditches. Management of this using small control structures (weirs and sluices) in the ditch system has a major impact on the soil water regime.

4.1.2 Surface water drainage management

The surface flow of water in washlands can be considered as a sheet flow phenomenon. The rate of water flowing off the surface is controlled by the hydraulic gradient at the water surface and the characteristics of the surface over which it flows.

With respect to the latter, vegetation cover is a key determinant of surface flow. The effect of different grass lengths on water flow was calculated using the Manning equation with the US Department of Agriculture's grass cover and average height values. It was found that dense tall vegetated sites retained water five times longer than short grass sites. This demonstrates that sward management is important in flood control. If water is required to be removed from the site rapidly it would be desirable to have short grass, if the water is to be retained then taller denser vegetation would be required, such as scrub, reedbed or swamp.

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[3] **Hydraulic conductivity:** the speed at which water percolates through the soil profile under unit hydraulic gradient. This is dependent on the soil pore space (Ashman & Puri 2002).

4.1.3 Modelling the hydraulics of washlands

There are a number of modelling methods currently available to support flood risk estimation and washland management. These can be considered under the headings of:

- Flood risk models
- Hydrodynamic models
- Soil water models

Flood risk models: In order to estimate the frequency and degree of inundation, it is necessary to estimate storm hydrographs for various return period events. In the UK, most the most commonly used approach is the Flood Estimation Handbook (FEH) Rainfall – Runoff Method (Houghton-Carr 1999). This is a unit-hydrograph model that has low data requirements and can be used for gauged or ungauged catchments in the UK using the datasets in the FEH CDROM.

Hydrodynamic models: Hydrodynamic models are used to estimate the impact of channel design on stage and the shape of the hydrograph. Given a storm (upstream) hydrograph, a suitable model should be able to:

- calculate the impacts of washlands on downstream hydrographs;
- calculate water levels within the washland.

The impact on downstream hydrographs can be determined from flood routing models however the estimation of water levels, requires more complex hydrodynamic models. There are three models in common use by engineers in the UK to model the dynamics of flooding.

ISIS – Wallingford Software Ltd and Halcrow Group Ltd. ISIS is a full hydrodynamic simulator for modelling flows and levels in open channels. It allows explicit simulation of floodplain conveyance and storage using full unsteady or steady state simulations. ISIS costs approximately £1,000.

Mike 11 – DHI software. Mike 11 is a dynamic, one-dimensional modelling tool for the detailed design, management and operation of river systems. The hydrodynamics module contains an implicit, finite difference computation of unsteady flows and can be applied to quasi two-dimensional flow simulation on floodplains. The complete non-linear equations of open channel flow (Saint-Venant) can be solved numerically at specified time intervals for given boundary conditions. The model allows the effect of embankments, storage reservoirs, channel improvements and pumps to be simulated.

HEC-RAS – US Army Corps of Engineers. HEC-RAS allows one-dimensional hydrodynamic steady and unsteady state simulations of water level. It also allows the modelling of floodplain storage through the use of side spill weirs and reservoirs. HEC-RAS has been tested on the River Severn and shown to give good predictions of inundated area (Horit & Bates 2002). HEC-RAS is free.

In general these models have been developed to simulate in-channel flow. As such, floodplain flow and storage have often been added on in a fairly simplistic manner, for example, by considering washlands as storage ponds, rather than an explicit simulation of washland hydraulics. There is a need for a greater understanding of the hydraulics of washlands to be able to model their impact on flood risk. Furthermore, washlands are dynamic such that the flood control impact of a washland may change over time.

Whilst modelling of a single, large washland may be feasible, the modelling of the impact of many small washlands is more complex. It is important that the hydraulic impact of washlands is modelled at the catchment scale.

Soil water models: From the point of view of habitat suitability, the soil water regime following an inundation event is as, if not more, important than the characteristics of the event. Soil water models can be used to simulate water table regimes in response to climate and inundation.

Water balance models: One-dimensional, mass balance models can be used to simulate how the water table rises and falls in response to climate. Models that include pipe or ditch drainage and surface inundation, such as the WaSim[4] model, have been used to simulate the soil water regime in floodplain and wetland habitats. WaSim is also able to simulate controlled drainage regimes.

Water table models: Water table models have been explicitly designed to simulate the movement of the water table in response to drainage design. For example, DRAINMOD[5] is a computer simulation model to simulate the hydrology of poorly drained, high water table soils on an hourly or daily basis. Although developed for agricultural situations, it has been used to analyze the hydrology of certain types of wetlands.

Groundwater models: Three-dimensional finite-difference ground-water models, such as MODFLOW[6] have been applied to wetland situations.

4.2 Washland management for flora

This section provides some tips on management of washlands to maximise their biodiversity potential. However, the information is found in more detail and of more practical use in other sources and it is beyond the scope of this report to try and duplicate those sources. For this reason, simple guidance is given, making reference to key sources of information in Table 4.1.

This section describes management regimes for vegetation on washlands. The decision trees in the Habitat Matrix (some examples in Appendix 1) would provide guidance on which management regime is required to produce specific habitats.

Annual grassland cut: The grass is cut with a tractor mower towards the end of the summer (Crofts & Jefferson 1999). This type of management prevents the establishment of woody vegetation and therefore maintains a herbaceous community. Its composition will depend on the water regime and the nutrient availability, but would vary from tall-oat grassland where dry, through fen, to reed swamp where wet. Cuttings should be removed from the site to limit the accumulation of nutrients within the system.

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[4] WaSim soil water balance model. Cranfield University. See http://www.silsoe.cranfield.ac.uk/iwe/wasim/

[5] DRAINMOD, North Carolina State University. See http://www.bae.ncsu.edu/bae/research/soil_water/www/watmngmnt/drainmod/

[6] MODFLOW, USGS. See http://water.usgs.gov/software/modflow-2000.html

Traditional meadow management: A cut in midsummer followed by grazing of the aftermath is the long-established management practice of floodplain grasslands. This management practice can result in very species-rich swards. A range of distinct grassland types will survive under this management, depending on other factors such as soil water regime and nutrient availability.

Pastoral management: Grazing throughout the year will limit the vegetation types to grassland and open vegetation communities. The intensity of grazing is important. High stocking with heavy beasts on wet soil will cause the sward to break up (poaching) and may encourage open vegetation types at the expense of grassland. Nevertheless a too relaxed grazing regime may result in grasslands giving way to swamp or scrub. The control and timing of grazing intensity is particularly important if the site is being managed for ground-nesting birds such as waders. Grazing pressures should ideally be reduced to a minimum during the main breeding season (April-June). However grass needs to be kept adequately short if species such as redshank and lapwing are to breed successfully. The species grazing the sward also have an effect on the vegetation type, eg cattle, sheep and horse grazing produce different species composition and vegetation structure. The type of livestock chosen needs to be able to cope with occasionally adverse conditions of wet and cold. A low intensity pastoral management plan is being developed at the Coombe Hill Nature Reserve. Gloucestershire Wildlife Trust, the landowner, is developing the plans to allow adequate grazing of the grassland habitat while limiting the disturbance to waterfowl.

Addition of fertilisers, limes and manures: Enhancement of the soil nutrient status is usually avoided in the context of biodiversity conservation. Nevertheless, for sustainable grassland management, these practices may be appropriate at a controlled intensity in order to maintain grass yields at a level sufficient to induce farmers to continue their management of the site. If the washland is regularly inundated by floods, the deposited sediment usually provides sufficient enhancement off nutrient availability for high productivity without artificial supplement.

Hedgerows: Best practice for hedgerow management would follow guidelines laid down in such texts as the BTCV's manual hedge management and maintenance (Brooks 1975) and in advice provided by organisations such as the Farming and Wildlife Advisory Group (FWAG). Three aspects which need emphasising are:

- Ditch management. Hedges often run along or occupy the sides of ditches such that decisions on hedge maintenance will consider the need to maintain the drainage performance of the ditch.
- Riparian trees. Trees in a hedgerow (or growing along a ditch not in a hedge) need careful management. As these trees grow, there is an increasing risk of their falling over and damaging the bank. This is incompatible with drainage requirements. On the other hand, it should be emphasised that fallen timber is an asset in terms of biodiversity.
- Pollarding. The proportion of willow in washland hedges is likely to be relatively high offering the opportunity for pollarding. The aim should be to have pollards of different ages.

Wet woodland: Wet woodland ranges in nature from natural woodland, ie carr, to plantations of species such as willow and poplar. Standard silvicultural practices apply as much to wet woodland as other woodland types. In biodiversity terms, woody vegetation requires management in order to optimise its biodiversity potential. This could include:

- keeping it open and patchy, thereby providing habitats for a range of bird and invertebrate species,
- coppicing to create a range of ages in the stands,
- pollarding to diversify niches, again aiming for a pollards of different ages,
- leaving fallen wood/dead wood,
- manipulating the composition/balance of tree species in order to meet specific biodiversity aims, eg invertebrates.

Left to its own devices, wet woodland will regenerate naturally becoming a significant habitat even without management. Washland creation gives the opportunity to allow this habitat type to increase through this process.

Factors to take into consideration include species composition of trees, age class composition, physical structure, distribution of trees, canopy, successional stage, understorey composition, edge structure and composition and the creation of additional niches.

Management can range from coppicing through to clear felling and replanting. Types of management which are particularly appropriate to wet woodlands include patch-cutting, use of woodland as a buffer zone, thinning, girdling, burning and non-collection of dead timber. Careful consideration needs to be given to the season in which management is undertaken and the type of harvest operation used. Operations should be carefully evaluated and planned including low impact access, manipulation of runoff/drainage and replanting.

Some wet woodland trees, eg alder and poplar, are particularly susceptible to attack from fungi.

No regular management: This scenario most commonly leads to the development of woodland and scrub. The exception is where flood duration is too prolonged to allow the establishment of woody vegetation in which circumstances a reed swamp or a truly aquatic community may develop.

Managing invasive species: Washland habitats are prone to invasion by both native species (eg birch) into wet grassland and alien species (eg Himalayan balsam) into wet woodland. Measures need to be taken to avoid such invasion occurring in the first place and to deal with invasions according well prescribed management techniques.

4.3 Washland management for fauna

Guidance for the manipulation of washland habitats for fauna already exists in key texts for the grassland and drainage channel components of the washlands. Several of these are quoted in the following text and in Table 4.1. Information on woodlands and optimising arable agriculture is not so readily available and research into these aspects is limited.

Grassland management: Benstead and others (1997) and Benstead and others (1999) deal with grassland management for bird and invertebrate communities. Both texts deliberate on the advantages and disadvantages of mowing and grazing regimes and describe both in some detail with references to more detailed studies.

Drainage channel management: Benstead and others (1997) include the management of drainage channels including maintenance, reprofiling, creation and bankside management. More detail is provided in Newbold and others (1989). The essential principles which should be adhered to are:

- A balance should be achieved between the different types of channel, main drains (usually the shortest in length and maintained by the Environment Agency), drains (often the responsibility of the Internal Drainage Board) and ditches which make up the bulk of the length (maintained by individual land owners).
- Within any one of these categories maintenance should seek to have channels at different stages of recovery from management, ie succession. This becomes more difficult/more expensive as the length of channel decreases.
- Channels permanently with water are considered to be of greater biodiversity value than those which dry out. Where the overall length permits, channels ranging from truly aquatic through amphibious to seasonally dry will add to the overall diversity.

Geomorphological features: Such features as oxbows, naturally occurring pools, and sediment deposition, eg bar and swales remnants need to be retained in the washland. This is primarily a process of protection, eg preventing oxbows from becoming eutrophicated or filled in, and avoiding the ploughing of other features in the floodplain. Allowing the river to behave naturally or recover such a situation will enable these features to be formed in the future enabling the dynamic nature of the system to be conserved. Such features contribute to the habitat/niche diversity across the washland. They span the gradient from wet to dry. For example, remnants bars have wet loving species at their base with species needing drier conditions on their tops. Nesting birds and invertebrates can also use this microrelief to good effect.

Other habitats and features: Best practice management is documented for other habitats within the washland, eg ponds, and droves and green lanes. Where such habitats do not already exist, there could be value in creating them, particularly if they existed in the washland in the past. For example, a pond could be dug where an oxbow had once been and the spoil used to recreate bar remnants. Whilst inevitably a poor replica, especially in terms of geomorphological integrity, such creation can contribute significantly to the biodiversity value of the washland.

Ecotones are not so well documented in terms of best practice, but valuable information can be found in guidelines for habitats, eg woodland management including managing woodland edges, and drainage channel management.

Different species and species groups have different requirements in terms of flood management regimes. These will be illustrated by reference to birds, invertebrates and flora.

4.4 Potential conflicts

Washland management for more than one function or interest feature may lead to conflict. Tensions may arise between two or more biodiversity interests or between biodiversity and flood defence interests. These will be dealt with in turn.

4.4.1 Potential conflicts between different biodiversity objectives

The three main aspects to consider in trying to resolve potential conflicts in drainage management relative to different biodiversity objectives, are the pattern and frequency of inundation, the depth of inundation, and the retention of appropriate water levels after flooding.

The season and duration of flooding of a washland are critical, dictating the make up of the flora and fauna. Birds are unable to feed and prepare for breeding if flooding is prolonged into the spring and waders are generally intolerant of summer flooding which disrupts breeding. Some invertebrates are similarly affected but are also intolerant of flooding beginning earlier than December. Prolonged flooding will kill and expel species. Vegetation too, will be damaged by long periods of flooding favouring those species which have a greater tolerance of such conditions. This reduces diversity including invertebrate diversity, eg butterflies which would have used species now drowned out. Long duration floods may provide visible birds and create the perception that this is best, however, prolonged surface flooding is not an essential or even desirable requirement of washlands for biodiversity.

The depth of flooding has also been identified as a significant factor. If flooding is relatively shallow and some vegetation remains exposed, then invertebrate survival is enhanced and damage to nesting birds in the case of summer flooding is reduced. Equally, a range of depths are required if the washland is to support dabbling and/or diving ducks, eg long necked species such as pintail can feed in water to a depth of 45 cm whereas teal prefer less than 25 cm. Diving ducks can feed down to more than 2 m. These conditions can be provided by the larger drainage channels under flooded conditions. Again maintaining some topographic variation within the washland can often be the best management tool for meeting a range of requirements.

Table 4.1 Water management regime requirements of birds, invertebrates and flora

Birds	**Flood management needs to take account of breeding, feeding and roosting requirements of the different groups and species of birds using washlands. (The information reviewed for birds is taken in the main from Benstead and others (1997).**
Wintering requirements of wildfowl:	Large areas of surface water with an average depth of <50 cm are required by most species (Thomas 1982). Suitable feeding conditions, lack of disturbance and suitable roost sites are broad requirements (Benstead and others 1997). Habitat variables including water depth linked to wildfowl species are summarised by Ward and others (1995). Flood management will influence vegetation composition and structure. Vegetation composition is important, for example availability of clover is desirable (Owen 1973) whereas coarse grass species such as *Phalaris arundinacea*, *Elymus repens* and *Deschampsia cespitosa* are almost completely ignored (Owen and Thomas 1979). Seed eating ducks such as teal and shoveler require, for example, patches of rushes, sedges or docks as seed sources (Burgess and others 1990). Vegetation structure is important, for example, most grazers prefer a short (5-15 cm) even sward (Benstead and others 1997), bean geese have been shown to have a preference for horse and/or cattle grazed pastures (Allport 1989). For dabbling ducks water depth preferences vary with the size of the bird, eg pintail 45 cm and teal <25 cm (Thomas 1982). Grasslands where flooding creates a succession of surface water areas ensure a steady supply of food throughout the winter (Benstead and others 1997). Diving ducks, for example tufted duck and pochard, require deep water (>2 m) with high densities of invertebrates (Benstead and others 1997).
Wintering wader requirements:	Soft damp soil (Benstead and others 1997) High soil water tables (Benstead and others 1997) Winter flooding to create islands of grassland and shallow open water suitable for roosting (Benstead and others 1997)
Breeding wader requirements:	Water table depth (Green and Robins 1993) and soil type (Benstead and others 1997) Amount of flooding/surface water in early spring, eg availability of shallow margins of temporary and permanent pools and associated invertebrate prey items (Benstead and others 1997) Vegetation structure and composition, eg sward height and structure with optimal conditions varying from one species to another.
Breeding wildfowl requirements:	All nest on the ground and typically close to water, hence the importance of drainage channels and associated marginal habitat Food availability is critical, eg high densities of aquatic invertebrates for diving ducks in breeding season (Benstead and others 1997) Specific conditions vary from one species to another, eg breeding garganey prefer tussocky pasture adjacent to shallow pools and appropriately managed drainage channel systems with rich marginal vegetation (Self and others 1994)

Table 4.1 continued

Invertebrates	Flood management needs to take account of the habitat requirements of the different stages of the life cycle of invertebrates groups and species using washlands. Aquatic invertebrates, eg chironomid flies, require permanent water for the duration of their egg, larval and pupal stages, being able to tolerate drying out post emergence. Other species require permanent water throughout the year, eg aquatic beetles with the water regime and associated aquatic vegetation dictating the communities of invertebrates occurring within. Water quality is also important and flood management can influence such aspects as nutrient concentration and salinity. Water of high nutrient status can be used to flood washlands and flood management can cut the washland off from saline water which is important for particular species which live in weakly saline waters, eg the crustaceans *Palaemonetes varians* and *Gammarus tigrinus*. To a large extent, terrestrial and semi-aquatic invertebrates require the reverse. Whilst part of the life cycle of some will be in waterlogged vegetation or soil, eg larval stages of some beetles, the adults are typically terrestrial. The presence of tussocks can be important as refuges for insects to climb up into as water levels rise.
Flora	The primary influence of flood management is on the water regime created for these different communities. For example, NVC community types such as tussocky wet meadows (MG9) are associated with impermeable soils and a high degree of wetness whereas floodplain meadows (MG4) are found on more permeable soils which generally have better drainage than those associated with MG9. Many of these requirements have been quantified by Defra-funded research (Gowing and others 1997, Gowing and others 2002) Most plant communities can tolerate periods of inundation, though the length and frequency of flooding will combine to dictate the plant community occurring in a given washland or part of a washland. Extent of flooding in the period November – February is often not critical. Floods in March and later need careful management. Grassland diversity often benefits from their rapid evacuation. In general, the diversity of grasslands and fens is best served by maintaining water levels within at least the top 0.5 m of the soil for as much of the growing period as possible. If a swamp vegetation is desired, then surface water should be retained well into summer. Flood management can have a significant influence on the quality of water used to flood a washland. In general, biodiversity benefits from reductions in nutrient availability (eg by harvesting and removal of biomass. Flood management can cut the washland off from saline waters which are important for particular species which live in weakly saline waters, eg *Ruppia maritime* and *Scirpus maritimus.*

The management of the water levels post-flooding is critical for the biota dependent on the grassland or within the woodland and in the aquatic habitats, eg oxbows, ponds and drainage channels. The needs of wading birds are various although overall they are reliant on a shallow water table. It should be noted that soil water tables are not necessarily at the same elevation as the water level in neighbouring water courses. The water-table positions across a site reflect a dynamic equilibrium between the vertical fluxes (rainfall and evapotranspiration) and the horizontal fluxes to and from the bounding water courses. Maintenance of shallow water tables through early summer is not only beneficial to the conservation interest if the plant community but they also influence the nature of the substrate, eg by softening the soil, they reduce its resistance to probing bills.

Where flood defence is a priority, it should not be expected that optimum conditions be achieved in all years. Indeed, they would not be met each year under natural conditions. However, designed habitats should achieve suitable conditions at a frequency of three to four out of five years.

4.4.2 Potential conflicts and operational challenges between flood defence and biodiversity objectives on washlands

There is a recognition that at one end of the drainage-land use spectrum drainage imperatives will have priority over and above biodiversity considerations, eg arable agriculture. In such a case water-table management is relatively precisely described and periods of inundation, when drainage channels are filled with water and water tables are high, can only to be tolerated for restricted periods of the year. At the other end, where the prime objective is wildlife and biodiversity, there is much more scope for hydrological conditions to favour the taxa that are being targeted.

Conflict can be acute especially in situations where different objectives are set within a given washland or hydrological unit within a washland, eg one landowner seeking to manage grazing marshland with the adjacent land owner managing an arable farm.

Conflicts typically revolve around the duration and depth of flooding, the duration and height of water tables and the operation of engineering structures from pumps to sluices. These conflicts can be mediated through forward planning either in a formal sense, eg Local Plans, Water Level Management Plans, and tier prescriptions in an Environmentally Sensitive Area, or informally by agreeing with farmers the criteria for sluice management and water levels in drainage channels.

In some cases the conflicts may be based on perceptions rather than grounded in reality, but much depends on local conditions and the expectations of stakeholders. As previously mentioned, the impact on flood management of retained high groundwater levels, or the retention of shallow water in engineered scrapes, might by small. Conflicts could be resolved by a better common understanding of what is required and what is possible.

4.5 Summary and preliminary conclusions

This chapter has reviewed management protocols for washlands with particular reference to flood defence, soil water control, habitat creation and habitat maintenance. The following conclusions can be reached.

- In support of the washland classification matrices proposed in Chapter 2 above, it is confirmed that existing and potential flora and fauna characteristics vary considerably according to flooding and soil wetness regimes. Fauna characteristics also depend on non hydraulic factors such as degree of connectivity with other sites and freedom from human disturbance.
- Consistent with the washland classification matrices, it is apparent that the management of wet conditions on the washland beyond the flooding period is a critical determinant of the type and quality of biodiversity that can be achieved. This may involve some degree of on-site water retention or storage, on the surface, in the soil profile, and /or within the drainage network of the washland.
- The main source of conflict between flood management and biodiversity objectives on washlands is likely to arise with respect to the duration and seasonality of flooding. Flood management generally requires the storage of flood water during the period of peak flows followed by evacuation of flood water as soon as possible in order to secure the storage facility for re-use. Biodiversity objectives, however, usually require some retention of flood water beyond the flood period. It may be appropriate to over-design flood storage capacity on washland schemes in order to exploit biodiversity without compromising the flood defence facility.
- It is important to define biodiversity objectives and related water regime requirements. There are potential conflicts of interest amongst different biodiversity objectives according to the need for, or sensitivity to, the timing and duration of periods of flooding and soil wetness. Some wetland habitats may be very sensitive to flooding in late spring and early summer, where as others may benefit from this.
- Washland biodiversity is also sensitive to the management of nutrient levels and sympathetic land management practices. Thus, opportunities to achieve synergy of flood defence and biodiversity also require attention to land use and farming practices within the washland, and indeed in the catchment as a whole, as these define the quality of flood water. In many respects, the dominant land use on the washland, namely arable, grassland, woodland, is a critical determinant of the potential for enhanced biodiversity. Of course, the pursuit of the integrated washland option may be associated with land use change, as in the case of agricultural set back schemes.
- Considerable guidance already exists on land, water and habitat management practices to support biodiversity. Selection of appropriate methods must be locally defined, depending on the objectives of the site management and site characteristics

5. Consultation with flood managers and conservation managers

This chapter reports on questionnaire surveys of flood managers and conservation managers which captured their views on the potential benefits and feasibility of an integrated approach to the creation and management of washlands. The findings of the surveys are discussed below.

5.1 Response of flood managers

A survey of flood managers was carried out by e-mail in order to obtain their perceptions of washlands, and to confirm the suitability of the Hydraulic Matrix as a means of classifying washlands. The questionnaires were developed and tested through consultation with senior Environment Agency Flood Managers. Questionnaires were sent to the 23 Environment Agency Area Flood Defence Managers. 11 completed responses were received incorporating responses from 6 of the Environment Agency's regions, namely: North West, Midlands, Anglian, Thames and Southern. This section analyses the perceptions given by the flood managers, most of whom were engineers.

The piloting of the questionnaire revealed that flood managers often used the term on-line and off-line to distinguish washlands in terms of the association between the channel and the floodplain. On-line implies that there is no barrier between channel and flood plain, whereas off-line implies that floodwater does not automatically drain directly back to the channel, but that it can be retained, behind a flood bank for example, and returned to the main channel when and if it is deemed suitable to do so. All off-line systems imply a degree of control, whereas on-line may or may not involve controls. A controlled on-line system may involve an adjustable weir crest for example. On-line washlands were perceived to involve mainly short duration flooding.

Table 5.1 shows that flood managers perceive that washlands can provide significant flood management benefits. There was little to choose between types, although the greater the degree of control, the greater the perceived benefits. Perceived benefits to the environment were highest for long duration off-line washlands, closely followed by uncontrolled on-line 'natural washlands'. These regimes are at the extremes of duration and control yet are perceived by flood managers to have the highest environmental benefit. Flood defence managers believe that washlands offer limited benefit to farming, but offer some potential for other benefits such as recreation, amenity and water resources, especially where flooding is controlled.

All respondents perceived the degree of hydraulic control to be extremely important for washlands to offer advantage for flood management. This justified a classification system for washlands based on hydraulic control as developed in the Hydraulic Matrix. The survey showed that the key attributes for flood management included ease of fill and emptying, storage capacity, engineering and infrastructural requirements and cost (Table 5.2). Acceptability to farming and to environmental interests were also deemed to be important factors affecting the feasibility of exploiting a washland facility.

Table 5.1 Benefits by washland type perceived by Flood Managers

Washland type	Benefit Types			
	Flood management 0=none, 5=high	**Environment** 0=none, 5=high	**Farming** 0=none, 5=high	**Other:** recreation, amenity, water resources 0=none, 5=high
A. On-line				
A1. Uncontrolled	4	4	2	0
A2. Controlled	5	2.5	1	3
B. Off-line controlled B1. Short duration flooding	5	3	2	2
B2. Medium duration flooding	4	2	0	2
B3. Long duration flooding	5	5	0	3

Note figures are the median values, n = 11

Table 5.2 Flood Managers' criteria for the suitability of washlands for flood management purposes

(0 = not important at all through to 5 = extremely important, response modes shown).

Degree of hydrological control	Ease of fill and emptying	Size (volume)	Engineering & infrastructural requirements	Costs	Acceptability to farming interests*	Acceptability to environmental interests*
5	4	3,5	4	3, 5+	3, 5+	3

*In terms of gaining agreements to flood for example, bimodal response

5.1.1 Conflicts

Flood managers were asked about their perception of conflicts between flood management and biodiversity on washlands. The main conflict was perceived to be that biodiversity requires standing water which reduces the amount of flood storage within the site. A flood manager stated:

> 'Flooding a site early in the winter for environmental reasons can reduce its capacity to accommodate the peak flow which can cause flooding.'

Of course, shallow flooding may not significantly reduce capacity, and it may be possible to 'engineer' scrapes to retain some water without reducing overall capacity. Further enquiry revealed limited evidence of engineering for water retention for biodiversity.

Flood managers often argued, in the context of flood risk, that human interests should take precedence over concerns of the natural environment. Consequently, it was thought that washlands (distinguished from wetlands) should be used predominately for flood management, only providing biodiversity enhancement where it is safe to do so. One respondent stated:

> 'Benefits of (a washland creation) scheme must be clearly demonstrable; there should not be funding (out of flood management budgets) for washlands without providing flood defence benefit.'

This suggests that the relative priority of objectives for a given washlands should be clear, along the lines of the classification by type of washland referred to in Chapter 3 above. It also implies that funding mechanisms are likely to reflect dominant priorities.

Retaining high water levels in ditch networks for biodiversity purposes was deemed by some to be incompatible with flood storage. Increasing ditch water levels was perceived to reduce storage capacity, thereby increasing the risk of flooding on adjacent agricultural or urban land. Views varied as to whether seasonally deep water stored on washlands for biodiversity enhancement was compatible with flood management, although it was recognised that this would reduce flood storage. Much seemed to depend on site circumstances, especially location in the catchment: retaining free flood storage capacity was particularly important up-stream.

The use of shallow surface splash water for enhancing habitat was perceived to neither conflict with nor enhance flood management, provided adequate storage potential was retained. However temporary deep flooding could prejudice habitat objectives, especially for breeding waders.

5.1.2 Compatibility

Flood managers were then asked to identify the scope for reconciling flood management and biodiversity interests. It was perceived that compatibility can only occur within a whole catchment approach, facilitated by Catchment Flood Management Plans. In most cases it was felt that compatibility on a site will occur only if the land owner/manager is ecologically aware and interested. A flood manager stated:

> 'CFMPs will identify potential sites where increased flood storage capacity, should be considered. Environmental bodies should participate in any follow-up studies to maximise environmental benefit.'

It is worth noting that CFMPs may not in fact do this, although they can and in many respects should provide an opportunity to exploit potential synergy.

It was suggested that the Environment Agency should seek ways to integrate Biodiversity Action Plans into new flood defence schemes. Flood Managers believed this was not occurring at present to the extent that it was possible. Flood Managers also felt that as washlands were for the most part created on farmland, agri-environment scheme agreements and other compensation mechanisms are needed to encourage compatibility between flood defence and biodiversity objectives.

When asked how conflicts between flood management and biodiversity interests could be resolved, two main solutions were mentioned. First, early stakeholder involvement in planning and creating washlands is required to promote a better understanding of the relationship between flood management and biodiversity, and the scope for compatibility. Second, improved communications and integration of action are needed within the

Environment Agency, especially between flood defence and conservation. A respondent suggested:

> ‘These issues could be resolved if the flood defence team worked more closely with other departments in the implementation of management strategies.’

To resolve the conflict of water level and flood storage capacity flood managers suggest that optimum water levels could be set during the early planning stages of new washland creation projects. This would help to reconcile flood defence and biodiversity needs.

5.1.3 Washland funding and engineering mechanisms

Flood managers believed that washlands could potentially deliver sustainable flood management solutions in the long term. Their responses were guarded as no long term monitoring has been carried out. The long term vision of many flood managers was to return the floodplain back to its natural state and functions. But it was felt that in the short term this would be difficult due to landowner opposition to a change in standards of flood protection.

The views of flood managers on the cost effectiveness of washlands were varied. Some flood managers considered that washlands could offer savings in capital and operating costs on flood defence budgets in the long term. However another perception was that cost of washland creation would be relatively high compared to the gain in flood defence. It was thought that washlands may not be as cost effective as other flood defence solutions because of the high cost of land acquisition, easements or compensatory payments. Guidance on this would help.

The suggested washland creation methods (Table 5.3) were perceived to have moderate value for overall flood management, with off-line farm reservoirs having the most benefit. Surprisingly the options were perceived to have a generally higher biodiversity value than flood defence, even though the response to overall benefit assessment (Table 5.1) suggested otherwise. It was perceived however that there is opportunity to develop washland options in future.

In terms of compensation mechanisms, land purchase by the Environment Agency was reported to be the most common method in England, followed by flood easements (Table 5.4). Land purchase, followed by flood easement was perceived to be most suitable for flood management purposes. This was apparent in the case studies (Appendix 4).

Preliminary discussions with senior flood managers had identified a number of factors likely to encourage washland creation as shown in Table 5.5. When these were put to area managers, the importance of these factors was confirmed. The availability of agri-environment schemes, a commitment to search for sustainable flood management solutions, a culture of catchment flood ‘management’ amongst engineers (rather than ‘flood defence’) and integration of funding mechanisms were particularly important. Interestingly, and surprisingly, reduced justification for continued protection of agricultural land had relatively moderate importance, although this was perceived to be happening at present.

It is apparent that, with the exception of the reducing importance of flood defence for agriculture and a gathering multi-agency approach to washland management, many of the factors perceived to be critical to positive washland development were not happening to any great extent at present. Respondents were optimistic however that these factors were more likely to be in place in future, especially those, such as the ‘culture of flood management and the search for sustainable flood management solutions, which fell within their responsibility. There may of course have been a strategic bias in this response. They predicted changing attitudes amongst farmers in favour of washland options. They did foresee greater opportunities to use agri-environment payments to fund washland creation, but were more cautious about the prospect of integrating agri-environment and flood defence budgets, even though they thought it important that this should happen.

Other important opinions included the perceived need for an integrated flood defence and biodiversity approach by the Environment Agency. It was felt that strong leadership is therefore required from Defra to help guide the Agency in pursuit of this.

5.2 Responses of conservation managers

A survey of conservation managers in the English Nature Flood Management Network, Wildlife Trusts and RSPB was carried out by e-mail in order to identify operational challenges of managing washlands for biodiversity, and perceived conflict between biodiversity management and flood defence. A total of 30 questionnaires were sent. 11 responses were received from across the regions.

5.2.1 Conflicts of interest

The most common conflict perceived by the conservation managers between biodiversity enhancement and flood defence involved the duration of flooding. An effective flood alleviation capability, they acknowledged, requires water to be removed from the site rapidly after the flood event. The majority of conservation managers perceived that they prefer water to stay on the washland for a longer duration than that that preferred by flood managers. The following comment illustrates this:

> ‘It would be beneficial to extend the length of winter flooding to support over wintering birds for longer periods and achieve a stable population rather than an opportunistic population. However flood managers want to remove water as quickly as possible.’

There was mixed opinion on the preferred period of inundation. Half of respondents suggested a period of between 3 days and 2 weeks and half suggested periods over 2 weeks, depending on habitats and associated biodiversity targets.

Short duration flooding not exceeding 3 days was perceived to be beneficial if the biodiversity target is to manage wet grassland, such as species-rich hay meadows. Longer periods would damage these habitats. Inundation periods of between three days and two weeks were perceived to provide some limited habitat for birds and will allow vegetation recovery. Flooding periods in excess of two weeks were perceived to be highly beneficial for wintering water birds as long as the surface water was shallow. However, this length of time was perceived by some to cause long term adverse changes to vegetation communities.

Thus there was evidence of conflicts between environmental objectives, for example between water regime management for birds and vegetation, with birds requiring longer periods of standing water. This confirms that it is essential for conservation targets to be identified in the early planning stage of washland creation and potential conflicts resolved at this early stage within and between flood management and conservation interests.

Conservation managers identified water depths in washlands as a source of potential conflict between flood defence and biodiversity enhancement. Deep flooding, sometimes preferred by flood managers, was associated with negative impacts on earthworm and invertebrate populations as well as vegetation communities. Shallow water levels were generally identified as most beneficial for wildlife.

Seasonality of flooding can also be a source of conflict, as much between conservation interests as between flood management and conservation. Early summer flooding is perceived to be detrimental for biodiversity, damaging grassland and flooding the nests of wading birds. But measures can be taken to mitigate potential risks, as one respondent stated:

> ‘Wading birds can withstand occasional summer flooding, particularly if the topography of the site is sufficiently varied so there are wet areas and dry areas.’

Other comments suggested that the Environment Agency and the Internal Drainage Boards (IBDs) were perceived to prefer otherwise dry washland sites to enable storage of large amounts of water. This hinders wetland creation in washlands because the water regime beyond the period of the flood event period is the most critical determinant of habitat quality

There was recognition of the need to resolve potential conflicts between flood defence managers and conservationists. One conservation officer responded that:

> ‘Flood managers and conservation organisations need to accept that flood storage will not maximise both interests and a compromise needs to be drawn up. Conservation objectives need to be developed to complement the flood defence requirement of the site.’

It was perceived that it was important to bring the various interested parties together. For example, there should be representatives of conservation organisations on IDBs to promote conservation practices in floodplains. Although IDBs in rural areas have traditionally provided drainage services for agriculture, it was thought that there is no reason why drainage services for integrated washlands should not be part of their brief.

Table 5.3 Perception of Flood Managers of the flood management and/or biodiversity benefits of washland-related actions

	Flood defence value: 0=none, 5=high		Biodiversity value 0=none, 5=high		Future opportunities for these in area: 0=none, 5=high	
	Median	Mode	Median	Mode	Median	Mode
Reduced maintenance of existing agricultural defences	2	0	4	4	3	3
Removal of agricultural defences (without risk to urban areas)	2	2	3	3	3	3
Set back and lowering of defence to agricultural land	2	2	3	3	3	3
Off line farm reservoir type schemes	3	3,4	3	3	3	3
Wetland creation in lowland flood plains	2	2	4	4,5	2	2

Table 5.4 Perception of Flood Managers of the use and suitability of washland funding methods

	Use of option in flood management area : yes /no/don't know			Perceived suitability for flood management 0=not at all, 5=high	
	Yes (%)	No (%)	Don't Know (%)	Median	Mode
Flooding easements: one off payment	36	27	36	3	2,5
Land Purchase by flood management agency:	42	33	25	4	4
Annual payments to land managers: as per agri-environ payments	27	46	27	2	2
Purchase and operation by conservation organisation	27	46	27	3	3
Purchase and operation by community trust	27	46	27	2	3

Table 5.5 Perceptions of Flood Managers of factors likely to encourage future washland development

	Importance 0=not at all, 5=high		Happening now		Likely to happen in future.		
			Yes (%)	No (%)	Yes (%)	No (%)	Don't know (%)
Reduced justification for continued flood protection of agricultural land	3	3	41	58	89	1	10
Changing attitudes and motivation of farmers	4	4	33	67	67	33	0
Availability of agri-environment scheme payments	5	5	20	80	86	14	0
Culture of catchment flood management amongst flood engineers (rather than Flood Defence)	4.5	5	8	92	100	0	0
Search for sustainable flood management solutions by responsible agencies	5	5	8	92	100	0	0
Integration of funding mechanisms (such as budgets for flood management and agri-environment schemes)	4	5	17	83	50	20	30
Integrated, cooperative approach by various organisations with interests in washland management	4	4	56	46	64	18	18

5.2.2 Compatibility

The responses of conservation managers confirmed that compatibility of flood defence and conservation depended upon the biodiversity targets for the site. As previously mentioned short duration flooding, which flood managers prefer, is compatible with the habitat needs of species-rich hay meadow communities, but may not be as beneficial to breeding waders.

Biodiversity and habitat quality in the washland critically depend on the management of water regimes outside of the flood event period as this determines the wetness of the soil profile, or the degree of shallow surface (splash) flooding. Compatibility of flood management and biodiversity can be achieved therefore were flood waters are retained long enough or deep enough to serve the interests of flood and conservation managers, and just as critically, the wetness of the soil profile is managed to maintain the desired habitat beyond the flood event period. This is illustrated by the statement from one conservation officer:

> ‘A wet washland with a controllable water level and managed to leave small wet areas in the bottom of hollows would support a more stable, if smallish, population of over wintering birds and provide ideal breeding conditions in the summer’,

and another

> ‘Flood management would be compatible for birds if the flood storage depth is of 0.15-1m and inundation occurred for a 7-10 day period.’

Opportunities to exploit these compatibilities further were however deemed few. Conservation managers confirmed the importance of Water Level Management Plans (WLMP) to provide guidance on resolving potential conflict in the case of designing new washlands and for enhancing existing ones. Of course, higher field water levels impede farming practices. It was important, conservation managers thought, that farmers were better informed about the potential benefits of washland creation for both flood management defence and biodiversity, that is that a washland option could make a difference. It was recognised however that it is unlikely that overcoming this perceived information deficit alone would encourage adoption of washland options by farmers, in the absence of financial inducement.

Nevertheless, it was thought that Defra, the Environment Agency and wildlife organisations need to collectively explain the case for washlands clearly to land owners and help construct a washland advisory package, with links into funding, which could support implementation of washland options.

With respect to compatibility, it was argued by some that, almost by definition, there was some scope for biodiversity on washlands, simply because these lands flood. However, concern was also expressed that ‘washlands may be created for flood defence purposes without environmental gain’. It was important therefore that ‘washland design needs to have conservation management built in from the start’. It was argued however that ‘washland sites need to be more extensive than the flooded area alone’ to allow for refuge sites and variations in wetness conditions which could encourage a mosaic of habitats, and links between washland and non-washland areas.

5.2.3 Washland creation and funding mechanisms

With respect to opportunities for biodiversity enhancement, conservation managers perceive that washlands provide the greatest biodiversity benefit where this involves the removal or set-back of agricultural flood defences or the creation of wetlands on lowland floodplains (Table 5.6). These two are of course not mutually exclusive. They also perceive that these interventions offer significant flood defence benefit. The general perception of conservation managers was that washlands would provide more benefit to biodiversity than flood defence. Indeed, this view was also held by flood managers.

Conservation managers reported that in their view, the main funding mechanisms presently used for washland creation are annual payments to farmers under agri-environment schemes, management agreement and the purchasing of land for washland creation (Table 5.7). The purchase of land by both conservation bodies and the EA was seen as the most suitable funding mechanism from a wildlife conservation interest, reflecting the degree of control available to the wildlife organisations in pursuit of biodiversity objectives. The responses to questions on the use of administrative and funding options showed that conservation managers were unsure about the use of easements and land purchase by the Environment Agency. This may not be surprising because the dominant purpose of these methods is for flood defence. But is does point to an information gap that could be a barrier to identifying and exploiting opportunities for integration.

Table 5.8 shows the views of conservation managers with respect to factors which encourage washland development in their areas. Responses confirmed that a broad mix of factors was important, and there was general convergence with the views expressed by flood defence managers on these aspects. Conservation managers reported that the factors such as availability of agri-environment payments and the search for sustainable flood management solutions were happening to degree. In their view, however, the need to integrate funding mechanisms, and changing attitudes of farmers an associated willingness to adopt lower levels of flood protection for agricultural land in some areas were not occurring as much as they should. They held the view that there was a good appreciation of the links between flooding, water regime and biodiversity relationships. Broadly, however, conservation managers were optimistic that the factors likely to favour washland development were likely to happen in future.

Many respondents stated that not only was it necessary to integrate biodiversity and flood defence objectives but also the funding mechanisms that support them. Many conservation managers felt that funding arrangements were insufficiently linked and in some cases acted against each other. It was felt that the Environment Agency and DEFRA need to develop prescriptions and payment rates to achieve joint objectives for the management of washlands . One correspondent stated that:

> ‘The Environment Agency and Defra need to combine funding streams to support biodiversity and the situation at present is ineffective’

Another said that:

> ‘Identifying a suitable vehicle for presentation to land owners is required. This could be an additional aspect of the Countryside Stewardship Scheme or

'floodplains' could be a new designated area like the Environmentally Sensitive Areas scheme'

It was felt by one respondent that payments to farmers 'to farm floods could be a cheaper option than continuing to put hard defences in towns'.

Another respondent said that to make an impact there was a need to acquire large blocks of land on which to create extensive washlands. This, it was thought, would require funding that went beyond that available from flood defence and agri-environment schemes. 'The greater costs associated with multi-functional washlands requires a partnership approach to funding', as one respondent put it.

However, echoing some of the concerns expressed by flood managers, it was felt that there was some institutional resistance to the washland option. One respondent held the view that:

'Defra will not fund schemes that are a bit different from normal'

Linked to this, there was a call for more guidance on how to identify and prepare a washland scheme, based on practical experience. One respondent said that

'More cases where the two objectives have been successfully integrated are needed to help encourage others'

Attention was drawn to the importance of washland identification as a critical point in the whole process of washland creation. One respondent thought that a catchment wide review of historic washlands, many of which had probably been 'reclaimed' for agriculture, was essential. Developing a positive attitude to washland recreation on the part of the owners of these historic sites was a fundamental step.

With respect to new washlands, the view was expressed that alternative land uses beyond grazing should be explored, especially as livestock were no longer a common feature of farming systems in some areas. Shallow lakes, reedbeds, and particularly wet woodland were considered to be options that should be given more attention. There was some concern that the recent move towards 'broad and shallow' agri-environment regimes might reduce funds available for 'narrow and deep' habitat specific support.

5.3 Summary and preliminary conclusions

This chapter has reviewed the perceptions of flood managers and conservation managers with respect to the potential synergy between flood defence and biodiversity objectives on washlands. The following conclusions can be drawn.

- Flood defence managers and conservation managers both agree that the duration of standing water is the main source of conflict between flood management and biodiversity. Flood managers perceive that standing water reduces the flood storage capacity of the washland, and they prefer water to be removed rapidly from the site. Many conservation managers perceive that water standing on the washland for at least two weeks can provide significant biodiversity benefit, especially associated with wildfowl and some vegetation types such as swamp or reedbeds. This points to the need to be explicit with respect to biodiversity objectives and their respective water regime requirements.

- There is consensus that biodiversity targets need to be agreed at the outset of washland creation in order to resolve potential conflict of interest. This would allow habitat enhancement to be integrated into the washland design. Designs could provide adequate flood storage capacity, allowing some surface water to be held on the site after the floodwaters recede,,retaining high ground water levels and thereby providing considerable scope for biodiversity. On a positive note, some species-rich grassland requires short duration flooding followed by rapid soil drainage which is fully compatible with flood defence preferences. This confirms that even within a predominantly flood defence framework there is scope for synergy.
- Flood defence managers and conservation managers agreed that flood defence should take precedence where there is serious risk to human welfare, such as during a major flood event. It was, however, perceived by many flood defence managers and conservation managers that washlands provide greater potential benefit for biodiversity than flood defence, although much depends on local circumstances. Flood defence managers perceived that off-line farm reservoir schemes offered greatest potential for flood defence. Conservation managers perceived wetland creation in lowland floodplains provided greatest environmental benefit as well as flood defence benefit. The responses pointed to some lack of understanding of the washland option, the potential benefits of washlands for flood management and biodiversity, and the scope for integration.
- Flood defence and conservation managers alike perceive that funding and institutional constraints act as barriers to integrated washland development They argued that funding for biodiversity enhancement was essential and felt that there were flaws in the current agreements. Some argued for changes to the primary agri-environment scheme, Countryside Stewardship, to provide greater incentive for farmers to develop washlands. Also both sets of respondents criticised the current Environment Agency and Defra funding streams, stating that there were no designated funds for biodiversity which, along with flood defence funds, would allow joint objectives to be met. They suggested that funding mechanisms for flood defence and biodiversity could be merged to good effect.
- Flood managers and conservation managers considered that the purchase of land in the washland area was the best mechanism to deliver washlands in that it provided the greatest degree of control of land and water management for their particular interests.

It is apparent that there is not an evenly distributed or common understanding of the concept, potential benefits and feasibility of integrated washlands amongst key players, especially flood defence managers, conservation managers and land managers. In this respect the scope for synergy of purpose may be under-identified. It is apparent that there is need to increase awareness of the washland option and guidance on how best to identify and promote integrated washlands where appropriate.

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Table 5.6 Perceptions of Conservation Managers of the management and/or biodiversity benefits of washland-related actions

	Perceived Biodiversity Value 0=none, 5=high		Perceived Flood Defence Value: 0=none, 5=high		Future opportunities for these in the area: 0=none, 5=high	
	Median	Mode	Median	Mode	Median	Mode
Reduced maintenance of existing agricultural defences	2	2	0	0	3	0,5
Removal of agricultural defences	4	4	3	3	2.5	0
Set back and lowering of defence to agricultural land	4	4	3.5	4	3	2,5
Off line farm reservoir type schemes	1.5	1	1	1	2	1,2
Wetland creation in lowland flood plains	5	5	4	5	4.5	5

Table 5.7 Perceptions of Conservation Managers of the use and suitability of washland funding methods

	Use of funding options in the area of responsibility:			Perceived suitability for wildlife conservation 0=not at all, 5=high	
	Yes (%)	No (%)	Don't know (%)	Median	Mode
Flooding easements: one off payment	14	14	71	2.5	3
Land purchase by flood management agency:	43	14	43	4	4,5
Annual payments to land managers eg agri-environment payments.	86	0	14	3	3,5
Purchase and operation by conservation organisation	86	14	0	5	5
Purchase and operation by community trust	43	57	0	3.5	3,4

Table 5.8 Perceptions of Conservation Managers of factors likely to encourage future washland development

	Importance 0=not at all, 5=high		Happening now 0=not at all, 5=high		Likely to happen in future. 0=not at all, 5=high	
			Median	Mode	Median	Mode
Reduced justification for continued flood protection of agricultural land	4	5	1	0, 2	3.5	1, 4
Changing attitudes and motivation of farmers	5	5	2	2	3.5	4
Availability of agri-environment scheme payments	5	5	3	3	4	4
Culture of catchment flood management amongst flood engineers (rather than Flood Defence)	4.5	4, 5	2	2	3	3
Search for sustainable flood management solutions by responsible agencies	4.5	5	3	3	3	3
Integration of funding mechanisms (such as budgets for flood management and agri-environment schemes)	5	5	0.5	0	3	3, 5
Integrated, cooperative approach by various organisations with interests in washland management	3.5	3, 5	2	2, 5	4	4
Better understanding of the links between flooding, water regime management and biodiversity by conservation organisations	3	5	3.5	3, 5	4	4

6. Administration, economics and funding

This chapter reviews the main administrative options for washlands, estimates of benefits and costs of washland management, and sources of funding that can be used to achieve integrated washland development.

Arrangements for the management, administration and funding of washlands are critical to the feasibility and eventual success of an integrated approach to washland development. This was clear from discussions with key informants, from the results of the survey of flood defence and conservation managers, from the analysis of the case studies and from the stakeholder workshop. The choice of arrangement largely depends on the dominant purposes to be achieved, whether flood management or bio-diversity, the degree of management control required, the willingness of land owners and occupiers to engage in a washland scheme, and linked to these aspects, the potential sources of funding. The analysis showed that these aspects vary considerably amongst schemes and within and between regions, and that local rather than generic solutions need to be found. These aspects are discussed in turn, exploring issues of ownership, management and funding.

6.1 Main options for washland administration

There appear to be three main types of management arrangements presently operating in washland schemes, with variation in detail. These are: land purchase from existing owners by an organisation promoting washland development, purchase of flood easements, and the use of management agreements, often associated with agri-environment schemes. Purchased land may be leased back to the original owners, assigned through a tenancy agreement, or transferred to another body, such as a conservation organisation or a community trust.

6.1.1 Land purchase and asset transfer of ownership

Under this arrangement the land is voluntarily sold by owners at prevailing market prices to a responsible organisation. The organisation involved may operate the site directly or may manage it indirectly on short term or seasonal tenancy agreements with farmers, possibly giving preference to previous owners/tenants.

The advantage of land purchase for washland development is that the new owner has greater freedom to manage the area. This approach was used on Beckingham Marshes to acquire a flood storage facility. Land was purchased from farmers by the Trent River Board as part of a flood storage scheme, with full agricultural tenancies subsequently offered to farmers. These tenancies are now being purchased from farmers (at a price of about £1750/ha) and converted into annual tenancies to support a wetland option in collaboration with RSPB. Where wetland creation is an important objective, conservation organisations have often purchased land to ensure full control, with short term tenancies to farmers under management agreements. This applies in the conservation area in the Coombe Hill site and has been widely used by RSPB in Somerset and elsewhere.

Land purchase also has the advantage of a one-off up-front capital payment, potentially eligibility for capital grants (as in the case of flood defence capital projects). Land purchase also avoids long term commitment on the revenue accounts of sponsoring agencies, and is therefore financially less risky. It removes the challenge of negotiating annual agreements, and variations in these in the light of changes in design or actual water regimes. Some of this complexity, however, transfers to the negotiation of tenancy rules and rental arrangements.

Land purchase, and related institutional management, has the potential disadvantage of weakening the links with the local farming community and the achievement of sustainable rural livelihoods. This can be avoided by award of tenancy agreements with local farmers, as for example at Beckingham and Harbertonford, and numerous other sites. It has however, proved a challenge to attract tenants where management agreements are particularly restrictive on land use, such as those required under raised water levels. Furthermore, in some areas, a shortage of cattle and graziers has left seasonal lets untaken.

Land for purchase is not always available, and this can be a problem. Purchasing land becomes administratively complex in areas characterised by fragmentation of holdings. It is easier if large blocks of land or whole farms can be purchased from a few individual owners. This may be feasible in some locations. Farmers may be inclined to sell land if they can replace it with other land elsewhere in the vicinity. A land bank could be used for this purpose, whereby sponsoring organisations buy land locally to achieve land or whole farm swaps. This model has been used to good effect in Denmark and the Netherlands, progressed on the understanding that compulsory purchase powers would be used by Local Government Authorities if necessary. There appears to be less support for compulsory purchase in England. It may be necessary in some instances to pay a premium above the market price for agricultural land to encourage transfer of ownership.

The sponsors of washland schemes often favour land purchase because it is perceived to be more easy to administer and control than other arrangements and therefore offers greatest scope for achievement of organisational objectives. For their part, some farmers see land sale as an opportunity to exit the industry, relocate or refocus.

6.1.2 Purchase of flood-storage easement

Easements involve up front payment, expressed as a percentage of prevailing market prices, to reflect loss of asset value (and related income loss into perpetuity) associated with specified increased flood risk. The arrangement is the subject of an easement agreement, specifying conditions. Owners retain rights which are not the subject of the easement and its effects. This model has been used over the last 20 years in flood alleviation schemes by responsible authorities. Easements were used in the case of the Leigh Barrier, where farmers were paid on a sliding scale according to the return period of the flood risk: about 80% of the market value of land for 2 year return period, about 60% for 10 years, 40% for 20, and about 10% for 100 years.

Easements are designed to accommodate changes in the risk of flooding borne by existing owners and occupiers. Owners (and occupiers through reduced rents) receive compensation for absorbing the risk of increased flooding. Occupiers can insure themselves against known risks if they wish.

As a funding mechanism for washlands, easements are designed to serve flood management objectives but are less effective for delivering environmental enhancement or livelihood objectives. Given that integrated washland will most likely involve frequent flooding, easements would approach the full market value of land, in which case outright purchase will be preferred.

Easements are attractive to flood defence organisations because they involve a one-off negotiated settlement, the cost of which can be charged to a capital scheme and which, in the case of flood defence, is potentially grant-aided from Government. In some cases, easements which serve the public interest can be compulsorily acquired by Government bodies. There are risks that the terms of the easement may restrict operational flexibility and be a source of contention if water regimes differ to those covered in the agreement. Indeed, the relative ease of negotiating easements with farmers to obtain permission to flood may discourage the pursuit of more complex but potentially beneficial options such as management agreements or land purchase. Persuading a large number of farmers in a washland area to simultaneously sign up to a washland stewardship scheme (see below) is a much greater challenge.

6.1.3 Annual payments

Under this arrangement, existing tenure arrangements continue. Farmers sign a management agreement for a specified minimum period with a responsible organisation which defines land management in accordance with the objectives of the sponsoring programme. Management agreements are commonly practised under the prescriptions for the Environmentally Sensitive Area Scheme (such as the Somerset Levels and Moors ESA and the Norfolk Broads ESA). They also feature as part of Countryside Stewardship Scheme and Local Authority (LA) Section 29 Schemes. See Appendix 5.

Payments may be negotiated on a site specific basis under Countryside Stewardship, or under management agreements with conservation organisations. These agreements focus on particular environmental objectives and are negotiated at rates which reflect individual farm circumstances.

Annual payments in return for management agreements under the ESA scheme are common place and well understood in many washland areas (Appendix 5). Eligibility within the ESA is automatic. ESA contracts have been widely adopted directly by farmers, and by institutional land owners (such as EN and RSPB) who use them as a basis for delivering their own environmental objectives, often through tenanted farmers. ESA annual payments for the conversion of arable to grassland are about £200/ha. Payments for the creation of wet grassland range from about £100 to £400/ha/yr, the latter where these involve raised water levels. These schemes are seen as major instruments of the Rural Development Regulation which seeks to strengthen the social and economic viability of rural communities through support for agri-environment and diversification initiatives.

The actual effectiveness of ESA arrangements in terms of environmental outcomes has been mixed (Lobley and Potter 1998), but they have undoubtedly injected extra income into the farming community. The main motivation for farmer adoption has been financial advantage rather than conservation benefit. The payment regime is a critical factor influencing participation and therefore effectiveness.

Countryside Stewardship, as a discretionary scheme, is more target driven and output focused (Morris and Young 1997). Stewardship includes components which are particularly relevant for washland development (Appendix 5). These include payments for arable conversion schemes (about £250/ha) and for maintenance of permanent grassland (£80/ha) with raised water level supplements (£60/ha). There are also payments for environmental features such as hedgerows, field margins and for public access. Stewardship has tended to attract conservation-minded farmers. It has been a driver for wetland and washland initiatives. This is apparent in the case of Long Eau, where the washland set-back scheme was identified following one farmer's wish to adopt the arable conversion option. The wetland sites on the Beckingham Marshes and Coombe Hill have been promoted under Stewardship, with the support of conservation organisations.

There is debate regarding the efficiency of annual payments from a public purse viewpoint. They are expensive, may pay farmers for doing what they would do anyway and can create dependency and vulnerability. Annual payments are set at levels which 'compensate' farmers for income foregone.. In this respect, their magnitude (like land prices) reflect the extent of subsidy to the farming sector, rather than any economic opportunity cost or the public good value of environmental enhancement. At a practical level, annual payments are at risk of policy change and funding availability, especially as they rely on revenue rather than capital funding. Farmers, perceiving a return to a previous and possibly irreversible wetland condition, will seek security of payments over the medium to long term, probably 20 years. Implementing organisations may also feel vulnerable in their dependency on Government funding.

Given the experience to date of annual payment schemes, a Washland type ESA or Stewardship scheme would be relatively easy to set up and administer, and could be an extension of existing arrangements. ESA or Stewardship type payments could be designed to accommodate different levels of flood risk, and specified environmental enhancement. At the time of writing, Defra are considering a 'High Level' agri-environment scheme for 'designed' washlands with payments for inundation grassland possibly offered over a 20 year period.

Annual payments have potential to meet the multiple objectives of washlands, and the institutional arrangements and experience are already in place. They offer some flexibility for the responsible management organisation to direct change in accordance with circumstances and priorities. Their greatest drawback is that they place a high ongoing burden and dependency on continued revenue funding. To be attractive to all parties, they need to be secure for the longer term.

Annual payments are not mutually exclusive to land purchase. The Environment Agency and conservation organisations such as RSPB have bought land and have subsequently used agri-environment receipts to fund conservation activities.

6.1.4 Other options: lease-back partnership

There are variants on the transfer of washland ownership and operation. This includes lease-back arrangements whereby land entitlement passes in the form of a lease from original land owners to a newly created project organisation or 'trust' for a specified period (20 to 30 years). As partners, farmers manage the land in accordance with programme objectives for which they receive annual payments. At the end of the lease term, the arrangement can be extended or terminated. In the latter case, land returns to the original owners. A joint management committee with representation by the major partners is formed to manage the initiative.

Such an arrangement has the advantage of focusing on the objectives of the washland scheme, establishing a management unit, and directly engaging land owners and occupiers in the process of delivery. The 'partnership' approach is consistent with the idea of sustainable and wise use of floodplains, and is likely to meet with approval from potential sponsors. It is likely to be more administratively and legally complex to establish, and there may be resistance from land owners to engage until the benefits are clear, especially as they, as contributors of the land assets, carry the greatest risk. They would, however, enjoy management participation and security of agreement. It is possible that a partnership approach would lend itself to a private-public partnership/private finance initiative. This leaseback option could suit situations where there is a clear community of interest (Ayling and others 2002).

The case studies draw attention to the diversity of land ownership and use arrangements. It may be that within and between flood storage areas, there is likely to be a mosaic of alternative land management arrangements suited to local circumstances and the purposes of washland creation and management.

6.2 Estimation of benefits and costs

Table 6.1 summarises the main types of benefits and costs of washlands, the exact nature and value of which vary according to circumstances. The diverse benefits of washlands were briefly reviewed in Section 2.2 above. The value and composition of benefits and costs of a given scheme tend to reflect not only scale but also the dominant purposes to be achieved, whether flood management or bio-diversity, or a mix of the two.

The definition and analysis of benefits and costs will also vary according to purpose, whether for benefit: cost appraisal or for estimating financing requirements. For example, annual payments to farmers are a financial cost for which funding is required, but they are transfer payments from Government and would not feature as a cost in an economic appraisal. Indeed, just the opposite, they can be used to reflect the value of the environmental benefits to society as shown by willingness to pay farmers for such public goods. This has been accepted in principle by Defra (MAFF 1999).

Table 6.1 Types of benefits and costs associated with washland development

Benefits
Off-site benefits relating to enhanced flood management facility
Increment in conservation and wetland benefits
Less: Reduced on-site benefits relating to change in flood risk where relevant
Capital costs
Acquisition of land or easements in washland
Engineering design and supervision: civil engineering structures, drainage networks, infrastructure, hydraulic controls, pumps, relocation of embankments, river reformation/restoration, land forming
Conservation: habitat creation materials and design, infrastructure and architecture
Less: Savings in replacement or rehabilitation of flood defence capital costs where relevant
Operating costs
Maintenance of flood defence and conservation assets
Annual payments to land owners/occupiers where relevant
Less: savings in operation and maintenance costs where relevant

6.2.1 Benefit estimation

It is difficult to generalise the contribution to flood defence standards of service without reference to specific site circumstances, but this can be expressed in terms of avoidance of flood damage elsewhere and savings in total defensive expenditure. Assessment of environmental benefits is theoretically possible but challenging in practice, and use of generalised estimates (eg per ha of wetland) derived elsewhere can be misleading (Turner and others 2000, de Groot and others 2002). Defra provides guidance on environment appraisal for food and coastal defence projects (MAFF 2000)

6.2.2 Cost estimation

Capital costs vary considerably according to scale and physical attributes of the washland, but broadly these tend to be higher, the greater is the degree of hydraulic control and related engineering costs. Acquisition of land or flooding rights is often a major capital expense for new washland development. Capital spending on conservation will reflect the degree of environmental change to be delivered, and the degree of engineering works required.

Annual costs include those for ongoing operations, maintenance and repairs for flood defence and bio-diversity, net of savings associated for example with reduced vegetation management or pumping.

There is limited information on the costs of washland creation and management, and there was limited scope to assemble this within the present enquiry. The major capital costs include acquisition of easement or land, engineering works, and design and supervision. Land costs have generally been at or above market rates for agricultural land, although often much higher where small areas have been purchased. Easements on frequently flooded washlands are likely to approach market rates. Engineering works vary considerably such that it is neither possible nor useful to produce standard estimates in the absence of information on site conditions, scale and design standards. The capital costs (2002 prices) to create the Long Eau setback scheme was about £75,000 for 15 ha (and 18,000m^3 storage, £4.2/m^3 storage), and about £2.5 M (including £54,000 for land purchase) for the 5 ha Harbertonford scheme (about 35,000m^3 storage). The Beckingham Marsh and Coombe Hill wetland initiatives have been carried out within, but to date largely independent of, existing washland flood storage facilities. At Beckingham, a visionary £4 M wetland development (including tenancy purchases) behind the flood embankments has been proposed. The Leigh Barrier, entirely justified against flood storage benefits, cost about £6 M (2002 prices) to provide about 6 M m^3 , about £1/m^3 storage.

Estimated capital cost (design and build) of washland online retention schemes in Somerset (Morris and others 2002) ranged between £2 and £5 per m^3 storage capacity depending on area and volume, equivalent to an average annual costs of about £0.16 and £0.34 per m^3 of storage capacity. Land purchase costs would increase these costs by a further 33% or so. Cost per m^3 actually stored per season will depend on throughput. A comparison of land management options showed that, in terms of annual equivalent costs of storage (£/m^3), management agreements were the most expensive, followed by land purchase and easements, but the differences were not substantial given the different purposes they serve.

Additional capital works carried out to deliver environmental enhancement relate to land forming, river and water course works and plantings. According to the Environment Agency, the additional cost of environmental enhancement on the Harbertonford Scheme was negligible once the washland option had been identified as the preferred project from a flood defence viewpoint. Material from washland scrapes for example was used to construct retention embankments, reducing the need for imported materials. On the Long Eau, a scheme to set-back embankments for environmental purposes, delivered benefits of flood storage at a capital cost of about £5,000 to the flood defence budget. It would be useful to assemble information on incremental costs and to relate these to the incremental environmental benefits obtained to inform future scheme design and justification.

There were limited available data on operation and maintenance costs of washlands, beyond the payment regimes paid to farmers under management agreements. There were some estimated savings of maintenance on flood defence infrastructure, such as bank maintenance, but these were generally off-set by additional operations and maintenance of soil water regimes and habitats.

6.3 Funding sources and mechanisms

There is a range of potential funding sources for integrated washland development, including agri-environment and rural development schemes, regional flood defence and IDB budgets, Local Government, regional Rural Development Programme funds, National and European Government environmental funding organisations, Voluntary Conservation Organisations, special project designated appeals and in some areas access to Landfill Tax credits for biodiversity.

Funding sources and arrangements reflect the relative importance of the various washland objectives, as well as the type of management arrangements. At present it appears that there is little coordination of funding streams such that opportunities for integration of flood management and bio-diversity are not fully exploited. Existing washlands have for the most part been managed for and funded by the flood defence function. Beckingham Marshes, Coombe Hill, and the Leigh Barrier are examples of this (Appendix 4). Where they have occurred, bio-diversity initiatives in these schemes have mainly been taken and funded independently, drawing on opportunities provided by agri-environment schemes or sponsorship by conservation organisations. As pointed out by conservation managers, however, the washland environment, albeit designed for flood defence, has provided a context for environmental enhancement that other wise might not arise.

In the case of the Long Eau (Appendix 4), about £70,000 (2002 prices) was found from the National Rivers Authority conservation funds to reset embankments that facilitated Stewardship membership for landowners. The cost to the flood defence budget was probably less than £5,000 (excluding design and supervision) and yet the benefits in terms of flood storage were substantial. This scheme was a good example of integrated management and funding, although its original driver was entirely conservation improvement. The experience has prompted the search for further opportunities for design breaching and/or set back in the same catchment, at relatively low cost (and possible savings) to the flood defence budget, to provide significant flood storage benefits, and environmental enhancement funded through Stewardship payments.

The Harbertonford scheme (Appendix 4) is an example of a modern integrated approach, justified in terms of flood defence. The washland creation option was preferred on benefit cost grounds to a conventional river widening and deepening defence scheme for Harbertonford. Incremental environmental costs were reported to be negligible.

In the case of the Leigh Barrier, as the Agency seek expansion of the flood storage area, agri-environment options could simultaneously deliver biodiversity benefits with possible savings to the flood defence budget. On this large flood management scheme, there is considerable potential to exploit biodiversity within and on the margins of the flood storage area. This may include actions in some areas to retain surface water and soil wetness beyond the flood periods under arrangements with land owners. It is possible that such ‘over-designing’ of flood storage could be achieved at relatively small additional capital costs, with operating costs for wetland habitat management drawn from other sources such as agri-environmental schemes.

In the case of the Long Eau and Coombe Hill, the take up of environment options by landowners has reduced the need for the previous agricultural defence scheme, reducing the burden on flood defence budgets. Here agri-environment funding provided the mechanism to achieve synergy between flood defence and environmental functions. This may be the case on the Beckingham Marshes in due course where the switch to wetland may reduce the need to replace the pumping station which was previously justified to provide rapid evaluation for agricultural purposes.

It is possible that redirection of expenditure from conventional, structural approaches to flood defence into washland creation can increase the overall efficiency of expenditure on the flood defence function whilst simultaneously providing an opportunity for biodiversity enhancement. Simultaneously, the washland approach to flood defence could increase the efficiency of environmental funds through the greater leverage afforded by the washland context.

At moment, it is apparent that although there is recognition of scope for synergy, decision making and funding for flood defence and environment remain functionally separate. Integration is *ad hoc* and coincidental, and in some cases dependent on individual managers. Without exception, flood defence managers and conservation managers recognise the need for a catchment based approach which would help identify opportunities for convergence of flood management and biodiversity interests. There is a requirement that public funds, for example for flood defence, should be committed for the purposes intended, but it does appear that by identifying washlands as a potentially viable flood defence option, there may be scope to provide greater efficiency not only of flood defence funds, but in the combined efficiency of funding for flood defence and environmental improvement.

6.4 Summary and preliminary conclusions

This chapter has reviewed the administrative, economic and funding aspects of integrated washlands. The following conclusions can be drawn.

- The administrative arrangements for the management of washlands are critical to the successful delivery of washland objectives. Where the washland option has involved a change in flooding regime with consequences for land managers, the main approaches, applied in practice, are land purchase by an organisation responsible for washland management, the purchase of flood easements, and the use of annual management agreements.

- The choice of most suitable administrative arrangement varies according to the dominant purpose of washland management, and the degree of control required by the responsible organisation.
- Land purchase and easements have been used for predominantly flood defence schemes. Land purchase and annual agri-environment payments, sometimes combined, have been used to achieve biodiversity objectives in washland areas. A mix of administrative arrangements may be appropriate.
- Integrated washland development mainly depends on the voluntary participation of land managers, whether this involves land sale or management agreements. Participation depends on the motivation of land managers and their response to incentives offered.
- Integrated washlands development involves bringing together a greater number of stakeholders and funding sources. This can make the process more complex than traditional flood defence solutions.
- It is possible that ‘over-designing’ of flood storage could be achieved at relatively small additional capital costs, with operating costs for wetland habitat management drawn from other sources such as agri-environment schemes, or designated biodiversity funds.
- There appear to be economies of scale in washland development, both with respect to the cost of providing storage, and the range of biodiversity benefits that can be achieved. This is not to underestimate the potentially significant value of small schemes when aggregated at the catchment scale.
- There is a lack of detailed information on the benefits and costs of washland creation. However, benefits and costs of washland development are very site specific such that generalised benefit and cost estimates are of limited value. Guidance and training on the practical application of methods for benefit:cost analysis of the washland option would however be useful.
- There appears to scope to redirect funds towards environmentally beneficial washland development, with potential efficiency gains to both flood defence and environmental budgets. This might include a Defra managed biodiversity budget which could contribute to washland creation. However, it probably remains the case that biodiversity gain could be achieved at little extra cost within existing flood defence expenditure.

7. Stakeholder workshop

This chapter reports on the findings of a one-day workshop held at Silsoe, 27 June 2003, and attended by 35 representatives of key stakeholder groups with an interest in integrated washland management.

7.1 Purpose and organisation of workshop

In collaboration with the project steering committee, invitations were sent to 40 representatives of organisations or named individuals with interests in the study topic. These included representatives from Defra, English Nature, the Environment Agency (flood defence and conservation functions), Non-governmental conservation organisations, the farming sector and from academic and research institutions. The aim of the workshop was to:

- report the findings of the study (essentially the output of Chapters 1 to 6 above) to key stakeholders
- confirm key issues arising from the study and draw out important conclusions
- formulate recommendations to support integrated washland development where appropriate.

Workshop papers were sent out before the meeting. 35 people attended the workshop, covering a range of responsibilities and interests. The workshop programme involved a presentation of the Phase 1 study outputs, followed by a plenary discussion in the morning session. After lunch, participants were allocated to break out groups which addressed selected issues. Allocation to a group was designed to give broad representation of stakeholder interests within each group. A plenary report back session concluded the day’s proceedings.

A report on the workshop was sent to participants within one week of the workshop with request for modifications or additions as deemed appropriate. Two replies were received which requested minor amendments relating to details on institutional and stakeholder issues. These amendments were made.

7.2 Workshop outcomes

7.2.1 Washland definition and classification system

There was general acceptance of the broad inclusive definition of washlands for the purposes intended here to include naturally as well as artificially flooded areas. The definition enables the inclusion of restored floodplains. Given this broad definition, the view was expressed that there may be more washlands than was originally thought, many of which are already providing significant biodiversity benefits.

It was generally thought that the classification system was useful at a broad scale helping to show the linkages between flood and wetness regimes and biodiversity potential, potential synergy between these, and ways that this might be achieved through intervention measures. However, it was pointed out that there is considerable variation at a local level, both within and between washlands, and that a flexible rather than a prescriptive approach is required.

It was agreed that the classification system and matrices can help to show where there is scope for synergy of flood defence and biodiversity. In most cases it appears there is scope for this, but much depends on local conditions and priorities.

A number of participants thought that the Habitat Matrix was insufficiently detailed. To be useful it needed to include broad BAP habitats or even NVC classes. This would allow the matrix to be applied in reverse: from specific habitat target to washland design. It was pointed out that the habitat opportunities and limitations are often very site specific and often independent of the flood regime.

There was also a need to show the links between hydraulic, ecological and agricultural management, and the farming practices that are possible or required. Whilst classification by benefit type is useful to reflect main objectives and related funding mechanisms, concern was expressed over a ‘site designation’ which might limit the scope for subsequent integration, when it might be possible, for example, to convert flood defence washlands into conservation washlands.

Although the case studies were useful, it was felt that they were not sufficient to capture the variation in circumstance and practices. It was argued that the case study examples should be extended, to provide a basis for experienced based learning, (although the number of actual cases of integrated washlands is relatively small at this point in time).

7.2.2 Opportunities for synergy

It was generally felt that in most cases there are opportunities for synergy between flood control and biodiversity benefits, even in a predominantly flood defence framework. The more frequent is the flooding, and the greater the chance for retaining wetness, the greater is the opportunity for synergy. However much depends on local conditions such that generalisation is difficult. Furthermore, this synergy tends to happen rather than occurring by design.

The importance of scale was emphasised: the larger the washland, the greater is the scope for synergy. An integrated approach also implies assessment of needs and opportunities at the catchment scale.

It was felt that opportunity for synergy must be built into original washland design, and where possible linked to specific habitat targets, especially if funding for biodiversity was to be obtained.

It was felt that with changes in agricultural policy and reduced justification for flood defence for agriculture, there were new opportunities for exploring the integrated washland option. This justifies the inclusion of setback schemes in the definition of washlands.

7.2.3 Policy issues

Participants emphasised the importance of policy drivers such as the Common Agricultural Policy, Habitats Directive, Biodiversity Action Plans, and the Water Framework Directive, as well as reorientation of flood defence priorities and the adoption of CFMPs.

Participants pointed to the apparent mismatch and in some cases conflict between some policy drivers, and this makes it difficult to pursue the integrated washland approach in practice.

It was pointed out that funding follows policy drivers. In this respect targets for BAP habitats and species are critical and will shape biodiversity opportunities for integrated washlands.

It was felt that there was not a need for a separate washland policy as such but rather an integration of policies within a catchment management plan. There was however a need for a policy commitment to an integrated approach, and this required funding mechanisms to support the biodiversity aspects of integrated washlands. Funding was identified as a key constraint on the development of joined-up approaches to integrated washland management.

7.2.4 Collaboration amongst stakeholders

It was thought that integrated washland development depends heavily on collaboration amongst stakeholders. The collaboration of NGOs is needed to support consultation with land managers, and help develop the personal relationships that are needed. It was reported that much depends on the actions of dedicated project managers. Collaboration takes time, and often there is pressure for quick solutions. Collaborative schemes, however, are potentially more sustainable.

The main constraint to successful collaboration was perceived to be lack of funding. For biodiversity led projects, it was argued that there is no access to Defra funds. Agri-environment incentives are helpful but not sufficient especially for large scale development of washland areas. Without funding, it was argued that land managers will not engage and washland development will be piecemeal.

It was thought that there is a clear need for guidance to support the identification, preparation and appraisal of the washland option, including the best way of engaging stakeholders in this process.

7.2.5 Funding

Two key points arose with respect to funding: the application of the appraisal system as it affects eligibility for funding and the availability of funds for integrated schemes.

On the first point, the view was expressed by some participants that the scoring method used to appraise flood defence schemes and optional designs should be revisited to ensure adequate treatment of the washland option. It was felt by some that the current prioritisation and appraisal methods undervalue the potential contribution of any biodiversity benefits that could arise from alternative flood management solutions, including those associated with the washland option. Counterbalancing this, it was argued that the appraisal methods and supporting guidance for flood defence schemes explicitly allow for the inclusion of biodiversity benefits and, if properly applied, can accommodate the washland option.

It was argued that flood defence cannot be expected to fund biodiversity and, for this and other reasons, there should be designated public funds provided by Defra for biodiversity. Some of these biodiversity funds could be allocated to washlands in accordance with priorities. Funds allocated to washlands will lever others funds, but it was felt the latter are not sufficient in themselves to make a difference. It was pointed out, however, that much could be done to enhance biodiversity at relatively little extra cost with existing flood defence budgets.

As previously mentioned, there was a call to rationalise policy and funding mechanisms with respect to washland development, for example amongst agricultural support, agri-environmental schemes, flood defence and biodiversity/habitat action plans, some of which can act against each other, especially at a local level.

It was felt that a catchment based approach to the identification and promotion of washland could help to line up and integrate funding sources for washland development.

There was a strong call for guidance on the application of Cost Benefit Analysis (CBA) for the appraisal of washland options. It is apparent that CBA may not be being applied sufficiently comprehensively or robustly, such that the washland option and its biodiversity components are being inadequately identified and valued. It was argued that the problem may be that existing guidance is not be being used: providing more guidance may not be the answer.

7.2.6 Knowledge-based approach and the need for guidance

There was a call for a science-based approach to integrated washland management, drawing on what was considered to be a considerable stock of knowledge about the hydrological regime requirements of many habitats and species, and about how to best to engineer rivers and drainage systems to achieve hydrological/hydraulic objectives. It was thought that the washland matrices give general guidance on this, but solutions are site specific.

There was a need for a greater understanding of the hydraulics of washlands to be able to model their impact on flood risk, especially as changes in hydraulic regimes may have an adverse affect on in-stream ecology and geomorphology. Furthermore, washlands are dynamic such that the flood control impact of a washland may change over time. It is essential to be able to integrate the impacts of many small washlands at the catchment scale.

It was noted that integrated, symbiotic solutions are usually more complex in terms of engineering, funding, and management. There are often institutional and/or communication difficulties which hamper linkages between these pools of knowledge.

The participants noted that flood defence ‘engineers’ and ‘conservationists’ have quite separate interests, knowledge and competency. There is a need to allow sharing of knowledge and understanding of purposes and approaches in order to identify potential for synergy and common action. There is a need for appropriate training on both sides.

Following the point raised earlier, the view was expressed by a number of participants that there is a gap in knowledge regarding the appropriate use of cost benefit analysis for washland appraisal. Guidance on how to approach CBA is needed by engineers and conservation managers alike. It appears that guidance that does exist is either not used, not understood, not easily accessible, or is perceived not to be what is needed. It is apparent that these issues need to be addressed.

7.3 Summary and preliminary conclusions

The main conclusions of the workshop were as follows:

- The workshop participants considered that the broad definition of washlands, the approach to washland classification and the methods developed to link flooding and wetness regimes and biodiversity were useful as a basis for identifying the scope for achieving the integration of flood defence and biodiversity.
- It was recognised however that more detail is needed to determine site specific opportunities and solutions. In particular there is a need to tie habitat specifications to BAP targets especially as these will determine access to funding.
- The choice of intervention methods very much depends on site conditions.
- The workshop confirmed the importance of policy, stakeholder collaboration, funding and experienced-based guidance as factors which strongly influence the development of integrated washlands. These factors are closely interrelated.
- Funding seems to be a key constraint on integrated washland, exacerbated in some cases by policy conflict at the local level.
- Engaging stakeholders is clearly a key to success, but this is difficult if funding cannot be secured.
- There is a considerable knowledge base as well as guidance on flood defence and biodiversity, but these appear to be fragmented and they are not perceived to be easily accessible by those who need information or assistance.

The workshop participants made recommendations on actions to address these issues in order to promote the integrated washland option where appropriate.

8. Conclusions and recommendations

The study has explored the extent to which flood management and biodiversity objectives can be met simultaneously in the washland environment. This chapter contains the main conclusions arising from the study, and makes recommendations for action accordingly.

8.1 Conclusions

Defining washlands

For the purpose of integrating flood defence and biodiversity objectives it is considered appropriate to adopt a broad, inclusive definition of washlands. This definition incorporates areas of floodplain that are allowed to flood or are deliberately flooded for management purposes, with potential to form a wetland habitat. This definition includes areas which provide natural as well as artificial storage. This is justified because in, the context England and Wales, virtually all river systems are managed in some way, and the retention or creation of natural storage is itself a management decision. This definition includes the setback of agricultural defences which restore natural floodplains and facilitate the recreation of a washland.

Classification framework for washland water regimes and habitats

The study constructed a framework which linked flooding and water management regimes with habitat potential. The framework shows how these regimes can be manipulated through the adoption of management interventions. The framework confirmed that flood duration, flood seasonality and wetness conditions in the washland are the key factors that determine the potential type and quality of washland habitat. The retention of surface and soil wetness beyond the flood event period is a particularly critical determinant of habitat quality. The study showed that habitat potential on washlands mainly depends on land and water management practices beyond the flooding period, especially the management of groundwater levels.

The importance of land use

In many respects, the scope for habitat improvement on the washland depends on the dominant land use, itself determined by flood and soil drainage conditions. Where the washland is under arable land (implying infrequent flooding and rapidly drained soils) the scope for habitat enhancement will be limited. Where washlands are under grassland or woodland (often implying more frequent flooding and wetter ground conditions), there is more scope for habitat improvement.

Given reductions in the profitability of arable farming due to changes in agricultural policy and reduced justification for flood defence for agriculture, there appears to be scope to promote land use change on washlands which can provide opportunity for wetland habitats. Such conversions are, and can be, promoted under agri-environmental schemes.

Scope for synergy between flood management and biodiversity

The main source of conflict between flood management and biodiversity objectives on washlands is likely to arise with respect to the duration and seasonality of flooding. Flood management generally requires the storage of flood water during the period of peak flows followed by evacuation of flood water as soon as possible in order to secure the storage facility for re-use. Biodiversity objectives, however, usually require some retention of water beyond the flood period. Opportunities for synergy rest on the ability to reconcile these interests by, for example, by over-designing flood storage capacity so that the wetness of the washland beyond the flood event period is retained without compromising flood storage capacity when it is needed.

In many respects, the potential to exploit biodiversity rests on the ability to separate out the management of flood events and non-flood water regimes. This could find acceptance amongst flood and conservation managers as a basis for exploiting synergy and reconciling perceived conflict of interest.

With respect to a key objective of this study, whether biodiversity objectives can be met within a predominantly flood defence framework, the answer appears to rest on whether the dominant land use requires flood and land drainage regimes which are not conducive to habitat creation. Where arable land is used to store infrequent flood waters, scope for habitat creation will be limited. There is much more scope for habitat improvement on extensively farmed areas such as grassland, and on woodland. On a positive note, some species-rich grassland requires short duration flooding followed by rapid soil drainage which is fully compatible with flood defence preferences. This confirms that even within a predominantly flood defence framework there is often scope for synergy, but much depends on dominant land use.

The study showed that it is possible to create a range of land uses and related habitat types in a given washland through intervention measures which modify flooding and soil drainage. The scope for habitat creation, and the suitability of engineering and management interventions, will however vary amongst sites. Large washlands in particular could support a diverse mosaic of habitat types involving a range of management interventions.

Evidence of integration

Although flood defence managers and conservation managers perceive potential synergy between flood management and biodiversity in washlands, the English case studies show that there has been limited achievement of this in practice. Older, established washlands appear to have been developed primarily for flood defence with little attention paid to biodiversity, although, in the light of reduced viability of conventional farming, biodiversity options have been taken up through agri-environment schemes independent of any changes in flood management. A review of European experience also confirmed few examples of integration of flood management of flood management and biodiversity, although there is growing interest in the topic.

Initial design

For new washland schemes, potential synergy is best exploited if it is included at the design stage. For example, species rich grassland and breeding waders require or can tolerate short duration flooding with rapid drainage, which is the regime best suited to flood storage. This can be engineered by creating a microtopography to give good drainage in general whilst maintaining wet features in scrapes and foot drains. In this respect, there is scope for compatibility of flood defence and biodiversity objectives. Biodiversity has been a more explicit aspect of scheme design for later schemes, and synergy has been achieved. The key to successful washland biodiversity is a site specific water level management plan targeted at specific outcomes, with appropriate interventions in place to deliver this.

Washland types

The study concludes that it is valid and useful to distinguish washlands by the dominant purposes to be served. These involve:

> *Flood Management Washlands* where flood management is the main concern and biodiversity is a secondary consideration,
>
> *Integrated Washlands* where flood management and biodiversity are given equal importance, and
>
> *Conservation Washlands* where biodiversity is the main concern and flood management is secondary.

Such a framework can help to define priorities for the management of a site, helping promote understanding and agreement about what a particular washland can reasonably be expected to deliver. The framework can also be used to help guide appropriate management arrangements, including the balance of funding from flood defence and other budgets. The washland case studies appear to validate this priority based classification.

Funding and administration

Funding is perceived to be a critical determinant of the feasibility of the washland option. During the questionnaire survey and stakeholder workshops, it was generally agreed that flood defence budgets cannot be expected to fund biodiversity per se. It was strongly argued however that designated funds for biodiversity channelled through Defra and the Environment Agency are required if the development of integrated washlands was going to happen to the scale possible or desirable. With respect to the types of washlands referred to above, designated biodiversity funds would be a key source for integrated washlands. Proposals for integrated washlands must focus on BAP targets, for it is these that will determine access to funds for biodiversity in future.

Administrative arrangements

The administrative arrangements for the management of washlands are critical to the successful delivery of washland objectives. Where the washland option has involved a change in flooding regime with consequences for land managers, the main approaches, applied in practice, have been land purchase by an organisation responsible for washland management, the purchase of flood easements, and the use of annual management agreements. The choice of most suitable administrative arrangement varies according to the dominant purpose and the degree of control required by the responsible organisation. Land purchase was perceived by flood and conservation managers to be the best arrangement for securing integrated washland development.

Stakeholder involvement

Multi-agency involvement, and early participation of other key stakeholders such as land managers and local communities, is deemed essential for successful integrated washland creation and management. Because the approach involves bringing together a greater number of stakeholders and funding sources, the process is more complex and can take longer than traditional flood defence solutions

Appraisal

Strong views were expressed by flood managers and conservation managers alike that the current priority scoring and benefit:cost appraisal methods used to judge the viability of schemes do not adequately recognise and value the environmental and other benefits associated with the washland option. This meant, in their view, that it is difficult to justify additional capital expenditure necessary to lever biodiversity gain on the back of a flood management scheme, even when it was felt this was desirable and offered good value for money. This may be due to a shortcoming in the policy and appraisal process, or it could be that existing guidance is misunderstood or not properly applied.

The study revealed a bias towards conventional solutions to flooding problems. The washland option is perceived (for the most part justified) to be a more complicated approach, even though there was wide appreciation that it has potential to provide a more sustainable outcome in the longer term. There was a call for guidance on the preparation and appraisal of washland development schemes, drawing on monitored pilot projects to help demonstrate good practice and help overcome some of the barriers to adoption.

Attitudes and understanding

Flood managers and conservation managers alike agreed that attitudes and motivation of land managers were critical to washland development and there was a need for increased awareness and understanding of washland options, including financial and environmental benefits, and the implications for practical land management and farming. Furthermore, amongst flood and conservation personnel (and also amongst wider stakeholder groups) it was felt important to encourage a culture of ‘flood management’ rather than ‘flood defence’, a commitment to search for ‘sustainable solutions’ to flood management problems, and an improved understanding between flood management and biodiversity functions. Views varied as to the extent this was happening now, but there was optimism for future beneficial change.

Barriers to adoption

There is a general feeling that a lack of awareness and understanding between the engineers and conservationists meant that opportunity for synergy is not identified or taken up. The perceived relative complexity of the washland option involving multiple objectives and stakeholders, and more complicated appraisal methodology and funding mechanisms presents particular challenges. There appears to be a need for guidance, experience-based learning and case study material to support washland development, targeting the needs of various stakeholder groups.

Catchment scale

It is perceived that the search for synergy must be considered at the catchment level, recognising that different sites will have potential to serve different needs. There is a strong call to integrate CFMPs and BAPs as a means of actively searching out opportunities for compatibility of flood management and biodiversity.

Policy review

Thus there is a general feeling that lack of integration of policy and related funding mechanisms currently acts as a barrier to integrated washland management. It was felt that the allocation of public funds into washland development could in some situations provide overall value for money in terms of expenditure flood defence, nature conservation, and support to farm incomes. Indeed, local initiatives that had used available funding with ingenuity showed the potential benefits of such an integrated approach, albeit generally on a small scale.

Overall, it is apparent from the various sources explored in this study, that in spite of the commonly held view that integrated washlands are feasible and desirable, they are unlikely to make a significant contribution to BAP targets without a major shift in policy, administration and funding regimes, except in a few places.

8.2 Recommendations

The following recommendations are made.

Enhancing awareness

Consideration should be given to developing a methodology which will provide a better understanding between engineers and conservationists of the extent to which flood defence and biodiversity objectives can be achieved through integrated washlands. This will refer specifically to the needs of the two functions, and how, for given washland circumstances, these can be reconciled for mutual benefit.

Policy guidance

Consideration should be given by Defra, English Nature and the Environment Agency to the production of a policy note on washland creation and management which states the purpose and potential benefits of an integrated approach to washland management and, in broad terms, how, under what circumstances and through what mechanisms this might be achieved in practice.

Guidance to support washland creation and management

In response to the very strong calls for guidance on the identification, appraisal and preparation of the integrated washland option, consideration should be given to undertaking a review of existing guidance to determine whether it is fit for purpose or accessible for those who need it. A review of the ways washlands are assessed as a potentially sustainable flood management solution is recommended. Furthermore, it is recommended that this guidance should be based on experience of cases, admittedly few at this stage, where integration has been achieved or is currently under way.

This also call for guidance on how engineers and conservationist can work together to find solutions that serve multiple purposes, rather than, as has been the case to date, having one or other added on as an afterthought. This requires guidance on:

- identifying the scope for and ways of achieving synergy;
- achieving open and transparent methods of working amongst engineers and conservationists;
- how to engage various stakeholder interests;
- how to prepare and appraise the washland case, including water management and habitat plans.

Such guidance will help to ensure that appropriate solutions can be found, adopted and implemented. This will help clarify, justify and gain acceptance of the balance of priority given to flood management and biodiversity on a given site or within a given catchment. Consideration should be given to formulating a training package to support the application of this guidance.

Funding for washlands

It was strongly felt that, in the absence of additional funds for biodiversity, the washland option will not take off. Consideration needs to be given to funding mechanisms for washlands, especially given the clear preference by engineers and conservationists for land purchase. Three types of washland schemes were identified in terms of the balance of priority, namely those which are predominantly for flood management, those where there is more or less equal balance between flood management and biodiversity, and those which are predominantly for biodiversity. It is recommended that funding sources are identified for each of these scenarios. Consideration should be given to establishing a biodiversity fund operated by the Environment Agency on behalf of Defra which could finance the biodiversity component of washland schemes. This would be a major source of funds for integrated washlands and possibly for some predominantly biodiversity washlands, although the latter would most likely continue to draw funds from other sources as they do now.

Development of Washland Management Plans

There is a need to develop Water Level Management Plans specifically for washlands which address the flood event and the management of water levels beyond the flood period. These water management plans will focus on intervention methods to retain surface, drainage network and/or soil water on site, including alternative sources of water, while at the same time securing the flood storage facility. Consideration could be given to the use of ecological storage, whereby retained waters are evacuated if a flood event is forecast.

It is recommended that the range and suitability of land and water management that could be used to create wetland habitats on existing washlands are reviewed. While it is recognised that practical recommendations must be site specific, this review, drawing on examples and existing knowledge, would help provide guidance on sources of information and the selection of appropriate management interventions.

Washland strategy

It is recommended that the Environment Agency seeks better ways of integrating Biodiversity Action Plan targets into flood defence schemes. River Basin or catchment specific biodiversity targets could assist in promoting such an integrated approach. Such targets would need to be developed in ways which combine local stakeholder knowledge and interests with high level biodiversity objectives in order to ensure they are realistic and have the necessary support. They could also help both identify priorities and resolve potential conflicts between competing biodiversity interests. The more general the biodiversity targets, such as increasing the area of wet grassland, the easier they will be to deliver. The study has shown that washlands could be one way of helping to achieve such biodiversity targets and it is suggested that as an initial step, Catchment Flood Management Plans should be used to identify potential storage areas within a catchment. It is strongly recommended that a review of washland potential in the context of BAP and CFMP is undertaken for selected pilot catchments, with a view to informing a washland strategy.

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Appendix 1
Illustrative Examples of Management Options for Habitat Creation

This appendix provides five examples of the decisions trees associated with the Habitat Matrix (Table 2.2). Each cell in that matrix needs a specific decision tree to support it. Only a selection of cells and supporting decision tress are presented here by way of illustration. A comprehensive development of the matrix was beyond the scope of the current study. Once the cell representing the habitat of the washland has been located in the matrix then a decision tree decision tree is used to classify the site further, linking land management regimes with the main washland habitats that are feasible for the prevailing hydrology. The habitat is labelled with reference to the NVC classification, which is widely adopted by government agencies in the UK.

The NVC codes used in the decision trees are briefly outlined in the following section and are summarised in Table A1.1.

Broad washland habitat types.
There are four broad habitat types associated with lowland washland sites, recognised by the National Vegetation Classification (J.S. Rodwell *et seq.*1991). These are:

Mesotrophic grasslands (MG):
Within this category are a number of general types, which are summarised below:

Alluvial meadows:
These grasslands occur on the floodplains of large lowland rivers. Soils are typically deep and well structured and the vegetation is supplied with nutrients from flood-deposited silt. The communities are primarily differentiated by their hydrological tolerances. (MG4, MG7C, MG8)

Poorly-drained permanent pastures:
Characteristic of clay or peaty soils with impermeable subsoil. The high moisture level leads to some ground-water gleying. The general floristic feature is the presence of plants tolerant of limited soil aeration. (MG9, MG10)

Inundation grasslands:
These assemblages are characteristic of fine-textured mesotrophic soils alongside fluctuating sluggish or standing water. They are periodically inundated by water. A characteristic feature of the component species is their capacity for rapid vegetative spread and/or prolific seed production. (MG11, MG13)

Drier grasslands:
These communities, whilst sometimes tolerant of occasional winter inundation, are usually found on soils that dry out in summer and are not characteristic of wetland systems. (MG1, MG5, MG6))

Swamps (S):
These communities are characterised as generally species-poor vegetation types, usually dominated by a single tall emergent species. They occur on both the margins of standing water in natural lakes and pools and artificial water bodies, and also alongside moving waters in wetter parts of the floodplain. Both organic and mineral soils are colonised and waters can range from oligotrophic to highly eutrophic. Variation in communities occurs primarily because of the ecology of the dominant species, but also due to natural gradients such as water level, water inundation frequency and duration and trophic levels.

Open vegetation (OV):
The relevant vegetation types within this category are the **inundation communities**: OV28-OV33. Usually these are found in the presence of fine textured substrates like silts or clays, in situations where flooding by fresh waters often destroys any existing vegetation by submergence or shifting of sediment and creates a new open and moist habitat available for colonisation. Such habitats can be found along the margins of fluctuating ponds, reservoir draw-down zones, river islands and banks. The vegetation tends to be characterised by short-lived plants with prolific seed production or sprawling species associated with inundation grassland. The habitat type includes substantial areas of bare ground.

Wet woodlands (W):
These are woodlands or scrub that are periodically inundated by freshwater from fluctuating water bodies. Floristic variations between communities can be understood in terms of interactions between soil moisture, the degree of base-richness of the soils and waters and the trophic state of the system. Normally dominated by species of alder, birch or willow.

Table A1.1 Brief description of NVC classes referred to in the decision trees, for further information refer to the "British Plant Communities" series edited by J.S. Rodwell.

NVC class	Description	Habitat type (as used in Table 2.2)
Grassland		
MG1	Ungrazed grassland	Hay meadow
MG4	Alluvial hay meadow	Hay meadow
MG5	Old hay meadow	Hay meadow
MG6	Semi-improved pasture	Pasture
MG7C	Floodplain meadow	Floodplain meadow
MG8	Water meadow	Water meadow
MG9	Tussocky grassland	Pasture
MG10	Damp rush-pasture	Rush pasture
MG11	Grazing marsh	Inundation pasture
MG13	Inundation grassland	Inundation pasture
Open vegetation		
OV28	Sprawling vegetation on bare mud	Inundation pasture
0V30	Ephemerals of eutrophic water margins	Inundation pasture
0V32	Vegetation of disturbed wet ground	Inundation pasture
Swamp		
S4	Reedbed	Reedbed
S5	Reed sweet-grass *(Glyceria maxima*) swamp	Swamp
S6	Greater pond sedge *(Carex riparia*) swamp	Swamp
S7	Lesser pond sedge (*Carex acutiformis) swamp*	Swamp
S19	Common spike rush (*Eleocharis palustris*) swamp	Swamp
S22	Flote-grass (*Glyceria fluitans*) water-margin vegetation	Inundation pasture
S26	Species-poor tall fen herb	Swamp
S28	Reed canary-grass *(Phalaris arundinacea*) tall herb fen	Swamp
Woodland		
W1	Willow-dominated carr	Willow carr
W6	Alder woodland	Alder woodland

Figure A1.1 Decision tree for Type 1 (Short duration surface, flooding in winter only, rapid soil drainage)

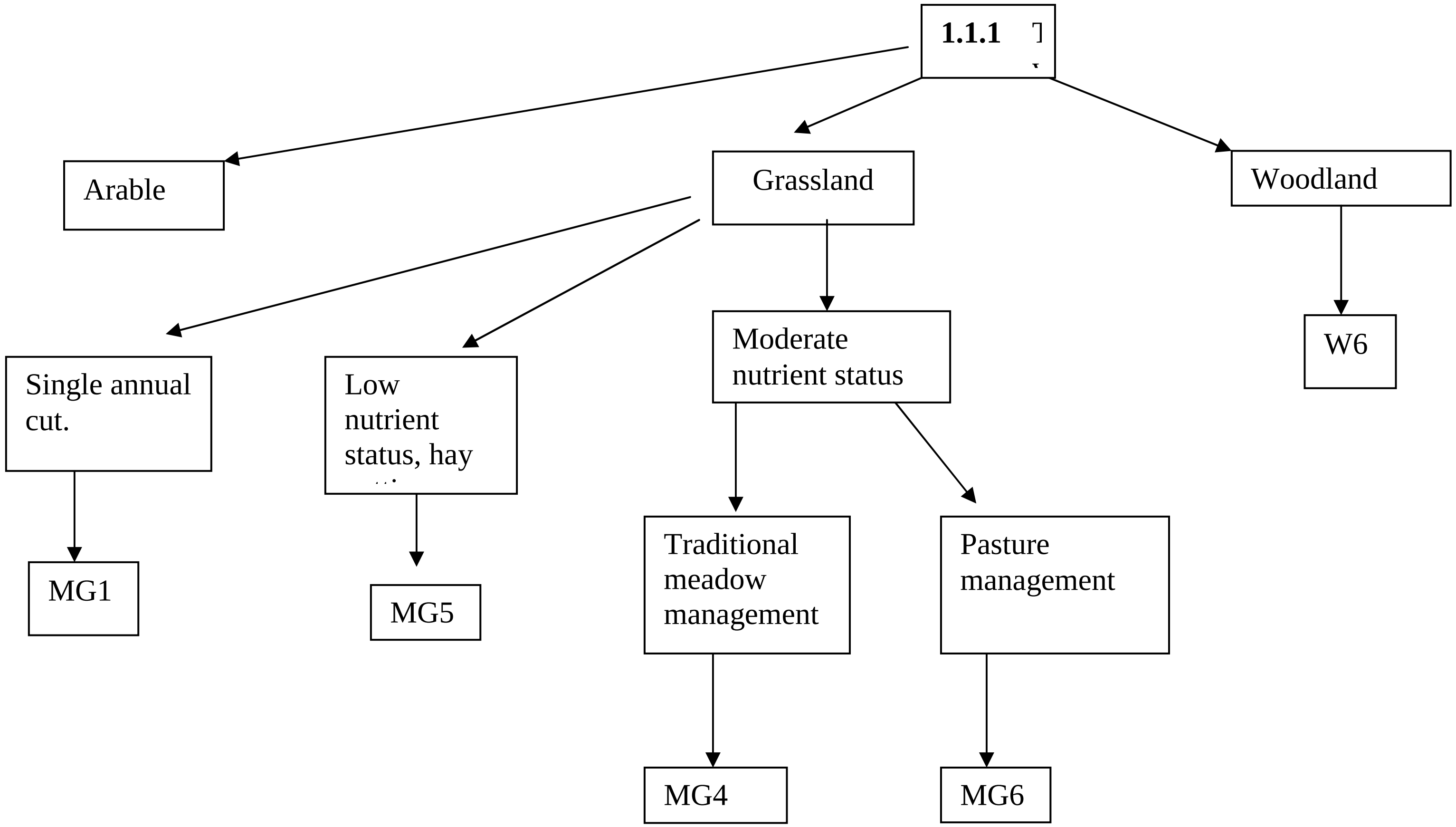


Figure A1.2 Decision tree for Type 6 (Short duration surface water, floods all seasons, slow soil drainage)

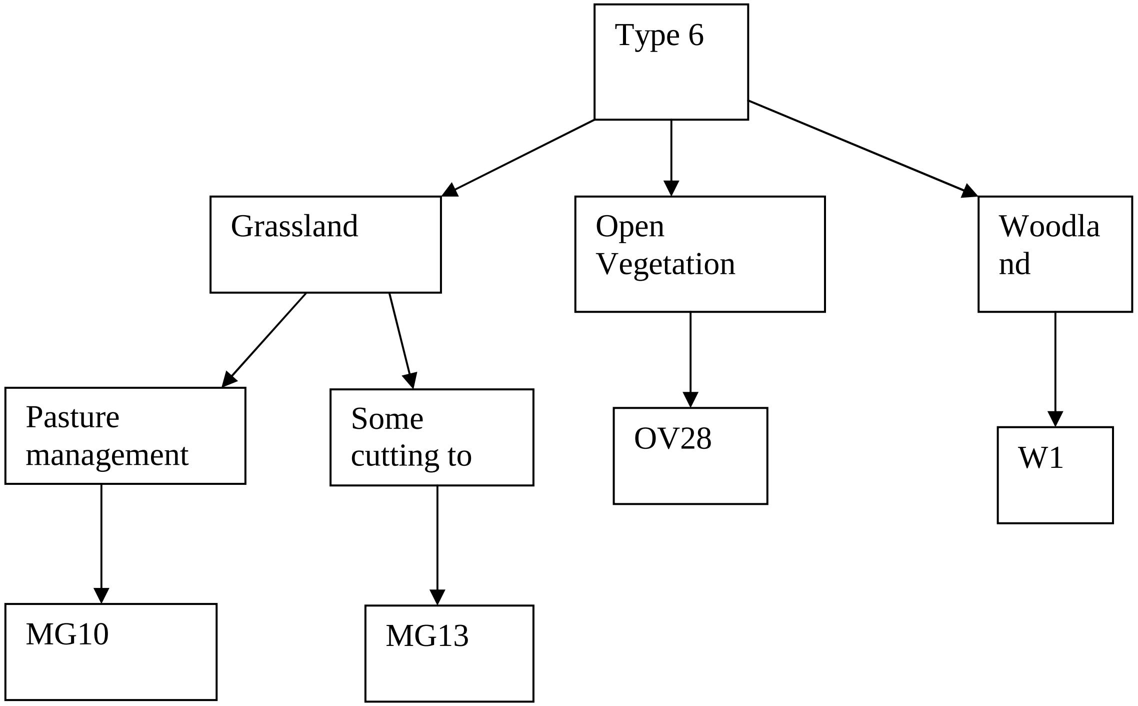


Figure A1.3 Decision tree for Type 12 (Medium duration surface water, floods all seasons, slow soil drainage)

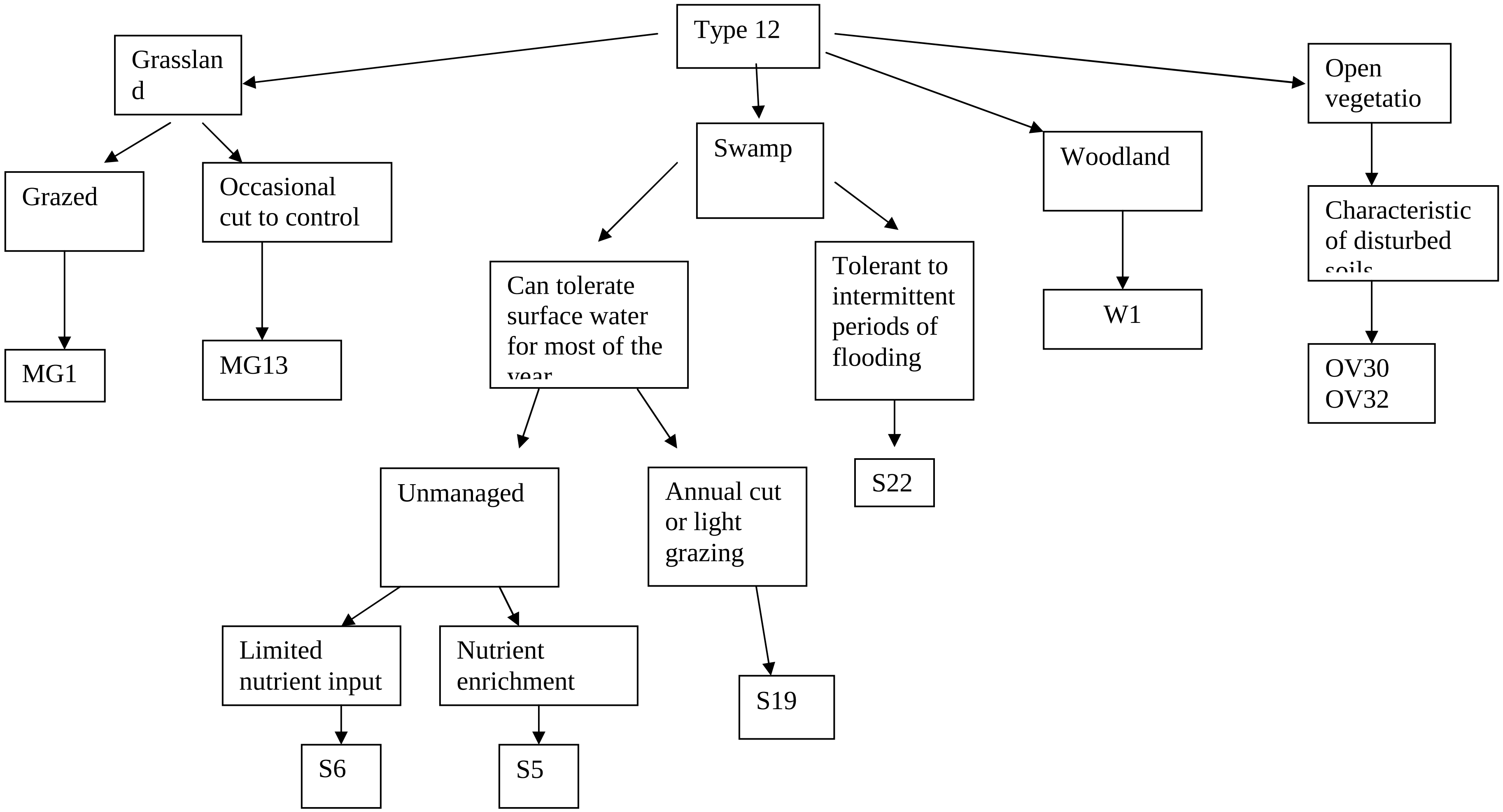


Figure A1.4 Decision tree for Type 18 (Long duration surface water, floods in all seasons, slow soil drainage)

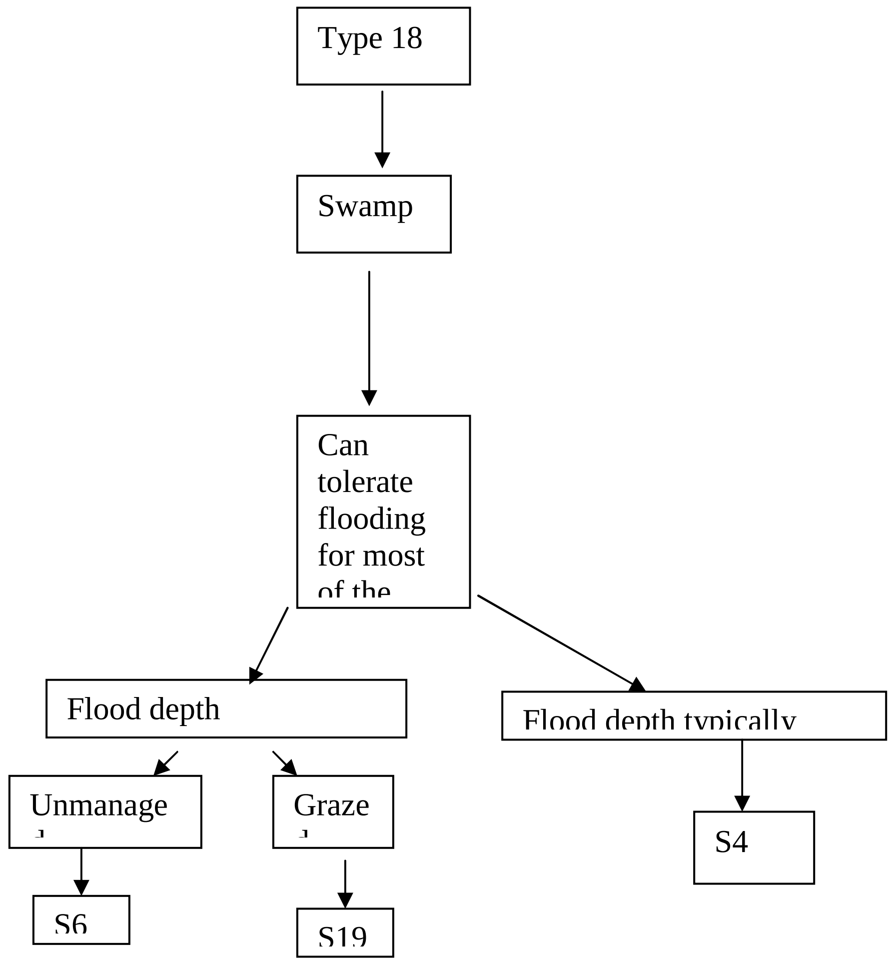
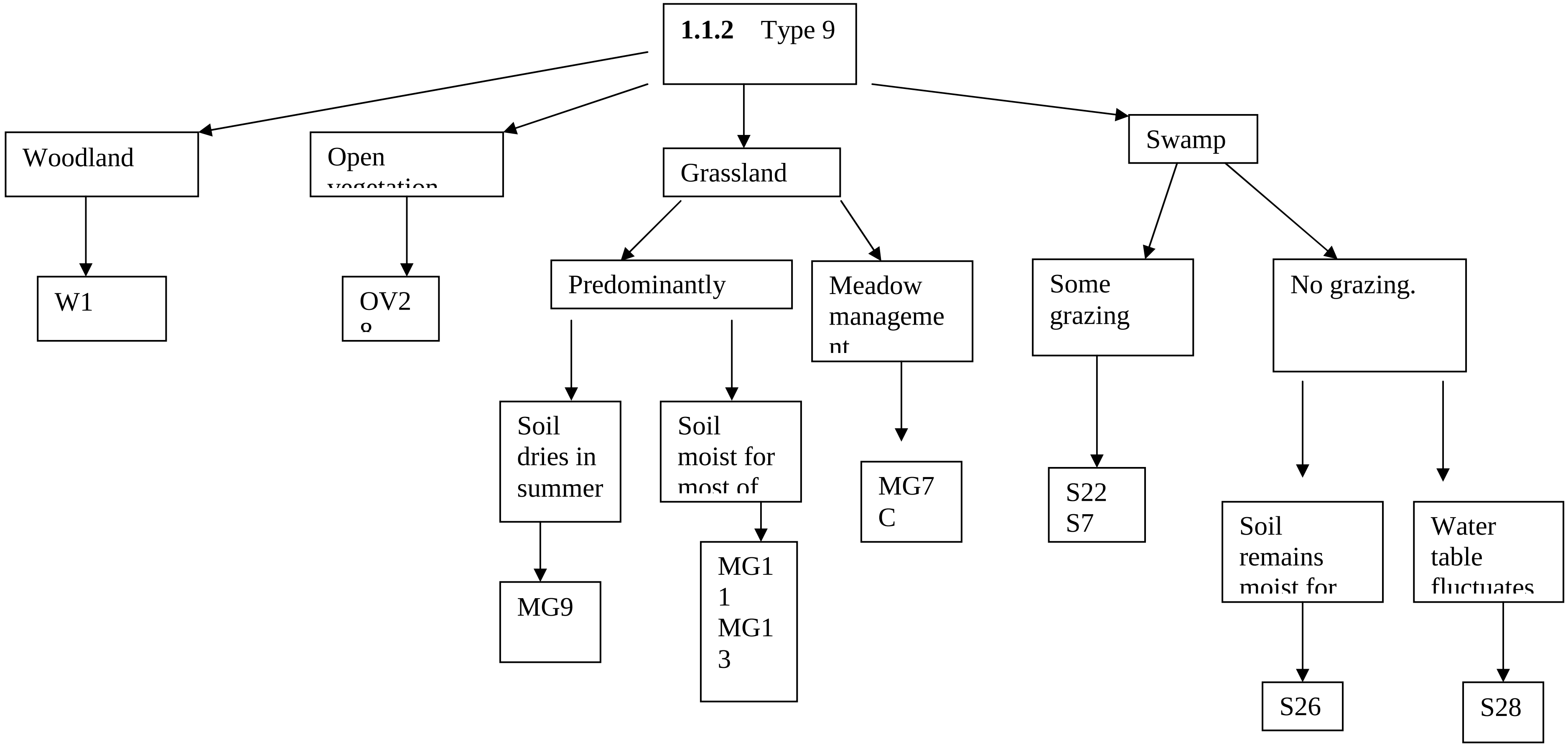


Figure A1.5 Decision tree for Type 9 (Medium duration surface water, winter floods, and slow soil drainage)



Appendix 2
Explanation of factors influencing faunal diversity on washlands

There are a range of factors which describe the conditions of any given washland in relation to the fauna and community dynamics. These are described and explained to provide an overall synthesis.

A.2.1 Area
The extent of a washland is a critical characteristic, typically encompassing a number of the factors described below (diversity of habitats, moisture gradients, home range and carrying capacity). Theoretically the more extensive the washland area the greater opportunity there is for diversity in the broadest sense of the term. In reality, this is not necessarily so. The larger an area of washland, the more attractive it is likely to be for agricultural purposes and the returns for improving the land in terms of agricultural productivity are likely to be greater than for a smaller area. The concept of area also applies to individual habitats, ecological theory dictating that the larger the area the greater the number of species. Reality is not necessarily so clear cut. Nevertheless, the principle needs to be recognised in assessing condition. For example, the greater the length of drainage ditches, the greater the number of invertebrate taxa. This is however in large measure due to ditches being in different stages of succession post management, itself being more likely as the length of channel in creases.

A.2.2 Isolation
Given that washlands are becoming more and more isolated in the landscape, the distance between washlands and other associated habitat is increasing with consequent impacts on movement between sites and a reduction in rates of colonisation. Distance is a complex variable in the context of washlands. For some elements of the fauna, the distance to the next upstream washland is considered to be more important than the distance to the nearest washland if another is nearer, either downstream or as the duck flies, for example, seeds and certain invertebrates. For more independently mobile taxa such as wildfowl and beetles, the emphasis is on the nearest most appropriate habitat. This relates to feeding and nesting sites (e.g. geese and heron) and discrete habitats (e.g. patches of wetland and ponds). From these observations, it is concluded that an assessment of isolation for a given washland necessitates consideration of the distance to a range of habitats including other washlands.

An aspect of isolation is the movement of animals between washlands and/or other suitable habitats. This can be natural, e.g. wildfowl transporting seeds between sites, and human assisted, e.g. moving sheep from one washland to another with associated plant species carried as seed on fleece.

A.2.3 Diversity of habitats
A washland has the potential to contain a variety of different habitats which can make a considerable difference to the condition of the washland. The most extensive habitats are fields, grasslands and arable crops, and occasionally woodland. These are

identified in the Habitat Matrix. The habitats could also be divided into natural features and human created habitats. The former include ox-bow lakes and associated features, e.g. bar and swale remnants. These typically represent diversity in sediment composition and gradients in moisture content. Woodland sits in between the two categories, some being of natural origin and others being plantations. Most washlands include field boundary habitats either drainage channels or hedges or both. The drainage channels can include streams running off the surrounding land, e.g. highland carriers, as well as completely man-made ditches and drains of differing dimensions. Ponds were also often created to provide for livestock. Flood embankments have some similarities to natural geomorphological features.

Any of these habitats can make a significant contribution to the biodiversity of washland. The impact is at least in part synergistic, i.e. in addition to species which can exist only in the ditch and those supported solely in the field, there are others which require both, e.g. birds nesting along the ditch and feeding in the field and dragonflies breeding and developing in the water and feeding in the woodland. A breeding wader has requirements for different habitats for breeding, feeding and roosting, e.g. pools for feeding in, tussocky grassland for nesting and open field areas for roosting. These may or may not be found within in a single washland complex.

Each habitat can be usefully broken down into its constituent niches some of which are potentially of particular importance in the context the washland, e.g. the pollarded head of pollarded willows and the aquatic component of a drainage ditch or pond. These niches are particularly important in wet woodland where certain niches will be occupied by particular animal species, e.g. birds and invertebrates.

Other habitats include droves, green lanes, berms and bunds.

A.2.4 Ecotones and gradients

A feature of all washlands is the potential to present a range of ecotones typically associated with gradients of wetness and to a lesser extent sediment type, for example, from river channel to bank top and from the landward edge of the washland into the upland. Ecotones are typically more diverse than other components within the landscape and hence are an important determinant of condition. The seasonal changes in drainage are a critical factor in maintaining the diversity of ecotones, i.e. the flora and fauna is adapted to these changes which usually occur within certain limits. If these limits are exceeded on too regular a basis, the rate of species change will not be able to keep pace and biodiversity will decline.

The pattern of ecotones can be complicated. For example, field boundaries often run along, i.e. within and parallel to, the ecotone. One side of the boundary may be grazed and the other not, thus impacting on the species composition. Ecotones can be eliminated, for example, by piling along the edge of the channel or concreting the base of a flood bank.

A.2.5 Carrying capacity and home range

Different species need different sized areas in order to feed, breed and maintain a viable population. This might be dictated by the availability of prey items, e.g. waders require a particular biomass of invertebrates in order to sustain adults and chicks. Whilst this is related in part to the wetness of the soil, it is also a function of area. This also applies to predatory birds such as barn owl and kestrel, these species requiring a larger area per pair for feeding in than a wader such as a redshank. However, not all factors work in the same way. For example, the presence of trees is good for birds of prey which can improve their catch to energy utilisation rate by using such vantage points to good effect. The converse is true of waders which will not nest within a particular distance of trees to avoid predation.

Home range will be important for a range of fauna including mammals such as otter and water vole, amphibians, reptiles and fish.

A.2.6 Drainage regime

Drainage is a critical aspect of the condition of a washland, cutting across a number of the other factors described here. For example, isolation is reduced due to flooding, a key characteristic of any washland. This can be critical to fish species which are able to migrate from the river along drainage ditches submerged in the flood, thereby avoiding predation in the main channel. Generally a drainage pattern which produces flooding in the winter with flood waters receding to leave a high water in the fields is the most desirable. This is important for wading birds, dictating the suitability of the soil as a habitat for invertebrates and their biomass. For some species such as redshank, surface water is particularly important as a foraging habitat. This and other species will feed around the edge of pools, e.g. lapwing, whereas snipe will often rear broods in fields without surface water only moving to ditch edges or pools if the soil becomes dry. The mud at the edge of pools and drainage channels provides a habitat for a range of invertebrates including shoreflies, dung flies, soldierflies, dolichopodid flies, muscid flies, ground beetles, rove beetles and shore bugs.

Under drier conditions, invertebrates become less abundant near the surface moving down into the soil to avoid desiccation. The softness of the soil is also related to the ease with which waders can probe for prey which in turn varies from one soil type to another, e.g. peat soils are easier to probe than silt or clay.

Extensive flooding in spring and summer is a negative condition and this can completely prevent nesting of waders and other bird species in some seasons. Some species are more tolerant of flooding than others, e.g. snipe is relatively tolerant whereas black-tailed godwit is intolerant. The balance between too much water and too little is a fine one as illustrated by snipe, a species in which egg laying will stop if the ground is not soft enough to allow unimpeded feeding. Duration of flooding is also critical for invertebrate species. Summer flooding is detrimental to a range of taxa which are at vulnerable stages in the development. Whilst some might be able to survive in pockets of air which are trapped, the warmer temperatures will quickly deplete oxygen and anoxic conditions will prevail in the soil and litter layer. Prolonged winter flooding can kill or expel species over-wintering in the soil or litter layer. Depth of flooding is also important, shallow flooding allowing species to survive in tussocks remaining above the water level.

High water tables also ensure the permanency of such habitats as ox-bow lakes, pools and ditches and drains. If such habitats dry out during the summer, they can lose their truly aquatic complement of species. Conversely, pools which do dry out for periods in the summer can support a particular community of plants and animals. The latter sometimes described as mud species often benefit from trampling by livestock. The animals include crustacean species and sometimes amphibians which can tolerate periods of drying out by adapting their life cycles to the periods of wet and dry.

A.2.7 Management

The management regimes in practice across a washland will have a significant effect on its condition. Management can be divided into three main categories: agricultural, woodland and drainage. Agricultural practice typically impacts on the field vegetation and can involve mowing, grazing, harvesting, ploughing, reseeding, application of organic and artificial fertilisers, use of pesticides and herbicides, and occasionally burning. Timing, frequency and intensity of such practices dictate the degree of impact. A pattern has been recognised based on the intensification of agricultural activity from wet grassland which receives little if any artificial fertilizer, and is associated with small field and high water levels in the drainage channels. With intensification, the livestock density and field size increase with increasing fertilization and low water levels in the ditches and drains. At this stage or earlier, the field would be ploughed and reseeded or might be converted to arable use with a greater use of fertilizers and pesticides and, in summer, the ditches are probably dry. The condition of a washland could usefully be assessed in relation to the stage of development in this pattern.

Grassland management is of particular significance to the condition of a washland. Such factors as species composition, sward height, tussockiness, flowering and proximity of field boundaries (ditches and hedges), all impact on the invertebrate community which in turn dictates to some extent the vertebrate communities. Two examples illustrate this well. A tussocky sward provides a humid litter-rich habitat, refuge from predators such as birds, protection from extremes of temperature and overwintering sites especially where there is flooding. The presence of certain plant species will dictate whether or not particular butterfly species will be able to undergo their full life cycle.

The use of chemicals in the washland is generally considered to be negative. These include pesticides to control pests including invertebrates, weeds and fungi as well as medication and other treatments given to livestock. Herbicides, for example, reduce plant species diversity in the grassland or other crop, and anthelminthics impoverish dung of invertebrates for beetles and other species to feed on. In contrast, herbicides used to maintain the drainage function of key drains/ditches will also maintain different aquatic floras and hence add to the overall diversity of the washland.

Woodland management includes a range of activities such as harvesting, replanting, clearance of fallen and dead wood and changing composition of trees species. Such management will have a potentially significant impact on the fauna, e.g. bird species and invertebrate communities.

The intensity and frequency of drainage management is typically correlated with the intensification of use of the land for either agriculture or forestry.

A.2.8 Historical geography

The condition of a washland is in part a function its past. Use of maps and other documentation for a site can show what land use and habitat has been present on the washland and how long ago changes occurred. It can also give valuable insights into management. The availability of former is important if the washland is to be restored to anything close to its former condition. Where changes occurred a long time ago, the washland typically has less value than one in which the changes are relatively recent. This relates to the condition of the hydrology, sediments and availability of propagules for re-establishment. The condition of a washland is made up of a wide range of factors many of which are interrelated. This makes for a difficult assessment. The following consideration aims to assist in simplifying this process.

It is necessary to determine the basis for an ecological assessment of a washland. This could be based on particular taxa, e.g. waders or invertebrates or plant communities or on habitat, e.g. grassland or woodland. This immediately focuses the assessment on key factors relevant to that taxon or that habitat. Given a priority for waders, the conditions for these birds can be established, enabling the assessment to then consider other factors which would give value added to the washland, e.g. beetles and/or amphibians. Whilst there is a clear conflict between certain taxa and certain habitats, there are other combinations which require broadly similar conditions, for example the ditch network and wet grassland.

There is broad agreement that the trend from grazing marsh to increased stocking rates to either intensive livestock management or arable agriculture is correlated with a general deterioration in condition from the nature conservation perspective. A washland could be assessed from this stand point which would give a useful overall assessment of its condition. Good indicators would be stocking rates, use of fertilizers and levels of water in ditches.

Where no priority has been established for certain taxa and/or habitats, the biodiversity of a washland would be optimised by ensuring a broad diversity of habitats with each habitat being represented by different stages in succession. Such a condition should reflect the washland in its natural state, i.e. a series of patches of different communities and habitats. This would have been based on natural features such as oxbows and bar and swale remnants which should be valued highly in today's washlands. These have been replaced by other features of human construction, e.g. ponds, ditches, flood banks and artificial berms. This target is closely linked to the area of the washland, the larger the washland is the more scope there is to achieve such an objective.

Underpinning the scenarios presented above is a drainage regime which reflects as closely as possible a natural pattern, in very summary terms, flooding over the winter with a high water table being maintained throughout the remainder of the year.

Appendix 3
European Washland Case studies

This appendix contains descriptions of four European case study sites chosen to demonstrate washland creation techniques and results. The availability of information in the English language influenced the selection of case studies. The case studies confirm the hydraulic matrix by demonstrating the range of engineering solutions used on washlands to control inflow and outflow. Where information is available, the sites also help to confirm the relevance of the habitat matrix.

All information on the case studies was derived from secondary information with occasional consultation by e-mail.

These case examples show that other countries have recognised the benefits of using floodplains for flood storage and that this approach is the best for combining flood defence and biodiversity objectives.

A.3.1 Altenheim Polders (Germany)

A.3.1.1Site description

This site is situated along the upper Rhine River between Strasburg and Kehl (Oudendammer, 2003). Flooding has become more frequent as a result of the highly modified river profile, affecting both the immediate and downstream areas. Polders were created to alleviate the flood risk and these have simultaneously benefited local biodiversity through the establishment of wetland habitats

A.3.1.2 Land use

The site consists of two polders adjacent to the Rhine (Figure A3.1), creating a 520ha washland area and a flood storage capacity of 17,500.000 m3. The soil type of the washlands is predominately gravel. Land use on the polder is composed of:

50% wooded.
35% gravel pits and small water bodies.
15% arable; mainly maize and tobacco.

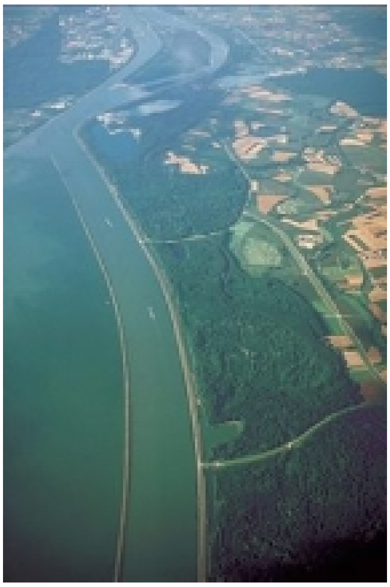


Figure A3.1 The Altenheim Polder

A3.1.3 Flood defence

The Polder is used for flood retention when the Rhine discharge exceeds 3800m^3/s. The water enters the site through an inlet structure in the embankment with a maximum discharge of 150m^3/s. The water is retained by lowering the outlet control structure and therefore controlling the outflow.

A.3.1.4 Biodiversity

As well as providing flood defence the site also has biodiversity management plans. The Polder is at present being rehabilitated into a floodplain ecosystem, with the establishment of inundation tolerant vegetation communities. Re-adaptation has been realised with the help of 'ecological flooding', a method of allowing controlled flooding to the site for biodiversity enrichment, while not affecting the main channel flow. This process is carried out in three steps (Table A3.1)

When the Rhine discharge is below 1550m^3/s no flooding of the polder is sanctioned as this flow rate is the minimum required for power stations down stream. When the discharge is above 1550m^3/s then ecological flooding is permitted and realised in three steps:

Table A3.1 Ecological flooding discharges and inlet rates

	Rhine discharge	Polder inlet rate
Step 1	> 1550 m^3/s until 1950 m^3/s	30 m^3/s
Step 2	>1950 m^3/s until 2300 m^3/s	50 m^3/s
Step 3	>2300 m^3/s until 2800 m^3/s	80 m^3/s

(Oudendammer. Per comms 2003)

The ecological flooding is interrupted when the local Rhine discharge is 2800m^3/s or greater, in order to evacuate water in case the site is required for flood storage. The polder is used for floodwater retention when the Rhine discharge exceeds 3800m3/s.

Ecological flooding has been used since 1989 and has been accompanied by extensive monitoring programmes of the several habitats and groups of species. The results have been encouraging; floodplain-typical species such as Dewberry (*Rubus caesius*) have increased in abundance, while flood intolerant species such as False Brome (*Brachypodium sylvaticum*) have decreased. A similar trend is occurring with the fauna.

One problem associated with ecological flooding is the creation of backwaters behind obstacles such as raised pathways. If water is trapped here after flooding it can become low in oxygen causing damage to vegetation. Also they are potential breeding grounds for mosquito.

A.3.2 Steenwaard Water Meadow Restoration Project (Netherlands)
This is a multifunctional project pertaining to nature development, water catchment and safety assurance (Pruijssen et al, 2000). The Steenwaard consists of two sub-projects - 'Veerweg' (ferry route) which encompasses the removal of substantial hydraulic bottlenecks and 'Nature & Water' which looks at nature development and construction facilities for water catchment

The Steenwaard area is between Utrecht and Den Bosch on the river Lek and has been developed into water meadows. The aim of the project is to provide natural water meadows and create room for the River Lek to flood safely. The project was under contract from the Ministry of Agriculture, Nature Management and fisheries. Construction started in 1999 finishing at the end of 2000. The work was designed to provide a starting point in the process of redeveloping the Steenwaard back to its natural form via natural colonisation and river processes.

The whole of the Steenwaard was freed from agricultural use and excavated to lower the floodplain producing water meadows and associated relief channels. The area provides a wildlife and recreation facility while also providing floodplain flood storage. The shallows provide room for reedbeds and the channels offer a place for fish to spawn. The land is to be managed by local farmers grazing cattle and horses.

The site has been designed to allow the river to flow through and over the area when in flood, reducing the peak of the flood hydrograph. The subsidiary channels within the Steenwaard will also provide room for flood storage when the water levels in the River Lek are high. This reduces the possibility of the dykes overtopping and reduces the stress on the dyke structures. In the creation of the Steenward 600,000 m^3 of earth has been removed and used for dyke construction 35km upstream.

A.3.3 River Dijle Restoration Project (Belgium)
This restoration project is taking place on the river Dijle, up stream of Leuven. The objective of the scheme is to improve the ecological value of the landscape by creating large areas of natural habitat on the floodplain, while protecting Leuven against flooding. The valley of the river Dijle south of Leuven is relatively narrow, and contains valuable wet hay meadows, sedge complexes, ponds and, along the edges, small alder swamp forests. The implementation of strategies to boost agricultural output lessened the valley's natural capacity to retain floodwaters, and consequently low-lying sections of the city of Leuven were flooded whenever water levels peaked.

The project takes an integrated approach of incorporating natural hydrological processes of the river with flood management schemes. There was conflict between the need to build a retention basin, and the protection of the biodiversity within the valley. The proposal is a compromise between the two, based on the development of natural retention areas. The main aim of the project was reducing peak river discharge by storing water on the floodplain. Floodwater retention on the floodplain was chosen as it improves the connections between the channel and the floodplain, develops wetland habitats and enhances biodiversity, and also because its implementation was straightforward and cost-effective. The creation of retention areas will help protect sites that are of European importance in terms of their biodiversity whilst providing sufficient flood alleviation for the city of Leuven.

Land was purchased in three subsites in succession, followed by hydrological engineering works, such as the removal of a culvert and filling drainage ditches, to restore the natural retention capacity of the floodplain. The cost of the project was €1,902,464 (40% contributed from EC). To restore grassland habitats, the project removed poplar tree plantations and sowed former arable land with seed mixtures taken from the local hay meadows. The banks of the ponds were excavated to make room for reed fringes to encourage the return of bittern and night heron, which both disappeared as breeding species ten years ago.

(Source: The Belgium Federal Department of the Environment Website, 2003;
Nijland & Cals 2000)

A.3.4 River Retention Scheme at Strasburg (Germany)

This case study demonstrates a river retention scheme along the River Rhine between Strasburg and Basel (The Integrated Rhine Programme, Bavaria website 2003). As can be seen by Figure A3.2 the river has been divided into two channels. The channel to the left is the natural channel. The right channel has been constructed to supply water to the power station situated on the river. When the river is in flood, the power station acts as a barrier to the water. The flood water is diverted into the natural channel where it is allowed to overtop or discharge into the polder which lies between the two channels. This allows flood water to be managed in a safe and environmentally beneficial way.

Figure A3.2 Image demonstrates the layout of a river retention scheme (Integrated Rhine Programme website, 2003)

Appendix 4
English Washland Case Studies

Introduction to washland case studies

This appendix contains detailed descriptions of the five English case study sites cited in the main report. The case studies:

- confirm the validity of the Hydraulic Matrix by demonstrating different engineering solutions used on washlands to control inflow and outflow,
- confirm the validity of the Habitat Matrix by providing information on biodiversity found on washlands,
- demonstrate the extent to which there is both compatibility and conflict between flood defence and biodiversity, and
- show the range of administrative and arrangement mechanisms used to achieve washland objectives.

Within the resources available, the sites were selected in order to provide examples of different flood engineering and land management solutions, to give an England-wide coverage of washlands, and according to the availability of information about the sites and local staff who could provide first hand knowledge. The sites were visited between the 15th January and 31st January 2003.

Table A4.1 at the end of this Appendix contains a summary of washland sites identified by respondents to the questionnaire of engineers and conservationists reported in Chapter 5 of the Main Report. These sites, 32 in all, are classified by degree of control and duration of inundation and demonstrate the considerable variation in circumstances and practices on washlands.

Case study 1 - Beckingham Marshes

A.4.1.1 Introduction

Beckingham Marshes acts as a flood storage area on the River Trent upstream of Gainsborough. The Marshes were protected against the 1 in 10 year flood event under an agricultural defence project in the 1960s, with land drainage assisted by pumping into the Trent. The site was chosen because it is an example of a washland site which is used for short duration, low frequency flood storage. The washland, has fixed control inflow and variably controlled outflow regimes (Hydraulic Matrix cell 8). The majority of the site is currently down to arable production (Habitat Matrix Type 1), but there are plans to extend the area given to wetland for wading birds by the Environment Agency in association with the RSPB. The case study also provides insights into land management and institutional issues, with scope for integrating flood management and environmental objectives.

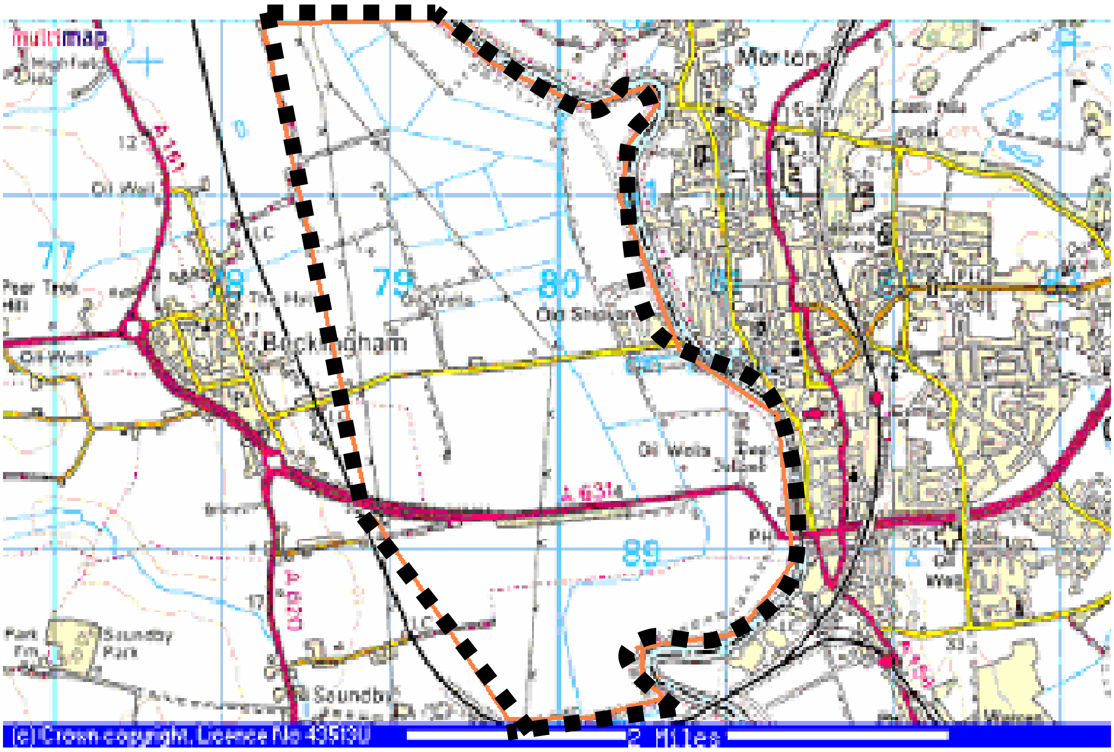


Figure A4.1 Map of Beckingham Marsh Site (note: the dashed boundary is approximate washland area).

A.4.1.2 Site Description

Habitat matrix: type 1
Hydraulic matrix: type 8
Area: 1000ha.
Soil Type: Predominantly clay (Morris *et al* 1984; Harding M 2002).
Average flood frequency: 1:10
Average flood duration: 2-3 days in winter.
Dominant land use: Arable

Beckingham Marshes lies on the western floodplain of the River Trent. They are bound to the east by the flood wall, and by the village of Beckingham and the railway to the west. To the south, the site is divided east to west by the new embanked dual carriageway (A631), the southern boundary of the marshes is boarded by the Saundby Beck (Figure A4.1).

A.4.1.3 Land Management

Most of the site is owned by the Environment Agency and was purchased for flood storage use in the 1960s. The site is used as a tidal flood storage reservoir, but let to five farmers under full farm business tenancies. The majority of the land is presently in arable production with a mixture of wheat, oil seed rape, barley, peas, beans and some set-aside. There are some small paddocks plus one grass field for grazing cattle. The fields are separated by ditches and hedges, the latter most recently planted rather than ancient (Harding, 2002). The site also contains a timber factory which has its own flood defence bunds. There are a number of small scale oil wells of the Pentex oil company, which are unprotected. The arable land use and intense drainage classifies the site as Type 1 in the Habitat Matrix at present.

A.4.1.4 Engineering Works and Controls.

Beckingham Marshes is part of the Gainsborough flood defence scheme on the River Trent. The site acts predominantly as a flood safety valve for the town of Gainsborough. The site is designed to store 2,000,000m^3 of flood water from events with a one in ten year return period. Minor localised flooding occurs every five years or so from overtopping, which usually subsides in a day or two, assisted by pumping.

The flood defences were originally justified in terms of agricultural benefits as part of the 1960s River Trent Tidal Improvement Scheme. These were designed to offer a flood storage facility to help protect Gainsborough. The main flood engineering solutions comprise of embankments, inflow spillways, flapped outfalls to the River Trent, with a pumping station as a back-up. Recently the flood bank and spillway were strengthened and the spillway levelled but not changed in height. Beckingham Marshes remain a key element in the local flood defence system providing for the protection of Gainsborough.

<u>The spillway:</u>

The spillway (Figure A4.2). is designed to overtop in a one in ten year flood event.. The height of the spillway is 5.64m above OD[7] compared to the main flood banks either side of the site which are 6.25m in height. The spillway overtops briefly during the year normally due to tidal or fluvial events. The overtopping only lasts for a few hours and water is drained into the network of ditches and gravity fed or pumped back into the Trent. In the last 30 years, the site has been flooded to full capacity twice, in 1977 and 2000. The full flood subsided after 2-3 days facilitated by the network of ditches and pumps. The fixed inflow and variably controlled outflow mechanisms at Beckingham Marshes classify the site as Type 8 within the Hydraulic Matrix.

[7] OD: Ordnance Datum, the point from which all measures of levels are recorded.

Figure A4.2 Flood storage area starts to fill by natural overtopping of flood banks.

The drainage network:

Most of the arable fields are under-drained, served by a the network of field ditches which discharge into deeply cut main channels, often with a freeboard of 2m (Harding 2002). The network of drainage channels convey the internal drainage water via the main 'Spine' drain (Figure A4.3) to Beckingham pumping station where it is lifted into the River Trent when required.

Figure A4.3. Main drainage ditch leading to pumping station.

The Pumping station:

The pumping station contains a large sluice gate as well as pumps. The gate allows gravity drainage when levels in the River Trent are low (Figure A4.4). When there is insufficient natural drainage, 4 pumps, 2 diesel and 2 electric, are used to lower ditch water levels in the Marshes. The pumps are maintained by the EA but the internal drainage board (IDB) operate them on a day to day basis to sustain desired water levels. The pumping station at Beckingham is the only point of outlet for water on the site. During extreme floods, such as the 1977 and 2000 events, the pumping station can itself become inundated and therefore inoperable. There is no remote control of the station, and engineers have experienced difficulty reaching the pumping station during severe flood events.

Figure A4.4. Beckingham Pumping Station is the only outlet for flood storage. A large sluice gate (centre) allows gravity drainage when the Trent is low. Otherwise pumps are used to lift water into the Trent.

A.4.1.5 Biodiversity.

Due to the low frequency of flooding at Beckingham Marshes, there is limited direct effect on biodiversity by the flood waters. The site was chosen as it is a highly controlled hydraulic regime. Arable farming within the washland requires the water regime to be highly controlled. As a consequence biodiversity is low and ditches have been cleared of vegetation to maximise conveyance (Figure A4.3).

At present the RSPB and the Environment Agency are working together to restore 488ha of the site to wet grassland under the aegis of a £4M 10 year programme for wetland creation. This will create a nature reserve for over 300 pairs of breeding waders, with snipe (*Gallinago gallinago*), redshank (*Tringa tetanus*) and lapwing (*Vanellus vanellus*) as the principal target wildlife species. The immediate objective is to create the habitat to attract these birds characterised by open wet grassland with few trees and hedges. The site will continue to be owned by the EA. By October 2003, it is proposed to purchase the full tenancies from incumbent farmers on about 100 ha, re-letting land on new annual contracts with management agreements prepared by the RSPB to maximise the habitat potential for waders. The purchase of these tenancies will be funded by the Environment Agency. Subsequent operation will be funded by RSPB partly through receipts under the Countryside Stewardship Scheme.

The new wetland will be created by diverting surface runoff from surrounding land into the washland rather than by floodwater from the River Trent because it is felt this is more reliable and controllable. The hydrological integrity of the site is perceived to be better managed with land drainage water that can be controlled by widening ditches and by using sluices and pumps. Although, the wetland creation and associated biodiversity is not linked with management of the site as a flood storage facility, the embankments and drainage infrastructure provide the context for wetland habitat management

The long term vision of the RSPB is to restore the area as part of the natural floodplain of the River Trent (Harding 2002). However, if the banks were removed or breached the site would lose its controlled regime and therefore could reduce the degree of flood protection afforded to Gainsborough. The spillway could be lowered to allow more frequent flooding for biodiversity, but this would reduce the capacity to retain flood waters when required. The present arrangements allow RSPB to control the hydraulic regime of the site, without reducing overall levels of protection to other occupiers in the Marshes. This protection to adjacent areas would need to be retained if the Trent embankments were set-back.

The proposed new land use and drainage regime by the RSPB would move the classification of the site to a wet grassland habitat, although it is not possible to define precisely this at this stage.

A.4.1.6 Issues Arising and Implications

The site is classified as a washland in terms of the definition used here, as it is flooded for flood management purposes, albeit infrequently, and it does offer wetland potential. Indeed, this wetland potential is now being taken up somewhat independently of the flood storage option, in this case demonstrating that there is compatibility, if not synergy. The Beckingham Marshes case study also demonstrates how the 'menu of actions' referred to in Section 2 can be used to control soil water regimes for habitat management purposes within the washland, in this case using water sourced from surrounding higher land. The site at present is within the Type 1 box in the Habitat Matrix. Increasing the wetness of the site by modifying land drainage can shift the position of the site within the Habitat Matrix.

The case study demonstrates that washland creation or restoration for the enhancement of biodiversity does not have to conflict with flood defence management. Here, biodiversity of a washland is being enhanced in partnership with the Environment Agency without additional expenditure on flood engineering. The washlands are retained as a flood storage reservoir. As land use in the Marshes changes from arable to wet grassland under the proposed Stewardship Scheme, it is likely that there will be reduced need for some of the flood defence infrastructure, such as the pumping station, which was mainly justified for agricultural purposes.

This case study demonstrates the advantage of institutional land ownership as it provides a high degree of control for organisations wishing to promote particular objectives. Acquisition of land rights, however, is expensive. The case study also confirms the importance of economic incentives and related funding mechanisms, either through sales of land rights or annual payments, to promote biodiversity in washlands. It also confirms the importance of a partnership approach amongst the Environment Agency and Non Government Conservation Organisations, farmers and other occupiers.

A.4.1.7 Conclusion

The Beckingham Marshes case study illustrates a washland with relatively infrequent flooding and rapidly drained soils capable of supporting extensive arable land use. In this respect it illustrates the characteristics of a Type 1 washland in the Habitat Matrix. The site also demonstrates a highly controlled flood management regime, providing an example of a type 8 washland on the Hydraulic Matrix.

The case also demonstrates that there is potential for biodiversity to be enhanced given a change in land use from arable to grassland on a large part of the washland, with proposals to retain greater degrees of wetness through the retention of non-flood waters from higher ground, as well as the possibility of controlled inundation from river water. In this respect the case study demonstrates scope to convert existing agricultural washlands into wetlands through change in land use and land drainage management without affecting the existing flood defence facility.

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Case study 2 - Coombe Hill Catchment: Washland Created by Overtopping of Embankments

A.4.2.1 Introduction

The Coombe Hill site comprises 658 ha which are annually flooded by the River Severn (Figure A4.5). The site was chosen as an example of a site which contains flood defence embankments which provide a degree of protection to agricultural land which when overtopped retain waters until there is sufficient outfall in the main channel to allow gravity outflow. This fixed control inflow with fixed gravity controlled outflow classifies Coombe Hill as Type 5 on the Hydraulic Matrix. Flooding tends to occur annually during over much of the site, although some areas are protected to the 1 in 5 year standard. Flood duration is often in excess of 2 weeks. Land use is mainly pasture for grazing livestock composed of wet grassland, positioning the site as Type 13 in the Habitat Matrix. Although investigation revealed that the washland offers a limited contribution to flood management it has considerable biodiversity potential which has been promoted through the establishment of a nature reserve and also by annual agreements with farmers.

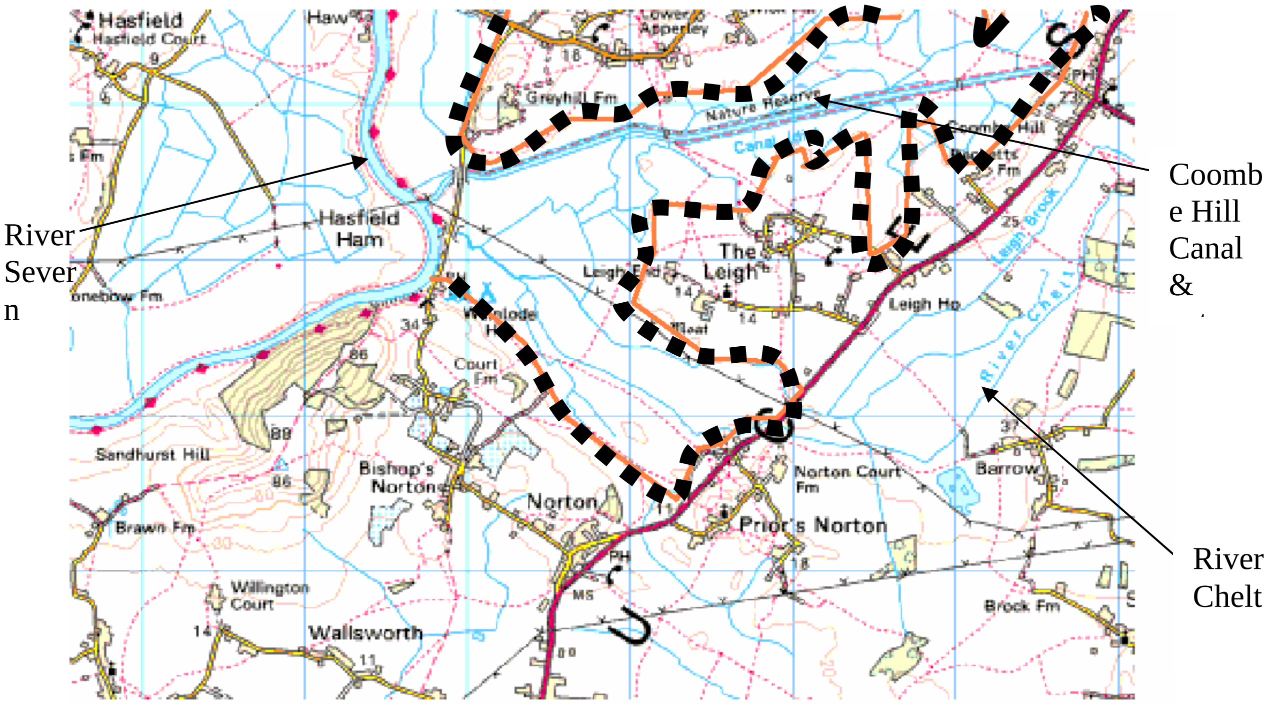

Figure A4.5 Map of Coombe Hill Washland (note: the dashed boundary is approximate washland area).

A.4.2.2 Site description

Habitat Matrix:	Type 13
Hydraulic Matrix:	Type 5
Area:	650 ha (Coombe Hill Reserve 56ha)
Soil type:	Gleyed silty-clay alluvium (Compton Series)
Average flood frequency:	Floods annually during winter.
Average duration:	Highly dependent on topography.

Integrated washland management for flood defence and biodiversity.

Dominant land use: Pasture.

Figure A4.6. Coombe Hill washland storing water (background) with low flood banks of the River Chelt in the foreground.

A.4.2.3 Land Management and Drainage Regime

Land is predominately under pasture interspersed with some areas of arable. 56 ha were purchased by the Gloucester Wildlife Trust and are now managed as a wetland nature reserve. The Coombe Hill washland is dominated by the flood regime of the River Severn (Figure A4.6) which floods the land every year. The River Chelt runs through the washland before discharging into the River Severn (Figure A4.5). The River Chelt makes a limited contribution to flooding, in terms of both frequency and area inundated. Alongside these rivers, there is a network of drainage ditches, the main one being the Coombe Hill Canal. This water body cuts through the washland to discharge into the River Severn. Historically the canal was used to move coal to the River Severn.

A.4.2.4 Engineering Works and Controls

The River Severn and the River Chelt have flood defence embankments which were constructed as part of an agricultural flood defence scheme in the late 1960s designed to protect the Coombe Hill site against the standard of 'one in one' year nominal flood (Figure A4.7), (Smith & Gilman, 2000) and in some places against a 1 in 5 year event. This was deemed appropriate for the needs of agriculture at the time. The scheme was justified in terms of the take-up of agricultural benefits associated with intensification of grassland management and some conversion of grassland to cereal production in those areas receiving relatively high levels of protection. It was reported that actual take-up of potential benefits was relatively modest. Grassland management remained extensive, and although there was some arable conversion, this has for the most part reverted to grass due to a mixture of inadequate flood defence (for arable purposes), declining incentives for cereal production and opportunities for agri-environment receipts.

Water overtops the embankments during peak flows. Local topography influences the flow of flood waters into the site with the water filling the drainage network before flooding the washland surface. Water can stand in the various troughs and hollows for long periods of time. Due to variations in topography, the duration of flooding varies. Flood waters outflow from the site via a network of ditches which connect with one-way flaps into the River Chelt. The River Chelt then discharges into the River Severn through a larger non-return valve (Figure A4.8). The above hydraulic mechanisms classify Coombe Hill as a Type 5 washland in the Hydraulic Matrix, as there is fixed control inflow and gravity controlled outflow.

Figure A4.7 River Chelt with small embankments providing protection of grazing land against the annual flood.

Figure A4.8 The non-retune valve controlling the outflow from the River Chelt into the River Severn.

At present the embankments are maintained by the Environment Agency, although the view was expressed that flood managers *'would like to stop maintenance on the embankments and allow the floodplain to return to its natural flood regime as the defences provide limited flood defence for the area'*. However it was pointed out that this could meet with some opposition from local occupiers unless they can be assured that they will not incur increased flood risk and associated losses.

It was reported that the amount of flood defence benefit derived from the storage capacity of the Coombe Hill washland site is small, mainly because the low embankments over-top during relatively low flows, offering little opportunity to hold back water in the larger, infrequent events. Although out of bank storage is useful, flood managers perceive limited contribution to overall catchment flood management and to the City of Gloucester down stream. Most of the benefit is given to other agricultural land over a 3 km reach immediately downstream.

The storage capacity of the site would need to be increased to make a significant contribution to flood management objectives, requiring engineering works to retain water and control its return flow to the main channel. At present the Environment Agency is not exploring this option. It does recognise the scope for generally adopting lower levels of protection on agricultural land, thereby saving on maintenance costs. At present this could be achieved without significantly compromising the current flood management facility. The area would be restored as a natural floodplain.

Figure A4.9.Large area of flood storage water on the Coombe Hill Nature Reserve, depth can be up to 0.5m.

A.4.2.5 Biodiversity

The Coombe Hill catchment is predominantly a pastoral landscape occupied by semi-improved grasslands. This landscape also contains a mosaic of flooded lowland wet grassland and associated wetland habitats.

The Coombe Hill Nature Reserve itself is a mixture of semi-improved and MG4 grassland. The site starts to flood during November and the water is retained until April (figure A4.9). This is perfect habitat for breeding waders as the water is fairly shallow (0.15m-0.2m). The main biodiversity objective of the site is to increase the habitat potential for lapwing (*Vanellus vanellus)*, curlew (*Numenius arquata*), snipe (*Gallinago gallinago*) and Bewick's swans (*Cygnus columbianus*). Habitat restoration involves increasing water levels in ditches during the summer and creation of scrapes to retain water. The Environment Agency does not object to the rise in water levels in the ditches during the summer period as flood storage is not affected during this period. The Gloucestershire Wildlife Trust is currently preparing management plans for low intensity grazing on the reserve to maintain the grassland habitat.

Figure A4.10. The Coombe Hill Nature Reserve contains a diverse mosaic of habitat from semi-improved grassland (foreground) to wet woodland and swamp (Left).

The creation of MG4 grassland is difficult on land recently farmed for arable crops due to high levels of phosphate in the soil. Slow reduction rates of the phosphate in the soil means that it can take up to 40 years to have suitable levels to allow a healthy MG4 community to thrive.

The Nature Reserve (Figure A4.10) is owned by the Gloucestershire Wildlife Trust, purchased with National Lottery funding. Management and operations are funded through charitable donations and some conservation funding from the Environment Agency. Half of the Reserve draws payments for arable reversion to wet grassland under Countryside Stewardship.

Beyond the Nature Reserve habitat creation and rehabilitation has proved more challenging due to the relatively large number of land owners. About 245 ha of farm land surrounding the Nature Reserve are managed under the Countryside Stewardship Schemes with payments of about £85/ha for management of existing permanent grassland, with raised water level supplements of about £60/ha. This has helped to protect the integrity of the Reserve area.

As mentioned earlier, any further development of a washland facility at Coombe Hill and proposals to increase the wetness of the washland has raised concerns with the local residents. They perceive any rise in water levels and the incidence of standing water as an increase in risk of flooding. One option already identified is for the

Environment Agency to purchase land in the washland, as at Beckingham Marshes. This would reduce the number of landowners and associated complications, allowing the site to be used more effectively for the purposes intended, whether flood management or biodiversity. At the present time, however, the Environment Agency is unable to purchase land to be used solely for biodiversity, other than to create compensatory habitat to offset losses elsewhere. Such a purchase would prove expensive, but as demonstrated elsewhere, would facilitate management control, including some savings to expenditure on flood defence operations,

A.4.2.6 Issues Arising and Implications

This case study illustrates a number of issues relating to situations where changes in land use, promoted by wetland creation through designated nature reserves or farm based Stewardship options, no longer appear to justify standards of flood defence previously designed for agricultural land use.

Winter flooding and extensive grassland farming, supported by Stewardship agreements, have encouraged environmental enhancement. Winter flooding has produced a habitat of good quality for breeding waders, and this has been extended by management interventions such as raised water levels in fields and ditches and retained water in scrapes. Indeed, the view was expressed that if the land did not flood, these non-flood wetland options would be difficult to promote and achieve. Thus the winter flood regime provides the potential for biodiversity. The site also shows that there is often considerable scope for a mosaic of conditions within a washland, from specific ecological targets on the managed reserve, to more general biodiversity improvements on farm land biodiversity on washland sites.

The Coombe Hill site also shows that land owners, including local residents and farmers, may resist a reduction in flood defence standards where they perceive that inundation or severance of their land or property is potentially detrimental to their income or property values. In the past, these conflicts of interest have often been resolved by purchase of land or flood easements. This does however significantly increase the cost of washland creation. Furthermore, the Environment Agency as the body responsible for flood management does not see itself as a land management organisation, and would therefore choose to work with others, including wildlife agencies, to manage washlands. More recently, in pursuit of this the Agency has promoted a participatory approach, bringing various stakeholders together in partnership, drawing down on funds to support wetland development. This has made progress towards wetland restoration particularly by alleviating fears that a change in flood regimes will have negative consequences.

A.4.2.7 Conclusion

The Coombe Hill site shows that sites with low standards of defences associated with grassland management are able to offer considerable scope for biodiversity while making a contribution, albeit small in this case, to flood defence. In this respect Coombe Hill can be classified as a Conservation Washland. Consideration could be given on these sites as to whether it is worth retaining embankments for flood defence purposes for low grade agricultural land or whether it is best to remove or neglect them in order to restore the natural floodplain. If in these circumstance reduced maintenance can deliver biodiversity benefit without compromising flood management, then it seems sensible to discontinue maintenance. The point was made in the Coombe Hill case that there was a risk that embankments were being retained to serve the interests of a minority of land managers when the larger part had taken up wetland options under Stewardship.

The Coombe Hill case provides an example of fixed controls on inflow and outflows which classifies the washland as Type 5 on the Hydraulic Matrix. The mix of flood regime and land drainage interventions currently produce a Type 13 Habitat. Proposals to modify ditch levels to influence surface water and land drainage will create a potential for Type 14 in the Habitat Matrix.

The case study demonstrates that flood management and biodiversity can be compatible, especially through the management of water regimes beyond the flooding period. It also shows the opportunity for diversity of habitats through managed variations in regime throughout the washland. The Coombe Hill flood regime provides ideal conditions for a wetland nature reserve and for wet grassland management under Countryside Stewardship, although local conservation officers felt much more could be achieved if designated biodiversity funds were available. The case illustrates the need to work closely with landowners and residents to inform them of the benefits of wetland creation and that washlands managed for biodiversity will not expose them to increased flood risk.

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Case study 3 - Long Eau Washlands, (Lincolnshire): Washland Recreation by Setback of Embankments

A.4.3.1 Introduction

The Great and Long Eau drain large areas of predominantly agricultural land. The Eau is a typical example of an agricultural improvement scheme where heavily engineered flood defence banks constrained geomorphologic processes and cut off contact between river and floodplain, thereby reducing its flood storage potential. In the mid 1990s embankments were set-back along a section of the Long Eau at Manby (Lincolnshire) at a cost of £60,000. The site was chosen as a case study as an example of a set-back scheme. The reduced control structures on the site illustrate the Type 1 class of washland in the Hydraulic Matrix. The grassland habitat provides an example of Type 8 class in the Habitat Matrix.

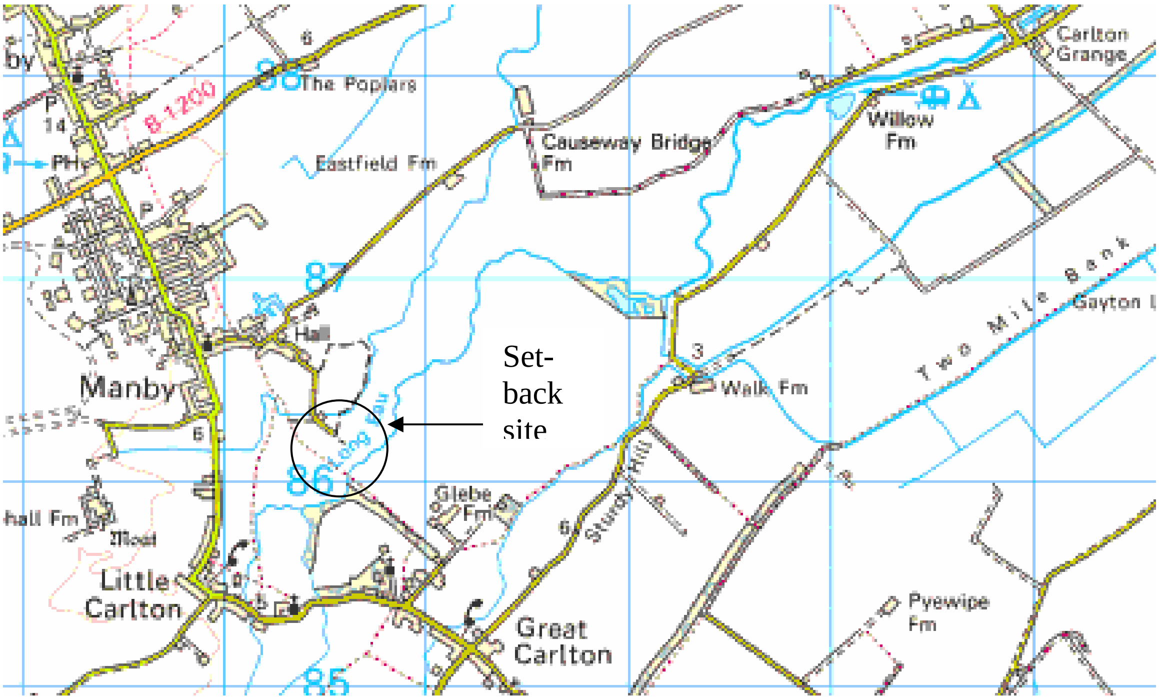

Figure A4.11 Map showing location of set-back scheme to Manby.

A.4.3.2 Site Description:

Hydraulic Matrix: 1
Habitat Matrix: 8
Area: 15 ha
Soil type: Clay, with peat lenses.
Average flood frequency: 3-4 times in winter.
Average duration: 3-4 days but can be months.
Dominant land use: Pasture

A.4.3.3 Land Management

The site lies on the outskirts of the village of Manby, in Lincolnshire (Figure A4.11). In order to increase the efficiency of land drainage for agriculture both rivers were modified with raised embankments to increase capacity. Both rivers are high level carriers relative to the surrounding land with the flood banks in place to protect adjacent land from flooding. In the mid 1990s a number of washlands were created in the floodplain of the Long and Great Eau by setting back the old trapezoidal banks, opening up areas of the floodplain for seasonal flooding (Figures A4.12 and A4.13)

Figure A4.12 Manby washland in flood nearing its 18,300m^3 limit, note setback embankment on the left.

Figurer A4.13 The two washlands can be seen flanking the Long Eau (centre).

The washland is situated on the River Long Eau in an otherwise intensive agricultural area. A farmer agreed to the washland creation scheme on his land after successful application for funding from the Countryside Stewardship Scheme. The Environment Agency agreed to carry out the setback works only when the farmer agreed that setback would be permanent and the banks could not be moved back to their former position in the future. The works were carried out by the then responsible organisation, the National Rivers Authority (NRA) (Figure A4.14). The NRA funded the setback scheme (about £60,000 in 1995) out of its environmental conservation budget which existed to promote the biodiversity aspects of flood defence and river management works. A further £2,000 was provided out of flood defence funds to modify existing embankments. These funding sources, together with Stewardship funding for annual payments, were essential to progress the scheme.

On the successful completion of the first scheme, the owner of land across the river also signed up to the CSS scheme to extend the washland to a total area of 22 ha. In both cases, land was in arable use before the scheme but was converted into pasture under the stewardship agreement.

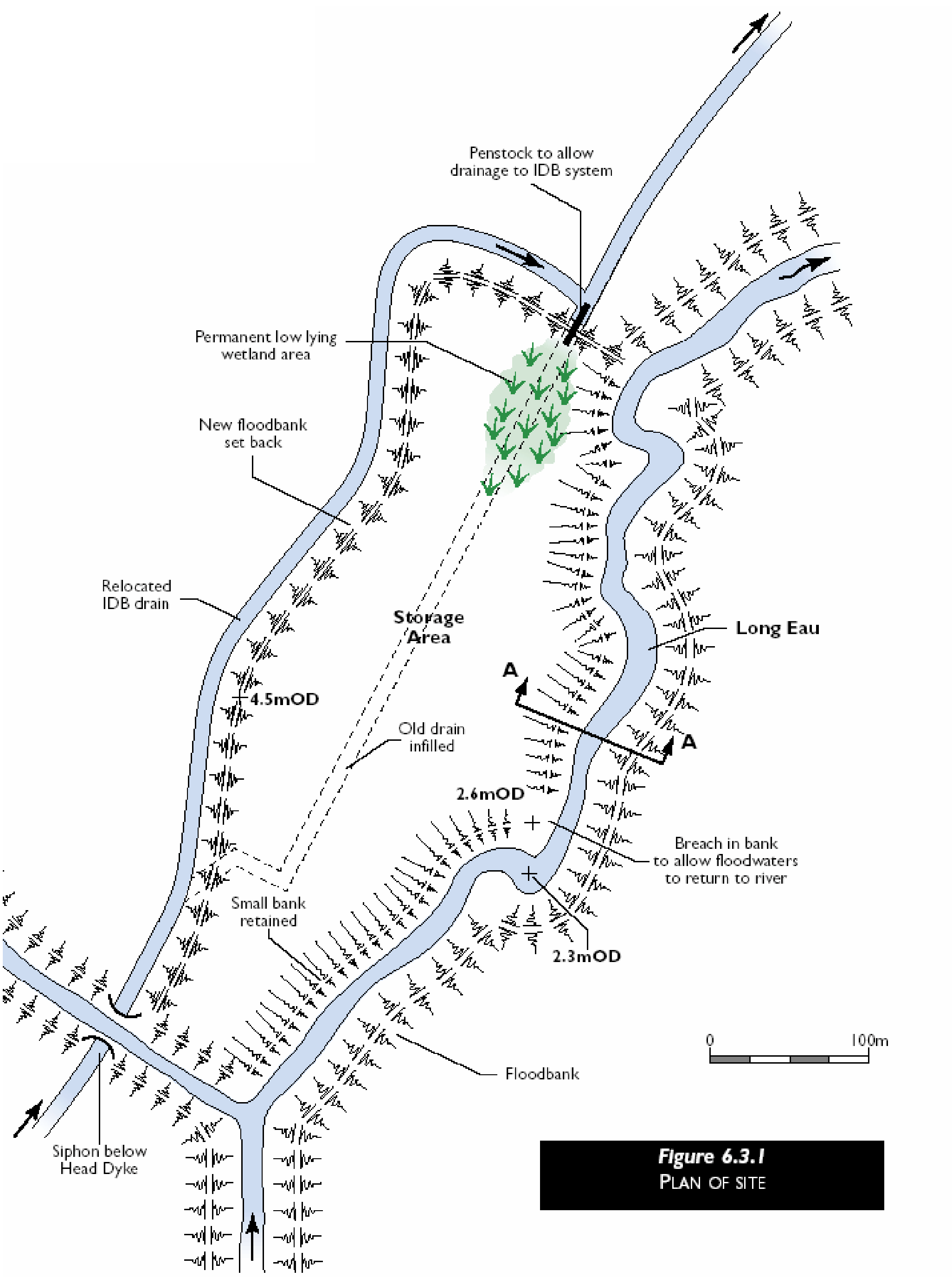

Figure A4.14 Plan of the first washland site on the Long Eau.

A.4.3.4 Engineering Works and Controls

The aim of the setback scheme was to restore the natural floodplain (Figures A4.15 and A4.16). This was accomplished by lowering the left flood bank to just above field level creating a new bank set-back 300m from the river channel. Although flood defence was a secondary element in the construction of the washland, the project created an area of floodplain with a storage capacity of 18,500m^3 offering flood defence benefits to dwellings down stream. The protection provided to these dwellings was used to justify the scheme in terms of flood defence.

Fig A4.15 Long Eau flanked by old engineered bank (right) and the lowered re-profiled bank (left).

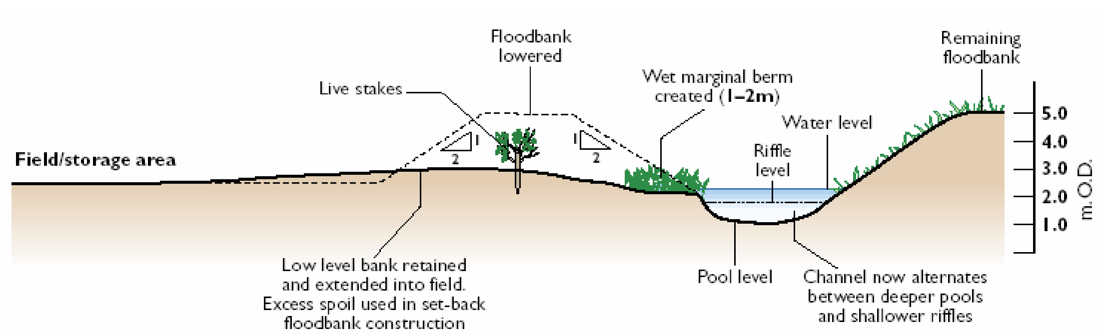

Fig. A4.16 Cross section through flood banks at Manby (Manual of river restoration techniques)

Flooding of the site occurs when the river water levels exceed that of a breach point in the low banks on the channel. This point is also the main outflow of water, which is gravity fed (Figure A4.17). Thus, the washland has natural inflow and outflow with very limited control. For this reason it is classified as Type 1 on the Hydraulic Matrix.

Fig A4.17 The main inflow and outflow point, a breach in the banks.

As the embankments are low inundation is rapid, but the rate is dependent on the water levels in the Eau. The lack of sluices and pumps reduces the control flood that managers have over the flood water which in turn reduces the amount of flood defence benefit produced by the site. Once the site is full, the rate of outflow is dependent on the natural ebb of the Eau after the flood event.

It is estimated that the combined flood storage capacity of these two sites has increased flood protection against the 1 in 30 year return period event along a 3 km section of the River. The old flood banks, isolated between the lowered banks of the two washlands, no longer serve a flood defence purpose and are no longer being maintained by the Environment Agency.

A.4.3.5 Biodiversity

A main objective of washland creation was to enhance the habitat in an area of low biodiversity. Arable land was sown with Countryside Stewardship approved grass seed to create semi-improved grassland. No objective was set for the creation of specific grassland types The arable farmer who owns the site now lets the land to local farmers for pasture and this provides the required grassland management. The grassland, however, suffers from perennial weeds associated with past arable farming practices. Permission has been given for some herbicide application to maintain the integrity of the grassland. The landowner rejected any specific habitat creation work on the site such as the creation of marshland, wanting the site to naturally return to its original habitat. At present a mosaic of grassland types are forming. In the low lying areas where water is held for longer periods, (Figure A4.18) some marsh flora is emerging, surrounded by grassland. The washland has been classified as habitat Type 8 because flood water is retained on the site for on average between 3 days and 2 weeks. The soil is moderately drained and flooding occurs in winter only.

Fig A4.18. The mosaic of grass and marsh vegetation enhances biodiversity.

The site attracts wading birds on the shallow waters around the margins, and dabbling ducks and geese on deeper open waters. Wildfowl include widgeon (*Anas americana*), teal (*Anas carolinensis*), redshank (*Tringa tetanus*), snipe (*Gallinago gallinago*), ruff (*Philomachus pugnax*) and curlew (*Numenius arquata*). Over 60 breeding pairs of redshank have been reported. The ideal condition for wildfowl is water retained on the site for 3-4 months over the winter months. The average duration of standing water is 3-4 days but can stand for months depending on frequency of flood events. The soil remains wet throughout the winter, especially in the low areas of the site, which is beneficial to birds such as snipe.

The path of the River Eau was not altered during the set-back scheme, mainly because the river course maintains a meandering path. However enhancements were made to the channel to encourage increased biodiversity. Wet ledges (berms) were created to allow wetland marginal flora and fauna to establish and develop along the edge of the river. Riffles were constructed within the channel to alternate the depth of water between shallows and deep pools, which attract fish and aquatic invertebrates. The right bank of river which was not set back was re-profiled in places to produce cliffs to encourage kingfishers to return to the river. However the cliffs were prone to slips and have now been colonised by vegetation.

The lowering of banks on the washlands has had some negative effects upon the water vole (*Arvicola terrestris*) population in the area. The steep profiles of the previous engineered banks provided excellent habitat for water voles. The removal of these banks and creation of new banks with gentler profiles at a distance from the river has degraded their habitat. As water voles are abundant in this area of the UK, the loss of this particular habitat was not deemed to problematic. The project took place before water voles were placed under BAP listings. Setback projects today would need to take this into account.

A.4.3.6 Issues

The case study provides an example of a more natural washland than previous case studies and therefore gives an illustration of a Type 1 washland in the Hydraulic Matrix. The flood regime provides an example of the vegetation typical of a Type 8 class washland in the Habitat Matrix. This assessment further confirms the relevance of the typology.

The scheme is a good example of a set back scheme which can jointly deliver flood management and biodiversity benefits. The scheme was funded from the NRA's conservation budget. The scheme benefited from availability of Stewardship funding to encourage arable reversion and therefore willingness by farmers to accept lower standards of protection. There have been benefits to the flood defence function in terms of storage, savings in ongoing maintenance, especially grass cutting, and the need for 'heavy' maintenance to secure the integrity of flood defence and drainage infrastructure, although these benefits were not used to justify the scheme. In isolation, the benefits to flood defence are modest, given relatively small storage capacity and limited control. However, viewed at catchment level, as flood managers pointed out, this type of set back schemes could make a significant contribution to flood management in aggregate. Flood managers argued that new set-back schemes (rather than existing washlands) can offer considerable scope for flood defence and biodiversity benefits. This requires a review of setback opportunities in the catchment as a whole, rather than at individual sites, taking a broad view of the impact on flood defence benefits and budgets.

Flood managers, drawing on the experience of the Long Eau, suggested that washland options should be identified as part of the appraisals for major urban flood defence programmes and projects. It was suggested however that the current cost benefit procedure, whereby environmental benefits, in their view, are not given full credit and thereby the environmental costs associated with obtaining these benefits cannot be justified against the scheme, works against washland options. Furthermore, the pressure to deliver quick solutions to urban flood risks favours short term engineering solutions rather than washland options which require joining up numerous strands of policy, funding and stakeholder interest.

The Long Eau also draws attention to the reluctance of local land and property owners to accept lower standards of flood protection due to perceived negative consequences, even though actual risk is small and in some cases the economic justification for continued protection is no longer valid. This emphasises the importance of informing and engaging stakeholders in the process of washland and wetland creation, especially promoting an awareness of potential benefits. In this respect, it was felt that sites like Long Eau could serve to demonstrate benefits and good practice which would prosper a positive attitude.

A.4.3.7 Conclusion

The Long Eau case illustrates that the action of set-back embankments as stated in the 'menu of actions' does significantly alter the classification of the washland. Originally the Manby washland was an agricultural protected area, with an intensive drainage network. The set-back action has reinstated a 'natural' washland, demonstrating the relevance of the 'menu of actions' in the typology to change the hydraulic regime.

Integrated washland management for flood defence and biodiversity.

The case study demonstrates that there can be conflict of interest within biodiversity objectives, as illustrated in the environments suited to aquatic birds and mammals, and that this needs to be resolved at a strategic level whereby priorities at set at catchment level.

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Case study 4 - Harbertonford Flood Alleviation Scheme, Devon:
A Modern Approach to Washland Creation

A.4.4.1 Introduction

The village of Harbertonford is situated between Plymouth and Torquay in South Devon. The village has experienced increased flood risk from the River Harbourne over the past 60 years, including 6 floods since 1998. A flood defence scheme for the village was given ‘accelerated status’ by Defra, with construction starting in February 2002 and finishing in October the same year (Jones *et al*,). The scheme design attempted to integrate engineering, cost and environmental considerations. The project consisted of two main components, firstly the creation of a washland flood storage area and secondly an innovative approach to lowering the river bed in the village. The creation of the flood storage area is the main focus of the case study.

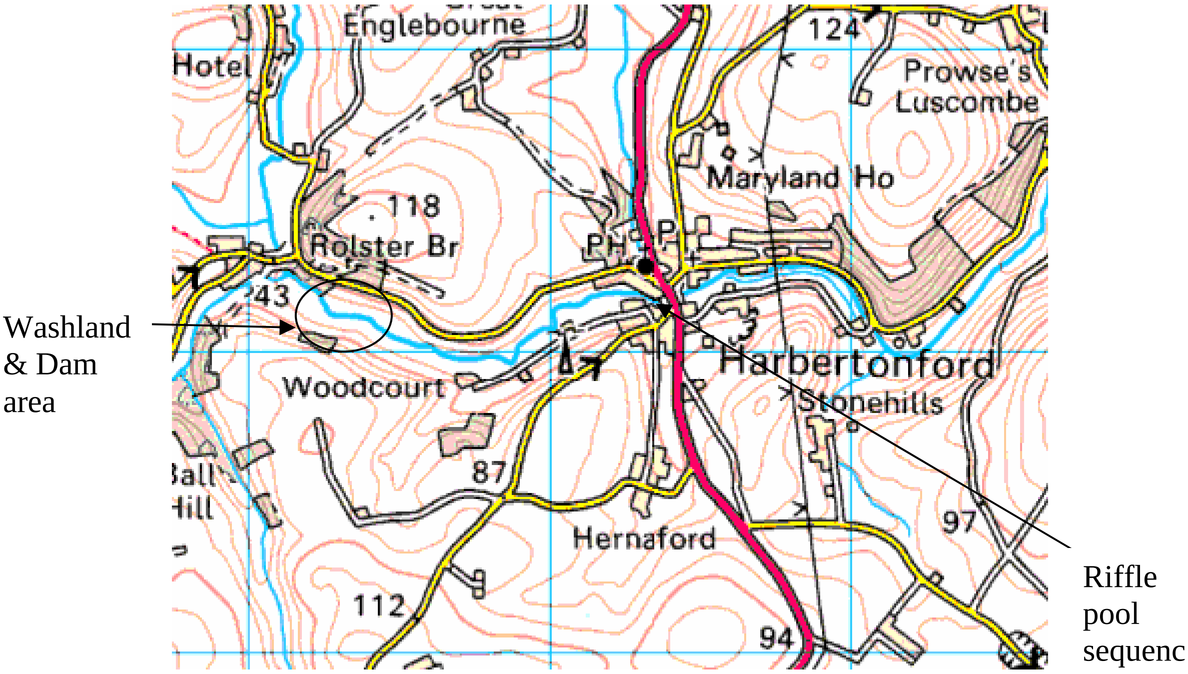

Figure A4.19 Map showing washland site in relation to Harbertonford..

A.4.4.2 Site description

Habitat Type: 11
Hydraulic type: 9
Area: 5 ha
Soil Type: Alluvial clay
Flood frequency: N/A
Average duration: 4 -5days
Capital cost: (overall cost of scheme) £ 2.5 million.

A.4.4.3 Land Management

The flood storage site lies on the River Harbourne upstream of the village of Harbertonford where the river runs through a steep sided valley (Figure A4.19). The River Harbourne drains from Dartmoor, a tributary of the River Dart, and has a catchment of 32.5km (Environment Agency, 2001b).

The site, previous to the development, was used as cattle grazing with the occasional hay cut in May. The Environment Agency purchased 5 ha of land from two farmers at a cost of £54,000, slightly above the market rate per ha, but a relatively small proportion of the total cost. Clay material for the scheme was taken from within the storage site itself, thus minimising haulage distances.

One of the main objectives was to consider the ‘environment’ as an opportunity, not a constraint. Opportunities for environmental gain were identified by the Environment Agency from the outset.

A.4.4.4 Engineering Works and Controls

The original proposal to alleviate flooding had been to widen and deepen the channel of the Harbourne as it passes through Harbertonford, with some loss of semi-natural woodland habitat. The washland design was soon identified as a more sustainable option, which provided the required standard of flood defence at similar cost and with inherent opportunity for environmental gain. The Engineering Design consultants (Halcrow) and the River Restoration Centre worked along with Environment Agency engineers to produce the preferred dam, control structure, channel and washland design.

An earth dam was constructed across the narrow floodplain. The dam has a culvert with double sluice gates incorporated into the structure. A washland storage area was created up stream of the dam. The dam was constructed from clay from the washland, the borrow pits forming a series of natural looking scrapes. The storage area fills and empties by gravity from and to the main channel with control exercised by the operation of the sluice gates. This was purposefully designed to restore the floodplain and its washland environment to a natural condition.

The total cost of the scheme was £2.5 M including land purchase and river works downstream of the storage area. The scheme was justified in terms of flood defence benefits. It was considered that there negligible additional costs associated with the environmental enhancements associated with the washland option. The scrapes provided construction material, and other aspects were regarded as normal good practice to produce a feature which complied with planning consent. There were some small additional costs for planting materials and some amenity infrastructure

<u>The Dam</u>

The dam is designed to blend with the surrounding landscape, with gently sloping embankments sides connecting to the valley sides at a point where the floodplain naturally narrows. The extra contouring on the dam also permits vegetation, including scrub, to be established along the dam, helping it to blend into the surrounding topography. Figures A4.20 and A4.21 suggest that this should work well when the vegetation is established. Eventually the embankments will be covered in grass with trees planted on the up-stream side in order to further screen the dam. On the down stream side trees were not planted to avoid hazard in the event of overtopping of the dam. Granite rocks have been placed along the banks to reduce the risk of bank erosion.

Figure A4.20. Sluice gates on the down stream side of the dam. In the foreground is a specially created pool for fish. Note how the dam structure has been naturalised as much as possible, and incorporates nesting facilities for dipper.

Figure A4.21. Upstream side of the dam includes the culvert structure. Note the newly planted broad leaf trees in the background.

The dam was constructed using soil excavated from three scrapes. The clay soil was suited to the dam construction, reducing the need for imported materials and haulage distance whilst helping to keep cost relatively low.

The dam contains a culvert with double sluices. The automated sluices shut when flows exceed the 1 in 10 year event. This causes the water to back-up along the river into the storage site. In the 1 in 10 year event only about 20 % of the washland area will be flooded. If the flow rate exceeds a 1 in 40 year event the dam will over top.

The culvert/sluice structure has been incorporated into the dam to minimise its visual impact although safety barriers could have been made to a more sympathetic design if budget had allowed.

The Scrapes

Three deep scrapes were created in the washland (Figure A4.22). They were designed to follow a paleo-channel discovered in the initial site survey. The scrapes were 0.75m deep with gently sloping sides. They were designed to be deep enough to sit just above the water table allowing water to drain slowly from the scrape but not to pond all year round.

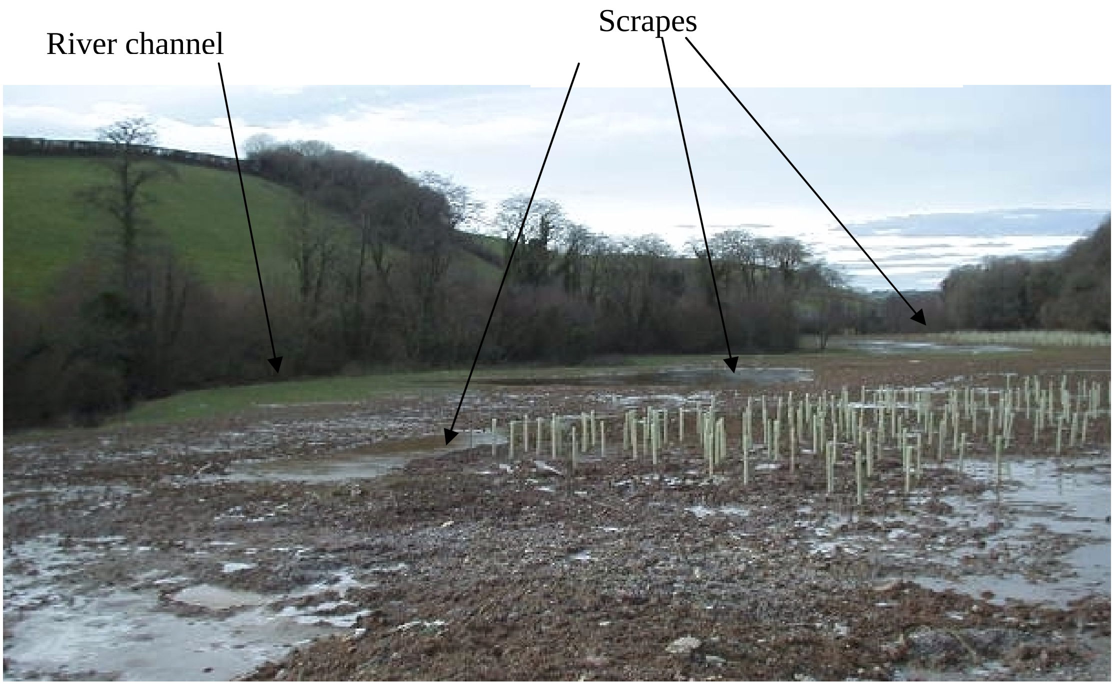

Figure A4.22 The newly created washland up stream of dam, with the three scrapes. New broad leaf woodland has been planted on the right which will merge with existing woodland. The open ground has been seeded with grass.

The River Channel

The river up-stream of the dam has been left unaltered and remains in its natural form. The river channel down stream of the dam has been modified by creating a series of fixed riffles and pools. This has lowered the river bed as it passes through the Harbertonford village providing further flood defence. The creation of a series of riffles and pools is a novel solution which achieves the same effect as lowering the river bed. It is believed to be more environmentally beneficial and cost effective than current methods, as the design integrates natural sediment transfer mechanisms, preventing the lowered bed from filling with sediment.

The orientation of the stone was laid to match the orientation of the natural rock strata, wherever it outcropped. At the village green, adjacent to the river, channel narrowing meant that a shelving beach was created once boulder revetment had been removed. This re-instated the connection of the green and river for the villagers. Further downstream the river had to be widened. Rather than grub out the woodland an embankment was replaced with a stone-clad wall and a wet berm.

The inflow and outflow of water on to the washland are controlled by the dam and sluice structure which classifies the site as type 9, although it is recognised that there are no controls on the washland itself. The scheme affords a high degree of hydraulic control.

A.4.4.5 Biodiversity

The site has been converted from pasture to a mixture of woodland and lowland wet grassland. The grassland was sown with a mixture of commercially available wild grass seed. Different seed mixes were used to increase the diversity across the site. As the grassland has yet to fully develop, it is hard to tell which NVC class will be achieved. The site will produce lowland wet grassland habitat which will contribute to UK BAP targets.

Numerous tree species including Alder, Ash and Oak have been planted on the site, both by the dam and within the washland area (Figure A4.23). The young trees in time will integrate with the existing trees to form a diverse wooded habitat. The trees will provide a mature carr/ wet woodland habitat, reducing in wetness with distance from the river channel.

Figure A4.23 The dam and adjacent vegetation is designed to suit the surrounding landscape.

The site has not been especially developed for birds. However many are attracted such as Dippers (*Cinclus cinclus*), Kingfishers (*Alcedo atthis*), and Grey Herons (*Ardea cinerea*). Bird boxes designed for Barn Owls (*Tyto alba*) and Dippers have been incorporated into the site. The river channel around the dam incorporates pools for fish to rest before and after they travel up the shallow culvert.

The scrapes will maintain wetness for prolonged periods allowing marsh vegetation and associated invertebrates to colonise. No other drainage infrastructure, such as ditches, have been engineered on the washland.

The washland was designed to provide a combination of marshy scrapes, woodland and wet grassland habitats. This recreates the natural mosaic of washlands which is so important for biodiversity and an important element in the design of the washland flood defence option.

Having been completed in October 2002 vegetation on the site is still establishing itself. The Environment Agency is producing a management plan which will involve a grazing regime with cattle, implemented by either the previous farmer or local resident under the supervision of the Environment Agency.

The wet berm is colonising with the appropriate emergent and riparian species, whilst schoolchildren helped plant wildflowers and more trees on the village green. Even the stone wall will colonise with ferns and other plant species typical of this type of habitat, which includes, a rare moss.

A.4.4.6 Issues Arising and Implications

This case study highlights the issues to be addressed in the early stages of development in order to make the site a success for both flood defence and environmental gain. The original conventional solution to residential flooding problem involved the construction of embanked defences in the vicinity of Harbertonford Village. This was reappraised, and the washland option was identified as potentially more appropriate. Landscape and biodiversity enhancement and protection, and participation of the local community in selecting the preferred solution, were key elements in the decision making process at the very beginning of the project. This route was not the easiest to take. Using more common structures and techniques would have possibly been more straightforward. However the results would not have been as environmentally beneficial. Nor would the flood defence solution been as sustainable in the longer term in this steep catchment. The completed project has been well received by the local community, which has been engaged in the whole project management cycle, including the use of the washland by the village school for education purposes.

The Harbertonford project demonstrates that with careful planning flood defence management can be integrated successfully with landscape and biodiversity management. The relatively small scale of the project, with benefits clearly to the local community, facilitated its development, as did the fact that it involved land purchases from only 2 landowners. The purchase of the land by the Environment Agency was important to provide the degree of control required both in design and operation.

Initially it was a challenge for the contractors to construct the scheme because of the sensitive environment design and natural appearance that was specified, rather than according to custom and practice of civil engineering construction. However the negative impacts of construction on the village were minimised, and the scheme is to receive a ‘considerate contractor’ award.

A.4.4.7 Conclusion

This project had a clear and defined flood defence need which required a flood defence solution. The aim was to produce effective flood defence with environmental gain. As a consequence of the engineering the Harbertonford site illustrates a type 9 class of washland with inflow uncontrolled and outflow controlled. Due to clay soils and limited soil water drainage mechanisms, the washland drainage is classified as moderate on the typology scale (Table 2.2) and the flood duration also is moderate. The site can flood in winter and summer. As a result the washland has been classified as type 11 on the Habitat Matrix.

The case study also demonstrates the use of scrapes as a method of varying soil wetness throughout the site, thereby producing the potential for a large variety of habitats. Without the scrapes the site would be drier, possibly changing the classification to a type 10. This is shows how elements from the ‘menu of interventions’ can be used alter the habitat type of a washland.

The effectiveness of the washland will be shown as time progresses. Its flood defence capabilities have not been tested and the environmental gain will not be demonstrated until the habitats are fully established. It will be important to monitor the site to record the establishment of the habitats and the effectiveness of the flood defences.

Albeit on a small scale, the Harbertonford Flood Defence Scheme is a model case in terms of the process and the design of washland development. In the context of the need to provide a solution to an urgent urban flood defence problem, the washland solution involved restoring the flood plain and its associated land use to a near natural condition. It is a good example of the integration of flood management and biodiversity objectives, as well as stakeholder involvement. Admittedly it is of small scale, but the basic concept has potential to be replicated across catchments to good effect, thereby addressing both localised and catchment wide purposes. It demonstrates what can be done when sustainability criteria, including biodiversity, are built into initial project design, and there is the will, flexibility and creativity, to prove that alternative approaches to flood alleviation are viable.

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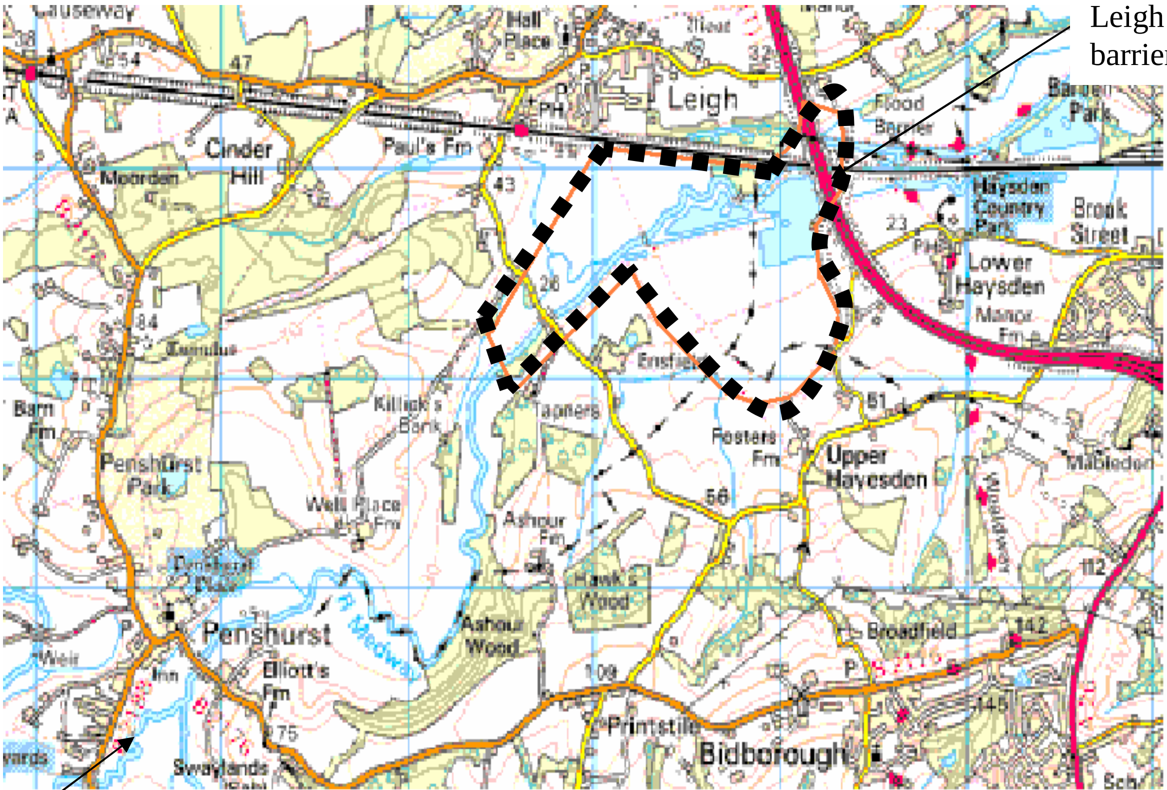
Case study 5 - The Leigh Barrier, Kent

A.4.5.1 Introduction

The Leigh Barrier is a flood defence structure built in 1981 to prevent the flooding of Tonbridge, Hadlow and East Peckham. It is situated up-stream of Tonbridge at the point where the River Eden joins the River Medway (Figure A.4.25). The barrier has been used to store water over forty times since its construction.



Leigh barrier

River Medway & River Eden confluence

Figure A4.24 Map showing location of Leigh Barrier (note: the dashed boundary is approximate washland area).

A.4.5.2 Site Description

Habitat Matrix: 8
Hydraulic Matrix: 9
Area: 278 ha.
Soil Type: Predominantly clay with some alluvial gravel.
Average flood frequency: twice a year.
Average flood duration: 3-4 days
Land use: pasture

A.4.5.3 Land Management

The Barrier is situated in a farmland landscape. Land use is a mixture of arable and pasture which is mostly for sheep grazing. The barrier was constructed where the mainline railway and the A21 cross the valley. The railway was embanked for

1,400m and the A21 was elevated across the storage are using a bridge structure in order to avoid inundation (Figure A4.25)

Figure A4.25 The Barrier in action during the 2000 floods. The road bridge and railway embankment can be clearly seen.

A.4.5.4 Engineering Works and Controls

The site was designed so the River Medway had a controllable throttle point, behind which flood waters could safely back-up in a storage reservoir. The Leigh Barrier is composed of a dam and radial gates.

<u>The Dam</u>

The Leigh Barrier consists of a 1.3 km dam wall which stretches horizontally across the River Medway. The dam is 5m high and designed to contain water to a depth of 4m with 1m freeboard. The dam was constructed with a clay core, enclosed with a reinforced tapered shell, and planted with grass but no tall vegetation.

<u>The Control Mechanism</u>

The output control mechanism consists of three electrically operated radial gates. Initially water is pumped from the surrounding land into the storage area where it flows into an outlet structure continuing the gates. These are designed to be lowered and raised to control the output flow rate. They are computer controlled. The outlet structure is a Fall’s type spillway constructed from concrete. The flood gates are carefully managed to allow outflow at a rate that will not overtop the flood defences downstream while allowing enough water to be released to stop the dam overtopping. During the 2000 floods the barrier had to be carefully controlled to avoid this occurrence.

Figure A4.26. The area of flood water retained by the barrier in the 2000 floods.

After the 2000 floods (A4.26), the outlet structure was reconditioned due to the damage caused by the volume of water passing through the structure. In order to allow the barrier to cope easier in future flood events the flood storage capacity in the washland has been increased with the addition of scrapes. Each scrapes has an area of 1,000m^2 and a volume of 15,000m^3 .

Further flood storage is being sought within the flood plain as an alternative to increasing the number of flood defence structures. The EA are attempting to reduce the number of defence structures along the Medway because they spoil the character of local villages, reducing their attractiveness for tourism on which many local businesses depend. The proposal to further increase storage within the body of the washland through engineered scrapes is perceived to be a preferred option.

A.4.5.5 Biodiversity

Typical of its time, the Leigh Barrier Scheme was designed with flood storage in mind. Very little attention, if any, was given to biodiversity in the original design. The dominant purpose of the washland remains that of flood management, but now it is apparent that where possible this runs alongside a wish to improve biodiversity. At the time of writing information was not available on the wildlife conservation projects linked to the scrapes but it is believed they will provide wetland habitat and niches for waders, invertebrates and vertebrates. No particular species or group of animals and plants are being targeted.

A.4.5.6 Conclusion

The original scheme involved the provision of flood easements for to farmers whose land was to be flooded. A large proportion of the £3.6 million (1980 prices) (Environment Agency, 2001c) cost of the project went towards the easement payments. The Environment Agency is now investigating purchasing land along the Medway and around the barrier to increase flood storage.

The control mechanisms in place on the Leigh barrier place the site into type 9, the same type of washland as Harbertonford. A flood regime of 3-4 days duration, moderate soil drainage and winter flooding classifies the Leigh barrier flood storage area type 8 on the Habitat Matrix. No biodiversity objectives are associated with the scheme.

The sustainable development of the River Medway is of key concern to the Environment Agency, evident in the fact that the Medway has been chosen as one of the pilot areas for a Catchment Flood Management Plan (CFMPs). The CFMPs include, amongst other things, opportunities for land care agreements, reduced maintenance of flood defence structures and setback initiatives

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Table A4.1 Summary of washland sites submitted by respondents to the questionnaires in section 5. Sites are classified by degree of control and duration of inundation.

Type	Name	Location	Area (ha)	land use	No. time flooded	Duration (Days)	Depth (m)	Summer flooding	Vegetation type	Biodiversity objectives	Controls
Online									-		
Controlled	Garstang Flood Storage Reservoir	Lancashire, River Wyre	89	Arable/ grass	-	1-1.5	16	Rare	-	Millennium green project	Sluices, flaps, embankments , drain.
	Durranhill	Carlisle	-	Pasture	2	1.5	0.5	No	-	-	Pump
	Milford-On-Sea	Hants	12	arable	1 - 2	2	4	Rare	-	-	Sluices
	Leigh Barrier	Kent	278	Grass	2.5	2 - 3	4	Yes	-	-	3 radial gates
	Bear Brook	Aylesbury	10	Marsh pasture	2 - 3	5 - 10	0.2 - 0.4	Yes	-	-	Spillways, embankments
	Scalford Dam	Nottingham	5.2	Grass	1-5	1 - 2	5	No	-	-	Dam
	Hartsbourne	Hertfordshire	3.9	Grass	2 - 3	1	0.5	Yes	-	-	Orifice plate, embankment
	Gowy Meadows	Chester	159	Pasture	-	-	-	-	-	Maintain wet grassland	Stop logs
Uncontrolled	Bembridge Marsh	Hants	-	Marsh	3 - 4	7 - 21	<1	rare	-	Maintain nature reserve	None
	Colney Heath	Hertfordshire	15	Grass	2	1	0.3	Yes	-	-	None
	Tent Lb	Gunthorpe	2300	Pasture	1-2	3 - 4	2	No	-	-	Minor flood banks
	Cam Washes	East Anglia	170	Grass	3 - 4	7	0.3-1.5	No	MG6/MG9/MG 10/MG13	Attract breeding waders	Earth banks
	Abram Flashes	NW	42	Pasture	-	3 - 4	-	-	M27/S28	Enhance wetland community	None
	Cawood & Selby Ings	York, River Ouse	15	Arable	5	3	0.3	Rare	Cereals	-	None

	Crowland & Crowbit Washes	East Anglia	700	Arable	1	2- 3	-	No	Arable	-	None

Type	Name	Location	Area (ha)	land use	No. time flooded	Duration (Days)	Depth (m)	Summer flooding	Vegetation type	Biodiversity objectives	Controls
Uncontrolled continued	Newton Mask	Yorkshire, River Derwent	20	Pasture	3 - 4	2- 3	1	No	Unimproved grassland	Maintain MG4 grassland	Ditches
	Puxton Marsh	Kidderminster	200	Marsh/ grass	1 - 2	1-2	<1	No	-	-	None
	Tadcaster Ings	Yorkshire	300	Arable	1 - 2	-	1	no	Arable	-	None

Type	Name	Location	Area (ha)	land use	No. time flooded	Duration (Days)	Depth (m)	Summer flooding	Vegetation type	Biodiversity objectives	Controls
Offline									-		
Short Duration (less than 3 days)	Catterall Flood Storage Reservoir	Lancashire, River Wyre	93	Arable/ grass	-	1	10	Rare	-	-	Sluices, flaps embankments , drain,
	Hall Place	Kent	13.8	Pasture/me adow	1	0.5-2	0.5	Yes	-	-	Siphonic inlet, controlled out let
	Mayes Brook	Hertfordshire	5	lake	4	1	0.2	Yes	-	-	Sluices
	Frisby on Wreake	Nottingham	20		3	2 -3	5	Yes	-	-	Lift gate
Medium Duration (less than 2 weeks)	Adventures Fen	East Anglia	84	Marsh	1	14	0.7	Yes	-		Spillway, embankments
	Acaster South Ings	Yorkshire	38	Grass	3	7	0.5	Rare	MG4	Create MG4 grassland	Flood banks & field drainage
	Aston Hall Farm	Stafford shire	140	Grass	3	4	0.5	Yes	mg10	Attract breeding waders	Ditches and bunds
	Relic Water Meadows	Dorset, River Frome	1000	Grass	3 - 4	5	1	Rare	improved grassland	SSSI	Sluice

Type	Name	Location	Area (ha)	land use	No. time flooded	Duration (Days)	Depth (m)	Summer flooding	Vegetation type	Biodiversity objectives	Controls
	Clifton Ings	York, River Ouse	-	Grass	2	7	1	No	Semi-improved grassland	SSSI	-
	Nene Washes	East Anglia	1310	Grass	10	5- 7	0.5	No	MG6/MG13/MG7/MG9	Attract breeding waders	Sluices
	Branston Island	East Anglia	200	Arable	-	7	-	No	arable	-	Pumps
Long Duration (more than 2 weeks)	Ouse Washes	East Anglia	1900	Grass /marsh	30-40	7-15	3.5	Rare	S5,OV30, OV32	Attract breeding waders	Controlled inlet and outlet, embankments
	Lower Derwent Valley	York	1000	Grass/ hay meadow	1 - 6	20-30	3	Yes	MG4 & swamp	Create MG4 grassland	Pumps, retention Ings
	Doxy & Tillington Marshes	Staffordshire	140	Marsh	4	6-15	0.8	Yes	S5/MG10	Attract breeding waders	Drains, weirs & sluice
	Wheldrake Ings	Yorkshire	20	Marsh & Swamp	1	14-16	2	Yes	S28 / Marsh	Maintain Hay meadow	Penstocks

If blank, data not available

Integrated washland management for flood defence and biodiversity

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