Wetlands, Land Use Change and Flood Management

A joint statement prepared by English Nature, the Environment Agency the Department for Environment, Food and Rural Affairs (Defra) and the Forestry Commission.

1. Background

1. The purpose of this paper is to provide a joint statement, on the role of land management practices and in particular, the role of Wetlands and Washlands in relation to flood management. This will:

- create a common understanding of the terminology in use.
- clarify the environmental benefits of Wetlands and Washlands and their potential role in sustainable flood management.
- explain how the principal flood management measures of conveyance and storage improvements relate to wetland and washland creation.
- provide a basis to review the opportunities and benefits for the increased use of wetlands and washlands in flood management and land use management and the need for consideration of policy issues that could facilitate this.

1.1 Terminology

In order to gain a common understanding within this information paper the following definitions are used.

Washland - 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 inlet threshold the land fills with water and then provides capacity for both temporary storage of flood water and flow. Washlands may have agriculture, amenity or recreational use.

Wetlands - are areas where the water table is either seasonally or permanently high. They naturally occur in river valleys where drainage is impeded either by topography or soil structure and they can be entirely natural or man made. Wetlands may be used for agriculture, forestry or amenity purposes that can tolerate intermittent high water tables. An area could be both a washland and a wetland, these are not mutually exclusive terms.

Floodplains - areas through which watercourses run and over which floodwater naturally extends. The extent and depth of flooding over a floodplain will vary and depend on the severity of the flood. Human activity can have considerable impact on the local mechanisms of flooding within these areas during minor floods but the scale of major floods usually overwhelms artificial controls and natural processes then dominate.

Flood Detention Reservoir - a man made structure specifically designed to store a proportion of floodwater in a way that will mitigate flooding at some point downstream. They can be either on line (e.g. Leigh Barrier on the Medway), where all water flows through the reservoir and impounding is controlled by a dam and sluice structure, or off line, where flow diverted from the river is controlled by a weir or sluice (e.g. Witham/Till Reservoirs upstream of Lincoln or River Irwell, Salford).

Storage - a term used to describe the holding back of water from its normal passage in watercourses. This can take many forms both natural and man-made processes. In the text it can be assumed to include all of the following unless specifically stated:

> *Sub surface storage* such as groundwater or infiltration zone water for which very different retention periods can apply - from minutes to days or months.
>
> *Biomass storage* where water is held within and on the surface of plants and their foliage.
>
> *Temporary Surface Storage* includes land undulations, watercourse, washland, wetland and reservoir capacity above normal retention level.

Runoff - is a term that encompasses all sources of water entering the river channel which can arise from overland flow, shallow subsurface flow, groundwater flow, drain flow or from direct precipitation onto open water.

1.2 Why rivers flood

River flooding is a natural process and part of the hydrological cycle of rainfall, surface and groundwater flow and storage. Floods occur whenever the capacity of the natural or man made drainage system is unable to cope with the volume of water generated by rainfall. Floods vary considerably in size and duration. Field-scale flooding is usually due to intense local storms where water and soil can flow straight off the land surface and may be over in a matter of hours. With prolonged rain falling over wide areas rivers are fed by a network of ditches, streams and tributaries and flows build up to the point where the normal channel is overwhelmed and water floods onto surrounding areas. On large rivers flooding can occur a considerable period after the rainfall and last for many days or weeks as the large volumes of water drain out of the catchment.

The ICE Commission of November 2001 - Learning to Live with Rivers, identified only two options to deal with flood flows, either to provide additional discharge capacity or to temporarily store excess water. Widening, duplicating or deepening channels or increasing the velocity provides increased capacity and reduces the depth of flooding. Additional temporary storage is typically provided by containing floodwater in purpose built reservoirs or through land management changes to reduce run-off rates. These measures temporarily reduce the flood flow and hence the severity of the flood. Floodplains have a natural function in the provision of both storage and conveyance at times of high flow.

1.3 Why flood management is necessary

Floodplains have been occupied by people from earliest times because of the opportunities they offer for agriculture and commerce. Damage due to flooding occurs when these floodplain areas are used for purposes that do not take account of the flood risk whether this is housing development or other inappropriate land management such as crops intolerant to inundation. Living on floodplains involves a balance of risks, which can be reduced but never eliminated by works or actions that control the flow of floodwater. A further option is to relocate property or activities out of the floodplain but the opportunities for doing this in the UK, where land is at a premium, is limited. The need for flood management can therefore be regarded as a response to land-use pressures. Society through time has made a considerable investment in floodplain areas in the form of building communities, business, infrastructure and improving agriculture. Flood Management reduces the risk to people, communities and other uses of floodplains and limits the damage to business and property. Good flood management must balance the expectation of people for effective protection against a changing risk environment with its ability to deliver sustainable and environmentally sound management solutions. If land use pressures change, such as with declining agricultural profitability, the need for protection may also decline. Section 4 describes the role that Catchment Flood Management Plans will play in achieving good flood management.

1.4 The need for environmental enhancement

Drainage of floodplains is a relatively recent historic phenomenon. For example, the Somerset Moors were largely untouched before 1200, and systematic drainage of large areas did not get underway until about 1770. By the 1930's only a quarter of historic floodplain wetlands remained in England, mainly in the form of periodically flooded grassland and grazing marsh. The vast majority of natural floodplain woodland has also been lost.

The next four decades saw a concerted programme of publicly funded drainage that resulted in further losses of wildlife habitat, often accompanied by conversion of grassland to arable crops. Losses of wet grassland in this period include – 37% in Broadland; 48% in North Kent; and 64% in the Thames Valley. Over 500 Sites of Special Scientific Interest have been designated in order to protect the remaining wetland fragments, but without regular flooding and higher summer water tables, at least two thirds of these are under severe threat. This has resulted in a programme of Water Level Management Plans sponsored by Defra, most of which remain to be implemented.

Surveys show that 85% of lowland rivers have been physically modified, usually straightened or deepened, with channels often disconnected from their floodplain (*A biodiversity strategy for England*, Defra 2002). Apart from lowland wet grasslands, other habitats that depend on periodic inundation include 'tall herb fens' the more widespread 'meadowsweet/angelica mires', 'reed beds' and 'wet woodland' species such as alder, ash and willow.

Wildlife that has suffered from the drying out of floodplain wetlands, includes the snakeshead fritillary, whose survival is linked to the periodic inundation of alluvial meadows and which is now virtually confined to nature reserves. Wading birds, which breed in wet grassland, have suffered some of the most dramatic declines. Breeding pairs of Snipe on the Somerset Levels decreased by 68% between 1977 and 1987 (Green and Robins 1993). In those few areas where water levels have been raised and more sensitive grazing regimes have been introduced, these declines have been halted and in some cases reversed.

Projects undertaken by English Nature, the Environment Agency the RSPB and others show that wildlife can recover with sympathetic water level management. At Holkham National Nature Reserve in Norfolk, for instance, breeding redshanks increased from 8 pairs in 1987 to 129 pairs in 2000, after water levels were raised.

Changes in land-use in floodplains to allow more frequent flooding and or reduced drainage would potentially provide a range of public and private benefits including flood defence for urban areas, biodiversity enhancement, improved water quality, groundwater recharge and new business opportunities linked to wetland crops or sustainable outdoor leisure and tourism. Whilst we should not assume that all natural environments reduce flooding and all developed environments increase it, stable natural environments do offer some physical features that work for flood mitigation. These include good temporary storage characteristics and providing room for floods to move within natural boundaries. Section 3 considers ways in which the synergies between wetland and other land use changes may contribute to flood mitigation.

1.5 National flood management policy

The overall aims of national flood management policy are to reduce the risks to people and the built and natural environment from flooding by investing in measures that are technically, economically and environmentally sound and sustainable. It should be noted, however, that most floodplain habitats do not require protection from flooding, and indeed benefit from seasonally higher water levels. Such sites require water level management that allows nature conservation interests to be maintained.

1.6 Other Government policy and drivers.

Other government policies for sustainable agriculture, the environment (including biodiversity and nature conservation), sustainable forestry, energy, climate change and planning may have a significant influence on issues raised in this paper. Consideration is increasingly being given to cross policy issues within government although solutions to often-complex interrelated areas may have to be developed over a period of time with experience and input from research.

Other drivers affecting solutions may include:

- Recent floods in the UK and Europe.
- Public expectation that flood risk will be managed.
- Climate change and increased risk of flooding.
- Requirements in the Water Framework Directive and other European Directives and UK legislation.
- European Common Agricultural Policy (CAP) reform and European Forestry Strategy.

2. Flood Management Practice

Defra encourages all operating authorities to carefully evaluate all flooding problems in an appropriate strategic framework and consider a full range of options for their solution embracing both structural and other measures.

Techniques used in flood management have altered considerably since the 1960's and 1970's in response to public demand for more visually acceptable defence measures, with greater understanding and implementation of legislation of the environmental issues and a willingness to pay for these. Reducing returns on agricultural production from around the mid 1980's have also tipped the balance against economic justification for agricultural flood protection improvements and these have now largely ceased. It is current practice in the Environment Agency to consider the environmental impact of all routine maintenance work to mitigate damage and seek additional biodiversity benefits in the process. For new schemes guidance on good flood management including environmental issues, sustainability, climate change and risk based design is given in the Defra Flood and Coastal Defence Project Appraisal Guidance (FCDPAG) series. The development of catchment flood management plans (CFMPs) is also considered essential for sustainable management and is described in Section 4.

The following sections give an explanation of how the two principal means of flood management, conveyance and storage changes are used in practice. Two ways of storage improvement are considered, engineered storage in the form of embanked reservoirs or washlands and land management changes which can increase storage though reduced rates of run-off. This will provide background understanding of how land management changes, wetlands and washlands fit into the range of flood management solutions. Although the solutions are described individually, in practice they are often used in combination to achieve the most effective overall flood management scheme. All potential impacts of flood management schemes are considered during their development including, fisheries, water quality, environmental and planning through consultation procedures. Environmental Impact Assessments (EIA's) are undertaken for all schemes and is normally the stage where opportunities for environmental enhancements are identified.

Appendix B gives examples of the use of storage in Flood Management.

2.1 The Role of Conveyance Improvements to Flood Management

Conveyance improvements to watercourses are a form of flood management that includes widening, deepening, straightening and measures to increase flow velocities in channels. The purpose is to reduce flood levels by getting water though an area by speeding it up or giving it a greater cross sectional area. Such solutions can apply on the floodplain and in upland areas. Because conveyance improvements are usually directly associated with river channels the synergies with wetland and washlands apply mainly along the margins and not in the wider catchment.

Widening Channels

By making a channel wider the cross sectional area of flow is increased and the channel will convey a flood at a lower level. The use of two (or more) stage channels is favoured above a general widening approach as it better accommodates low and high flows. This is usually achieved by constructing a "berm" which is a widening at a higher level than the river bed allowing low flows to continue in their natural size channel and higher flows to occupy a greater area as levels rise. Berms can offer good environmental habitats on the margins of watercourses that can be semi wetland in nature depending on the ground conditions locally. This form of river widening also allows retention of meanders, pools and riffles in the lower stage of the channel whilst more hydraulically efficient conditions are managed within the higher wider channel shape. Some management of channels is essential, such as removal of large scrub on the berm, which would block flows but many other forms of vegetation are acceptable.

Deepening Channels

The purpose of channel deepening by lowering the bed is to reduce local flood levels. This usually necessitates long-term maintenance. Rivers develop a natural bed gradient over thousands of years as hills erode and valleys develop. By seeking to change this gradient we work against natural processes, such as siltation, which will work to return the bed to a stable regime. In addition local deepening alone will not increase conveyance if downstream influences are controlling the water level - the water will simply flow at a slower rate. For these reasons channel deepening has become a less favoured engineering option in recent years. However, it can be an effective option on steeper watercourses and where other options are constrained by the proximity of development in urban areas or to resolve local pinch points such as bridges. Channel deepening is unlikely to offer any environmental benefits and more likely to do damage to habitats. Unfortunately channel deepening, "dredging" is often an option favoured by the public and the lack of it is perceived as a "cause of flooding.

Channel deepening is also undertaken as a water level management measure to lower normal river/ditch levels to facilitate agricultural practices by either reducing ground water tables or providing "water fencing". This has limited flood management benefit but can provide some additional storage capacity at times. This practice can also lead to a reduction in the biodiversity value of areas such as grazing marshes if water levels are not managed carefully.

Creating Flood (Bypass) Channels

Flood Channels are usually purpose built channels designed to convey flood flows across a floodplain in an additional route to the natural channel. They may take flood flows away from a built up area where widening the channel may not be possible. Built as natural channels with their designed capacity retained by management they can offer considerable opportunities for wildlife habitat creation.

Constructing Flood Banks or walls.

Flood Banks and walls work by effectively deepening a river channel so that a greater conveyance capacity is achieved without flooding of the area behind the flood bank, although upstream levels will also be raised. Flow velocities can be increased by the reduced friction of smooth walls or grass banks. There is a balance to be drawn between additional depth and the loss of conveyance through the area to be protected from flooding but higher flow velocities within the channel compared with floodplain flows and loss of storage usually make this an effective solution.

Setting Back Flood banks and walls.

Changes in land use or attitudes in areas protected by flood banks and walls can offer the opportunity to move the position of the defence away from the watercourse to increase conveyance. With increasing flood risk it may be more acceptable to allow agricultural land, parks or recreation areas or land released by redevelopment to flood in return for a higher or retained standard of protection elsewhere. The degree of benefit that this provides for flood management will depend on the proximity of risk areas upstream, the river gradient and the additional flow area obtained.

Floodplain Improvements

It is not only changes to the normal river channel that can improve flood conveyance. Examination of the flow of floods across floodplains can identify flow path obstructions such as railway embankments; bridges, roads and other features. Alteration of such features could help manage the process of flood spreading as it spills from the river channel onto the floodplain. Understanding the mechanism and sequence of floodplain flooding in extreme floods is vital to flood management and managed flood spreading.

2.2 Role of enhanced storage in the floodplain to Flood Management

Washlands and flood detention reservoirs can be used to store excess floodwater that can then be released after the peak has passed to reduce peak flood flows downstream. The design of such structures is critical to their success. Every river has its own particular shape of flood hydrograph related to catchment characteristics such as area, slope, tributary pattern and soil permeability. Rainfall patterns and ground wetness are other variables affecting the shape of a flood hydrograph. Storage is designed to "engineer" the shape and timing of the flood hydrograph below that which would cause damage in downstream areas. In off-stream washlands or reservoirs the inlet spillway level, volume and the rate at which water transfers into the storage is critical to effective performance. If the washland inlet is too low, the storage is used up too soon and the peak flow may not be reduced with minimal flood management benefit - as demonstrated in Fig 1.

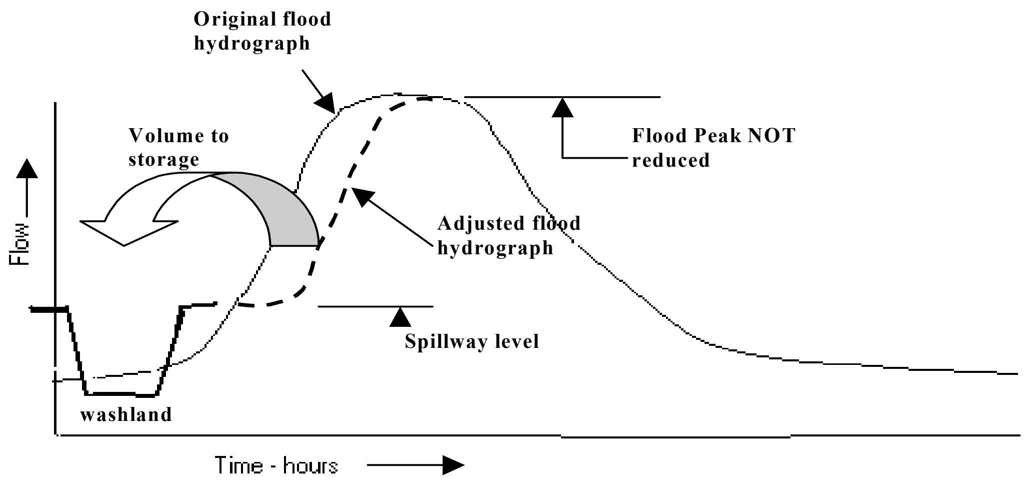

Fig. 1 - The effect of washland storage on a flood hydrograph CASE 1 - Flood peak not reduced - hence no benefit.

Figure 2 below however shows how the flood hydrograph can be successfully changed to reduce the peak flow if the washland inlet spillway is set higher. The aim of a flood management scheme is to reduce the peak flow and hence flood levels in the area being protected. This requires effective design and appropriately siting of storage areas, relative to the area being protected, is important.

To give some idea of the scale of storage required, a moderately sized catchment of 200Km^2 (e.g. River Cherwell upstream of Banbury) would require 5 million cubic metres of storage (equivalent to a reservoir of 2m depth over 250Ha) to contain just 25% of a 100mm rainfall event over the catchment.

A significant increase in storage volumes of existing reservoirs can generally only be achieved by allocating a greater area of the catchment for storage.

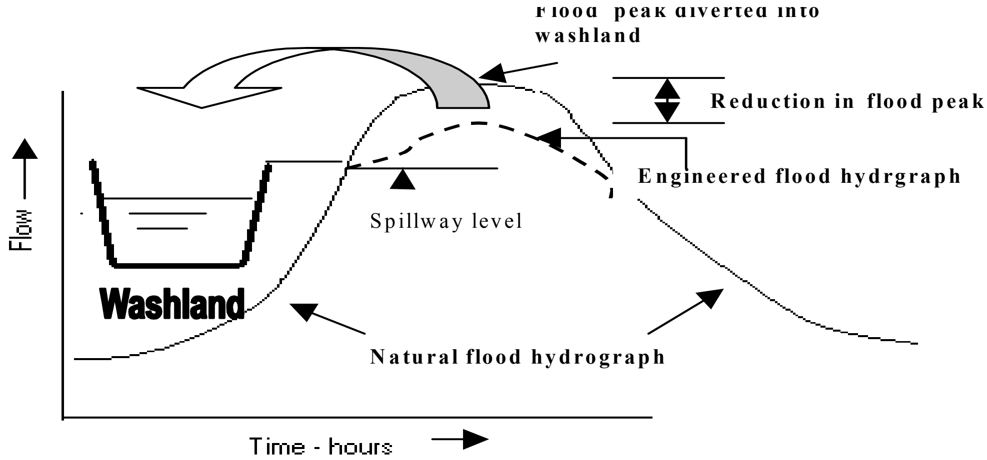

Fig. 2- Effect of washland storage on flood hydrograph
CASE II - Flood peak effectively reduced,

All storage areas have a finite capacity and the catchments remain vulnerable to longer duration events typified by the Autumn 2000 floods. Once the storage is filled the limit of the defence benefit is reached. Flows and therefore flood levels downstream can then increase rapidly due to further rain on the catchment until flows fall for a sufficient length of time to enable the storage areas to be emptied.

Provision of Storage outside the floodplain - Upland flood reservoirs

Where there are relatively steep valleys it may be possible to construct reservoirs for flood control. These create additional storage by temporarily raising the water level significantly above its natural level at the downstream end by building a dam. Such reservoirs are usually termed "on-stream" and the area behind the dam is subject to intermittent flooding and hence can be considered a washland. With on-stream reservoirs it is the volume and shape of storage (usually the valley shape) and the design of the outlet, which control the flood hydrograph. Fig 3 shows how the flood hydrograph is modified to benefit flood management.

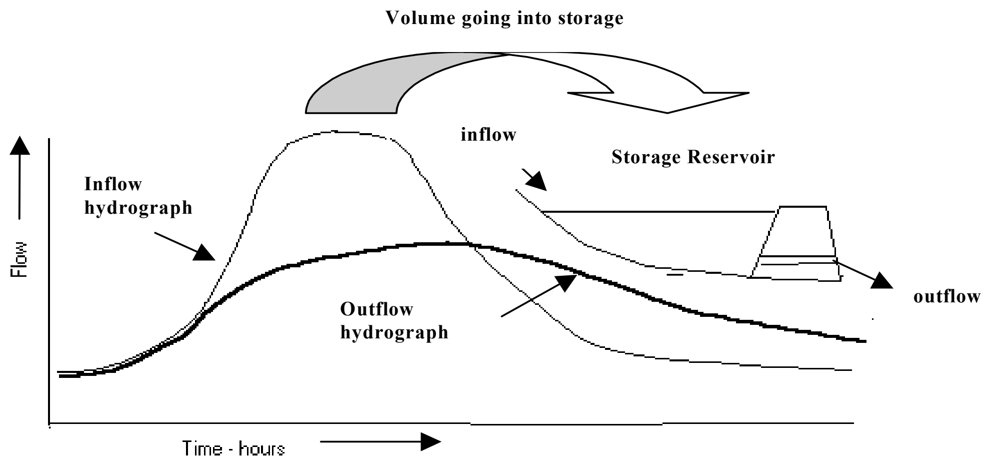

Fig 3 - Effect of on-stream storage reservoir on a flood hydroghaph

By definition this clearly requires a substantial structure and there are generally few suitable sites remaining in catchments that have not been exploited already, e.g. for water supply or where the environmental impact is acceptable. Furthermore, they generally control only a small area of the whole catchment and areas downstream can still be vulnerable to severe events in other parts of the catchment. The current works at Cheltenham are an example where a redundant water supply reservoir has been taken over for flood control purposes.

Land use/management changes to increase storage

2.3. A further option is to increase water storage in the catchment both on and outside the floodplain either on the surface, within the soil structure or within the vegetative canopy. This type of storage is important because it directly affects the rate of runoff feeding watercourses. Generally the greater the storage the lower the rate of runoff and flood peaks are lower and longer, a feature that is usually beneficial to flood mitigation. There are a number of mechanisms by which land use changes can impact on water storage and other associated effects such as soil erosion and these are discussed below. The impact and potential benefits of land use/management options to flood management is an important aspect in the development of CFMP's (catchment flood management plans -see Section 4.)

In urban areas increased storage may be achieved by measures known as Sustainable Urban Drainage (SUDs). Typically these encourage the sub-surface retention of water through enhanced soil infiltration or temporary surface storage in recreational and amenity areas or shallow storage in roads and parking areas.

In rural areas soil infiltration is reduced by intense husbandry practices (caused by heavy machinery and high stocking densities), the long term effects being soil degradation and compaction leading to overland flow and the non use of moisture storage deeper in the soil profile. This situation is exacerbated if machinery and animals encroach onto waterlogged soils. Tillage regimes can reduce overland flow and increase storage, however, deeper long, term compaction of soils may still be increasing the runoff losses. There is also some debate as to how land drains and mole drains influence the balance of overland flow and subsurface flow (dependent on the age of the drains), but it is evident that the net effect of land drainage is an increase in runoff response and a lower soil moisture storage capacity. Land drains can also introduce siltation problems in watercourses affecting the water quality and entire ecology of watercourses.

Loss of hedge and ditch features to enlarge field size can have local impact on flood development by reducing storage in shallow inundations and creating fast overland flow paths to watercourses. Soil erosion is also enhanced when surface flow velocities are increased by such changes. In upland areas reduced stocking rates may show benefits by improving soil structure, infiltration, and storage and reducing erosion and pollution. Re-establishment of bogs, vegetation and certain types of woodland creation in uplands may also increase storage in these areas.

Floodplain forests may have an important role in attenuating flood peaks, as well as providing many other environmental benefits. Flood flows are able to spread out over natural floodplains and the presence of a diverse woodland structure, e.g. in the form of multiple woody dams on the woodland floor, is likely to aid the retention and delay the release of floodwaters. In addition forests have a significantly higher water retention capacity than open grassland simply because of their vegetative (bio) mass in trees and ground leaf litter.

Strategically placed floodplain forests may therefore offer a means of assisting downstream flood defence. However, several concerns need to be investigated: the effect of the backing-up of floodwaters in developed areas, river access for maintenance, a reduction in engineered flood control, and an increased risk of large woody debris blocking downstream structures. Floodplain woodland is unlikely to cause a significant reduction in storage capacity through the trees themselves (usually less than 1%)." All these approaches can only be as effective as the storage or infiltration capacity available. Once the ground is fully saturated and ponding or the rate of input from rainfall exceeds the infiltration capacity then no infiltration system or surface treatment can have any significant impact on the subsequent rate of run-off and it is then usually termed "sheet run-off". At such times (typical of extreme floods such as those experienced in Autumn 2000) it makes very little difference whether the surface is concrete, grass, bare soil or woodland. However, soil treatments and cropping can have a noticeable effect during the early stages of severe events and in lower duration/more frequent events, particularly on the smaller catchments where a larger proportion of catchment area is cultivated. There are many examples where the threshold return period of localised flooding events has been reduced, or runoff increased as a result of poor land management practices. More work needs to be done to understand how the scale of land use changes effects flood development and the potential for flood management. This is the purpose of research indicated in Appendix A.

3. Wetland creation options

There is a good case for seeking to address both the loss of wetland habitat and the potential for improved flood mitigation as explained in Section 1.4. The benefits from improvements to each of these issues may not be equal and options can be considered to assess the mutual benefits. However these common interests should be moved forward together in suitable cases if the relative benefits are built into the justification of flood mitigation and environmental improvements or woodland creation and funded appropriately. The following section reviews a number of situations where wetland creation can be considered in relation to flood management schemes. The impact of the wetland creation on the effectiveness of the flood management scheme is explained.

Creation of wetlands on land previously protected from flooding to a high standard – where an acceptable change in land use to a wetland allows the standard of protection to the land to be reduced then additional floodwater storage can be gained that provides flood management benefit. The most appropriate flood protection standard to optimise this additional storage would be based on an assessment of flood volumes and flow capacities at critical risk areas in the river system and on the principles of reshaping the flood hydrograph as described in Section 2.1. In assessing the effective storage capacity the maintained water level will need to be taken into account (the higher the water level the less flood storage available). The frequency and depth of flooding that can be tolerated by the wetland habitats will also be a factor to be considered.

Creation of wetlands in existing or new washlands, flood detention reservoirs and flood bypass channels – maintaining a high water table and/or standing water in such areas reduces the storage available for flood management and will require the storage area to be "over-designed" to compensate for this. In a typical washland storing water to a peak depth of 2m, 5-20% additional area might be required to have the same flood alleviation impact. (This assumes two cases where the ground water table is raised by 0.3m to ground level and another where the ground water is raised to allow standing water to a depth of 0.2m) Sustainable wetland creation requires consideration of long term water resource issues in the catchment concerned.

Wetlands created alongside river channels by removing or setting back existing defences or during widening of channels – unless a very large area is involved this will have a neutral impact on storage processes within the floodplain but can increase the capacity of the channel to pass flood flows as described in Section 2.3. Such schemes often provide opportunities for environmental enhancements, especially in urban parks -e.g. R, Quaggy, south London.

Channel vegetation options-Vegetation within the channel can be an effective means of enhancing bank protection and improving biodiversity. Adoption of appropriate maintenance regimes is important and the reduction of flow capacity (conveyance) caused by the vegetation needs to be taken into account in the hydraulic design. Where maintenance is essential, a more biologically diverse but sustainable channel can be achieved through careful design and management though, typically, this will require a greater land area.

Wetlands created by land management changes - changes in land management that can result in increasing temporary storage are discussed in Section 2.3. These include measures such as removing/not maintaining under drainage, restoring ditches, reducing stock levels, restoring arable land to rough pasture and creating woodlands. Given these conditions wetlands will naturally re-establish themselves where they are sustainable. Land management changes that increase storage are nearly always beneficial to flood management. The participation of landowners and managers in this will be crucial and government policy issues that affect, plan for and facilitate this need to be developed. Agri-environment and woodland creation grants are likely to be key delivery mechanisms in this context.

4. Role of Catchment Flood Management Plans (CFMPs) and Water Framework Directive River Basin Management Plans (RBMPs)

CFMPs are a vehicle for assessing the sensitivity of catchments to flood risk as a result of different scenarios, including development, land use change and climate change. They will look at different policy options for flood risk management including strategic storage, local protection and, where appropriate, large-scale changes in land use or alternative development locations. Identifying environmental impact and enhancement opportunities will be an integral part of this process. Multipurpose scheme opportunities such those linked to woodland creation under the England Forestry Strategy will be facilitated by the longer time frame of the strategic approach and improved understanding of catchment processes.

Over the next 5 years or so CFMPs will create a much wider picture of needs and viable approaches to flood management for the whole of England and Wales. These will help assess potential impacts and possibly drive relevant policy changes at the national level. CFMPs should also influence development policy by clearly identifying effective long-term flood management. Measures within a catchment and steering development away from areas that compromise these.

Under the Water Framework Directive (WFD) River Basin Management Plans (RBMPs) will be developed to address ecological objectives.' The choice of flood management measures can impact on water quality and the ability of a watercourse to meet ecological objectives under the WFD, both in terms of the impact of measures on morphology, flow, riverine habitats etc and in terms of the risk of pollution incidents as a result of flooding. It is essential, therefore, that CFMPs and RBMPs are mutually supportive. To this end, each must take account of the other at an early stage of development. The Environment Agency will be the competent authority for the Directive, and will be under a duty to co-ordinate production of RBMPs. Draft RBMPs have to be published by 2008 and earlier preparatory assessments of water quality have to be completed by December 2004.

5. Conclusions and Recommendations

5.1 Conclusions

This paper provides an agreed position statement between Defra English Nature the Forestry Commission and the Environment Agency on washlands, wetlands and land use changes in relation to flood management. It is recognised that this is the first stage of considering policy development linking these issues and that further work will follow.

There is a good case for seeking to address both the loss of wetland habitat and the potential for improved flood mitigation. The benefits from improvements to each of these issues may not be equal. Common interests should be moved forward together in suitable cases if the relative benefits are built into the justification of flood mitigation and environmental improvements or woodland creation and funded appropriately.

Planned and integrated approaches and policies will be required in land management, flood management and nature conservation to deliver an increase in target wetland habitats through the creation of washlands and other flood management approaches.

There is a current shortfall in knowledge and understanding as to the scale and best approach on land use changes. Research has been identified and is progressing that will provide future direction - see Appendix A

5.2 Recommendations

This paper should be widely circulated in the sponsoring organisations and amongst other interested parties to provide a common basis for future research and policy development.

Defra should develop revised guidance on biodiversity and flood management to encourage a more integrated approach and to help reverse the decline in wet habitats.

All Operating Authorities should give greater consideration to flood storage solutions for the management of flood risk, where appropriate.

Partnership initiatives, which deliver multiple objectives through different funding routes, should be encouraged, with the aim of developing at least one pilot project.

Further research on impacts of land use change should follow on from current scoping studies at the earliest opportunity. This should include assessing the scale of land use/management changes required to deliver significant increases in wetland habitats and appropriate levels of reduction in peak flood flows. Results should be used to guide future direction of policy.

Whilst recognizing the limitations of the methods currently available for analysis at catchment scale, those developing Catchment Flood Management Plans should be encouraged to consider the full range of potential approaches to future flood risk management. These should include the impact of changes in run-off and alternative approaches to flood plain use. The Plans should also promote greater understanding of flood risk management through clear explanation of the processes involved and the potential impacts of future changes.

A.1. RESEARCH RESULTS

Many investigations have been carried out on the impacts of land use change both at a general and site specific level. Three examples are as follows.

Impact of agricultural soil conditions on floods - Autumn 2000 (National Soil Resources Institute (NSRI), Cranfield University)

NSRI were commissioned to carry out targeted surveys of agricultural soils in selected catchments which flooded during the Autumn 2000 Floods in order to find any evidence that the condition of agricultural soils had contributed to the severity of the flooding. The work was focused on the Severn, Yorkshire Ouse and Southern Region flood catchments (Uck and Bourne).

Enhanced soil degradation was found in all four catchments with the most severe associated with late harvested crops. Simple calculations based on the potential range of impact on Standard Percentage Runoff suggested a potential increase of between 0.5 and 12% in the total volume of runoff entering the river network during storm events. The report concluded that more research was required to (a) quantify the hydrological impact of enhanced soil degradation on stream response through linked field studies and modelling, and (b) investigate in the field the potential for improved crop, pasture and stock management practices to reduce soil degradation and runoff.

Other research as described in Section 2 of this Appendix will be looking at such effects at the catchment scale.

Wise use of floodplains – Cherwell modelling study

This EU LIFE Nature funded project was undertaken by a partnership including the Environment Agency and the RSPB. It consisted of a series of sub-projects, mostly based on individual catchments in UK, Ireland and France. Most were directed towards understanding how public participation could be used to help deliver wetland creation. However, one element of the project was a hydrological modelling study of the Cherwell. The aim was to compare the effect of different rainfall scenarios on flooding a) with the existing hydrological system and b) with the original, unengineered watercourse.

As it turned out, the Cherwell was not well suited for this comparison because of the complexity of the drainage system: the river flows in and out of a canal. The study was not able to confirm that flooding of urban areas would be less severe with the original, more natural floodplain.

Best Farming Practices - Profiting from a good environment - EA R&D publication (1999)

This was developed in consultation with farmers to introduce good land management practices and explain how following these is also cost effective. Practices covered include avoiding the damage if topsoil through taking heavy agricultural plant into wet fields.

Sustainable Flood Defence - The Case for Washlands - English Nature research report No. 406

This report sets out the case for washlands as a viable flood defence option

Importance of land use on the flooding of the upper Severn in Shrewesbury

Further details are not currently available

The Restoration of Floodplain Woodlands in Lowland Britain

This report describes the findings of a literature review of the potential benefits and problems associated with the development of floodplain woodlands. The report contains recommendations for further modelling work and field based research.

Opportunity Mapping for Trees and Floods

The Parrett Catchment Project, which includes the Environment Agency, Forestry Commission, English Nature and Somerset County Council, are supporting Forest Research in developing a woodland suitability map that may have potential for aiding flood control in the River Parrett catchment in Somerset.

A.2. CURRENT AND PLANNED FURTHER RESEARCH

Review of impacts of rural land use and management on flood generation (FD 2114)

DEFRA with support from the Environment Agency is taking a lead on researching cross-cutting soil management issues through a joint project with the Forestry Commission. This study is intended to cover all Flood Management R&D interests in Rural Land Management.

Traditional rural land management placed considerable emphasis on soil / water management and the effects of ground conditions on run-off. Indeed, best practice in land drainage (an adjunct to flood defence in many rural areas) will ensure that drainage improvements sustain a viable soil / water regime. Equally, poor land management practice is recognised as a major cause of local runoff and soil erosion.

The DEFRA / EA initiative for a programme of Catchment Flood Management Plans (CFMPs) lie at the centre of catchment planning and will in due course form the flood management component of Water Framework Directive plans. On the land management side the National Soils Strategy and the EA's Land Quality Programme are equally significant.

The impact of rural land use management on catchment flood response is a critical issue for CFMPs, closely intertwined with wider issues of farming, forestry and the rural economy. However, as far as modelling is concerned progress on both data and methods is necessary before the full aspirations of being able to analyse and predict the effects of land management on flood generation at a catchment scale can be realised. Information on the impacts of agricultural practice on runoff is far from comprehensive, and there are significant methodological issues to be addressed in extrapolating small-scale experimental observations for catchment-scale application. In order to progress the necessary research BSM has commissioned an overall study, *Scoping the Broad Scale Modelling Hydrology Programme (Calver & Wheater 2002)*. Project FD1913, *Revitalisation of the FEH rainfall-runoff method* is also relevant (see 2.2).

Having improved the representation of land management within the CFMP process, it is essential that the means exist to translate policies to mitigate the impact of land management on flooding into practical interventions on the ground. The ultimate target of the project is thus the control and mitigation of flooding through appropriate modelling tools for policy planning and subsequent management interventions.

The overall objectives of the project are two fold:

Part 1: To review the factors contributing to runoff and flooding in the rural (managed, not natural) environment, and to scope out the research needed to improve the identification of the management policies and interventions to reduce the impact of flooding. Part 1 will provide a critical assessment of the overall picture provided by assembled sources, encompassing both scientific and rural socio-economic issues.

Part 2: To deliver in the short term an improvement in the estimation of the effects of changes in rural land management on flood generation to the CFMP programme.

Others

Land Use Policy Group (LUPG) - " The integration of agricultural, forestry and biodiversity conservation policies with flood management in England and Wales" - Lead by the Countryside Council (CCW) for Wales and due for tender in September 2002.

Joint English Nature and Defra research on " Development of washland creation to benefits both flood defence and biodiversity". Commissioning autumn 2002. (www.english-nature.org.uk)

EPSRC-led Consortium in Flooding

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DEFRA and the EA are supporting EPSRC in the development of an interdisciplinary research consortium in Flooding. The 4-year £4M consortium programme is currently being identified and defined. It will dovetail with the current Joint Defra / EA Flood Management R&D Programme. Subject to final approvals, the research work is due to start in early 2004. The programme aims to enhance our understanding of and ability to reduce flood risk, and to support the development of longer-term flood prevention, management and mitigation strategies. Deliverables will focus on tools and techniques for improving the flood management infrastructure and reduction of flood risk to people, property and the environment.

Three specific objectives have been specified – all include issues of relevance to land management and flooding:

- *Land use and management as a source of flooding* - providing guidance on the effects of agriculture, forestry and urbanisation on flood risk. Potential areas include: use and interpretation of field data; understanding, characterisation and modelling of processes; effects of antecedent conditions, scale and location within the river catchment; responses to mitigate run-off and flooding; communication, socio-economic and institutional factors.
- *Rational approach to flood modelling* – supporting the development and uptake of an integrated suite of models for flood management. Potential areas include: use of methods ranging from simple process representation to advanced full process higher-dimensional models (including advances in CFD); nested and hybrid models; optimising sources of data (including use of remotely sensed data and existing models).
- *Infrastructure as a control of flood risk* – providing guidance on the performance of key types of infrastructure under flood or storm conditions. Potential areas include: response of infrastructure to extreme events; characterisation of structures and systems for modelling and performance assessment; identification, adaptation and replacement of critical infrastructure; interaction between urban drainage and fluvial or coastal flooding.
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An overall study, *Scoping the Broad Scale Modelling Hydrology Programme (Calver & Wheater 2002,* Project FD2104*)* has set the scene for future hydrological research work. (Contact - Defra FM)

Revitalisation of the FEH rainfall-runoff method (Project FD1913) is also relevant bringing the currently used Flood Estimation Handbook up to date. (Contact - Defra FM)

Research projects all take account of other national catchment modelling exercises such as the MAGPIE Model used for estimating diffuse pollution from agriculture, and the MAGIC model [is this really a model? I thought it was more of a GIS-based data system.] which aimed to integrate a large amount of agricultural and land-use information.

The Humberhead Levels Land Management Initiative, known locally as "Value in Wetness", (which involves the Environment Agency, English Nature, English Heritage, Grantham Brundell and Farran (on behalf of IDBs) and the Countryside Agency) will shortly be starting Phase 3 of a research project to assess the wider potential public and private benefits of water and wetlands within the Humberhead Levels - the large, flat, predominantly intensive arable landscape surrounding the top end of the Humber Estuary. The work is being undertaken by Royal Holloway Institute for Environmental Research. Phases 1 and 2 have investigated the different functions of water and wetlands within the area. Phase 3 will assess the social, economic and environmental benefits that these functions can deliver. It will be completed in late 2003. This forms one strand of the Initiative's work to explore new, economically viable and environmentally sustainable approaches to water and land management. (Contact - Countryside Agency)

3. Examples of use of storage for flood management

Lincoln Scheme (Witham/Till detention reservoirs)

These large reservoirs were created upstream of Lincoln to store floodwater that exceeds the capacity of the channel of the River Witham through the centre of Lincoln. There were limited options to improve channel capacity through this length of the river where industrial and commercial development had taken place on the floodplain close to the riverbanks. The detention reservoirs, which increase the threshold of flooding in Lincoln from an annual probability of 1 in 10 to 1 in 100, were created by the embanking of some 1122ha of arable agricultural land and the provision of inlet and evacuation sluices. The area continues to be farmed for arable crops and in recognition of the need to deliberately flood the area with approximately a 1% to 10% annual frequency, one off ‘right to flood’ payments were made to landowners when the scheme was initiated. The average depth of flooding when the reservoirs are at capacity is about 1m so if the groundwater table were permanently raised to provide wetland rather than arable land within the reservoir areas between 100-350ha of additional area would probably be required to provide the same standard of flood alleviation to riverside areas of Lincoln. Purchase of additional land to compensate for this may be justified through environmental budgets.

Ouse Washes

The Ouse Washes cover some 1900ha in a 30km long strip between Earith and Denver Sluices. They are an essential element in the flood control system for the River Great Ouse in Cambridgeshire, which flows across the fens well above the level of the adjacent intensively cultivated land. They provide storage and additional flow capacity to reduce flood risks in the Middle Level area to the north west and the “Littleport and Downham” and “Haddenham Level” Drainage Districts of the South Level, on the Southeast side. The Ouse Washes provide transient storage of flood flows from upstream of the tidal reaches of the River Great Ouse, where the tidal and fluvial waters meet. In a typical winter, excess flood water diverted at Earith into the Washes can be about 70 to 80 million cubic metres, stored for up to three weeks, with an average depth of 3.3 metres over the summer grazing land in the lowest middle reach of the Washes. Over the centuries the system of farming and water management in the washes has created a valuable habitat for waterfowl both during the winter and as a breeding site in the summer. The impact that prolonged flooding has on these habitats, particularly in the summer months provided a subsidiary benefit to justify improved facilities for water evacuation into the tidal river in the form of the recently completed £5 million John Martin Sluice at Welmore Lake, some 3 km upstream of Denver. This has the benefit of making better use of the available capacity for flood management with 50% greater sluice capacity, plus pumping facilities. This allows faster evacuation of late spring floods and so improves opportunities for ground nesting species.

Severn/Vyrnwy washlands

Situated at the confluence of the Severn and the Vyrnwy this extensive area of some 6800 ha of low-grade farmland is embanked to levels that exclude floodwater up to approximately the 1 in 5 annual probability. This ensures that the maximum volume is available to store the peak flows that threaten riverside properties in Shrewsbury and increase their frequency of flooding. The 1997 strategy for these washlands estimated that they increased the threshold of flooding in Shrewsbury from an annual probability of 1 in 5 to 1 in 15. For maximum impact the level of protection to these upstream areas needs to be closely linked to that of the developed areas in the town.

Parrett Catchment, Somerset

The lower reaches of the rivers Parrett and Tone are embanked tidal channels that flow across the Somerset levels where water levels are controlled by a complex system of embankments, sluices and pumps. The levels support a wide variety of habitats and human economic activity. The river flows and levels of the banks are such that many agricultural areas in the levels experience prolonged periods of winter flooding. There are complex relationships between upland run-off, tidal flows, the capacity of the channel and lowland water levels that determine the frequency and duration of flooding on the land and degree of flood risk to the adjacent urban areas. Achieving raised winter/spring/summer water levels is also an issue for some of the environmental interests. The Parrett catchment project has identified some potential solutions with local stakeholders but their likely contribution to overall flood risk management has yet to be evaluated through the current CFMP and further strategic studies.

Leigh Barrier, River Medway, Kent

The Leigh barrier, the largest on line flood control reservoir in Europe, is situated on the River Medway upstream of Tonbridge. The reservoir when full extends to some 278 ha and is designed to increase the threshold of flooding in the centre of Tonbridge from an annual probability of approximately 1 in 10 to between 1 in 150 to 1 in 175 in conjunction with the existing floodwall. During the Autumn 2000 floods the barrier was operated during several flood events. These consecutive events demonstrated the scheme's susceptibility to serial events where there are limited opportunities to discharge the reservoir before the next flood peak. There was criticism that the reservoir was not operated in a way that provided protection to towns further downstream, particularly Yalding. Operating staff were faced with the dilemma that if they operated the barrier at a lower flow level to alleviate some of the flooding in Yalding there would not have been sufficient capacity to reduce the peak flow in Tonbridge and more damage would have been caused. The storage area is maintained for general recreational and low-grade agricultural use but has little specific environmental interest. Retention of higher low flow water levels to create wetland in this area would reduce its flood storage capacity and the standard of protection offered by the facility.

Sussex Ouse strategy for Lewes

Development of this strategy, which includes Lewes (which suffered extensive flooding in Autumn 2000), includes some interesting considerations of storage and wetland creation to alleviate the flood risks in the town. River levels in the town are influenced by both tidal levels and river flows. Upstream of the town there may be opportunities to raise banks to agricultural land so that flooding is less frequent but when extreme events occur there is more storage available to reduce flows through the town. Downstream it may be preferable to remove flood banks so that fluvial and tidal flows can be dissipated over a larger area creating salt marsh and brackish wetland habitat thus reducing river levels in the town. These options have been subject to the outcome of detailed modelling studies and are considered technically viable. However questions are still outstanding over the economic assessment. In addition this work would see the loss of a freshwater SSSI.

Aire Washlands (EA NE study)

In its upper reaches the river Aire passes through extensive washlands in the river valley consisting mainly of grazing land behind low riverbanks. Following the Autumn 2000 floods, a Preliminary Strategic Review (PSR) was prepared that indicated that these washlands can provide up to 25Mm3 of storage and are an essential element in the provision of flood protection in the catchment. Without these washlands the PSR indicates there would have been extensive flooding through Leeds in Autumn 2000 with potential damages of £10's millions. The general view is that the washland systems are not being used to their full potential. Increased use of controlled washlands is likely to be part of the long-term objective for the catchment, however, local solutions are still expected to be needed at individual urban locations.

River Irwell, Salford

An offline flood storage basin on existing sports fields is being constructed as part of the ongoing River Irwell Flood Alleviation Scheme at Salford, which also relies on raised flood defences. Excavating the sports fields to provide the material for the retaining bank and thereby increase the volume of storage available has created this storage. Significant under drainage is required to enable the basin to continue to be used for recreational purposes.

Remotely operated sluices control inundation and evacuation, which requires high standards of forecasting during an event. The reservoir is sited close to the main areas of flood risk so, with good knowledge of the shape of the flood hydrograph, best use can be made of the storage capacity of the reservoir and the flow capacity of the channel through the risk area. However, errors in operation or forecasting can equally lead to non-optimal use and increased risk, if for example the filling of the reservoir is activated prematurely. Such issues are being addressed through the detailed design and operational procedures process.