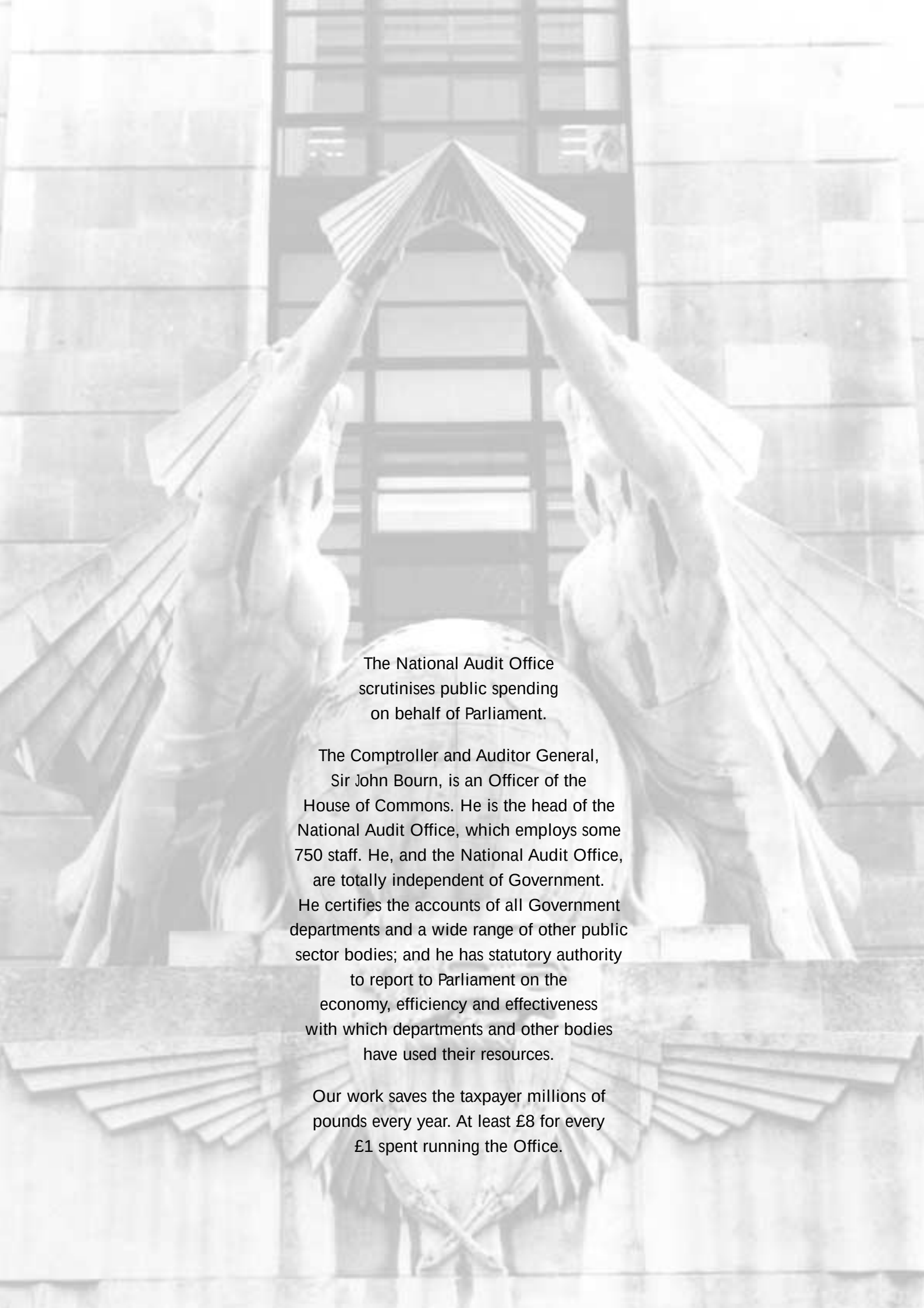
NATIONAL AUDIT OFFICE

Inland Flood Defence

REPORT BY THE COMPTROLLER AND AUDITOR GENERAL
HC 299 Session 2000-2001: 15 March 2001



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John Bourn
Comptroller and Auditor General

National Audit Office
2 March 2001

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Overview

1 The floods in England in 2000 demonstrated the serious consequences which flooding can have for people and their property. 11,000 people were requested to evacuate their homes or businesses. Some 10,000 properties were flooded, out of at least 150,000 in areas which were directly at risk. The rainfall in autumn 2000 was the greatest since records generally began in 1766. In York, river levels rose higher than the previous record of 1625. Forecast changes in climate, storminess and rainfall patterns during this century are expected to lead to an increased risk of flooding. Many houses and business premises in this country have been, and more are likely to be, built in flood plains.

2 The policy aim for flood defence is to reduce the risk to people and the developed and natural environment from flooding. Flood defences are designed to protect against flood events of a particular magnitude, expressed as risk in any one year. For example, defences in urban areas may be built to provide protection against flood events of a size which might occur on average once in one hundred years or less.

3 The Ministry of Agriculture, Fisheries and Food (the Ministry) has responsibility for establishing flood and coastal defence policy in England. It administers the legislation that permits flood defence works to be carried out by others. It maintains an overview of flood defence investment across England. It has established investment priorities and high level targets for the Environment Agency (the Agency), local authorities and Internal Drainage Boards. The Ministry grant-aids some capital works. Other capital works by the Agency and maintenance activities are funded mostly by levies on local authorities, who also fund directly their own work on ordinary water courses. The Agency has a duty to exercise a general supervisory role over all flood defence matters. It is the largest single authority carrying out flood defence work in England. However, the Agency is not responsible for all flood defences. Its powers to disseminate flood warnings, to monitor water levels and to build and maintain defences are only permissive; and these permissive powers are exercised almost exclusively on main rivers. Permissive powers in respect of ordinary watercourses lie mainly with local authorities and Internal Drainage Boards established in certain low-lying areas. Private landowners also have powers to act on their land, subject to relevant consents.

4 Our main conclusions are:

i) Up to 2 million homes and buildings are in areas at risk of flooding. As seen in late 2000, flood defences can reduce the risk or extent of damage; they cannot prevent all flooding. Awareness of the risk and actions necessary before and during a flood - among those responsible for new developments, for flood defence activity and those who live or work in areas at risk - can be the single most important defence against the worst effects of flooding.

ii) The extent of joined-up working required in all aspects of flood defence to protect those at risk represents a massive challenge. The number of bodies involved and the fact that they have separate budgets rather than a single flood protection programme causes confusion and absorbs energy and resources that might otherwise be devoted to planning and implementing flood defences.

iii) Some £300 million is spent each year by all operating authorities in building and maintaining inland flood defences. This requires careful prioritisation of capital and maintenance programmes based on an assessment of risk. The results of a condition survey of the Agency's flood defence assets, completed in 2000, showed some 43 per cent of structures and 36 per cent of linear barriers in England are categorised as only fair, poor or very poor.

iv) In reviewing the lessons learned from flooding in late 2000, the Agency and the Ministry should consider whether the division of responsibility for provision of flood defences and the operation and permissive nature of powers increased the risks of suffering flood damage for some citizens. They also need to do further work to explore whether the basis on which watercourses are currently categorised between main rivers and non-main (ordinary) rivers leads to inadequate and inconsistent levels of flood defence service across different parts of the country.

5 By early 2000, our concern about flood protection had been motivated by the significant amount of work still to be completed by the Agency and others in producing a comprehensive record of the condition of flood defences in England, and in strategic planning of river and water management and provision of flood defence systems in the face of finite resources. Our interest was heightened by the potential threat from changes in rainfall patterns and from building more homes in areas at risk from flooding. And so, at the time the flooding occurred in late 2000, we had already commenced an examination of the issues facing the Environment Agency, the Ministry of Agriculture, Fisheries and Food and others in the provision of flood warning and defence. This report contains our findings, conclusions and recommendations in respect of three main areas:

- Flood warning and public awareness
- Building new defences
- Performance and maintenance of defences

6 The Agency's own review following the floods in late 2000 examines the causes and effects of that flooding; the accuracy of weather forecasting; how the response was managed, including emergency and flood warning arrangements; and lessons that can be learned from flooding that tested the quality of defences to or beyond their design limit. Our report considers more generally the actions taken by the Agency in recent years to protect the public from flooding, and our recommendations and conclusions should contribute to the Agency's and the Ministry's considerations about future action in the wake of recent flooding.

7 In carrying out this examination we explored the scope for international comparisons. However, we found that differences in geography - such as terrain, climate and amount of land and people at risk from flooding - made this difficult. The scale and regularity of flooding in parts of Asia, for example, do not bear comparison. Even in Europe there are significant differences in the size of main rivers and severity of flooding compared with England. For example, although the low-lying land and land drainage in the Netherlands have some similarity with the geography of East Anglia, the rest of England, including those regions affected by severe flooding in Easter 1998 or late 2000, is very different. In terms of severity, we note that in Poland, 54 people died and over 160,000 people were evacuated in floods of 1997; in Italy in October and November 2000 flooding caused more than 30 deaths and over 4,000 people to lose their homes

Building temporary flood defences at Barlby, Yorks - photo courtesy of the British Army

permanently. On the other hand, comparisons of the arrangements for administering flood protection show some similarities between countries. These include the sharing of responsibilities for flood defence between central and local government, and increasing attention being given towards seeking to plan flood defence, management of water supplies and environmental concerns on the basis of river catchment plans, such as in the Netherlands and France.

Our detailed findings

8 Flood forecasting, warning, protection and flood risk information form the basis of risk management by the individual citizen and relevant authorities. Since 1996 when the Agency was established, it has improved the quality and coverage of flood risk mapping for local authorities, emergency services and others. As at mid 2000, the Agency was still working on some 70 per cent of the maps it had expected to produce to assist local authorities in deciding on planning applications in areas at risk of flooding. However, flood risk maps covering the whole of England using the best information available to date were published in 1999 and updated towards the end of 2000.

9 In areas where a flood warning facility exists, the Agency has, on behalf of flood defence committees, increased the percentage of people who receive at least two hours notice of flooding from 13 per cent in the early 1990s to 65 per cent in 1998 and has targets to increase this further to 80 per cent over the next 10 years. The Agency continues to carry out flood awareness campaigns on behalf of flood defence committees, to ensure the public recognises the risks and takes appropriate action. Research by the Agency (which predated flooding across many parts of England in October and November 2000) showed that 19 out of 20 people in flood risk areas did not take the possibility of flooding seriously.

10 The organisational arrangements for the provision and funding of flood defence are acknowledged to be very complex and were already under review by those responsible prior to flooding in late 2000. Responsibility spans the Ministry, the Agency, all local authorities and district councils, 9 Regional and 11 Local Flood Defence Committees, and 235 Internal Drainage Boards. While complex, these arrangements do have some benefits in terms of identifying and attempting to address local needs and priorities for flood defence.

11 The Ministry estimates that existing defences reduce the annual cost of damage as a result of flooding by over £2 billion. To that extent, therefore, the annual investment by operating authorities of some £400 million on flood defences, more than half of which is managed by the Agency, represents good value for money. However, even before the floods in late 2000, there was pressure to build more defences, to maintain existing defences in good condition, to take more account of environmental issues and of the changes which can occur in flood risk areas as a result of new development. We suggest there are a number of areas, such as strategic planning of flood protection, benchmarking and economic appraisal of maintenance, where more progress is needed to enhance the effective allocation of resources in the longer term.

12 The condition survey of the Agency's flood defences completed in October 2000 showed significant variations across regions. In the North East region, for example, some 85 per cent of linear barriers were assessed as fair, poor or very poor, and the Midlands and South West regions had around 54 per cent of their linear defences in these categories. These contrast with the North West and Thames regions which had, respectively, 84 per cent and 74 per cent of their linear defences assessed as in good or very good condition. The number of structures categorised as fair, poor or very poor ranged from 18 per cent in the North West region to 50 per cent in the Southern region. The Agency sees this as the result of different policies and practices from individual flood defence

Chinook transport helicopter dropping sandbags - photo courtesy of the British Army

committees, the cumulative effect of local funding decisions by them, and the availability of grant-aid. Agency staff offer advice to Flood Defence Committees but they may or may not accept such advice. Work by the Agency to analyse the results of a similar survey of flood defence assets built and maintained by other public bodies must be completed urgently so that remedial action can be identified and prioritised.

Our specific recommendations

On flood warning

13 The Ministry estimates that eight per cent (around 10,000 square kilometres) of land area in England is at risk from flooding from rivers, tidal rivers and estuaries. The Agency has in recent years made progress in preparing priority area flood risk maps to assist local planning authorities but of the 821 maps in its programme only 200 had been produced at June 2000, with 376 in progress and a further 245 not started. The original programme commenced in 1995. The Agency also seeks to provide map based information on indicative flood risk which is intended to inform the emergency services, via local authorities, and the public, about areas at risk. These two sets of maps have now been merged and made available on CD-ROMs and the Agency's website. It is not clear whether all users fully understand the purpose and contents of these maps, or are satisfied with their quality (paragraphs 2.4-2.14). We recommend:

- The Agency and the Ministry should work with the Department of the Environment, Transport and the Regions, and the Local Government Association to develop a strategy for the way ahead for priority area information on the maps. This is necessary to ensure that the appropriate information is available to local authorities in applying new guidance on building development in areas at risk, which is being revised in early 2001.
- In the light of this, the Agency should review progress by its regional offices in producing this information, and set targets for its completion. For example, in Southern Region - one of the first areas to be hard hit by flooding in late 2000 - only one out of the 40 maps planned had been completed.
- The Agency should establish a programme for consulting all groups of users of the maps to ensure their purpose is clearly understood and the maps are meeting their intended purposes. The feedback obtained can be used to improve any maps still to be produced, and be taken into account when existing maps are due for revision.
- The preparation and maintenance of maps is expensive, and has been largely funded through local authorities by Regional Flood Defence Committees. It would seem appropriate for developers and other beneficiaries of the maps to contribute towards their cost, especially when such users require more information on the risk of flooding in specific locations. The Agency has suggested that in certain circumstances the onus should be on developers to provide detailed assessments of risk.

14 Since Easter 1998 when flooding in England revealed scope for improvement, the Agency has made significant progress in developing a strategy for flood warning, in establishing a national centre to identify and promote best practice, and in developing the techniques for disseminating flood warnings. The most effective warning mechanism can vary depending on, for example, the extent of urbanisation and the time of day when flooding is imminent. The Agency aims to provide one direct and one indirect method of disseminating flood warnings to the areas for which it offers a service. Less than five per cent of the 1.5 million properties at specific risk are connected to automated voice messaging, which provides one method of direct warning via telephone or fax when flooding may occur. The highest percentage, 16.4, is in Southern region where the service was

piloted and was used extensively during floods in October 2000. This compares with only 1.3 per cent in the North East. Other direct methods include the use of locally recruited flood wardens. Sirens and vans with loudhailers can augment radio and television bulletins and have benefits too as indirect methods (paragraphs 2.15 to 2.26). We recommend:

- The Agency, through the flood defence committees, should examine the reasons for the variations between regions in the number of properties in areas at risk which have access to different direct warning methods, especially automated voice messaging. They should consider the effectiveness of the methods and whether a consistent service exists across the country. Experiences from the floods in late 2000 may prove useful in this respect.

15 The reasons for current classifications of watercourses as main rivers or ordinary watercourses are largely historical. For example, the North West region has the second highest length of watercourses classified as main river after Anglian region, although it is one of the smaller regions in terms of size and properties at risk. The designation of a stretch of water can have important implications for the level of flood warning and defence services, and existing classifications may lead to inconsistencies in the standard of service provided (paragraphs 2.27 to 2.35). We recommend:

- The Agency should consider, in conjunction with other operating bodies, whether clearer principles for classifying watercourses are needed to provide a more balanced approach to service provision across regions. The Ministry would also need to be involved in setting a framework for consideration of these issues.
- The incidents of flooding in October and November 2000 should be examined to determine whether the lack of clear criteria for classifying watercourses as main or ordinary impacts on the overall prioritisation of flood defence measures across the country, and on the quality of service to the public.

On building new defences

16 Guidance issued by the Ministry in 1993 stresses the importance of a strategic approach to planning river and water management, which considers the impact of building flood defences and the interrelationship between watercourses, land use and development by river catchment. The preparation of strategic river catchment plans would assist in balancing the differing interests of environmental groups, users of the land and others, and help create a more joined-up approach between relevant organisations at local and regional levels. However, progress towards comprehensive river catchment planning of this sort is a long-term commitment. In the four years of the Agency's existence, it has focused first on strategies for flood warning and coastal shorelines, in line with the Ministry's priorities. The first versions of these shoreline management plans are now in place. The flooding of late 2000 has reinforced the need for catchment planning (paragraphs 3.3 to 3.10). Additional funding announced by the Government in November includes provision for development of the methodology and piloting of catchment flood management plans. We recommend:

- The Agency should seek the agreement of flood defence committees to make progress with the proposed catchment flood management plans to improve the identification and prioritisation of the need for flood defences. Preparation of such plans requires joined-up working between those responsible for planning, building and maintaining defences. Consistent with its supervisory duty, the Agency should consult with them and establish a programme and timescales for its regional offices to develop these plans.

17 On a scheme by scheme basis the Ministry has established a system for prioritising projects to assist in effective allocation of the overall funds available. The Agency and the Ministry also use benefit:cost analysis to help them choose the most cost-effective option for providing flood defences, and they take account of environmental factors (paragraphs 3.11 to 3.17, Appendix 5). We recommend:

- The Ministry's follow up to its recent consultation exercise on the present scoring system for ranking individual projects should consider whether relative affluence or other local factors inappropriately influence prioritisation of projects.
- The benefit:cost appraisal process should be strengthened by reviews of outturn costs of all elements of the project after the project is complete. This would better inform the process of assessing likely costs at the initial and tendering stages of a scheme.

18 For the 168 new flood defence schemes between 1996 and 1999, for which we compared outturn costs with original contract price, the overall aggregate cost overruns were 7.6 per cent. However, larger projects were the most likely to overrun and by a significant amount (13 per cent on schemes over £500,000). Unforeseen ground conditions and extra works identified by the contractor were the most common contributing factors in cost overruns in the past. This suggested to us that scheme design could be improved, for example, by more thorough site investigation procedures. The Agency has adopted a new policy for the amount invested in such investigations, based on an assessment of risk and experience from past projects. The Agency has also modernised its approach to managing the risks involved in construction contracts, in line with construction industry initiatives and best practice, for example by the use of target cost contracts and arrangements for sharing risk with contractors. The Agency monitors the performance of all construction contracts by benchmarking and the use of performance indicators measuring the delivery of projects to time, cost and quality criteria (paragraphs 3.18 to 3.25). We recommend:

- The Agency should monitor the application and impact of its recent initiatives, to ensure best practice in procurement and project management is applied across its regions, and to disseminate lessons from reviews of completed schemes to help ensure the best use of resources.

On the performance and maintenance of defences

19 The quality of flood defences is difficult to assess as they protect against the risk of relatively severe and unusual weather conditions. Many will not have been tested by the extent of flooding they were designed to withstand or reduce. Post-incident reviews of lesser events demonstrate that defences stand up to their tasks and that flooding is most often the result of extreme events rather than failures in defences. Events in late 2000 have highlighted that defences generally reduce rather than eliminate extreme flooding, which reinforces the importance of public awareness of living in areas of risk. Until 2000, there had been no national record of individual incidents of flooding. Since floods in Summer 2000 in the North East of England, the format and content of the lessons learned report prepared for those incidents have been adopted as the best practice standard for use by all Regions. These reports will now be shared nationally via the Regional Flood Defence Managers Group (paragraphs 4.2 to 4.9). We recommend:

- The Agency needed to collect more information nationally on the success of schemes in coping with lesser flood incidents. The reports for this purpose introduced in 2000 should be used to help in evaluating the effectiveness of flood defences and to ensure that lessons arising and good practice are disseminated across the Agency's regions and also to other operating bodies such as local authorities.

Breached flood defences at Gowdall, Yorks - photo courtesy of the Environment Agency

20 The Agency has been carrying out visual surveys on the condition of flood defences, in part to indicate where maintenance work, and in some cases capital work, is required. For the first time there will be a central record of the location and condition of all flood defences, whether the responsibility of the Agency or other operating authorities. The surveys of main river defences have revealed that the condition of around 40 per cent of the Agency's flood defence assets is fair, poor or very poor and giving cause for concern. The Agency has experienced difficulties in obtaining the assistance of up to 135 local authorities in completing surveys of non-main river defences. 27 of these were assessed by the Agency as having significant lengths of critical ordinary watercourses in their area (paragraphs 4.10 to 4.17). We recommend:

- The Agency's regional maintenance and capital programmes submitted to flood defence committees for approval are being reviewed to take account of the results of the surveys of Agency assets. Where defences are still intended to serve some useful purpose, work should be put in hand on those 400 structures and 165 kilometres of flood defences which have completely failed.
- The analysis of the condition ratings for other flood authorities' assets should be completed quickly, particularly in view of the severe flooding in late 2000 and of the results from the survey of the Agency's own flood defences. Additionally, the Agency should confirm the accuracy of its own condition survey in those cases where defences were tested in the recent flooding.
- The Agency should monitor centrally progress by its regions, flood defence committees and by local authorities and other operating bodies. The aim would be to encourage the undertaking of appropriate action, maintenance and other works with the prospect in the long term of appropriate and more broadly consistent standards of flood protection across the country, taking account of economic benefits.
- Variations between regions in the condition of assets should be investigated by the Agency, with a view to establishing whether the criteria for assessment have been applied consistently, and ultimately with the aim of developing a strategy with local authorities and others for improving the condition of defences in the poorer rated regions.

21 The Agency employs a workforce of 1,570 across England to provide an emergency response to flood events. As flood emergencies occur infrequently, the Agency seeks to employ these staff throughout the year on its maintenance programmes. Reviews commissioned by the Agency suggest that the in-house workforce provides an effective emergency response and carries out a high standard of maintenance work (paragraphs 4.18 to 4.35). We recommend:

- The Agency should monitor the proportion of time spent by its in-house staff on emergency response across areas and over time. Such data might assist the Agency in confirming whether the need for resources is matched to maintenance requirements and whether there is scope for more efficient use of resources.
- In one region where maintenance or other work was insufficient to keep the in-house staff usefully employed, they were awarded, without competition, a contract to build a new defence estimated to cost £1.2 million. The cost of the work overran by 74 per cent. The Agency has assessed the lessons arising from this contract and is implementing a new approach across the regions. The Agency should ensure full compliance with this new policy and approach.

- The Agency should consider establishing common standards and best practice in maintenance to be applied across regions and seek the agreement of flood defence committees to these. It should consider the need for closer monitoring by its regional offices and headquarters to ensure maintenance is efficient and targeted to the standards of service required.

Flooding in late 2000: and the way forward

22 Prior to flood events of late 2000 the Agency had asked us to indicate whether future actions we identified in our report were of primary or secondary significance. Relative priorities and resource implications are mainly matters for those responsible for delivering services and for their customers. In the case of flood defences, the Agency has to secure approval from flood defence committees to provide funding and agree priorities. Priorities will also depend on the outcome of the reviews by the Agency and others of funding and organisational matters already underway in 2000 and the review of lessons from the flooding in late 2000. Of our main findings listed above, we regard the following as high priority, although it will be for flood defence committees, with the advice of the Agency, to determine the speed of progress.

- The development of strategic plans for all river catchments is of pressing importance. Whilst these will take several years to complete, the setting and agreement of targets for the Agency's regions to produce such plans and the close monitoring of progress is a priority. These plans are fundamental to the long-term upgrading of flood defences to take account of local conditions, existing risks and defences, and the impact of changes in sea level, climate and rainfall.
- The Agency's mapping of areas at risk to meet local planning authority needs has been underway for some years now. The recent floods have raised concerns that further or inappropriate development in flood plains will lead to more frequent and extensive flooding. In view of this, and new guidance to local authorities on this matter which is to be issued in early 2001, completing and modifying these maps must be a high priority.
- Urgent action is needed in response to the condition surveys of flood defences. Until the need for remedial work is clarified and advice given to local authorities and others in respect of their assets, defences in areas of risk may not provide the level of safety the Agency and residents believe. Monitoring progress in improving the condition of defences, whether belonging to the Agency, a local authority or an Internal Drainage Board, will be a priority for the Agency.
- During the course of our work, the Agency had already started work on benchmarking and economic evaluation of maintenance. This too is important because of its contribution to the quality of flood defences and the possible scope for identifying savings and releasing resources for other flood defence work.

Part 1

Introduction

Why is inland flood defence important?

1.1 The threat of flooding has been present since people began to settle close to rivers in order to maintain trade and communication links. For centuries therefore, it has been necessary to protect these areas from flooding, by building defences that supplement natural features such as riverbanks. Up to 5 million people and 2 million homes, businesses and other buildings in England are in areas at some risk of flooding. The Ministry of Agriculture, Fisheries and Food (the Ministry) has estimated that if there were no defences in England and Wales, the annual average value of damage from flooding and coastal erosion would be of the order of nearly £3 billion. With the existing defences, damage still occurs but is of the order of an average £600 million a year.

1.2 Over the next 50 years, climate change is expected to lead to changes in rainfall patterns and more unpredictable meteorological conditions and storminess. These would increase the frequency with which existing flood defences are overwhelmed and flooding occurs; and increase the rate at which defences deteriorate. The following is just one example of the extent of rainfall suffered in one region at the start of severe flooding in October and November 2000.

What is the nature of inland flood defence?

1.3 There is no absolute definition of 'inland' but by implication it includes all river (or 'fluvial') defences and excludes those defences located on the coastline and in the sea. Tidal and estuary areas - where rivers and the sea interact - by their nature fall between inland and coastal defences. For example, Lewes in East Sussex is a coastal estuary town. The flooding it suffered in October 2000 reflected a combination of rainfall and tidal effects which prolonged the period it took for river levels to return to normal and for floodwater to recede. For the purposes of this study, we include tidal defences in the definition of inland flood defences.

1.4 Flood defence seeks to reduce the risk of flooding and to safeguard life, protect property and sustain economic activity. Constructed defences take a number of forms, and some examples are shown in **Figure 1 (overleaf)**. Lesser forms of defence, such as sandbags provided by local authorities, can also provide some protection in the face of flooding. Maintenance work is carried out on flood defence structures, but maintenance also includes work to control rivers and banksides such as annual removal of channel vegetation and regular dredging.

Extent of rainfall, October 2000: an example

In October 2000, South east England experienced further prolonged and intense rainfall after an exceptionally wet September. The total rainfall was four times that of the average for the month. In the first half of October, the Agency's Southern region recorded twice as much rainfall as is normally experienced in the whole of the month. The majority of this fell between 10 and 14 October when an area of low pressure moved less quickly than usual. In that period, over 700 properties were flooded in Sussex, mainly Uckfield and Lewes, 100 plus in Kent, mainly Yalding, Maidstone and Tonbridge, and 80 in Ryde, Isle of Wight.

Rainfall in November led to the ground being so wet that the Agency was warning that even an average amount of rainfall might lead to flooding anytime between then and the Spring.

Photo: The town of Lewes under floodwater. Courtesy of PA News

1.5 Flood warning systems are also a form of defence in that they seek to reduce the risk to life and the economic impact of flooding. Warnings enable advance action to be taken by emergency services, individuals at risk and public utilities. The level of water in some rivers and weather forecast information are used to make predictions about when and where flooding might occur. Apart from an "all clear", there are three categories of flood alert: severe flood warnings; flood warnings; flood watches, as indicated in **Figure 2**.

Who is responsible for flood defence?

1.6 The administrative arrangements for the provision of flood defences are highly complex. In broad terms, the responsibilities and activities relating to flood defence in England are reflected in **Figure 3**. These can be divided into two main categories:

- policy, strategic guidance and administration of legislation are the responsibility of the Ministry. The Ministry also sets investment priorities and grant-aids some capital projects.

1 Examples of inland flood defences

Flood defence schemes are primarily concerned with the protection of the surrounding land. This can be achieved through a variety of flood defence constructions. These include:

Building up riverbanks

The natural slope of the riverbank can be built up to increase the water-flowing capacity of the river channel and provide enhanced protection against floods. Routine maintenance is necessary to ensure that the sides of the slope remain stable and are not eroded.

Photo: An estuary on the South Coast. Courtesy of the Environment Agency

Building walls or providing defences along the river

Steel, concrete or brick structures along the length of the river to provide man-made protection against flooding. These structures provide a higher level of protection than existing natural defences and can also regulate the speed at which water flows down the river. Maintenance is required to ensure that these structures are not eroded or suffer corrosion.

Photo: A structure on the River Trent at Gainsborough. Courtesy of the Environment Agency

Outfalls and storage reservoirs

When water reaches a certain level in the river an outfall regulates the flow of water in the main channel by allowing water to be redirected to a holding area. This water is allowed to flow back into the main channel when the peak surge has passed. Maintenance is required to ensure that the outfall does not become blocked by debris in the river stream and the working parts are operable.

Photo: An outfall on a tributary of the River Trent. Courtesy of the Environment Agency

Sluices

These are used to control and regulate the flow of water down the river channel. They can also be used to protect against tidal surges upstream. Maintenance is required to prevent blockages and ensure the structure remains operable.

Photo: Welmore Lake Sluice on the Ouse Washes, East Anglia. Courtesy of the Environment Agency

Source: National Audit Office

- flood defence measures. These are the responsibility of the "operating authorities", mainly the Environment Agency through Flood Defence Committees; Internal Drainage Boards; and Local Authorities. In addition, flood defences may be privately provided. For example, by companies such as Railtrack and those involved in power generation and owners of land near rivers.

1.7 An important attribute of the legislation is that it provides **permissive powers** for operating authorities and private owners to carry out flood defence work. Work is not mandatory and the powers do not specify benchmarks as to the standards that flood defences should meet. For the most part, private owners and companies cannot be required to build flood defences even if flooding on their land affects others, although private owners of watercourses have a responsibility to maintain them to an appropriate standard, under the Land Drainage Act 1991.

2 Flood warnings 12 October - 12 November 2000

In the middle of October, few parts of the country were not under flood alert. For example, at midday on 12 October there were:

- **5 severe flood warnings - where large numbers of people and property are at risk; there is imminent danger to life and property; people must be prepared to evacuate at short notice and to lose power and water supplies** - covering stretches of five rivers in Kent and Sussex.
- **47 flood warnings - where people in areas of risk are advised to begin preparations in case of evacuation** - covering certain stretches of river or rivers in Devon, Isle of Wight, Sussex, Kent, Surrey, Warwickshire, Staffordshire, Derbyshire, Leicestershire, West Midlands, Powys, Shropshire, Yorkshire.
- **92 flood watches - where people are advised to be aware that flooding is possible** - covering certain rivers in Devon, Dorset, Wiltshire, Cornwall, Hampshire, Isle of Wight, Sussex, Kent, Surrey, Essex, Suffolk, Norfolk, Hertfordshire, Oxfordshire, Gloucestershire, South West Wales, the Midlands, West Yorkshire, the North Sea Coast, North Pennines, Tyne, Wear and Tees Valleys.

On 16 October floodwaters were receding and no severe flood warnings were in place for England and Wales, although there were 4 flood warnings in East Sussex and a number of flood watches in Hampshire, Kent and Sussex. The affected parts of the country began the cleaning-up process after flooding. Then on Sunday 29 October, heavy rainfall and storms and forecasts of gale force winds led to the Agency issuing new flood warnings. Over the 14 days 30 October to 12 November at any one time there were between 8 and 43 severe flood warnings; and between 60 and 300 flood warnings. For example, at a peak at 17.30 on 7 November there were:

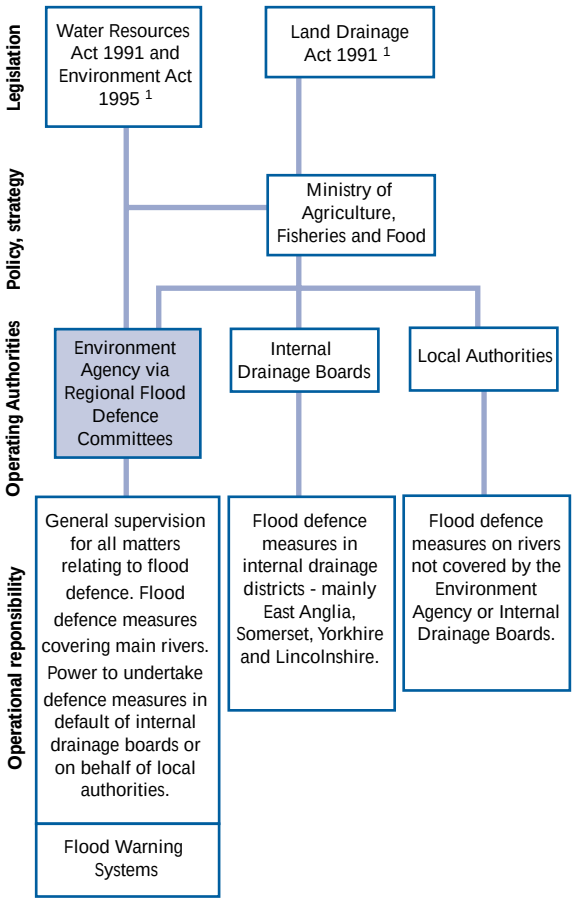
- **43 severe flood warnings on some 26 rivers** - covering stretches of the Rivers Trent, Severn, Dove, Sow, Derwent (Midlands); Rother, Arun, Tiese, Bourne, Beult, Medway, Eden, Great Stour, East Stour, Wey, Thames (Southern); Ouse, Aire, Derwent, Calder, Gaunless, Wear, Ouseburn; Wansbeck, Pont (North East); and Lower Dee (Wales).
- **232 flood warnings across England and Wales.**

By the weekend of 11 and 12 November, there was a general improvement in the flooding situation as river levels steadied or decreased. However 8 severe and 67 flood warnings were still in force on parts of 5 rivers in England and Wales, and the Agency was advising that rivers were still extremely sensitive to further rainfall.

Source: National Audit Office

1.8 Watercourses in England are categorised as main rivers and ordinary watercourses. These categories are important in determining where responsibility for flood defence lies. Broadly, measures for main rivers are the responsibility of the Environment Agency whereas ordinary watercourses are the responsibility of local authorities and, in some parts of the country, internal drainage boards. There are no strict criteria for determining what should be a main river although they include all the longest and greatest rivers in England, stretches of many other rivers and many watercourses. Ordinary watercourses are all other watercourses, with critical ordinary watercourses being those which have the potential to put at risk from flooding large numbers of people and property. By way of illustration the map at **Figure 4 (overleaf)** identifies the main rivers and some ordinary watercourses of the River Trent and its tributaries.

3 Key responsibilities for inland flood defence in England



Note: 1. This legislation specifies the legal competencies and powers for flood defence activity.

Source: National Audit Office

4 **The main rivers and some ordinary watercourses of the River Trent and its tributaries**

5 **Environment Agency - structure and responsibilities for flood defence**

The Agency has a wide range of duties relating to different aspects of environmental management including water management (of which flood defence is a part) and environmental protection. The Agency has an in-house workforce of some 1,570 staff to carry out flood defence work, mainly maintenance and response to emergencies.

The Agency's eight regional offices are responsible for implementing policy and delivering flood defence services as approved by Flood Defence Committees.

The Agency's 26 area offices are responsible for programme delivery, maintenance of flood defences and flood warning, as approved by Flood Defence Committees.

The Agency's Headquarters is in Bristol and is responsible for developing policy, setting standards and external liaison, including interface with the Ministry.

Source: National Audit Office

Policy and strategy: the role of the Ministry

1.9 The Ministry has responsibility for establishing flood and coastal defence policy in England and administers the legislation that enables flood defence works to be carried out. The Ministry's main tasks involve issuing national strategic guidance, the approval of proposed measures, the payment of capital grants to operating authorities, funding a research and development programme, and ensuring dissemination of best practice. Regionally based staff of the Ministry take decisions or advise on the approval of individual flood defence capital schemes. In April 2000, the Ministry set a series of high level targets for operating authorities to monitor achievement of its aims and objectives for inland and coastal flood defence.

Operations: the role of the Environment Agency

1.10 The Environment Agency (the Agency) is a non-departmental public body which succeeded the National Rivers Authority on 1 April 1996. The structure and organisation of the Agency is shown in **Figure 5**. The Agency has a duty to exercise general supervision over all matters relating to flood defence. This includes activities such as:

- providing advice to planning authorities and developers on flood risk;
- surveys of flood risk areas and of the condition of flood defences;
- monitoring and encouraging other operating authorities to inspect defences and critical ordinary watercourses; and
- assessing flood risk and the means by which it might be reduced.

1.11 The Agency's permissive powers are to regulate and influence; and more specifically to disseminate flood warnings; maintain, operate or build flood defences and associated structures. The Agency's permissive powers for flood defence building and operations apply only to watercourses designated by the Minister of Agriculture as 'main rivers'. The Agency, through a Ministerial direction in 1996, provides a flood warning service on all watercourses. In practice this applies mostly to main rivers. The key aspects of the flood warning service are:

- monitoring tide and river levels and weather forecast information from the Meteorological Office to identify where flooding is a possibility;

- issuing general flood warnings via the media; and specific warnings to the emergency services and properties in high-risk areas; and
- encouraging the public to seek information via the Agency's Floodline telephone service.

1.12 The Agency is required to exercise all of its flood defence operations through regional and local executive flood defence committees. These were set up under statute to raise funds, mostly from local authorities, and to determine flood defence programmes with advice and recommendations from the Agency. There are nine Regional Flood Defence Committees supported by 11 Local Flood Defence Committees in England, and, in one region, three local advisory committees (**Figure 6**). Flood defence committees provide a direct link with the public and other customers of flood defences.

1.13 Regional Flood Defence Committees comprise a Chairman and a number of members appointed by the Ministry, two members appointed by the Agency and a statutory majority of councillors from local authorities. Three of the nine Regional Flood Defence Committees have appointed three or more Local Flood Defence Committees. These comprise a Chairman and members elected by the Regional Flood Defence Committee and councillors from local authorities, the latter comprising the majority on the Committees.

1.14 Regional Flood Defence Committees are responsible for raising the necessary funding from local authorities for the Agency. Where there are Local Flood Defence Committees, these have delegated powers from the Regional Committee to raise funding in the same way for their local area. These levies fund maintenance, flood warning, advice to planning authorities, consent for work affecting flood drainage systems, and administration expenditure and that proportion of capital projects not funded by the Ministry. Income and expenditure, as approved by the flood defence committee, is ring-fenced to flood defence. It may only be spent in the committee's area or on costs incurred by the Agency on work for that area. Local authorities receive funding for flood defence through the Revenue Support Grant made available by the Department of Environment, Transport and the Regions. However, this element of Revenue Support Grant is not "ring fenced" to be spent only on flood defences. Local authorities may decide to spend it on other priorities.

6 **Flood Defence Committees**

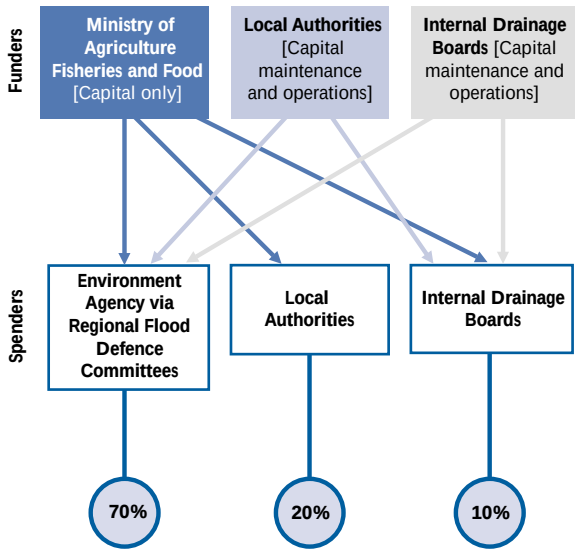
Environment Agency Region	Regional Flood Defence Committees	Local Flood Defence Committees
Anglian	Anglia	Essex
		Great Ouse
		Lincolnshire
		Norfolk and Suffolk
		Welland and Nene
North East	Northumbrian	—
	Yorkshire	—
North West	North West	Three local advisory committees
Midlands	Severn Trent	—
Southern	Southern	Hampshire and Isle of Wight
		Kent
		Sussex
South West	South West	—
	Wessex	Avon and Dorset
		Bristol and Avon
		Somerset
Thames	Thames	—

Source: National Audit Office

Operations: the role of internal drainage boards and local authorities

1.15 Internal Drainage Boards are independent bodies created under land drainage statutes, which can trace their ancestry in some cases back to the 13th century. There are 235 such boards in England concentrated in the lowland areas of East Anglia, Somerset, Yorkshire, and Lincolnshire where there are special drainage needs. Many of the boards operate as consortia, of which there are 65. They have permissive powers to undertake flood defence works, other than on main rivers, in a defined geographical area. Each board includes those elected by and representing the occupiers of land in the area and members nominated by the local authority or authorities in that area. Internal drainage boards secure income mainly from drainage levies on farmers and other occupiers and from special levies on local authorities. They must also pay levies to the Agency to fund works on main rivers that protect internal drainage board areas.

7 Funding of inland flood defences in England



Source: National Audit Office

1.16 Local authorities - primarily district councils and unitary authority councils - have permissive powers to undertake flood defence works on watercourses not designated as main rivers and which are outside drainage board districts. In addition, through levies paid to Regional and Local Flood Defence Committees, local authorities - primarily county councils and unitary authority councils - fund most of the flood defence work on main rivers carried out by the Agency. Local authorities and the emergency services are responsible for implementing emergency plans in the event of serious flooding, including rescue of those at risk.

1.17 One of the considerations local planning authorities take into account in examining applications for planning permission is flood risk. For example, they consider whether development is proposed in an area of risk and whether the plans take account of that; or whether the development could have an impact on flood risk in other locations. The Agency provides advice to the authorities on these considerations in the context of development proposals. However the local planning authority takes into account many other material considerations arising from the public interest, such as the need for additional housing or the benefit of development to the local economy. Therefore local authorities may allow development even if it may have an adverse impact on flood risk.

What are the aims and objectives for inland flood defence?

1.18 The Government's policy aim is to reduce the risk to people and the developed and natural environment from flooding and coastal erosion. The Ministry and the Agency seek to meet three main objectives:

- to encourage the use of adequate and cost effective flood warning systems;
- to encourage the provision of adequate, economically, technically and environmentally sound and sustainable flood and coastal defence measures; and
- to discourage inappropriate development in areas at risk from flooding and coastal erosion.

How much is spent on flood defences and who funds it?

1.19 In 1999-2000 total expenditure on all flood defences by all operating authorities in England and Wales was estimated by the Agency to be some £400 million. Expenditure by the Agency on behalf of flood defence committees, at £275 million, accounts for almost 70 per cent of this sum (**Figure 7**). Of this the Agency spends some £240 million in respect of inland flood defences. £125 million is the Agency's estimate of local authority and other operating authorities' expenditure on flood defences on non-main rivers and some coastal defences.

1.20 The main components of funding for the Agency's flood defence programme are shown in **Figure 8**. Agency expenditure is planned to increase to £283 million in 2000-01 and to £290 million the following year. A further £51 million over four years was announced by the Government in November 2000. A funding package was arranged in January 2001 to assist in meeting the Agency's emergency costs arising out of the floods in 2000. This included £6.6 million additional funding for 2001-02.

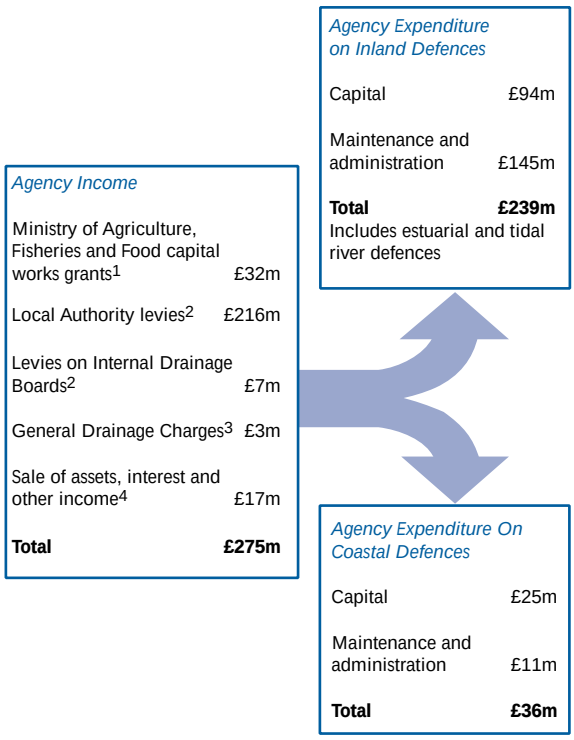
Why did we do this study?

1.21 The subject is clearly topical. A number of reviews of flood defence issues relating to the work of the Ministry and the Agency had taken place in recent years (**Figure 9**). However, the very severe flooding in late 2000 confirms the need for continuous assessment. While experts may vary in their predictions and estimates of the long-term significance of climate changes and rainfall patterns, the apparent consensus is that the risk of flooding is likely to increase in the future.

1.22 Spending is increasing. As shown in Figure 8, the Agency spends approximately 87 per cent of the funding that it receives for flood measures on inland flood defences, with around 13 per cent being devoted to coastal defences. The Government's Comprehensive Spending Reviews in 1998 and 2000 provided for an increase in the grants payable by the Ministry and in the flood defence element of Revenue Support Grant/Standard Spending Assessments for local authorities. Following severe flooding in 2000, the Government announced additional expenditure of £57.6 million over the next few years.

1.23 More properties may be built in areas of risk. The Government is expecting 4.4 million extra homes to be created by 2016. The nature of this country's geography and its housing needs are such that there is significant pressure to build in "flood plains" which by their nature are more prone to flooding than other areas. In the light of this and the recent incidents of flooding, the need for people to be satisfied with the action taken to protect them and their property is unlikely to diminish.

8 Environment Agency - flow of funds for flood defence in England in 1999-2000



Notes:

1. The Ministry grant-aids capital projects but not maintenance expenditure. The rate of grant varies depending on the region or district and whether the scheme is fluvial or tidal. The Ministry sets a limit for each Regional and Local Flood Defence Committee area, which is referred to as their grant earning ceiling.

2. See paragraphs 1.15 and 1.16.

3. General drainage charges payable by farmers. Is used to fund Agency expenditure in the Anglian Region only, probably with its origins in the extent of drainage necessary in East Anglia.

4. Interest (£5 million): bank interest earned on funds collected and on contingency balances held by flood defence committees in case of emergencies. Sale of assets (£1 million) - in order to construct some of the larger flood defences, the Agency purchases land, which is sold once the construction is complete. Other income (£11 million) includes donations and amounts from beneficiaries of flood defence measures, such as developers.

Source: National Audit Office

9 Some major reviews of inland flood defence

Easter 1998	Floods in the Midlands threw doubts on some aspects of the quality of flood warning and emergency response. The Agency reviewed its performance but also commissioned an Independent Review Team chaired by Peter Bye, a retired County Council Chief Executive.
August 1998	The Agriculture Committee of the House of Commons reported on Flood and Coastal Defence (HC 707 of 1997-98). Their report outlined the current administrative and financial framework, and examined the obstacles to effectiveness of current policies. The Government's response indicated that it proposed no fundamental changes to the present institutional arrangements. However, several reviews to be carried out by the Ministry and the Agency were initiated. These included a review of the Agency's supervisory duty; a review of flood defence funding; a review of flood defence committees; and updating of the Ministry's guidance on appraisal of capital measures and other activities. The Ministry was also tasked with preparing a series of high level targets to meet its aims and objectives.
October 1998	The previous month the Bye report made a number of recommendations, mainly on how flood warning measures could be improved. A statement in the House of Commons set out: ■ how such improvements could be brought about; and ■ that "a seamless and integrated service of flood forecasting, warning and response" was required.
November 1998	The Agency produced an *Easter Floods Action Plan* (the Action Plan) reflecting its response to the recommendations of the Bye report and the improvements identified in the ministerial statement of October. A summary of the key targets is at Appendix 1.
November 1999	The Ministry published 'high level' targets to deliver its flood defence aims and objectives to operate from April 2000 and beyond. As the principal operating authority the Agency has a key role in ensuring the targets are met.

Source: National Audit Office

1.24 We decided that our study should focus on the work of the Environment Agency in respect of inland flood defences in England. The Agency, established in 1996, is the largest single operating authority in terms of the level and breadth of its flood defence activity. The Agency has a range of responsibilities covering water management and environmental protection, but nearly half (45 per cent) of its annual expenditure is on flood defence. The Ministry has an important role in respect of policy and strategic direction, and also features in the main focus of our study.

1.25 We decided to examine:

- flood warning and public awareness (Part 2);
- the provision of new defences (Part 3); and
- the performance and maintenance of defences (Part 4).

1.26 The Agriculture Select Committee of the House of Commons in its Report published in August 1998 had focused in part on policy and structural issues such as funding arrangements and levels; and the complex organisational framework for flood defences. The Government is undertaking a review of funding arrangements which is expected to report in September 2001. We do not therefore specifically examine these issues. We do, however, in Part 2 consider the impact of the different arrangements for main river and ordinary watercourses.

1.27 Nor does this report specifically examine the third objective for flood defence set by the Government: to discourage inappropriate development in areas of risk from flooding (paragraph 1.18). The issues about development in flood plains are significant ones. Indeed, the Agency and others suggest that the floods of October and November 2000 demonstrate the need for future development to take more account of the risk from building in flood plains. However, at the time of our study there were already a number of initiatives seeking to address these issues. As described earlier, local authorities have the major role in respect of planning decisions on development in areas of risk from flooding. With effect from 2000, the Agency is required to report annually on the outcome of its advice to local authorities on planning applications. This will identify cases where it had objected to applications on the grounds of flood risk and where final decisions by local planning authorities, or on appeal, were in line with, or contrary to, Agency advice. Also, in early 2001, the Department of the Environment, Transport and the Regions, the Agency, and the Ministry were in consultation on revisions to guidance for local planning authorities about development in areas at risk, to replace that issued in 1992.

What methods did we use?

1.29 Our methodology for carrying out the examination is described in more detail in Appendix 2. It included:

- Examination of arrangements on the Trent-Humber river system - which contains one of the areas of the country with greatest number of properties at risk of river flooding - to assist in analysis and understanding of flood defence work.
- Visits to three Agency regional offices and four area offices to examine the planning and construction of 16 new schemes and to examine area maintenance plans. Analysis of management information held at the Agency's headquarters in Bristol and interviews with key staff at the Agency and the Ministry.
- Seeking the views of other operating authorities engaged in the provision of flood defences such as local authorities and internal drainage boards and other organisations who have an interest in flood works such as those representing environmental groups. A list of all parties consulted is provided at Appendix 3.
- Employing the Flood Hazard Research Centre at Middlesex University to provide some comparisons with other countries, summarised at Appendix 4.

1.30 All our main work was carried out before October 2000. In drawing together the results, we have reviewed the emerging facts about the incidents of flooding in October and November 2000. However, in October 2000 the Agency was tasked with examining those flood events and was expected to report by Easter 2001.

Part 2

Flood warning and public awareness

2.1 The risk from flooding can be reduced but not eliminated by building flood defences. In October and November 2000 the scale of rainfall in some locations and the severity of the resulting flooding emphasises how essential it is to identify and monitor the risk of flooding; to make people aware if they live or work in an area at risk; and to warn them of emergency situations where flooding is likely to occur. Never having been the victim of flooding does not itself mean the risk is low: for example, the Agency estimated that only one in eight people who suffered flooding in 1999 had previously experienced a flood. On the other hand, there are incidents in 2000 when people experienced flooding of their homes several times within the year.

2.2 In early 1996 the Environment Agency was directed by Ministers to take the lead responsibility for the issue of flood warnings. By 1998, reviews that followed severe flooding in the Midlands suggested that improvements were necessary in areas such as forecasting, issuing warnings and co-ordination of emergency responses. The Agency produced an action plan to implement improvements. The specific targets set for the Agency and progress made are reflected in Appendix 1.

2.3 The targets set for the Agency by Ministers covered actions to be taken between 1998 and early 2000. In the light of this, we examined the position by mid 2000 on whether:

- areas generally at risk of flooding are identified;
- imminent flooding is detected and timely warnings issued; and
- the arrangements for main river and ordinary watercourses impact on the quality of service provided.

Are areas at risk of flooding identified?

2.4 The Ministry estimates that some eight per cent of the total land area in England is at risk from flooding from rivers, tidal rivers and estuaries. This amounts to some 10,000 square kilometres. In recent years, the Agency has been engaged in preparing maps indicating flood risk areas, for several purposes:

- to assist local authorities in their planning and development control role;
- to assist in emergency planning; and
- to raise public awareness of flood risk areas.

2.5 The Agency (previously the National Rivers Authority) has a role in mapping flood risk to assist planning authorities. This derives from the Water Act 1989, consolidated in the Water Resources Act 1991 and is also reflected in guidance issued by the Department of the Environment in December 1992 (under review in early 2001). Flood risk maps prepared for this purpose have to be robust enough to withstand challenge should appeals against decisions by local authorities occur or should developers claim that maps are inaccurate. These maps - known as priority area or hot spot maps - cover those areas identified by the Agency regional offices and local authorities as areas at risk of flooding but which are targeted for building development. The coverage and required contents of such maps were finalised in 1994 after lengthy consultation with the three Associations representing County Councils, Metropolitan Councils and District Councils (now merged into the Local Government Association).

2.6 In July 1995 expenditure of some £22 million was approved by the National Rivers Authority Board on the mapping programme, over a ten year period, but with most of the work expected to be completed by March 2001. Since 1996 when the Agency came into existence, it has faced two principal difficulties affecting the progress made in mapping:

- competing priorities, particularly since April 1998, in responding to the Easter floods and to new targets or duties in respect of flood defence;
- the ability of contractors to cope with the volume of work in modelling or other technical input necessary to produce these maps.

2.7 These difficulties, linked to the availability of funding from flood defence committees, meant that Agency regions have progressed at different rates. To avoid competition between regions for contractor capacity, the Agency appointed a national team to establish a procurement strategy and, since July 1999, there has been a framework agreement with four specialist providers.

2.8 We examined the progress made by mid 2000. **Figure 10** shows that progress varied across the regions. While the Midlands region had produced 43 per cent of the programmed number of maps, Thames had produced only three (4 per cent) and Southern region had finalised only one out of its 40 programmed maps. Southern was the region hardest hit by severe flood warnings and flooding in mid October 2000. Since the region is generally an area of high development, the delay in production of these maps is of particular concern if authorities are to take account of flood risk in reviewing planning applications.

10 Production of flood risk priority area maps by June 2000

Environment Agency	Maps in current Programme	Maps produced		Maps in progress		Maps not yet started	
	No.	*No.*	*per cent*	*No.*	*per cent*	*No.*	*per cent*
Midlands	35	15	43	16	46	4	11
South West	95	34	36	38	40	23	24
North East	260	90	35	104	40	66	25
North West	173	55	32	57	33	61	35
Thames	81	3	4	15	18	63	78
Southern	40	1	3	31	77	8	20
Anglian	137	2	1	115	84	20	15
Total	**821**	**200**	**24**	**376**	**46**	**245**	**30**

Source: Environment Agency

2.9 When the Agency took on the lead role for the dissemination of flood warnings as directed by Ministers in September 1996, it decided that a single set of map based information should be used. A key lesson from the Easter 1998 floods was that many people had not been aware they lived in a flood risk area. Following those floods, Ministers agreed that the Agency should, on a best endeavours basis, produce flood risk maps for the whole of England and Wales based on the best information then available. These maps were prepared and issued in CD-ROM form to all local authorities in May 1999, at a cost of some £600,000. They provided for the first time a reasonably comprehensive set of flood risk maps for both main river and ordinary watercourses. An improved set, including the facility for the reader to seek information according to postcodes, was issued in November 2000 and placed on the Agency web-site in December 2000. This web-site for flood risk maps received over two million visits in its first month of availability to the public.

2.10 These maps utilise all the completed detailed flood risk appraisals shown in Figure 10, combined with the recorded extent of historic floods, other modelling outputs (for example from the design of flood defence schemes) and broad based mapping work carried out by the then Institute of Hydrology. As better information becomes available from further detailed appraisals or actual flooding, as in the recent autumn and winter floods, the maps will be updated and re-issued.

2.11 The maps do not indicate those areas where the risk is mitigated by existing flood defences (**Figure 11**). For example, the maps show low lying areas close to very large rivers or other watercourses - such as one fifth of East Anglia and the Thames Basin, including much of London - as being at risk. Whilst this is true, the areas are in fact relatively well defended against floods. However, the Agency told us that defended areas were purposely excluded in order not to give the public a false sense of security. In part this reflects the fact, highlighted by the late 2000 floods, that those living in areas at risk may believe mistakenly that flood defences can remove entirely the risk that flooding will occur. Indeed, for example, the Leigh flood barriers near Tonbridge in Kent afford good protection against routine flooding. However in extreme conditions, as in October 2000, the Agency may have to open the barriers in order to relieve rising waters and to enable controlled flooding.

Views on indicative floodplain maps in April 2000

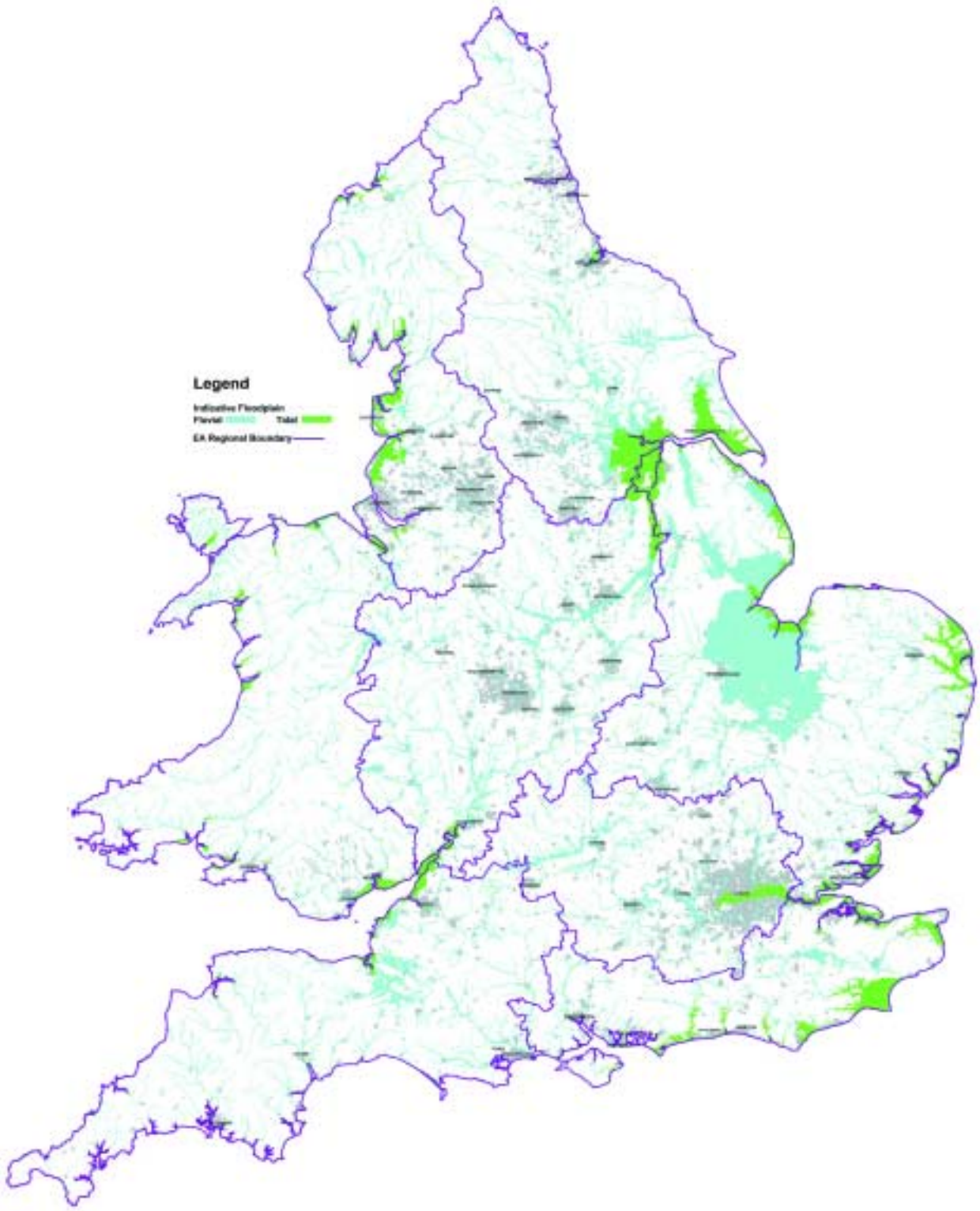
"It is essential for local authorities to have improved maps and the indicative floodplain maps provide a welcome update on the basis of best available information. However, there are claims by some authorities that they are inconsistent, unreliable and inaccurate." **Local Government Association**

".the circulation of the maps are of limited use to planning authorities as their accuracy is poor and they could draw attention to some areas generally not known to be at risk because in reality they are very marginal." **Birmingham City Council**

2.12 We had asked interested organisations for their views on indicative maps issued in 1999 and their value. Whilst seen as a helpful advance, some reservations existed as to the usefulness of the maps. However, as indicated above, the maps have since been updated and these views may indicate a misunderstanding as to their intention. The Agency is clear that, at present, these maps should cause organisations and individuals to seek further information on the nature of the flooding for a given location. For instance, whether the area is defended and, if so, to what standard.

2.13 Over the next few years the Agency aims to provide better information on the maps for targeting its flood warning service, and for local authorities, other organisations and individuals, by indicating specific addresses as high, medium or low risk. For example, it has run a pilot exercise in the Anglian region to identify

11 Indicative Floodplain map 2000



IoH Acknowledgement:
Some features of this map are based on digital spatial data, depicting the undefended 100-year floodplain, licensed from the CEH Institute of Hydrology, (© IH, © MAFF); that license in clause 4(a) states
'The flooded areas have been generated using a generalised technique and should not, by themselves, be used to infer that specific areas are, or are not, at risk of inundation. Flood risk at any specific location may be influenced by local factors - not least flood defences - that have not been taken into account'. This method has not been applied to rivers with catchment areas less than 10sqkm nor has it been applied downstream of the tidal limit.

Map: Based upon Ordnance Survey © Crown Copyright Licence No GD03177G

Urban Areas: © Bartholomew 1999. Reproduced by permission of Harper Collins Ltd

Note: Map as available to local authorities for planning purposes. For further information the Environment Agency should be consulted on its Floodline 0645 881188 or its website www.environment-agency.gov.uk

by postcode all properties in high-risk areas (those facing a one in 50 or greater chance of flooding in any year). This will also assist in assessing the most appropriate methods of flood warning.

2.14 Some criticism has been recorded of the lack of absolute certainty about the flood risk recorded on these maps. The Agency is currently in the position of defending the validity of the maps when developers challenge the accuracy of the identification of an area as being at risk of flooding. The Department of the Environment, Transport and the Regions is currently reviewing the Planning Policy Guidance on flood risk. The Agency has suggested that in this the onus should be placed on developers, who do not accept the assessment of risk on these maps, to provide a detailed assessment of risk for Agency consideration. If the assessment provided by the developer is accepted as more accurate, then it would be used to improve the published maps.

Conclusions and recommendations on whether areas at risk of flooding are identified:

The Agency has in recent years made progress in preparing flood risk maps which assist local planning authorities in considering applications for building development in priority areas at risk of flooding; and indicative flood plain maps which form the basis for informing the emergency services, via local authorities, and the public, about areas at risk.

These maps are intended to meet the needs of other organisations or individuals. The Agency should establish a programme for consulting users to ensure the content of the maps is clearly understood and they meet their intended purposes. The feedback obtained can be used to improve any maps still to be produced, and be taken into account when existing maps are due for revision.

The date of March 2001 for completion of the mapping of areas targeted for development was originally set in 1995. As at mid 2000, 70 per cent of these priority area maps for regions in England had yet to be finalised. For example, in Southern region, which was one of the first areas to be hard hit by flooding in October 2000, only 1 out of 40 maps had been completed.

The Agency and the Ministry should work with the Department of the Environment, Transport and the Regions, Flood Defence Committees and the Local Government Association to develop a strategy for completing and reviewing priority area maps. This is necessary to ensure that the appropriate information is available to local authorities in applying new guidance on development in areas at risk, being prepared in early 2001.

The floods of late 2000 have made this work a matter of even more urgency, and the Agency should review progress on the production of maps with Flood Defence Committees, and set targets for completion of any further work.

Preparation and maintenance of maps is expensive and has been largely funded by local authorities via Regional Flood Defence Committees. It would seem appropriate for developers and other beneficiaries of the maps to contribute towards the cost of their production and updating, especially when such users require more information on the risk of flooding in specific locations. The Agency has also suggested that the new planning policy guidance should in certain circumstances place the onus on developers to provide a detailed assessment of risk

Is imminent flooding detected and are timely warnings issued?

2.15 Flood detection and forecasting play an important role in the Agency's ability to provide a timely and effective warning service for main rivers. As an example, the box below indicates the succession of flood warnings issued for Uckfield, Sussex in mid October 2000. Detection systems such as gauging stations and telemetry equipment, measure factors including rainfall, water level, water flow and wind. Data is gathered by the Agency's regional offices in order to evaluate the likelihood of flooding on main rivers, and to determine whether flood warnings should be issued. Improvements to the gauging and telemetry network are expected to cost over £20 million across the next five years.

Flood risk warnings issued in respect of Uckfield, Sussex 9 - 12 October 2000

21.25	Monday 9 October	Flood watch issued. The Agency says: "Flooding is possible. Be aware! Be prepared! Watch out!"
Midnight	Monday 9 October	Flood warning issued. The Agency says: "Flooding of houses, businesses and main roads expected. Act now!"
02.40	Thursday 12 October	Severe flood warning issued. The Agency says: "Imminent danger to life and property. Act now!"
07.00	Thursday 12 October	Severe flood warnings justified when river bursts its bank.
		Severe flood warning downgraded to flood warning.
		All clear: The Agency says: "Flood water levels are receding. Check all is safe to return. Seek advice."

2.16 In April 2000 the Agency established a National Flood Warning Centre in Frimley, Surrey. The Centre is charged with:

- Identifying best practice and developing improved techniques for forecasting, warning and public awareness.
- Forging stronger links with the Meteorological Office, the Centre for Ecology and Hydrology (a constituent organisation of the Natural Environment Research Council), universities and consultants specialising in flood warning, and overseas centres of flood warning expertise. For example, the Agency has agreed with the Meteorological Office a ten-year strategy to secure and enhance the weather radar network in order to improve the accuracy and reliability of rainfall data.
- Identifying and developing a suite of models designed to improve quality and consistency of forecasting techniques used by regional offices.
- Advising and guiding regional and area flood warning centres, which provide the flood warning service to the public.

2.17 The Agency uses a range of methods for disseminating flood warnings, as set out below, and information is available via the Internet. It aims to provide one direct and one indirect method of disseminating flood warnings to the areas for which it offers a service. As in the case of Uckfield in October 2000 the method of warning can be crucial. While there were some 4 hours between issue of severe flood warning and the river bursting its banks, this was in the early hours of the morning of 12 October. At such times, warning sirens or vans with loudhailers may be more effective than answer machine messages, although lower category flood warnings had been in operation for the previous two days. In the case of Gowdall, a village in the North-East where 135 out of a total of some 150 homes had to be evacuated, four days warning of imminent flooding was given.

Methods of disseminating flood warnings:

Automated voice and fax messaging: Automated voice messaging relays warning messages to individuals or organisations via telephone, fax or pagers. The system plays a recorded message and registers whether it has been received. Individuals identified as living or having business interests in high risk areas of flooding may be asked whether their contact details can be added to the automated voice messaging database.

Warning sirens: Fixed sirens are used as a first line alerting system in some localities.

Public address equipment: The equipment is designed to be fitted to vehicles to deliver warning messages. Some regions use this method to cover large urban areas where the maintenance of an automatic voice messaging database would be too large.

Flood wardens: Local volunteers from the public who work under Agency guidance, often alerted by automated voice messaging.

Radio and television bulletins: Warnings can be transmitted regularly via local radio, television, Ceefax, Teletext, AA Roadwatch, BBC Weather Services and the Meteorological Office.

"*Floodline*": Members of the public are encouraged to maintain detailed information for their locality by contacting Floodline, the Agency's telephone 'dial and listen' service. The information is regularly updated during flood events. It was launched in 1999.

2.18 The automated voice messaging system was introduced in 1996. It is one of the methods by which people in high-risk areas are likely to learn directly and personally about possible flooding and probably the most sophisticated in seeking to transmit information to individual properties. The number of properties connected to the automated system has increased from 23,000 in 1996 to some 58,000 in 2000. Properties are only connected to the System with the occupier's prior consent. The Agency is extending and improving the system, for example, by enabling it to differentiate between personal receipt of a message and connection to an answering machine. In England, the proportion of properties linked to the automated voice messaging system is 3.8 per cent of those at any risk of flooding. However, the position varies between regions, ranging from 32,500 properties (16.4 per cent) in the Southern region to 2,500 (1.2 per cent) in the Thames region (**Figure 12**).

12 Properties at risk from flooding in England (fluvial, tidal and coastal) and proportion for which automated voice messaging was taken up in mid 2000

Environment Agency Region	Number of properties at risk from flooding	Automatic voice messaging recipients	
	Number	*Number*	*per cent of those at risk*
Anglian	330,029	3,630	1.1
North East	246,829	3,277	1.3
Thames	203,508 [1]	2,500	1.2
Southern	198,069	32,530	16.4
North West	162,293	9,090	5.6
Midlands	98,615	4,630	4.7
South West	43,050	2,220	5.2
Total	**1,503,309**	**57,877**	**3.8**

Note: 1. Fluvial only. A further 220,916 properties are at risk from tidal flooding.

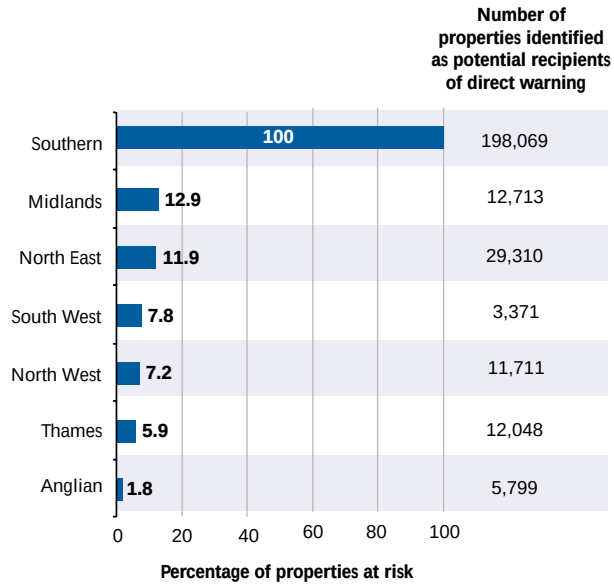
Source: National Audit Office analysis of Environment Agency data

2.19 Explanations for these variations between regions include:

- Limitations on how many messages can be sent at the same time - the system is less practical in densely populated urban areas such as the Thames basin.
- Regional variations in the extent to which properties with potential to receive direct warning have been identified through mapping and risk assessment.
- Extent of use of flood wardens alerted by automated voice messaging.
- The piloting of the automated voice messaging system in the Southern region. The region has a high number of people living behind shingle bank sea defences - a form of defence which is of special significance in that region and which requires high numbers to be connected to the automatic voice messaging system. As a consequence of these two factors the region is more advanced in identifying potential recipients than other regions (**Figure 13 overleaf**).

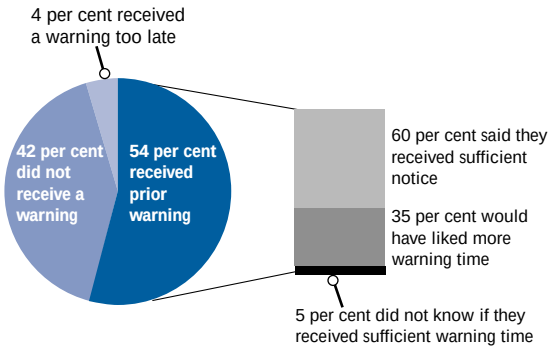
2.20 In 10 days of flood warnings in the middle of October, some 17,000 automated voice messages, 13,000 telephone and 12,500 fax warnings were sent to those at risk. The Agency's Floodline Recorded Message Service received 40,000 calls for information over a similar period. Other means of disseminating warnings such as loudhailers and flood wardens were also used. These may be equally effective in speed, coverage or direct contact with those at risk, particularly in large urban areas. After the first incidents of flooding in October 2000, some members of the public suggested they felt that greater use of cars with loudhailers would have resulted in them hearing of the risk of flooding earlier than via the radio or TV; and that this method would also more clearly have indicated that the risk was real and local.

13 Proportion of properties at risk identified as potential recipients of automated voice messaging by mid 2000



Source: National Audit Office

14 Prior warning and the adequacy of the notice given 1998-99



Source: British Market Research Bureau International

2.21 The greater the length of time between warnings and onset of flooding, the more chance there is for people to take action or at least obtain further information. The Agency's Customer Charter requires prior warning, generally two hours, to be given to people living in those designated flood risk areas where a flood forecasting facility exists. For those areas, the Agency's target is to improve the success rate for the receipt of warnings within two hours from 65 per cent in 1998 to 80 per cent in 2009-10. As demonstrated in October and November 2000, a warning of two hours is not a long time in which to protect property and evacuate, particularly where elderly or infirm people are involved, for example. However, a severe flood warning may be preceded by lesser levels of alert, enabling those at risk to prepare or to be assisted.

2.22 To see if warnings are actually received, the Agency employs consultants, British Market Research Bureau International. In 1998-99, post-event surveys in six areas subject to flooding found that 54 per cent of people at risk had received a prior warning, whether from the Agency, personal observation, the police or neighbours (**Figure 14**). A similar survey will be carried out following the floods in October and November 2000.

2.23 The Agency's consultants also interviewed a sample of 47 people who had received flood warnings from the Agency. The survey found that 68 per cent had received at least two hours notice, compared with 60 per cent during the Easter 1998 floods (also derived from a small sample of 65 people). These percentages represent a significant improvement on the position in the early 1990s, when the police were responsible for issuing flood warnings, and only 13 per cent of people (sample size not known) were said to have received a warning.

2.24 Since 1997, the Agency has also commissioned independent surveys by the British Market Research Bureau to test understanding of the role of the Agency, the flood warning system and action to be taken. These show that for people at risk from flooding in 2000, 78 per cent of those interviewed were aware that they were living in an area of risk compared with 73 per cent in 1997. Awareness and prompted awareness of the Agency's responsibilities for flooding information had generally improved also over that period, from nine to 24 per cent for spontaneous awareness and from 59 to 80 per cent when prompted.

2.25 In October 1999 the Agency ran a week-long flood awareness campaign with the theme Floods Don't Just Happen To Other People. In September 2000, the Agency held a Flood Action Week aiming to bring home the dangers of flooding and help people take action to protect themselves. This included an 800,000 direct mailshot to properties in high risk locations. The Agency also introduced a set of new flood warning codes which its research had indicated were clearer and more easily understood by the public. In October and November 2000, the flooding in England put the Agency's systems and public awareness to the test. The results of reviews by the Agency of how well its systems worked are expected by Easter 2001.

2.26 Research by the Agency suggests that only one in 20 people who are in a flood risk area take the risk of flooding seriously enough to prepare for what can be devastating damage and loss. In a flood risk area, the chance of flooding is greater than the risk of fire. Yet two in five households at risk said that they did not know if their insurance will cover them in a flood.

Conclusions and recommendations on whether flooding is detected and warnings issued

The Agency has made progress since 1998 in developing a strategy for flood warning, in establishing a national centre to identify and promote best practice, and in developing the techniques for disseminating flood warnings. Following the severe floods of late 2000 the Agency should review how successful in practice these changes have been.

Some 1.5 million properties have been identified by the Environment Agency's regional offices as being at specific risk from flooding. The Agency, through the flood defence committees, should examine the reasons for the variations between regions in the number of properties which have access to different warning methods, especially automated voice messaging. The experience in October 2000 of the Southern region, which is particularly well served by automatic messaging, may prove useful for comparison. The Agency should also consider with the flood defence committees whether an equal standard of service in issuing of flood warnings is provided to areas at risk across the country. The reviews following floods of October and November 2000 should also be used to provide evidence of the public's opinion on methods of warning.

The National Flood Warning Centre should review the implementation of the voice messaging system, which has been developed differently in each of the Agency's 26 area offices, and consider whether to issue guidance on best practice in database management. It should also set targets for, and monitor progress of, area offices in offering potential recipients of warnings access to the automatic messaging system.

The Agency has increased the percentage of people, in areas where a flood warning facility exists, who receive at least two hours notice of flooding and has targets to increase this further to 80 per cent over the next 10 years. Sample sizes used by the Agency to assess whether it has met its target are small. The Agency should base its samples on sound statistical methods to give a reliable picture of its performance.

The Agency continues to carry out flood awareness campaigns spending £2 million a year but clearly there is an ongoing requirement to ensure the public recognises the risk and takes appropriate action. The experience of flooding in October and November 2000 might be used to raise awareness and recognition of the risks in the 19 out of 20 people in flood risk areas who the Agency's research prior to those events suggested did not take the possibility of flooding seriously.suggested did not take the possibility of flooding seriously.

Temporary sandbagging

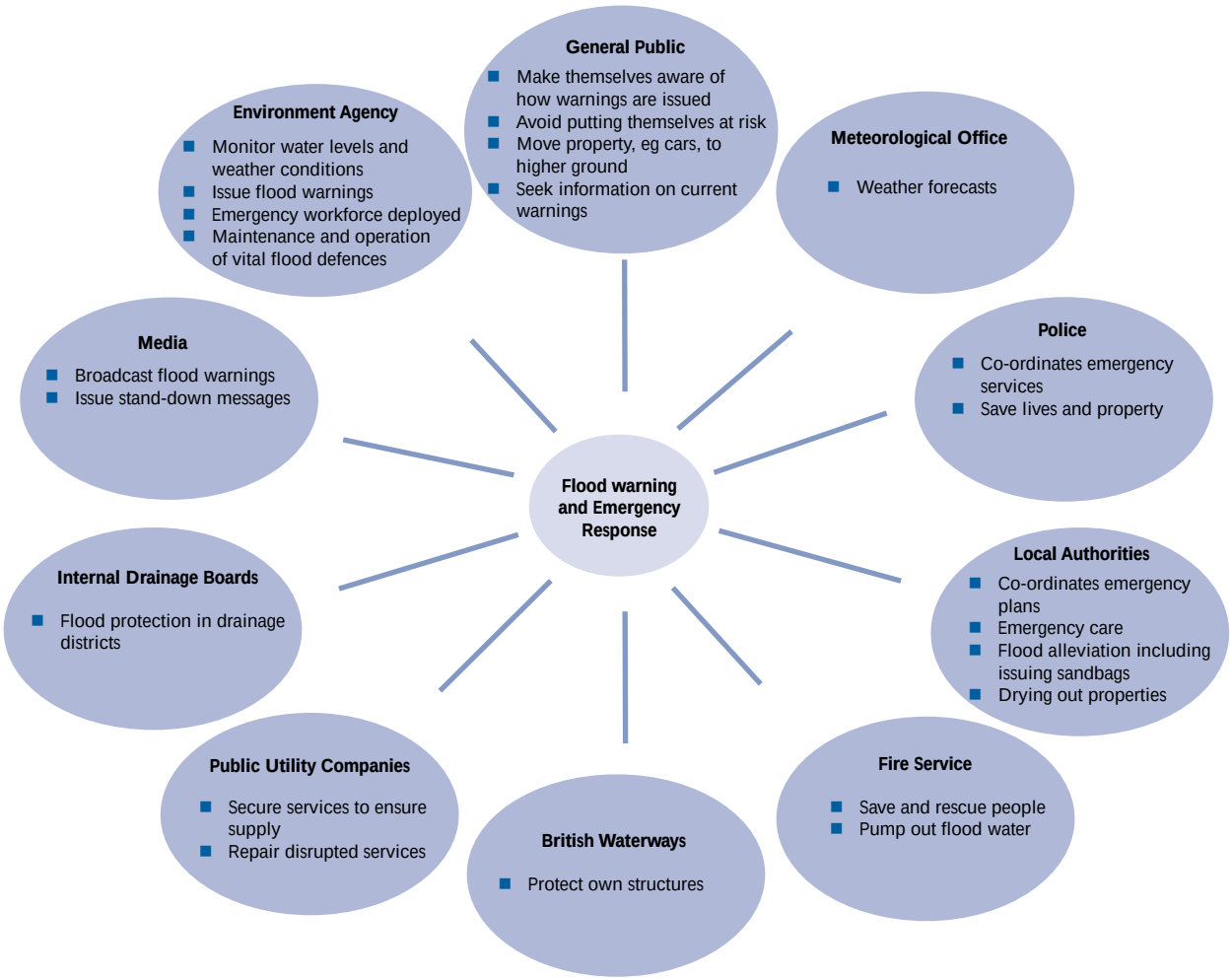
Do the arrangements for main river and ordinary watercourses impact on the quality of services provided?

2.27 The Agency's focus for the issue of flood warning is main rivers, and not ordinary watercourses. The Agency produces flood warnings dissemination plans which record those areas which are designated to receive flood warnings, the arrangements that will operate to issue flood warnings and the emergency activities likely to be required. The target coverage of the Agency's flood warning service is to be 80 per cent of properties at risk. This takes account of locations where there are particular difficulties in issuing a warning with sufficient lead-time. The remaining 20 per cent will receive a broadcast "flood watch" service on a best endeavours basis. The Agency has discussed these plans with the local authorities since it is local authorities which have a lead role in co-ordinating emergency activities and, in those areas where the Agency does not provide a flood warning service, it is for the local authority to consider what arrangements to implement.

2.28 In September 1999 the Agency published a Flood Warning Strategy which set out the roles of those involved in flood warning (**Figure 15**). In November 1999, the Agency published a statement of its supervisory duty for flood defence matters, and the way this would be exercised, alongside the high level targets for flood and coastal defence set by the Ministry. These include a requirement on the Agency to arrange, in conjunction with local authorities, emergency services and other partners, a programme of flood emergency exercises at national, regional and local levels starting in January 2001 and at no more than three yearly intervals thereafter.

2.29 We sought views from our surveyed organisations in mid 2000 on the effectiveness of emergency response arrangements, as these depend upon effective joined-up action between all flood defence bodies. Some local authorities believed that there was still some way to go. At the time of publication of our report, information was not yet available from the flooding of late 2000 on how well emergency responses had been co-ordinated.

15 **Those involved in flood warning and emergency response on main rivers**



Source: *National Audit Office*

Views as at mid 2000 on emergency arrangements

"The emergency response arrangements are as yet untested and many members are not confident that the service the public expects will be delivered. There is a general consensus among authorities that there is scope for improvement in liaison arrangements".
Local Government Association

"Emergency response arrangements are in themselves fine. However, it is important that all parties embark upon training and understanding of each others role, integrating to provide a much improved emergency response to the public."
National Association of Flood Defence Chairmen

"The flood warning and emergency response systems are generally good within Birmingham City Council's area. No major problems have been experienced with emergency response arrangements in cases of serious flooding. The co-ordination of the various bodies involved in emergency response is good but not to a nationally recognised model."
Birmingham City Council

"Within the Humber area there are multi agency emergency planning committees at both a tactical and strategic level involving the emergency services, the Environment Agency and other agencies. These Committees ensure a co-ordinated approach to emergency planning..."
Kingston upon Hull City Council

2.30 While the Agency has a **duty** to exercise general supervision over all flood defence matters, through flood defence committees, its powers to implement flood defences are permissive. Flood warning is the subject of a Ministerial Direction. It is not practical for the Agency to detect all events throughout the country that may lead to flooding. However, using its supervisory powers the Agency can investigate problems, encourage improvements to ordinary watercourses or give advice, in so far as it has resources to do so.

2.31 The different arrangements that apply for rivers deemed to be main and ordinary watercourses can result in difficulties for members of the public, or indeed smaller local authorities, in understanding where responsibility lies, where to obtain further information, and the nature of service which can be expected. While the provision of a flood defence service by local authorities may be constrained by local priorities or lack of in-house engineering or other expertise in flood defence issues, it is their responsibility to be aware of their role and it is

Views on the services provided on ordinary watercourses

"The public generally have no idea of the distinction between an ordinary watercourse and a main river. The definitions may not be understood by partners involved in flood defence work. The administration of large flood defence schemes is onerous for small district authorities."
Local Government Association

"There is often no-one in a local authority with any interest in, or knowledge of ordinary watercourses - and certainly no budget to maintain or improve them. As a result the quality of flood warning, maintenance and new works for ordinary watercourses tends to be significantly lower than for main rivers."
The Chartered Institution of Water and Environmental Management

"Localised flooding in recent years has in very many areas been influenced by non-main river systems. Non-main rivers within urban areas but outside internal drainage districts are generally not as well maintained as those by the Agency."
The Association of Drainage Authorities

"Flood warning and flood defences on non-main river are limited and, in the case of flood defences, often with poor standards of maintenance".
The National Association of Flood Defence Chairmen

they who have the powers permitting them to act in respect of ordinary watercourses. Where the quality of life of people is at risk, the nature of the watercourse giving rise to that risk should not be the determining factor in whether action is taken.

2.32 In order to examine the impact of this, we looked for instances of flooding on ordinary watercourses in the Trent-Humber system. Small towns and villages were the worst affected and although the number of flooded properties was not usually very high, the flooding could be regular and frequent, causing distress to residents and damage to businesses. In some places we found that although flood problems could be mitigated either through flood warning, or an alleviation scheme, they were often unlikely to be resolved satisfactorily. A typical example is illustrated by Norton Green below.

Norton Green on the River Trent

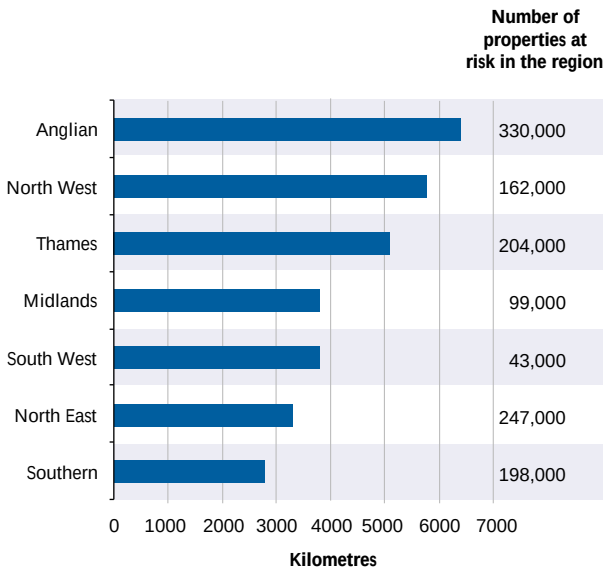
The headwaters of the Trent are an ordinary watercourse and the responsibility of Stoke-on-Trent City Council. At Norton Green, the river Trent flows through the village where it has caused minor flooding on a regular basis, but more extensive flooding has occurred in 1987, 1998, and 1999. It affects approximately 13 residential properties and three commercial properties on these occasions. Other properties in the area are affected by surface water flooding. The nearest Agency gauging station is located 5km downstream in Stoke-on-Trent, and is not suitable for issuing flood warnings for the village of Norton Green. The Agency considers that it would be possible to install a new gauge so as to issue warnings to residents, albeit with lead times less than the normal 2 hours. The gauge has been identified within the Agency's proposed programme of telemetry improvements. The Agency has written a preliminary report regarding the flooding and outlining some possible solutions. These ranged from the construction of a flood relief channel (estimated cost £115,000) to a flood warning system with the aim of the residents implementing a self-help approach (estimated cost £7,500). The Agency's recommendation being that Stoke on Trent City Council, as the drainage authority, should undertake a full feasibility study to determine justifiable solutions. The Agency agreed to provide support and advice where necessary.

While the Agency has the ability and expertise to investigate and provide advice, unless the local authority has the appropriate expertise and chooses to allocate appropriate funding, the 16 properties will continue to suffer the risk of flooding similar to that experienced in the last two years.

2.33 The Ministry requires all operating authorities to publish policy statements by March 2001 setting out their responsibilities and their approach to delivery of the Government's policy aims and objectives. For the purposes of those statements, the Agency has sought, with local authorities and internal drainage boards, to define 'critical' ordinary watercourses according to the types of land-use they pass through. For example, critical ordinary watercourses may include those which pass through intensively developed urban areas at risk from flooding, less extensive urban areas with some high grade agricultural land, or through environmental assets of international importance requiring protection. The aim is to highlight which rivers have the greatest potential to cause a flooding incident, and to stress to those with permissive powers for the river channel maintenance (for example local authorities) the need for proper oversight.

2.34 The Water Resources Act 1991 allows for ordinary watercourses to be reclassified as main rivers by a process called "en-maining" so that the Agency has permissive powers to alleviate floods and provide flood warning systems. In practice each Regional Flood Defence Committee may apply to the Minister of Agriculture, Fisheries and Food for a river, or more usually a short section of river, to be en-mained. Over the years significant differences have arisen between regions with regard to which rivers are classified as main rivers and ordinary watercourses. In the North West region for example, many small watercourses are classified as main rivers simply because in the late 1970s internal drainage boards in that region opted for their own abolition and all their watercourses were en-mained. As a consequence the North West has the second highest length of main river after Anglian **Figure 16** although it is one of the smaller regions in terms of properties at risk and size of the region (Figure 5 on page 12).The Agency does not know the length of ordinary watercourses in the regions.

16 **Length of watercourses deemed to be main river**



Source: National audit Office

2.35 Although flood defence committees put forward proposals for extending main rivers from time to time, they are generally small variations and major changes are rare. These are generally proposed in agreement with the relevant local authority. Flood defence committees are reluctant to take on extra rivers if, by doing so, they become responsible for significant future maintenance costs. In 1995 in the Yorkshire Area for example, the National Rivers Authority identified 925 kilometres of ordinary watercourse where the Authority could alleviate flooding. But the Yorkshire Regional Flood Defence Committee was reluctant to en-main all of the 925 kilometres because of the additional maintenance expense it would incur and preferred to examine proposals for en-maining on an individual basis. In 1996 the Ministry en-mained 105 kilometres involving 14 different watercourses in Yorkshire with an estimated annual maintenance cost of £154,000.

Conclusions and recommendations on services on main and ordinary watercourses

From mid 2000, the emergency response arrangements involving the Agency, local authorities, the emergency services and others were due to be subject to a programme of testing at regular intervals. The flooding of late 2000 will have tested these arrangements in a "live" situation, and the lessons learned will need to be passed on to other regions as well as actioned by those affected.

There are no strict criteria for designating watercourses as main rivers or ordinary watercourses, and the reasons for current classifications are largely historical. However, the designation of a stretch of water can have important implications for the level of flood warning and defence services provided. It is therefore almost certain that the current system leads to inconsistencies in the standard of flood defence and warning service between regions across England.

The Agency view is that the system of en-maining is bureaucratic and complicated. The Agency should consider, in conjunction with other operating bodies, whether clearer principles for classifying watercourses are needed to provide a more balanced approach to service provision across the regions as a whole. The Ministry would also need to be involved in setting a framework for looking at these issues.

The flooding in October and November 2000 should also be examined for any lessons that can be learned about the impact on quality of service to the public as a result of distinctions between main and ordinary watercourses.

Flooding in the North East - November 2000

On Monday 30 October, after two days of heavy rain across England the Agency began issuing flood warnings for Rivers Aire, Ouse and Calder in the North-East. In addition it:

- opened flood incident rooms in Leeds, York and Newcastle and was monitoring river levels throughout the region on an hour by hour basis;
- began operating flood defences such as the Foss Barrier in York to minimise flooding in the city centre; and sluice gates on the River Derwent to reduce river levels upstream.

In the first two weeks of November, the North East region suffered some two months of rainfall. Some of the events are as follows.

By 1 November river levels on the Upper Aire were the highest for 50 years. Over 250 properties had already been flooded in Skipton, Stockbridge, Bingley and Ripon. The Agency was already repairing damaged flood defences and doing maintenance work to clear river channels. The River Aire was flowing at 150 tonnes of water per second through Leeds causing flooding to roads and properties adjacent to the river and closure of the railway station; and downstream at Mickletown 900 homes were evacuated, although in the event no flooding occurred.

Heavy rain **on 2 November** was in line with predictions earlier that week. In York, vulnerable riverside properties on the edge of the City had been flooded and the extent of rainfall led to drainage problems, causing some flooding; some 5,500 properties in the City of York and areas nearby were subject to severe flood warnings; and the Army was helping to sandbag properties at risk.

Overnight on 3 November, river levels in York rose to 17.8 feet - one inch higher than the previous high in 1625 and only two inches lower than the limit of the flood defences. Sandbags had been added to the top of the defences, there had still been no breaches in the defences, but there had been some overtopping and localised seepage of floodwater affecting 100 city homes. At the peak, 1,000 tonnes of water per second were flowing down the Ouse. The Foss Barrier had been operating since 30 October at full capacity to pump water at a rate of hundred million litres an hour to stop waters from the Foss and Ouse, which meet at the south side of the city, from backing up and flooding the city centre. The barrier had been built in 1987 at a cost of £3.4 million and can cost about £11,000 in electricity to run at full capacity for a week.

By Saturday 4 November the level of the Ouse at York was dropping. However, elsewhere on the Ouse that day flood defences had been overtopped, 250 properties had been flooded and more were being evacuated at Barlby where flood defences had been breached in 3 places. Snaith and Gowdall on the River Aire were giving cause for concern. Flood banks at Gowdall had been breached but were repaired immediately and at Snaith **on 6 November**, the Agency and Police were giving special loudhailer warnings because of the risk of leakage or breach of flood banks. 100 people were evacuated from Snaith and 70 from Gowdall and the centre of Wakefield was flooded by the River Aire.

At the same time across the region as a whole the Agency was inspecting many miles of flood defences to determine stress points which were at risk of being compromised by the weight of water. This would enable emergency measures to be put in place. Sandbagging to protect individual properties and roads, to shore up existing defences and river banks or to create a wall of sandbags was taking place, with the assistance of the Army, at a number of locations across the region, including Ferrybridge, Wakefield, Knottingley, Barlby and Selby, South Church, West Auckland, Doncaster.

By 8 November the risk of flooding in Barlby and Selby was so great that military helicopters were brought in to assist with the sandbagging of defences where overnight the Ouse had been just inches short of the defences. It was still feared that tidal levels could breach the defences, such that three high capacity mobile water pumps were being brought from Holland for use around the Selby area.

On 9 November, the Agency reported that the area of land under flood water to the South of York and Selby was bigger than lake Windermere, amounting to some one third of a billion tonnes of water. The mobile water pumps, hired by the Agency at a cost of £150,000 a month, are capable of pumping two tonnes of water per second and began work on **10 November** at Chapel Hadlesey, Selby and Market Weighton. The water pumped out of the area was directed to the Humber via the River Foulness.

On Thursday 9 November seepage and overflowing at Wressle Clough in the Selby area was threatening nearby villages. **By 11 November,** 10,000 sandbags had been put in place there and an Army helicopter hired by the Agency was positioning one tonne rubber blocks made from recycled tyres to stem the overflowing flood banks. Two days later, the Agency reported these measures to have been successful in protecting the 500 properties in Howden and surrounding areas.

By 13 November, a suspect barrier bank holding flood water away from Snaith was under 24 hour surveillance, a sandbag wall had been built in case the bank failed.

On 14 November, many of the severe flood warnings in the North-East had been withdrawn. However, Gowdall on the River Aire was still under water and work by the Agency and the Internal Drainage Board was underway to drain water from homes and to repair damaged defences. Even by **22 November** a severe flood warning remained in place for Gowdall and two temporary sluices were being constructed on the banks of the River Aire. Homes there remained flooded. The Agency was also considering new temporary flood defences for Gowdall to be completed before Christmas, involving either a new earth bank or sheet piling to strengthen the existing bank. The pumping operation using a giant pump from Holland was continuing.

Over the whole period some 2,500 properties had been flooded in the North East region.

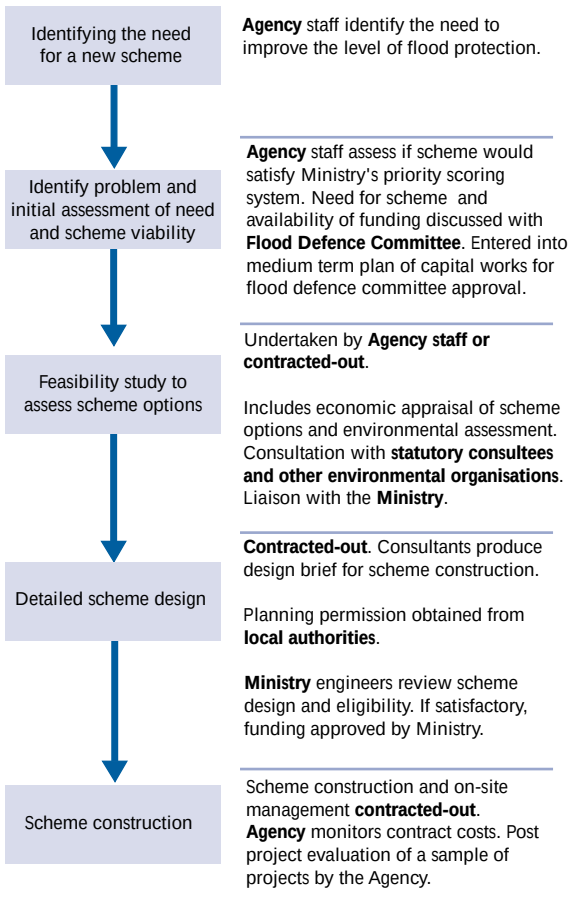
The small photographs show mobile waterpumps; floodwater near Gowdal; and Army helicopter delivering sandbags.

Part 3

Building new defences

3.1 The Ministry and the Agency aim to reduce the risks to people and the developed and natural environment from flooding and coastal erosion by encouraging the provision of technically, environmentally and economically sound and sustainable defence measures. The Agency spends some £90 million a year on the construction of new inland flood defence schemes on main rivers in England. **Figure 17** sets out the key stages and which organisations are involved. This excludes any construction by local authorities on non-main rivers.

17 Key stages and responsibilities in building flood defences on main rivers



Source: National Audit Office

3.2 Our examination focussed on the Agency's approach to identifying, appraising and building new schemes. In particular we examined in detail the approach adopted by the Agency's Midlands and North East regions on the Trent and Humber river systems, which were recommended by the Agency as being representative of their approach throughout England. We considered the following questions:

- Is there a strategic approach to identifying the need for flood defences and how are they prioritised? The importance of such an approach was highlighted very strongly by the floods in October and November 2000.
- How are schemes assessed to ensure that they are technically, environmentally and economically sound?
- Are the costs of construction managed effectively?

Is there a strategic approach to identifying the need for flood defences and how they are prioritised?

3.3 In 1993 the Ministry and the Welsh Office published their Strategy for Flood and Coastal Defence in England and Wales. This set out a framework for operating authorities to work within in planning and building flood and coast defences. The strategy highlighted the importance of not planning new defences in isolation, rather to consider the impact of building flood defences and the interrelationship between watercourses, land use and development by river catchment. For this purpose, the Ministry proposed the preparation of river catchment plans by the National Rivers Authority (now the Agency). The catchment plans were intended to cover the Agency's wider water management responsibilities and address environmental issues in consultation with interested parties.

Views on the overall strategy to inland flood defences:

"Flood defence works should now be developed within a strategic framework which recognises the significant impact on the form and long term development of river systems which such works can impose."
English Nature

"The Ministry promotes strategic approaches in their Strategy for Flood and Coastal Defence in England and Wales. However, thus far there have been few examples of implementation of river flood defence strategies."
Royal Society for the Protection of Birds

"Schemes that are in accordance with catchment-based strategies are the way forward if sustainable flood defence for the country is to be achieved."
Chartered Institution of Water and Environmental Management

3.4 Many of the organisations in our survey also recognised the benefit of a more strategic, integrated approach to flood defence and river management. They thought, for example, that new schemes paid insufficient attention to the knock-on impact on the risk of flooding along the remainder of the river.

3.5 However, the preparation of strategy and plans is a complex, technical and time consuming process, as well as requiring significant consultation and co-ordination within and between those responsible for water management and those with an interest in it. Since 1996 the Agency has made progress in a number of areas and carried out studies based on single towns or stretches of river. Examples of progress are:

- To date the Agency has focused on developing a more strategic approach to coastal defences and producing shoreline management plans for specified lengths of coastland. The emphasis on coastal strategies has been in line with the Ministry's priorities.
- Its Midlands region has carried out studies on the Trent catchment area to gather and analyse information on the need for new or upgraded flood defences as the basis for future investment planning. For example, the resulting strategy for Derby identified the need for £8.7 million to be spent over the next 50 years.
- Its North East region has produced a major strategic plan for the River Humber. This is regarded by the Agency as one of the most comprehensive studies of its kind in England and is the first estuary plan by the Agency.
- The Agency has produced Local Environment Agency Plans that identify and prioritise local environmental issues, taking into account consultation with local "customers" and interested parties on a river catchment basis.

The Humber Estuary Shoreline Management Plan

In 1997 the Environment Agency began developing a long-term flood defence strategy for the Humber Estuary. The aim is to produce a co-ordinated strategy built on a sound understanding of the processes within the estuary. There was a need to assess the standard and condition of existing defences and to set a framework for the long-term upgrading of flood defences. Studies were undertaken to improve the understanding of the estuary - land use, flood defences, conservation, hydraulogical processes, including sea level rise and climate variability - which could affect it. The review was undertaken in conjunction with the Ministry of Agriculture, Fisheries and Food, English Nature and other organisations with Estuary interests.

"The Humber Plan does not guarantee joined up action but it does provide a platform to try and get some wider and common understanding of the competing demands on estuaries."
Kingston upon Hull City Council

- The Agency and other operating authorities were also required to complete Water Level Management Plans by December 2000. These plans take an integrated approach to water level management and serve a wider purpose than flood defence. However, they are relevant only to a particular type of area where control of water levels is important to conservation but which need also to take into account agriculture and flood defence interests. For example, priority is given to Sites of Special Scientific Interest, particularly those of international importance.

3.6 While all these types of plan serve useful and different purposes, they do not represent river catchment plans as envisaged by the Ministry and desired by the Agency. Our international comparisons showed that other countries were in a similar position to England in that while it is routine to call for the integration of land and water management across a catchment, there has been little achieved in practice. France is notable in having sought to introduce comprehensive water and land planning through its Plan d'Occupation des Sols. Similarly, France has gone furthest in requiring the preparation of flood hazard maps and making hazard zones part of the land use control process. All foreign comprehensive flood action plans for rivers as a whole, such as the International Rhine Action Plan, the 'Stork' project in the Netherlands, and the "Loire Grandeur Nature" project in France, require actions about land use and water management and not simply actions about the river channel. The Rhine Action Plan, for example, involves afforestation, land use controls, converting some land currently protected back to wetlands and washlands, and control of rivers and other water sources.

3.7 While significant progress has yet to be made in producing catchment strategies, there are methods for prioritising individual schemes. The Ministry's priorities for awarding grants for new defence measures, in descending order, are:

- flood warning systems;
- urban coastal/tidal defences; environmental assets of international importance;

- urban flood defence (but, following the floods of 2000 and announcement of new funding of £51 million, this category is to be awarded the same priority as other urban defences);
- rural coastal/tidal defences; existing rural defences and drainage works; environmental assets of national significance; and
- new rural flood defence works; environmental assets of local significance.

3.8 The Ministry grant aids expenditure for between 15 and 55 per cent of the cost of individual flood defence schemes (now 35 to 75 per cent for fluvial defences, in response to the flooding of 2000). Grant rates are at the higher end of these ranges where local resources are low. In 1997 the Ministry introduced a scoring system to ensure that funds are allocated in accord with its priorities for making use of limited flood defence resources.

3.9 An impact of these arrangements is that for people living in areas where flooding affects only a small number of homes, perhaps in a rural area, it is unlikely that a flood defence scheme would score enough points to be considered for grant from the Ministry and such schemes would not therefore be submitted by the Agency. However, the damage or effect of flood risk on the value of a person's property may not be any less than for someone living in a large urban area. A scheme in relation to Robertsbridge in Sussex - a town where some houses have been under water no fewer than six times since Christmas 1999 - did not proceed some years earlier because it did not meet the priority scoring criteria. However, the scheme was designed to address a one in 50 years flood event. As such even if built, it would have been overwhelmed by floods in October 2000.

3.10 One issue the Agency might examine following the floods in late 2000 is whether there were any recent or current proposals for flood defence projects which could have alleviated flooding. For example, there was a proposed scheme in respect of floodwalls for Lewes that was under consideration although there were schemes elsewhere in Sussex with higher priority. However, even if the local contribution to funding had been available, there were disputes about ownership that needed to be solved; and the scale of flooding could still have been more than the plans for floodwalls could withstand. On the other hand, there is the example of York where flood defences were upgraded in the 1980s. Although seepage from defences did lead to flooding of 100 homes in the city, over 5,000 properties were successfully protected, despite, at a peak, over 1,000 tonnes of water per second flowing down the River Ouse.

Conclusions and recommendations on identification and prioritisation of new defences

The Ministry guidance stresses the importance of a strategic approach to river defence and the key steps to be followed. However, this is a long-term programme and in the first four years of the Agency's existence, it has focussed on strategies for flood warning and coastal shorelines, in line with the Ministry's priorities. Therefore, the Agency has yet to draw up strategic plans on a river catchment basis across England. To improve the identification and prioritisation of the need for flood defences and joined up working between interested parties the Agency should identify a programme and timescales for regions to develop strategic river catchment plans - taking the approach adopted in the Humber Shoreline Management Plan - albeit an estuary plan - as a model. Progress will require the agreement of flood defence committees and consultation with other operating authorities and interested parties.

Following severe flooding in late 2000 there were calls by the public and others for increased investment in flood defences. Despite the increase of £51 million in expenditure announced by the Government in November 2000, competition is likely to remain very high. River catchment plans are now even more essential therefore to assist good long term planning of flood defence which takes account of the standard and condition of existing defences, local land use, sea level rise and climate variability, and development planning. The extra funding includes £2 million a year for three years to help the Agency to develop and apply catchment plans.

It is right that the Ministry has established a scheme for prioritising projects for grant aid to assist in effective allocation of the overall funds available. The scheme is based on projects meeting minimum scores set by the Ministry. The Ministry should monitor the impact of the present criteria to ensure that deserving schemes of more localised impact are not unduly disadvantaged by the current system. They should also consider the impact of the lack of clear criteria for classifying watercourses as main or ordinary (Part 2 of this Report) on the overall prioritisation of flood defence measures across the country.

How are schemes assessed to ensure they are technically, economically and environmentally sound and sustainable?

3.11 Once the need in principle for a new scheme has been identified, the Agency appraises the method for supplying defences. This involves examining a range of options, including a “do nothing” or “do minimum” case, with a view to selecting one which is technically and environmentally sound and offers best value for money.

Benefit:cost analysis

3.12 Benefit:cost analysis is used to determine how worthwhile it is to undertake a scheme, to compare the different options and how to meet the flood defence requirement. It forms the basis of the decision to proceed. To qualify for a Ministry grant, schemes must demonstrate a predicted benefit:cost ratio of 1:1 or better (where benefits exceed costs). As an indicator of

achieving good value for money from the programme, the Ministry aims to achieve an annual aggregate benefit: cost ratio for all schemes (inland and coastal) of 5:1 or better.

3.13 We examined the 108 grant-aided Agency inland flood defence schemes in England (excluding flood warning systems and river studies) approved by the Ministry between 1997-98 and 1999-2000. All achieved a 1:1 ratio or better. The aggregate benefit: cost ratios on inland flood defence schemes for each year were 1997-98: 7:1; 1998-99: 19:1 and 1999-2000: 20:1. We found that the Ministry's target of 5:1 can be easily met if only a handful of schemes have very high ratios. For example if the five highest ratio schemes are excluded from the aggregate for inland schemes, the ratios fall to 5:1 in 1997-98 and 1998-99 and to 6:1 in 1999-2000.

3.14 We also found that between 1996 and 1999 benefit: cost ratios for approved schemes varied considerably from between 1:1 (for a scheme on the River Thames) and 318:1 (a scheme on the River Humber). Very high ratios may be feasible in some works, for example emergency works. However, the Ministry's engineers consider that opportunities exist to claim larger areas of land to be at risk than is actually the case, as this can never be certain, and hence benefits may be overstated. This does not mean that schemes achieving very high ratios are not necessarily the highest priority cases.

3.15 There were other issues drawn to our attention on benefit:cost appraisals:

- There appears some confusion about whether the application of benefit: cost ratios can lead to unequal treatment in some cases, for example by unfairly favouring more affluent areas and giving insufficient weight to social factors rather than economic benefits. The National Association of Flood Defence Chairmen told us “There is growing concern that, in poorer urban areas that have a need of flood defence measures, schemes do not go ahead due to the benefit:cost ratio being below unity...” . The Ministry guidance provides for a range of benefits to be taken into account and for potential damage to houses to be based on national average figures. However, local values may be used in certain circumstances where they are significantly different. As a general principle, the Agency is concerned that the question of whether rigid adherence to benefit:cost ratios may have perverse outcomes in a sample of cases be kept under review.
- Benefit:cost appraisals are re-examined at tender stage, to review the impact of revised estimates of contract costs. The Ministry also re-examines the economic appraisal if tenders are higher than estimated costs and if the Agency has to seek an increase in approved costs. However, the cost of construction is only one element of the cost. For example, post construction compensation claims - where property owners claim compensation for damage or disruption - can also affect benefit: cost ratios. The Agency told us that there has been an escalation in the number and value of such claims.

3.16 The Ministry has provided a set of guides on best practice in project appraisal: Flood Defence Project Appraisal Guidance - Economic Appraisal (December 1999); Approaches to Risk (February 2000) and Environmental Appraisal (March 2000). This guidance includes advice on the need to assess and quantify at the economic appraisal stage the risk of later increases in scheme costs. The Agency is also taking steps to ensure the quality of future economic appraisal proposals, for example, by strengthening the Agency's skills on project appraisal; appointing a national manager with responsibilities for the capital programme to be accountable for independent technical quality assurance for option selection and appraisal; and the creation of two national review groups to provide quality assurance and scrutiny.

Environmental considerations

3.17 Flood and coastal defence works are expected to be environmentally sound and sustainable. We examine the role that environment considerations play in scheme proposals and design and sought the views of interested bodies. A summary of the results is at Appendix 5.

Conclusions and recommendations on economic appraisal and environmental considerations

The Agency and the Ministry use benefit:cost analysis to help them choose the most cost effective option for providing flood defences. The Ministry has set a target of an aggregate annual benefit:cost ratio of 5:1 for all schemes but achievement against this can be heavily influenced by a small number of schemes anticipated to deliver significant benefits. The Ministry and the Agency should review periodically the application of this measure, especially as benefits cannot be assessed with certainty.

The benefit:cost appraisal process could be strengthened by reviews after the project is complete, when actual outturn costs are known. Comparisons with estimates at earlier stages would test the accuracy of cost estimating and the results from across a number of projects could inform the process of assessing likely costs. This would assist in ensuring that limited funds are not taken up by cost overruns and thus delaying new projects.

Balancing effective flood defence and environmental concerns is a significant challenge and the Agency has done much to ensure that environmental factors are taken into account in planning flood defence work. However, the difficulties of balancing the differing interests of environmental groups, users of the land and others might be better handled through a more integrated approach to river management and wider environmental issues. The preparation of strategic river catchment plans would help in this, and in creating a more joined-up approach between relevant organisations at local and regional levels.

Are the costs of construction managed effectively?

3.18 Between 1996 and 1999 the Agency built 168 inland flood defences (excluding flood warning) at a total construction cost of £111 million. The cost of individual projects varied from small schemes, such as the repair of a culvert on the River Maun costing £83,000, to major defences such as the construction of raised flood embankments at Salt End on the River Humber which cost nearly £8 million. Larger schemes are split into phases and built over a number of years.

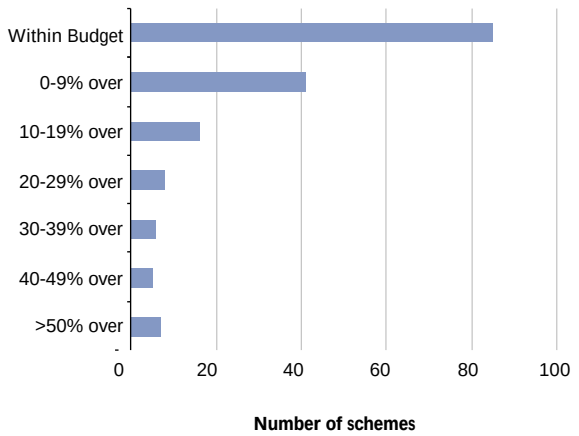
3.19 We examined construction costs of new schemes compared with the original contract price for all 168 schemes from 1996 to 1999. The total cost exceeded the contract price by £7.8 million, 7.6 per cent. Half of new schemes were completed for less than the original contract price representing a saving of £4.8 million (**Figure 18**). Schemes costing over £500,000 were more susceptible to cost overruns. The total cost of schemes over £500,000 exceeded the total contract price by £9.4 million (13 per cent); whereas on schemes below £500,000 there was an aggregated saving of £1.6 million.

18 **A) Comparison of construction cost against original contract price for all schemes in 1996-99**

	Number	*per cent*	*Total (saving)/cost overrun £m*
Schemes within budget	85	50.6	(4.8)
Schemes over budget	83	49.4	12.6
Total	**168**	**100**	**7.8**

Source: National Audit Office analysis of Environment Agency data

B) Comparison of construction cost against original contract price for individual schemes 1996-99



Source: National Audit Office analysis of Environment Agency data

3.20 The aggregate cost overrun of 7.6 per cent for all schemes represented an improvement on the overrun of 17 per cent against tender prices identified on post project appraisal work carried out in 1994-95 on 86 schemes. These schemes included both inland and coastal defences, and defences constructed by local authorities and internal drainage boards as well as by the Agency's predecessor, the National Rivers Authority. However, in 1996 independent consultants, Gardiner and Theobald, reported to the Agency that median cost overruns on its projects at that time of six per cent compared favourably with the private sector and other civil engineering projects in the public sector.

3.21 To examine the Agency's approach to managing the cost of new schemes in more detail, we reviewed 16 new schemes on the Trent-Humber system from the Midlands and North East regions. All of the schemes were let competitively and all but two of the schemes (Burton-on-Trent and Derby South) received grant-aid from the Ministry. The total cost of the 16 schemes was £27.8 million, an excess of 19 per cent over the original contract price (**Figure 19**). Construction cost overruns varied from £4,000 to £2.8 million.

3.22 We found 11 schemes were subject to cost over-runs. Although contracts contain a contingency sum, additional amounts were required to cover:

- Extra works identified by the contractor on seven schemes. For example 40 contract variation orders reflecting design changes for the Bee Bank project resulted in additional expenditure of £357,000.
- Unforeseen ground conditions were discovered after the commencement of construction works in four cases. For example, in the case of raising the flood banks at Salt End, additional costs arose in disposing of contaminated land. This was the major factor in the £2.77 million (54 per cent) overrun in this project. Agency policy is to spend up to two per cent of estimated costs on ground condition investigations.

3.23 Of the 16 schemes we examined, the cost of site investigations averaged less than two per cent of total project costs. Project managers in the Agency's regional and area offices told us that there is scope for more thorough site investigations during the project design stage as the discovery of unforeseen ground conditions is a common problem. Being aware of such problems can save money at later stages by avoiding costly contract additions.

19 Outturn construction costs compared with contract price for 16 schemes built in the Trent-Humber catchment 1996-99

Scheme (type of scheme)	Contract cost (£000)	Final cost (£000)	Difference (£000)	Difference (per cent)
Midlands Region				
Schemes over budget				
Bee Bank (raised embankment)	1,870	2,232	362	19
Torksey Lock (new lock gates)	729	1,057	328	45
Derby South (embankment and flood walls)	1,429	1,565	136	10
Gunness Wharf (flood wall)	221	281	60	27
Lysaghts Drain (replacement culvert)	650	694	44	7
Schemes under budget				
Gainsborough - phase 2 (flood wall)	4,850	4,443	(407)	(8)
Burton upon Trent (flood wall)	2,090	2,032	(58)	(3)
Coleshill - phase 1A (embankment)	226	188	(38)	(17)
Trent Embankment (concrete embankment)	178	149	(29)	(16)
Metal Box Culvert (culvert repair)	104	83	(21)	(20)
North East Region				
Schemes over budget				
Salt End (raised embankment)	5,180	7,950	2,770	54
Albert Dock (flood wall)	1,226	2,133	907	74
King George and Alexandra (new lock gate)	2,804	3,058	254	9
Reedness (raised embankment)	1,199	1,270	71	6
Saltmarshe Village (raised embankment)	350	360	10	3
Humber Urgent Works 5&6 (raised embankment)	270	274	4	1
Schemes under budget				
None				
Total	**23,376**	**27,769**	**4,393**	**19**

Source: National Audit Office analysis of projects in the Midlands and North East regions

3.24 The Albert Dock project incurred the largest overrun in percentage terms, 74 per cent of the original contract cost. A contract for the construction of new floodwalls and the replacement of lock gates was awarded, without competition, to the Agency's in-house workforce. This was because the region could identify no other available capital work to keep them usefully employed (paragraphs 4.31-4.36 cover the role of in-house workforces). It was recognised that this contract would represent a major challenge. The original tender was checked by an independent quantity surveyor for accuracy and reasonableness. However, the workforce team misjudged the extent and complexity of works. This resulted in increased costs of £907,000 for works either not included by the internal client or under-estimated in the tender. In our view the Agency should assess its in-house skills and experience, and consider issuing guidelines on the use of in-house teams on capital projects. The Agency was undertaking an internal review of lessons arising in October 2000.

3.25 The Agency is taking a number of steps seeking to implement best practice and construction industry initiatives:

- in April 2000 it implemented a National Capital Programme Management Service comprising a small central team managing dedicated staff in each region specialising in the preparation and delivery of capital projects. The Service aims to achieve efficiencies and best value for money in construction of flood defences and other capital procurement;
- target cost contracts; and risk sharing arrangements with construction contractors. The aim is to remove adversarial relationships that traditional construction contracts engender and minimise the number of claims requiring variation orders against contract specifications.

Conclusions and recommendations on cost control

For the 168 schemes between 1996 and 1999, for which we compared outturn costs with original contract price, the overall cost overruns were 7.6 per cent. However, larger projects are the most likely to overrun and by a significant amount (13 per cent on schemes over £500,000). Unforeseen ground conditions and extra works identified by the contractor were the most common contributing factors, suggesting that there had been scope to improve scheme design, for example, by more thorough site investigation procedures.

The Agency should monitor the use of in-house teams on capital projects and the success of its new National Capital Programme Management Service and other recent initiatives in terms of their impact on, for example, better procurement and in ensuring that good management practices and lessons from completed schemes are applied throughout the Agency's regions.

Part 4

Performance and maintenance of defences

4.1 Flood defences are designed to last for many years - for example an earth embankment may have an expected life of 50 years or more. The flooding in October and November 2000 included some events more severe than any experienced for many years. Regular inspection and maintenance of defences is essential to prevent deterioration in condition, to ensure that they perform effectively throughout their life or indeed to identify whether they are still fulfilling their original purpose. We therefore examined:

- whether the performance of flood defences has been tested, and with what results;
- if flood defences are in good condition; and
- if flood defences are well maintained.

Is the performance of flood defences tested?

4.2 Flood defence schemes are designed and built to provide a standard of protection against flood events of different magnitudes. The standards are expressed in terms of the expected frequency of flooding. For example, a "1 in 100" year event refers to a flood that would be expected to occur, on average, once in every 100 years. However, since this is an average, it does not mean that flooding will not occur more than once in a period of 100 years. The performance of flood defence schemes against these standards is difficult to assess as the defences are designed to protect against random and extreme weather events, which by their nature occur infrequently. The flooding in parts of England in late 2000 did test some defences to their limits and the Agency will be able to assess how well they worked. For example in the case of York, the defences are built to defend against a one in one hundred year event. Water levels in early November 2000 rose to one inch higher than the previous record in 1625. The flood defences do not appear to have failed against the standards they were designed to meet, although some overtopping and localised seepage of water did occur. Flooding was prevented by reinforcing the defences with sandbags.

4.3 There is no management information available centrally that records operational performance or effectiveness of defences throughout England in coping with flood events and periods of high rainfall. The performance indicators published by the Ministry and the Agency focus on the level of work carried out, such as the number of schemes built and the number of properties protected by these defences each year, and do not seek to measure the effectiveness of defences. However, staff in the Agency's area offices monitor the performance of flood defences in coping with flood events by:

- carrying out an analysis of flood incidents after all major flooding events to assess how defences performed, identify any damage caused to them by flooding and consider whether the standard of protection should be improved; and
- undertaking post-project appraisal of flood defence schemes to provide feedback on the performance achieved in terms of project design and management.

4.4 We examined these flood incident reviews and post-project appraisals to consider, firstly their quality and coverage, and secondly the results on how flood defences have performed. We examined the post-incident reviews for the Agency's Midlands and North East regions, the two regions responsible for the Trent and Humber river systems, and the post-project appraisals completed by all regional offices since 1998. In addition, we looked at the results of the Independent Review Team's report on the 1998 Easter floods. At the time of writing this report, the post incident flood reviews of events in October and November 2000 were still awaited, and would provide material for reporting to Ministers in early 2001.

Post-incident flood reviews

4.5 Between December 1997 and January 2000 the Midlands and North East regions carried out six post-incident flood reviews. We found that although information on performance was collected it was not done so in a consistent or systematic way and reports varied in the detail provided. Some had essential detail

on whether defences performed to their design standards but others gave little information at all. Minimum standards for what should be included in these reports would have improved consistency. Without this, it is difficult to assess whether, based on a series of incidents, defences are performing as they should over a long period. The results from the reviews were collected and disseminated at regional level but there was little dissemination at national level. Since floods in the Summer of 2000 in the North East of England, the format and content of the lessons learned report prepared for those incidents have been adopted as the best practice standard for use by all Agency regions. These reports will also now be shared nationally via the Regional Flood Defence Managers Group.

4.6 Very few schemes will have been tested against the standard of protection they were designed to provide - and some will not have been subjected to any significant flood events at all. The six post-incident reviews in the Midlands and North East which we examined indicated that defences stood up well to their tasks and that flooding was more often caused by extremity of events rather than the inadequacies of existing defences. The summary of an incident on the River Derwent (below) illustrates a good example of how defences successfully withstood serious flooding.

Derwent incident March 1999

In March 1999 the River Derwent and its tributaries in Yorkshire experienced their worst floods in living memory. The peak river level at Malton was the highest this century. During the event 198 properties were flooded, mainly at Malton, Pickering, Stamford Bridge and Norton, and the rail link between York and Scarborough and many roads were closed for a number of days. After the event the Agency report included the following:

- There were no failures or breaches of flood banks. However, there were no flood banks protecting any of the towns that suffered the worst property damage.
- All washlands filled automatically and performed in accordance with their design parameters.
- The sluices at Kirkham, Elvington, and Weir Head and the gate at Stamford and the barrage at Barmby operated according to procedures including those monitored remotely.

The Agency identified several points of improvements to its emergency response procedures but concluded that overall performance of defences and their response had been effective.

4.7 The post incident reviews in respect of flooding in October and November 2000 will provide information on how well flood defences have coped, and whether weaknesses requiring immediate or long-term action have been exposed. Media coverage in October indicated, for example, that near Lewes in Sussex a brick retaining wall alongside the River Ouse, recently built, collapsed as a result of surging flood waters. In the North East, while seepage and overflowing at Wressle Clough in the Selby area occurred, this did not apparently represent a breach of flood defences. It did however, require reinforcement by 10,000 sandbags and a wall of one tonne rubber blocks to stem overflowing riverbanks.

Post-project appraisals

4.8 Since 1998 each of the Agency's regional offices has been required to carry out two post-project appraisals of flood defence schemes each year. Two types of appraisal are undertaken:

- construction appraisal - to evaluate the appraisal, design and construction of the scheme against time, cost and quality criteria. 29 of these have been carried out since 1998 and provided useful information on lessons to be learned in design, construction and cost control; and
- performance appraisal - to determine the success of the scheme in providing the standard of flood defence of protection for which it was designed. Only 3 of these had been carried out, assessing their likely effectiveness by examining performance against lesser flood events, and reviewing design standards and the adequacy of emergency procedures.

4.9 We also noted in respect of post-project appraisals that:

- several of the Agency's regions, including Southern, Anglia and the South West had not completed the minimum requirement of two flood defence appraisals a year in 1998 and 1999.
- regions choose which of their schemes are to be appraised, which creates a risk that the better examples or those which are easier to assess are selected and the results may not be representative or may not provide lessons learned which can be applied elsewhere; and
- as for post-incidents reviews, the results of post-project appraisals are collated at a regional level and disseminated to relevant staff locally but there is little national dissemination of issues arising.

Conclusions and recommendations on performance of flood defences

By their nature, flood events of the severity for which defences are built occur infrequently. Post incident flood reviews by regional or area offices are carried out after all major flood events. Minimum standards have now been set for what is included in these reports. These should be used in future to disseminate lessons and assess defences based on a series of incidents.

The Agency should now be collecting more information nationally on the success of schemes in coping with flood events and developing a national record of flood incidents. This would help in evaluating the effectiveness of flood defences and could be used to ensure that where appropriate, lessons arising and good practice are disseminated across the Agency's regions and to other operating bodies such as local authorities.

Are flood defences in good condition?

4.10 Physical condition will affect the performance of flood defences and up-to-date information is needed on their general state of repair to ensure that defences are maintained in good condition and to identify and prioritise necessary works. One of the Agency's supervisory roles relates to the assessment of the condition of flood defence assets (paragraph 1.10). The Agency has been engaged in two main tasks to survey and record the condition of flood defences:

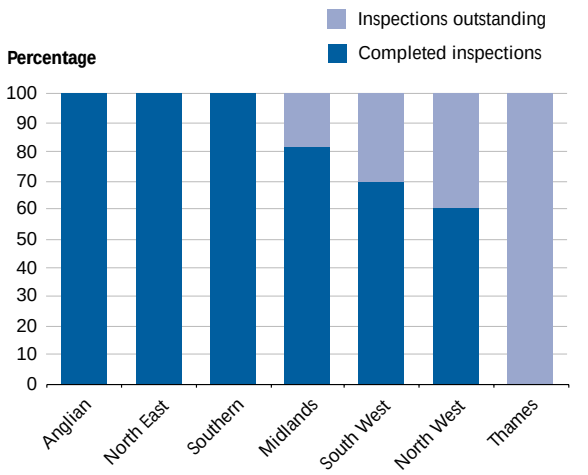
- following the 1998 floods the Agency was to complete, by 1 April 2000, a visual survey of all flood defences irrespective of ownership;
- in November 1999, the Ministry set the Agency a target requiring a National Flood and Coastal Defence database of assets to be created and maintained with effect from September 2000. This database would in part rely on the results from the visual surveys.

4.11 In February 1999 the Agency wrote to all local authorities and internal drainage boards to seek their assistance in carrying out inspections of defences on ordinary watercourses. By February 2000, 436 local authorities and boards were willing to assist but 82 local authorities had replied that they were unwilling or unable to carry out inspections or had not responded to the Agency's request. The Local Government Association has pointed out that most local authorities agreed to supply the information required but had limited capability to carry out surveys and the employment of consultants would be a significant cost burden. In January 2001 the Agency reviewed the latest position and found:

- Eight local authorities were still not prepared to inspect defences or to assist the agency by supplying information and 21 had not responded to requests. However, only four out of these 29 were estimated by the agency to have "significant critical ordinary watercourses and defences" of more than 10 kilometres in their area;
- 106 were now willing to assist but considered themselves unable to so so. 14 others had supplied information on where defences were located. 23 of these were areas with significant critical ordinary watercourses and defences;
- 200 were assisting and supplying information as requested, of which 53 were areas with significant critical ordinary watercourses

4.12 By April 2000, the Agency had completed the surveys on main river defences for which it was responsible. In cases where the local authority declined to inspect defences and had not provided information identifying the location of defences the Agency, where possible, sought to identify and inspect the authority's defences. In a refinement of the original target of completing all surveys by April 2000, the Agency was required to reach agreement by that date with the other operating authorities on the means by which private defences were to be identified and inspected. In fact by April 2000, inspections had been completed in three regions, including the North East and Southern which were two of the regions most hard hit by flooding in late 2000 (**Figure 20**). In three others good progress had been made. The Agency told us that resource constraints had prevented Thames region from undertaking any inspections by April 2000. As at February 2001, inspections of defences on critical ordinary watercourses had not yet been completed by local authorities.

20 **Progress in completing visual surveys of flood defences on ordinary watercourse by the target date (April 2000)**



Source: Environment Agency

What is the condition of flood defences in England?

4.13 Each asset has been defined as one of two types, structures or defences, and each type has been separately assessed. **Structures** include sluices, weirs, barriers, locks, outfall culverts and pumping stations. The results for Agency defences only are in **Figure 21**. **Defences** are generally linear barriers, walls and embankments between the river and defended areas and have been surveyed by length (**Figure 22**). Each region carried out its own visual surveys in accordance with nationally set criteria which graded the condition of defences from 1: very good - fully serviceable; to 5: very poor - completely failed. The analysis of results from surveys of local authority and others' flood defence assets were to be completed later.

21 Condition rating of Agency defences (by structure) October 2000

Environment Agency Region	Number of structures	Condition rating (per cent) Very good	Good	Fair	Poor	Very poor
Southern	13,803	7.9	42.2	39.2	8.7	2.0
North West	2,907	3.2	78.9	16.3	1.2	0.4
North East	1,595	7.8	45.3	41.6	4.3	1.0
Midlands	1,532	5.9	46.6	38.2	7.0	2.3
South West	1,173	16.8	46.1	27.7	6.6	2.8
Anglian	1,054	31.5	48.2	16.7	3.2	0.4
Thames	756	7.7	57.4	31.0	2.5	1.4
Total	**22,820**	**8.7**	**48.3**	**34.5**	**6.8**	**1.7**

Source: Environment Agency

22 Condition rating of Agency defences (by length of defence) October 2000

Environment Agency Region (km)	Total length of defence	Condition rating (per cent) Very good	Good	Fair	Poor	Very poor
North West	6,197	1.0	82.8	16.1	0.1	0.0
Southern	5,276	9.3	48.9	35.6	4.2	2.0
Anglian	1,854	18.4	45.6	28.3	6.3	1.4
North East	1,312	0.5	14.3	74.1	9.6	1.5
Midlands	1,001	2.3	43.6	47.9	6.1	0.1
South West	883	9.3	36.9	44.0	9.2	0.6
Thames	312	5.6	68.2	22.0	3.7	0.5
Total	**16,835**	**6.1**	**57.7**	**31.5**	**3.7**	**1.0**

Source: Environment Agency

4.14 The results in total showed that more than half the assets were categorised as good or very good but a lot of structures (43 per cent) and linear defences (36 per cent) were rated as fair, poor or very poor. Assets in that condition are regarded by the Agency as "giving cause for concern". Of greatest concern are the nearly 400 structures (1.7 per cent of the total number of structures) and over 165 kilometres of defences (1 per cent of total length of river inspected) which were categorised as very poor and therefore in a completely failed or derelict state. Clearly lives or property may be at risk unless these structures and linear defences are repaired urgently, alternative protection provided or the risk they were originally built to protect against has gone or diminished.

4.15 There were also some significant variations between regions:

- the number of structures categorised as very good or good ranged from 2,400 (82.1 per cent) in the North West Region to 6,900 (50.1 per cent) in Southern Region;
- Southern region has over 50 per cent of the total number of structures in England and over four times the number of structures in the North West; and
- Linear defences categorised as very good or good ranged from 83.8 per cent in the North West region to 14.8 per cent in the North East Region.

4.16 The method for identifying the number of assets is flexible. It allows regions to classify each structure as one whole or as a series of component elements. The need to complete surveys by April 2000 meant that some regions adopted the whole asset rather than component approach. This accounts for some of the variation between regions in numbers of assets. The Agency suggests that the variations in the percentages of assets which are fair, poor or very poor is the result of different policies and practices from individual flood defence committees, the cumulative effect of local funding decisions by them and the availability of grant aid.

4.17 By September 2000, the Agency had largely met the target of recording assets on a new National Flood and Coastal Defence database in respect of assets managed by it. Structuring the database to identify changes in flood risk is proving more technically challenging than anticipated. The Ministry and the Agency are working together on a database, which will provide a single easily accessible and definitive store for all data on all flood and coastal defences in England.

4.18 The target set by the Ministry also required a programme to be put in place from April 2000 for the regular inspection of all the flood defence assets that would be included in the database. In the future, the frequency of the inspections will be risk-based, taking account of factors such as the status, nature and significance of the flood defence and whether it is on a main river or critical ordinary watercourse. Compared with other

countries the Environment Agency appears to be ahead in terms of formally undertaking assessments of flood defence assets and maintaining databases of standards and of defects.

Conclusions and recommendations on the condition of flood defences

The asset surveys are a useful source of information on the state of England's flood defences and they indicate where maintenance work, and in some cases capital work, may be required if the defences are still required to meet the original assessed risk for which they were designed.

In September 2000, the asset surveys had already revealed that a significant proportion of structures and linear defences were in need of attention. Around 40 per cent of flood defence assets have been rated as fair, poor or very poor, categories which are regarded by the Agency as giving cause for concern. 400 structures (of which some 270 are in the Southern region) are categorised as very poor and therefore in a completely failed state. At the time of writing it is not possible to identify how many of the assets which are only fair, poor or very poor are in areas that suffered severe flooding in October and November 2000. However, the Agency had so far found no evidence that the condition of defences or structures had been the cause of flooding.

The Agency's regional maintenance and capital programmes submitted to flood defence committees for approval should take account of the results of the surveys and works should be put in hand on those assets which have completely failed. In view of the severe flooding in late 2000 and the earlier results from the surveys of Agency defences, it is essential to complete the condition ratings for other authorities' assets. Additionally, the Agency should use the experiences from the flooding in late 2000 to confirm the accuracy of the results from the condition surveys in those cases where defences were tested.

The variations between regions as to the state of assets should be investigated by the Agency, with a view to establishing whether the criteria for assessment have been applied consistently or they reflect the level of resourcing by flood defence committees and ultimately with the aim of encouraging the adoption of a strategy for improving the condition of defences in the poorer rated regions.

Progress by its regions, flood defence committees, local authorities and other operating authorities should be monitored centrally by the Agency to encourage appropriate actions to be taken by the flood defence committees and others, with the prospect in the long term of an appropriate and more consistent standard of flood defence across different parts of the country.

Are flood defences well maintained?

4.19 Following the flood events of October and November 2000, the Agency was undertaking a survey of well over 2,000 kilometres of flood defences to identify and undertake necessary repair to restore the appropriate levels of protection. This section of our report examines the position on maintenance prior to the events of late 2000.

4.20 The aim of maintenance work is to ensure that the effectiveness of flood defences is not compromised and the level of protection is not reduced. This includes maintaining the natural flow of the river, as the effectiveness of defences may be impaired if this is reduced or impeded. In 1999-2000 the Agency spent £126 million on the maintenance and administration of 34,000 kilometres of main river in England - which accounted for 50 per cent of the Agency's annual expenditure on flood defence. The bulk of maintenance expenditure is spent on routine maintenance, which includes structural, embankment and equipment repairs; painting; vermin control; de-silting (or dredging) of rivers; clearing excessive weed growth, debris (such as trees) and blockages (such as shopping trolleys); and grass cutting on embankments and river banks.

4.21 We examined how the Agency assessed the need for maintenance works and the approach to determining maintenance programmes using Agency's area offices in the Midlands region (Upper and Lower Trent Areas) and the North East region (Dales and Ridings Areas) as case studies.

Is the need for maintenance works adequately assessed?

4.22 Unlike the construction of new flood defences, maintenance works are not subject to Ministry review or approval as the funding comes mainly from levies on local authorities. However, the Agency has a responsibility to those who fund the work and the Environment Act states that the Agency should have regard to an assessment of the likely costs and benefits prior to carrying out the maintenance. In 1997 the Agency introduced a "Flood Defence Management System" for the justification and prioritisation of expenditure on maintenance works through applying similar principles as for capital expenditure. This means that for each river - or section of river called a 'reach' - the value of the area of land protected against damage is compared with the cost of maintenance works and a benefit:cost ratio is determined.

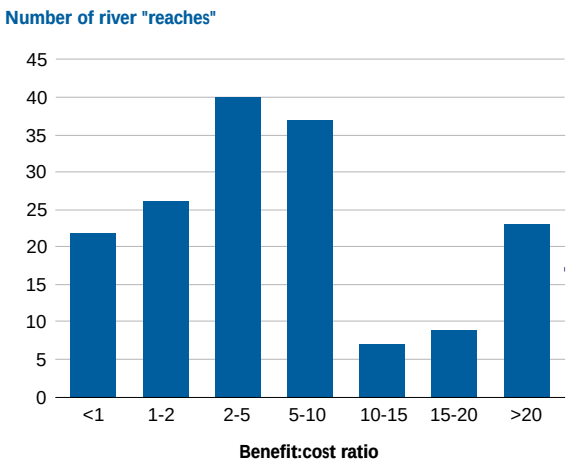
4.23 All regions achieved the target of subjecting 20 per cent of their maintenance work to economic justification in this way by April 1998; and some achieved 70 per cent by April 2000. The target of 100 per cent by April 2001 was being reviewed in late 2000 due to staff being engaged in flood response activities. As a result, it is estimated that regions will have subjected between 65 and 100 per cent of maintenance work to economic justification by April 2001.

4.24 We found in the Midlands and the North East region - which acts as a lead region for this initiative - that for three quarters of maintenance expenditure which had been appraised, the benefit:cost ratios were 1:1 or greater for 87 per cent of rivers. For the remainder there was some maintenance work where the ratio is less than 1:1 but the Agency justified it on the grounds of environmental considerations or of taking into account local pressure to maintain the condition of the defence or its visual impact.

4.25 The techniques are intended to identify both stretches of river that are under- and those that are over- maintained. For nearly half of all rivers in the two regions, the benefits of maintenance work was at least five times greater than the costs of it (**Figure 23**). Where the benefits far outweigh the costs, the economic justification does not question, as it should, whether the existing level of maintenance is necessary, for example if significantly lower levels of expenditure would still deliver a high level of benefit.

4.26 At the area offices we visited we also found that some staff found it difficult to identify revisions to the level of maintenance as a result of their application of the new economic assessment techniques. This suggests that use of the techniques may not be fully effective yet. Therefore, the Agency is right to continue its efforts to ensure that all area offices understand the techniques fully, apply them effectively and consistently; and receive advice from the North East region.

23 **Benefit: cost ratios for maintenance works in the Midlands and North East regions (1999-2000)**



Source: National Audit Office analysis

Is there a consistent approach to maintenance across England?

4.27 Prior to our examination we found that the Agency had not sought to benchmark maintenance expenditure between area offices or to produce performance indicators by which the cost of maintenance might be compared, although they did begin work on this in 2000. We calculated a crude indicator of the cost of maintenance per kilometre of main river in the four area offices responsible for the Trent and Humber river systems. This showed wide variations in cost from £930 per kilometre in the Dales Area to £2,820 in the Lower Trent Area (**Figure 24**). Many of the variations can be explained by differences in land use and the type of terrain along riverbanks. For example, the Lower Trent

24 **Maintenance costs by length of river in four Area Offices**

Environment Agency Area Office	Total length of main rivers in area (kilometres)	Total maintenance expenditure per kilometre £	Routine maintenance expenditure per kilometre £
Midlands Region			
Lower Trent	1,104	2,820	1,840
Upper Trent	790	1,590	860
North East region			
Ridings	1,170	1,471	1,385
Dales	1,402	930	898

Source: National Audit Office analysis of Environment Agency data

area in the Midlands is far more urbanised than the other areas, requiring greater and more frequent maintenance. However, it is doubtful whether all differences can be explained in this way. It may be that inappropriate levels of maintenance are being undertaken or that maintenance is not being carried out in the most cost effective manner. The condition surveys reflected in Figures 21 and 22 suggest what can happen if appropriate maintenance is not carried out.

4.28 Our review of maintenance programmes at the area office in the Midlands and North East regions also showed wide variations in the standard or extent of maintenance works carried out. For example, routine expenditure in Lower Trent was three times larger than Upper Trent. Variations in standards applied can be illustrated by the approach to grass cutting (which accounts for some 30 per cent of routine maintenance expenditure). In the Upper Trent Area most river banks received four grass cuts a year, five cuts a year was common practice in the Lower Trent South Area, whereas in the Lower Trent North Area nearly half of the rivers received only one cut a year.

4.29 We also analysed the maintenance programmes at four area offices. We noted significant differences between the Midlands and North East region in funding minor construction works from the revenue budget (**Figure 25**). The Trent Area offices in the Midlands spent nearly £1.7 million (or 38 per cent of all its maintenance expenditure) on this work in 1998-99, whereas the North East Region spent only £146,000. Such variations may be significant in understanding the current state of repair of defences in different Flood Defence Committee areas (Figure 22).

25 **Expenditure on maintenance in four Areas Offices, 1998-99**

Environment Agency Area Office	Routine and periodic maintenance (£000)	per cent	Non-routine maintenance (e.g. minor capital works) (£000)	per cent	Total (£000)
Midlands region					
Upper Trent Area	682	54	571	46	1,253
Lower Trent Area	2,029	65	1,086	35	3,115
North East region					
Dales Area	1,259	97	45	3	1,304
Ridings Area	1,620	94	101	6	1,721
Total expenditure	**5,590**	**76**	**1,803**	**24**	**7,393**

Source: National Audit Office analysis of Environment Agency data

4.30 One possible reason for the level of non-routine maintenance was that new schemes in the North East attracted a capital grant rate of 45 per cent from the Ministry, compared to 15 per cent in the Midlands. (In future, to be 65 and 35 per cent respectively - see paragraph 3.8). In effect the Yorkshire Flood Defence Committee may be encouraged to identify capital works rather than use its maintenance budget. On the other hand the Severn-Trent Flood Defence Committee has funded minor construction works from the maintenance budget and the emergency workforce has carried out jobs up to £100,000 without attracting Ministry grant. In its evidence to the Agriculture Select Committee in 1998 the Agency noted that there was anecdotal evidence that the capital grant system had unintentionally encouraged capital replacement rather than maintenance and that this was an issue in delivering economic flood defence measures. Similar comments were made by our surveyed organisations.

Views on funding capital and maintenance work

"Where a high rate Ministry grant is available there is a tendency to concentrate funds on capital works rather than maintenance which has the effect of skewing the decision-making process in favour of renewal rather than repair"
The Chartered Institute of Water and Environmental Management

"The Ministry's grant can encourage a capital scheme against the alternative of an adequate level of maintenance. Whilst in the expending of public funds it is implicit that this investment would be protected by maintaining the asset provided, this needs to be more robustly enforced through the conditions applied to the grant."
Association of Drainage Authorities

How is maintenance carried out?

4.31 The Agency employs a workforce of 1,570 across England to provide an emergency response to flood events. As evidenced in the floods of October and November 2000, by their nature, floods of emergency proportions develop quickly and an instant response capability, with good local knowledge, is necessary to operate flood defences, and to work with local authorities who have lead responsibility for emergency situations and co-ordinating rescue operations. The size of the Agency's workforce has been assessed in each region and is based on the number of staff required to cope with the first 12 hours of a one in 10 year flood event, (that is, an event of a size that is estimated to happen, on average, once every 10 years). Multi-functional working during flood emergencies means that all regions have a workforce significantly below the level assessed on this basis. For floods of longer duration, procedures are in place for requesting assistance from other areas or regions or from military personnel. During October 2000, for example, the Southern Region was assisted by the Anglian region emergency workforce and by technical staff from Thames Region and Wales. In early November, the

emergency workforce in the Dales and Ridings areas of Yorkshire were supported by staff from East Anglia and the North West, which had been less hard hit.

4.32 The annual cost of the workforce is £32 million. As flood emergencies occur infrequently, the Agency employs these staff throughout the year on its maintenance programmes. The proportion of time spent by the in-house work force on emergency response will vary between areas and between years depending upon the location and severity of floods.

4.33 The Agency has adopted a client-contractor role with the in-house workforce and agrees, at the start of each year, the level of expenditure on and approach to maintenance works. The in-house workforce carries out all but specialist maintenance jobs: as the Agency has to provide work for the workforce, the bulk of maintenance works are not subject to competitive tendering. In some areas, the size of the workforce and scale of maintenance allows offices to contract out some work, such as specialist electrical maintenance. In other areas, the in-house workforce has successfully tendered in competition for external work, for example on maintenance programmes of Internal Drainage Boards. This suggests rates charged in such cases are competitive.

4.34 The Midlands region estimated that up to 90 per cent of the in-house workforce's time is spent on flood defence maintenance; whereas maintenance works in North East region provide work for approximately half of the region's in-house workforce. To some extent this can be explained by the Midlands region willingness to undertake minor construction works from its revenue budget. The North East region regularly uses the in-house workforce on large capital schemes, and undertakes to restore defences that have been affected by mining subsidence. However, the staff may not have all the necessary skills to undertake specialist construction works and, as our review of capital projects in Part 3 shows, this has led to construction problems (Albert Dock in Hull, paragraph 3.24).

4.35 In 1997 the Agency commissioned consultants, Brown & Root Projects Limited, to review the effectiveness of the in-house workforce. They found that:

- The emergency workforce was providing an effective emergency response and the necessary maintenance work was being carried out. The risk of ineffective emergency response was minimised by using a directly employed workforce.
- There was wide diversity in approach to managing the same type of business between regions. None of the regions were as efficient or effective as they could be. The Agency was not getting all round value for money from the current arrangements and improvements could be made which would show significant benefits.

4.36 Brown & Root recommended an improvement programme which involved setting up nationally consistent client and contractor partnerships to remove the previous adversarial relationships between the Agency and the in-house workforce, the introduction of a performance measurement system to assist in demonstrating value for money, and clarification of overall accountabilities. The consultants envisaged long term benefits from the improvement programme including a saving of over £10 million over five to seven years. The Agency intended to implement the recommendations but work on the Action Plan and other reviews in 1998 intervened and full implementation was delayed. However, a partnering implementation team was set up and identified improvements in procurement, work programming, and communications.

Conclusions and recommendations on maintenance

There are variations between Agency area offices in the approach to and level of maintenance carried out and no national monitoring to ensure maintenance is efficient and targeted to the standards of service required. The Agency began work on benchmarking in 2000. It should consider:

- whether common standards should be established and applied across regions and seek the agreement of flood defence committees to these;
- benchmarking maintenance expenditure between areas and establishing a regime of performance indicators to facilitate comparisons and investigation of variances. Performance measures might include, for example, cost per kilometre of main river; the percentage of river distance where maintenance standards are met ; and the rates charged by the area workforces;
- benchmarking routine maintenance expenditure such as grass cutting against externally procured services;
- promulgation of best practice in maintenance work; and
- whether there is a need for closer monitoring by the Agency's regional offices and headquarters.

Internal reviews commissioned by the Agency suggest that the in-house workforce provides an effective emergency response and carries out a high standard of maintenance work. However, the Agency does not monitor nationally the proportion of time spent by its in-house staff on emergency response across areas and over time. Such data might assist the Agency in determining whether the need for resources is matched to maintenance requirements and whether there is scope for more efficient use of resources, for example, by increased cross-area initiatives.

The Agency's review of how the emergency response was handled in the flooding of late 2000 will also be useful in identifying lessons to be learned; how well emergency maintenance was carried out during the crisis; and whether any failures in routine maintenance were the cause of flooding or damage to defences.

Appendix 1

Environment Agency response to the Independent Review Team Report on the Easter 1998 floods

1. In November 1998, the Agency published its Action Plan in response to the Independent Review Team Report on the Easter 1998 Floods, which it had commissioned. The Action Plan set out what the Agency was to do to ensure the lessons from Easter 1998 were applied to management and delivery of an effective flood warning service. In October that year, a ministerial statement to the House of Commons set out eight specific targets for the Agency to achieve a "seamless and integrated service of flood forecasting, warning and response" by April 2000.

2. The progress made against these targets by April 2000 and some aspects of the independent review which these actions address are set out overleaf. In addition, the Agency had:

   - In September 1999 published a Flood Warning Strategy for England and Wales, setting out the roles of those involved in flood warning, the aims of the flood warning service and the way forward for the next five years.
   - In July 1999 obtained approval from the Ministry for an investment strategy for flood warning, involving £45.4 million over 5 years. Of this, £20 million is for improved telemetry and gauging equipment; and £20 million for staff and consultants work on flood warning. The remainder was for improving public awareness and collection of data on condition of assets. In 2000-01 the Ministry also agreed a further investment of some £60 million for the period ending 2010.

Environment Agency Action Plan: Progress made as at September 2000

Ministerial targets set for the Agency in October 1998	Reason for target eg Independent Review findings	Progress made by 2000
By December 1998, urgently check all flood warning dissemination plans for errors and omissions.	The Independent Review had earlier identified that not all local authorities had been consulted by the Agency on the existing plans.	The Agency employed consultants in 1998 to review plans. These found mostly minor errors, omissions or overlaps in information and coverage and some unclear boundaries. The Agency is now revising dissemination plans to a new template and meets regularly with other bodies responsible for responding to flood situations.
By March 1999, in conjunction with the Ministry and other operating authorities, develop its current supervisory responsibilities for all flood defence matters, including the adequacy of defences owned by others	The Ministry was responding to an Agriculture Select Committee finding for the Agency to develop its current supervisory responsibilities for all flood defence matters including the adequacy of defences owned by others .	The Ministry set out an elaboration of the Agency's flood defence supervisory duty in November 1999. It has been agreed by representatives of the other operating authorities.
By April 1999, review its internal management structures and take action to address skills shortages.	The Independent Review recommended measures to improve management of flood defence, partly to permit more authoritative direction and bring about greater national consistency.	The introduction of revised management structures took place between April and September 2000.
By September 1999, publish revised flood risk maps, using best available information.	The review had found that significant work had been completed on surveys and maps of areas at risk required under the Water Resources Act 1991, but that there was a long way to go before mapping would be complete. Using existing information would enable early issue of indicative maps.	Simplified maps provided to local authorities by April 1999. Presentations by the Agency explained purpose of the maps and how to use them. Further progress in 2000 (see report paragraph 2.9).
By September 1999, carry out a more detailed review of dissemination plans for content, scope and coverage, and review the content of flood warning messages.	Although flood warnings were issued according to Agency policy, there was a lack of awareness by the public of what they meant, together with inconsistent procedures. Warning messages were colour coded: few people understood coding system.	Publicity and awareness surveys and campaigns undertaken. Increase in number of properties linked to the automatic voice messaging system. New coding system due by September 1999. Slipped, could have been introduced in early 2000, delayed until September 2000 to coincide with onset of winter.
By March 2000, introduce improvements in its network of telemetered river flow monitoring equipment and other hydrometric standards.	On flood forecasting, some organisational and technical issues may have inhibited the provision of effective warnings. Each region used different forecasting techniques for historic rather than scientific reasons.	In April 2000 the National Flood Warning Centre was set up with responsibilities for identifying best practice, improved techniques and forging links with other experts. Completion of the first phase of the telemetry works resulting in an additional 109 river level gauges, 16 river flow gauges and 65 rain gauges. These will enable conditions to be monitored during flooding and the calibration of flood models.
By April 2000, complete visual surveys of all flood defences and undertake regular updates thereafter. This would be coupled with less frequent, but more rigorous, structural surveys of defences from mid-1999.	The Agriculture Select Committee recommended that the survey be completed at the earliest possible date.	The Agency has completed its programme of visual inspections of its flood defences. Local authorities have inspected between 75 per cent and 90 per cent of other defences. The remainder were scheduled for completion by September 2000. Defences belonging to third parties have been inspected through discussions with local authorities.

Appendix 2 Study Methodology

Part 1: Introduction

Information obtained from the Ministry of Agriculture, Fisheries and Food, (Flood and Coastal Defence with Emergencies Division) and the Environment Agency Headquarters. Further information from the Agriculture Committee's Sixth Report of 1997-98 on Flood and Coastal Defence (HC 707 1997-98).

Part 2: Flood warning service

Our methodology involved:

- Examination of:
  - Easter 1998 Floods: Assessment by the Independent Review Team by Peter Bye September 1998.
  - The Easter Floods Action Plan published by the Environment Agency in November 1998.
  - Ministry of Agriculture, Fisheries and Food: High Level Targets published in November 1999.
- Interviews with key staff of the Easter Floods Action Plan Team and examination of reviews, files and progress reports held by the Southern Region, Environment Agency Worthing, Sussex.
- A review of the Environment Agency's Easter Flood Investment Strategy and papers held by the Ministry.
- Interview with the head of National Flood Warning Centre in Frimley and examination of papers.
- Survey of Environment Agency Regional offices on implementation of the Easter Floods Action Plan.
- Examination and analysis of annual flood surveys carried out for the Agency by the British Market Research Bureau International 1997-2000.
- Survey of interested parties (from those listed at Appendix 3) as to their views on the flood warning service.

Part 3: Building new defences

Our methodology involved:

- A review of the Ministry's guidance to operating authorities on strategic planning, economic appraisal, and code of practice on environmental assessment.
- Survey of Agency Regional offices on the estimated expenditure and outturn of schemes.
- Examination and analysis of Ministry information on approved schemes, including benefit:cost ratio analysis.
- Focus on schemes built in the River Trent-Humber catchment. The examination of one river system allowed for sufficient analysis and understanding of flood defences. The Trent-Humber river system has the following features:
  - A major river system with a mix of urban and rural settings. Several major urban and industrial areas are protected including much of the Birmingham and South Yorkshire conurbations but also cities such as Nottingham, Derby, and Stoke on Trent. Rural areas include South Yorkshire, North Lincolnshire, Derbyshire and Staffordshire.
  - A substantial number of completed and on-going flood defence schemes.
  - Maintenance expenditure is typical of a catchment which has invested heavily in capital defences - on the Humber Estuary alone there are 280 kilometres of flood defences to be maintained.
  - Environmental issues are to the fore, such as on the Humber Estuary, parts of which are protected by European Union Directives. There are also many other environmental sites in the system which are affected by flood defences. In addition, the Humber Estuary is the subject of an Agency initiative to manage estuaries and river systems as a single and sustainable entity.
  - Substantial numbers of people and properties along the river system are at risk and require a flood warning service.
- Visits to three Agency regional offices: Solihull in the Midlands, Leeds in the North East and Peterborough in Anglian which have responsibility for flood defence and managing capital schemes on the Trent-Humber river catchment. In addition, we visited four Agency Area offices - Lichfield and Nottingham in the Midlands region and Leeds and Willerby in the North East. The visits involved:
  - a review of the region's strategic approach to identifying, appraising and building new flood defence schemes and Local Environmental Agency Plans;
  - interviews with Agency staff to establish their approach to the construction of new flood defences;

- case file examination of 16 new schemes built between 1996 and 2000, including economic appraisals and environmental assessments; and
- a review of Regional Flood Defence Committee and Local Flood Defence Committee papers.

- Survey of interested parties (from those listed at Appendix 3) as to their views on the construction of new defences.

Part 4: Performance and maintenance of defences

On performance our methodology involved:

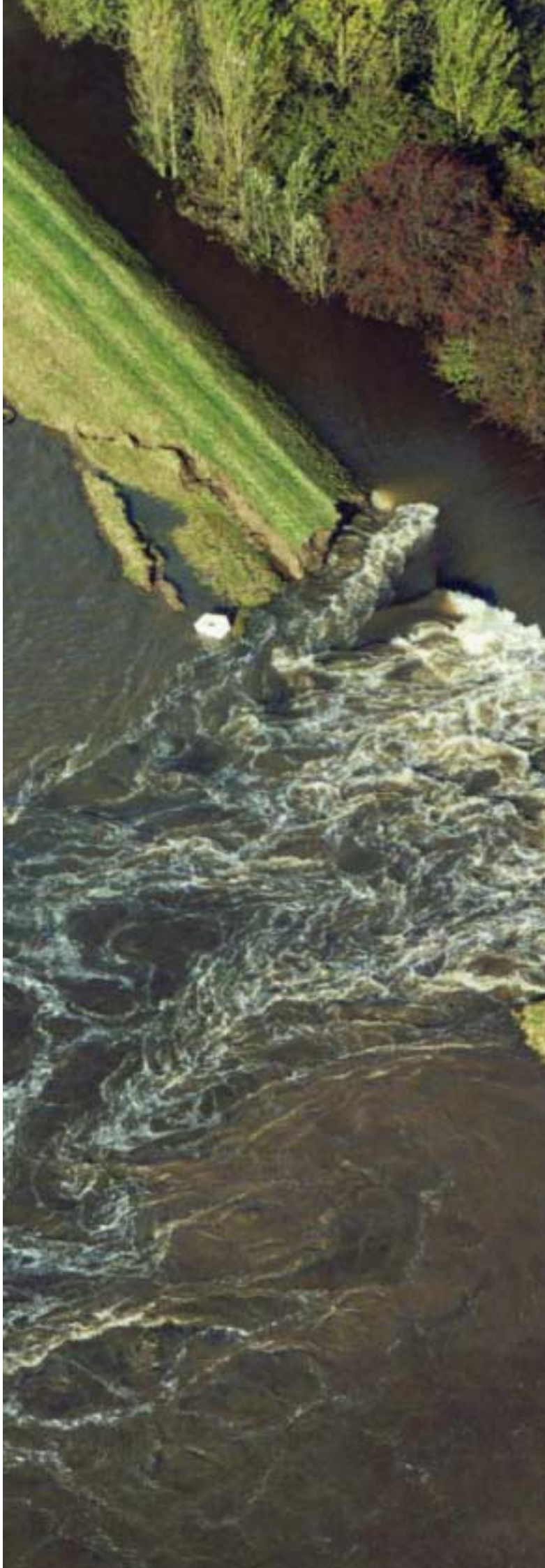
- Examination of the state of repair surveys and the condition of flood defence assets carried by the Agency.
- Review of Regional and Local Flood Defence Committee papers.
- Review of the Easter 1998 Floods Independent Review Team findings.
- Analysis of flood incident reports carried out by the Agency between December 1997 and January 2000.
- The results of post-project appraisals carried out by the Ministry and the Agency.

On maintenance our methodology involved:

- Visits to two Agency regional offices: Solihull in the Midlands and Leeds in the North East and four Agency Area offices - Lichfield and Nottingham in the Midlands region and Leeds and Willerby in the North East - to examine maintenance programmes, justification and prioritisation of work and expenditure, and carry out interviews with key staff.
- Review of a study, carried out by Brown and Root Projects Limited for the Agency, to examine the value for money obtained from maintenance and emergency work.
- A survey of interested parties (from those listed at Appendix 3) as to their views on the maintenance work carried out on flood defences.

International comparisons

We employed the Flood Hazard Research Centre at Middlesex University to research how other countries carry out flood defence work compared with England (Appendix 4).



Appendix 3

Organisations consulted

In addition to our work with the Environment Agency and government departments referred to in this report, we consulted the following organisations with an interest or involvement in inland flood defences:

Associated British Ports

Association of Drainage Authorities

Association of British Insurers

Birmingham City Council *

Bullen Consultants

The Chartered Institution of Water and Environmental Management

Country Land and Business Association

East Staffordshire Borough Council *

English Nature

English Heritage

Kingston upon Hull City Council *

Local Government Association

National Farmers Union

National Association of Flood Defence Chairmen

The Royal Society for the Protection of Birds

The Wildlife Trusts

* Local authorities in the Trent-Humber area, the focus of our examination of key issues

Appendix 4

Summary of characteristics of flood defence in four countries

We commissioned the Flood Hazard Research Centre at Middlesex University to make comparisons between countries on flood defence activities.

Countries are not generally comparable because of differences in terrain, climate and population density. On the European Continent for example most rivers are much larger and longer than those in England. However, the table below illustrates some areas for comparison between England, two of England's near neighbours, France and the Netherlands, and Poland, a country which suffered devastating floods in 1997, when 54 people died and 160,000 were evacuated. Elsewhere in Europe the impact of flooding in 2000 was also greater - for example in Italy in October and November there were 30 deaths, 4,000 people lost their homes and 22,000 were displaced.

Characteristic	Country			
	France	The Netherlands	Poland	England
How many people are at risk of flooding and what is the extent of flood risk?	22,000 km², 2 million people	17,000 km², 7.5 million people. 50 per cent of country at risk of flooding.	Major flooding in 1997 affected 20 per cent of the country and 3.8 million people	12,000 km², 8 per cent of land area, 1.6 million properties
Are there differences between types of watercourse e.g. main river/ordinary watercourse?	Yes	Yes	Partly	Yes
Are flood defences organised centrally or locally?	Not clear	Main rivers: national government Local rivers: Watterschappen	Provinces/Municipalities	Main rivers: Environment Agency Non main rivers: local authorities and inland drainage boards.
What is the total expenditure on flood defence (rivers? Or rivers and coastal?)	400-500 million FF per year (£40-50 million), central government provides 100-120 million FF	960 million NLG (£270 million)	Not identified	£400 million (rivers and coastal)
Is the need for flood defences identified through river catchment plans?	Yes	Yes	No	No, although Local Environment Agency Plans based on river catchments discuss flood defence issues.
Who gives flood warnings?	Ultimately, the Mayor of the Communes has a legal duty to warn citizens, although other organisations are involved.	Central government	Local government	Environment Agency
Who funds capital works?	Central government and other levels of government	Main rivers: national government Local rivers: provincial government	At present, through overseas loans	Central and local government
Is benefit-cost analysis used to select the most cost-effective option in building new defences?	Required in principle, but absence of flood damage data, not clear how possible	No, reliance on achievement of standards of protection (against the 1250 year return period flood in the case of rivers)	No	Yes
Are environmental interests considered in flood alleviation projects?	Yes; the increasing adoption of a catchment approach e.g. the Loire	Yes (e.g. Meuse and Rhine plans); and also the extensive adoption of river restoration	Yes	Yes
Does the government provide compensation to victims of flood disasters?	No, although a compulsory levy of 12 per cent added to all household insurance premiums provides flood insurance cover	Yes, and it also compensates those who have to evacuate on a precautionary basis.	Yes	No. Coverage by domestic insurance premiums.

Appendix 5

Environmental considerations in flood defence schemes

1. There are statutory obligations on operating authorities to protect the environment arising from both United Kingdom and international legislation. In 1996 the Ministry and the Welsh Office published a Code of Practice on Environmental Procedures for Flood Defence Operating Authorities. We examined the operation of the Code in respect of the new schemes in the Trent-Humber catchment area between 1996 and 2000. We found that the Agency formally consulted English Nature, English Heritage, and the Countryside Agency on all schemes and generally other organisations such as landowners and local conservation organisations. The Agency's flood defence staff sought the advice of the Agency's own conservation staff. All scheme proposals involved an assessment of the environmental impact of the options under consideration even where monetary value was not quantified. We asked interested bodies whether they were satisfied with the consultation arrangements and the weight given to environment considerations in flood defence work.

Views on consultation:

"There is a long history, dating back to the early 1980's and beyond of consulting English Nature on annual and three-year flood defence and maintenance programmes. For example, the Anglian Region of the Agency produces an annual programme of works on which English Nature then comments. However, we believe that the consultation could be improved by including a justification of the need for works and prioritisation according to criteria which take account of nature conservation." **English Nature**

"As far as we are aware we hear of all relevant new proposals, are consulted in a timely fashion and our comments appear to be given due weight in the formulation of schemes. We would welcome more explicit guidance on the various stages in project appraisal and their inter-relationship with rounds of consultation."
English Heritage

2. In our survey replies there was a distinction between organisations seeking to promote environmental concerns, such as English Nature, the Royal Society for the Protection of Birds, The Wildlife Trusts and the Chartered Institution of Water and Environmental Management, and other organisations seeking to protect agricultural and other interests - the National Farmers Union and the Country Land & Business Association, for example. The environmental organisations told us that:

   - The current thrust of strategy is correct in giving priority to protecting human life and the most valuable assets, including environmental assets.
   - Too much emphasis is given to hard engineering solutions such as walls, embankments, and sluices.
   - The Agency does not look at environmental opportunities afforded by new works and seeks to retain the status quo. Too little is done to reverse past damage.

3. Organisations seeking to protect the agricultural interest, while not unsympathetic towards the environment, considered that the right balance between environmental concerns and flood defence had not been struck, and that productive agriculture and the built environment had to be protected.

Views on the weight given to environmental consideration (agricultural organisations)

"Whilst acknowledging the increasing importance of environmental factors in flood defence policy and practice, there is a widespread feeling in the farming community that perhaps the balance is swinging too far in favour of environmental concerns at the expense of effective and necessary flood measures." **National Farmers Union**

"Past public and private investment in flood defences has provided tremendous opportunities to develop land for more productive use - both for agriculture and many forms of built development. This national investment needs to be sustained." **Country Land & Business Association**.

4. The Association of Drainage Authorities considered that although environmental interests were given the appropriate level of consideration, a problem existed with regard to maintenance in that any activity, even vegetation control or silt removal, could be viewed as damaging and could lead to adverse criticism. The Association told us that 'whilst the understanding between flood defence and the environmental interests had improved beyond measure, there is still much to do in reaching the position whereby a broader based and longer term countryside management culture is in place'. In addition, achieving conservation objectives and European directives can be costly and as such may take a share of available funds with potential to reduce the total number of flood defence projects that can be undertaken.

5. The Ministry's new guidance on environmental appraisal issued in March 2000 advises, for example, on how scheme design can take account of environmental objectives and sustainability and comply with European directives; and on the range of techniques available for use in environmental valuation. The Ministry has also set operating authorities a high level target that they should aim, for example, to avoid damage to environmental interest and seek opportunities for environmental enhancement.

Glossary

Catchment	the whole area that drains either naturally or with artificial assistance to a river. It includes the drainage channels, tributaries, floodplains and washlands associated with a river and an estuary, if there is one
Coastal defence	a generic term that includes both coastal protection against erosion and flood defence
Development	in accordance with the definition given in Section 55 of the Town and Country Planning Act 1990, with certain exceptions, development means the carrying out of building, engineering, mining, other operations, in, on, over or under land or the making of any material change in use of any buildings or other land
Estuary	the tidal mouth of a river
Flood defence	defending a coastal or river hinterland against flooding
Flood plains	overflow areas, adjacent to a river channel, where water from rivers that break their banks, for example, during exceptional storms can drain slowly into the ground, usually leaving behind muddy sediment
Fluvial	relating to a river
Hard engineering	the use of rigid structures which ameliorate the effects of flooding or erosion by blocking or obstructing these processes. Soft engineering uses natural forms of defence, such as flood plains, salt marshes or beaches which adjust to environmental change
Internal drainage districts	districts where statutory bodies - internal drainage boards - have been created to manage land drainage in areas of special drainage need
Main river	watercourses shown as such on the statutory main river maps held by the Environment Agency and the Ministry of Agriculture, Fisheries and Food
Managed realignment	the management of a process of establishing a new defence line, often set back from the existing position, with the aim of improving the long-term sustainability of the defence, or contributing to other aims such as habitat creation
Ordinary watercourse	an ordinary watercourse is one which does not form part of a main river
Operating authorities	those responsible for, or with permissive powers relating to, flood defences
Return period	the average length of time separating flood events of a similar magnitude: a 100-year flood will occur on average once in every 100 years
Telemetry equipment	devices for recording and measuring events from a distance, such as rising water levels, and transmitting data to a receiver
Washlands	areas of flood that store water during storm events, thereby ameliorating the risk of flooding downstream