National Audit Office

ENVIRONMENT AGENCY

Building and maintaining river and coastal flood defences in England

REPORT BY THE COMPTROLLER AND AUDITOR GENERAL | HC 528 Session 2006-2007 | 15 June 2007

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John Bourn
Comptroller and Auditor General
National Audit Office

8 June 2007

The National Audit Office study team consisted of:

Marcus Popplewell, Kate Harrison, Naomi Lock, Amma Boamah, Madeline Gunner, Chris Joyce, Pauline Ngan, Tim Pryce and Emma Moorton under the direction of Philip Gibby

This report can be found on the National Audit Office web site at www.nao.org.uk

For further information about the National Audit Office please contact:

National Audit Office
Press Office
157-197 Buckingham Palace Road
Victoria
London
SW1W 9SP

Tel: 020 7798 7400

Email: enquiries@nao.gsi.gov.uk

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SUMMARY

1 Around 469,000 households and businesses in England are at significant risk of flooding. Flooding can damage property and belongings, and any householders affected face the stress and inconvenience of having to move into temporary accommodation while their home is cleaned, allowed to dry out and repaired.[1] The cost of flooding will depend on the scale of damage and nature of the property, but existing research suggests that flood repairs can be up to £40,000 per household.[2] The Environment Agency expects the risks of flooding are likely to rise significantly over the next century as a result of, for example, climate change and the building of new houses.

2 The Environment Agency (the Agency) is responsible for managing the risk of flooding from "main" rivers and the sea in England and Wales.[3] The Agency's functions include the construction of new flood defences (£162 million in 2006-07), the maintenance and operation of existing flood defences (£176 million), as well as raising public awareness of the dangers of flooding and responding when such incidents arise (£39 million). The Agency has developed information and warning systems so that the public can determine whether their property is liable to flooding and register to receive automated advance warnings if a flood is likely to occur. Minimising the financial cost of flooding, however, largely depends upon the effectiveness of the flood defences, and this report focuses on the Agency's construction of new flood defences and the maintenance of 24,000 miles of flood defences and 46,000 flood defence structures.

Summary text continued

3 At the time of our last report on flood defences in 2001[4], 20 regional and local flood defence committees were responsible for overseeing the management of flood defences in England. Since then, the numbers have been streamlined to 11 regional committees and funding arrangements have changed so that the Environment Agency now receives a single grant-in-aid from the Department for Environment, Food and Rural Affairs (the Department) to allocate to the committees. Whilst the 11 flood defence committees still have a formal role in flood risk management in their local area, the Agency has started to recommend priorities to them on the basis of needs nationally. The Agency has also taken over responsibility for the management of critical ordinary watercourses from local authorities and internal drainage boards, and the Department is considering whether the Agency should also take on a greater role in coastal protection from local government. The key improvements in performance we identified during our examination were:

- **Greater oversight of flood risks.** The Agency implemented the 2002 Spending Review and recommendations from the 2003 Flood and Coastal Defence Funding Review which included taking on new duties, such as the responsibility for certain important rivers (known as critical ordinary water courses) from local authorities and internal drainage boards and integrated them into its existing inspection and maintenance regimes. In addition, the Agency is developing a more strategic approach to managing systems of neighbouring defences within individual river catchment areas as part of a shift in thinking, by the Agency and the Department, from flood defence to flood risk management more broadly.
- **Improved management of major construction projects.** Our examination confirmed that the Agency had improved its cost control by establishing a centralised team to oversee more complex construction work and through better risk management. The forecast outturn costs of the 43 major projects completed in 2005-06 were 7.2 per cent less than the total pre-construction estimates.
- **Protecting more people.** The Agency improved the standard of protection for 100,000 houses between 2003-04 and 2005-06 against the target which the Department set for the Agency of 80,000. The Agency appears to be on track to exceed a second target to protect 85,000 properties in England and Wales between 2005-06 and 2007-08. In addition, the Agency has mapped the probability of flooding for almost all the land in England and Wales. Over 99 per cent of properties are now covered and the information is available to householders for free at its website (www.environment-agency.gov.uk). Almost 300,000 of those properties at highest risk are now registered on the Agency's free, direct flood warning service.
- **The Agency has established a more rigorous system for classifying, recording and monitoring the condition of flood defence assets.** The Agency's database included a more comprehensive list of flood defences compared to when we conducted our previous examination. Our consultants, Atkins, also confirmed that the inspection process developed by the Agency was effective and practical.

4 Building on this progress, this report sets out those areas where there is room for further improvements in the Agency's value for money performance. The Committee of Public Accounts' previous report on flood risk management in 2001 concluded that complex organisational arrangements had led to inconsistent service levels across England.[5] Although the arrangements have been simplified, levels of expenditure on locally managed construction and maintenance work continue to vary across the country and do not yet adequately reflect the risk of flooding in each region. In addition, there may be an imbalance between the Agency's focus on the construction of new flood defences and its maintenance of existing assets. The Agency has not met its target to maintain 63 per cent of flood defence systems in target condition; and the Agency estimates that only 57 per cent of all systems and 46 per cent of high risk systems, such as those protecting urban areas, are in their target condition, with consequent risks should a flood occur.[6] In practice, however, the Agency's investigation of the autumn 2000 floods found that instances of flood defences failing were rare (less than one per cent of flooding was due to such instances).[7] Until the Agency develops more comprehensive data on the typical lifespan and maintenance costs of its assets, it is difficult to establish future resource requirements accurately, although the Agency has estimated that it requires an additional £150 million a year. In the meantime, there is scope to improve cost-effectiveness and thus reduce any additional funding that may be required.

5 To improve cost-effectiveness, the Agency needs to address:

- **Inconsistencies in the management of assets across the country.** Our analysis of Agency expenditure found that whilst all regions spent a higher proportion of their maintenance budget on high risk systems than on low and medium risk systems, the share on high risk systems varied from 24 per cent in the North East to 67 per cent in the Midlands and Thames. The variations reflect the fact that the Agency has only recently adopted a risk-based approach and are also a result of historic imbalances in the funding available to regional and local flood defence committees before the Agency started to receive a single grant-in-aid from the Department in 2004-05.
- **The absence of reliable data on the lifespans of assets while scientific research is ongoing.** As a result, the focus is on repairing faults identified rather than weighing up future maintenance requirements against the cost of asset replacement. The Agency confirmed that it is planning to develop asset plans to address this for a sample of 200 flood risk management systems across all areas during 2007. Deciding whether an asset should be replaced and the best time to do this should also be driven by the flood risk management policy for the whole river catchment or stretch of coastline. The Agency only expects, however, to complete 40 of its 68 Catchment Flood Management Plans (which set out a long term strategic plan for how flood risk should be managed in a river catchment or basin) by its December 2007 deadline and has set a new target for completion of December 2008.
- **The lack of a clear management policy for dealing with assets owned and managed by third parties.** Many of the flood defence assets on the Agency's database are owned and managed by third parties and the proportion in good or very good condition is lower than for Agency maintained assets. The Agency has very limited powers to force other bodies to improve the condition of their assets but does not necessarily notify the relevant third party when Agency inspections identify faults. The Agency is developing a national policy on the management of third party assets and seeking to codify regional land drainage by-laws which give powers over owners of structures obstructing the river channel.
- **The need for further changes to existing work practices.** The Agency's local construction and maintenance regimes are still influenced by long-standing working practices but are slowly responding to emerging issues, such as the greater emphasis on high risk defences. The Agency employed a workforce of 1,400 staff in 2005-06 (at a cost of £45 million) compared to 1,570 in 2001 to respond to flooding incidents, maintain flood defences and river channel capacity, carry out environmental and conservation works and minor construction projects.[8] From April 2007, the Agency substantially revised the pay structure of the workforce and reduced the number of allowances. The Agency had not yet devised common standards for some areas of its work, such as grass cutting, however, and has thus made only limited progress in benchmarking costs between areas and with other organisations.
- **The focus on the construction of new flood defences to protect large numbers of additional households and to meet the Department's Public Service Agreement target is unlikely to benefit smaller rural communities.** These less densely populated communities have not generally scored highly enough on the Department's assessment system to qualify for funding. In these circumstances, other possible solutions may be applicable, such as temporary or demountable flood defences. The use of such defences depends on the geographical conditions on site, such as whether the ground is level. Temporary and demountable defences have proved successful in trials in the Midlands but have not been widely used elsewhere. The Department and the Agency expect a new prioritisation system based on outcome measures to provide a more balanced approach.
- **The proportion of construction funds spent developing proposals, which limits the number of schemes that could otherwise be built.** According to the Agency's data, £76 million out of the £266 million construction expenditure in 2005-06 was on programme and project development, amounting to 29 per cent. Our analysis of planned spend in 2007-08 indicates that only 33 new projects are expected to start and 84 per cent of funds will be utilised on existing commitments. The Agency has an initiative under way to streamline the decision making process for flood defence construction schemes.

- **Weaknesses in its data systems.** The Agency has substantially increased the number of assets recorded on its database, but records are not yet complete and other operating authorities are reluctant to use the system due to cost and technical difficulties. The database was not designed as an asset or work management system and it cannot hold data on the maintenance history of each flood defence or clearly link the inspection results to records of maintenance carried out. The Agency has taken steps to improve system performance but it is still unwieldy when extracting large volumes of data. The Agency has set a number of targets relating to maintaining and building defences in England but has found it difficult to collect sufficient data to monitor these effectively. For example, it is unable to produce a report which gives an accurate and satisfactory report of system condition, partly because not all the required data have yet been entered. By 2006-07, the year in which it was supposed to be met, the Agency had only just managed to set a baseline against which to measure progress against its target to reduce the cost of development and inception to 20 per cent of total project costs. The Agency has recently started to collect a central list of all flood defence projects, including those which are regionally managed. The Agency conducted only 26 post project appraisals between April 2001 and March 2006.

6 We recommend that the Agency:

i) Focuses attention more consistently on the maintenance of those flood defences which are considered to be medium or high risk. Area managers should develop maintenance strategies and work programmes to reflect this approach.

ii) Implements a national management policy for dealing with third party assets. Whilst the Agency may not have the authority to enforce repairs, the Agency should nevertheless bring such defects to the attention of the landowner or third party. The strategy should include a risk-based approach of writing to landowners or other third parties to highlight any significant deficiencies identified during inspection, the consequent risk to neighbouring land and property, and what actions they consider are necessary.

iii) Draws upon the findings of the planned benchmarking exercise to generate real maintenance efficiency savings by applying good practice from similar public and private sector organisations and from within the Agency's areas and regions more widely across the Agency.

iv) Introduces the planned improvements to training for staff involved in maintenance and emergency response during 2007. Regional managers should incorporate a minimum training requirement into staff objectives to monitor and encourage attendance on suitable training courses.

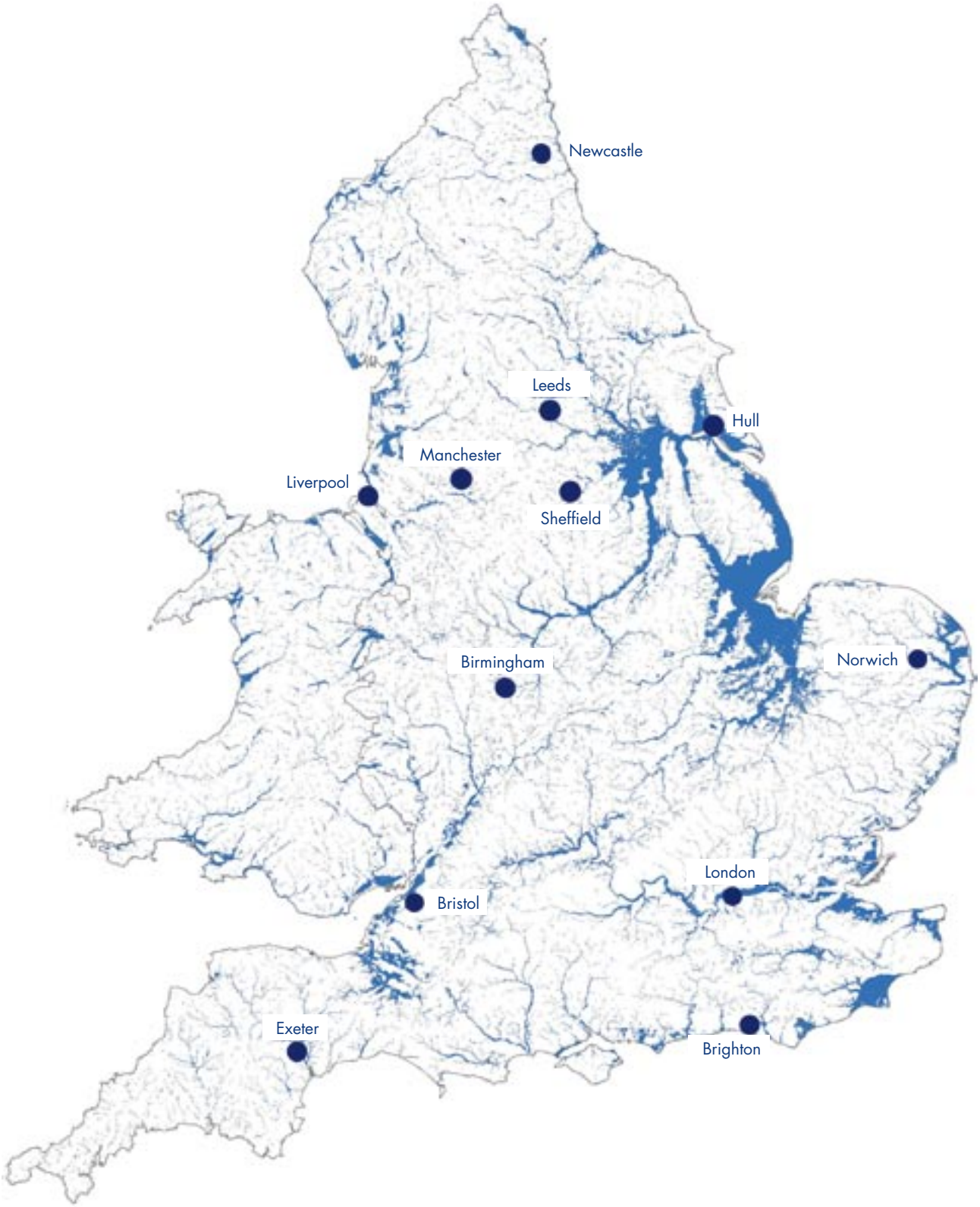
v) Conducts a review in accordance with OGC good practice at the end of each major project to determine whether benefits were realised and identify any lessons learned. The extent of each review should be tailored to the size and nature of the associated scheme, and the results held centrally so that they are accessible by other areas and regions.

vi) Streamlines its approval process so that detailed plans are not commissioned until the proposed project has been through a simplified gateway review and work is likely to start within, for example, the next two to three years, drawing on the current project by the Agency to reduce the costs of project development.

vii) Make improvements to the computer asset database, in particular to:

- Assess the long term suitability of the current computer database and if applicable, set out a timetable for the possible development of a replacement, drawing on the outcome of its current review;
- Improve its suite of reports which can be run nationally from the asset database each month to monitor progress by areas and regions in improving the condition of high and medium risk systems, improving data quality and completing inspections;
- Improve the quality and usability of data on asset management by delivering its targets for areas to include all information on the database, and including a cross reference on each inspection report to confirm that the remedial work has been done and where the paper based record can be found;
- Confirm that, following inspections, key remedial works identified have been completed satisfactorily, applying a risk-based approach so that more significant defects are followed up by inspectors, while more minor works can be checked by the maintenance manager on site.

1 The Environment Agency's analysis of the flood zones in England and Wales



Source: Environment Agency

NOTE

The map does not take account of flood defences.

PART ONE

Flooding has a significant impact on households and businesses in England

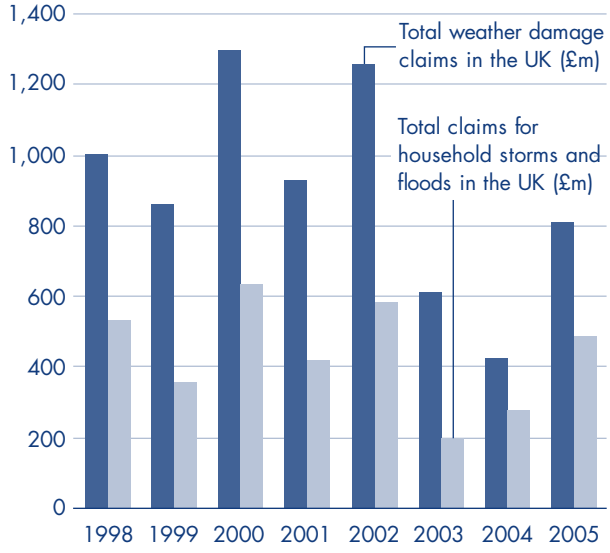
Over two million properties are at risk of flooding each year and such incidents can endanger life and result in significant financial loss

1.1 Large parts of England are at risk of flooding from rivers and the sea. Areas particularly at risk include the Humber corridor, the coastal areas in the South and East, low lying areas in East Anglia and the South West and major estuaries **(see Figure 1 opposite)**. Some 2.1 million properties are in flood risk areas, affecting 4.3 million people (8.7 per cent of the population). Of these, around 469,000 properties are at significant risk of flooding (affecting 900,000 people).[9] The last major inland floods in England were during autumn 2000, when 9,000 properties were flooded, although there have been significant localised incidents since then, such as at Boscastle in August 2004 and in the North West of England in January 2005.[10] England has not experienced serious coastal flooding for many years, the last major occurrence being the North Sea flood of 1953, which resulted in the deaths of over 300 people in the United Kingdom.

1.2 Flood waters damage belongings, such as soft furnishings, carpets and electrical goods, affect the building itself (such as plasterwork and wood fittings) and can cause structural damage. The flood water can become contaminated with sewage or chemicals, and householders will typically have to move into temporary accommodation while their home is cleaned, allowed to dry out and repaired. Most losses are covered by insurance[11] and research by Dundee University and Halifax Bank of Scotland found that flood repairs can cost up to £40,000 per household.[12] Insurers provide cover if they estimate the risk of flooding as less than once in every 75 years. If the risk is more than one in 75 years, and no defences are planned, insurers will examine the risks case by case and work with owners to see whether the property can be made insurable.[13] The stress and inconvenience to households from a flood is more difficult to measure, although research by the Department for Environment, Food and Rural Affairs suggests that it equates to £6,000 per household.[14]

1.3 Quantifying the financial risks of flooding in future depends on a wide range of factors and assumptions, including the extent of climate change. The Office of Science and Technology estimated that losses from river and coastal flooding in the United Kingdom could be between £1 billion and £20 billion a year by 2080.[15] The Environment Agency (the Agency) estimates that the expected annual damage from flooding in England is £1.1 billion a year, although this figure excludes the risk of damage to transport infrastructure, agricultural land and any environmental or social costs.[16] Between 1998 and 2005, the insurance industry paid out £7.2 billion in weather damage claims in the United Kingdom, of which £3.5 billion was for storm and flood damage to household properties. The additional cost of uninsured losses is excluded **(see Figure 2)**.

2 Insurance industry claims for weather damage in the United Kingdom



Source: Association of British Insurers

NOTE

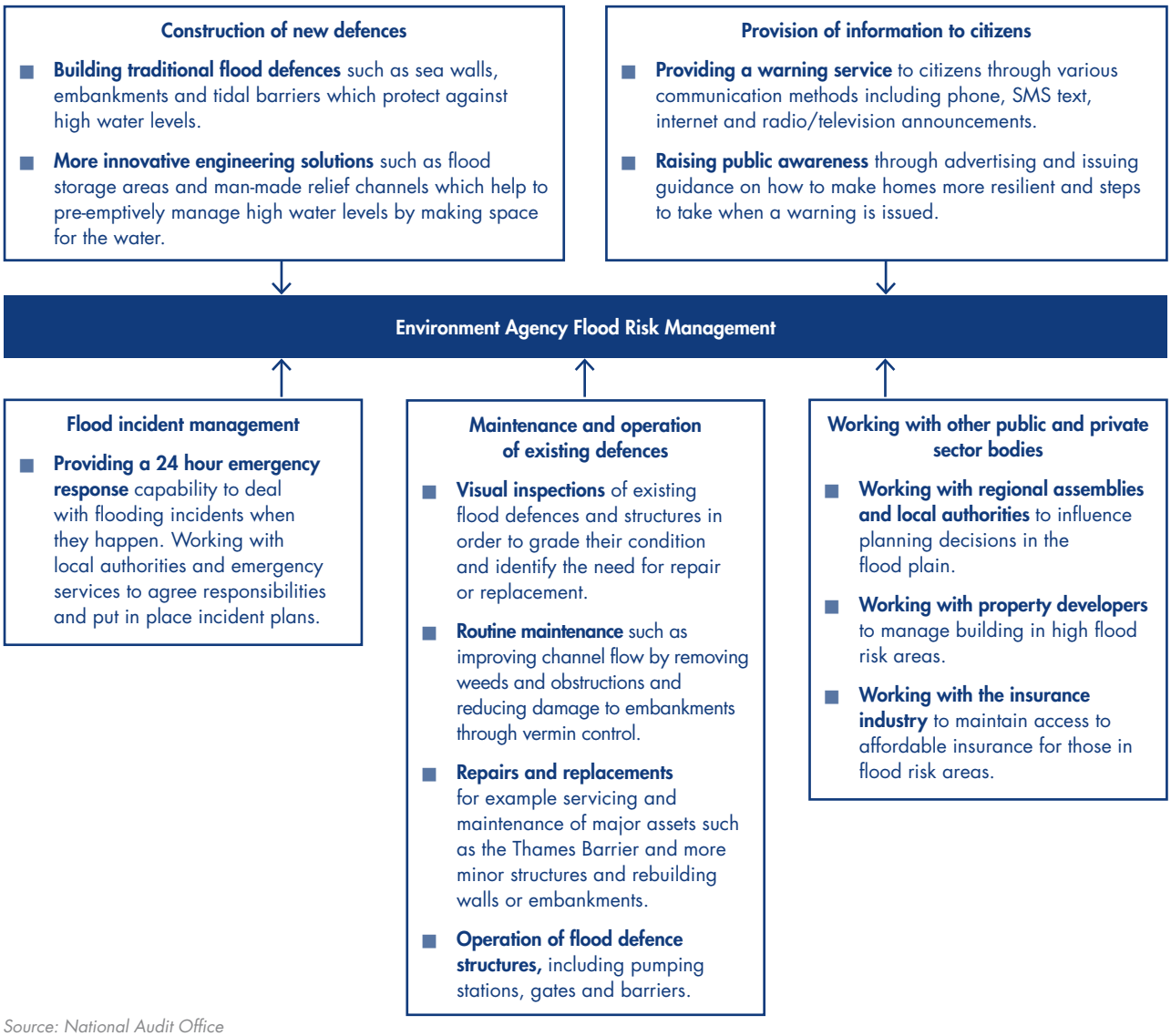
The data in this figure include damage from flooding from all sources, not just rivers and the sea.

The Environment Agency has primary responsibility for flood risk management in England

1.4 The Agency is the principal flood risk management authority in England. It has permissive powers, under the Water Resources Act 1991, to manage flood risk arising from designated "main" rivers and the sea. The Agency manages the risk to the public in a number of ways: building new and replacement flood defences, channel clearance and maintenance of existing defences, emergency response during flood events, forecasting and warning services to alert people when flooding is likely and public awareness raising. The Agency also supports the planning system to avoid the creation of new risks through inappropriate development in floodplains. These and the other key components of flood risk management are shown in **Figure 3**.

1.5 The willingness of the insurance industry to continue to provide cover for flooding depends on their confidence that the Environment Agency will maintain standards for those already protected and increase the level of protection for those households most at risk, especially given the potential increase in risk as a result of climate change and housing development. Building and maintaining defences are therefore key flood risk management activities for the Agency. In other countries, the government acts as insurer of last resort. In the Netherlands, for example, flood insurance is largely unavailable and the government provides compensation for flood victims in special cases, depending on the seriousness of the flood; in France, the government typically would cover the insurance companies for losses incurred due to flooding, based on a levy on insurance premiums.

3 Environment Agency roles and responsibilities for flood risk management

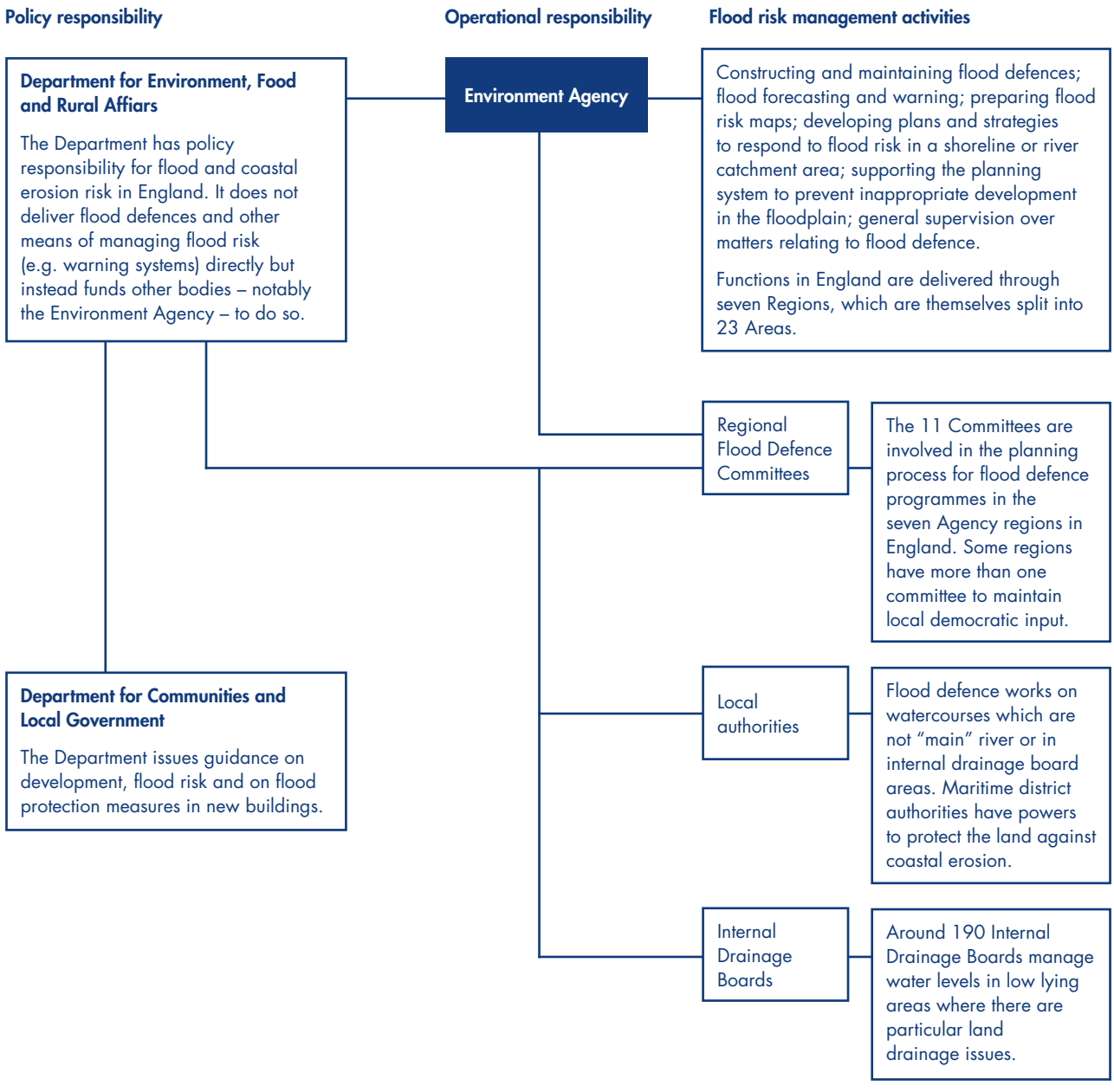


Source: National Audit Office

1.6 The Agency seeks to manage the risk of flooding rather than to prevent all damage from flooding. As a consequence, the Agency generally builds new river defences to withstand a one-in-100 year flood event and sea defences to a one-in-200 year standard, in accordance with indicative standards set by the Department for Environment, Food and Rural Affairs. In comparison, the Netherlands has a higher level of protection: the statutory standard of protection varies from one-in-1,250 for rivers to one-in-10,000 for sea defences in the most densely populated central part of the country.

1.7 The Agency's responsibilities have changed since we reported on inland flood defences in 2001.[17] Whereas at that time flood defences were effectively funded and managed by 20 regional and local flood defence committees, the Agency has since taken over the national responsibility for such matters and now refers its decisions for approval to 11 regional flood defence committees. The current responsibilities are shown in **Figure 4**. The Agency has taken over the management of some rivers (known as critical ordinary water courses) from local authorities and internal drainage boards and the Department for

4 The key components of flood risk management in England



Source: National Audit Office

Environment, Food and Rural Affairs has undertaken consultation on whether the Agency could take on a wider strategic role for coastal erosion (see **Figure 5** for key events since 2001).

1.8 Expenditure by the Agency on flood risk management has increased from £303 million in 2001-02 to £483 million in 2006-07 (including local levy), an increase in real terms of 40 per cent **(see Figure 6)**.[18] The increased funding was announced by the Government in the 2002 Spending Review to improve flood defences, warning and incident response following the widespread and devastating flooding which occurred in 1998 and 2000.

Scope of our examination

1.9 This report examines the management, by the Environment Agency, of flood risk from rivers and the sea. In our previous report, which looked at inland flood defences, we examined the organisational and funding arrangements for flood defence, flood warning and public awareness, building new defences and the performance and maintenance of existing defences. A summary of progress against the recommendations made in the subsequent Committee of Public Accounts' report is set out in Appendix 2.[19] Since those reports, the Agency has taken on new responsibilities as noted above, is on track to have reduced flood risk for over 158,000 houses

5 Key developments in flood defence since 2001

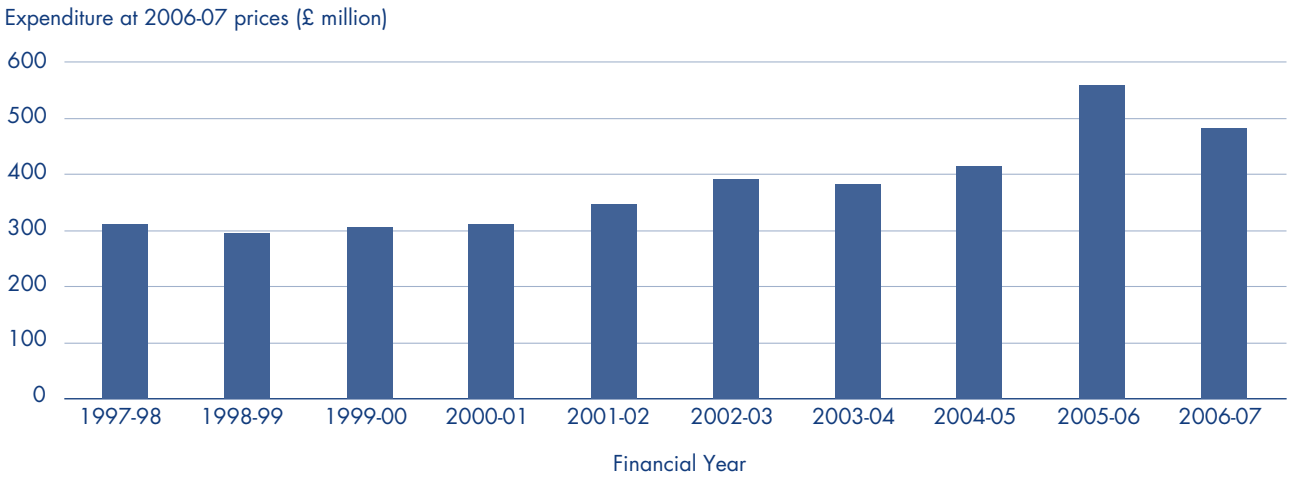
July 2002	**Spending Review 2002** set progressive increases in the level of annual funding to the Department for Environment, Food and Rural Affairs for flood and coastal erosion risk management, rising to an increase of £150 million by 2005-06 against a 2002-03 baseline and set a target to improve protection for 80,000 houses over this period.
June 2003	**Flood and Coastal Defence Funding Review** recommended the transfer of certain rivers (critical ordinary watercourses) to the Agency from local authorities and internal drainage boards, the rationalisation of regional and local flood defences committees, a single stream of central government funding for the Agency, an increase in contributions from beneficiaries of flood defences and streamlining of flood defence project approvals.
April 2004	A **single annual grant-in-aid** from the Department to the Agency replaced the previous funding mechanism of capital grants on a scheme by scheme basis combined with levies by the Agency (through Regional Flood Defence Committees) on local authorities.
July 2004	**Target to improve protection for 100,000 homes** agreed by the Department over the spending review period (2005-06 to 2007-08), of which 85,000 were to be delivered by the Environment Agency.
July 2004	Work began on the main programme of **Catchment Flood Management Plans** (large scale, strategic plans setting out policies for future management of flooding at a catchment level) for 68 catchments in England. Progress on each plan is listed in Appendix 1.
November 2004	1,700 **Critical Ordinary Watercourses** began to be transferred to the Agency in three phases: November 2004, April 2005 and April 2006.
March 2005	**Making Space for Water** – Government announced its first response to the autumn 2004 consultation on this policy, proposing to give the Agency a wider strategic responsibility for coastal erosion and all types of flooding. The plans placed greater emphasis on flood risk management and alternatives to traditional forms of flood defence, such as resilience and resistance for individual properties, warning systems, and the incorporation of risk management for flooding into land use planning and managed realignment.[1]
April 2005	**Flood Defence Committees** reduced to a single tier of 11 regional committees, removing local flood defence committees.
April 2006	**National capital investment prioritisation system** devolved to the Agency, so that the Agency became responsible for approving local authority and internal drainage board improvement projects and distributing grant to them.
August 2006	**Proposal for a strategic overview** of sea flooding and coastal erosion risk management for the Agency as part of *Making Space for Water* is subjected to a three month consultation. The Agency supported this in principle, provided that Shoreline Management Plans were placed on a statutory footing, the remit of regional flood defence committees was reviewed and additional funding provided to cover the Agency's expanded remit.
December 2006	**'Outcome Measures'**, which will form the basis of new targets for the Department and the Agency to replace the target to increase households protected and inform the prioritisation of flood defence improvement schemes, were subjected to three month consultation. The measures had not yet been finalised at the time of this report.

Source: National Audit Office

NOTE

1 Making space for water, Taking forward a new Government strategy for flood and coastal erosion risk management in England, First Government response to the autumn 2004 Making space for water consultation exercise, Department for Environment, Food and Rural Affairs, 2005.

6 Expenditure on flood risk management by the Environment Agency in England and Wales between 1997-98 and 2006-07 (at 2006-07 prices)



Source: Environment Agency

NOTES

1 Figures include 'local levy' expenditure funded by local authorities through the Regional Flood Defence Committees in addition to expenditure funded by the Department for Environment, Food and Rural Affairs.

2 All figures have been adjusted to 2006-07 prices using the GDP deflator index.

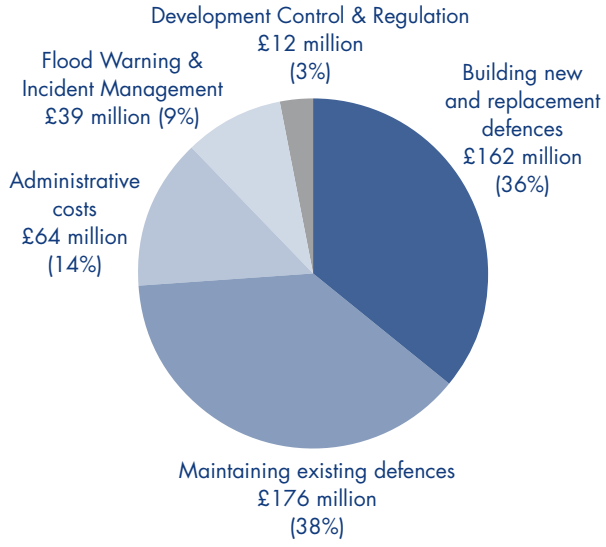
3 Expenditure was higher in 2005-06 than in other years because of the requirement on the Agency to spend historic balances held by the flood defence committees.

4 The audit of the 2006-07 figures had not been completed at the time of our report.

between 2003-04 and 2007-08 through the building of new defences, has mapped the probability of flooding for almost all the land in England and Wales, improved the coverage of its flood warning service so that almost 300,000 of those properties at highest risk are now registered with a free, direct flood warning service and developed a new flood forecasting system.

1.10 This report focuses on the building and maintenance of flood defences, which accounted for 74 per cent of expenditure on flood risk management in 2006-07 **(see Figure 7)**. Part 2 of the report examines the condition of existing flood defences and the Agency's arrangements for managing them. Part 3 looks at the Agency's programme for building new defences. Although flood risk management in Wales is also the responsibility of the Agency, oversight of its work rests with the National Assembly for Wales and the Wales Audit Office plans to report on the management of coastal erosion and tidal flooding risks in Wales in 2007-08. Responsibility for flood defences in Scotland rests primarily with local authorities and the Scottish Environment Protection Agency. Our methodology is explained in more detail in Appendix 3 and stakeholder responses are set out in Appendix 4. A summary of the approach to flood risk management in France, the Netherlands and Poland is set out in Appendix 5.

7 Breakdown of expenditure by the Environment Agency on flood risk management in England by activity in 2006-07



Source: National Audit Office analysis of Environment Agency data

NOTE

Figures only include expenditure funded by the Department for Environment, Food and Rural Affairs and exclude 'local levy' expenditure funded by local authorities through the Regional Flood Defence Committees. The audit of the 2006-07 figures had not been completed at the time of our report.

PART TWO

The condition and maintenance of existing flood defences

The Agency has increased the number of assets recorded since our 2001 report, but general conditions have not improved significantly

2.1 According to the Environment Agency's National Flood and Coastal Defence Database, there are 24,000 miles of flood defences and 46,000 flood defence structures protecting properties in England.[20] Recorded numbers have increased substantially since our 2001 report, when the Agency had some 11,000 miles of defences and 23,000 structures. The increase arises from the inclusion of coastal defences, the transfer of flood defences which were previously the responsibility of local authorities and internal drainage boards, and more accurate and comprehensive Agency records. Defences include the river channels themselves (which need to be kept free of obstructions to enable water to flow through) and barriers such as embankments and walls. Flood defence structures include pumping stations, weirs, barriers and sluices (see Appendix 6 for further details of the types of flood defences). The Agency estimates the replacement cost of these assets, including the Thames Barrier, to be £20 billion.

2.2 The Agency assesses the condition of its flood defences and structures through a programme of regular visual inspection. The frequency of inspection varies from six months to 60 months, based on the risk of failure and any consequent impact on people (see Appendix 6 for more details). Each asset is classified according to its apparent condition **(see Figure 8)**.

2.3 Since our report in 2001, the Agency has moved towards a risk-based approach to setting target conditions for its flood defence assets. This means that the Agency sets lower condition targets for assets it considers to be low or medium risk, than for those which are high risk.[21] In other words, 'fair' or 'poor' may be the Agency's target condition for some assets protecting low value agricultural land. The Agency now assigns assets to flood risk systems, which are groups of assets protecting particular areas from flooding. Appendix 6 sets out the factors which the Agency considers when designating systems as high, medium or low risk. In 2006-07, the Agency had a target to maintain 63 per cent of its flood defence systems at their target condition by March 2007, rising to 80 per cent in 2007-08 and 100 per cent in 2008-09. In practice, the Agency estimates that it achieved 57 per cent[22] by the end of March 2007, although the Agency noted that, in many cases, failures were marginal since it only needed one asset to be in a relatively poor state for a whole system to fail to meet its target condition.[23] The areas we visited pointed out two of the key reasons why they were failing to meet the systems target: the target changed during 2006-07 from 63 per cent of *assets* in good or very good condition to 63 per cent of *systems* at their target condition; and the additional work needed to assess and improve the conditions of the new defences taken over from local authorities and internal drainage boards. During our visits to area offices, some staff commented to us that the 100 per cent target seemed unrealistic given the continual deterioration of defences over time.

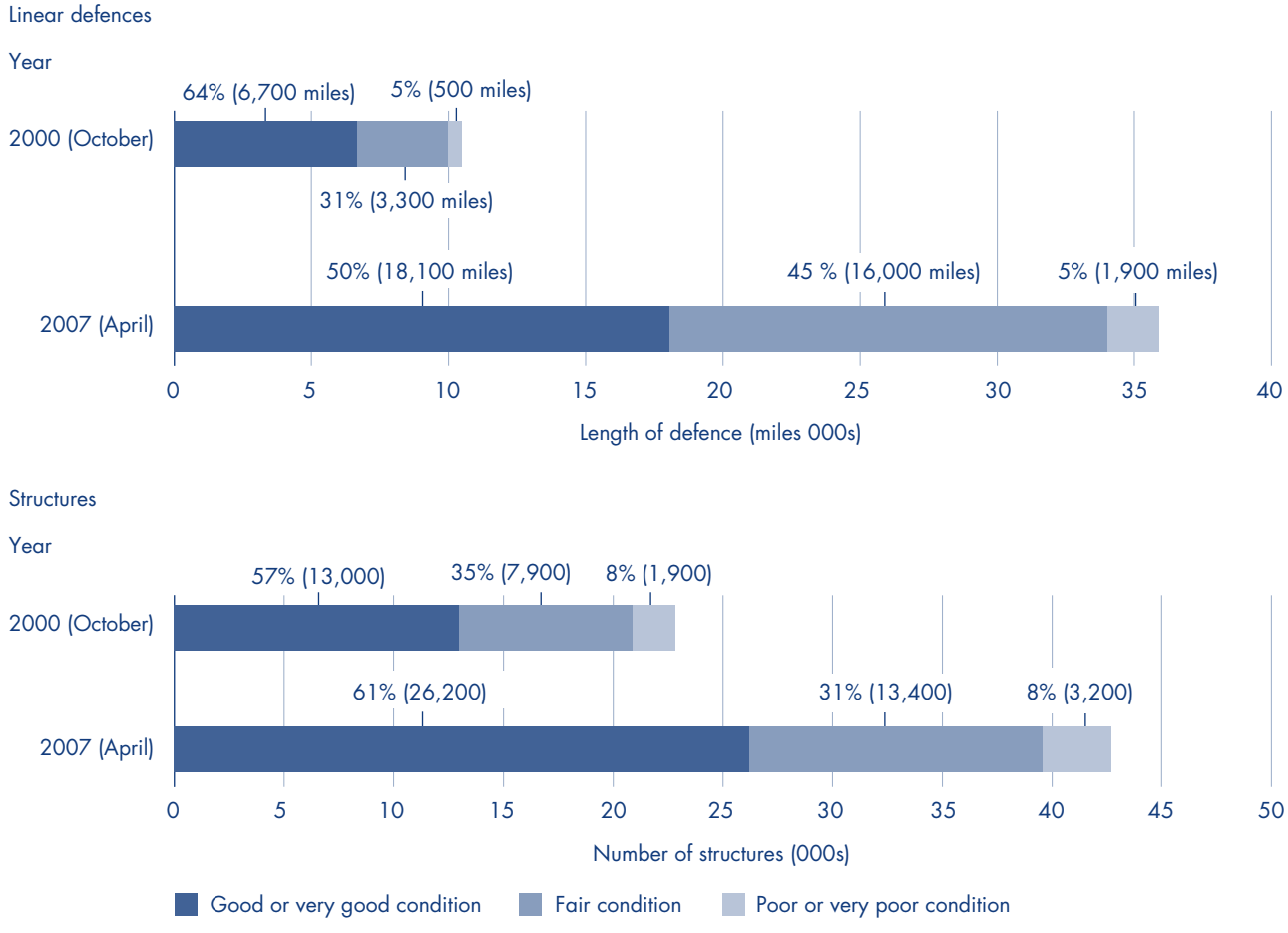
8 Environment Agency asset condition classifications

- **Very good** – Cosmetic defects which will have no effect on performance.
- **Good** – Minor defects which will not reduce the performance of the asset.
- **Fair** – Defects that could reduce the performance of the asset.
- **Poor** – Defects that would significantly reduce the performance of the asset. Further investigation needed.
- **Very poor** – Severe defects resulting in complete performance failure.

Source: Environment Agency

2.4 Although the Agency now uses a system-based approach, in order to assess the progress made since our previous report, we analysed the Agency's database in April 2007 to identify the absolute condition of its flood defences and structures. We found that the proportion of flood defence structures in good or very good condition had increased from 57 per cent in 2000 (13,000 out of 22,800) to 61 per cent in 2007 (26,200 out of 42,800) and the proportion of structures in poor or very poor condition had remained stable at around eight per cent (1,900 out of 22,800 in 2000 and 3,200 out of 42,800 in 2007) over the same period.[24] However, the proportion of linear defences in 'good' or 'very good' condition appears to have decreased from 64 per cent in 2000 (6,700 miles out of 10,500 miles) to 50 per cent in 2007 (18,100 out of 36,000 miles) although again the proportion of linear defence structures in 'poor' or 'very poor' condition has stayed constant at five per cent (500 miles out of 10,500 miles in 2000 and 1,900 miles out of 36,000 miles in 2007) **(see Figure 9)**. Comparisons between the status of the Agency's assets in 2007 and when we last examined this area in our 2001 report should take into account the change in the recorded number and type of flood defences over the period. The 2007 figures cover data on both river and coastal defences whereas the 2000 data only cover river defences. Unfortunately, the extent of the changes and a lack of reliable data for 2000 precluded us from comparing the 2007 status of the same assets we examined in our earlier report.

9 Comparison of asset conditions between 2000 and 2007



Source: National Audit Office analysis of Environment Agency data

NOTE

There are differences between the total length of defences and numbers of structures shown in this figure and in paragraph 2.1. This is because the data in this figure include natural channels which are inspected but not maintained and those assets for which an inspection form has been entered onto the database.

2.5 The transfer of some watercourses, known as critical ordinary watercourses, from local authorities and internal drainage boards to the Agency in three stages between November 2004 and April 2006 appears to have had a significant impact on conditions in aggregate. The Agency's data show that assets on these watercourses are generally in a poorer condition than the asset base as a whole. Only 55 per cent of structures and 49 per cent of linear defences on these watercourses are in good or very good condition, compared to 61 per cent of all structures and 50 per cent of all linear defences. In 2006-07, the Agency estimates that it spent £17 million on pioneering work and other improvements to critical ordinary watercourses. The Local Government Association noted that the transfer of critical ordinary watercourses to the Environment Agency has mainly taken place in urban areas or where they relate to new developments and that some watercourses already subject to a good standard of maintenance were not transferred.

2.6 Our interviews with area managers highlighted that the difficulty in keeping flood defence assets in a satisfactory condition is partly due to the large numbers owned and maintained by other bodies. These include purpose-built flood defences constructed by developers to protect particular buildings and existing structures such as factory walls which form part of a continuous linear defence. The Environment Agency maintains only 62 per cent of the total length of raised defences and maintained channels and only 17,000 (37 per cent) of the 46,000 flood defence structures. Underlying this are significant regional variations, with the percentage of assets maintained by third parties ranging from 84 per cent of structures and 81 per cent of defences in the Thames region to 16 per cent of structures and 14 per cent of defences in the Midlands. The proportion of defences and structures maintained by third parties which are in a 'good' or 'very good' condition is lower than for those maintained by the Agency: only 47 per cent of the defences and 58 per cent of structures maintained by third parties are in 'good' or 'very good' condition compared to 54 per cent of defences and 66 per cent of structures maintained by the Agency.

2.7 The Agency's powers to compel third party maintainers to take action to improve the condition of their defences are very limited. Where a third party has an existing liability to maintain the defence on a river, the Agency can serve notice under sections 21(2) of the Land Drainage Act 1991 and 107(2) of the Water Resources Act 1991, but such a liability can be difficult to prove. One area we visited, North East Thames, was particularly proactive in trying to identify third parties and to ask them to take remedial action to repair and maintain their defences. At the time of our visits, they explained that they had written to almost 400 third parties, 30 per cent of whom took action as a result. The Agency explained that the Thames River (Prevention of Floods) Acts 1879 to 1962 give it additional powers to compel action from riparian owners in relation to the Thames tidal defences which it does not have elsewhere in the country.[25] Elsewhere our visits to Agency areas highlighted difficulties in establishing the owners of third party assets, which is needed to notify them of any maintenance work required.

2.8 The Agency has some additional powers arising from local by-laws which permit it to take action against those who increase flood risk by damaging flood defences or banks, building too close to the river bank without seeking permission or allowing buildings over or next to the river to deteriorate to such an extent that they are in danger of obstructing the flow of water. These by-laws are different in each region and although the Agency is in the early stages of drafting a consistent set of national by-laws, they cannot be implemented without the agreement of all 11 regional flood defence committees to the revised wording. The Agency recognises that third party assets play a key role in the performance of some of its flood risk management systems and plans to introduce a single national policy in autumn 2007 on how areas should deal with third party assets.

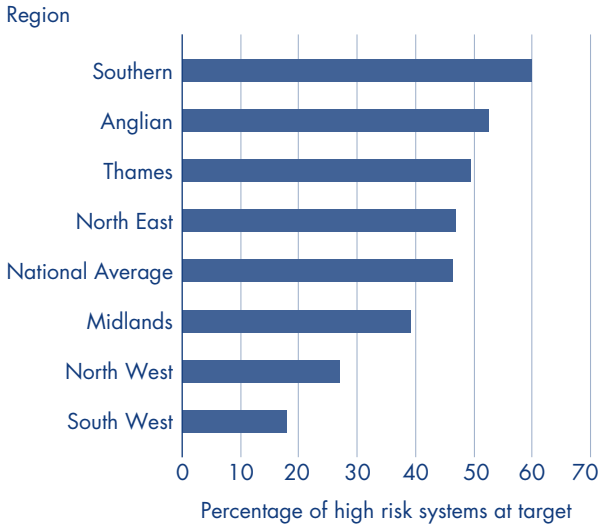
The Agency has sought to prioritise resources on those flood defence systems which safeguard larger numbers of people or environmentally significant areas of the country

2.9 The Agency spent £176 million on maintaining flood defences in 2006-07. To make best use of the resources available, the Agency has categorised flood defences into high, medium and low priorities, so that it can focus on those assets where failure would have the greatest impact. The categories are based upon the estimated impact of flooding and the risk to life (see Appendix 6). The Agency estimates, based on information from its area managers, that 46 per cent of high risk systems were at target at the end of 2006-07, compared to 62 per cent of medium risk systems and 71 per cent of low risk systems. The Agency's database showed that 35 per cent of high risk systems, 58 per cent of medium risk systems and 61 per cent of low risk systems were at their target condition. However, the Agency confirmed that, due to the fact that the database was not yet fully populated with all the data in the correct format required to run the report and the fact that the reporting tool was only able to produce separate reports on structures and defences, the figures provided by the area managers were a more accurate reflection of performance against the target at the time of our report.

The Agency does not maintain a central register of its high risk systems that are not in target condition although we understand that it plans to develop such reports in 2007-08 for consideration each month by the Head of Flood Risk Management. Estimates by the Agency's area managers of the percentage of high risk systems at target identified regional variations, as shown in **Figure 10**, from 18 per cent of high risk systems in target condition in the South West to 60 per cent in the Southern Region.[26] To some extent, the variations will reflect local circumstances, such as the differing types and lengths of river catchment or coastline, or the number of high risk systems and proportions of third party maintained defences in each region.

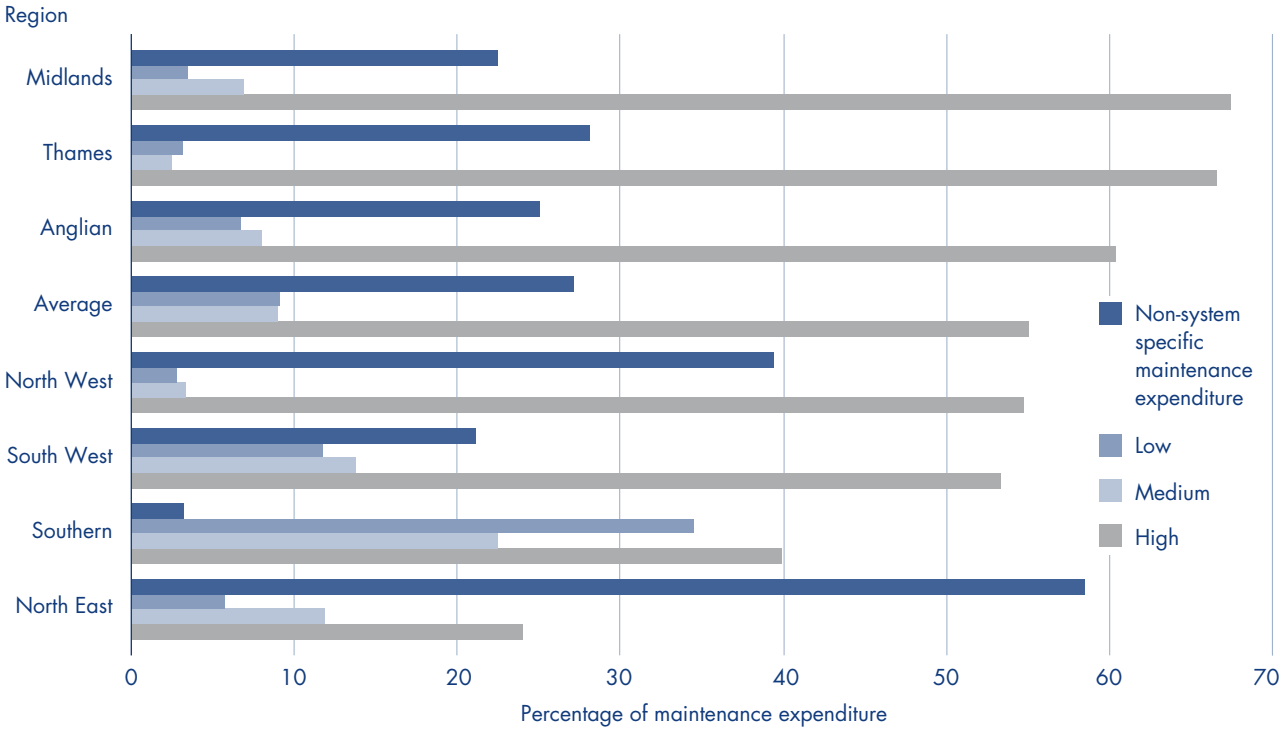
2.10 Agency data show that, in 2005-06, all regions spent a higher proportion of their maintenance budget on high risk systems than on low and medium risk systems **(see Figure 11)**, although the percentages varied from 24 per cent in the North East to 67 per cent in the Midlands and the Thames. Our visits to seven areas within those regions also highlighted variations in the extent to which maintenance work was focused on high risk systems with

10 Percentage of high risk asset systems at the target condition in 2007



Source: National Audit Office analysis of Environment Agency data

11 Proportion of maintenance expenditure on high, medium and low risk flood defence systems in Environment Agency regions in England in 2005-06 and 2006-07



Source: National Audit Office analysis of Environment Agency data

NOTE
This analysis excludes expenditure on major assets.

four areas, Ridings, Eastern Anglian, Sussex and Northern North West spending more on medium or low priority systems. Our interviews suggest that the relatively high spend in some areas on low priority systems reflected the past working practices of teams who were used to conducting specific tasks, such as silt removal or cutting back vegetation, at certain locations at the same time each year.

2.11 There appears to be little relationship between the amount of revenue funding allocated to each region in England and the risk of flooding. The Agency produces a National Flood Risk Assessment most years, based on a model assessing the severity and probability of a range of different flood events and the number of properties at risk. When we compared this assessment against the actual revenue expenditure in 2005-06 and planned expenditure in 2006-07, we found higher allocations in North West and South West England than in Southern and North East England or in the Thames region. These variations may reflect, in part, the relative condition and importance of each flood defence system. The Agency also noted that the variations reflected historic imbalances in the funding available to each regional and local flood defence committees. The Agency has sought to even out any imbalances since it started to receive a single grant-in-aid from the Department in 2004-05, and intends to ensure revenue funding is wholly based on the risk of flooding through an investment planning process agreed with the 11 regional flood defence committees.

Efficiency savings in the Agency's inspection and maintenance work will help improve the condition of flood defences

The system for inspecting assets is thorough but could be simplified

2.12 We commissioned Atkins to carry out a review of the Agency's asset condition assessment system (see Appendix 3). Atkins confirmed that using visual inspections to identify any assets requiring more detailed structural investigation was effective and practical, and that the inspectors applied a consistent approach in the five areas they visited. Atkins concluded that other approaches, such as more detailed surveys or some form of automated monitoring, would not be cost-effective. Nevertheless, existing work practices could be simplified by removing the requirement to inspect all defences along a river reach or sea frontage at the same frequency. Checking low risk defences less frequently could free up inspection time and reduce the risk that maintenance time is diverted onto lower priority work. In two of the five areas visited, inspectors had already adopted this method and the Agency has confirmed that it intends to roll out this approach nationally during 2007. At the end of March 2007, Agency data showed that one out of seven regions exceeded its planned programme of inspections for the year and four had fallen short of the target. The remaining two could not be measured because they set their targets on a reach basis and the database records inspections completed of individual assets. Interviews with Agency staff indicated that some areas were falling behind because of a lack of trained inspectors or because they have a higher number of assets requiring frequent inspection.

2.13 Once an inspection has been completed, subsequent maintenance work should ultimately bring the asset back to its target condition. We were assured that the issues identified during inspection were dealt with, although we were unable to establish this at the seven areas we visited due to a lack of a clear link between paper-based maintenance records and the inspection results held on the asset database. The asset database was designed as a place to store asset location and condition information which could assist with organising inspections. It is not an asset or work management system so maintenance plans and records of completed work are kept by the area offices on paper-based records. The Agency is currently reviewing the database and its future potential as an asset management system.

2.14 We found various problems with the operation of the asset database. During our area visits in autumn 2006, staff commented on the difficulties they had downloading information from the database. Since then, the Agency has sought to speed up the database by streamlining the recording of data on the geographical location of assets. The system can still fail when large volumes of data are extracted, however, and it cannot handle reports of more than around 300 assets at a time. Although the database is supposed to be a national system, local authority usage of it for non-main river assets, including coastal assets maintained by maritime district authorities, is still low (208 users in around 80 local authorities). In a survey conducted in March 2006, maritime district authorities expressed dissatisfaction with the Agency's handling of the rollout of the database.[27] The Agency has identified a number of barriers to uptake by local authorities, including cost, time, their own existing databases and technical issues relating to the reliance on obsolete software and the lack of compatibility between the database with other operating systems.

2.15 At the time of our visits to area offices in autumn 2006, the Agency was experiencing problems with running consistent national level reports on asset systems at target condition or on asset inspections completed,

limiting the ability of central teams to regularly monitor area and regional performance against the Agency's key targets. At the start of 2007, the Agency developed a range of standard web-based reports including, for example, reports on overdue inspections and performance specifications for each system to assist with developing maintenance programmes. The Agency has also developed a report which identifies which systems are at their target condition, although the results are still unsatisfactory, partly because the data required to run the report, which amounted to almost one million entries, is not yet fully entered onto the database. In addition, the reporting tool only enables the Agency to report separately on structures and defences so it is not possible to produce a definitive list of systems which are not at their target condition.

2.16 Alongside the asset database, the Agency has a separate inventory of its 16,000 mechanical and electrical assets, which are located across 2,000 sites. Data on these assets have recently been put into a standard work management system used in industry. This should allow regional teams to raise work orders, track their progress, monitor costs and store site specific health and safety information. In the future, the Agency hopes to generate a condition grading for these assets so that they can be entered onto the asset database alongside the Agency's other flood defence assets.

The Agency continues to employ a large workforce to maintain assets and to provide an emergency response service

2.17 The limited improvement in asset conditions since 2000 suggests that, at the current rate of progress, the Agency will struggle to meet its future condition targets (see paragraphs 2.3 and 2.4). The Agency estimates that an extra £150 million a year would be needed over the next ten years to bring all its systems up to their target condition, although this estimate is difficult for us to validate as it is based on the experience of Agency's staff and depends on their predictions of future maintenance work. Any increase in funding would depend on negotiations with the Department and the Treasury although any improvements in the efficiency of maintenance work could reduce the extent of any additional funding required.

2.18 The Agency employed 1,400 in-house maintenance staff in England at March 2007 at a cost of approximately £45 million, compared to 1,570 at the time of our last report. In-house maintenance staff are employed to respond to flooding and environmental incidents and to repair and maintain flood risk management assets (flood risk maintenance accounts for 59 per cent of their time). They carry out a range of activities including operational inspections, maintenance of minor structures and major assets such as the Thames Barrier, maintaining channel capacity through vegetation clearance and obstruction removal, environmental and conservation works and minor construction projects up to the value of £200,000. In 2005-06 the Agency set a target to reduce its in-house maintenance staff to 1,357 posts by April 2008 and to contract out more work. Our 2001 report recommended establishing common standards for some areas of work, such as grass cutting, to benchmark performance between areas and with other organisations.[28] The Agency has not yet implemented such an exercise, although it confirmed that it still intended to do so. Our examination of timesheet information for all regions highlighted large differences in the time reported spent on activities such as grass cutting, although this may have reflected differences in geography, weather conditions and the extent and type of assets in each area **(see Figure 12 overleaf)**.

2.19 From 1 April 2007, the Agency substantially revised the pay structure for its maintenance staff. The pay structure has been simplified into two national grades each divided into a number of levels. The historical localised variations on pay and allowances have been removed, with a reduction in the number of pay points from 178 to 20. This significant simplification should allow the Agency to compare costs more easily between areas and with other organisations in the future. Nevertheless some historic working patterns remain, as staff continue to work a nine day fortnight and claim an average of five hours a week per person in overtime.

2.20 More cost comparisons and potential contracting out of work may generate efficiency savings, but the Agency argues that a locally based, skilled workforce needs to be available during a flood event to remove obstructions, carry out emergency repairs, erect temporary defences and operate sluices and other defences. Our visits confirmed it was the responsibility of each area to organise training locally and that much of it was based on informal on the job training. The Agency noted that practical familiarity with the equipment and defences on each area could be more critical in an emergency than any desk based training. Nevertheless, the Agency was implementing a new training and development framework for its Operations Delivery workforce in 2007 which would be closely tied to the new pay structure. All workforce members will be assessed against personal development plans and it will be compulsory to complete NVQ Level 2 in Environmental Conservation along with other structured training programmes.

12 Analysis of the proportion of time spent by Agency staff on different flood defence maintenance activities during 2005-06, by region

Activity	Anglian %	Midlands %	North East %	North West %	Southern %	South West %	Thames %	Average %
Grass cutting	7	11	9	14	16	14	3	10
Maintain channels and defences	12	4	9	13	3	15	26	13
Maintain structures	12	9	13	7	15	16	7	11
Obstruction removal	5	15	18	13	5	4	7	9
Operational inspections	5	17	6	12	13	15	13	11
Tree work	5	8	6	4	4	6	4	5
Weed control	14	4	4	8	7	3	5	7
Other routine maintenance	7	2	7	5	6	1	0	4
Projects and other activities	33	30	28	24	31	26	35	30

Source: National Audit Office summary of Environment Agency data

Existing assets appeared to be maintained in perpetuity and the Agency has not yet developed a suitable strategy for asset replacement

2.21 Regular maintenance work on assets, to maintain them at their current condition, can be relatively straightforward and includes cutting the grass, weed control, vermin control and removal of obstructions which may affect the water flow (see Figure 12 for details of the time spent on such activities). Our 2001 report noted that the Agency had reviewed the economic justification for this work by comparing the values of the surrounding area protected by a flood defence to the estimated cost of the maintenance work.[29] The Agency has not repeated this exercise since then, largely because broadly the same maintenance work is done each year. Where the inspection process identifies a more significant concern requiring structural works, the Agency requires a cost benefit appraisal for any maintenance projects likely to cost over £50,000. The Agency confirmed that it intends to address these issues by developing plans setting out timescales and costs for maintenance and replacement of assets for a sample of 200 flood risk management systems across all areas during 2007. The Agency is also in the process of developing a methodology for justification of maintenance work and a policy on the withdrawal of maintenance from low risk coastal defences.

2.22 Our consultants, Atkins, noted during their review of the inspection process that assets appeared to be maintained in perpetuity; there was no systematic assessment of when it may be appropriate to replace an asset. In part, this may be because inspectors are part of the local maintenance team rather than the local asset management team. Determining whether it is cost-effective to continue to maintain its other assets year on year, or to construct new flood defences, depends on three key factors:

- The strategic importance of each flood defence.
- The likely lifespan of a flood defence and the projected cost of maintenance work required each year.
- The estimated cost of new construction.

2.23 The Agency has sought to determine the strategic requirement for flood defences in future by developing policy documents for each major river and stretch of shoreline. Catchment Flood Management Plans set out how flood risk will be managed over the next 50 to 100 years within a single river catchment or basin, such as the Severn or Thames. The plans are intended to take into account various factors over the long term, such as the effects of climate change and property development, so that decisions about maintenance and construction of defences can be made in the context of the catchment as a whole.

2.24 The Agency commenced the development of Catchment Flood Management Plans in 2001 and aimed to have all 68 plans in England completed by December 2007. By April 2007, the Agency had completed six of the plans and prepared consultation drafts for a further 32.[30] The Agency expects to complete 40 out of 68 plans (59 per cent) by the December 2007 deadline, with the rest due to be completed by December 2008 (see Appendix 1). Our interviews with managers in the

Agency suggest that the delays were originally due to the unexpected complexity of developing such a strategy, and more recently because of the reductions in funds available to the Agency due to the budget cuts imposed by the Department for Environment, Food and Rural Affairs in 2006.

2.25 Similarly, Shoreline Management Plans provide high level policy statements on the management of erosion and flooding on the coast. The division of responsibility between maritime district authorities (coastal erosion, under the Coastal Protection Act 1949) and the Agency (sea flooding), results in a patchwork of responsibility along many stretches of coastline. Shoreline Management Plans, which have been in place for over ten years, were the result of collaboration between the Agency and local authorities. Of the 38 plans, only three are led by the Agency and the remainder are led by local authorities. The Department has recently issued guidance on second generation Plans, which are due to be completed by 2010. In practice, however, predicted rises in sea levels from climate change may require the construction of additional flood defences or the managed realignment of the coast with consequent disruption to the communities affected **(see Figure 13)**. As a result, such plans are likely to be difficult to agree with all relevant parties.

2.26 The Agency and the Department jointly undertake research into flood and coastal erosion risk, with some 50 ongoing projects. In 2006-07, the Agency spent £600,000 on research into asset management out of £1.6 million on the flood risk research programme as a whole. One of the key research projects for asset management is the Performance-Based Asset Management System, which looks at how asset management influences flood risk, including the performance of specific assets, the influence of maintenance measures on flood risk and what visual phenomena reveal about performance. The research phase of the project is due to be delivered by 2008-09 and the resulting performance assessment software system by 2011, although the Agency has already used the interim findings to rewrite the Condition Assessment Manual for asset inspections to emphasise performance related concepts and developed a tool to allow teams to model the conveyance of a river channel, including the impact of bridges and other obstacles. The Agency lacks reliable unit cost information from its financial system which would allow it to make direct comparisons between maintenance and replacement of assets, although it has now started to use cost information on the construction of new assets to estimate the replacement cost of the asset base as a whole. In 2007-08, a workload calculator model was used for the first time to set budgets for the maintenance of mechanical and electrical assets. In April 2007, the Agency's asset database recorded the estimated replacement cost of 63 per cent of assets, compared to just 22 per cent in July 2006. The costs of new construction are addressed in Part 3 of this report.

13 The development of the Kelling to Lowestoft Ness Shoreline Management Plan in East Anglia

A draft second generation Shoreline Management Plan, covering the coastline from Kelling in Norfolk to Lowestoft Ness in Suffolk, is currently under consideration by the relevant local authorities and internal drainage boards following public consultation. The draft Plan recommends significantly different policies from those set out in the first generation Plan. The new Plan concludes that:

"Continuing to defend the shoreline in a manner similar to today would produce a significant alteration in the nature of the coast, with large concrete seawall structures and few beaches. This might maximise protection to property and land, but would be both difficult and very expensive to sustain. It could also be damaging to the natural environment, and coastal industries, such as tourism, that rely upon the character of the coast to attract visitors."

The Agency told us that the new Plan concludes that, in many places, a 'managed realignment' or no active intervention on the coastline is the only appropriate long-term solution to coastal erosion. If implemented, this approach would mean allowing retreat of the shoreline with monitoring and, if appropriate, management to limit or control movement. The earlier Plan had recommended 'holding the line' in many places. Until it has been agreed by the relevant local authorities, however, the draft second generation Plan recommends that the Environment Agency and the local authorities continue to maintain existing defences.

The second generation Plan for Norfolk predicts that the cost of maintaining existing sea defences in the county will increase. To maintain the current coastline, existing defences are likely to need extending along the coast to prevent the sea from 'outflanking' them. This is likely to reduce the amount of sand or shingle that is carried along the coast to less well protected areas, meaning they too will require further defences to prevent further erosion. In all areas, rising sea levels over time resulting from global warming are likely to mean that increasing levels of protection are required to protect every square metre of land. When viewed in this context, coastal protection measures that are only just economically viable now are unlikely to be able to demonstrate their viability over the one hundred year period used by the Department to assess bids for funding.

Source: National Audit Office summary of Environment Agency information

PART THREE

The construction of new flood defences

The Agency has improved its management of the construction of new flood defences, although a large proportion of funding is used to develop detailed plans for the proposed work

3.1 Since our last report in 2001, the Agency has invested over £900 million (at 2006-07 prices) in the construction of new flood defences. The Agency improved protection to over 100,000 households by completing 169 projects between 2003-04 and 2005-06, including new sea and river defences and the reconstruction of existing defences (see **Figure 14** for some examples of completed projects).[31] The construction of major new flood defences, defined by the Agency as complex schemes or those likely to cost over £250,000, is managed centrally by the Agency's National Capital Programme Management Service. The Agency completed 43 major construction projects in England in 2005-06.

14 Examples of the different types of flood defence construction work completed by the Environment Agency since 2001

Alkborough, Humber Estuary

The managed realignment scheme at Alkborough is part of the Environment Agency's overall strategy for the Humber Estuary, developed in response to climate change and sea level rise. The main feature of the scheme is a 20 metre breach of defences which provides more space for water in the estuary by allowing the flooding of 450 hectares of land at the confluence between the Trent and Humber. The scheme cost £10.2 million in total, with costs shared between the Environment Agency and a number of partners. It is the largest estuary habitat creation scheme in Europe which the Agency expects to result in the creation of a range of new habitats including saltmarsh, mudflats, saline pools and a freshwater habitat.

Quaggy River, South East London

The Quaggy River Floor Alleviation Scheme cost £18 million in total and is designed to reduce future flood risk to 600 homes and businesses, in the London Boroughs of Lewisham and Greenwich. The scheme was delivered in three phases consisting of two separate upstream flood storage areas and improvements to the banks and river channel in Lewisham. As well as providing space for flood storage, the scheme generated recreation and regeneration benefits for the local community and created a habitat for wildlife.

Source: National Audit Office synopsis of Environment Agency data

3.2 To help with risk management, the Agency estimates the costs and benefits of each flood improvement scheme in a Project Appraisal Report prepared by external engineering consultants and supervised by appraisal teams within the National Capital Programme Management Service. Construction cost estimates are validated by engineering or cost consultants and benefits are assessed using a manual developed by the Flood Hazard Research Centre at Middlesex University on behalf of the Department for Environment, Food and Rural Affairs.[32]

3.3 The estimated cost of the 43 major construction projects completed in 2005-06 in England increased by £12 million (an average of 8.7 per cent) between the date of approval by the Agency and the date a contract was agreed to commence construction. In practice, the increased estimate does not necessarily mean a reduction in value for money as the revised figures typically reflect changes in the design specification and more accurate estimates of final spend. Estimated benefits outweighed the original estimated costs of the major projects completed in 2005-06 by an average of 13.2 to 1.[33]

3.4 In our 2001 report, we found that the outturn cost for schemes carried out between 1996 and 1999 exceeded the pre-construction budget by an average of 7.6 per cent.[34] In comparison, the major projects for which construction was completed in 2005-06 were, on average, 7.2 per cent below the pre-construction budget, according to the Agency's latest expenditure forecasts as at 31 March 2007. However, between 2001-02 and 2005-06, the Agency experienced significant problems with cost overruns. These arose in part from the need, following the floods in 2000, to quickly improve levels of flood protection in certain areas by fast-tracking schemes. We examined 69 requests for additional funding submitted to the Agency board for approval between 2001-02 and 2005-06. We found that £100 million of additional expenditure was requested and approved above the original project budgets. Some 66 per cent of the total requested related to changes to the pre-construction budget, that is, increases in the budget after the start of construction. We looked at the underlying reasons for the increases and found that the main ones were: unforeseen changes to the original design specification or the underlying assumptions (42 per cent of cases), inadequacies in the original plans (59 per cent of cases) and disputes with contractors or other parties (28 per cent of cases).[35]

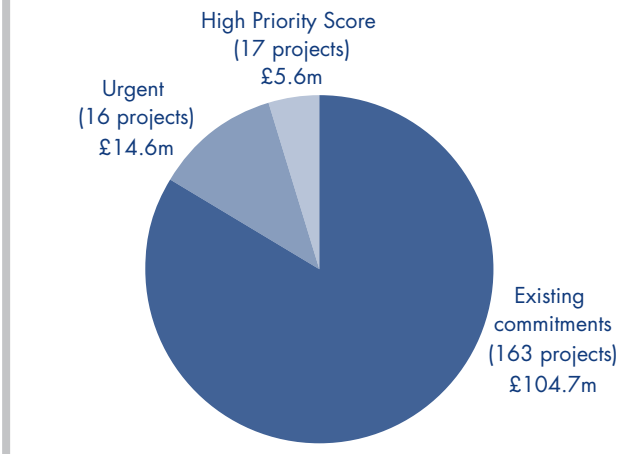
3.5 We compared target and actual completion dates for all major flood defence projects in 2005-06 and found that the programme over-ran as a whole by 17 weeks, equivalent to one per cent of the timespan. We also examined the Agency's performance against project milestones for the 2005-06 projects and confirmed that 75 per cent of milestones were met on time, compared to just 34 per cent in 2001-02.

3.6 There are three potential factors behind the improvement in performance by 2005-06:

- **Better risk contingency estimates.** Although the Agency has been developing quantitative approaches to the calculation of project risks since 1997, more recently it has increasingly used a method which generates a risk profile for the project using estimates of the probability of each risk occurring and the most likely, maximum and minimum costs if it occurs.[36] The approved project budget then includes a contingency based on the 95th percentile of the risk.
- **Better partnering work with construction suppliers.** Since 2004, the Agency has incentivised construction suppliers through a "pain/gain" arrangement and by monitoring performance of the supplier against the agreed target cost. The partnering appears to have led to better programme management, productivity and the reduction of costs associated with claims from contractors.[37]
- **Setting a target each year for savings identified during projects.** Savings made during the project are recorded on value registers and £12.2 million savings were recorded in 2005-06.

3.7 In 2007-08, the Agency plans to invest £124.9 million in new or improved defences to raise the standard of flood protection for households and businesses across England.[38] Our analysis of this sum showed that most of it was already committed to existing construction works, leaving a relatively small amount for new projects **(Figure 15)**. Some £104.7 million (84 per cent) was allocated to existing commitments, with £20.2 million set aside for 33 new schemes. Of this latter amount, £14.6 million was allocated to urgent works, with the rest assigned to other high priority schemes.[39]

15 Allocation of funding for flood defence construction projects in 2007-08



Source: National Audit Office analysis of Environment Agency data

3.8 Given the requirement to operate within its budget, the Agency needs to avoid spending too much on developing proposals that are unlikely to be funded in the next five years. The Agency had a target to reduce the cost of developing and introducing schemes to 20 per cent by the end of 2006-07.[40] In the financial year 2005-06, according to the Agency's own estimate, it spent £76 million out of total programme and project costs of £266 million (29 per cent) on project development.[41] The Agency has now removed its specific target to reduce the cost of developing schemes from its 2006-09 Corporate Plan, which states the Agency will 'increase the efficiency of delivering Flood Risk Management capital projects through modern procurement and streamlined processes'.[42] Determining the proportion of funds to be spent on pre-construction work is a difficult balance between making sure that the construction stage is properly planned and estimated, and that there are sufficient funds available to maximise construction work completed in the year. The Agency spends 19 per cent of funds up to the point when approval is given for detailed project planning compared to the 15 per cent which the National Audit Office reported in 2000 that the Ministry of Defence expected to spend at the equivalent stage (known as "Main Gate").[43] In practice, the difference may reflect the different nature of the projects by each organisation, and the Agency noted that the inherent uncertainty of ground works near rivers or the coast necessitates very detailed planning. Nevertheless, there may be scope to tighten up the project development stage without undue impact on the costs of construction work. Two of the organisations we consulted suggested the Agency could reduce the costs of project development by streamlining the approvals process. The Agency has an initiative under way to streamline the decision making process for flood defence construction schemes.

The Agency aims to prioritise those schemes that offer the most benefit, although this is unlikely to benefit smaller communities

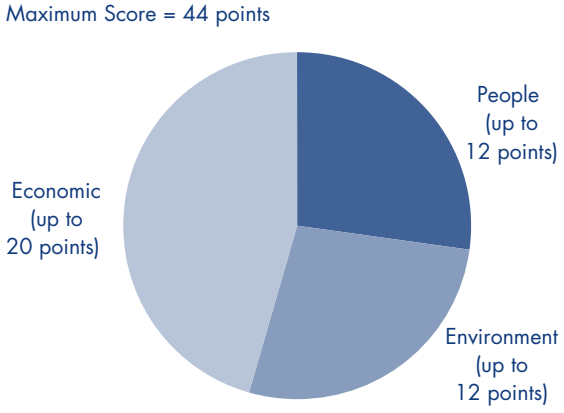
3.9 To help decide which proposed schemes should receive the remaining funding, once existing contractual commitments and urgent projects have been dealt with, the Agency assigns a priority score according to a system determined by the Department for Environment, Food and Rural Affairs. The process by which the Agency identifies, approves and then constructs schemes is complex and is outlined in more detail in Appendix 7.

3.10 The three components of the priority score (**Figure 16**) are:

- **Economic**. Compares the financial benefits of a proposed flood defence (financial damage to the economy which each flood would cause, multiplied by the probability of it happening) and the total cost of building, maintaining and operating the defence over its lifetime to calculate a benefit cost ratio. The benefit cost ratio must be at least 10.5 to score the maximum 20 points.
- **People.** Based on the number of houses protected for every £1,000 spent on the project. The total number of houses protected is multiplied by 75 and divided by 1,000 to give a maximum score of eight. Four additional points are available for schemes which protect vulnerable people or areas where there is a risk of rapid, serious flooding which poses a risk to life.
- **Environment.** Projects which help meet the Government's Biodiversity Action Plan targets by creating or improving wildlife habitats and/or protecting existing conservation designated areas, such as Sites of Special Scientific Interest, score up to a maximum of 12 points based on the number of hectares protected per £1,000 of project cost.

3.11 Our analysis of proposed new flood defence schemes between April 2005 and March 2007 showed that the Agency agreed to fund 27 of the 40 projects with the highest priority scores, **(see Figure 17 and Figure 18)**. The Agency explained that one reason why schemes with relative low priority scores received funding was that they were initiated at a time when the Department's indicative threshold priority scores (the minimum score which a project must reach to expect funding) for future years were low. In March 2004, the Department indicated that the threshold would be 15 in 2005-06 falling to 10 in 2006-07. By May 2005 this had increased to indicative scores of 19 in both 2005-06 and 2006-07. As more

16 Priority score elements



Source: Environment Agency

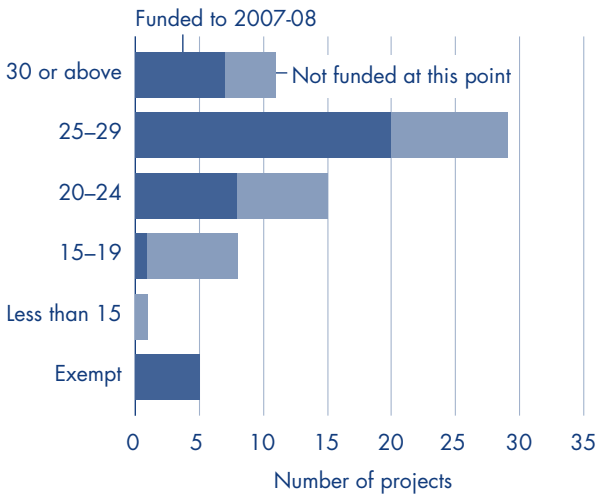
projects have been considered, there is now considerable competition for funding and only those with a priority score of 25 have been able to be funded in 2007-08.

3.12 Less densely populated communities, which may flood repeatedly, have received lower scores because the number of households affected or the economic loss is relatively small compared to the cost of a new or improved defence. The Agency expects to address this problem with a new scoring system based on outcome measures. The measures are expected to assess the Agency's performance in reducing the risk of flooding (based on expected annual damages), the probability of flooding (based on the number of households in each risk category), the consequences of flooding (through preventing inappropriate development, providing flood warning and emergency planning) and promoting sustainability (through, for example, monitoring the level of flood risk to the most deprived communities or achieving a net increase in United Kingdom biodiversity action plan habitat through flood risk management interventions).[44] The Agency is also piloting new types of cost benefit analysis (such as Multi Criteria Analysis) to help appraise options against a wider range of possible benefits.

3.13 Determining which projects should proceed has depended, in part, on the Agency's commitment to protect an extra 85,000 households from the risk of flooding between 2005 and 2008, which represents its contribution to the Department's Spending Review 2004 target. Protecting extra houses also allows the Agency to meet the request of the insurance industry to reduce the annual probability of flooding each year for a substantial number of properties in England.[45] New or improved flood defences constructed by the Agency protected an extra 100,300 houses between 2003-04 and 2005-06 allowing it to meet the 2002 Spending Review target to protect an additional 80,000 houses **(Figure 19 overleaf)**. The Agency estimates a further 58,000 houses will be protected by the end of March 2008 which would enable it to meet its Spending Review commitment. A regional analysis of houses protected is shown in **Figure 20 overleaf**. Outcome measures will replace the houses protected target from 2008-09.

3.14 The National Flood Forum argues that, where it is not cost effective to build a new flood defence, the Agency should consider alternative solutions, such as temporary barriers (which are stored entirely off site and erected by trained staff when flooding is expected) or demountable barriers (which are partially stored off site but with foundation and supporting walls remaining in place all year round) and flood resilience for individual properties.

17 Agency funding of new flood defence projects since April 2005 compared to priority scores



Priority score band	Projects funded to 2007-08		Projects not funded at this point	
	Number	Total budget £ million	Number	Total budget £ million
30 or above	7	76	4	18
25–29	20	169	9	28
20–24	8	35	7	24
15–19	1	7	7	36
Less than 15	0	0	1	16
Exempt	5	27	0	0

Source: National Audit Office analysis of Environment Agency data

NOTES

1 "Exempt" is where other factors override the priority score, such as a legal requirement for a new defence.

2 The chart analyses which of the 69 new flood defence projects approved since April 2005 were given funding, and their priority score. It includes projects which have been awarded funding for 2007–08.

18 Examples of projects which did not receive funding in 2007-08

River Douglas in Wigan: The proposed scheme has a priority score of 18.4, protects 610 households at a cost of £8.4 million and had a planned start date of January 2007. It is designed to protect areas flooded in 1966, 1987 and 2000 and the appraisal was carried out in 2001, with £836,000 already spent on development prior to 2007-08.

Banbury Flood Alleviation Scheme: The scheme has a priority score of 16.9, protects 386 households and was originally scheduled to start in July 2003 at a total cost of £12.7 million, with over £1 million already spent on development prior to 2007-08.

Source: National Audit Office synopsis of Environment Agency data

NOTE

The Agency noted that these schemes were not funded in 2007-08 as other projects were considered higher priority. However, the Agency confirmed that they would be considered for funding in future years.

Temporary barriers were successfully trialled by the Agency in the Midlands and protected 100 homes in three areas (Shrewsbury, Ironbridge and Worcester) from flooding in February 2004. The barriers have not been widely used in other regions for a number of reasons. For example, they are only suitable for slow reacting catchments where flood warnings are received early enough to allow sufficient time to erect the barriers. In May 2007, the Department announced £500,000 of funding for a pilot scheme to test the feasibility of direct aid to improve the resilience and resistance of vulnerable properties. The pilot will focus on areas where conventional community defences are not a viable solution.[46]

3.15 The Agency has adopted a more national approach to determining which projects to approve than the other European countries we looked at. Our consultants, Atkins, found that in France, for example, prioritisation of expenditure on flood risk prevention is set locally through Risk Prevention Plans and it is ultimately the decision of the Prefect (the central government representative in the area). A recent Organisation for Economic Cooperation and Development report on France found that the consultation and negotiation process, which is aimed at determining the locally acceptable risk within the limitations set by central government, did not provide a consistent framework and suggested the use of cost benefit analysis.[47]

The Agency does not routinely conduct post project appraisals of major construction projects to identify good practice or determine whether new flood defences will work as intended

3.16 When we reviewed flood defences in 2001, post project appraisals were considered the primary method by which the Agency evaluated the success with which a project had been carried out and the Agency had a target of completing at least two a year for each region (that is, 14 a year across England). Since then, the Agency has put less emphasis on the need to carry out formal post project appraisals. Between 2001 and 2006 we found a total of 26 appraisals had been completed, 11 of which were produced in the South West region **(see Figure 21)**. We examined all of the appraisals completed since 2001. There was often a significant delay between completing the project and carrying out the post project appraisal. While there may be advantages in allowing time to elapse before assessing the benefits delivered by a scheme, project management issues need to be identified quickly so that lessons learned can be shared and applied to other projects. Of the 17 reports where the appraisal and project completion dates were clear, two had been completed within a year of project closure and five were completed more than two years after the end of the project.

19 Number of houses with an improved standard of flood protection between 2003-04 and 2007-08

Financial year	Number of houses protected	Performance against target
2003-04	17,700	100,300 houses protected against the 2002 Spending Review target of 80,000
2004-05	30,000	
2005-06	52,600	
2006-07	28,300	Agency estimates indicate that 110,600 houses could be protected against the 2004 Spending Review target of 85,000
2007-08 (Forecast)	*29,700*	
Total	**158,300**	

Source: National Audit Office analysis of Environment Agency data

20 Number of houses with an improved standard of flood protection (or projected to receive an improved standard) between 2003-04 and 2007-08 by region

	Region							
	Anglian	Midlands	North East	North West	Southern	South West	Thames	**Total**
Numbers of houses protected[1]	59,000	18,700	25,200	15,900	13,800	10,400	15,300	**158,300**

Source: National Audit Office analysis of Environment Agency data

NOTE

1 The number of houses with an improved standard of flood protection varies between regions for a range of reasons including the relative priority of the flood defence project, the condition of existing defences and the timing of the project.

21 Regional distribution of the Agency's post flood defence project appraisals since 2001

	Region							
	South West	North East	Anglian	Midlands	North West	Southern	Thames	**Total**
Number of projects completed contributing to houses protected (2003-06)[1]	31	32	37	12	10	31	16	**169**
Number of post project appraisals completed (2001-06)	11	5	6	3	1	0	0	**26**

Source: National Audit Office analysis of Environment Agency data

NOTE

1 Equivalent data before 2003 are not available.

3.17 Most appraisals followed a standard format focusing on the areas with the greatest potential for lessons learned (such as timing, costs and project management). Good practice and improvements identified by the reports included: establishing the ownership of land and assets and resolving land acquisition issues early in the development of projects; good communication between the Agency's National Capital Programme Management Service, area client and others involved in the project; early involvement of the construction contractor and those responsible for operating the asset; clearly defined roles and responsibilities; and formal handover reports to reduce the loss of knowledge when teams change.

3.18 The Agency has a number of formal and informal methods by which its project teams learn lessons from each other's work, including awards, a magazine and mentoring. Such methods are likely to have helped with the improvement in project delivery mentioned at the start of Part 3 above, in particular through an improved management of risk. Since our 2001 report, the Agency has set up an online "Lessons Learned Database" to help share knowledge of common problems and good practice from completed flood defence projects. This has the potential to provide a more accessible alternative to post project appraisals but we found the database included too many possible categories of activity such as "managing suppliers" and "risk identification" (65 in total) and too many possible descriptions of the nature of the risk such as "unforeseen ground conditions" and "inadequacy of site investigation" (42 in total) some of which appeared similar to each other. The Agency kept records of usage of the database between February and July 2006 which showed it was accessed 108 times for an average of one and a half minutes. There are 140 project managers and 20 team leaders in the National Capital Programme Management Service who might be expected to use the database in its present form. Improvements to the lessons learned database are planned as part of a wider review of knowledge management in the National Capital Programme Management Service and the Agency aims to have a business case for this by September 2007.

3.19 In addition to the lack of a clear process for sharing lessons learned, the Agency appears to have limited data on how well its flood defences are likely to perform. Only 15 out of 26 post project appraisals had a section on post completion and benefits delivery. This is in part due to the fact that flood defences are only rarely tested against the standard of protection they were designed to provide.

3.20 The Agency reported on the performance of defences during the autumn 2000 floods.[48] In terms of the reasons for particular floods, the report found: 40 per cent of the flooding occurred where no defences existed; 32 per cent of cases were due to flooding from watercourses outside the Agency's responsibility, inadequate local surface water drainage and third party defences; 26 per cent were due to overtopping; two per cent were due to outflanking; and less than one per cent were due to the failure of defences. Although similar reviews have been carried out for other large events, such as the flooding in the North West of England in 2005, the Agency may not be making the most of information on how defences have performed during lesser flood events. Guidance issued by the Agency in December 2004 on carrying out post incident flood reviews does not require data to be collected on the performance of defences. In April 2007, the Agency's asset database recorded the actual height of 72 per cent of raised defences, which had increased from 64 per cent in July 2006.

3.21 The Agency is taking steps to address these issues. For example, during 2007-08, the Agency plans to test a process for reviewing the benefits delivered in the original business case on six projects completed in the North East Region between 2003 and 2006, following the OGC Gateway process.

APPENDIX ONE

Catchment Flood Management Plans

The list below sets out the Agency's progress with drawing up Catchment Flood Management Plans for the 68 different catchment areas in England (at April 2007).

Region	Catchment Flood Management Plan area		Estimated date of approval by Regional Director
Anglian	1	Broadlands Rivers	November 2007
	2	River Great Ouse	May 2008
	3	Grimsby and Ancholme	November 2007
	4	Louth Coastal	March 2008
	5	River Nene	November 2007
	6	North Norfolk	July 2008
	7	North Essex	Approved April 2007
	8	South Essex	February 2008
	9	River Welland	December 2008
	10	River Witham	December 2008
	11	East Suffolk	September 2008
Midlands	12	Severn	Pilot (completed and approved)
	13	Severn Tidal Tributaries	May 2007
	14	Trent	March 2008
North East	15	Aire	October 2007
	16	Blyth and Wansbeck	July 2007
	17	Calder	October 2007
	18	Derwent	Pilot (completed but not approved)
	19	Don/Rother	July 2008
	20	Esk and Coastal	July 2007
	21	Hull and Coastal Tributaries	July 2008
	22	North East Northumberland	July 2008
	23	Ouse	July 2008
	24	Tees	July 2008
	25	Till and Breamish	July 2008
	26	Tyne	July 2007
	27	Wear	October 2007
North West	28	Alt/Crossens	June 2008
	29	Cumbria Derwent	January 2008
	30	Douglas	June 2007
	31	Eden	December 2007
	32	Irwell	Pilot (completed and approved)
	33	Kent/Leven	December 2007

Region	Catchment Flood Management Plan area		Estimated date of approval by Regional Director
North West *continued*	34	Lune	April 2008
	35	Mersey Estuary/Sankey/Ditton	August 2007
	36	Ribble	June 2007
	37	South West Lakes	June 2007
	38	Upper Mersey/Glaze	July 2007
	39	Weaver/Gowy	March 2008
	40	Wyre	March 2008
Southern	41	Adur	January 2008
	42	Arun and Western Streams	Approved April 2007
	43	Cuckmere and Sussex Havens	Approved January 2007
	44	Isle of Wight	December 2008
	45	Medway	Pilot (completed but not approved)
	46	New Forest	December 2008
	47	North Kent Rivers	October 2008
	48	Rother and Romney	April 2008
	49	Ouse	October 2008
	50	Stour	Approved April 2007
	51	South East Hampshire	April 2008
	52	Test and Itchen	October 2007
South West	53	Bristol Avon	December 2007
	54	East Cornwall	November 2007
	55	West Cornwall	August 2007
	56	East Devon	November 2007
	57	North Devon	November 2007
	58	South Devon	July 2007
	59	Exe	August 2008
	60	Frome and Piddle	November 2007
	61	Hampshire Avon	November 2007
	62	North and Mid Somerset Rivers	July 2007
	63	Parrett	December 2007
	64	Stour	July 2007
	65	Tamar	July 2007
	66	West Somerset	December 2007
	67	West Dorset	December 2008
Thames	68	Thames	September 2007

APPENDIX TWO

Progress against the recommendations of the Committee of Public Accounts

Inland Flood Defence, Committee of Public Accounts, March 2002, HC 587, 18th Report, 2001-02

Conclusion/Recommendation	Action taken by the Agency	National Audit Office assessment
On responsibilities for flood defence (i) The Agency has limited ability to carry out its supervisory and advisory role in respect of all flood defence issues where it is not the operating authority but it cannot insist on others taking action, and cannot intervene to do the work itself. Nevertheless, the Agency has an essential role in monitoring and reporting on to its sponsor department's decisions or lack of action by other operating authorities which represent a threat to existing defences or might lead to a failure to provide an adequate level of service.	■ The consultation paper, 'Making Space for Water' and the Government's first response to it, published in March 2005, proposed strengthening the role of the Environment Agency from a 'general supervisory duty' to a 'strategic overview'. ■ During 2006, the Government carried out a consultation specifically on transferring responsibility for all sea flooding and coastal erosion risk management to the Agency. The outcome of this consultation is due to be announced in 2007 followed by a consultation on the inland element of the Agency's strategic overview. ■ Following the Flood and Coastal Defence Funding Review in June 2003, the Department simplified the funding arrangements for flood risk management. From 1 April 2004, the Agency was funded from a single grant-in-aid from the Department for Environment, Food and Rural Affairs, which replaced capital grants on a scheme by scheme basis and levies on local authorities. ■ From April 2006, the Agency took over responsibility for operating the national capital investment prioritisation system across all operating authorities, approving local authority and internal drainage board improvement projects and distributing grant to them.	■ Although the Department for Environment, Food and Rural Affairs signalled its intention to strengthen the role of the Environment Agency, it is still too early to determine what impact the strategic overview of flooding and coastal erosion will have in practice. ■ The Department has not yet set a clear policy on the future of Regional Flood Defence Committees, which are still the executive bodies responsible for flood defence in each region, now that the Department funds the Agency directly through a single grant.

Conclusion/Recommendation	Action taken by the Agency	National Audit Office assessment
(ii) Responsibility for flood defence measures is partly determined by whether a watercourse is regarded as main or ordinary, and a further category of critical ordinary watercourses has recently been introduced. In some instances, the categorisation of watercourses arises more from historical circumstances than an up-to-date assessment of relative risks and priorities. The categorisation of watercourses in England should therefore be simplified, and a review undertaken to determine responsibilities for flood defence measures based on a current assessment of the severity of the flood risk issues and their relative priority.	■ 1,717 critical ordinary watercourses have been designated as main river and transferred from local authorities and internal drainage boards to the Environment Agency in three phases: November 2004, April 2005 and April 2006. ■ The Agency has agreed funding transfers with local authorities and internal drainage boards. ■ The Agency has moved to digital mapping for both critical ordinary watercourses and the existing main river maps.	■ The Agency is in the process of surveying the transferred critical ordinary watercourses and entering them onto the National Flood and Coastal Defence Database. ■ Despite the fact that the database is supposed to be a national system, local authority usage of it for non-main river assets, including coastal assets maintained by maritime district authorities, is still low (208 users). ■ This is less of an issue now that critical ordinary watercourses, the highest risk watercourses previously operated by local authorities and internal drainage boards, have been transferred to the Agency.
(iii) During the autumn 2000 floods, responsibility for the provision, distribution and placing of sandbags to protect individual properties was unclear. Members of the public whose properties are at risk should not live with uncertainty about whether sandbags will be provided should flooding occur, or about who will provide them where relevant. The Agency should work with local authorities to develop a clear policy on the provision of sandbags, and to provide appropriate guidance to householders in flood risk areas.	■ A Local Government Association and Environment Agency working party approved a sandbag policy in summer 2004 (two years later than anticipated in the Treasury minute) following which a policy statement was approved by all Flood Defence Committees for their areas. ■ The Agency pointed out that the improved arrangements were in evidence during the January 2005 flood event in Carlisle; the Agency made sandbags available which were then deployed by both the Agency and local authorities. ■ The Agency has made available information on how to obtain and deploy sandbags as part of its public awareness campaigns.	■ The Agency's agreement with local authorities advises homeowners to make their own arrangements for sandbags although they may also be available in an emergency from local authorities. ■ The limitations of sandbags in providing protection are widely recognised. Temporary freestanding flood defences and removable products for individual properties, such as barriers for external doors and air brick covers, are considered more effective than sandbags. ■ The Agency has produced a series of leaflets for the public on flood protection products, adaptations (for example raising sockets and wiring, replacing carpets with rugs on the ground floor) and actions people should take during a flood, such as moving furniture and valuables upstairs.
On investment in flood defence		
(iv) The Agency's approach to maintenance is determined by its area offices and local and regional flood defence committees, and hence the extent of maintenance varies across the regions. This is reflected in the significantly different condition of flood defences across regions as revealed by a recent Agency survey. The Agency should put in place common minimum standards of maintenance and monitor the performance of its area offices to ensure these standards are met. They should disseminate best practice in maintenance programmes across the regions to ensure the most effective use of the limited funds available.	■ The Agency has identified flood risk management systems, groups of assets which contribute to the management of flood risk in a particular area. Systems are identified as high, medium or low risk. Target conditions for assets within those systems are set according to the level of risk and recorded in performance specifications. ■ The Agency has begun to issue guidance to its local teams to enable them to plan and carry out maintenance work within the new organisational structure and following a risk-based approach. ■ The Agency is developing 68 Catchment Flood Management Plans which set out policies for managing flood risk in individual catchments in the long term.	■ The national operations delivery process team has started to issue guidance to local teams to enable them to plan and carry out maintenance work within the new organisational structure and following a risk-based approach. ■ There are still significant variations in the percentage of time spent on different maintenance activities. ■ The Agency has not yet introduced benchmarking between areas to identify examples of good practice and set minimum standards. It has confirmed that it still intends to do so (see paragraph 2.18). ■ The Agency has encountered difficulties in developing its Catchment Flood Management Plans and it does not expect to complete all 68 plans until December 2008 (see paragraph 2.24).

Conclusion/Recommendation	Action taken by the Agency	National Audit Office assessment
(v) Between a third and a half of flood defence assets on main rivers are in fair, poor or very poor state, and a survey of the condition of assets maintained by local authorities was incomplete. In the light of flooding in 2000, it is essential that all parties give priority to ascertaining the true state of flood defences under their control, and to putting in place a programme of repair where necessary to ensure flood defences remain fully effective.	■ National targets for the condition of flood risk management systems have been set as follows: 63 per cent to be at the target condition by the end of 2006-07, 80 per cent by 2007-08 and 100 per cent by 2008-09. ■ For a flood risk management system to be at target, at least 95 per cent of all assets in the system must meet their own target standard and no asset is more than one grade away from its target standard. ■ There is a risk-based inspection process whereby all assets recorded on the Agency's National Flood and Coastal Defence Database are inspected at least once in every five years. ■ The Agency has put in place a data action plan to improve the completeness and accuracy of data in its National Flood and Coastal Defence Database. ■ The Agency directors approved an Asset Management Strategy in June 2006.	■ Measured on the same basis as in 2001, the proportion of flood defence structures in good or very good condition has improved from 57 per cent to 61 per cent but the condition of linear defences has deteriorated from 64 per cent in good or very good condition to 50 per cent. The populations are not entirely comparable due to the increase in the number and type of flood defences recorded over the period (see paragraph 2.4). ■ At April 2007, the Agency estimated that 57 per cent of flood risk management systems were in their target condition. ■ Data is still missing from the National Flood and Coastal Defence Database and take up by local authorities is still low. At the end of 2006-07, the Agency provided funding of £10,000 to the Association of Drainage Authorities for a project which will enable their members' data to be collected nationally in a format compatible with the Database. ■ The Database records replacement cost for 63 per cent of assets and actual height for 72 per cent of raised defences. ■ The Agency is still unable to run a satisfactory report which shows the number of systems at their target condition.
Flood warning and preparedness		
(vi) Not all people at risk from flooding live in areas covered by the Agency's flood warning systems. The Agency should review the availability of warnings to such people and consider with other authorities whether a more joined-up approach to flood warning services would improve the overall safety of those at risk.	■ At the end of 2005-06, 78 per cent of households and businesses within the floodplain in England and Wales were offered a suitable flood warning service.[49] ■ In January 2006, the Agency launched a new national flood warning dissemination system, Floodline Warning Direct, which replaced the previous Automated Voice Messaging system. ■ The implementation of a new national flood forecasting system is ongoing. ■ The Agency is developing a methodology for responding to flash flood events (those where it is very difficult to issue a warning which meets the two hour standard of service). ■ In the Carlisle flood event in January 2005, the most recent major event, post event surveys found that 86 per cent of people received a suitable flood warning service and took appropriate action (the national target in 2005-06 was 68 per cent).[50]	■ There has been an increase in the number of people offered an appropriate flood warning, although take up is still an issue. ■ The Agency's own research in 2005-06 found that 41 per cent of people living in flood risk areas were unaware of the risk.[51]

Conclusion/Recommendation	Action taken by the Agency	National Audit Office assessment
(vii) The Agency should review the reasons for variations in the use of different types of warning systems between regions, and satisfy themselves that the methods used are the most effective for the circumstances rather then a reflection of local attitudes or the willingness to make funds available for warning systems.	■ The Agency now issues standard procedures to areas and regions through the Agency Management System and has issued new levels of service which define the minimum standards for delivering the flood warning service. ■ Floodline Warnings Direct implemented in January 2006 is a national system, funded from a national budget and therefore is not subject to local decision making. It has removed some disparity between the regions.	■ The Agency has addressed this issue through the implementation of a national flood warning system, Floodline Warnings Direct from January 2006 and the introduction of standard levels of service for areas and regions. ■ The change in funding arrangements from locally raised funding through the flood defence committees to national funding via grant in aid from the Department should also help to reduce regional variations in investment in flood warning.
(viii) The Agency has now available maps covering the entire country identifying areas of flood risk which are also targeted for building development. However, some parties have expressed doubts about the usefulness of the maps in their current form. The Agency should work with other authorities to meet the needs of planning authorities, developers and the public, and consider how this work should be funded, for example by charging for maps.	■ Flood Zones, as required by the Government's Planning Policy Guidance (PPG 25, now superseded by PPS 25), were released to local planning authorities in June 2004. ■ A new improved flood map was published on the internet in October 2004 based on the National Flood Risk Assessment. This enables individual householders to search for their postcode and find out their level of risk. ■ A postcode database, also drawn from the National Flood Risk Assessment, is made available by the Agency to local authorities and insurers. ■ The Agency provides mapping data to over 500 organisations and charges a fee to those who use this information for commercial purposes. ■ The Agency's flood data is used, under licence and for a fee, in over 700,000 environmental reports requested each year in property searches. ■ The Government's latest policy on development and flood risk (Planning Policy Statement 25) places a statutory requirement on developers to ensure that all of the flood risk criteria outlined in the policy document are met before planning permission can be awarded. They are required by law to consult the Agency making them a statutory consultee for flood risk.	■ The Agency has improved its flood maps since we last examined this issue and the public can examine the risk of flooding near their home by using the Agency's website. Work is ongoing to improve the stability and robustness of the National Flood Risk Assessment. ■ The Agency charges fees to some users of its flood mapping data.
(ix) The Agency has improved the quality of its flood warning services, and recognises the importance of making the public aware that they live in an area of risk. The Agency should build on heightened awareness from the autumn 2000 floods to further encourage householders to take appropriate actions, for example review the adequacy of their insurance policies. The Agency should also pursue other options for raising awareness such as the provision of flood risk information in the house seller's pack which is being developed.	■ The Agency's flood risk awareness campaign is now an annual event. ■ The National Flood Risk Assessment was developed in 2004 and is updated and published most years. It calculates the number of households at low, moderate and severe risk of flooding in any given year. ■ This information is available to the public through the flood map published on the Environment Agency website. This enables individual householders to search for their postcode and find out their level of risk.	■ The Agency has sought to raise awareness through annual campaigns and through making risk information available on their website. ■ The Agency has improved its flood maps since we last examined this issue and the public can examine the risk of flooding near their home by using the Agency's website. Work is ongoing to improve the stability and robustness of the National Flood Risk Assessment.

APPENDIX THREE

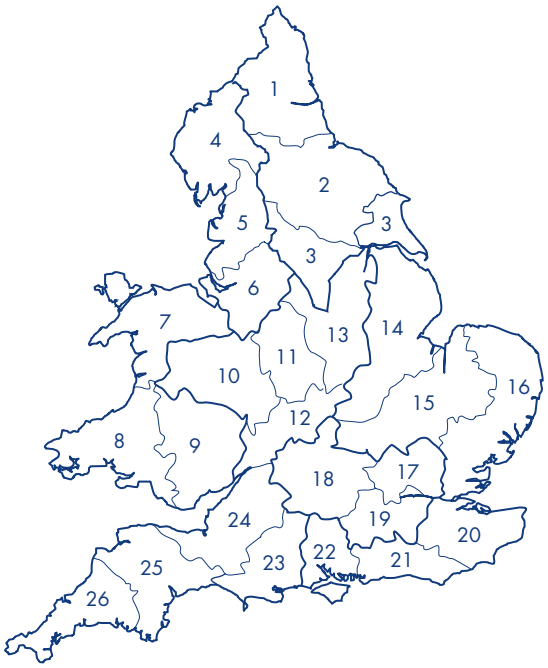
National Audit Office methodology

This appendix sets out the principal methods we used to collect and analyse information for the study.

Interviews

- We carried out field visits to seven area offices, one from each Environment Agency region in England: Eastern Area (Anglian Region), Ridings (North East Region), Sussex (Southern Region), North Wessex (South West Region), North East Area (Thames Region), Northern Area (North West Region) and Upper Trent (Midlands Region).
- In each area, we interviewed staff including the Operations Delivery Manager, Technical Support Team Leader, Field Team Leaders, Area Flood Risk Manager and Asset System Management Team Leaders.
- In each region, we interviewed Regional Asset and Investment Planning Team Leaders or members of their teams and some Regional Flood Risk Managers.
- We interviewed staff from head office divisions, including Flood Risk Management Finance, Investment and Funding, the National Capital Programme Group, the National Capital Programme Management Service, Operations Delivery Process and Flood Risk Planning.

22 Environment Agency Areas and Regions



North East Region
1 Northumbria
2 Dales
3 Ridings

North West Region
4 Northern
5 Central
6 Southern

EA Wales
7 Northern
8 South East
9 South West

Midlands Region
10 Upper Severn
11 Upper Trent
12 Lower Severn
13 Lower Trent

Anglian Region
14 Northern
15 Central
16 Eastern

Thames Region
17 North East
18 West
19 South East

Southern Region
20 Kent
21 Sussex
22 Hants & IOW

South West Region
23 South Wessex
24 North Wessex
25 Devon
26 Cornwall

Source: Environment Agency

NOTE

This map shows the area boundaries at the time of our visits in Autumn 2006. The Agency has since changed the boundaries within the Midlands and South West regions.

Data analysis, including financial analysis

- We extracted data for analysis from the following databases:
  - National Flood and Coastal Defence Database
  - 1B1S Financial Accounting System
  - STAR database (staff hours)
  - Capital Works Database (capital project information)
  - National Flood Risk Assessment
- We collected and analysed information from national and area offices, including maintenance plans, maps of asset systems, Agency guidance documents, the national flood defence construction programme, performance specifications for asset management systems and post incident reviews of recent flood events.

Review of asset inspection process

- We commissioned Atkins to review the Agency's flood defence asset inspection process. We asked them to look at the accuracy and usefulness of the inspections in evaluating flood defence asset condition, the training and experience of inspectors and whether there were any cost effective alternatives to the system.
- Atkins attended and reviewed the Environment Agency's training course for flood defence asset inspectors.
- They visited five area offices Eastern Area (Anglian Region), Ridings (North East Region), Upper Trent (Midlands Region), North Wessex (South West Region) and North East Area (Thames Region). In each area they interviewed asset inspectors and accompanied an inspector for a day to observe and discuss the inspection of a number of assets in that area.

Meta-analysis of existing information on the cost of flooding

- We commissioned Atkins to review existing published reports on the costs of flooding to households and businesses in England. Specifically, we asked them to look at:
  - financial and economic costs of flooding to households and businesses, over the short and long term;
  - risk to life, social, health and environmental impacts of flooding; and
  - the link between public expenditure and flood risk.

Review of flood risk management in three European Union countries

- We commissioned Atkins to review the approach to flood risk management in three European Union countries (France, the Netherlands and Poland) focusing on the following:
  - Country characteristics (population, gross domestic product, and numbers at risk of flooding).
  - Organisation of flood risk management (central and local government responsibilities).
  - Effort and expenditure on flood risk management (expenditure, sources of funding, asset condition and inspection, and flood risk insurance arrangements).
- Atkins analysed published information and conducted interviews with officials from government organisations responsible for flood risk management in the three countries. A summary of their findings can be found in Appendix 5.

Stakeholder consultations

- We surveyed a variety of third party stakeholders with an interest or involvement in flood risk management. We asked for views on:
  - the direct impact of flooding on the organisation, their industry, or those they represent;
  - the extent to which flood defences are adequately inspected and maintained;
  - whether new flood defences constructed by the Agency have delivered value for money;
  - whether the current method of allocation of funding between maintenance and construction delivers the best possible outcome in terms of protecting households and businesses from flooding; and
  - suggestions for improving flood risk management in terms of expenditure on defences.
- A full list of the stakeholders who responded to our consultation and a summary of their responses can be found in Appendix 4.

APPENDIX FOUR

Summary of stakeholder responses

1 We consulted a wide range of organisations with an interest in flood risk management and in particular in the building and maintaining of defences. The organisations that responded were:

- Association of Drainage Authorities.
- Association of British Insurers.
- Black and Veatch Ltd.
- Faculty of the Built Environment, University of the West of England.
- Highways Agency.
- Institution of Civil Engineers.
- Jackson Civil Engineering Ltd.
- National Farmers Union.
- National Flood Forum.
- Royal Society for the Protection of Birds.

2 Many of the respondents expressed strong interest in a wide range of issues. We took account of their views in our examination of the Agency's performance. A summary of the responses relating to the areas covered by our report are shown below, under three headings: impact of flooding; condition and maintenance of existing defences; and building new flood defences.

Impact of flooding

3 Several respondents highlighted the traumatic experience of being flooded. They noted that apart from the immediate risk to life and damage to property, longer term problems from flooding included the loss of personal possessions (such as family photographs), the difficulties and inconvenience in making repairs and the fear of being flooded again in future.

4 Part 1 of our report highlights the consequences of flooding and the estimated financial cost to households. Further information on dealing with flooding is available from the National Flood Forum, a community-based not for profit company limited by guarantee (www.floodforum.org.uk) and from the Environment Agency's website (www.environment-agency.gov.uk).

Condition and maintenance of existing defences

5 Respondents raised concerns about the condition of some flood defences – in particular those assets likely to be regarded as lower priority by the Agency and thus less likely to be regularly maintained than higher priority defences. The National Farmers Union, for example, highlighted the financial cost of flood damage to crops.

6 Some respondents raised concerns about the resource constraints on maintaining existing flood defences and whether undue amounts were spent on construction rather than maintenance. The respondents recognised that resources available for maintenance will inevitably be limited, but delaying maintenance work could allow a potential defect to become more significant before it is repaired, thereby increasing the cost.

7 Part 2 of our report examines the condition of flood defences in England and the risk-based approach used by the Agency to determine priorities. The Agency has introduced a more rigorous inspection process since our previous report in 2001 to determine the actual condition of flood defences, but further progress in improving the condition of assets depends in part on finding efficiency savings in the Agency's inspection and maintenance work.

8 Maintaining a suitable balance between the proportion of funds used to construct new assets and the cost of maintaining existing assets depends upon accurate information on the status and lifespan of each type of defence. Determining a better balance between construction and maintenance depends upon the development of Catchment Flood Management Plans to provide a strategic overview of the flood defences in each area, and the research being done by the Agency to determine the typical life cycle of key types of asset.

Building new flood defences

9 We received differing views on the Agency's methods for deciding on the best option for building a particular defence and subsequent project management. While Jackson Civil Engineering thought that the Agency's approach was industry leading, others suggested that the benefit assessment process did not consider a wide enough range of options and commented on the length of time taken to deliver an approved scheme.

10 Part 3 of the report examines the prioritisation of potential construction projects. We found that the same prioritisation process was applied to each project, and that the Agency generally opted to fund the higher priority schemes (see Figure 17). The existing scoring system does tend to disadvantage smaller communities prone to frequent flooding, however, as the relatively small number of households will score less than larger urban areas. The Agency has confirmed that it is piloting new types of cost benefit analysis to help appraise options against a wider range of possible benefits.

APPENDIX FIVE

International comparisons

We commissioned consultants (Atkins) to review the approach to flood risk management in France, the Netherlands and Poland. This is a summary of their findings.

Economic and geographic data for each country

Figure 23 is a summary of economic and geographic data relevant to flood risk management in each country.

France

Approximately four per cent (22,000 square kilometres) of the area covered by France is prone to flooding, affecting potentially two million people (around three per cent of the population). Flooding is a common event, particularly in the South East, where major events in 1999, 2002 and 2003 led to 66 fatalities. The average annual cost attributed to flood damage is estimated at €250 million (£170 million), whilst the major floods in 1999 cost €533 million (£360 million) and those in 2003 more than €1 billion (£680 million).

The main organisations involved in flood risk management in France are:

- **Central Government** – led by the Ministry of Ecology and Sustainable Development, which is responsible for establishing a national flood risk policy. Central government drafts Risk Prevention Plans for each commune which identify risks and their appropriate mitigation measures.
- **Provincial (Département) Prefects**. After local consultation the Prefects approve the Risk Prevention Plans, thereby determining the priorities for expenditure. The prioritisation of expenditure based on Risk Prevention Plans was recently criticised in a report by the OECD which recommended the use of cost benefit analysis to provide a more consistent approach to risk analysis.[52] Prefects chair the Commissions on Large Scale Risks, which aim to highlight and improve flood risk management, and also have the authority to assume control of mayoral responsibilities for maintaining flood defences and ensuring public safety.

23 Economic and geographic information for France, Poland, the Netherlands and the United Kingdom

	France	Poland	The Netherlands	United Kingdom
Area of country	547,000 km²	313,000 km²	42,000 km²	242,000 km²
Length of coastline	3,400 km	460 km	450 km	12,400 km
Population estimate (July 2006)	60.9 million	38.2 million	16.5 million	60.6 million
Population density (July 2006)	111 people per km²	122 people per km²	397 people per km²	251 per km²
Gross Domestic Product, at Purchasing Power Parity (2006)	€1400 billion[1] (£950 billion)	PLN 1500 billion (£270 billion)	€380 billion (£260 billion)	£960 billion
Gross Domestic Product per capita (2006)	€22,000 (£15,000)	PLN 39,000 (£7,100)	€23,000 (£16,000)	£16,000

Source: Atkins review of flood risk management in France, Poland and the Netherlands in conjunction with National Audit Office

NOTE

1 Financial information is presented in the currency of the country of origin and converted into pounds sterling at the rate on 16 May 2007.

- **Municipal Mayors are** responsible for implementing Risk Prevention Plans in their area. Approximately one third of all municipalities are exposed to flood risk. By the end of 2005, 5,013 (14 per cent) of the 36,800 municipalities had approved their Risk Prevention Plans and Plans had been initiated for a further 6,000.
- The public have responsibilities under the Water Act (1964 and 1992) to maintain the non-major watercourses on their property.

Flood prevention measures can be funded by all levels of government. Flood Prevention Action Programmes, which are funded both centrally and regionally, were introduced in 2002 to provide an integrated approach to the prevention and mitigation of flood risks. For the period 2004-08, 42 Programmes, covering almost a quarter of France, have been adopted at an estimated cost of €500 million (£340 million).

For fluvial flood risk the standard level of protection to which flood defences are built is against either a one-in-100 year event or the highest known historical event, whichever is greater. A recent report by OECD criticised the lack of information held on the actual condition of existing defences, stating that 'there appears to be no mechanism for the systematic collection of information on the condition of these (flood defence) structures'.[53]

In recent years, the French government has strengthened flood warning systems, introducing a network of 22 flood warning services during 2006. Regional Environmental Directorates produce flood maps showing the 100 year flood outline based on historic information and aerial photographs.

In France, insurance companies are required by law to provide cover against natural risks, including floods, but can mitigate the risks by reinsuring with the state owned reinsurer.

Poland

In the event of a major flood, approximately one million people (circa three per cent of the population) would need to be moved away from flooded areas. Localised flooding occurs regularly with larger events every three to five years centred around the two largest rivers, the Vistula and Odra. Major flooding in 1997 led to 105 deaths in Poland and surrounding countries. Between 1997 and 1998, floods in Poland are estimated to have cost the nation PLN 15 billion (£2.7 billion). Lesser floods continue to have a significant economic impact with damage totalling PLN 477 million (£87 million) in 2004 and PLN 289 million (£52 million) in 2005.

The main organisations responsible for flood risk management in Poland are:

- **Central Government** – the National Water Management Board, which is answerable to the Ministry of Environment, develops flood and drought protection plans and supervises the maintenance of water related equipment.
- The seven **Regional Water Management Boards**, which are supervised by the National Water Management Board, are responsible for large reservoirs (greater than five million cubic metres capacity) and for developing regional flood protection plans, flood protection measures and investment prioritisation.
- The 16 **Provincial Boards of Melioration and Water Facilities**, which are answerable to the Provincial Marshals and the central Ministry of Agriculture, are responsible for maintenance work and smaller reservoirs (less than five million cubic metres capacity). The Boards cooperate with local authorities who implement many aspects of the flood protection plans.

Funding for water management in Poland, which includes flood measures, is sourced from a wide range of international, national, regional and local bodies. In 2004, PLN 2.0 billion (£360 million) was spent on water management, declining to PLN 1.7 billion (£310 million) in 2005. During the period 1997–2003 over PLN 1.5 billion (£270 million) was spent specifically on repairing and rebuilding flood embankments and another PLN 1.5 billion (£270 million) was spent on rebuilding, modernising and erecting hydro-technical equipment.

A report by the Polish Supreme Chamber of Control in 2003 revealed that investment in new and existing water management systems was inadequate and in 2004 the Provincial Boards of Melioration and Water Facilities, which hold registers of the structures they supervise, deemed that 2,279 kilometres of embankments (some 27 per cent of the total length) were in an unsatisfactory condition, including 578 kilometres which were hazardous.

The Institute of Meteorology and Water Management provides warning against severe weather and the likelihood of flooding in specific areas.

Insurance cover against flood damage is available to householders. The government also provides funding for welfare and financial support to those affected by flooding.

The Netherlands

Approximately 70 per cent of the Netherlands is susceptible to flooding and if all coastal, large lake and river defences were to fail, about nine million people (circa 55 per cent of the population) would be directly affected. A quarter of the country lies below sea level and this area accounts for 70 per cent of the nation's Gross Domestic Product.

Major flooding from the North Sea in 1953 affected 2,000 square kilometres, destroyed 3,300 houses, and led to 1,836 fatalities and affected many more. Floods in 1993 and 1995 on the rivers Rhine and Meuse affected 400 square kilometres and affected a quarter of a million people.

The main organisations responsible for flood risk management in the Netherlands are:

- **Central Government** – the Ministry of Transport, Public Works and Water Management directs flood risk management policy, whilst its Directorate General for Public Works and Water Management is responsible for ensuring policy is implemented. They manage and maintain certain primary flood defences, such as the major storm surge barriers.
- The twelve **Provincial Authorities** supervise all primary flood defences in their region, create regional water management plans and supervise the water management activities of the local Water Boards and Municipalities, including the co-ordination of emergency responses to large-scale flooding.
- The 27 **Water Boards** manage approximately 90 per cent of the 3,000 kilometres (1,900 miles) of primary defences in the country. They design, construct and maintain flood defences and must assess the condition of the defences and report to Parliament every five years. They are able to levy taxes, which cover approximately 95 per cent of the cost of their activities. The balance is usually met by national taxation.
- **Municipalities** are responsible for a small number of primary flood defences but generally contribute to flood risk management in their role as spatial planners and in times of emergencies.

Flood prevention in the Netherlands is funded by national taxation and local levies raised by the Water Boards. In 2005, the Ministry spent €397 million (£270 million) on flood defences and intends to increase expenditure to €633 million (£430 million) by 2010. The Water Boards spent approximately €190 million (£130 million) on flood defences in 2005.

Standards of protection for flood defences in the Netherlands are defined in law by the Flood Defences Act 1996 but many existing primary flood defences managed by the Water Boards are failing to reach statutory safety standards. Standards are based on the type of flooding, the number of people affected, the value of the areas protected and some conservation and historical interests and range from one-in-1,250 years to one-in-10,000 years. In May 2004, a report for the Dutch Ministry of Transport, Public Works and Water Management found that only 50 per cent of such defences met the standard, whilst 15 per cent failed and 35 per cent lacked sufficient information to make a proper evaluation. Nevertheless, the Ministry considers that safety standards are higher than ever.

The number of flood defence schemes subjected to cost benefit analysis as a means of assessing different options and taking into account non-financial impacts, such as the effect on the environment, has increased in recent years. The Netherlands has also undertaken a project to better understand the consequences and probability of flooding. This indicated weak areas within the 16 dike ring areas (of 53 areas in total) considered in the study and enabled the setting of reasoned priorities for maintaining the dike ring areas. There has been a shift in flood risk policy away from building ever higher defences and deeper channels towards 'making room for the river', for example by enlarging the flood plain or providing flood storage areas.

Since the devastating floods in 1953, insurance cover in the Netherlands has excluded river or sea flooding but the government can provide some compensation up to a certain maximum depending on the scale of flooding.

APPENDIX SIX

Flood risk management terms and types of flood defences

1 Various flood risk management terms and types of flood defence are listed below.

Flood risk management terms

Flood Risk: A combination of the likelihood of flooding and the impact or consequence if a flood occurs.

Flood Risk Management System: A group of flood defences and structures which work together to protect a particular area from flooding. Flood Risk Management Systems are explained in more detail in paragraph 3 on page 42.

River Reach: The stretch of watercourse lying between two bends in a river.

Flood Defence Asset: A structure, flood defence or watercourse channel which contributes to flood risk management.

Structure: An installation such as a pumping station, weir, or moveable flood barrier which controls water flow and therefore contributes to flood risk management.

Defence: A raised embankment or wall which lies between the watercourse and the nearby land and buildings and protects them from flooding.

Catchment Flood Management Plan: A large scale planning document that identifies long term sustainable policies for the holistic management of flood risks in a defined river catchment or group of related catchments.

Shoreline Management Plan: A large scale planning document which assess the risks associated with coastal processes and presents a long term framework to reduce these risks to people and the developed, historic and natural environment in a sustainable manner.

Priority Score: A scoring system used by the Department for Environment, Food and Rural Affairs and the Environment Agency to compare the relevant merits of flood and coastal protection schemes, based on their relative benefit cost ratio, contribution to the environment and people protected.

Floodplain: Land adjacent to a watercourse or coastline over which water flows, or would flow but for the presence of flood defences, in times of flood.

Managed realignment: A managed process of establishing a new flood defence line for river corridors or coastlines, 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.

River defences

Channels: Natural rivers or man-made flood relief channels constructed to reduce the risk of flooding. Obstructions and vegetation reduce the volume of water which can flow along a channel and therefore increase flood risk.

Culverts and debris screens: Culverts allow water to pass, for example, underneath a road, railway or embankment. Debris screens are grills which cover the entrance to the culvert, preventing objects such as branches and litter from entering and blocking it.

Weirs: Small dams over which water flows, usually built to raise the water level. They can also be used to measure the rate of flow in smaller watercourses.

Sea and river defences

Embankments: A man made slope, constructed from earth, stones or bricks which prevents flooding by acting as a barrier between the watercourse or sea and a protected area.

Revetments: Rock, timber or concrete structures which protect cliffs or sea walls by absorbing wave energy or are used to reinforce the banks of rivers to protect them during severe weather or flooding.

Sluice gates and barriers: Structures used to control water flow in a river, divert water into a flood storage area or relief channel or to hold back tidal surges.

Outfalls, flap valves, penstocks: Outfalls and penstocks regulate flow of water in a channel by allowing water to be redirected to a flood storage area or relief channel and they are also the point at which small watercourses discharge into larger rivers or rivers discharge into the sea. Flap valves cover the opening of an outfall or penstock to ensure water only flows in one direction.

Demountable defences: Removable barriers erected only when flooding is forecast, although foundations and support walls remain in place all year round.

Sea defences

Seawalls: Walls which deflect wave power and protect coastal towns from erosion and are usually constructed from reinforced concrete and curved in shape.

Beaches: Important natural flood defences which protect towns from flooding and erosion. Maintenance is needed to repair erosion by bringing new materials to the beach or returning shingle carried along the beach by the sea to its original position.

Groynes: Wood structures or piles of large rocks perpendicular to the shore which protect against coastal erosion by reducing the drift of sediment along the beach and forcing the tidal current out beyond the end of the groyne.

Saltmarsh: Marshland commonly found along estuaries, which protects land behind them from flooding by absorbing tidal inundation as well as supporting a diverse community of plants and wildlife.

Offshore breakwaters: Structures parallel to the shoreline but some distance offshore which reduce the intensity of wave action and therefore protect the coast from erosion and flooding.

Numbers of different flood defence assets

2 The numbers of different types of flood defence assets are shown in **Figure 24**.

3 A flood risk management system is a group of assets which work together to protect a particular area from flooding. Flood risk systems are designated as high, medium or low risk based on the matrix in **Figure 25 overleaf**.

24 Numbers of different types of flood defence assets

Flood defence structures	**Number**
River defence structures	40,200
Sea defence structures	3,800
Coastal protection structures	1,300
Other types of structures	700
Total	**46,000**

Linear flood defences	**Miles**
Maintained channels	15,300
Raised defences (man-made)	4,200
Sea defences (man-made)	900
Culverted channels	900
Flood storage areas	600
Coastal protection (man-made)	300
Raised defences (natural)	300
Coastal protection (natural)	300
Raised coastal defences (man-made)	100
Sea defences (natural)	100
Other	1,000
Total	**24,000**

Source: Environment Agency

NOTE

The total length of linear flood defences shown here includes raised defences and maintained channels. It excludes natural channels which are not maintained.

4 Within each system, assets are assigned a target condition based on their importance to the system as a whole. The matrix in **Figure 26 overleaf** sets out the condition criteria for a high risk system, as an example. There are different criteria for low and medium risk systems. A system fails if five per cent or more of the assets in the system are below their target condition, or one or more assets are two condition grades or more below the required standard.

5 Defences and structures in each river reach or coastal frontage are assigned an inspection frequency between six months and 60 months, as set out in **Figure 27 overleaf**. This takes account of the consequence of failure, which is based on factors such as land use, population, environmental designations, topography, development proposals, and the risk of failure, influenced by the integrity of the defence (present condition, age, material, gaps, breaches and low spots) and likely deterioration rate (maintenance regime, residual life, vermin, channel conveyance and susceptibility to erosion).

25 Environment Agency performance standard matrix for flood risk management systems and major assets

Impact of flooding

	Low[1]	Medium[2]	High[3]	Very High[4]
High (land use band A/B or protecting sites under Habitats Regulations)	High	High	High	High
Medium (land use band C or protecting Sites of Special Scientific Interest)	Low	Medium	Medium	High
Low (land use band D/E)	Low	Low	Low	Medium

Potential impact on people from system failure

1 Low: (negligible risk to life, for example, defences protecting agricultural land)

2 Medium: (sufficient time to evacuate, for example, significant watercourses with no raised defences)

3 High: (little warning of flooding to residential or commercial property, for example, raised defences)

4 Very High: (little warning of failure, possible loss of life, for example, very significant defences and structures)

Source: Environment Agency

26 Asset maintenance and inspection performance standards for a high consequence flood risk management system[1]

Type of asset	Target asset maintenance standards	Inspection frequency
Raised defences	Good	Operational inspection[3] of structures, penstocks, culverts, blockage points, weed screens, floodgates etcetera at least monthly, in some cases much more frequently. Formal visual asset inspection frequency to be set according to guidance (see Figure 27). Expected to be six monthly.
Structures	Good	
Minor structures[2]	Fair	
Channels	Good, remove blockages	

Source: Environment Agency

NOTES

1 The Agency assesses flood risk management systems as high, medium or low consequence based on a combination of the potential impact of flooding on people and the impact of flooding on property, as set out in Figure 25. This is only one part of flood risk related to assets, the probability of failure of the assets in a system being the other.

2 A minor structure is one which performs a limited role in the system as a whole.

3 Operational inspections include all inspections such as those of electrical and mechanical installations, penstocks and flap valves, bridges and culverts which form part of a routine inspection regime in addition to the formal visual inspection programme.

27 Determination of inspection frequency

Inspection frequency in months

Consequence of failure within the reach	Low	Medium	High
High	24	12	6
Medium	36	24	6
Low	60	36	18

Probability of failure within the reach

Source: Environment Agency

APPENDIX SEVEN

Main stages of flood defence construction projects

Environment Agency Flood Defence Construction Projects[1]

Identification of need and pre-feasibility

Environment Agency area or regional staff review the existing information about flood risk in an area (Shoreline Management Plan, Catchment Flood Management Plan, strategy study, flood incidents, poor condition of existing assets) and identify potential solutions, outline risks and relevant stakeholders. They then carry out preliminary economic analysis of benefits and costs to assess the potential viability and priority of the project.

Gateway 0

↓

Handover to National Capital Programme Management Service

The area/region transfer management of the project to the National Capital Programme Management Service who commission consultants to carry out project planning in order to establish a robust programme and costs. The National Capital Programme Management Service obtain funding and approvals for the next stage of the project.

↓

Project Appraisal and Approval

National Capital Programme Management Service project team commission consultants to carry out a comprehensive appraisal, including cost benefit analysis, topographical surveying, structural surveying, site investigations, environmental surveys, computer modelling and stakeholder liaison. This results in the identification of a preferred option. Project risks are also identified and initial consents obtained for the scheme. The preferred option is then scrutinised by National Review Group (if over £2 million) leading to formal approval under the Agency's financial scheme of delegation. The scheme is authorised to go ahead when funding is available.

Gateway 1

↓

Detailed design work and construction contract award

Engineering consultants are commissioned by the project team to prepare a detailed scheme design and develop the contract documentation. The design budgets and programme are then reviewed by the area client. At this stage, the project team usually obtains final permissions, consents and approvals to satisfy legal requirements and further work is carried out to identify cost savings and identify project risks. The project team agree the cost for the construction with the contractor and responsibilities for risks are allocated. The contract for construction is awarded.

Gateway 2

Gateway 3

↓

Construction

Before construction begins, a pre-commencement meeting is held between the project team and contractors to agree supervision arrangements and ensure the contractor will meet Agency standards on for example health and safety, the environment and disposal of waste. Throughout the construction of the flood defence, the project team monitor expenditure against budget and contractor performance. Once construction is nearing completion, the contractor prepares operational manuals to allow the new defence to be maintained and operated by Agency area staff in the future.

Gateway 4

Gateway 5

↓

Handover to area client and post project appraisal

A meeting is held between the project team and the contractor to identify defects or omissions, methods of operation and outstanding works, carry out pre commissioning tests and consider safety issues. Once the defence is operational, it is formally handed over to the region/area with formal sign off once all remaining defects have been corrected. A post project appraisal may be carried out for some projects. The project is then formally closed on completion of all outstanding matters

Gateway 6

Gateway 7

Source: National Audit Office

NOTE

1 Although this is the standard process for flood defence construction projects, it may vary for some schemes.

ENDNOTES

1 *National Flood Risk Assessment 2006 Results – Headline Figures*, Environment Agency, January 2007.

2 *Financial Costs of Property Damages, The Halifax Dundee Flood Loss Tables 2005*, Dundee University and HBOS, 2005.

3 While we refer to the Agency as responsible for flood risk management in England, it actually has permissive powers, under the Water Resources Act 1991, to manage flood risk arising from designated "main" rivers and the sea. This report focuses on the Agency's work in England as the Wales Audit Office plans to report separately to the Welsh Assembly on the Agency's performance in Wales.

4 *Inland Flood Defence*, HC 299, 2000-01, March 2001.

5 *Inland Flood Defence*, HC 299, 2000-01, March 2001.

6 The Agency assesses flood risk management systems as high, medium or low consequence based on a combination of the potential impact of flooding on people and the impact of flooding on property, as set out in Figure 25. This is only one part of flood risk related to assets, the probability of failure of the assets in a system being the other. Reports from the asset database suggested that the proportion of high risk systems at their target condition was 35 per cent and the proportion of all systems at their target condition was 46 per cent. These figures were obtained from an average of two separate reports, one identifying the number of systems which pass on the basis of flood defence structures alone, and one identifying the number of systems which pass based on their linear defences alone. The Agency has advised us that, as a result of the database not yet being fully populated with area office data in the correct format and the problems with reporting we have described, the information obtained from area managers, which we quote in paragraph 4, was a more accurate reflection of asset system conditions at the time of our report.

7 *Lessons learned Autumn 2000 floods*, Environment Agency, March 2001.

8 *Inland Flood Defence*, HC 299, 2000-01, March 2001.

9 Areas at flood risk are those where the risk of flooding in any given year is greater than 0.1% (one in 1,000 years or more frequent). Significant flood risk is defined as the probability of flooding in a year being greater than 1.3% (one in 75 years or more frequent), *National Flood Risk Assessment 2006 – Questions and Answers*, Environment Agency, January 2007.

10 Carlisle has two new flood defence schemes, one of which was already planned before the flood happened. These have a lifetime budget of £28.4 million. Boscastle defence improvements will cost £8.2 million. Some eight per cent of total planned expenditure on new defences in 2007-08 is in Boscastle and Carlisle.

11 Our discussions with the Association of British Insurers indicate that 93 per cent of households have insurance and 80 per cent have contents insurance against the risk of flooding. Insurers' definition of storm damage includes flooding to homes that occurs during storms.

12 *Financial Costs of Property Damages, The Halifax Dundee Flood Loss Tables 2005*, Dundee University and HBOS, 2005.

13 The agreement between insurers and the government is set out in the Association of British Insurers' Statement of Principles, November 2005.

14 *The appraisal of human related intangible impacts of flooding,* Department for Environment, Food and Rural Affairs, 2003. The intangible benefits to a household of having a flood defence scheme are around £200 a year which, discounted over 100 years, gives a present value of £6,000.

15 *Future Flooding*, Foresight Programme, Office of Science and Technology, 2004, Executive Summary. The Foresight Project examined future flooding under four scenarios. Expected annual damages of £20 billion would only occur under the high carbon emissions 'World Markets' scenario. Under the 'Local Stewardship' scenario, with medium-low emission, costs would be less than £1 billion.

16 *National Flood Risk Assessment 2006 – Economic Results*, Environment Agency, February 2007.

17 *Inland Flood Defence*, HC 299, 2000-01, March 2001.

18 The audit of the 2006-07 figures had not yet been completed at the time of our report.

19 *Inland Flood Defence*, Committee of Public Accounts, March 2002, HC 587, 18th Report, 2001-02

20 24,000 miles is the total length of raised defences and maintained channels. It excludes natural channels which are not maintained.

21 The Agency assesses flood risk management systems as high, medium or low consequence based on a combination of the potential impact of flooding on people and the impact of flooding on property, as set out in Figure 25. This is only one part of flood risk related to assets, the probability of failure of the assets in a system being the other.

22 Reports from the asset database suggest that the percentage of systems which were at their target condition was 46 per cent, which was an average of the outcomes of two separate reports, one which identifies the number of systems which pass on the basis of flood defence structures alone, and one which identifies the number of systems which pass based on their linear defences alone. The Agency has advised us that, as a result of the database not yet being fully populated with all the data held by the area offices in the correct format and the problems with reporting we have described, the information they have obtained from area managers which showed that 57 per cent of systems were at target condition represents a more accurate reflection of the position at the time of our report.

23 The assets are inter-dependent and a system meets its target condition only if at least 95 per cent of all assets in the system meet their own target standard and no asset is more than one grade away from its target standard.

24 Although the National Audit Office report on Inland Flood Defences was published in March 2001, asset condition data was collected in October 2000.

25 A riparian owner refers to someone owning land bordering a river.

26 Reports from the asset database suggest that the range is from 15 per cent of high risk systems at target in the North West to 58 per cent at target in the Thames region. However, these figures are based on an average of the outcomes of two separate reports, one of which identifies the number of systems which pass on the basis of flood defence structures alone, and one which identifies the number of systems which pass based on their linear defences alone. The Agency has advised us that, as a result of the database not yet being fully populated with all the data held by the area offices in the correct format and the problems with reporting we have described, the information they have obtained from area managers represents a more accurate reflection of the position at the time of our report. We have therefore used this information in the report.

27 Review of local authority skills and capacity for coastal defence functions, Coastal and Country Projects Ltd on behalf of the Department for Environment, Food and Rural Affairs, March 2006

28 *Inland Flood Defence*, HC 299, 2000-01, March 2001.

29 *Inland Flood Defence,* HC 299, 2000-01, March 2001.

30 The Agency estimated the cost to date of producing catchment flood management plans at some £6.3 million as at January 2007.

31 This only includes projects which contributed to the target to increase protection to an additional 85,000 households.

32 *The Benefits of Flood and Coastal Risk Management: A Manual of Assessment Techniques* also known as *The Multi-Coloured Manual*, is a detailed guide to the assessment of benefits arising from a flood defence scheme, including the avoidance of damages to residential and non-residential properties, road disruption and emergency costs.

33 The calculation is based on 35 completed projects in 2005-06. It excludes eight projects where a cost benefit calculation was not required (such as where the Agency was legally obliged to build a defence).

34 *Inland Flood Defence*, HC 299, 2000-01, March 2001.

35 In some cases, more than one reason was applicable, and therefore they do not sum to 100.

36 A numerical technique for assessing the probability of different outcomes from two or more variables.

37 *Improving Public Services through Better Construction*, National Audit Office, HC 364, March 2005, p.40 and 45.

38 This figure is the total of funding allocated to specific schemes and does not include information technology, flood mapping and data management expenditure which also contribute to the capital programme.

39 Urgent works are defined as those where the risk of failure of the existing structure or defence would otherwise be unacceptably high. A good example of this is the Alt Pumping Station in the North West, where the pumps are both old and increasingly unreliable. Failure could lead to the flooding of several thousand properties in a severe flood event. These "urgent" schemes have priority scores of 25 or above.

40 *Target for the 2004 Spending Review Period Delivery Plan*, Department for Environment, Food and Rural Affairs, May 2005, p.15.

41 The proportion of spend is that up to OGC Gateway 3, the end of detailed design. Total project costs in 2005-06 were significantly higher than in other years because of the requirement on the Agency to spend historic balances held by the flood defence committees.

42 *Environment Agency Corporate Plan 2006-09*, Translating Strategy into Action, p.23.

43 *Ministry of Defence: Major Projects Report 2000,* National Audit Office, HC 970, 1999-00, p.13. The proportion of spend quoted is up to Main Gate, which is the approval point between the Assessment and Demonstration and Manufacture phases. Part 2 of the *Ministry of Defence: Major Projects Report 2005* (National Audit Office, HC 595, 2005-06) discusses this issue in more detail.

44 The outcome measures were not yet finalised at the time of our report.

45 Association of British Insurers' Statement of Principles, November 2005.

46 The pilots are for local schemes offering grant aid to a number of particularly vulnerable properties. Detailed arrangements have yet to be agreed but are likely to include direct aid from the department to individuals.

47 *France: Policies for Preventing and Compensating Flood-Related Damage*, OECD Studies in Risk Management, 2006.

48 *Lessons learned Autumn 2000 floods*, Environment Agency, March 2001.

49 *Environment Agency Annual Report 2005-06*, p.50.

50 *Environment Agency Annual Report 2005-06*, p.50.

51 *Environment Agency Annual Report 2005-06*, p.49.

52 *France: Policies for Preventing and Compensating Flood Related Damage*, OECD Studies in Flood Risk Management, 2006.

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Building and maintaining river and coastal flood defences in England

A report by the Comptroller and Auditor General

The Stationery Office