Environment Agency

the climate is changing

time to get ready

We are the Environment Agency. It's our job to look after your environment and make it a better place – for you, and for future generations.

Your environment is the air you breathe, the water you drink and the ground you walk on. Working with business, Government and society as a whole, we are making your environment cleaner and healthier.

The Environment Agency. Out there, making your environment a better place.

Published by:

Environment Agency
Rio House
Waterside Drive, Aztec West
Almondsbury, Bristol BS32 4UD
Tel: 08708 506 506
Email: enquiries@environment-agency.gov.uk
www.environment-agency.gov.uk

March 2005

Time to get ready

The weather is changing. Temperatures and sea levels are rising. Summers are getting hotter, winters wetter. What does that mean to England and Wales? What will it be like to live here? Should you care? What can we – the Environment Agency – and you do about it?

Here at the Environment Agency, climate change is our highest priority. We are building the country's resilience to some of the biggest impacts: water shortages, flooding and environmental deterioration. And, in our regulation of industry, we are playing our part in addressing the causes.

In this, our first national report on climate change, we answer some of the questions above by using real examples of conditions that will become more common as the climate changes. We report from our own point of view and focus on the threats rather than the opportunities, because that is where we need to take action. This is also an invitation. We are making it clear what we already do and what we want to do. If you are working on climate change, you need to talk to us so that we can work together.

I look forward to hearing from you.

Barbara Young
Chief Executive, Environment Agency

Contents

The issue

Climate change is the biggest threat to our future. Already in the first years of this century, floods, storms and droughts have shown how vulnerable the UK is to the weather. We at the Environment Agency work with local communities all around England and Wales. We know from our on-the-ground experience the devastation that recent unusual weather events have caused.

Climate change means that extreme weather events will become more frequent and more dangerous. The severity will depend on the amount of greenhouse gases released into the atmosphere from now on, and how the climate system responds. By 2100 we can expect global temperature increases of 1.4 to 5.8˚C.[1] At the upper end of this range, changes are likely to be so extreme that it will be difficult to cope with them. The European Union (EU) has proposed that global temperature rises need to be limited to 2˚C to avoid dangerous climate change.[2]
To achieve this, society must cut emissions of carbon dioxide, the most common greenhouse gas, now.

Find out about further sources of information where you see this symbol.

It is now clear that climate change has been triggered by increases in greenhouse gases, in particular those released from the use of fossil fuels.[3] The carbon dioxide already released has determined the changes for the next 30 to 40 years. But beyond that there is a choice. Further changes depend on how well the causes are mitigated (reduced) from now on. In the meantime, resilience to current climate variability and extreme weather must be developed.

Find out more about our views on climate change.
www.environment-agency.gov.uk/ourviews/

What might happen? Current projections for the UK

The UK Climate Impacts Programme scenarios[4] indicate that:

- By the 2080s average annual temperature across the UK may rise by between 2 and 3.5˚C but some areas could warm by as much as 5˚C.
- Heavy winter rainfall events that occur every two years are expected to increase in intensity by between five and 20 per cent.
- Relative sea-level around the UK could rise by as much as 86 cm in southern England by the 2080s, and extreme high sea levels will occur more frequently.

These scenarios are currently being updated. See www.ukcip.org.uk/

It's not all bad

'Listen – I am as worried as anyone else about global warming, but having lunch outdoors five times by the middle of March has been a bit of a treat.'

Nigel Slater, writing in the *Observer*, 14 April 2002

Global warming could bring opportunities. Most people will enjoy warmer summers, provided they are not too hot – but not the winter rain. Farmers could use the longer growing season to expand their range of crops – as long as there's enough water. Higher levels of carbon dioxide may allow plants to grow faster – again if there's enough water. Warmer temperatures will allow some plants and animals to expand their range – but for others it will contract.

1 IPCC (2001)
2 European Commission (2004)
3 See for example the IPCC's *Third Assessment Report* (2001) and Oreskes (2004). The latter presents a review of the 928 papers published about climate change in scientific journals between 1993 and 2003
4 UKCIP (2002a)

At the Environment Agency, we are already building the country's resilience to some of the most significant impacts of climate change.

These impacts include (see Figure 1):

- The strain on water availability for people and ecosystems brought by longer, hotter, drier summers and development in areas where water resources are scarce.
- An increase in flood risk caused by wetter winters, greater storminess and sea level rise. In England and Wales, 5 million people already live in flood risk areas and about 12 per cent of farmland and a quarter of industrial sites are at risk. Some 11 per cent of new homes are built in flood risk areas in England.[5]
- An increase in air and water pollution triggered by longer, hotter summers.

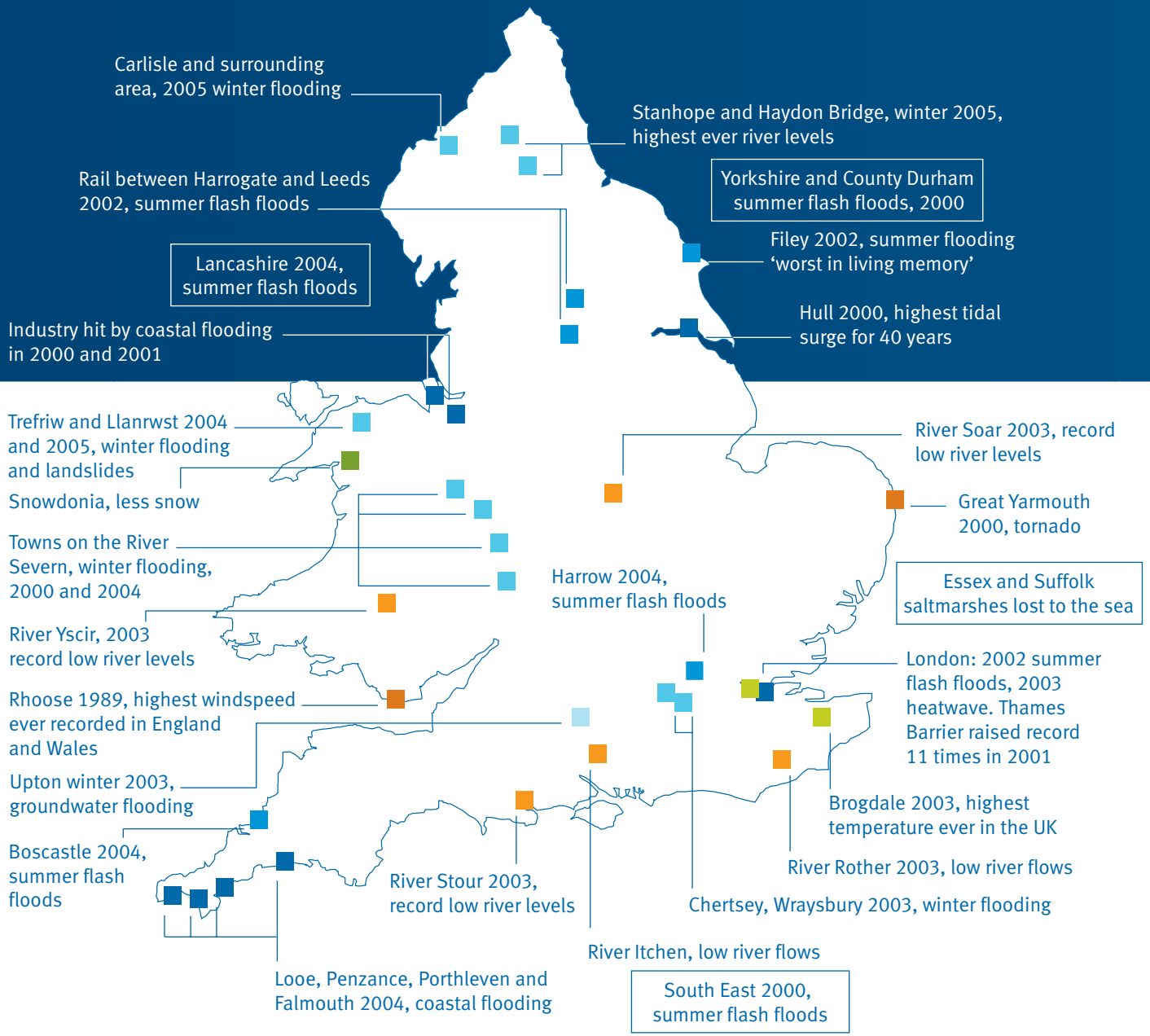


Figure 1 **Recent weather events around England and Wales described in this report**

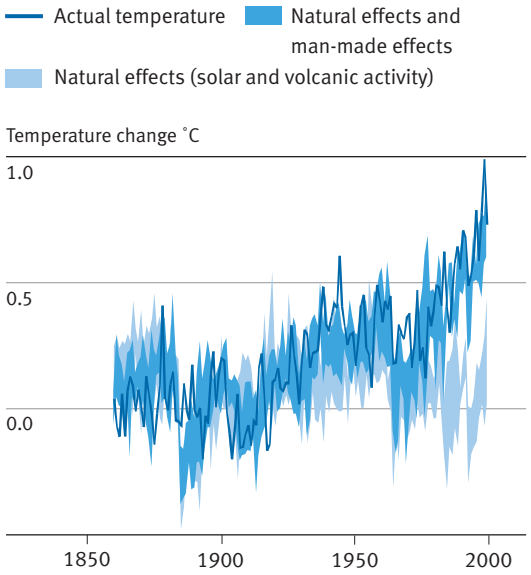
The cause

Global climate change has been caused by an increase in greenhouse gases[6] in the atmosphere. These gases come from both natural and man-made sources, but the increase is the result of human activity[7] (Figure 2), mainly the release of carbon dioxide from the use of fossil fuels such as coal, gas, oil, petrol and diesel.

Overall, UK emissions of carbon dioxide fell between 1990 and 2002 (Figure 3). This was largely the result of reductions made by the industries we regulate and a move away from coal and oil to gas-fired power stations. But releases from both domestic sources and transport rose over the same period, and the output from coal-fired power stations is now rising again.[8]

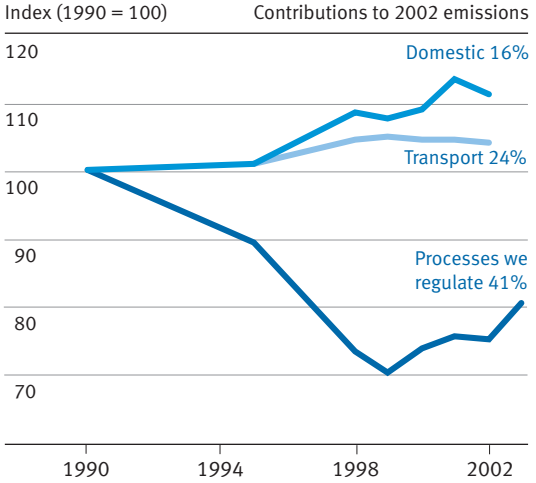
More and more of us are taking to the roads and skies. Traffic levels are predicted to rise by 40 per cent between 2000 and 2025[9] and worldwide air travel is expected to double between 1995 and 2015.[10] But there is a cost for the climate. New technologies are reducing the pollution from individual vehicles, but the benefit is offset by the increasing volume of traffic. Transport is now the second most important source of carbon dioxide emissions. These include releases by aeroplanes in the upper atmosphere, which have an important effect compared to emissions at ground level.

Figure 2 **The effect of human activity on global temperatures**



Source: IPCC (2001)

Figure 3 **UK carbon dioxide emissions, 1990 to 2003**



2002 is the latest year of data available for domestic and transport emissions. Emissions from transport do not include shipping or aviation. Source: NETCEN, Environment Agency

5 ODPM (2004a)
6 The main greenhouse gases are carbon dioxide, methane, nitrous oxide, perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF6)
7 See for example Stott *et al.* (2004)
8 Due to an increase in gas prices and maintenance costs at nuclear power stations in the last two years
9 Department for Transport White Paper (2004)
10 Measured in passenger-kilometres, from 1995 base. *Transport 2000* (see www.transport2000.org.uk/factsandfigures/Facts.asp)

Creating a better place:
limiting and adapting to climate change

'The ultimate objective ... is to achieve ... stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.'

United Nations Framework Convention on Climate Change.[11]

The climate is already changing and the UK has to adapt to the inevitable effects. Global carbon dioxide emissions must be reduced and stabilised in order to limit the extent of climate change to manageable levels. This means moving to low carbon energy – increasing the use of renewable and other non-fossil fuel based energy, reducing demand and improving efficiency. In the long term, these measures will also save money – the average UK household could save £200 a year by improving energy efficiency, for example.[12]

The UK has the largest potential for wind, wave and tidal energy in Europe, but currently generates only three per cent of electricity from renewable resources,[13] way behind Austria (59 per cent), Sweden (43 per cent), Portugal (42 per cent) and Spain (26 per cent).[14] If the UK is to meet the target of generating 20 per cent of electricity using renewable energy by 2020, rapid adoption of these renewable energy schemes is needed.

The UK is a world leader in the drive to reduce carbon dioxide, but is not currently on track to meet national commitments by 2010. The Prime Minister has said that 'we have to do more to achieve our commitment to reduce carbon dioxide emissions by 20 per cent by 2010.'[15] We support more stringent effort, as we think it is vital that the UK meets both this commitment and the target of a 60 per cent reduction in carbon dioxide by 2050.

The Government has identified opportunities to further reduce carbon dioxide releases and will publish a review of the Climate Change Programme this year after consultation.[16] We also support its proposal of a UK-wide adaptation framework that sets out clear objectives, roles and responsibilities for government, government bodies and other stakeholders to ensure that the UK is sufficiently prepared for climate change. Only by taking action now can we minimise the impact of climate change on our quality of life.

11 See http://unfccc.int/ for more information on the UNFCCC
12 Energy Saving Trust (see www.est.org.uk/myhome/climatechange/forecasting/makeadifference/)
13 DTI (2004)
14 EurObser'ER (2004)
15 14 September 2004 speech. www.number10.gov.uk/output/page6333.asp
16 Defra December 2004 review of the UK Climate Change Programme
17 Environment Agency (2004)
18 Environment Agency (2001c)

The results of decisions taken today to protect society from a changing climate may last many decades or even centuries. If they are to stand the test of time, they need to be resilient to the future climate. Building resilience into the early stages of big infrastructure projects for example will save money in the long run.

Development in inappropriate locations can exacerbate the problems associated with flood risk and limited water supply. To avoid creating problems in the future it is essential that planners and developers work with us to ensure that development is located in the best place and is resilient to climate change. We need better application of national policy to prevent inappropriate development on flood plains or areas of flood risk – over half the planning proposals that we objected to last year lacked appropriate assessment of flood risk. Almost 12 per cent of the proposals we objected to were approved contrary to our advice by local planning authorities (Figure 4).[17] In some areas water supplies are already almost fully used by the existing population.[18]

But designing and building in ways that are more water efficient and resilient to flooding need not be costly. We believe that designing in efficiency measures can reduce an average household's water use by 25 per cent at no extra cost.

As an organisation, we consider climate change in everything we do. We are defining and planning for the impacts of climate change on water, land, biodiversity, waste management, flooding, air quality, health, emergency planning and how we monitor and report on the state of the environment. Our science programme is helping us develop risk-based responses to these impacts across all our functions.

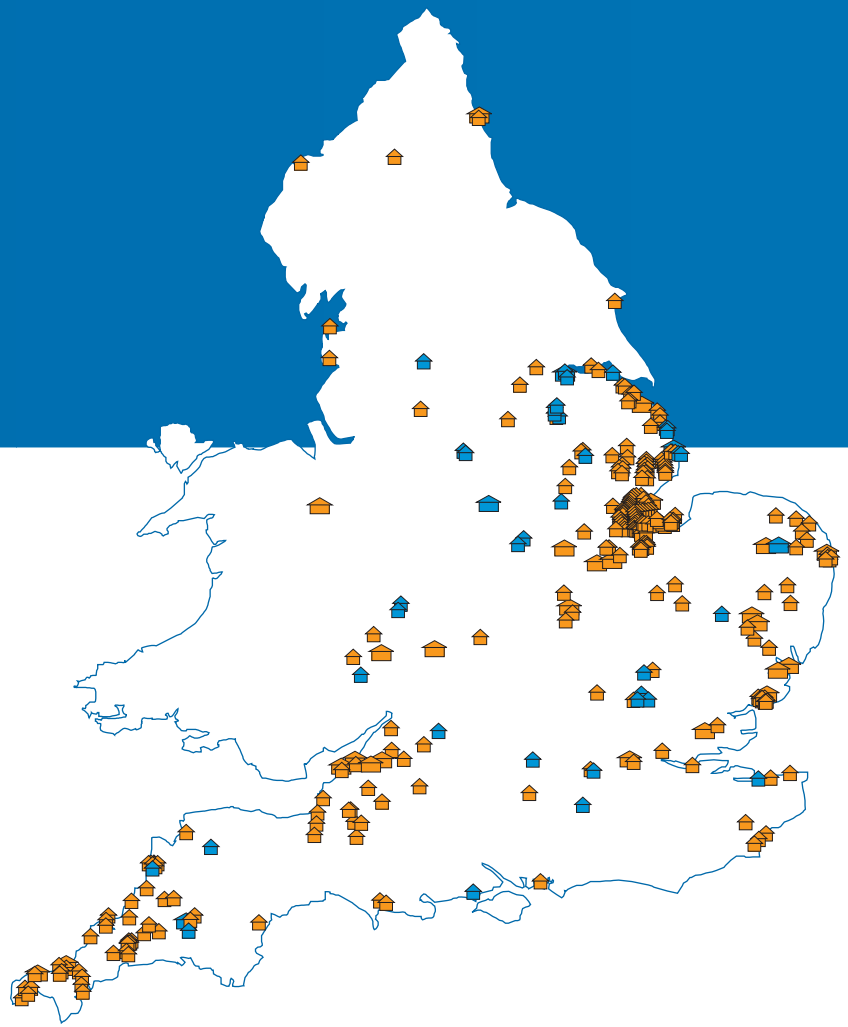


Figure 4 **Development applications granted against Environment Agency advice 2003/04**

Planned development sites

Planned development sites that lie in areas that have flooded in the past

Major development

Minor development

Source: Environment Agency

Find out more about renewable energy
www.dti.gov.uk/renewables/

Use less energy
www.est.org.uk/

Cut carbon emissions
www.thecarbontrust.co.uk/

In 2004 we organised and took part in 'Exercise Triton 04' with more than 60 other organisations to test how well we would all respond to, and cope with, a national-scale flooding event. Improvements since the 1998 and 2000 floods were recognised. Valuable lessons were identified that will be followed through with action plans for all the organisations involved to further strengthen the nation's capability to deal with major flooding events.

Make buildings more climate proof by flood-proofing (e.g. raising floor height) and incorporating water efficiency measures

www.practicalhelp.org.uk/housing/guidance/

The Thames Gateway

Climate change presents a particular challenge to the Thames Gateway.[19] Much of the area is in the floodplain of the Thames Estuary and – as in the rest of south east England – the balance of water demand and supply is already fragile. Successful planning for the extra 120,000 homes planned to be built by 2016[20] needs to ensure that the development minimises both extra demand for water and flood risk. We are working with organisations such as the Thames Gateway London Partnership to ensure that this is the case. We have set up the Thames Estuary 2100 project, which will produce a flood risk management strategy for the estuary for the next 100 years. This will balance the need for existing and new development with the challenge of rising sea levels and storm surges caused by climate change. We are working with partners in the Netherlands, Belgium and Germany on some of the future challenges. With all partners working together, the Gateway can be sustainable. The area is too important to miss this opportunity.

19 ODPM (2004c)
20 ODPM (2004c)

How the Environment Agency fits in

We consider climate change in everything we do and have a major role in both limiting the scale of climate change by addressing its causes, and limiting its impact by adapting to change.

Addressing the causes:

- Over 40 per cent of the carbon dioxide released in the UK comes from industries that we regulate. We consider their energy use and limit releases of pollutants.[21]
- We are running the EU Emissions Trading Scheme (ETS) in England and Wales.[22]
- We promote adoption of low carbon technologies and support the Carbon Trust and Energy Saving Trust. We only use renewable energy in our 2,000 sites and facilities.
- We will be working with a government-led multi-agency cross-sector communication partnership to help people, industry and businesses understand how serious the situation is and what action can be taken.

Limiting the impact by adapting:

- We license water use, balancing the various demands for drinking, for industry and for the environment.
- We are the largest flood risk management authority in England and Wales, responsible for 36,000 km of flood defences along rivers and coast.
- We provide a 24-hour flood forecasting and warning service, raise public awareness and promote uptake of Kitemarked flood-proofing measures.
- We advise planners and developers on the flood risk of new developments.
- We protect wetland habitats and species.
- We aim to prevent or reduce the risk of pollution wherever possible, and to ensure that it gets cleaned up if pollution occurs.
- We regulate and protect fisheries and promote recreation and navigation.
- We are one of the organisations involved in protecting and managing the marine environment.
- We are building climate change into our catchment-scale plans for the Water Framework Directive, which will allow us to tackle its impacts on water, land and biodiversity in an all-embracing way.
- We operate monitoring and surveillance programmes to improve our understanding of climate change.
- We work with many other organisations, such as central government, local councils, planning authorities and the emergency services. We are involved in all of the regional climate change partnerships, supporting their work to develop and promote the need for adaptation responses.

21 See www.environment-agency.gov.uk/business/444217/444663/298441/ for details about pollution prevention and control (PPC) permitting

22 See www.environment-agency.gov.uk/business/444217/590750/590838/556574/ for details about the EU ETS

Putting a price on climate change

It will be expensive to build resilience to climate change. Reducing the risk of tidal and river flooding already costs us £0.4 billion a year.

We estimate that over the next 80 years the cost of engineered flood defences to meet the demands of climate change in England and Wales will be £22 to £75 billion.

It is worth doing. Flood damage already costs about £1 billion a year and our flood risk management prevents further yearly damages of £3.4 billion. But we can't defend everywhere. Damage costs from flooding are predicted to be as much as £25 billion under a worst-case scenario in the 2080s.[23]

Since 1998 the cost of repairing the damage from extreme weather events and floods has increased by 60 per cent.[24]

- 1998 – Easter floods led to the evacuation of 1,500 people from their homes, and a cost to the insurance industry of around £500 million.
- 2000 – Heavy autumn rainfall led to 10,000 flooded properties, and nearly £1 billion in insurance claims.
- 2003 – Soaring temperatures combined with low rainfall doubled the previous year's insurance claims for subsidence to £390 million.
- 2004 – Torrential rain and flash flooding across Britain cost over £300 million in the first nine months alone.[25]

The Association of British Insurers (ABI) estimates that the increased cost to households due to extreme weather events will be up to 4 per cent extra each year.[26] The things we own are increasing in value, so we have more to lose.

Insurance may get more expensive for everyone. The ABI agree it is time to bring planning for climate change into the mainstream of business life.

www.abi.org.uk/climatechange/

[23] Foresight Flooding 2004 (see www.environment-agency.gov.uk/subjects/flood/763964/)
[24] Association of British Insurers (ABI) (2004a)
[25] Data provided by ABI, 2005
[26] ABI (2004b)

Living in the twenty-first century

‘It’s the extreme weather and climate events that will have some of the most severe impacts on human society as the climate changes.’

Jerry Meehl, US National Center for Atmospheric Research

In the following sections, we look at the conditions many people have already experienced this century. While these individual events cannot be attributed to climate change now, they are conditions that we expect to become more common as the climate changes.

Too much rain

This century has started with the third wettest year since records began in 1766.[28] In autumn 2000 some places flooded for the first time in decades. Torrential rain in August 2004 caused some of the worst flood events ever recorded in Britain.

Summer flooding

On the whole, we expect that summers will be drier.[27] But when it does rain, it will probably rain harder. Parched soils are unable to absorb heavy rain fast enough, resulting in localised, but severe, flooding.

In 2000 the May bank holiday was washed out as rivers burst their banks in south east England, causing local flooding. Unusually severe summer rain in June 2000 caused 1,000 homes to be flooded across Yorkshire and County Durham. In August of the same year, a tornado rained a cloudburst of fish on the beach in Great Yarmouth, Norfolk.

At the end of July 2002 rail services between Harrogate and Leeds were affected by severe flooding. In August 2002, in Yorkshire, the River Wharfe exceeded its previous August flow maximum in a 47-year record and Filey experienced 'the worst flooding in living memory'. In the same month, there were localised floods in the London area,[29] with some places receiving 60 mm of rain in just one hour. The rail network was badly disrupted.

Heavy rain and flash flooding hit the headlines again in summer 2004. At the beginning of August, flash floods devastated Boscastle in north Cornwall. Lancashire was also badly affected. In Harrow, an hour of heavy rain submerged roads under 18 cm of floodwater.

Check out our Flood Warning service online and do something to protect yourself if your home is at risk.

www.environment-agency.gov.uk/subjects/flood/

27 UKCIP (2002a)
28 Met Office data
29 Hydrographic information – 2002 (see www.nwl.ac.uk/ih/nrfa/monthly_summaries/2002/08/summary.html)
30 North Cornwall District Council (2004)
31 Catovsky/ ABI (2004)
32 Defra, Thames Water, Environment Agency, Greater London Authority and Ofwat

Flood devastates village – Boscastle

On the high ground around Boscastle, 196 mm of rain fell in just four hours on 16 August 2004. The local topography channelled the rainfall into the River Valency, which broke its banks, and three metre high floodwater rushed through the village devastating everything in its path. Nearby Crackington Haven, Canworthy Water, Helebridge and Bude were also hit. One hundred properties in the area were flooded, hundreds of people were evacuated from their homes, and over a hundred people were plucked from roofs, trees and vehicles in the largest peacetime rescue in the history of mainland Britain. Trees were uprooted and four bridges were washed away. Four buildings collapsed or had to be demolished and at least 70 cars were washed into the sea. Over 50 of our staff helped to handle the crisis.

The repair bill for this single event will be in the millions. Infrastructure damage alone could cost £2 million.[30] Insured damage to buildings and cars is estimated at £4–6 million, with a further £5–10 million in business interruption.[31] Estimates of uninsured losses to businesses and individuals have not yet been recorded.

Flood defences can be breached during extreme rainfall events. Permanent flood defences are not always suitable for reducing the risk from flash flooding. Instead, we need to make the best use of emergency plans, flood warning schemes and advice campaigns, controls over development and temporary defences to reduce the risk from flooding.

The London storm sewage problem

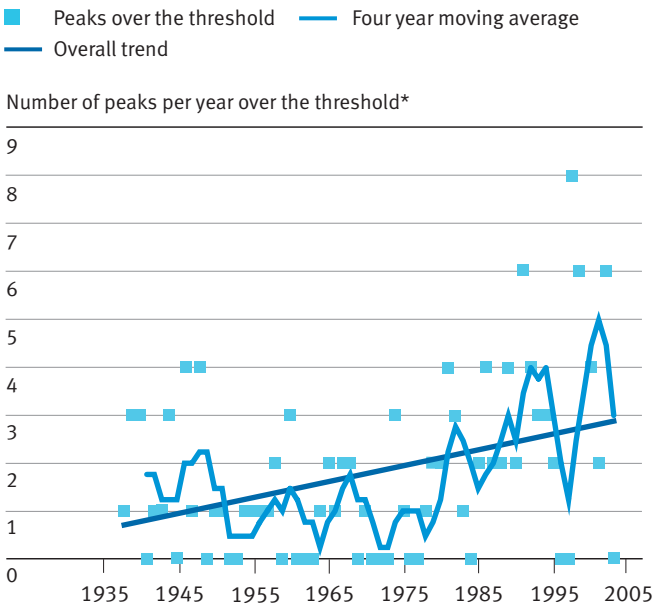
London's Victorian sewerage system is easily overloaded during storms. Properties can be flooded and large amounts of raw sewage released into the tidal section of the River Thames. The ecological consequences can be severe. In August 2004 heavy rainfall led to appalling pollution events that killed tens of thousands of fish, left sewage debris and a foul smell along the foreshore, and significantly increased *E. coli* levels in the river.

- Every year 12 million tonnes of untreated sewage enter the river because of storm overflows.
- A single storm can create 3 million tonnes of sewage overflow.
- About 10,000 tonnes of sewage solids are discharged to the river each year. The solids include paper, faecal matter, sanitary items, condoms and hypodermic needles.
- These discharges occur 50–60 times per year.

These problems are the result of a lack of capacity within London's sewer network, and a solution to the problem is being developed by the Thames Tideway Strategic Partnership.[32] It will need substantial investment.

Winters have become significantly wetter since records began in 1766 – an average increase equivalent to a month of extra rainfall.

Figure 5 **Flood levels in the River Wye at Erwood, Wales**



*The level exceeded on average between 1980 and 2000
Source: Environment Agency

Winter flooding

Winters are becoming wetter and more rain is falling in heavy downpours.[33] Six of the seven rivers we use to indicate flooding show an increase in frequency of peak river levels (see Figure 5 for example).

The autumn and winter floods of 2000 were the worst in some areas for 270 years and devastated the lives of thousands of people. In total, 700 places were hit and 10,000 properties were flooded, some five times.[34] Significant areas of farmland were flooded causing an estimated loss of up to £500 million to the farming industry.[35] Parts of the M1, M3, M20, M23 and M25 were shut, and railway services throughout Wales, southern, north east and south west England were disrupted. Sewerage systems in many areas were overwhelmed, causing up to 30 per cent of all property floods. Over half a million people called our Floodline, our 24-hour information and helpline service. Almost a third of our staff were involved in dealing with the floods.[36]

At New Year 2003, 30 houses were flooded by high groundwater levels in the area around Upton in Hampshire. The Thames had its highest flood since 1947 and many properties were flooded in Chertsey, Wraysbury and surrounding places.

In February 2004, Trefriw and Llanrwst (Conwy) were cut off, buildings were flooded in 60 cm of water and five schools were closed as floodwaters poured off Snowdonia. Main roads were cut off by associated landslides.[37] These villages were flooded again when the River Conwy burst its banks in the New Year flooding of 2005.[38]

Heavy rainfall in early January 2005 caused extensive, and in places repeated, flooding across the north of England. High spring tides

increased the risk of flooding for many. The worst affected area was Cumbria. Across the Pennines, over a hundred properties were flooded around the River Tyne and in the Yorkshire Dales. River levels on the upper Tyne catchment at Stanhope and Haydon Bridge were the highest ever recorded. Nearby, 11,000 properties in Hexham were without mains water for days as, in the midst of all the flooding, a water main was damaged.

We delivered 1,437 flood warnings and protected 280,000 homes from flooding in 2000 alone.[39] Many more may need protecting in the future. We expect flood flows to be 20 per cent higher by 2050.[40] Just 15 cm of fast flowing water will knock adults off their feet, 60 cm of water will float a car, and 90 cm of floodwater in an average house can cause up to £30,000 of damage.

Saving the Severn

In response to the devastating autumn 2000 floods, we are working with the Department for Environment, Food and Rural Affairs (Defra), local authorities and Severn Trent Water to reduce flood risk along the length of the River Severn. We are looking at the causes of flooding, reviewing the performance of existing flood defences and assessing the effectiveness and viability of flood management options for the next 50 years. We are also addressing wider issues such as changes in land use, farming practice, new development and urban drainage.

The benefits of this work have already been seen. New defences in Worcester, Ironbridge, Bewdley and Shrewsbury saved about £20 million of damage and disruption to home and business owners during flooding in 2004.

Boats replace traffic in New Year flooding, January 2005

In the second weekend of 2005, Carlisle was hit by its worst flooding since 1822. Almost 2,000 properties were flooded in Carlisle when the River Eden and its tributaries overtopped 8 km of flood defences, in some places by more than a metre. Thousands of people were evacuated from their homes and police and fire stations were flooded. Communications were severely disrupted as the town was virtually cut off by floodwater. About 70,000 properties experienced power cuts, telephone lines were down and only one mobile phone operator was functioning. As well as the serious flooding in Carlisle, flooding occurred in the towns of Cockermouth, Keswick, Appleby and Kendal. Numerous isolated properties and villages also suffered flooding.

33 UKCIP (2002b)
34 Environment Agency (2001a)
35 NFU press release, 5 January 2001
36 Environment Agency (2001b)
37 BBC News 3 February 2004
38 BBC News 10 January 2005 (see http://news.bbc.co.uk/1/hi/wales/4159471.stm)
39 Environment Agency (2001b)
40 Planning Policy Guidance 25 (PPG25), section A7 (ODPM 2004b)

Winter storms and sea level rise

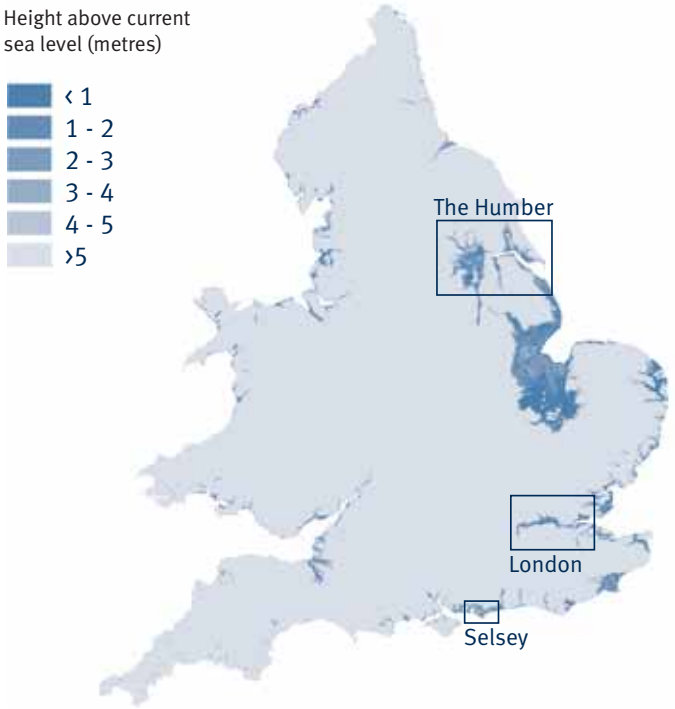
As much as 65 per cent of all flood risk is from coastal and tidal flooding. Across England and Wales, over a million properties are already at risk. As storms and sea levels increase, more properties, businesses and people will be affected (Figure 6).

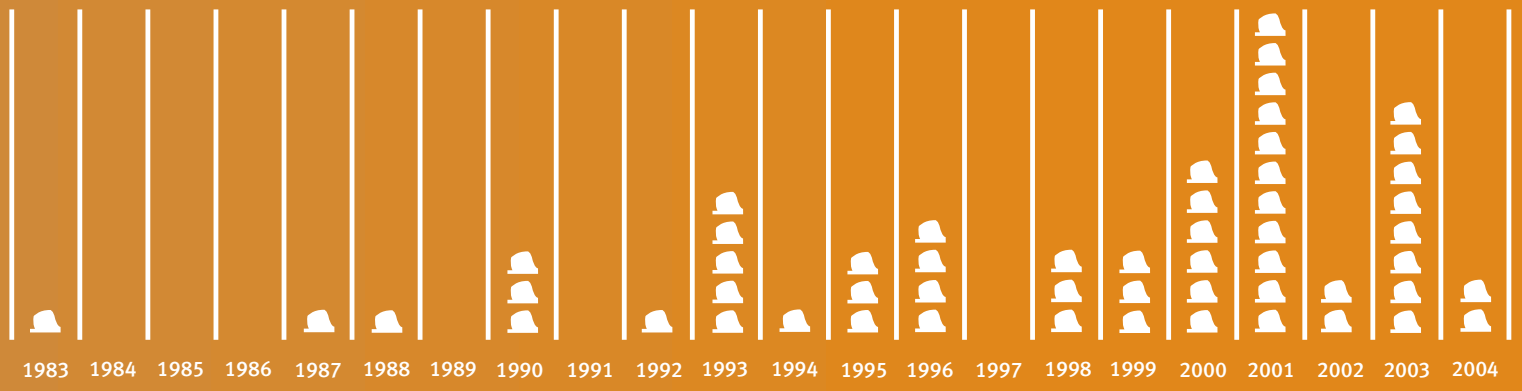
Sea levels around the UK are now about 10 cm higher than they were in 1900.[41] At the same time, the south east of England is sinking at a rate of 15 to 20 cm a century.[42] And the average number of winter storms has increased significantly, with the largest increases in the south.[43] New records for wind speeds in England and Wales were set by 124 mph (200 km/hour) gusts at Rhoose (South Glamorgan) in October 1989.[44] For some east coast locations, extreme sea levels (storm surges) could occur between 10 and 20 times more frequently by the 2080s than they do now.[45]

Coastal flooding such as that seen in Cornwall at Looe, Penzance, Porthleven, Flushing and Falmouth on 27 October 2004 will become increasingly common, damaging property and threatening lives. Not all flooding will be temporary; some places, such as Selsey in Sussex, could become islands again if our flood defences don't keep pace with climate change. Other areas, such as Essex, have already lost vast areas of land under the sea.

We use the latest available technology to monitor sea conditions 24 hours a day to forecast coastal flooding and trigger the closure of tidal barriers. Clear warning systems will continue to be an essential element of flood risk management to enable people to take action to protect themselves and their properties. In some cases prompt evacuation will also be necessary.

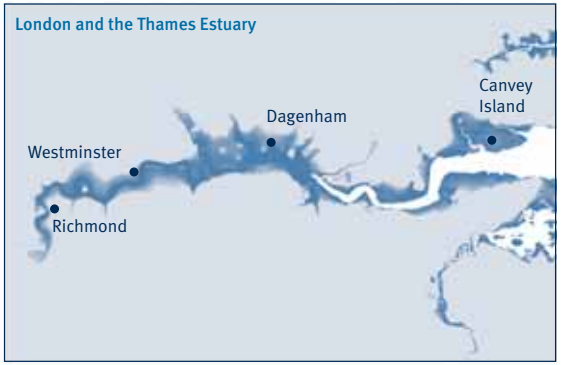
Figure 6 **Low-lying land in England and Wales**

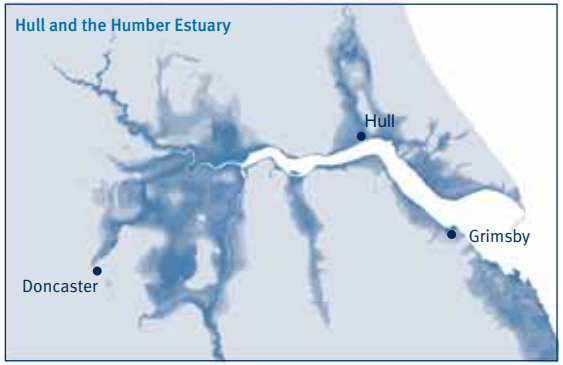




The world's largest movable flood barrier – the Thames Barrier – has been raised 55 times against tidal surges in the 20 years since it was built, half of which were in the last five years.

Figure 7 Thames Barrier closures against tidal surges, 1983 to 2004 Source: Environment Agency = one raising of the Barrier





Check if you are at risk of flooding by using our flood risk maps.

www.environment-agency.gov.uk/flood/

Foresight – a project to produce a long-term vision for the future of flood and coastal defence in the UK.

www.foresight.gov.uk/fcd.html

41 Proudman Oceanographic Laboratory (see www.pol.ac.uk/ntslf/data.html). See also our sea level change environmental indicator (www. environment-agency.gov.uk/yourenv/eff/natural_forces/sealevels/)

42 During the last glaciation, the mass of ice pushed the north west of the UK down which in turn raised the south east. Even though the ice sheets are long gone, the land is still rebounding – the north west is rising and the south east sinking. This is called isostatic rebound

43 Met Office/Hadley Centre (2003)

44 Met Office: Extreme weather (see www.met-office.gov.uk/climate/uk/location/england/index.html and www.met-office.gov.uk/climate/uk/location/wales/index.html)

45 UKCIP (2002a and 2002b)

A safe climate for industry?

Large tracts of the north west's industry – including petrochemicals and a nuclear power plant – are vulnerable to tidal surges and river flooding because they are only just above the existing high tide sea level or located on flat, low-lying land.

In 2001, high tides and storms flooded Bromborough sewage treatment works on Merseyside, shorting out all power and damaging the infrastructure. It was several weeks before the plant was fully operational again. Fortunately, although the potential for environmental damage was high the actual impact was not significant. In 2000, floodwaters from the River Gowy reached a new part of the Gowy landfill site (near Chester) and mixed with contaminated leachate. This cost the company about £50,000 to tanker away and dispose of safely. A major programme of works has now been completed to reduce the risk of this happening again.

Turning the tide for Hull

One of the highest tidal surges for four decades hit Hull in January 2005. Water levels rose to about 90 cm above normal levels – about the same height that flooded the city centre in 1969. But the city was saved from certain flooding by our tidal barrier, which protected about 1,800 properties and saved £250 million worth of damages.

Sea level rises, storm surges and intense erosion are a threat to the whole Humber Estuary. Over 300,000 people live on the Humber's floodplain, protected by flood defences. After the Thames, the Humber has the greatest concentration of people and property on a tidal floodplain in the UK.

We are now putting into effect the Humber Estuary Shoreline Management Plan to combat the effects of climate change. In Hull, existing defences will be heightened. At Alkborough some embankments will be set back, allowing the sea to reclaim about 1,000 hectares of farmland; defending the shore by neutralising the energy of waves and creating an intertidal habitat. As part of the project the Environment Agency, English Nature, the Countryside Agency and North Lincolnshire Council are creating 440 hectares of habitat where the Rivers Ouse and Trent meet to replace 'coastal squeeze' losses in the inner part of the estuary and tidal washlands. There will be opportunities for countryside leisure activities that will connect with the Waters' Edge area at Barton upon Humber.

Set up your flood plan – more businesses flood than burn down, yet most businesses have no flood plans in place.

www.environment-agency.gov.uk/subjects/flood/

Longer, drier, hotter summers

By 2080 the high temperatures experienced in 2003 may seem cool. High summer temperatures could cause ill health and even death, and poorer air and water quality. We think summers will also be drier, and what rain does fall is likely to be in intense bursts. Droughts will be more frequent.

Water supply

October is the start of the annual 'water year', usually marked by the onset of heavier rain. As the dry weather of 2003 continued late into October, our concerns about water supply increased in a number of areas. Soil moisture levels were extremely low until early November. This delayed the replenishment of groundwater stores, which provide 80 per cent of water supplies in some places, and levels across England and Wales fell by as much as 35 per cent. Record lows for river flows were recorded across the country from the Stour in Dorset to the Yscir in South Wales and the Soar in the Midlands. The River Rother in the south east was flowing at just eight per cent of average. By October 2004, and despite a wetter than average summer,[46] water levels were still low in some areas (Figure 8).

Periods of drought spanning more than one season or one year present a serious threat to water supplies. South east England is under greater pressure than most places; 8 million people already live there and more development is planned. It is one of the driest regions in the UK, with less available water per person than Spain (265,000 compared to 2,711,000 litres per person).[47] Several reservoir proposals are being explored in the south and south east of England. Southern Water, South East Water, Portsmouth Water and Mid Kent Water may have to build four new reservoirs by 2020 to maintain reliable water supplies, including the first ever reservoir in Hampshire. We will be assessing these plans and ensuring that existing water supplies are used efficiently.

Figure 8 **In October 2004 water levels were still low in some places even after a wet year**

Source: Environment Agency and UK Groundwater Forum, BGS and NERC

[46] Met Office: 2004 weather (see www.met-office.gov.uk/climate/uk/2004/seasonal.html)
[47] World Resources Institute 2004 (see www.wri.org/)

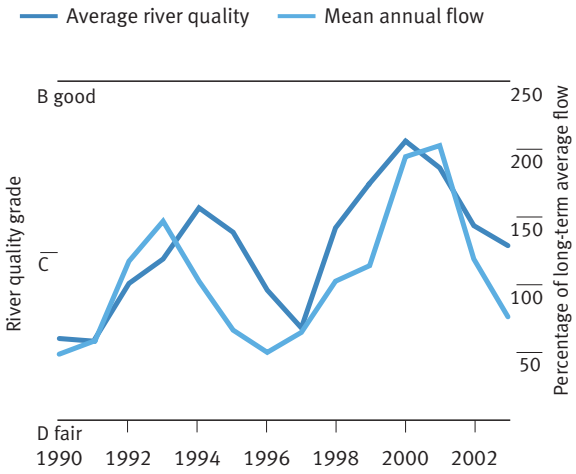
Use less water

www.environment-agency.gov.uk/subjects/waterres/

Water quality

We are concerned that lower river flows and groundwater levels will mean poorer water quality. We have seen higher nitrate levels in groundwater in drought years and poorer river quality when flows are low in our Anglian Region (Figure 9). This has impacts on wildlife and habitats, the cost of cleaning water for drinking, and the amenity value of our countryside.

Figure 9 **Impact of river flow levels on chemical river quality, Anglian Region**



Source: Environment Agency

Higher temperatures

Six of the ten warmest years on the UK record were between 1995 and 2004. Globally, 2003 was the second warmest year and 2004 the fourth since records began in 1861.[48] In Europe, the August heat wave was the hottest for 500 years. In the UK, March to August 2003 were the warmest on record[49] and included the country's hottest temperature ever of 38.5°C at Brogdale in Kent.[50] Even 2004, which many people perceived as a disappointing summer, was the UK's fifth warmest yet.

Temperatures in 2003 were warmer than the long-term average by just over 1°C. This is well below predictions for 2080, but in the short time between 4 and 13 August 2003 more than two thousand people died in the UK because of the heat.[51] By 2080, the UK is three times more likely to experience these conditions and the hottest days could be in the mid 40s.

48 Met Office News Release 2004: Another warm year (see www.met-office.gov.uk/corporate/pressoffice/2004/pr20041216.html)
49 Met Office News Release 2003: Great weather events – Temperature records fall (see www.metoffice.com/corporate/pressoffice/anniversary/records2003.html)
50 Met Office website August 2003 – Hot spell (see www.metoffice.com/climate/uk/interesting/aug03maxtemps.html)
51 National Statistics (2003)

Feeling the heat in the city

Central London can be up to 7°C warmer than the surrounding countryside, especially at night, because of the heat island effect.[52]

In August 2003, temperatures on the Underground were so severe that the London Mayor offered a reward of £10,000 to anyone who could devise an effective cooling solution. Parts of the M25 melted. The London Eye had to be closed because the pods were too hot. And more than a thousand people in London died in the heat.[53]

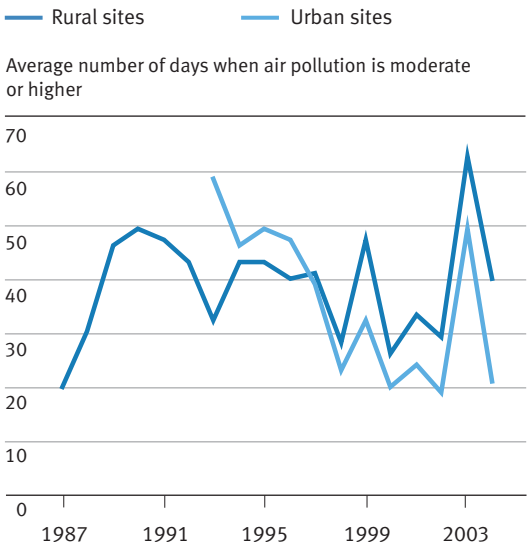
By 2080 temperatures in London are predicted to be 'outside comfort levels' for people at work for 23 per cent of working hours.[54]

Air pollution

The heat wave in summer 2003 caused the poorest air quality for years (Figure 10). High levels of pollution were measured on 10 consecutive days in August, and ozone pollution reached its highest peak for more than a decade in London.[55] High levels of pollution were again recorded in late July/early August 2004 as temperatures rose to about 30°C.[56]

Hot, dry summers favour the production of air pollutants like ground-level ozone, volatile organic compounds and fine particles. An increase of just 1°C in summer has been linked with a 14 per cent increase in ground-level ozone.[57] Poor air quality can lead to significant respiratory problems for sensitive people[58] and was responsible for up to 38 per cent of the deaths caused by the August 2003 heat wave.[59]

Figure 10 **Air pollution in the UK**



Source: NETCEN on behalf of Defra

52 Wilby (2003)
53 National Statistics (2003)
54 London Climate Change Partnership (2002)
55 Kent (2003)
56 Targa (2004)
57 Lee (1993)
58 Donaldson *et al.* (2001)
59 Stedman (2004)

Biodiversity impacts

There is a great deal of uncertainty about how climate change will affect biodiversity and ecosystems. But if temperatures and sea levels rise and rainfall patterns change, we think the range and behaviour of plants and animals will too.

With only a 1°C increase, egg-laying dates of 20 bird species are already 4–17 days earlier than 25 years ago. As spring becomes warmer and longer,[60] swallows are arriving earlier, and there is a trend towards the early leaf emergence of oak trees.

Freshwater, wetland and coastal habitats and species are among the most vulnerable to climate change. Tidal wetlands like saltmarshes are threatened by sea level rise, salinity changes and storm erosion.

Areas of bog in the Peak District are at the most northerly range of some species and the most southerly of others, so are highly sensitive to even slight changes in temperature and rainfall. In warmer, drier conditions, the bog itself could decompose, releasing yet more carbon dioxide.[61] Increased rainfall intensity and surface cracking during droughts make bogs and sparsely vegetated peat surfaces more vulnerable to erosion.

A key indicator of climate change in Wales is the snowline on the hills of Snowdonia. Snow cover here has been declining over the last 10 years, apart from 2001. The area is home to rare mountain plants like the Snowdon lily and tufted saxifrage, but the habitat is threatened by even very small climate changes. As Arctic–Alpine plants are at the southernmost limit of their range here, this is the first place where this habitat will be lost. Other habitat pressures, such as grazing, have been removed at sites like Cwm Idwal in eastern Snowdonia,[62] so future records of vegetation change will reflect the impact of climate on the habitat.

The saltmarshes of Essex are one of the least modified habitats in a densely populated county and account for a tenth of the national resource. They are a vital component of natural flood defence systems, acting as a buffer that reduces wave energy and stores water. They are critical to biodiversity, functioning as important nursery grounds for a range of fish species and as feeding grounds for birds such as the curlew and oystercatcher. And they are of great aesthetic and recreational quality. But between 1973 and 1998 more than a quarter (about 1,000 hectares) of these saltmarshes were lost to rising sea levels.[63]

60 See 'Longer growing season' at Tyndall Centre website (www.tyndall.ac.uk/media/press_releases/pr_16.shtml)

61 East Midlands Sustainable Development Round Table (2000)

62 Countryside Council for Wales News releases in 2004 at www.ccw.gov.uk/news/index.cfm?action=Press&ID=678&lang=en and www.ccw.gov.uk/news/index.cfm?action=Press&ID=697&lang=en

63 Coastal and Geomorphological Partnership (2000)

Track climate changes in your local environment – join the phenology network and record dates such as the first appearance of frogspawn in your pond or when you first cut your lawn.

www.phenology.org.uk/

Low river flows and temperatures higher than about 24°C cause problems for migrating salmon.[64] Temperatures in Southampton Water already reach as high as 23°C in late summer when most salmon are near the upper estuary. In 2003, salmon migration in Wales and the south west and south east of England was badly affected. In Hampshire, the River Avon reached its lowest ever October flow and poachers were able to pluck salmon out of the river as they tried to make their way upstream to the spawning grounds. We now send out extra anti-poaching units at times of low flow. Already, the salmon stock in rivers such as the Itchen in Hampshire is well below its conservation limit and struggles to sustain itself. Salmon could disappear from some rivers.

A helping hand for habitats[65]

The Great Fen Project is one of the most ambitious habitat restoration projects ever undertaken in Britain. Over the next 50 years or so, 3000 hectares of fenland habitat will be restored by a partnership including the Environment Agency, English Nature, the Wildlife Trust and Huntingdonshire District Council. The restoration of the fen and wet grassland habitats will have great amenity value and help wading birds such as the bittern, wetland mammals like the water vole and otter, and plants including the fen violet and reeds. The Great Fen will lie between Peterborough and Huntingdon in Cambridgeshire, connecting Woodwalton Fen National Nature Reserve (NNR) with Holme Fen NNR. Land adjacent to both fens has been acquired and restoration work has already begun.

As well as boosting the local economy, this project has the potential to enhance flood protection and help manage water resources in the area. Rainfall in Cambridgeshire is lower than most other parts of the country and there are plans to build 100,000 new homes here by 2025.

[64] Alabaster *et al.* (1991) and Solomon *et al.* (2003)
[65] See www.greatfen.org.uk for more information

Addressing climate change

Warmer and sunnier summers may seem like something to look forward to. But climate change comes as a package and the good comes with the bad. The worst extremes will be devastating. To offset them, everyone must reduce fossil-fuelled energy use **now** and improve the efficiency of that energy which is used. Some impacts are inevitable (as listed on page 25), and everyone must be ready to cope with and be resilient to these changes. Solutions need to be a realistic mix of those that meet the needs of society and the economy as well as those demanded by the environment.

We think that a radical change in effort is needed to ensure we meet targets to cut emissions of carbon dioxide by 20 per cent below 1990 levels by 2010, and 60 per cent below 1990 levels by 2050. We support a focus of energy policy on reducing demand, increasing industrial and domestic energy efficiency and developing renewable energy supplies.

We want to see resilience to climate changes built into new developments and infrastructure. New developments should be built to the highest standards and away from flood risk areas to avoid increasing the risk to life and damage from flooding, and they should incorporate water- and energy-efficient design and sustainable drainage.

We support Defra's proposal of a UK-wide adaptation framework that sets out clear objectives, roles and responsibilities for government, government bodies and other stakeholders to ensure that the UK is sufficiently prepared for climate change. **Only by taking action now can we minimise the impact of climate change on our quality of life.**

Key impacts of climate change

Water supply

- increased water demand plus droughts could worsen water supply problems in parts of England
- low summer rainfall may stress protected sites
- saline intrusion to coastal aquifers

Built environment

- flooding
- sewerage system overflow following intense rainfall
- structural damage and subsidence
- heat and air quality problems

Environment

- loss of land and biodiversity to the sea
- low river flows reduce effluent dilution, which increases the likelihood of algal blooms and damage to wetlands and aquatic habitats
- biodiversity losses due to higher water temperatures, poor water quality and eutrophication
- major ecological change in upland areas, wetlands and aquatic habitats
- invasive species
- change in timing of event (biological phenology)

Health

- increase in heat-related summer deaths and more cases of food poisoning and vector- and water-borne diseases
- significantly fewer cold-related deaths (mainly the elderly)
- mental stress to victims of extreme weather events

Agriculture

- water shortages could lead to reduced crop production
- increased costs for irrigation and livestock feed
- intense rainfall and periods of drought would lead to soil damage and erosion
- reduced frost damage, longer growing season

Business and industry

- power cuts due to storm and flood damage
- restrictions on industrial water supply (e.g. for cooling)
- insurance industry – higher payouts for storm damage, flooding and subsidence
- expansion of wave and wind power potential

Transport

- high temperatures can cause damage to road and rail infrastructure and restrictions to navigation on waterways
- gales and flooding during winter will affect all modes of transport and ports, especially in coastal areas
- passenger discomfort in hot weather

Tourism/leisure

- low flow and poor water quality may restrict recreational activities on rivers/lakes
- extreme weather may create problems for conservation of heritage sites (both built and archaeological), especially at coastal sites
- warmer, drier and sunnier summers could benefit domestic summer tourism

Further information

How we fit in
Climate change and the work we do on the causes and effects of climate change, including reports on Boscastle and the autumn 2000 flooding, regulating industry and more.
www.environment-agency.gov.uk/yourenv/

Find out more about our views on climate change
www.environment-agency.gov.uk/ourviews/

Warning and advice services
These include our Flood Warning service and the Met Office's 'Heat-health watch'.
www.environment-agency.gov.uk/subjects/flood/floodwarning/

www.met-office.gov.uk/weather/europe/uk/heat_health.html

Future climate changes
The Met Office's Hadley Centre makes predictions of future climate change using computer models.
www.metoffice.com/research/hadleycentre/

Future flooding
Flood risk maps – check if you are at risk.
www.environment-agency.gov.uk/flood
Foresight – a project to produce a long-term vision for the future of flood and coastal defence in the UK.
www.foresight.gov.uk/fcd.html

Preparing for climate change
The UK Climate Impacts Programme helps organisations assess how they might be affected by climate change.
www.ukcip.org.uk/

Association of British Insurers
Insurance may get more expensive for everyone. The ABI agrees it is time to bring planning for climate change into the mainstream of business life.
www.abi.org.uk/climatechange/

Better buildings and development
The communities being built now will set the pattern of urban living for many decades into the future, but development must respect environmental limits and the potential for climate change. The government department overseeing building and development is the Office of the Deputy Prime Minister.
www.odpm.gov.uk/

UK greenhouse gas emissions statistics
www.defra.gov.uk/environment/statistics/globatmos/gagccukem.htm

Reducing energy use and carbon emissions
The Energy Saving Trust.
www.est.org.uk
The Carbon Trust.
www.thecarbontrust.co.uk

What you can do
Use less water.
www.environment-agency.gov.uk/subjects/waterres/286587/

Set up your flood plan – more businesses flood than burn down, yet most businesses have no flood plans in place.
www.environment-agency.gov.uk/subjects/flood/

Avoid waste – waste costs money, whether it's water, energy or materials.
Envirowise – www.envirowise.gov.uk/

Check if your home is at risk from flooding and do something to protect yourself.
www.environment-agency.gov.uk/subjects/flood/826674/830330/876970

Make buildings more climate proof by flood-proofing (e.g. raising floor height) and incorporating water efficiency measures (e.g. re-use of grey water and dual flush cisterns).
www.practicalhelp.org.uk/housing/guidance/

Use less energy – how will you choose your next kitchen appliance or car?
www.est.org.uk/myhome/whatcan/

Find out more about renewable energy.
www.dti.gov.uk/renewables/

Track climate changes in your local environment – join the phonology network and record dates such as the first appearance of frogspawn in your pond or when you first cut your lawn.
www.phenology.org.uk/

References

Alabaster, J.S., Gough, P.J. and Brooker, W.J. 1991. **The environmental requirements of Atlantic salmon, *Salmo salar L.*, during their passage through the Thames Estuary,** 1982–1989. *Journal of Fish Biology*, 38, 741–762.

Association of British Insurers (ABI) 2004a. **A Changing Climate for Insurance: A Summary Report for Chief Executives and Policymakers.** ABI, 20pp.

Association of British Insurers (ABI) 2004b. **Evidence to EFRA Committee Report on 'Climate Change and Water Security'.** Available at www.publications.parliament.uk/pa/cm200304/cmselect/cmenvfru/558/4050502.htm

Catovsky, S. (Association of British Insurers) 2004. **Boscastle and Climate Change: Implications for Insurance,** *Journal of Meteorology,* 29, 340.

Coastal Geomorphological Partnership 2000. **Erosion of the Saltmarshes of Essex between 1988 and 1998.** CGP, University of Newcastle.

Department for Transport 2004. **The Future of Transport.** *White Paper CM 6234*. Available at www.dft.gov.uk/stellent/groups/dft_about/documents/divisionhomepage/031259.hcsp

Donaldson, G., Kovats, R.S., Keatinge, W.R. and McMichael, A.J. 2001. **Overview of climate change impacts on human health in the UK: heat- and cold-related mortality and morbidity and climate change.** In: *Health Effects of Climate Change in the UK. Expert Group on Climate Change and Health in the UK.* Department of Health, 238pp.

DTI (Department of Trade and Industry) 2004. **Digest of UK Energy Statistics 2004.** Available at www.dti.gov.uk/energy/inform/energy_indicators/ind3_2004.pdf

East Midlands Sustainable Development Round Table 2000. **The Potential Impacts of Climate Change in the East Midlands:** *Technical Report.* 196pp.

Environment Agency 2001a. **Lessons Learned: Autumn 2000 Floods.** Environment Agency, 56pp.

Environment Agency 2001b. **'Reducing flood risk'** section of *Annual Reports and Accounts 2000/01*. Available at www.environment-agency.gov.uk/commondata/acrobat/reducing_flood_risk.pdf

Environment Agency 2001c. **Water Resources for the Future.** Available at www.environment-agency.gov.uk/subjects/waterres/137651/

Environment Agency 2004. **High Level Target 12 Report: Development & Flood Risk in 2003/04.** Available at www.environment-agency.gov.uk/subjects/flood/571633/

EurObserv'ER 2004 **European Barometer of Renewable Energies.** 4th Report. 32pp. Available at www.energies-renouvelables.org/observ-er/stat_baro/barobilan/barobilan4.pdf

European Commission 2004. **Action on Climate Change Post 2012.** Available at http://europa.eu.int/comm/environment/climat/pdf/background_paper.pdf

IPPC (Intergovernmental Panel on Climate Change) 2001. **Third Assessment Report: Climate Change 2001.** Available via www.ipcc.ch/

Kent, A. 2003. **Air Pollution Forecasting: Ozone Pollution Episode Report (August 2003).** Netcen report. Available at www.airquality.co.uk/archive/reports/cat12/o3_episode_august2003.pdf

Lee, D.O. 1993. **Climatic change and air quality in London.** *Geography,* 78, 77-79.

London Climate Change Partnership 2002. **London's Warming: The Impacts of Climate Change on London.** Summary report, 22pp.

Met Office/Hadley Centre 2003. **Climate Change Observations and Predictions: Recent Research on Climate Change Science from the Hadley Centre, December 2003.** Met Office, 12pp.

National Statistics 2003. **Summer Mortality: Deaths Up in August Heatwave.** Available at www.statistics.gov.uk/cci/nugget.asp?id=480%20

North Cornwall District Council 2004. **Boscastle: The Flood.** Available at www.ncdc.gov.uk/media/adobe/e/s/BoscastleFlood.pdf

ODPM (Office of the Deputy Prime Minister) 2004a. **Land Use Change in England to 2003: Additional Tables.** LUCS-19A. ODPM, 46pp. Available at www.odpm.gov.uk/stellent/groups/odpm_planning/documents/page/odpm_plan_032255.pdf

ODPM (Office of the Deputy Prime Minister) 2004b. **Planning Policy Guidance 25: Development and Flood Risk.** Available at www.odpm.gov.uk/stellent/groups/odpm_planning/documents/page/odpm_plan_606931-11.hcsp

ODPM (Office of the Deputy Prime Minister) 2004c. **Overview of the Thames Gateway.** Available at www.odpm.gov.uk/stellent/groups/odpm_communities/documents/pdf/odpm_comm_pdf_030604.pdf

Oreskes, N. 2004. **The scientific consensus on climate change.** *Science*, 306, 1686. Available at www.sciencemag.org/cgi/reprint/306/5702/1686.pdf

Solomon, D.J. et al. 2003. **Salmon Migration and River Flow – Results of Tracking Radio Tagged Salmon in Six Different Rivers in South West England.** Environment Agency, Research & Development Publication 4.

Stedman, J.R. 2004. **The predicted number of air pollution related deaths in the UK during the August 2003 heatwave.** *Atmospheric Environment*, 38, 1087–1090.

Stott, P., Stone, D. and Allen, M. 2004. **Human contribution to the European heatwave of 2003.** *Nature*, 432, 610–614.

Targa, J. 2004. **Air Pollution Forecasting: Ozone Pollution Episode Report** (July–August 2004). Available at www.airquality.co.uk/archive/reports/cat12/0409060846_03_episode_summer2004_ final.pdf

UK Climate Impacts Programme (UKCIP) 2002a. **Climate Change Scenarios for the UK: The UKCIP02 Technical Report.** Tyndall Centre for Climate Change Research, 120pp.

UK Climate Impacts Programme (UKCIP) 2002b. **UKCIP02 Briefing Report,** April 2002. Tyndall Centre for Climate Change Research, 15pp.

Wilby, R.L. 2003. **Past and projected trends in London's urban heat island.** *Weather*, 58 (7), 251–260.

WM203/RD/10K

Would you like to find out more about us, or about your environment?

Then call us on **08708 506 506** (Mon-Fri 8-6)

email **enquiries@environment-agency.gov.uk**

or visit our website **www.environment-agency.gov.uk**

incident hotline **0800 80 70 60** (24hrs)
floodline **0845 988 1188**

Environment first: This publication is printed on paper made from 100 per cent previously used waste. By-products from making the pulp and paper are used for composting and fertiliser, for making cement and for generating energy.

GEHO0205BIRS-E-P