South East Climate Change Partnership
A partnership of the public, private and voluntary sectors

Sustainable Development Round Table for the East of England

LONDON climate change PARTNERSHIP

Adapting to climate change: a checklist for development

Guidance on designing developments in a changing climate

November 2005

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(Bottom) Gold Lane, Barnet, photograph by Project 35 Architects

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This document has been produced by the Three Regions Climate Change Group, made up of representatives from the East of England Sustainable Development Roundtable, London Climate Change Partnership and the South East Climate Change Partnership.

Endorsement of the Checklist for Development

The following climate change partnerships have offered their support for and endorsement of the Checklist for Development:

East Midlands Climate Change Steering Group

North West Climate Group

South West Climate Change Impacts Partnership

Sustaine – the North East Partnership for Sustainable Development

West Midlands Climate Change Partnership

Yorkshire and Humber Climate Change Partnership

UK Climate Impacts Programme

They recognise that there may be differences in the detailed application of the checklist according to regional variations in climate as well as social and economic conditions. Nevertheless, the principles that underpin the document provide a robust framework for developers to use in making planning and design proposals for new development.

ministerial foreword

Elliot Morley MP,
Minister of State

Climate change is a real and immediate threat. At the Exeter conference on *Avoiding Dangerous Climate Change*, in February 2005, scientists re-stated that the UK will see significant climate change throughout this century.

The UK has long been at the forefront of efforts to prepare for the anticipated impacts of climate change. Since 1997, the UK Government has supported the UK Climate Impacts Programme (UKCIP), raising awareness of impacts and helping public and private sector organisations across the UK assess the risks and prepare adaptation strategies.

National policy on climate change adaptation is being taken forward through the Adaptation Policy Framework, which is currently out for consultation. The Framework is aiming to develop a better understanding of climate change adaptation, and to co-ordinate policy, roles and responsibilities for adaptation across the UK.

This document is an excellent example of building capacity to adapt to climate change. It also shows how regional bodies such as the *Three Regions Climate Change Group* are working together to prepare for climate change.

The impacts of climate change will increasingly affect the integrity of the built environment unless action is taken now. New buildings need to be able to withstand the impacts of climate change over the next 50 to 80 years to guarantee their long term sustainability.

This document is an important part of achieving that goal. This is an England-wide document, a fact underlined by the endorsement received from all the English regional climate change partnerships and I would urge all developers across the country to take on board the messages within the checklist and guidance.

Three Regions Climate Change Group

The following people are represented on the Group and contributed greatly to the development of the document:

Penny Bramwell (Chair)	Government Office for London
Sebastian Catovsky	Association of British Insurers
Simonne Baker	CIRIA
Mark Goldthorpe	South East Climate Change Partnership
Geoff Leigh	English Partnerships
Tim Reeder	Environment Agency
Vanessa Tilling	Government Office for East of England
Will Lochhead	Government Office for London
Richard Lemon	Government Office for the South East
Louise Whall	Government Office for the South East
Matthew Chell	Greater London Authority
Jane Carslen	Greater London Authority
Alex Nickson	Greater London Authority
John Rumble	Hertfordshire County Council
Carole Forrest	Housing Corporation
Richard Jackson	London Development Agency
Phil Sivell	Surrey County Council
Kate Nelson	Thames Gateway London Partnership
Keith Colquhoun	Thames Water
Richenda Connell	UK Climate Impacts Programme

The Group would like to acknowledge the breadth of knowledge referenced from existing sources to compile this document, in particular the Environment Agency, CIRIA and Woking Borough Council.

The Group would like to thank all those who responded to the consultation on this document which ran between February and April 2005.

The Group would particularly like to thank Matthew Chell and Will Lochhead for drafting, editing and leading on producing the document, Government Office for London for sponsoring the printing of the consultation document and the Mayor of London for hosting the launch of the consultation in February 2005.

foreword

John Rumble
Chair of Climate Change Steering Group
East of England Sustainable Development Roundtable
www.sustainability-east.com

Gerry Acher CBE LVO
Chair of London Climate Change Partnership
www.london.gov.uk/climatechangepartnership

Graham Tubb MBE
Chair of South East Climate Change Partnership
www.climatesoutheast.org.uk

Climate change is one of the greatest challenges facing the world's environment, society and economy today. Its impacts can already be seen across the globe and the UK will not be immune.

There is clear evidence that the climate is changing now. Every one of the hottest 15 years on record has occurred since 1980 – the five hottest since 1997 and over the last three years there have been a number of extreme weather events; torrential rainfall in London, extreme heat waves in Paris and flooding affecting the cities along the River Elbe.

And as more climate change is inevitable the need to adapt to our changing climate becomes more pressing, not just in the way we live, but in the way we build our new buildings. Consequently, this document's focus is on adapting to climate change, an issue that has largely been ignored.

In the South East and East of England, we are particularly vulnerable to the impacts of present and future climate change. That is why we are taking action now, to minimise the expected impacts of climate change and to make sure people, property, infrastructure and biodiversity can adapt to climate change in the future.

As buildings generally have an expected lifetime of between 20 and 100 years, thinking about climate change today, when planning new developments for tomorrow, will help to ensure a lasting legacy in the building stock. Buildings and their locations could all be adversely affected by climate change, including their structural integrity, external fabric, internal environment and service infrastructure.

That is why representatives from the East of England's Sustainable Development Roundtable and London's and the South East's Climate Change Partnerships have come together to form an informal *Three Regions Climate Change Group* to produce this checklist and guidance.

Adapting to Climate Change: a Checklist for Development is designed to highlight to developers, their design teams, architects, investors, as well as policy makers, the need for developments to be *climate proofed*, at the outset, to our changing climate.

Although produced with the East of England, London and South East regions in mind, a large majority of the messages are applicable throughout the UK and that is why we are particularly pleased to have received endorsement from all the other regional climate change partnerships in England.

To ensure that new developments have a long-term sustainable future, we urge developers and national Government to take on board the messages in this guidance and factor in climate change adaptation in all their new developments.

introduction to checklist and guidance

Introduction

This document contains a checklist and guidance for new developments to adapt to climate change. The main actions are summarised in a simple to use checklist, however, it is not intended to be a design manual, although it does contain signposts to more detailed guidance. It has been produced by the *Three Regions Climate Change Group*[1].

The document is primarily aimed at developers, their partners, design teams, architects, surveyors and engineers[2], but it is also expected to be useful to those within the wider development community, including investors, land purchasers, insurers and lawyers, as well as planners and experts from, for example, the Environment Agency. The guidance is designed to meet the needs of smaller builders, as well as major developers, all of whom have an important role to play in adapting to climate change.

While it will be necessary to adapt existing buildings and infrastructure retrospectively to climate change, this document is targeted at how to incorporate adaptation measures in new development. Extensions and/or refurbishments to existing buildings should be included.

Climate Change

It is now accepted by the overwhelming majority of the world's scientists, as represented on the Intergovernmental Panel on Climate Change[3], that climate change is already happening and further change is inevitable; over the last century, the average global surface temperature rose by around 0.7°C and global sea levels have risen 10-20cm over the past 100 years.

The new UK Sustainable Development Strategy *Securing the Future*[4] confirms that we need to adapt to better manage the future impacts of climate change on the environment, economy and society, while Part G of the Framework for Sustainable Development on the Government Estate, *Estates Management and Construction*[5] commits Government Departments to carrying out climate change assessments to adapt estates practices and policies in the face of a changing climate.

In addition, the UK Government has agreed to develop an *Adaptation Policy Framework* by the end of 2005. Public and private sector organisations at local, regional and national levels will be instrumental in delivering the objectives identified by the Framework.

The Avoiding Dangerous Climate Change[6], conference in Exeter 2005 sought to advance the scientific debate on climate change, headline conclusions included:

- that man made climate change is an increasing risk to the world;
- identifying some particular new threats to biodiversity and the world economy; and
- helping clarify what the more likely effects of climate change will be at different levels of temperature rises and when and where they are likely to occur.

At the same time we also need to reduce the UK's contribution to the causes of climate change. The carbon dioxide already released into the atmosphere 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 from now on. The Government's Energy White Paper[7] sets an ambitious target to reduce the UK's emissions of Carbon Dioxide by 60% by 2050 and move to a low carbon economy, increasing the use of renewable and other non-fossil fuel based energy, reducing demand and improving efficiency.

We therefore need to both mitigate against future climate change and adapt to the impacts we are already committed to. This document though is focused on how to adapt new developments to the impacts of climate change to ensure their long term sustainability.

This document aims to guide all those involved in the development process to put in place appropriate climate change measures, whatever energy policies are implemented in the future.

Aim

It is vital that the effects of climate change are considered over the lifetime of a development[8], especially with regard to its location and design. If they are not, then the long-term sustainability of the development could be compromised. For while development may have a design life of between 20-100 years (or even less in intensely used areas with extremely high land values such as central London), developments may well be used and lived in for much longer. For example, 29% of London's housing stock was built pre-1919[9].

Climate change could mean that the development proves to be too uncomfortable to live in, too expensive to run and maintain, and affordable insurance may no longer be available. It could also contribute to or exacerbate problems for neighbouring development(s) and the wider region.

However, if climate change is taken into account, then the development is more likely to have a long and successful future. And, as understanding of the importance of climate change increases, a *climate-proofed* development could become a better investment and command a higher price.

This checklist and accompanying guidance is aimed at helping developers and their design teams, allowing them to incorporate the appropriate measures at the design stage of developments. It should also help planners make any necessary modifications to their local planning documents and to incorporate appropriate checks in their scrutiny of planning applications. **The aim is to future-proof developments and to build-in resilience to climate change impacts now and in the future.**

In areas at risk, where relocation is not a viable option, reducing the vulnerability of developments and communities to climate change is a priority. London, the South East and East of England are areas at the front line in the UK facing climate change and they are also the areas identified by the Government's Sustainable Communities Plan[10] as being key areas for new development.

Getting it right in these three areas and across the UK, where the majority of the messages in this document remain relevant, is vital to achieving long term sustainability in the UK.

climate change impacts

As a result of increasing atmospheric concentrations of carbon dioxide and other greenhouse gases from the burning of fossil fuels and other land use changes, the Earth's climate is changing and is expected to continue to change over this century and beyond.

The main impacts of climate change are:

- Warmer, wetter winters;
- Hotter, drier summers;
- Extreme rainfall events may happen twice as often by the 2080s;
- Rising sea levels;
- Possible intensification of the urban heat island effect; and
- Possible higher wind speeds.

The latest UK climate change scenarios indicate that, on average, summers will become hotter and drier; there may also be an intensification of the heat island effect in urban areas. Winters will be milder and wetter leading to increased flood risk. As well as seasonal changes, there will be more extreme climate events – very hot days and intense downpours of rain, leading to an increased risk of flooding in some areas, as typified by the summer heatwave in 2003 and the extensive flooding in Central Europe in 2002. Sea levels will continue to rise, increasing the risk of coastal flooding and erosion, and current extremes of high water levels will occur more frequently. The number of storms crossing the UK in winter could also increase.

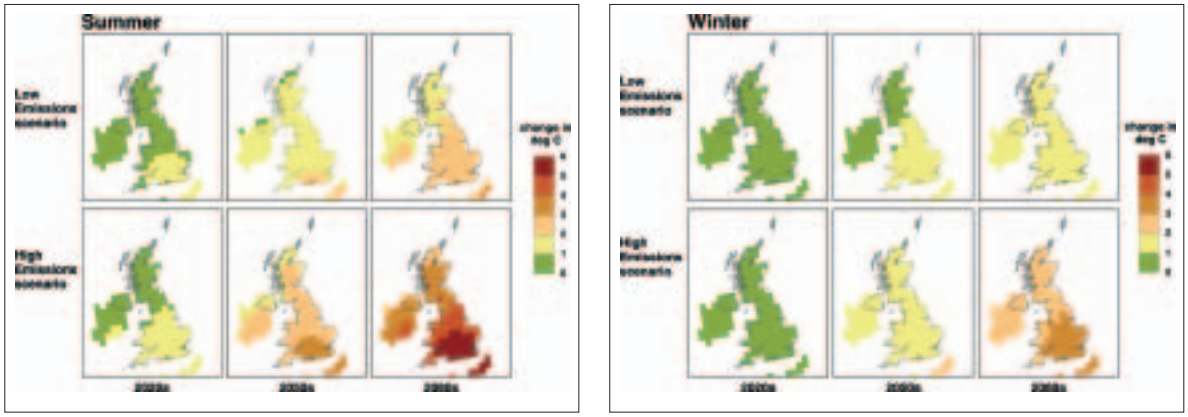
It should be noted that there will be changes to both the average and extreme weather conditions, and that not all years will fit a clear trend of, for example, "hotter, drier summers", as the weather becomes more variable in a changing climate.

A summary of expected climate change in the United Kingdom and its impacts is available in the reports of the UK Climate Impacts Programme (UKCIP) (2002)[11], the London Climate Change Partnership's *London's Warming Report*[12], the South East Climate Change Partnership's *Rising to the Challenge Report*[13] and the East of England's Sustainable Development Roundtable's *Living with Climate Change in the East of England Report*[14].

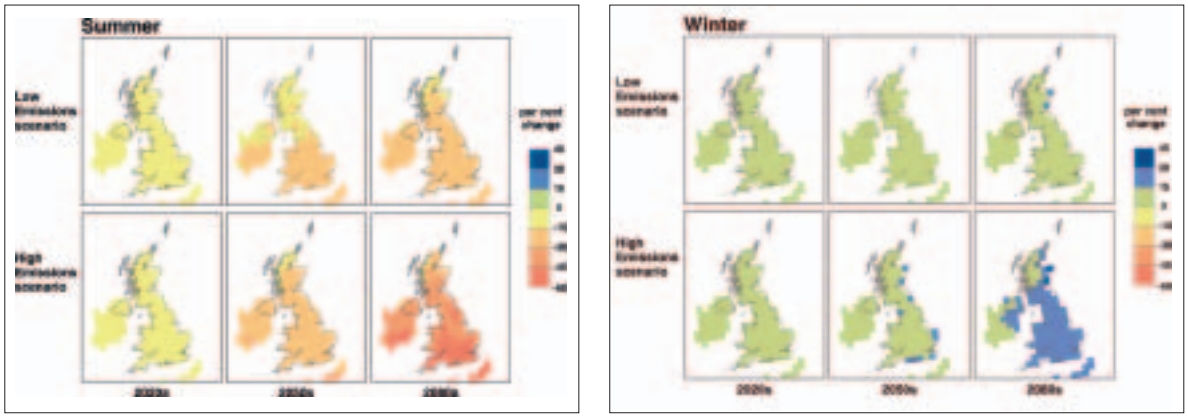
UKCIP02 scenarios for UK on temperature and precipitation

The UKCIP scenarios illustrate how our climate might change. These are based on data produced by the Hadley Centre for Climate Change Prediction[15] and the Tyndall Centre for Climate Change Research[16] and provide a common national reference point. The following diagrams show the expected change in average summer and winter temperature and precipitation respectively.

The UKCIP02 report highlighted the uncertainty in the scenarios and recommended taking a wider view (i.e. other climate models) when making important planning decisions. The trends outlined in UKCIP02 are thought to be robust, although the rate of change may be faster or slower than those illustrated in UKCIP02.



Changes in average summer and winter temperature for the 2020s, 2050s and 2080s for the low and high emission scenarios.



Changes in average summer and winter precipitation for the 2020s, 2050s and 2080s for the low and high emission scenarios.

Work is in progress to reduce and quantify these uncertainties so that risk assessments can be more easily undertaken for major projects and work is also underway to update the scenarios including the analysis of probability of different outcomes.

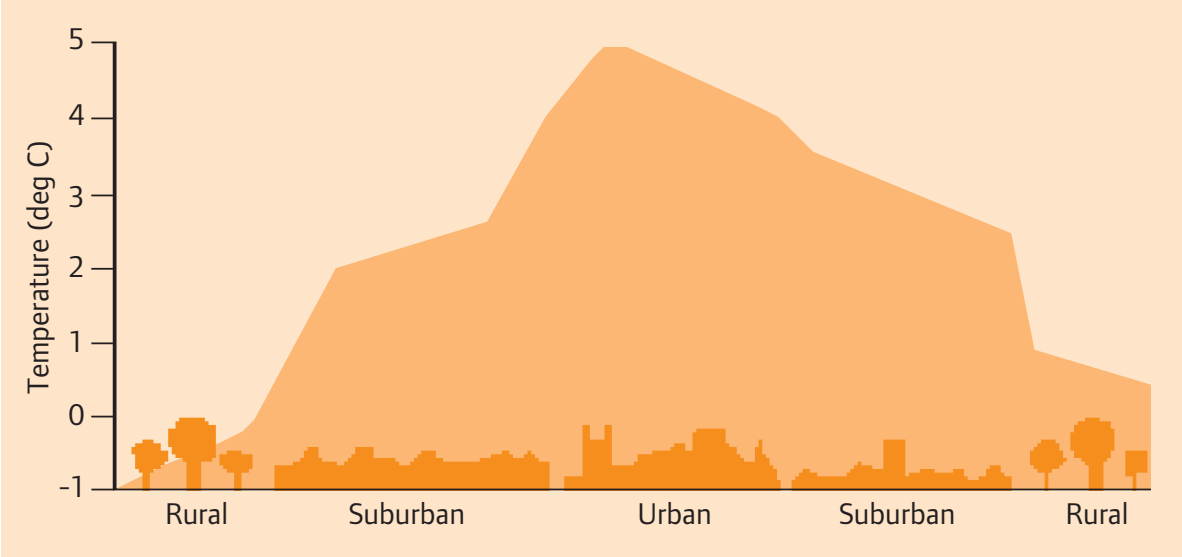
For further information, you should access the UKCIP02 Scenarios Gateway at **www.ukcip.org.uk/scenarios/**. New scenarios will be available in 2007-08.

Hotter temperatures and urban heat island effect

The UK climate will become warmer, especially in the summer. By the 2020s annual temperatures may increase by 1°C and by the 2080s by up to 6°C (in the South East) under the High Emissions scenario above 1990 levels. Though new evidence from climateprediction.net[17] suggests the increase could be significantly higher. Very cold winters will be increasingly rare.

The effect this will have on the comfort of buildings throughout the South East and East of England will be noticeable, as both regions are particularly sensitive to increases in temperature, while urban centres will be even hotter than surrounding areas due to the added effect of the urban heat island[18].

The Met Office has produced a map of a typical urban heat island profile to highlight this.



Derived from Microclimates, Met Office, www.metoffice.com/education/secondary/students/microclimates.html

In addition, dealing with higher indoor temperatures will be particularly important for homes, hospitals and residential care facilities. Failure to deal with higher temperatures will lead to increased heat stress, possibly leading to increased mortality rates, especially amongst older people, as seen in the hot summer of 2003. The other side is that winter deaths due to extreme cold weather should reduce.

Rainfall

Climate change projections predict significantly wetter winters and an increase in frequency of heavy downpours. In parts of the South East, winter rainfall could increase by 15-20% by the 2050s under the High Emissions scenario. It is likely that winter rainfall will also be more intense, further increasing the risk of flooding. Indeed current observations suggest that we are already seeing changes in the patterns of UK rainfall.

Summers may become drier everywhere, and in parts of the South and East of the UK, summer rainfall may decrease by 30% by the 2050s under the High Emissions scenario. In summer, soil moisture could be reduced by 20% or more over large parts of England by the 2050s and by 40% or more by the 2080s. Together with expected more intense rainfall, the risk of both urban, flash, and river or fluvial flooding will increase.

Water resources will be reduced as rainfall becomes more seasonal, but increasing storage capacity at every scale from rainwater butts to reservoirs could alleviate the reduction.

Sea level

Sea levels will continue to rise relative to most of the UK's shoreline, and extreme high water levels, due to a combination of storm surges, high tides and increasing mean sea level, are predicted to become more frequent.

It is expected that sea levels will rise by between 25 and 86cm by the end of the century. Taken together with the predicted increased size of storm surges, particularly around tidal estuaries, the risk of tidal flooding will increase.

business case for adapting to climate change

Developers and those who invest in new development should consider the financial implications of climate change as a key component of the business case for building, and investing in, a development. As climate change impacts become more widely understood, well-designed buildings properly protected from climate change risks, not just from flooding, will be easier to sell or let, and at a higher price.

Already research indicates that homebuyers are increasingly interested in the environmental performance of homes. Research released in 2004 by CABE, WWF and Halifax revealed that 84% of homebuyers will pay 2% extra on the purchase price for an eco home[19].

Long-term running costs, including insurance, will be less and the future asset value higher. Where finance is needed from long-term investors such as pension funds, taking a long-term view at the design stage makes a lot of financial sense. For example, climate change could affect a business' bottom line and reputation.

Climate change presents a number of opportunities, as well as risks, to a developer and the wider organisation and some are listed below. Note that the opportunities and risks identified have not been ranked in any order of significance.

Opportunities

Financial:
- Higher future asset values due to lower long term running costs, e.g. insurance and heating and cooling costs, by climate proofing a development.
- Good financial sense for long term investors taking a long-term view at the design stage, especially to those considering corporate social responsibility (CSR).
- In addition, investors with climate vulnerable assets may start to offload these assets and invest in climate proofed assets instead.

Market differentiation:
- Properties are easier to sell or let at a higher price as clients are attracted to well designed buildings, properly protected from climate change risks.
- Opportunity to position the organisation as a market leader on climate proofed buildings and highlight the organisation's "sustainability credentials", attract new customers, and gain a competitive edge over competitors by being able to demonstrate clearly the organisation's CSR credentials.

Better risk management:
- Reduce the potential risks and liabilities through pro-active risk management of climate change issues.
- This will also help to "mainstream" climate impacts and adaptation into conventional business strategies. The ABI agree "it is time to bring planning for climate change into the mainstream of business life[20]".

Staff retention:
- Improve working conditions for staff by climate proofing the work premises and ensuring that the premises are comfortable to work in due to the changing climate.

Assist innovation, creativity:
- Encourage staff to find new innovative solutions to building long-term sustainable developments in a changing climate and helping to gain a competitive edge.

Socially Responsible Investor (SRI) Funds:
- Although the market for specific SRI is still relatively small, it is increasing, as demonstrated by the creation of new financial indexes such as FTSE4Good and the Dow Jones Sustainability Index (DJSI).
- Investors are increasingly interested in ranking organisations according to their environmental and social performance.
- In addition, the Global Reporting Initiative[21] (GRI) seeks to make sustainability reporting comparable on a company by company basis.

Risks

Operational/financial:

- Failure to adapt to climate change may mean that a development proves too expensive to run, too uncomfortable to live or work in, and even uninsurable later in its life.
- This will have serious implications when attempting to sell or let property as the asset value will be less in the future, making it a less attractive investment now.

Consumer expectations:

- Built environment stock in the UK is generally expected to last between 20 and 100 years. It is therefore important to recognise that there will be an expectation among buyers and tenants that developments designed and built now will withstand the impacts of climate change within the lifetime of the development.

Legislation:

- Building regulations and standards will change. By failing to take voluntary measures now (that anticipate future requirements), there is a risk that more expensive remedial measures may need to be taken at a later date to ensure compliance as legislation comes into force.

Funding:

- Public subsidy may not be available to developers that have not incorporated climate change into the location and design of their development, or investing bodies may not want to invest in non-climate proofed developments.
- ODPM Sustainable Communities Funding is contingent upon an appropriate Flood Risk Assessment for example.

Reputation risks:

- There is a threat to the organisation's reputation and brand if a failure to address climate change threatens the sustainability of a building, development and/or land by, for example, flooding or high temperatures that make the building undesirable.
- There might also be a negative impact on reputation if property insurance cannot be provided in areas of increasing risk e.g. due to high subsidence risk and/or flood risk.

Increased weather risks:

- Increased insurance premiums could add to running costs, affecting the value of the development. Insurance claims from increased weather risks are already increasing by 2-4% per year on household and property accounts due to changing weather. Claims for storm and flood damages in the UK have doubled to over £6 billion over the period 1998-2003, compared to the previous five years, with the prospect of a further tripling by 2050[22].

Delaying action:

- Although fewer delays on-site through snow and frosts, workers will be more likely to suffer heat stress in summer and flooding on site is expected to become more common adding cost to construction.

Loss of productivity:

- Climate change may threaten working conditions and travel arrangements for staff, e.g. internal environment becomes uncomfortable as a result of increased summer temperature.

UKCIP has produced a set of reports Costing the impacts of climate change in the UK[23], which introduce a method for putting a value on climate change impacts and also show how to compare these to the costs of adaptation, so that organisations can make financial assessments for adapting to climate change.

Another UKCIP report, A Changing Climate for Business[24], helps business assess the impact that climate change will have on its operation and begin the essential process of adapting to climate change.

key issues to consider

Due to compelling socio-economic considerations, development may continue in areas vulnerable to the impacts of climate change. However, the principles in this guidance can help to optimise the development's location within these areas and reduce their vulnerability.

The main design issues affected by climate change which developers and their design teams will need to consider are:

- location;
- site layout;
- buildings;
- ventilation and cooling;
- drainage;
- water;
- outdoor spaces; and connectivity

Climate change resilience

The location and design of new buildings should minimise vulnerability to climate change. It is important that decisions made now should not constrain future options to adapt or enhance vulnerability to climate change.

Acting early may mean that resilience to climate change can be incorporated into the planning and construction process at a relatively low cost. In the longer term, building climate resilience into new property will avoid unnecessary climate-related damages and costs, as the impacts of climate change begin to be felt more intensely. This may mean leaving some space without buildings, such as providing increased run-off storage now.

Planners

Planners have an important role in ensuring that new developments take account of climate change adaptation, for example in the Local Development Frameworks being produced by Local Planning Authorities.

Planning Policy Statement 1: Delivering Sustainable Development[25] (PPS1) references the need to adapt to climate change, including a Key Principle (paragraph 13ii) that "Regional planning bodies and local planning authorities should ensure that development plans contribute to global sustainability by addressing the causes and potential impacts of climate change through policies which…take climate change impacts into account in the location and design of development".

Planning Policy Guidance 25: Development and Flood Risk[26] (PPG25) sets out Government policy on the approach which should be adopted by planners and developers in order to reduce current and future damage to property and loss of life and contains guidance on how flood risk issues should be addressed. Government has decided to replace PPG25 with a new Planning Policy Statement and hope to consult on a draft later in 2005[27].

You should also note that flood risk assessments may also be required outside obvious flood plains. Further guidance is also available from the Environment Agency website[28].

The first Government response to the autumn 2004 *Making space for water* consultation in March 2005[29] emphasises the need for local planning authorities to follow the existing guidance to require site specific Flood Risk Assessments for development in areas at risk of flooding.

In addition, Government will include questions in the Standard Planning Application form to determine whether a Flood Risk Assessment is required. This will back up the fact that where an application is proposed in an area at risk of flooding, the Environment Agency will be minded to object to applications not accompanied by a Flood Risk Assessment (or not cross referenced to a Strategic Flood Risk Assessment).

ODPM's *Planning response to climate change*[30] provides guidance for Regional Planning Bodies and local planning authorities on planning for climate change adaptation. Planning issues that will be impacted by climate change, and for which specific guidance is provided include:

Infrastructure	Flooding	Water resources
Biodiversity	Land and landscape	Economic development
Tourism	Transport	Waste and resources
Energy systems	Built environment	

The Environment Agency and the South East of England Regional Assembly, as part of the ESPACE[31] project, have produced *A toolkit for delivering water management climate change adaptation through the planning system*[32] which is aimed at planning professionals and focuses on three key areas of climate change adaptation for "water-related" impacts and how these measures can be delivered through the planning system:

- Adapting to minimise the risk of flooding on new development;
- Adapting to respond to water resources and water supply issues; and
- Adapting to respond to water related impacts on built structures (e.g. increased weathering of facades).

Checklist

This Checklist is principally about new developments in terms of design. It is recognised that implementing these suggested approaches could be carried out in a staged way. For example, it is important that if Sustainable Drainage Systems or SUDS[33] are needed, they should be designed and built in at the outset of a development.

Similarly, consideration of site location and layout is vital at the outset, while adaptation actions, such as those associated with altering the facade of a building, could be implemented at a later date.

The Engineering and Physical Sciences Research Council (EPSRC)/UKCIP *Building Knowledge for a Changing Climate programme*[34] is looking at the impacts of climate change in the following areas: urban drainage; urban environments and planning; energy and telecoms; buildings; transport; built heritage; slope stability; and risk management.

The programme, aimed at planners, designers, architects, engineers and those responsible for infrastructure, should be seen as complementary to this checklist and subsequent guidance.

location

Issues

1. Flooding

The choice of location will affect the risk of flooding of all types. The likelihood of flooding will increase over time due to climate change, including rising sea levels, higher average winter rainfall and more intense rainfall events. Across all the Growth Areas in the South East, annual costs of flooding could increase by 75% (or £55 million) if flooding and climate change are not factored in at the planning stage[35].

Areas currently not at significant risk could become so during the lifetime of developments. This needs to be taken into account in the choice of location, as well as the design of the development. The type of development will affect what level of risk is acceptable. For example, an area that might be suitable for a warehouse might not be suitable for a hospital.

In accordance with PPG25, development in flood risk areas should be avoided where possible. A flood risk assessment should be undertaken to demonstrate that the development is appropriate and that flood risk can be maintained below an acceptable level for the lifetime of the development. A flood risk assessment will also ensure that flood resilient design and construction techniques are adopted.

You should also note that flood risk assessments may also be required outside obvious flood plains. HR Wallingford have produced a helpful bulletin, with links to further information, on guidance on flood risk assessment for new development[36] and the CIRIA guidance *Development and flood risk – guidance for the construction industry*[37] is also very helpful.

The Association of British Insurers (ABI) document *Strategic Planning for Flood Risk in the Growth Areas – Insurance Considerations*[38] sets out the key considerations that should be addressed to minimise flood risk for developments in the Growth Areas, so that insurance may remain readily available for new properties.

The Environment Agency currently produces flood risk maps which can be found at **www.environment-agency.gov.uk/subjects/flood/826674/829803.** Information on the effects of climate change may be available at a local Environment Agency office during 2006. Following the guidance in this checklist will be the best approach since decisions need to be risk based and cannot rely on any one estimate of the effects of climate change.

The Environment Agency has also produced helpful diagrams demonstrating the most appropriate location to site a new development in a non-functional well-defended floodplain. This is replicated in the ABI's *Strategic Planning for Flood Risk in the Growth Areas – Insurance Considerations*[39].

2. Higher temperatures

Higher temperatures will become more frequent, and very cold winters will become increasingly rare. Annual temperatures are likely to rise by the 2050s by 1-2°C and by the 2080s by 2-4.5°C. Daily maximum temperatures of 33°C could occur 10 days per summer by the 2080s. Overall, summers in the 2050s will be 1.5-3.5°C hotter, and as much as 5°C hotter by the 2080s, while winters will become warmer by 1-2°C by the 2050s and by up to 3.5°C by the 2080s.

Due to the urban heat island[40], urban centres can be a lot warmer than the surrounding countryside[41], especially at night. The urban heat island effect currently adds up to a further 5-6°C to summer night temperatures and will intensify in the future. Consequently developers must have regard to the heat island effect on any urban conurbation, in particular, how it will affect buildings and vulnerable groups of occupiers, such as the elderly.

3. Water resources

The availability of adequate water resources for development in the area, water saving and whether further supply measures such as reservoirs are required should have been addressed in the Regional Spatial Development Strategy and in Local Development Framework documents, and by water supply companies.

Climate change will increase the demand for water and reduce supply, particularly in summer. Particular types of development might have unusually high requirements for water, which were not foreseen. The location of development with high demand for water will require special consideration.

4. Subsidence

Particular areas are more at risk from subsidence, for example when built on clay soils. Subsidence is likely to be aggravated by the dry summers brought by climate change and where developments are at risk, they should be designed with suitable foundations to cope with increased subsidence risk.

5. Coastal Erosion

Climate change is likely to increase coastal erosion, erosion of salt marshes and the risk of landslides due to sea-level rise and storm surges. Developers should not necessarily rely on defences to protect the land in all cases and should consider how the coast will change due to climate change over the development's lifetime.

To consider this problem, developers should consult local coastal groups, such as SCOPAC[42] which work to promote sustainable shoreline management.

Developers and their design teams should:

- establish the Environment Agency flood risk designation(s) for the site and ensure that the design of the development accords with it. Check the Environment Agency's Flood Map resource at www.environment-agency.gov.uk/subjects/flood/826674/829803;
- check with the Local Planning Authority to review any strategic flood risk assessments;
- undertake an appropriate flood risk assessment and evaluate the flood risk over the design life of the development. Demonstrate that this is acceptable for the proposed use(s) and, at a minimum, that there will be no overall increase in flood risk (likelihood and negative impact);
- consult the insurance industry guidance *Strategic Planning for Flood Risk in the Growth Areas – Insurance Considerations*[43] about the viability of the development for insurance purposes;
- help reduce the urban heat island[44] effect e.g. by planning green space and using appropriate shade when locating your development; and
- consider the implications of coastal erosion when planning a development.

site layout

Issues

1. Flooding

Development will change the way in which an area is affected by flooding through the placing of buildings, the topography of earthworks and the changes in permeability of surfaces.

The risks of tidal, fluvial and flash flooding must all be considered. In assessing risk, future climate change, including sea level rise and the likely increase in tidal surges and average seasonal and extreme rainfall should be considered. In areas at risk, only floor levels above the expected flood water level should be used for living accommodation and other high occupancy activities.

Space should be left for existing flood defences to be enhanced and for new flood defences to be added in the future.

2. Heat gain

The layout of new development should balance the benefits of minimising heat loss in winter with the risk of excessive solar gain during the summer.

Therefore, site layout should use landform and landscape to benefit from shelter to minimise heat losses in winter and provide adequate shade in summer[45]. For example, lower sun angles in winter allow rays through solar shading and deciduous trees help minimise heat loss but also provide shading in summer.

3. Outdoor spaces

People will also want more access to outdoor natural spaces in the future, to make the most of warmer weather. Again this is more difficult to achieve at higher densities.

Developments should include balconies and roof gardens or green links to nearby greenspaces in higher-density developments where gardens cannot be provided[46].

The provision of outdoor natural spaces also has the added benefit that trees and vegetation can play a part in helping to reduce the urban heat island effect[47], although the implications for subsidence risk will need to be assessed.

4. Subsidence

The foundation design used for new properties will have to allow for the increased risk of subsidence caused by the potential for shrinkage of clay soils.

Some new buildings will require deeper foundations, depending on the ground properties and the proximity, size and species of adjacent trees. However, this does not necessarily mean more expensive buildings in the long-term. For example, climate proofing new buildings in southern England against subsidence may only total £32 million, compared to a possible annual cost of up to £400 million from damage claims if no action is taken[48].

It may also be necessary to site buildings away from some especially large trees.

Suggested techniques:

- Use flood prevention/mitigation techniques including building bunds, designing higher defensive road systems, and landscape features such as wells and ponds.
- Use the ground floor space for flood compatible uses e.g. car parking or raise the ground floor above the likely flood level.
- Reducing the ratio of building height to the spacing between buildings generally has a positive effect on natural ventilation.
- Green roofs can insulate against heat gains, absorb rainfall and provide useable outdoor space as well as improving the external environment.
- Arranging gardens down a slope means that any water can be used several times over, as in many Italian and Spanish gardens.
- Deciduous trees can provide shade in summer, while permitting solar gain in winter when it is useful.
- Build new buildings with foundations between 0.7m and 3.5m deep depending on the site, type of soil and proximity, size and species of adjacent trees.
- Root barriers can help to deal with risks of subsidence from existing mature trees.

Developers and their design teams should:

Ensure that the overall layout and massing of the development:

- does not increase the flood risk and where possible reduces risk;
- minimises solar gain in summer;
- maximises natural ventilation;
- maximises natural vegetation;
- takes account of the increased risk of subsidence; and
- provides homes and other appropriate uses with a private outdoor space wherever possible.

buildings

A. Structure

Issues

1. Wind speeds

The effect of climate change on wind speeds is uncertain. Speeds may be higher in the future, and thus structures, especially tall ones, may need to be stronger, or able to be strengthened.

2. Soils

As rainfall becomes more seasonal, certain types of soils will experience more extreme cycles of wetting and drying. Trees, which are valuable for shade, windbreaks and heat and water absorption, may aggravate this in certain soils.

3. Higher temperatures

Higher temperatures mean that mechanical ventilation and cooling may need to be added to buildings in the future, even if not installed initially. Developers should first consider using alternative methods to traditional air conditioning so that comfortable temperatures can be maintained while minimising additional greenhouse gas emissions. If this is not viable, mechanical ventilation and cooling may be necessary.

4. Heat loss and gain

The thermal mass of the building is important in how it responds to heat losses and gains. Heavy construction can help to regulate temperatures, but lightweight (e.g. pre-fabricated) construction can heat and cool quicker. The choice of appropriate thermal mass will depend to some extent upon expected use and occupancy.

Suggested techniques:

- Larger floor-to-ceiling heights will generally help in allowing later addition of any cooling mechanisms. In addition, higher ceilings also trap hot air above the heads of people using the room, making the room feel cooler.
- Alternatively chillable beams could be considered from the outset.

Developers and their design teams should:

Demonstrate that the structure of the development is:

- strong enough or able to be strengthened if wind speeds increase in the future due to climate change;
- strong enough to avoid movement due to expected future levels of subsidence and heave;
- able to incorporate appropriate ventilation and cooling techniques/mechanisms; and
- of an appropriate thermal mass for the intended use and occupancy.

B. Physical envelope of structures

Issues

1. Rainfall

Climate change is likely to result in more intense rainfall, especially in winter, and therefore roof and local drainage systems need to adapt to cope with it. The risk of flash flooding will increase, while at the same time Building Regulations now require level thresholds for disabled access. Both of these increase the risk of ingress of water at ground level. The design response should depend on the overall level of risk.

2. Heat gain

The envelope should be designed to reduce heat gain in summer, in order to make it easier to maintain comfortable temperatures inside the building, but passive heat in winter is still desirable.

3. Air Tightness

Under Part L2 of the Building Regulations[49], there is a responsibility to ensure that new buildings are air tight.

The overall envelope of the building needs to be sufficiently tight to avoid infiltration from increased wind and temperatures while ensuring there is adequate controllable ventilation.

4. Wind speed

The possibility of stronger winds also needs consideration. Loose items such as roof tiles may need to withstand higher winds, while rain may be driven harder against walls and roofs. The design of openings and the choice of materials need to allow for this.

Suggested techniques:

- The size of guttering and down pipes could be increased.
- Reduce the use of secret and parapet gutters and internal downpipes.
- Alternatively water could be thrown clear of buildings using spouts and gargoyles, and storm drains on the ground.
- In areas of low flood risk, the size of up-stands could be increased.
- Heat gain could be reduced by more thermally reflective surfaces (high albedo), especially roofs.
- In addition, openings facing the sun could be shaded from summer sun, for example by trees, recessed or given overhangs, blinds or shutters, and reflective glass.
- Greenery, such as vertical gardens, climbers and green roofs on the building envelope can help ameliorate the heat gains in summer[50].
- Insulation helps to keep heat out in summer as well as keeping heat in winter.

Developers and their design teams should:

Demonstrate the envelope of buildings is designed so that:

- drainage systems and entrance thresholds can cope with more intense rainfall;
- there are opportunities for incorporating green roofs or walls;
- the exterior of buildings reduces heat gain in the summer;
- the overall envelope avoids infiltration from increased wind and temperatures; and
- cladding materials are able to cope with higher wind speeds.

C. Materials

Issues

Materials will be affected by climate change. For example, materials like brick and concrete once warmed up, stay warm for a long time, while light materials such as wood are warmed up quickly, but also cool down quickly. Consequently, walls built with heavy materials retain heat and let it out slowly.

It is important that the structure should have the optimum thermal mass to maintain a comfortable internal environment with the least use of energy. For high occupancy uses such as houses and hospitals, this usually means high thermal mass.

The characteristics of materials may also change with changes in temperature and humidity. Some considerations are listed below.

Concrete:	*strength affected by curing at higher temperatures*
Lime mortar, stone:	*affected by increased CO2 and driving rain*
Plastics:	*affected by increased UV*
Bricks:	*strength affected by change in moisture content*
MDF/Chipboard:	*not to be used where flooding is expected*
Roofing felt:	*increased UV is likely to accelerate degradation*

Some developers are already using different materials to build new buildings. For example the MAKE designed Kite building in Leeds which replaced much of the glass with aluminium cladding, backed by a layer of insulation that deflects heat in summer and retains warmth in winter[51].

Developers and their design teams should:

- ensure the materials specified will perform adequately in the climate throughout the lifetime of the development; and
- ensure the construction methods to be used are suitable for the weather conditions at the time of construction.

South East Climate Change Partnership
A partnership of the public, private and voluntary sectors

Sustainable Development Round Table for the East of England

LONDON climate change PARTNERSHIP

checklist for adapting to climate change

This checklist summarises the key issues that need to be considered when climate proofing your development against the impacts of climate change, and is followed by more detailed guidance on each aspect.

	✔
Location	
Establish the Environment Agency flood risk designation(s) for the site and ensure that the design of the development accords with it. Check the Environment Agency's Flood Map resource at **www.environment-agency.gov.uk/subjects/flood/826674/829803**	☐
Check with the Local Planning Authority to review any strategic flood risk assessments.	☐
Undertake an appropriate flood risk assessment and evaluate the flood risk over the design life of the development. Demonstrate that this is acceptable for the proposed use(s) and, at a minimum, that there will be no overall increase in flood risk (likelihood and negative impact).	☐
Consult the insurance industry guidance *Strategic Planning for Flood Risk in the Growth Areas – Insurance Considerations*[i] about the viability of the development for insurance purposes.	☐
Help reduce the urban heat island[ii] effect e.g. by planning green space and using appropriate shade when locating your development.	☐
Consider the implications of coastal erosion when planning a development.	☐
Site layout	
Ensure the overall layout and massing of the development:	
• does not increase the flood risk and where possible reduces risk;	☐
• minimises solar gain in summer;	☐
• maximises natural ventilation;	☐
• maximises natural vegetation;	☐
• takes account of the increased risk of subsidence;	☐
• provides homes and other appropriate uses with a private outdoor space wherever possible.	☐

Buildings

A: Structure

Demonstrate the structure is: ✔

- strong enough or able to be strengthened if wind speeds increase in the future due to climate change; ☐
- strong enough to avoid movement due to expected future levels of subsidence and heave; ☐
- able to incorporate appropriate ventilation and cooling techniques/ mechanisms; ☐
- of an appropriate thermal mass for the intended use and occupancy. ☐

B: Physical envelope of structures

Demonstrate the envelope of the building is designed so that:

- drainage systems and entrance thresholds can cope with more intense rainfall; ☐
- there are opportunities for incorporating green roofs or walls; ☐
- the exterior of buildings reduces heat gain in summer; ☐
- the overall envelope avoids infiltration from increased wind and temperatures; ☐
- cladding materials are able to cope with higher wind speeds. ☐

C: Materials

Ensure the materials specified will perform adequately in the climate throughout the lifetime of the development. ☐

Ensure the construction methods to be used are suitable for the weather conditions at the time of construction. ☐

Ventilation and cooling

Ensure that ventilation brings clean pollution-free air into the building and does not compromise noise levels or security. ☐

Demonstrate the building has or is capable of having installed a ventilation system which will deliver comfortable temperatures (i.e. exceeding 28°C for less than 1% of the time and exceeding 25°C for less than 5% of the time) for the expected climate throughout the design life of the development. ☐

Cooling and ventilation systems, where necessary, should be designed to use as little carbon-based energy as possible by utilising renewable energies and being as energy efficient as practicable. ☐

Drainage

	✔
Carry out a site survey to determine which SUDS techniques will be appropriate for use on the site. For example, ground conditions will determine the suitability of infiltration systems. Consider rainwater harvesting, green roof systems and opportunities for permeable paving if soil permeability is low.	☐
Ensure, in consultation with the Environment Agency, that the requirements of the Groundwater Regulations are complied with (you should though note that shallow, extensive infiltration systems will minimise risks to groundwater).	☐
Demonstrate consideration is given to future maintenance requirements of SUDS including the need, where necessary, for the removal of silt which will be treated as a controlled waste, and that space requirements for this purpose are allowed for in the design.	☐
Ensure that responsibility for maintaining SUDS is clear at the planning application stage[iii].	☐
Consider using permeable paving anywhere that loadings will not cause structural failure. In practice, all pavements, driveways, footpaths, car parking areas and access roads could have permeable surfaces.	☐
In developing the drainage plan for the site, ensure that the design standard takes account of climate change and that carriageways, paths and other features of the site are designed to convey this excess flow safely.	☐

Water

Estimate the net water consumption of the development under normal use and under water conservation conditions (i.e. during a drought), both initially and during the lifetime of the development in consultation with the relevant water company.	☐
Discuss existing sewerage infrastructure and sewage treatment capacity with the local sewerage provider.	☐
Regarding water use, for housing, achieve a target of 30 cubic metres per person per year under typical use and for offices, 1.05 cubic metres per person per year.	☐
Minimise water use in buildings, consider the use of rainwater collection/re-use systems and consider the environmental impact (in terms of water consumption) of products, materials and building methods.	☐

Outdoor spaces

	✔
Incorporate an appropriate range of public and private outdoor spaces in developments, with appropriate shade, vegetation and water features.	☐
Ensure the design of surfaces take account of more intense use, permeability, potential for causing dust and for soil erosion.	☐
Ensure the selection of vegetation with longer life (over 10 years) takes account of future climate change.	☐
Ensure water features have minimal net water use.	☐
Provide a rainwater collection system/grey-water recycling for watering gardens and landscaped areas.	☐
Ensure there are arrangements for storing waste which allow for separation and prevent excessive smell in hotter conditions.	☐

Connectivity

A: Infrastructure Resilience

Ensure there are safe access routes above the likely flood levels and the routes are clearly marked (e.g. by a series of poles) during the design life of the development.	☐
Negotiate with utilities and others over the resilience of services and infrastructure to the development.	☐

B: Impact on Neighbours

Identify immediate neighbour impacts as well as the cumulative impacts and the increased demands on services.	☐

i Strategic Planning for Flood Risk in the Growth Areas – Insurance Considerations, Association of British Insurers July 2004, www.abi.org.uk/display/File/Child/554/Strategic_Planning_for_Flood_Risk_thamesgateway.pdf

ii Microclimates, The Met Office, www.metoffice.com/education/secondary/students/microclimates.html

iii Interim Code of Practice for SUDS, National SUDS Working Group 2004, www.environment-agency.gov.uk/business/444304/502508/464710/465036/466851/?land=_e

ventilation and cooling

Issues

1. Ventilation

Buildings should be designed to allow and make best use of natural ventilation and that the internal layout supports the building in coping with ventilation and cooling. Ventilation should be designed so as not to compromise security, ambient noise levels and air quality. The levels of pollutants will be affected by more frequent summer temperature inversions expected in the future, while the amount of dust is likely to increase in summers, as they become hotter and drier.

The cooling potential of ventilated air falls with rising temperatures caused by climate change. On the warmest days, natural ventilation may even have the effect of raising internal temperatures. This is especially true in urban centres such as London or Bristol, due to the urban heat island effect.

Buildings should be designed to be able to maintain comfortable internal temperatures during heat waves, which are likely to become more frequent and more intense over their design life. One way to do this is to design in at the outset the use of heat exchange/groundwater cooling.

2. Cooling systems

Providing summertime thermal comfort does not mean you have to use air conditioning systems. Passive design, such as solar shading, thermal mass and the proper use of ventilation, will be instrumental in the way buildings adapt to climate change impacts.

Rather than use air conditioning, it might be better to consider adopting some building elements like those found in the Mediterranean, for example, using Mediterranean style shutters and verandas to keep cool.

Where air conditioning cooling systems are used, it should be recognised that they will dump heat somewhere. This heat has the potential to cause problems for the occupants of other developments, people in public spaces and the environment in general. Heat from cooling systems should be "dumped" where it will not cause a problem for others or the environment.

It might also be possible to use this waste heat as an energy source, especially as the electricity supply network, in the future, is likely to be most stretched during hot spells, as conventional air conditioning systems are used more extensively to cool existing buildings.

If possible, cooling systems should be powered by local renewable energy sources. For example, solar energy is most available when cooling is most needed, and local energy supplies will increase both the development's and the region's resilience to power shortages and outages.

Suggested techniques:

Reduce solar gains in summer by using shading devices such as blinds and external shading.

Design secure ventilation so that users can close ventilation easily in high temperatures and open in cooler temperatures such as at night.

Traditional southern European buildings are designed for a warmer climate, using techniques not often used in the UK. These include:

- use surface treatments which reflect heat in summer, such as light coloured paints;
- keeping the interior air cool by screening out the sun using shelters and shades;
- regulating ventilation through the day and night in an intelligent way to maximise its cooling potential; and
- building with materials with high "thermal mass", such as concrete, stone and tiled floors, that can soak up unwanted heat during the day.

Cooling technologies which could be considered include:

- free cooling;
- slab cooling;
- night cooling;
- evaporative cooling;
- chilled ceilings with displacement ventilation; and
- ground cooling.

Ground water cooling should also be considered, although recognising that there are limitations to groundwater capacity.

Systems should be as energy efficient as practicable and renewable sources of energy should be used where possible, especially solar energy which is most available when cooling systems are most needed.

The concept of trigeneration (such as district cooling and combined heat and power – CHP) should be considered as an alternative to using traditional energy sources

Where active cooling systems may be needed, space should be provided at the outset, so that they can be added later when required.

Developers and their design teams should:

- ensure that arrangements for ventilation brings clean pollution-free air into the building and does not compromise noise levels or security;
- demonstrate the building has or is capable of having installed a cooling and ventilation system which will deliver comfortable temperatures (i.e. exceeding 28°C for less than 1% of the time and exceeding 25°C for less than 5% of the time) for the expected climate throughout the design life of the development; and
- cooling and ventilation systems, where necessary, should be designed to use as little carbon-based energy as possible by utilising renewable energies and being as energy efficient as practicable.

drainage

Issues

1. Increased surface run-off

Development may reduce surface permeability by replacing permeable ground with roofed buildings and impervious paved areas. This reduces the amount of water infiltrating into the ground and increases surface run-off. Climate change affects the risk of flooding primarily because more intense rainfall is expected. In addition, rising sea levels can have an impact by reducing the ability of rivers to drain floodwaters away.

2. Flash floods

Flash floods in urban areas may include inundation of the sewerage system which can result in sewer flooding where sewage (foul water) can enter buildings. Building Regulations now require downstairs toilets and this can increase the risk of foul water flooding, and on contaminated sites, flooding can release contaminants in the ground.

In London, and other areas such as Portsmouth, consideration needs to be given to the problems associated with combined foul and surface sewers systems.

Increased flow rates in waterways can also cause erosion and damage stream and streamside habitats. Water quality issues are also important because pollutants from built up areas are washed into rivers or groundwater, harming fish and wildlife and the quality of water available for treatment into potable water.

3. Traditional drainage system

The traditional approach to drainage has been to install underground pipe systems designed to convey water as quickly as possible away from the development and prevent flooding locally. However, this increases the speed of run-off and can change the flooding regime of the catchment. Built development can lead to problems elsewhere within the river catchment, particularly flooding and pollution further downstream in the catchment.

Suggested techniques:

Sustainable Drainage Systems

Sustainable Drainage Systems (SUDS) are an approach to drainage that should be considered on all sites, for example, Green Roofs are considered a SUDS technique.

SUDS mimic natural drainage patterns (e.g. by mimicking greenfield run-off rates for development in areas of flood risk) and can attenuate surface water run-off, encourage recharge of groundwater, provide significant amenity and wildlife enhancements, and by employing pollutant trapping and degradation processes, SUDS can protect water quality.

The SUDS approach includes:

- preventive measures like good housekeeping, rainwater harvesting, green roofs and water butts;
- filter strips and swales - vegetated landscape features with smooth surfaces and a gentle downhill gradient to drain water evenly off impermeable surfaces;
- infiltration devices like soakaways which allow water to drain directly into the ground;
- storm water tanks if necessary;
- permeable and porous pavements;
- basins, reed beds and ponds designed to hold water when it rains.

In the use of SUDS it is important to recognise that their primary purpose as drains is for the conveyance of water away from buildings. The secondary use of SUDS as amenity and/or wildlife habitats must not compromise the ability to maintain them effectively to ensure their drainage characteristics are preserved. It is therefore not desirable for SUDS to be subject to statutory wildlife designations.

To help further, Woking Borough Council have produced a *Good Practice Guide to Sustainable Drainage Systems*[52], and the Environment Agency's SUDS webpage http://www.environment-agency.gov.uk/suds is also a helpful guide.

The most relevant information though is from the National SUDS Working Group who have produced an interim code of practice[53].

Green Roofs

Green roofs are an important SUDS technique. A group of industry experts concluded that green roofs are best able to cope with the expected impacts of climate change[54]. Further information can be found via the joint British Council for Offices and Corporation of London *Green Roofs Research Advice Note*[55], which includes an introduction to the concept of the green roof as well as further technical information, as well as the recent Mayor of London publication *Living Roofs: Promoting green roofs, roof terraces and roof gardens across London*[56]

Developers and their design teams should:

- carry out a site survey to determine which SUDS techniques will be appropriate for use on the site. For example, ground conditions will determine the suitability of infiltration systems. Consider rainwater harvesting, green roof systems and opportunities for permeable paving if soil permeability is low;
- ensure, in consultation with the Environment Agency, that the requirements of the Groundwater Regulations are complied with (you should though note that shallow, extensive infiltration systems will minimise risks to groundwater);
- demonstrate consideration is given to future maintenance requirements of SUDS including the need, where necessary, for the removal of silt which will be treated as a controlled waste, and that space requirements for this purpose are allowed for in the design.
- ensure that responsibility for maintaining SUDS is clear at the planning application stage[57];
- consider using permeable paving anywhere that loadings will not cause structural failure. In practice, all pavements, driveways, footpaths, car parking areas and access roads could have permeable surfaces; and
- in developing the drainage plan for the site, ensure that the design standard takes account of climate change and that carriageways, paths and other features of the site are designed to convey this excess flow safely.

water

Issues

1. Water Services

Water is a precious resource and due to climate change, the availability of water resources will become more restricted, while the demand increases due to hotter summers, population and household growth and increased levels of consumer durables like dishwashers. There will also be more demand for water for bathing as well as for gardens and parks.

Initiatives such as "Water cycle management for New Development" or WaND[58], should also be consulted for the provision of tools and guidelines for project design, implementation and management. Much of the cost of water efficient devices can often be included in the sale price of new homes and will deliver longer term benefits to the home owner.

Developers need to identify early that the existing sewerage infrastructure and sewage treatment capacity is able to accommodate the new development by talking to the sewerage providers as early as possible.

2. Water Efficiency

It is important to minimise use of water from the mains in new buildings. In order to reduce internal water consumption, new homes should be built to the BREEAM Ecohomes[59] standard of "Excellent" with specific reference to water use. This includes the fitting of water efficient toilets, taps, showers, dishwashers and washing machines, as well as the installation of water re-use systems. External water use also needs to be reduced by encouraging the recycling of rainwater for irrigation purposes, car washing etc.

In 2003, the Government commissioned an investigation into the cost effectiveness of water efficient products in households. The study found that a significant level of water efficiency can be achieved at little or no over-cost to construction[60].

In addition, saving water can also be promoted by installing water meters; water is as much a limited resource as electricity and natural gas, both of which, in existing properties, are generally metered, although all new developments and buildings are now compulsory metered.

3. Rainwater Collection and Grey Water Recycling

It is important that homes become increasingly self reliant in collecting their own rainwater for grey water recycling for toilet use and garden watering. Such systems will reduce the burden on mains water supplies, in particular during the summer months.

a) Rainwater Collection Systems

Rainwater can be used for irrigation purposes, car washing or toilet flushing and is beneficial for two reasons:
(i) it reduces household water demand and eases pressure on the mains water supply, reducing upstream energy and environmental costs
(ii) it helps to reduce the risk of flooding during storms by storing rainwater and buffering run-off before it reaches the drains

b) Grey Water Recycling

Domestic water from baths, showers and washbasins can be re-used for toilet flushing but requires filtration and disinfection. The benefits include reducing household water demand and eases pressure on the mains water supply, reducing upstream energy and environmental costs.

Suggested techniques:

- Install water meters in existing properties which are re-developed (compulsory for new development/buildings).
- Install dual-flush and low-flush toilets. This can save more than half the water used for flushing toilets and cut household water use by up to 20%.
- Install waterless urinals.
- Install water efficient showers and smaller baths.
- Use water-efficient devices, such as "A-rated" washing machines and dishwashers.
- Install spray taps.
- Minimise amount of piping between boiler/hot water tank and tap, to reduce the need to "run" the water.
- Utilise rainwater harvesting, to flush toilets, clean clothes and water the garden.
- Install leak detection systems for major supplies.
- Use water re-use systems, such as rainwater collection or grey-water recycling.
- Provide green roofs including terraces.

Developers and their design teams should:

- estimate the net water consumption of the development under normal use and under water conservation conditions (i.e. during a drought), both initially and during the lifetime of the development with the relevant water company;
- discuss existing sewerage infrastructure and sewage treatment capacity with the local sewerage provider;
- regarding water use, for housing, achieve a target of 30 cubic metres per person per year under typical use and for offices, 1.05 cubic metres per person per year; and
- minimise water use in buildings, consider the use of rainwater collection/re-use systems and consider the environmental impact (in terms of water consumption) of products, materials and building methods.

outdoor spaces

Due to higher temperatures caused by climate change, especially in urban areas affected by the urban heat island, you should ensure that the development includes provision for greenspace and tree cover which can help ameliorate the extremes of the urban microclimate.

Issues

1. Demand for outdoor spaces

With generally warmer weather throughout the year, there is likely to be more demand for outdoor spaces (both public and private) of all types, including places to play, eat and drink outside.

What spaces there are will also be used more intensively. Lifestyles are likely to change; it is not possible to predict these exactly, but observing how people behave now in places with warmer climates, such as parts of the Mediterranean, may give us a clue.

2. Type of surface

As outdoor spaces are used more, there will be a need for more hard wearing natural surfaces. Landscaping that mimics Mediterranean marquis or lowland heathland for example can be hard wearing and appropriate to an urban environment.

It is important that surfaces are permeable to avoid aggravating run-off. Surfaces should also be chosen to avoid creating dust. Outdoor spaces can and should be used to detain floodwaters (see section on drainage). They should also be planned to avoid soil erosion.

3. Shade

It is important to provide natural shade in outdoor spaces. As people spend more time outside, their exposure to solar radiation which causes skin cancer will increase. This is in addition to providing shade for buildings to reduce solar gain in summer.

4. Soils

Changes in temperature and water balance will impact on soil, however, improved management of soil in the built environment should also help adaptation to climate change, e.g. increases in water storage reducing flooding and subsidence. Careful planning of green spaces can mitigate the loss of soil functions in developed areas.

For example, it is important to ensure that the increased vegetation (not just trees) required for the SUDS and to provide shade is carefully chosen and managed to ensure that this does not contribute to subsidence problems on clay soils.

5. Vegetation

Vegetation will need to be appropriate to the climate, as it changes. Alternatives to traditional lawns may be needed as the seasonality of rainfall together with hotter summers may make it difficult to maintain lawns, especially given the more limited water availability.

Short-lived plants can be replaced over time, trees will need to be selected very carefully, given their expected potential to last between 50 and 120 years.

Climate change could affect longevity and should therefore impact on long-term planning. For example, beech trees in parts of East Anglia and southern England have already experienced limited dieback during recent droughts and such problems are likely to occur with increasing frequency. However, species such as Corsican Pine are predicted to benefit most from climate change.

The Royal Horticultural Society provides extensive advice on trees, gardens, woodland in a changing climate[61].

In addition, the distribution of various species of wild plants and animals are likely to change due to climate change. Outside spaces should provide habitats to accommodate predicted changes in wildlife populations.

6. Water features

Water features such as ponds and fountains can help to make outdoor spaces more pleasant and provide cooling. But care must be taken over the demand for water these create; they should be run from local sources of water wherever possible, such as harvested rainwater, and the water should have a subsequent use. Net use should be confined to evaporative and other minor losses.

7. Waste

In the warmer climate, decaying waste will smell more and issues may arise with infestation. Consideration is needed on where to store waste so that it does not detract from quality of life. This needs to be done together with consideration of separation of waste to enable effective recycling.

Suggested techniques:

- Consider gravelled or paved areas rather than lawns, so long as a high proportion of permeable surface can be provided.
- Provide deciduous vegetation to provide summer shade, but taking care that foundations of nearby buildings are sufficient to prevent movement.
- Introduce soil management strategies to mitigate against flooding and subsidence.
- Water running through water features should be recycled or reused, for example for watering vegetation rather than putting into drains.
- Use solar energy to power pumps to recirculate water in water features.
- Provide wormeries for compostable waste (although this is only applicable at the domestic scale, large scale composters could be considered for business/industrial operations).

Developers and their design teams should:

- incorporate an appropriate range of public and private outdoor spaces in developments, with appropriate shade, vegetation and water features.
- ensure the design of surfaces take account of more intense use, permeability, potential for causing dust and for soil erosion;
- ensure the selection of vegetation with longer life (over 10 years) takes account of future climate change;
- ensure water features have minimal net water use;
- provide a rain-water collection system/grey-water recycling for watering gardens and landscaped areas; and
- ensure there are arrangements for storing waste which allow for separation and prevent excessive smell in hotter conditions.

connectivity

A. Infrastructure Resilience Issues

Climate change will affect a development's infrastructure, it is therefore important to liaise closely with the utility companies when planning a development. For example, areas liable to flood risk will require better protection for gas mains and electricity and telephone cables. In addition, the positioning of an electricity sub-station will need to be carefully considered if the area is to face an increased risk of flooding.

Connections to and from the development may also be vulnerable to climate change impacts. Underground pipes and cables will be more vulnerable to damage from the wetting/drying cycle of the soil, unless this is factored into their design. Bridges, tunnels and other earthworks will also be affected by the wetting/drying cycle of the soil, geology, slope profile and the groundwater regime. In addition bridge piers may be subject to increased scouring.

Pylons carrying electricity and telecommunications cables may be vulnerable to higher winds in the future. Including local renewable energy sources will enhance the resilience of the development to power shortages and outages.

Suggested techniques:

- Earthworks at risk can be treated by adding lime to clay soils, building retaining structures at the toe of the slope and/or planting deep-rooted trees, as appropriate.
- Incorporate local renewable energy sources.

Developers and their design teams should:

- ensure there are safe access routes above the likely flood levels and the routes are clearly marked (e.g. by a series of poles) during the design life of the development; and
- negotiate with utilities and others over the resilience of services and infrastructure to the development.

B. Impact on Neighbours

Issues

The development will have an impact beyond its own borders, most obviously on its immediate neighbours. Any development in an area will affect the ability of other developments, existing or future, to adapt to climate change.

Issues include:

- increased surface water run-off;
- causing changes to the flood or groundwater regimes elsewhere, for example lower down a river;
- increased pressure for new or enhanced flood or coastal defence measures, e.g. land raising to elevate a site above a flood level, but then reducing the flood storage capacity, leading to possible flooding of areas that previously were not at flood risk;
- provision of wind protection, ventilation and shade;
- fragmentation and vulnerability of habitats;
- increased land instability;
- service infrastructure: water, electricity, drainage.

It is therefore important that developers work with neighbouring developments (either already in existence or being developed/planned) to identify immediate the impacts and try to mitigate against any adverse impacts that may affect the long-term sustainability of developments.

Developers and their design teams should:

- identify immediate neighbour impacts as well as the cumulative impacts and the increased demands on services.

footnotes

1 *The Three Regions Climate Change Group* is made up of representatives from the East of England's Sustainable Development Roundtable, London Climate Change Partnership and the South East Climate Change Partnership.

2 Throughout the document there is reference to developers and their design teams. Please note that this is only to avoid repetition and design teams should be taken to include the wider development community.

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annex A: glossary

Climate change
Climate change, according to the UNFCCC, is a change in climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

Corporate, social reporting (CSR)
CSR is about how a business takes account of its economic, social and environmental impacts in the way it operates – maximising the benefits and minimising the downsides.

Department for Environment, Food and Rural Affairs (Defra)
Defra works for the essentials of life – food, air, land, water, people and animals. Its remit is the pursuit of sustainable development – weaving together economic, social and environmental concerns. It is the lead Government department responsible for climate change.

Energy efficiency
Making the best or most efficient use of energy in order to achieve a given output of goods or services, of comfort and convenience.

Flooding
There are more than 2 million homes at risk from coastal or inland flooding and around 400,000 homes at very high risk of flooding. In the long term, the situation could worsen. Climate change will increase winter rainfall, the frequency of heavy rainfall and sea levels and storm surge heights.

Greenhouse gas effect/"enhanced" greenhouse effect
The greenhouse effect is the effect produced as greenhouse gases allow incoming solar radiation to pass through the Earth's atmosphere, but prevent most of the outgoing infrared radiation from the surface and lower atmosphere from escaping into outer space. This process occurs naturally and has kept the Earth's temperature about 30°C warmer than it otherwise would be.

However, the natural greenhouse effect has been enhanced by increased emissions of greenhouse gases due to human activity, which are disturbing the way the climate maintains the balance between incoming and outgoing energy. As a result, the climate will have to adjust to get rid of the extra energy; namely temperatures will increase and weather patterns change.

Intergovernmental Panel on Climate Change (IPCC)
The IPCC was established by the United Nations Environmental Programme and the World Meteorological Organisations in 1988 to assess the scientific, technical and socio-economic information relevant for the understanding of human induced climate change, its potential impacts and options for mitigation and adaptation.

Kyoto Protocol
The Kyoto Protocol sets out legally binding emissions targets for industrialised countries with the aim of a total cut of these countries' emissions by 5.2% from 1990 levels by 2012. The Protocol entered into force on 16 February 2005.

Local development framework (LDF)
LDF is the term for the portfolio of local development documents which will comprise the spatial planning strategy for a local planning authority's area. The LDF will also include the statement of community involvement, the local development scheme and the annual monitoring report.

Planning Policy Guidance 25: Development and Flood Risk (PPG25)
PPG25 explains how flood risk should be considered at all stages of the planning and development process in order to reduce future damage to property and loss of life. It sets out the importance of managing and reducing flood risk in the land use planning process, to act on a precautionary basis and to take account of climate change.

Regional Spatial Strategy (RSS)
The RSS should provide a broad development strategy for a region for a 15-20 year period. The RSS provides a spatial framework to inform the preparation of LDFs, Local Transport Plans and regional and sub regional strategies and programmes that have a bearing on land use activities. The RSS should also take account of those strategies and programmes as they evolve.

Storm surges
A storm surge is primarily caused by the wind pushing the sea towards the coast, but can also be coupled with low air pressure. Storm surges are huge elevations in sea level which strike unpredictably during the winter months.

Strategic flood risk assessment (SFRA)
A SFRA provides a detailed and robust assessment of the extent and nature of the risk of flooding to a specific area and its implications for land use planning.

Sustainable development
A model of development founded on the idea that society, the natural environment and the economy depend on each other and are equally important. Normally defined as "Meeting the needs of the present generation without compromising the ability of future generations to meet their own needs" – World Commission on Environment and Development (the Brundtland Commission), taken from the report Our Common Future (Oxford: Oxford University Press, 1987)

Sustainable drainage systems (SUDS)
SUDS offer an alternative approach to drainage in developed areas, taking account of the quantity and quality of runoff and the amenity value of surface water in the urban environment. SUDS aim to reduce the impact of developments by mimicking natural processes of infiltration of water into the soil and underground rocks.

Three Regions Climate Change Group
The Three Regions Climate Change Group is made up of representatives from the East of England's Sustainable Development Roundtable, London Climate Change Partnership and the South East Climate Change Partnership.

UK Climate Impacts Programme (UKCIP)
UKCIP helps organisations assess how they might be affected by climate change, so they can prepare for its impact.

United Nations Framework Convention on Climate Change (UNFCCC)
The UNFCCC defines a global framework for addressing climate change and requires industrialised countries to take the lead in modifying their long term emission trends.

The Convention sets an "ultimate objective" of stabilising "greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system".

Urban heat island

The term urban heat island is used to describe the dome of warm air that frequently builds up over towns and cities. The precise nature of the heat island varies from urban area and it depends on the presence of large areas of open space, rivers, the distribution of industries and the density and height of buildings. In general, the temperatures are highest in the central areas and gradually decline towards the suburbs.

annex B: further information

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annex C: website addresses

ARUP
Arup is a professional firm providing technical solutions.
www.arup.com

Association of British Insurers (ABI)
The ABI represents the collective interests of the UK's insurance industry.
www.abi.org.uk

Avoiding Dangerous Climate Change, Exeter Conference
Aim of the conference was to advance scientific understanding of and encourage international scientific debate on the long term implications of climate change, relevance of stabilisation goals, options to reach goals; and encourage research on these issues.
www.stabilisation2005.com

BRANCH Project
The BRANCH project aims to develop and advocate spatial planning mechanisms to allow for the adaptation of biodiversity to a changing climate in North West Europe.
www.eci.ox.ac.uk/biodiversity/branch.html

Building Research Establishment (BRE)
BRE is committed to helping the UK's environment industries to be the best.
www.bre.co.uk

CABE
CABE works to achieve a higher quality of life for people and communities across England, with particular concern for those living in deprived areas.
www.cabe.org.uk

Carbon Disclosure Project
The Carbon Disclosure Project requesting information from the world's 500 largest companies. The responses received are available on this site.
www.cdproject.net

Carbon Trust
Helps businesses and the public sector to cut carbon emissions.
www.thecarbontrust.co.uk

Chartered Institution of Building Services Engineers (CIBSE)
CIBSE is an international body which represents and provides services to the building services profession.
www.cibse.org

CIRIA
CIRIA is a leading provider of performance improvement products and services in the construction and related industries.
www.ciria.org

Climateprediction.net
Climateprediction.net is the largest experiment to try and produce a forecast of the climate in the 21st century.
www.climateprediction.net

Climatic Research Unit
The Climatic Research Unit is widely recognised as one of the world's leading institutions concerned with the study of natural and anthropogenic climate change.
www.cru.uea.ac.uk

Department for Environment, Food and Rural Affairs (Defra)
Provides information on government policy on climate change.
www.defra.gov.uk/environment/climatechange/index.htm

Department of Trade and Industry
The Climate Change Projects Office at DTI assists UK businesses who wish to pursue opportunities arising from the Kyoto Protocol.
www.dti.gov.uk/ccpo/

East of England Sustainable Development Roundtable (SDRT)
The SDRT for the East of England works for the promotion of Sustainable Development principles.
www.sustainability-east.com

East Midlands Climate Change Steering Group
www.emra.gov.uk/s_d_briefings/climatechange.asp

Energy Saving Trust
One of the UK's leading organizations tasked with sustainable energy solutions in the home and in transport.
www.est.org.uk

Engineering and Physical Sciences Research Council (EPSRC)
The EPSRC is the UK Government's leading funding agency for research and training in engineering and the physical sciences.
www.epsrc.ac.uk

Environment Agency
Lead public body for protecting and improving the environment in England and Wales.
www.environment-agency.gov.uk

Environment Agency Flood Maps
Find out the likelihood of flooding in a particular area.
www.environment-agency.gov.uk/subjects/flood/826674/829803

Environmental Reporting
Site aimed at helping business play a part in reducing greenhouse gas emissions, by setting targets for improvement and reporting publicly on progress.
www.defra.gov.uk/environment/envrp/index.htm

European Spatial Planning: Adapting to Climate Events (ESPACE)
ESPACE is a four-year European project that aims to promote awareness of the importance of adapting to climate change and to recommend that it is incorporated within spatial planning mechanisms at local, regional, national and European levels
www.espace-project.org/index.htm

Framework for Sustainable Development on the Government Estate
The Framework covers all key environmental and social impacts of the running of Departments. Part G includes a section on adapting to climate.
www.sustainable-development.gov.uk/delivery/integrating/estate/estate.htm

Greater London Authority (GLA)
The GLA is the unique citywide strategic government for London, comprising a directly elected Mayor and a separately elected Assembly.
www.london.gov.uk

Global Reporting Initiative (GRI)
The GRI is a multi-stakeholder process and independent institution whose mission is to develop and disseminate globally applicable Sustainability Reporting Guidelines.
www.globalreporting.org

Hadley Centre for Climate Prediction
Provides a focus in the UK for the scientific issues associated with climate change.
www.metoffice.com/research/hadleycentre

Housing Corporation
Housing Corporation's role is to fund and regulate the provision of affordable homes in England.
www.housingcorp.gov.uk

Indicators of Climate Change in the UK
Site shows how climate, environmental, social and economic indicators, such as frequency of flooding, crop yields and wildlife activities have altered in recent years.
www.nbu.ac.uk/iccuk

Intergovernmental Panel on Climate Change
World organisation that assesses scientific technical and socio-economic information relevant to the understanding of climate change.
www.ipcc.ch/

Living Roofs
An independent UK resource for green roof information.
www.livingroofs.org

London Climate Change Partnership (LCCP)
The purpose of the LCCP is to help ensure that London is prepared for climate change.
www.london.gov.uk/climatechange partnership

London Thames Gateway Partnership
Representing the London Thames Gateway area.
www.thames-gateway.org.uk

MAKE Architects
www.makearchitects.com

Met Office
One of the world's leading providers of environmental and weather-related services.
www.met-office.gov.uk

Natural Environment Research Council (NERC)
The NERC provides independent research and training in the environmental sciences.
www.nerc.ac.uk

Office of the Deputy Prime Minister (ODPM)
ODPM is responsible for Planning and Sustainable Communities.
www.odpm.gov.uk

Practical Help
Practical Help is an EST programme offering local authorities and housing professionals advice, information and support on the best options for improving the energy efficiency of housing stock.
www.practicalhelp.org.uk

Royal Horticultural Society (RHS)
The RHS is a leading gardening charity dedicated to advancing horticulture and promoting good gardening.
www.rhs.org.uk

South East Climate Change Partnership (SECCP)
SECCP's mission is to investigate, inform and advise on the threats and opportunities arising from the impacts of climate change in South East England and to promote adaptive planning in the region.
www.climatesoutheast.org.uk

South West Climate Change Impacts Programme (SWCCIP)
SWCCIP's mission is to investigate, inform and advise on the impacts of climate change in SW England, to influence the strategies and plans of key partners and stakeholders and, through dialogue and research with priority sectors, develop and share practical adaptation strategies which respond to the challenges and opportunities presented by these impacts.
www.oursouthwest.com/climate

Standing Conference on Problems Associated with the Coastline (SCOPAC)
SCOPAC works to promote sustainable shoreline management, and to facilitate the duties and responsibilities of local authorities and other organisations managing the coastal zone of central southern England.
www.scopac.org.uk

Sustaine
The North East Partnership for Sustainable Development.
www.sustaine.com

Thames Water
Thames Water provides sewage services to 13 million people and drinking water to eight million people.
www.thames-water.com

Town and Country Planning Association (TCPA)
The TCPA is an independent campaigning charity calling for more integrated planning based on the principles of accessibility, sustainability, diversity, and community cohesion.
www.tcpa.org.uk

Tyndall Centre for Climate Change Research
Brings together scientists, economists, engineers and social scientists to develop sustainable responses for climate change through research and dialogue.
www.tyndall.ac.uk

UK Climate Impacts Programme
Helps organisations assess how they might be affected by climate change, so they can prepare for its impact.
www.ukcip.org.uk

UK Sustainable Development
The Government's approach to delivering sustainable development.
www.sustainable-development.gov.uk

United Nations Framework Convention on Climate Change (UNFCCC)
International treaty, the UNFCCC, considers what can be done to reduce global warming and to cope with whatever temperature increases are inevitable.
http://unfccc.int

Water Cycle Management for New Development (WaND)
The aim of WaND is to support the delivery of integrated, sustainable water management for new developments by provision of tools and guidelines for project design, implementation and management.
www.wand.uk.net/

Woking Borough Council
Leading local authority on adapting to climate change.
www.woking.gov.uk

annex D: list of organisations responding to consultation

Adas Consulting Ltd
AMA Environment
ASCCUE/TCPA
Aylesbury Vale District
British Council for Offices
British Institute of Facilities Management
Cambridge Environmental Research Consultants
Cambridgeshire County Council
Capita Symonds
Country Land and Business Association
Earth Energy Ltd
En Venture
Enabling Projects
English Heritage
English Nature
Environment Agency
Greater London Authority
Hampshire County Council
Hartlepool Borough Council
Hertsmere Borough Council
Hywel Davies
Land Securities Group
London Climate Change Partnership
Mid Sussex District Council
Nazeing Glass Works Ltd
North Hertfordshire County Council
Northern Ireland Housing Executive
Norwich Union
Redcar and Cleveland Partnership and Redcar and Cleveland Borough Council
Renew Tees Valley Ltd
Sedgefield Borough Council's LSP Environment and Leisure Policy Group
South West Climate Change Impacts Partnership
Sustain Consulting Ltd
Urban Catalyst
URS Corporation

Supporting organisations

London Climate Change Partnership
www.london.gov.uk/climatechangepartnership

Government Office for London
www.gos.gov.uk/gol

Government Office for the East of England
www.gos.gov.uk/goeast

Government Office for the South East
www.gos.gov.uk/gose

Environment Agency
www.environment-agency.gov.uk

Thames Water
www.thames-water.com

South East Climate Change Partnership
www.climatesoutheast.org.uk

South West Climate Change Impacts Partnership
www.oursouthwest.com/climate

Surrey County Council
www.surreycc.gov.uk

UK Climate Impacts Programme
www.ukcip.org.uk

Greater London Authority
www.london.gov.uk

MoL/Nov 05/JWD&P/GLA841