

RISING TO THE CHALLENGE

THE CITY OF LONDON
CLIMATE CHANGE ADAPTATION STRATEGY

2010 Update



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Project management

City of London Corporation – Emma Bara, Sustainability Coordinator;
Simon Mills, Head of Sustainable Development;
Birte Berlemann, Policy Officer for Sustainability

Acclimatise – Dr Richenda Connell, CTO and Co-founder

Approved by

Chris Duffield, Town Clerk and Chief Executive, City of London Corporation
John Firth, CEO and Co-founder, Acclimatise

City of London Corporation
PO Box 270
Guildhall
London
EC2P 2EJ
T: +44 (0) 207 3323598
F: +44 (0) 207 7962621
E: simon.mills@cityoflondon.gov.uk
W: www.cityoflondon.gov.uk

Acclimatise
Hexgreave Hall
Farnsfield
Newark
Nottinghamshire
NG22 8LS
T: +44 (0) 1623 884347
E: r.connell@acclimatise.uk.com
W: www.acclimatise.uk.com

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Foreword

In 2007 The City of London Corporation became the first Local Authority in the UK to produce a dedicated Climate Change Adaptation Strategy.

In the three years since “Rising to the Challenge” was published, adaptation has become a mainstream activity. Under the 2008 Climate Change Act, the UK has become the first country in the world to create a duty for public sector organisations to consider adaptation, and as a result the City’s example has been emulated by Councils up and down the country.

However, we are not content to rest on our laurels. Adaptation is an ongoing process, and that is why this updated strategy reviews the progress we have made in the light of the latest predictions produced by the UK Climate Impact Programme. In this way we hope to ensure that the infrastructure and services contained in the Square Mile will continue to function effectively in a warming world.

Chris Duffield

Christopher Duffield
Town Clerk and Chief Executive
City of London
January 2010



Executive summary

There is widespread scientific consensus that man-made greenhouse gas emissions are leading to rapid and potentially irreversible climate change. Even if the world were to cease all greenhouse gas emissions tomorrow, we would still face many decades of climate change, due to inertia in the climate system. Whilst efforts to cut emissions are vital if we are to avoid the worst effects of climate change in the longer-term, it is essential that we begin adapting assets, infrastructure and services to cope with the unavoidable impacts.

The threat that inevitable climate change poses to the UK economy has been well documented in the Stern Review, published by the Treasury at the end of 2006, as well as research published under the framework of the UK Climate Impacts Programme (UKCIP). Government policy across a range of issues is beginning to reflect this fact. The UK Climate Change Act, which came into force in November 2008, requires that a UK-wide climate change risk assessment is undertaken every five years and that a national adaptation programme is put in place.

The City of London's Climate Change Adaptation Strategy (2010 update) uses the latest UK Climate Projections, UKCP09. The original strategy built on the impacts previously identified in the London Climate Change Partnership's publication, *'London's Warming'*¹. This was the first UK climate impact study focused on a large urban area.

The climate change risks for the City are summarised below:

- Hotter, drier summers,
- Milder, wetter winters,
- More frequent extreme high temperatures,
- More frequent heavy downpours of rain,
- Significant decreases in soil moisture content in summer,
- Sea level rise and increases in storm surge height,
- Possible higher wind speeds.

The City of London's Climate Change Adaptation Strategy, the first of its kind by a UK local authority, aims to identify the priority risks associated with climate change and proposes adaptation measures which are designed to ensure that the City's infrastructure and services cope under a changing climate.

Both strategies were developed in consultation with large groups of stakeholders including City of London Corporation departments, external service providers and City businesses.

The report identifies risks and opportunities under the following themes:

- Managing flood risks,
- Managing water resources,
- Managing heat risks and air pollution,
- Managing ground conditions,
- Cross-cutting issues,
- Opportunities.

The adaptation options identified are grouped into research and monitoring, policy and practical actions, which are then categorised under the following criteria:

¹ London's Warming. London Climate Change Partnership. Final Report November 2002.
http://www.cityoflondon.gov.uk/Corporation/living_environment/sustainability/climate_change/impacts.htm



'No-regrets' measures, delivering benefits that exceed their costs, whatever the extent of climate change,



'Low-regrets' measures are low cost, and have potentially large benefits under climate change,



'Win-win' measures contribute to climate adaptation and also deliver other benefits,



'Flexible' measures are useful for dealing with uncertainties in the extent of longer-term climate change.

The principle practical adaptation options recommended in this report are summarised below. Many of the recommendations, regarding flood risk for example, are in line with central and regional government planning guidance, and will be incorporated within the City of London Corporation's new Local Development Framework. Others, for instance, those concerning the City's water budget or transport issues, will require close cooperation and partnership working with other bodies. To this end a series of five thematic adaptation action plans were developed in 2009 that provide the mechanism for management, implementation, monitoring and reporting on progress against the recommended actions contained within this strategy, in partnership with City of London Corporation stakeholders.

Managing flood risks

The City of London Corporation should assign responsibility for coordination and liaison on flood risk management and identify, map, and manage risk in flash flood hotspots.

The City of London Corporation should examine a range of incentives to encourage sustainable drainage systems and green roofs.

Developers should be encouraged to install sustainable drainage systems and green roofs in targeted flash flood 'hotspots' for new developments, redevelopments or major refurbishments.

The City of London Corporation should consider installing sustainable drainage systems, green roofs or green walls on City of London Corporation-owned car parks and buildings when they are refurbished or replaced.

The City of London Corporation should ensure drainage systems can cope with heavy rainfall events by improving the monitoring and recording of gully overflows linked to heavy rainfall; assessing the capacity of the 72km of sewers that it manages to cope with increasing rainfall; and should coordinate with the Thames Tideway Tunnel project.

The City of London Corporation should encourage businesses to consider relocating flood-sensitive IT equipment and archives to areas at low risk of flooding. Assets and equipment which need to be on-site should be moved away from locations at higher risk of flooding, such as basements.

Managing water resources

The City of London Corporation should investigate the feasibility and cost of incorporating rainwater harvesting systems in its operational properties, gardens and large open spaces where appropriate and should require rainwater harvesting and greywater recycling, where appropriate, in all new developments.

The City of London Corporation should develop a coordinated and sustained awareness-raising campaign aimed at City businesses, property developers and residents regarding water use and water efficiency.

The City of London Corporation and developers should where feasible design and install drought-resistant landscaping schemes and 'low water gardens' in open spaces that require minimal irrigation. The Open Spaces Department should investigate opportunities to improve water efficiency and ensure that drought-tolerant species are planted in appropriate places.

The City of London Corporation should ensure that water quality is monitored and maintained in water bodies and consider the use of 'bio-bombs' or barley straw in water courses when needed to absorb nutrients and prevent algal blooms.

The City of London Corporation should work with Thames Water Utilities to discuss contingency planning for vital City functions in times of extreme drought.

Managing heat risks and air pollution

The City of London Corporation, in partnership with other organisations, should examine the provision of 'cool' centres (cooled public buildings) during heatwaves, with extended opening hours for vulnerable people, and should include them in emergency plans.

The City of London Corporation should ensure that new buildings are designed to provide a comfortable internal environment in the face of climate change, with the least use of energy over their lifetimes, and cooling systems should maximise the use of natural ventilation and low-carbon cooling techniques. For existing buildings, the Corporation should identify those most at risk of overheating and make plans to manage this.

The City of London Corporation should liaise with electricity providers in the City with a view to ensuring security of supply for City buildings and infrastructure, taking account of climate impacts on seasonal demands.

The City of London Corporation should encourage Transport for London and tube companies to do all possible to manage high temperatures on the underground and make the underground environment more comfortable.

The City of London Corporation Open Spaces Department should work with the Emergency Services to undertake an analysis of the relationship between weather conditions and fire risk in open spaces.

The City of London Corporation should work with strategic health authorities and primary care trusts to implement the local heatwave plan in the City and to include actions to manage air pollution health risks in these plans, as high air pollution levels often coincide with heatwaves. Vulnerable residents should also be identified and visited during heatwaves.

The City of London Corporation should build awareness among workers and residents over the wider impacts of high temperatures, such as increased risk of bacterial contamination of fresh food and the greater potential for noise due to increased use of outdoor space in warm temperatures.

Managing ground conditions

When designing landscaping, the City of London Corporation and developers should choose the types and locations of trees carefully, considering how subsidence and root penetration will be affected by climate change.

The City of London Corporation should keep a watching brief on the incidence of subsidence in City of London Corporation-owned property outside the City, to ascertain whether the problem increases as the climate changes.

Cross-cutting issues

The City of London Corporation should thoroughly address climate adaptation in the Sustainability Appraisal (SA) of the LDF and review design standards and codes of practice for assets, infrastructure and services, to identify those that include climatic factors. Based on the outcome of the review, the City of London Corporation should consider upgrading design standards and codes of practice where required to take account of projected climate changes.

The City of London Corporation should develop Supplementary Planning Guidance for the LDF that focuses specifically on climate change adaptation, in the event that the GLA's guidance does not adequately cover issues relevant to the City of London.

The City of London Corporation should integrate adaptation considerations into purchasing and tendering decisions.

The City of London Corporation should review existing measures in place for managing health and safety risks to people when they are outside, to see whether they provide sufficient protection against changing climate risks, such as educating outside staff on sun safety and ensuring that clothing has a sufficient sun protection factor (SPF), or providing shade in school playgrounds.

The City of London Corporation should monitor climate change impacts on biodiversity and link in to research on the issue.

The City of London Corporation should ensure that resourcing and delivery of waste management services is appropriate to cope with the added threats from climate change.

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1. Context and purpose

1.1 Adapting to inevitable climate change in the City of London

Our climate is changing and is likely to continue to change for many years to come. The latest research on climate change predicts that even if we were to make significant reductions in greenhouse gas emissions tomorrow, the inertia in climate systems means that we will need to cope with a changing climate for the next 40-plus years, due to emissions we have already put into the atmosphere.

Organisations and individuals need to grasp the reality we face – that we have to both reduce our emissions and adapt to inevitable climate change. There is no choice between mitigation and adaptation – we have to pursue complementary actions on both.

The UK Climate Change Act, which came into force in November 2008, requires that a UK-wide climate change risk assessment is undertaken every five years. The Act also lays out an expectation that the public sector consider the risks that climate change pose to their operations in a systematic manner.

It is within this context that the City of London Corporation has developed this climate adaptation strategy. The City of London Corporation wants to understand and manage changing climate risks, to ensure that its assets, services and infrastructure continue to function appropriately and that the City as a whole continues to thrive. This adaptation strategy and the associated five thematic adaptation action plans will also help the City of London Corporation in reporting against the UK national performance indicator NI188, *'Planning to Adapt to Climate Change'*, which local governments use to measure progress in assessing and addressing the risks and opportunities posed by climate change, as part of the Local Government Performance Framework (see **Info Point A** below).

Since climate change will continue to intensify over coming decades and centuries, and much of our infrastructure and assets will be in place for decades or more, this strategy considers climate risks to the end of the 21st century. It emphasises cost-effective measures that can be taken now to minimise risks and maximise opportunities over the longer term.

1.2 Making the City of London climate-resilient

The overall aim of the City of London's Climate Change Adaptation Strategy is to ensure that the City's assets, services and infrastructure continue to function appropriately in the face of climate change. This aim can be described by the general term 'building climate-resilience'. With respect to climate-resilience, the City of London Corporation has several important roles:

- Initiating research and monitoring to help develop appropriate policy and actions on climate adaptation,
- Making its own policies climate-resilient,
- Making its own practices, assets, services and infrastructure climate-resilient,
- Working in partnership with others to assist them in addressing climate adaptation, including:
 - Other utility and service providers in the City,
 - City businesses,
 - City residents,
 - Other public sector bodies.

The City of London Corporation recognises that some of the adaptation measures required to address climate risks will be the responsibility of these other groups.

One of the routes for delivery of this adaptation strategy is the City of London Corporation's Local Development Framework (LDF), which will be subject to external consultation and examination in public, prior to expected adoption in 2011 (see **Info Point A** below)². City of London Corporation departments also have a major role to play in ensuring that adaptation measures are supported in their policy frameworks and business plans.

1.3 How to use this report

This report is organised according to the main climate risks that the City of London will experience, under the following headings:

- Managing flood risks,
- Managing water resources,
- Managing heat risks and air pollution,
- Managing ground conditions,
- Cross-cutting issues.
- Opportunities.

Each section outlines the highest priority risks and corresponding adaptation measures to manage the risks. Additional information on climate risks and adaptation measures is provided in Appendices 1 and 2 respectively. Two 'climate-proofing checklists' are also provided (see Appendix 3) – one aimed at City of London Corporation staff developing policies and projects, and one specifically for City developers and infrastructure managers.

The methodology used to develop this adaptation strategy is summarised in Appendix 4.

² http://www.cityoflondon.gov.uk/NR/rdonlyres/0DA4A82C-50F7-4D7D-ABC3-7E5A8E1F0241/0/DP_PL_UDP_Issues_OptionsMainWeb.pdf accessed on 15.09.06



Info Point A: The City of London Corporation Local Development Framework (LDF) and NI188

The LDF

The City Corporation is preparing a Local Development Framework (LDF) that will set out its planning strategy for the City of London. The LDF will replace the current strategy, the Unitary Development Plan (UDP), adopted in 2002.

The LDF will consist of a number of planning documents which will be separately prepared. The most important of these documents is the Core Strategy, which will set out the planning vision for the City and the key policies to deliver this vision. The Core Strategy draws together the spatial planning aspect of all the City's other strategies, including The City Together Strategy and the Climate Change Adaptation Strategy. Other documents making up the LDF will include policies for deciding planning applications and guiding development.

The achievement of sustainable development is a central consideration in the Core Strategy, and its preparation has been subject to a sustainability appraisal. The Core Strategy sets out policies to enable increasing prosperity of the City's economy while protecting the environment and ensuring the well-being of its communities.

Preparation of the Core Strategy has been informed by public consultation throughout the process. The final version of the Core Strategy will be published in summer 2010, before being considered by a planning inspector at a public examination and adopted in 2011.

NI188 'Planning to Adapt to Climate Change'

The Local Government Performance Framework, introduced in 2008, includes a set of 198 National Indicators (NIs) that UK local governments must use to measure the national priorities that have been identified by Government. The City of London has chosen to report against NI188, which measures a local authority's progress in assessing and addressing the risks and opportunities of a changing climate.

NI188 has five levels, starting at Level 0 (Identifying Priority Areas) through to Level 4 (Maintaining and Delivering an Action Plan). The City has mapped itself against a performance curve- last year, the first year performance was measured, the City was assessed at Level 2; putting itself in the top 5% of Local Authorities in the country. Implementing the five thematic adaptation action plans will help the City of London eventually attain the highest level of NI188, where a robust process for monitoring and review has been implemented, and the local authority has mainstreamed adaptation considerations into its normal business.

2. Overview of the City of London Corporation

The City of London Corporation³ provides local government services for the financial and commercial heart of the UK, the 'Square Mile'. Its responsibilities extend far beyond the City boundaries in that it also provides a range of additional facilities for the benefit of the nation, including open spaces such as Epping Forest and Hampstead Heath and art centres such as the famous Barbican Arts Centre.

There are around 300,000 daily commuters into the City, as well as a large number of visitors for business and tourism. Most people travelling to the City are dependent on public transport, and there are 7 mainline stations and 13 DLR/tube stations within the City of London boundary (see Figure 1). Around 80% of the workforce in the City is employed in the financial and business services sectors. Any disruption to the City has the potential to seriously affect not just the local economy but also national and global economies.

There are a large number of entertainment premises, including restaurants, pubs, clubs and theatres in the area which cater for the residential population and workers and tourists. Wholesale and retail sectors are also important to the local economy. The City of London Corporation also owns three premier wholesale food markets which supply London and the South East with fresh produce.

Within the Square Mile there are galleries, theatres, museums and concert halls, including the Barbican Centre and the Guildhall. As well as being the third largest sponsor of the arts in the UK, the City of London Corporation owns and cares for a significant number of historic buildings and monuments. The City also has extensive libraries and archives, with approximately 15km of archives and records held underground at the London Metropolitan Archives, another 15km at Guildhall Library and information held at Shoe Lane Library and City Business Library.

The City of London Corporation looks after more than 2,700 properties across six London boroughs and has two housing estates - Golden Lane and Middlesex Street - within the City itself. There are approximately 7,900 residents within the City boundary⁴. The City of London Corporation directly manages commercial property in the City, the West End and Southwark.

The City of London Corporation manages and maintains the highway drainage system and 820 fire hydrants throughout the Square Mile. The City of London Corporation is also responsible for the management and maintenance of 6km of service subways under the highway in which water, gas, electricity and telecommunications companies' apparatus is housed.

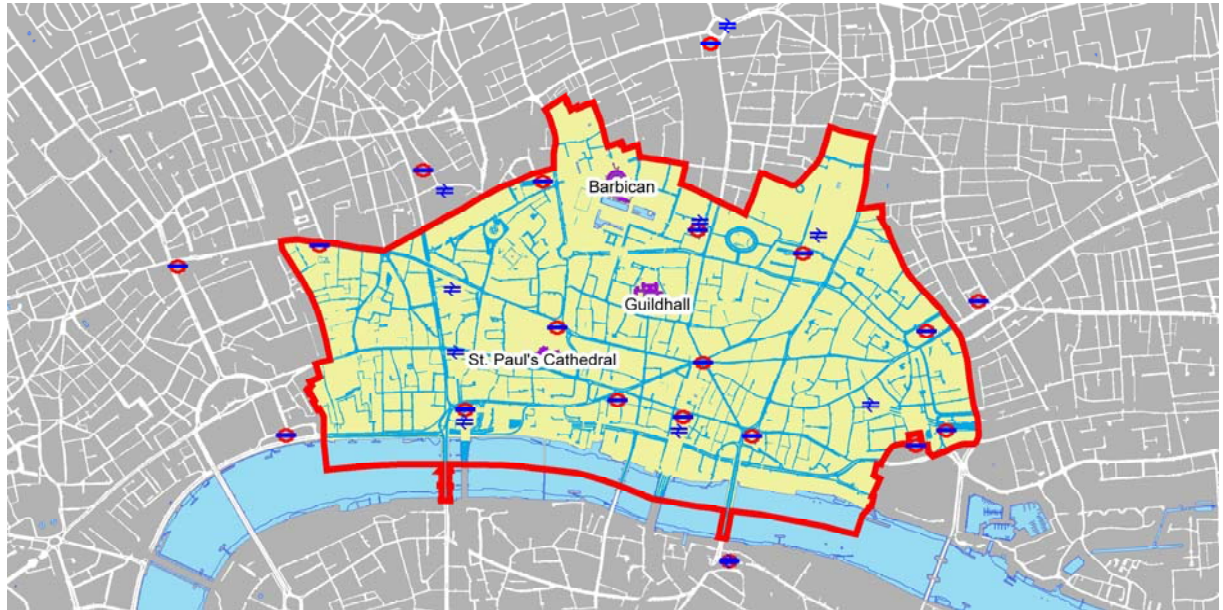
Thames Water Utilities employs the City of London Corporation as its sewer management contractor in the Square Mile, with responsibility for the day to day maintenance of 72km of the sewer network, and to look after its interest in any associated planning issues.

The City of London Corporation owns and manages over 10,000 acres of open spaces in and around London for the recreation and enjoyment of the public and as 'breathing spaces' from built-up developments, such as Hampstead Heath.

³ <http://www.cityoflondon.gov.uk/Corporation> - accessed on 06.11.06

⁴ Based on 2008 figures from UK National Statistics Office

Figure 1: The City of London Corporation 'Square Mile' showing mainline stations, DLR / tube stations and key buildings



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3. A changing climate for the City of London

London has experienced, and will continue to experience significant changes in climate over the coming decades. These changes can be summarised as:

- Hotter, drier summers,
- Milder, wetter winters,
- More frequent extreme high temperatures,
- More frequent heavy downpours of rain,
- Significant decreases in soil moisture content in summer,
- Sea level rise and increases in storm surge height,
- Possible higher wind speeds.

These changes will be more pronounced over London and the South East than in other parts of the UK, according to the recently released UK Climate Projections 2009.

3.1 Updated climate projections for the UK

The UK Climate Projections 2009 (UKCP09) were published by the Department for Environment, Food and Rural Affairs (Defra) and Department of Energy and Climate Change (DECC) in June 2009. They provide information on observed and future changes in the UK's climate, and have been created to help UK organisations plan and prepare for a changing climate in the coming century.

For the first time, UKCP09 provides probabilistic projections of climate change, based on quantification of the known sources of uncertainty in climate modelling. These probabilistic projections can be used to illustrate ranges of future changes in climate variables over a selected location. The information they provide on low probability (extreme) events will be of particular relevance to those involved in contingency planning. This climate change adaptation strategy has been updated to reflect these probabilistic projections and is thus based on the precautionary principle, using the best available information.

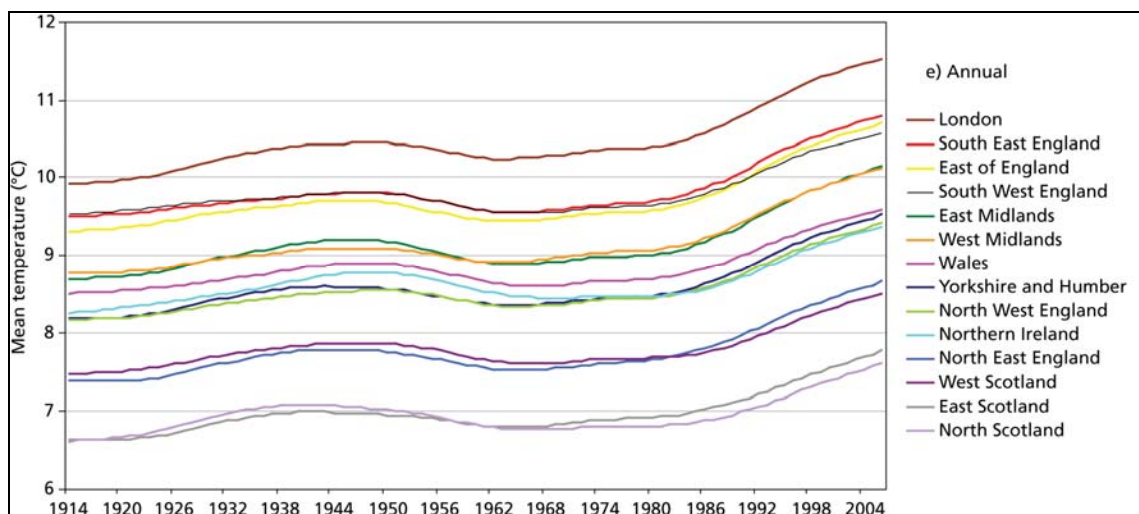
3.2 Observed changes for London

From 1961 to 2006, annual mean temperatures in all UK regions increased by between 1°C and 1.7°C. Over that period, annual mean temperatures in London, already the hottest place in the UK, increased by 1.7°C (Figure 2).

Seasonal rainfall over London appears to have decreased by as much as 16% in summer and increased in winter by 22% between 1961 and 2006. Over the past 45 years, heavy precipitation events have increasingly contributed to total winter rainfall over London, while heavy downpours make up less of London's summer rainfall total.

Sea levels near London have been rising at a rate of 1mm per year over the 20th century, though this rate has been higher for the 1990s and 2000s. This rise is partly due to expansion in the volume of ocean water as it warms, as well as melting of land-based ice (glaciers and ice caps) into the oceans. In addition, land in the south of the UK is gradually sinking (subsiding), exacerbating the effects of sea level rise.

Figure 2: Annual average temperature (°C) by region from 1914-2006. The individual regional time-series have been smoothed to show decadal variations⁵



3.3 Future changes for London

Examining observed and projected changes over London shows that the changes evident in recent decades are set to continue, with trends of rising temperatures and sea levels, and changes in rainfall patterns.

The ranges of projected changes in temperature and precipitation are shown in Figure 3 to Figure 10. These graphs are compiled from UKCP09 data⁶, based on two different greenhouse gas emissions scenarios, each of which portrays a different pathway of economic and social change (e.g. changes in population, economic growth, technologies, energy intensity, and land use) over this century⁷. It should be noted that until about the 2040s, the amount of climate change that will be experienced has largely already been set, due to emissions of greenhouse gases that are already in the atmosphere. Changes from the 2050s onward depend on present-day and future emissions:

- the 'low' emissions scenario⁸ (SRES B1) assumes that global emissions will fall below today's levels by the 2080s,
- the 'high' emissions scenario (SRES A1FI) assumes that emissions increase at a faster rate than current levels until the 2080s, when emission rates will be approximately four times today's levels.

⁵ Jenkins, G., M. Perry, and J. Prior. (Revised edition, 2009). The climate of the UK and recent trends. Met Office Hadley Centre, Exeter, UK.

⁶ Murphy, J.M., Sexton, D.M.H., Jenkins, G.J., Boorman, P.M., Booth, B.B.B., Brown, C.C., Clark, R.T., Collins, M., Harris, G.R., Kendon, E.J., Betts, R.A., Brown, S.J., Howard, T. P., Humphrey, K. A., McCarthy, M. P., McDonald, R. E., Stephens, A., Wallace, C., Warren, R., Wilby, R., Wood, R. A. (2009), UK Climate Projections Science Report: Climate change projections. Met Office Hadley Centre, Exeter.

⁷ These scenarios do not assume any planned mitigation measures and cannot currently be assigned probabilities.

⁸ Nakićenović, N., and R. Swart (eds.), 2000: *Special Report on Emissions Scenarios. A Special Report of Working Group III of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 599 pp.

Changes in average annual temperature

Figure 3 shows the range of projected future increase in annual mean temperature for London under a high greenhouse gas emissions scenario, for seven 30-year time periods (2020s to 2080s). As a comparison, Figure 4 shows the central estimate of change for both the low and high emissions scenarios. Under a high emissions scenario, the likely range of increase in annual mean temperatures over London is 1.2-1.7°C by the 2020s and 2.4-3.2°C by the 2050s.

Figure 3: The black line shows the central estimate (50th percentile) of increase in average annual temperature for the high emissions scenario. The wide grey bars show the likely range of increase (33rd to 66th percentiles). The error bars show the 10th and 90th percentile events (future increase is very unlikely to be outside this range).

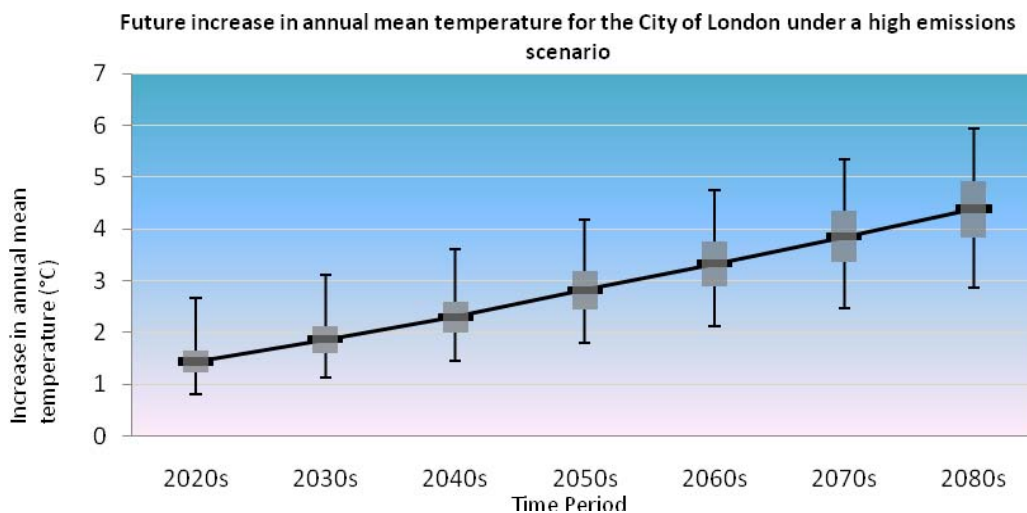
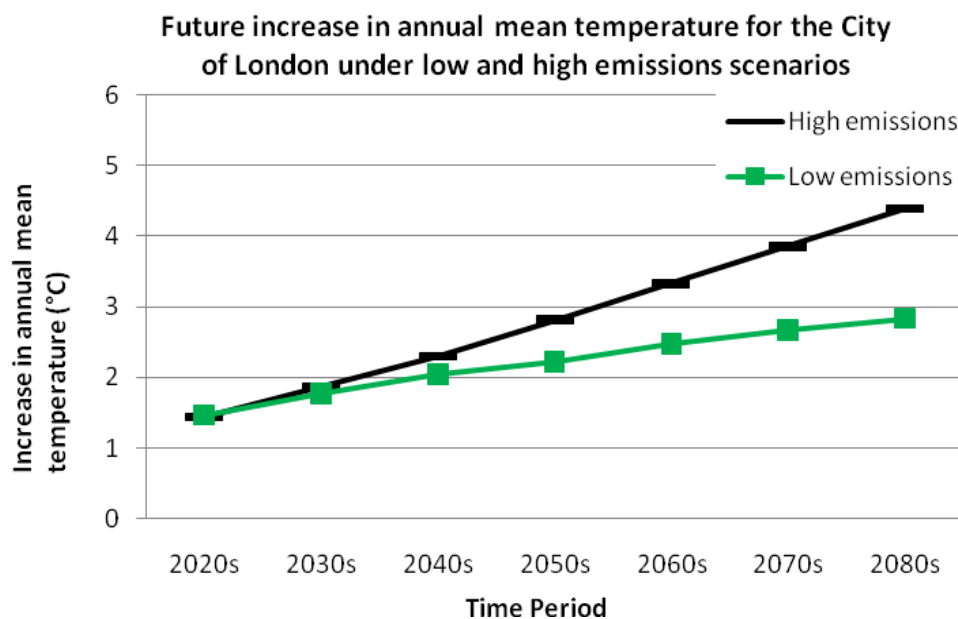


Figure 4: The black line shows the central estimate of increase in average annual temperature for the high emissions scenario, while the green line shows the corresponding estimate for the low emissions scenario for comparison.



Changes in average seasonal precipitation

Figure 5 shows the range of projected future decrease in average summer rainfall for London under a high greenhouse gas emissions scenario, while Figure 6 shows the central estimate of decrease for both the low and high emissions scenarios. Under a high emissions scenario, the likely range of change in average summer rainfall is +2 to -11% by the 2020s and -11 to -27% by the 2050s.

Figure 5: The black line shows the central estimate (50th percentile) of the change in average summer precipitation for the high emissions scenario. The wide grey bars show the likely range of change (33rd to 66th percentiles). The error bars show the 10th and 90th percentile events (future change in average summer precipitation is very unlikely to be outside this range).

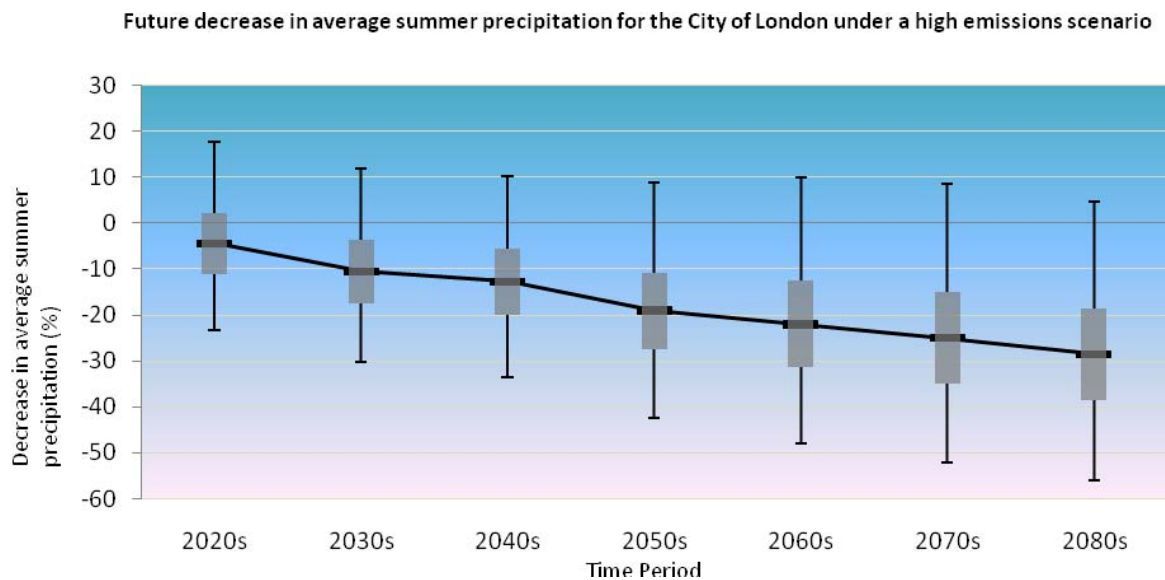


Figure 6: The black line shows the central estimate of the decrease in average summer precipitation for the high emissions scenario, while the green line shows the corresponding estimate for the low emissions scenario for comparison.

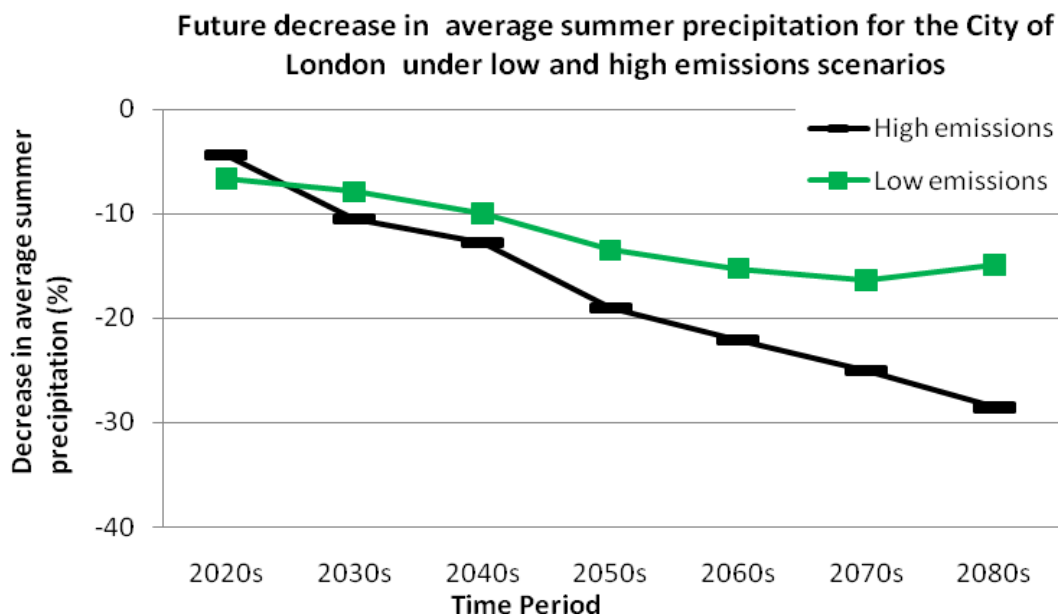


Figure 7 shows the range of projected future increase in average winter rainfall for London under a high greenhouse gas emissions scenario, while Figure 8 shows the central estimate of increase for both the low and high emissions scenarios. Under a high emissions scenario, the likely range of change in average summer rainfall is +3 to +10% by the 2020s and +11 to +22% by the 2050s.

Figure 7: The black line shows the central estimate (50th percentile) of the increase in average winter precipitation for the high emissions scenario. The wide grey bars show the likely range of change (33rd to 66th percentiles). The error bars show the 10th and 90th percentile events (future change in average winter precipitation is very unlikely to be outside this range).

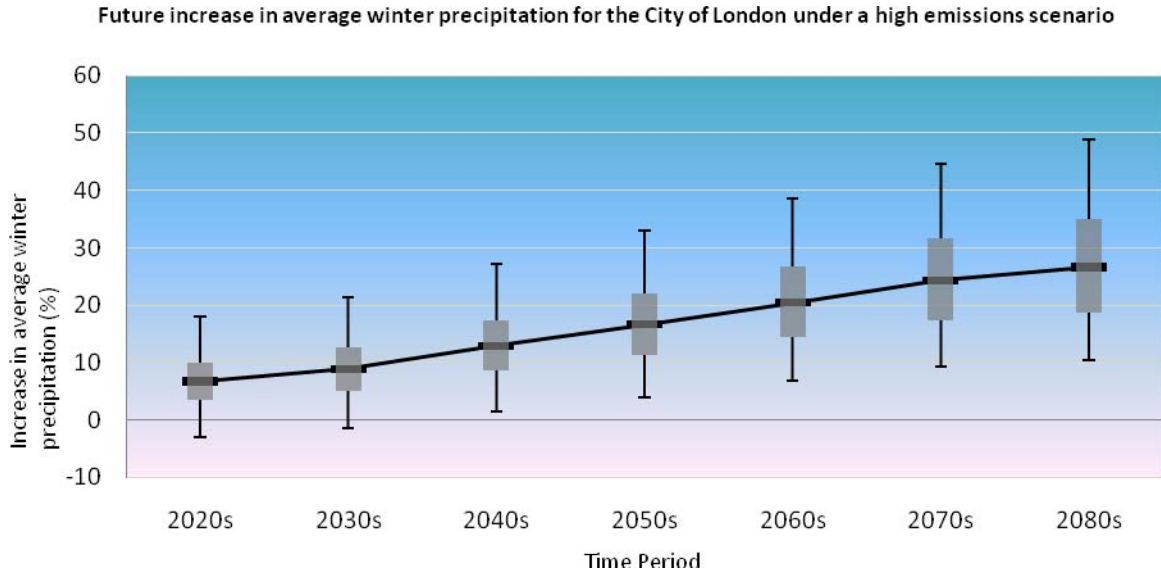
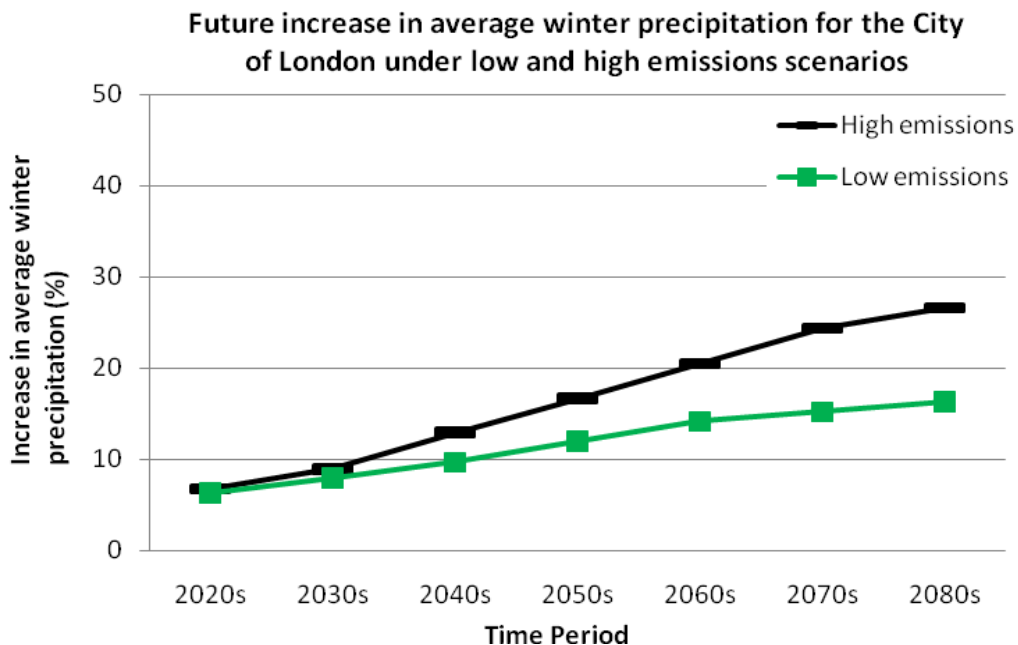


Figure 8: The black line shows the central estimate of the increase in average winter precipitation for the high emissions scenario, while the green line shows the corresponding estimate for the low emissions scenario for comparison.



Changes in extreme events

Although the changes illustrated so far have described shifts in annual or seasonal average conditions, climate change will also affect the severity of short-term climatic extremes (e.g. the hottest or the wettest events). Figure 9 shows the range of projected future increase in the temperature of the warmest day of the summer under a high greenhouse gas emissions scenario. Under this scenario, the likely range of increase in the temperature of the warmest day of the summer is 0.3 to 2.6°C by the 2020s and 1.0 to 4.5°C by the 2050s.

Figure 9: The black line shows the central estimate (50th percentile) of the increase in temperature on the warmest summer day for the high emissions scenario. The wide grey bars show the likely range of change (33rd to 66th percentiles). The error bars show the 10th and 90th percentile events (future change in temperature on the warmest summer day is very unlikely to be outside this range).

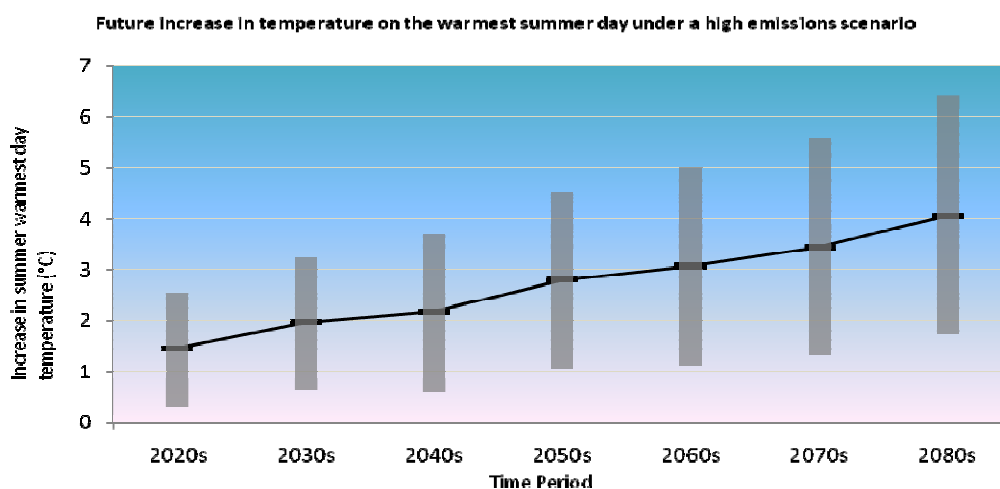
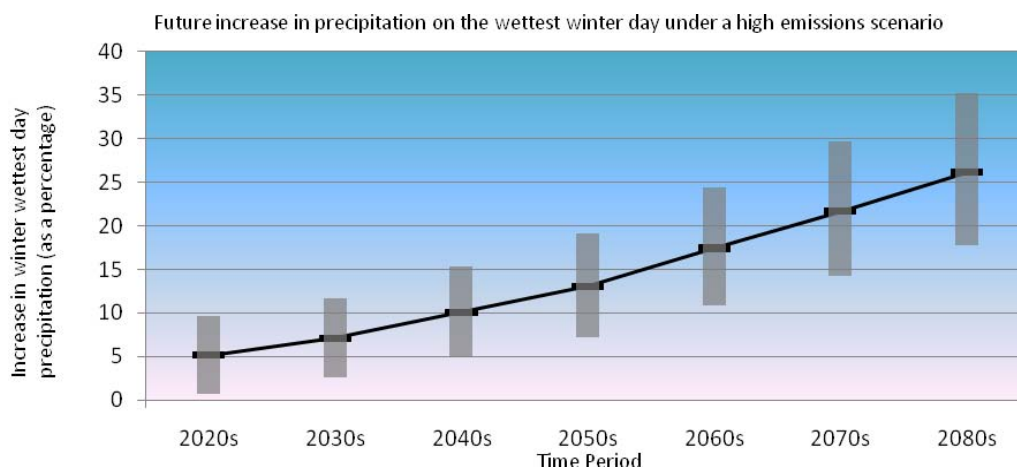


Figure 10 shows the range of projected future increase in rainfall on the wettest day of winter under a high greenhouse gas emissions scenario. Under this scenario, the likely range of increase in rainfall on the wettest day of winter is 0.7% to 9.6% by the 2020s and 7.2% to 19.1% by the 2050s.

Figure 10: The black line shows the central estimate (50th percentile) of the increase in precipitation on the wettest winter day for the high emissions scenario. The wide grey bars show the likely range of change (33rd to 66th percentiles). The error bars show the 10th and 90th percentile events (future increase in precipitation on the wettest winter day is very unlikely to be outside this range).



Sea level rise

Sea level rise is a very real threat to London and the Thames Estuary region. The Thames tidal defences, including the Thames Barrier, aim to provide a high standard of protection against this hazard. The IPCC Fourth Assessment Report estimated that global sea levels would rise by 0.2 to 0.6m by 2095. However, these numbers have been challenged by recent research, which suggests that global sea level rise by 2100 may be higher – in the region of 0.75 to 1.9m. The Thames Estuary 2100 project, led by the Environment Agency, is developing a long-term tidal flood risk management plan for London and the Thames Estuary. This work has projected that sea level rise in the Thames will likely be in the range 0.2 to 0.9m by 2100, but TE2100 has also considered a worst-case scenario of a rise of 2.7m.

4. Managing flood risks

4.1 Why act now?

It is clear that unless action is taken, flood risks in the City of London will increase. Climate change is increasing the magnitude and frequency of intense rainfall events that cause flash flooding. Rising sea levels mean that risks of tidal flooding from the Thames are increasing. River flood risk is also escalating, as climate change is causing heavier average winter precipitation. According to the London Local Climate Impacts Profile (LCLIP) published by the Greater London Authority (GLA)⁹, heavy rain and flash flooding were the most frequently occurring weather incidents reported in the media, with cases of river flooding also being reported.

Recent research on flooding events clearly demonstrates the costs and implications of inaction on flood risk. A report by the London Climate Change Partnership (LCCP) 'Climate change and London's transport systems'¹⁰ looks at the implications of flash flooding on the underground. The report notes that 'between 1992 and 2003, over 1,200 flooding incidents have been recorded on the London Underground, including 200 Underground station closures.' The cost of these closures was estimated at £14.6m in terms of passenger delays, and just one event on 7th August 2002 cost approximately £0.74m. According to the London LCLIP, transport was the sector most frequently reported to be affected by weather events, of which the majority were heavy rain or snowfall.

On 14th September 2006, the 'London Lite' newspaper reported that heavy rainfall caused signal failures on the tube, with commuters stranded and roads under water. Major floods occurred in London in June and July 2007 due to exceptionally heavy rainfall which affected a number of boroughs: over 500 properties, 80 schools and several hospitals were flooded, and some were closed due to flooding. In August 2004, more than 600,000 tonnes of raw sewage were flushed in to the Thames at Brentford, Kew and Isleworth after flash flooding, when one month's rain fell in one hour.

Existing problems have also been identified within the City. For example, the existing drainage system at the Guildhall Art Gallery can not cope with intense rainfall at times, and this has led to flooding of its basement and thousands of pounds worth of damage.

⁹ Standley, S., Miller, K., Okamura, S., Wynn, D., Greenhalgh, S. and Horrocks, L. (2009). Wild weather warning: a London climate impacts profile. Greater London Authority, London, UK. Available from: <http://www.london.gov.uk/lccp/publications/docs/wild-weather-warning.pdf>

¹⁰ Arkell, B and Darch, G. Climate change and London's transport systems. Technical report for the Greater London Authority and London Climate Change Partnership. 2005.

'London will flood, and flood badly'
Norwich Union website ^(a)

Merrycon Ltd, business continuity specialists, warned that a potential devastating flood will affect London in the future. They also claimed that many London-based firms had not taken this risk into account.

They recommend that businesses review their business continuity plans. A resilience exercise demonstrated that extensive flooding had not been considered by businesses and some firms had disaster recovery sites located in the Docklands, which Merrycon pointed out would flood as well.

(a)<http://www.nurs.co.uk/news/artic>

'Commuters stranded as storms bring floods and traffic gridlock'
The Times August 4th, 2004

A flash flood event left hundreds of thousands of commuters stranded as much of the Underground network and major routes out of the capital closed. The capital's tube, bus, rail and road routes were paralysed as flood waters failed to subside. Some homes and offices in West London flooded. Basement flats in Acton were flooded causing significant damage to property and loss of possessions. The Television Centre in the West End was flooded, causing the filming of Newsnight to have to be moved.

Before 1990, the Thames Barrier was closed on average once or twice per year. Since 1990, the number of barrier closures required to protect London against tidal surges has increased to an average of about four per year.¹¹

According to reinsurer Munich Re¹², London is ranked within the top ten 'at risk' cities in the world exposed to catastrophic loss of life and property from natural disasters.

4.2 What does it mean?

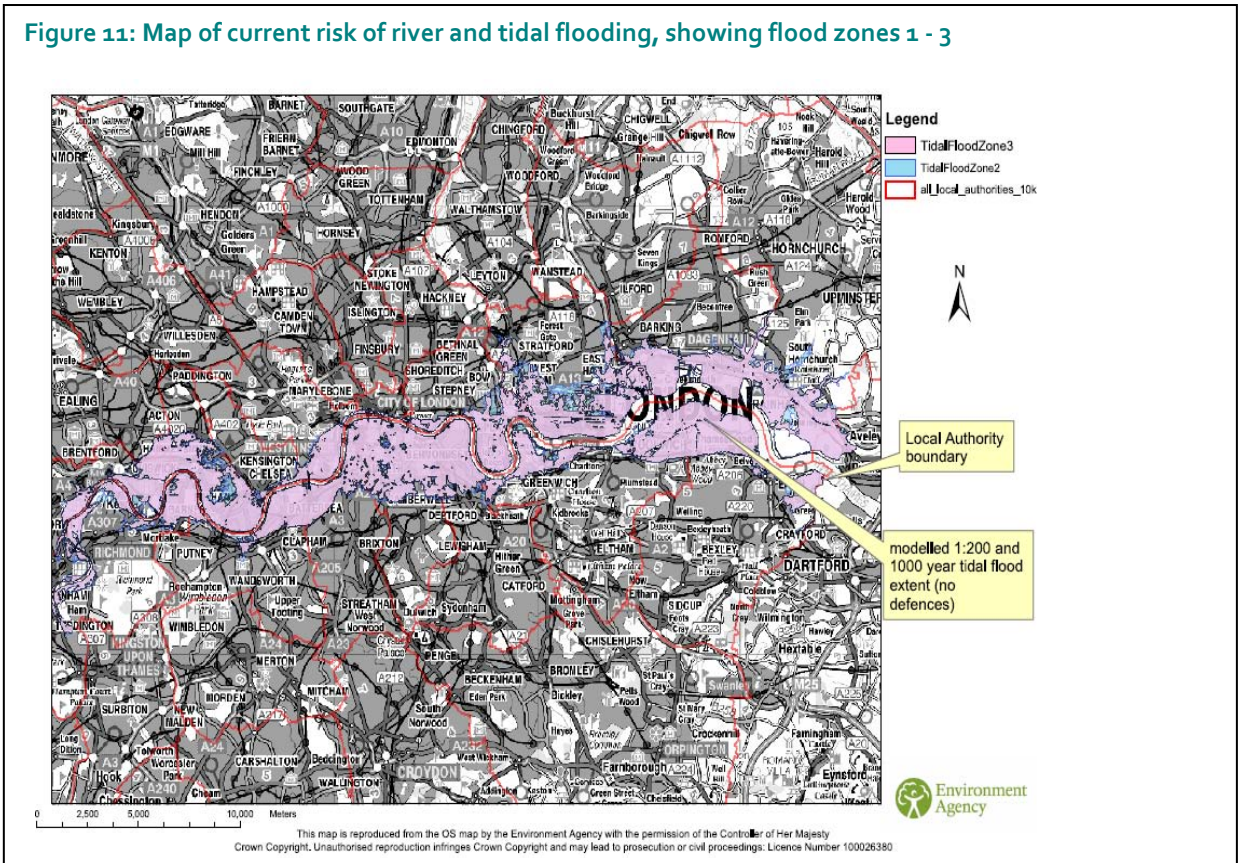
Flash flood risk will increase in the future with climate change, which means there is a greater risk of injury and health risks to the public and City workers. The loss of open rivers, natural infiltration and surpassing of sewer capacity have exacerbated the risk of flash flooding in London. Flooding also causes damage to property, infrastructure and open spaces.

Transport is disrupted by floods, which in turn affects commuters and deliveries of goods and services. This ultimately leads to business costs and interruption.

Tidal and river flooding has long since been highlighted as a major risk for London. Around 45 square miles of London is at risk of tidal flooding, an area containing 400,000 properties and home to 1.25 million people. Figure 11 shows existing flood risks from river and tidal flooding. River and tidal flooding cause similar impacts to flash flooding, although the floods are more widespread and can last for days, causing far greater damage and disruption. Other specific risks such as rising insurance premiums in high flood risk areas or even withdrawal of insurance cover also need to be considered.

Further details on flood risks to the City due to climate change can be found in Appendix 1.

Figure 11: Map of current risk of river and tidal flooding, showing flood zones 1 - 3



¹¹ http://www.environment-agency.gov.uk/yourenv/432430/432434/432475/436993/?version=1&lang=_e

¹² Megacities: megarisk. Munich Re. knowledge series. 2004. http://www.munichre.com/publications/302-04271_en.pdf?rdm=22452 accessed on 03.11.06

4.3 What actions are already underway?

Action is underway at all levels from national to local authority level to manage flood risks to London.

National action

Flood risk management is addressed at a national level through planning policy. The Department for Communities and Local Government (DCLG) has published Planning Policy Statement on flood risk and development (PPS25)¹³, which replaced PPG25. One of the key changes in PPS25 is that the Environment Agency is a statutory consultee on all planning applications for development in flood risk areas, including those in areas with critical drainage problems, and for any development on land exceeding 1 hectare outside flood risk areas. The full application of PPS25 provides a strong mechanism for addressing current and future flood risk in London in a more sustainable way.

London-wide action

The Thames Barrier and associated defences provide a high standard of protection to London and the Thames Estuary against a combination of tidal and fluvial flood risks, the principal risk being from tidal surge events. A generous allowance for sea level rise was built into the design of the Thames Barrier and associated defences, and today they offer a standard of protection of 0.05% risk of flooding from tidal surge in any one year. However, the gradual deterioration of present flood defences, which will reach the peak of their design lives over the next 20-30 years, coupled with the potential for increased frequency and severity of flooding due to climate change, mean that the originally intended standard of protection is gradually reducing.

The Environment Agency, with support from the Department for Environment, Food and Rural Affairs (Defra), has addressed this issue through a number of studies, notably the Thames Estuary 2100 (TE2100) project¹⁴, which has the aim of creating a long-term risk management strategy for the tidal Thames to the end of the century. Work conducted so far on this project has increased understanding of how climate change and sea level rise will affect the Thames Estuary. Collaboration between the Environment Agency and the UK Met Office has helped improve understanding of what degree of sea level rise London will be faced with in the future. According to this research, sea level rise in the Thames due to thermal expansion of oceans and melting glaciers over the next century could be between 20 and 90 cm, although the much less-well understood contribution of polar ice melt to sea level rise may cause a rise of maximum sea levels by up to 2m. According to research as part of TE2100, the worst-case scenario for increases in maximum water levels on the Thames has been revised to 2.7m (from a previous estimate of 4.2m). However, this scenario is considered highly unlikely.

A key finding of the TE2100 project is that the Thames Barrier, with continued maintenance and planned improvements, and with later modification, could continue to provide protection to London and the estuary through to the end of the century. However, as a result of economic assessment and Barrier failure analysis, it has also been suggested that it may prove safer and most cost-beneficial to construct a new barrier further downstream at Long Reach before the end of the century (to become operational around 2075). Upgrading the current system of associated tidal defences will be required from around 2035. The plan has been designed to be adaptable, due to the uncertainties in potential climate change impacts on water levels in the future. This means that if sea levels are found to be rising faster than current estimates have projected, the plan will indicate what changes are required and when

¹³ For information see the DCLG website <http://www.communities.gov.uk/consultations>.

¹⁴ Thames Estuary 2100 Plan. See <http://www.environment-agency.gov.uk/research/library/consultations/106100.aspx#docs>

they need to be implemented. It is due to be reviewed every 5 to 10 years against a list of indicators detailed in the plan. The final TE2100 plan is due to be submitted to Defra by the beginning of 2010.

To help manage flash flood risks, the Mayor's Further Alterations to the London Plan¹⁵, his Supplementary Planning Guidance on Sustainable Design and Construction¹⁶ and the Checklist for Development published with the South East and East of England regions¹⁷ all promote the incorporation of Sustainable Drainage Systems (SuDS) in new developments. For details of SuDS techniques see **Info Point B**.

Storm drainage and surface water flooding have been highlighted in the GLA's draft climate change adaptation strategy as a particular risk to London, due to the large area of impermeable surfaces in the city. It projects that surface water flooding will increase in the future as a result of increasing winter rainfall and extreme rainfall events, as well as the fact that most drainage systems are designed for high frequency, low volume rainfall. The GLA draft adaptation strategy proposes to address flood risk through a series of actions intended to prevent, prepare for, respond to, and recover from it. Certain actions are recommended for implementation by boroughs in London. These include:

- requiring that new developments demonstrate how they are located, designed and constructed for the climate change expected over their design life,
- requiring that new developments are set back from flood defences,
- undertaking local Strategic Flood Risk Assessments,
- requiring developers building in areas of flood risk to contribute to the development and maintenance of a local flood emergency plan,
- producing recovery plans that identify their likely immediate and long-term recovery commitments.

To help manage sewer overflows as a result of heavy rainfall events, Thames Water is implementing the London Tideway Tunnel project, which involves the construction of two separate tunnels (the Lee and Thames Tunnels) that will substantially reduce the pollution entering the River Thames by capturing sewer overflow before it enters the river and transporting it back to Beckton Sewage Treatment Works for treatment.

City of London Corporation action

Following the adoption of Rising to The Challenge in 2007, The City of London Corporation implemented a number of actions to manage flood risks. These include:

- The assigning responsibility for coordination and liaison on flood risk management to a named officer
- The carrying out of a Strategic Flood Risk Assessment (SFRA), published in October 2007, has identified risks of flooding from a range of sources and produced flood risk maps identifying areas where flooding is an important consideration in development planning, business planning and emergency planning. This assessment has been done based on historic data of past flood events, data available at postcode scale, and topography. A more detailed (finer scale) map of surface water flood risk, which differentiates risk within postcodes, is due to be prepared in 2010 as part of the Drain London project. This will feed into the review of the SFRA and Surface Water Management Plan.

¹⁵ Mayor's Further Alterations to the London Plan. See <http://www.london.gov.uk/mayor/strategies/sds/further-alt/ docs.jsp>.

¹⁶ Supplementary Planning Guidance on Sustainable Design and Construction. Greater London Authority. May 2006. http://www.london.gov.uk/mayor/strategies/sds/sustainable_design.jsp

¹⁷ Adapting to climate change: a checklist for development. Guidance on designing developments in a changing climate. Greater London Authority. November 2005.

- The development of a methodology for assessing risk from surface flooding as part of the Drain London project. This aims to address flash flood risk by mapping flash flood hotspots and developing surface water management plans.
- The inclusion of policies on Flood Risk and Sustainable Design and Climate Change within the draft LDF Core Strategy. These promote the use of SuDS such as green roofs etc in developments and street enhancements. This document will be subject to external consultation and examination in public prior to adoption in 2011.
- Where feasible, planning permissions are subject to a 'green roof condition'. This would apply to any redevelopment proposals for City of London car parks and buildings.



Info Point B: Sustainable drainage systems^(a)

Sustainable Drainage Systems (SuDS) offer an alternative to traditional approaches to managing runoff from buildings and hardstanding. SuDS mimic natural drainage patterns and can attenuate surface water runoff, encourage recharge of groundwater, provide amenity and wildlife enhancements, and by employing pollutant trapping and degradation processes, SuDS can protect water quality.

SuDS approaches include:

- Preventive measures, e.g. 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,
- Permeable and porous pavements,
- Basins, reed beds and ponds designed to hold water when it rains.

It is important that consideration is given to the future maintenance requirements of SuDS, including the need to remove silt, and that space requirements for this purpose are allowed for in the design.

Green roofs^(b)

Green roofs are considered a SuDS technique. They are vegetated roofs, or roofs with vegetated spaces. Modern green roofs have largely developed in the last 50 years, with increasing sophistication to meet a growing range of needs. The main benefits of green roofs include:

- Reduced stormwater runoff, (and hence potential savings to developers, as the number of drainage outlets required on a building can be reduced),
- Reduced urban heat island effect (by reducing building heat loss and increasing evapotranspiration),
- Creating natural green spaces in urban areas,
- Reduced energy consumption and fuel costs, since green roofs provide cooling in summer and thermal insulation in winter,
- Benefits for biodiversity,
- Reduced air pollution,
- Extended roof life, since the green roof protects the roof's waterproofing membrane, almost doubling its life expectancy.

Many of these benefits help to address climate change risks. There are several examples of green roofs around the City, including the large roof garden above Cannon Street station and the landscaped walkways in the Barbican. Over recent years the City of London Corporation has encouraged developers to include extensive green roofs in their building designs, and several are now under construction. The City of London Corporation has worked with the British Council for Offices to produce a publication to raise awareness of green roofs^(c).

(a) South East England Climate Change Partnership, Sustainable Development Round Table for the East of England and London Climate Change Partnership. Adapting to climate change: a checklist for development. GLA, London. 2005.

(b) www.livingroofs.org and www.toronto.ca/greenroofs

(c) http://www.greenroofs.com/pdfs/sg-green_roofs_advice_note_corpoflondon.pdf, accessed on 03.11.09

4.4 What further actions are recommended?

Key adaptation actions to manage flood risks included in the City of London Corporation's Adaptation Action Plans are summarised below.



'No-regrets' measures deliver benefits that exceed their costs, whatever the extent of climate change.



'Low-regrets' measures are low cost, and have potentially large benefits under climate change.



'Win-win' measures contribute to climate adaptation and also deliver other benefits.

Research and monitoring



The City of London Corporation should work to identify and map flash flood 'hotspots' and assign responsibility for coordination and liaison on flood risk management in order to ensure its practical implementation.



The City of London Corporation should improve the monitoring and recording of gully overflows linked to heavy rainfall events and assess the capacity of the 72km of sewers managed by the City of London Corporation to cope with increasing rainfall due to climate change, as well as coordinating with the Thames Tideway Tunnel project.

Policy



The draft LDF Core Strategy includes policies on Flood Risk and Sustainable Design and Climate Change, which promote the use of sustainable drainage systems, such as green roofs, in developments¹⁸ and street enhancements. Sustainable drainage systems such as green roofs should be encouraged as part of new developments, redevelopments and major refurbishments through the LDF. Section 106 planning agreements should be used to secure long-term commitment to the management and maintenance of SuDs.



The City of London Corporation LDF should require that drainage systems in all developments have the capacity to cope with heavier rainfall events expected over their lifetimes, taking account of climate change.

Practical actions



The City of London Corporation should encourage businesses to consider relocating flood-sensitive IT equipment and archives to areas with low risk of flooding. The Contingency Planning Department should encourage businesses with assets and equipment that need to be on-site, to move them away from locations at higher risk of flooding, such as basements.



Developers should be encouraged to install sustainable drainage systems and green roofs in targeted flash flood 'hotspots' for new developments, redevelopments or major refurbishments.



The City of London Corporation should consider installing sustainable drainage systems, green roofs or green walls on City of London Corporation-owned car parks and buildings, when they are refurbished or replaced.



The City of London Corporation should examine a range of incentives to encourage sustainable drainage systems and green roofs.

¹⁸ For 'development' please read new developments, redevelopments and major refurbishments throughout this report.



Info Point C: Information on flood resilience for home owners and businesses

Information for home owners and businesses on flood resilience is available in the Association of British Insurer's (ABI) fact sheet on Flood Resilient Homes(a), ODPM's (now DCLG's) 'Preparing for Floods'(b) and the Environment Agency's 'Damage Limitation – how to make your home flood resilient'(c). There is also Environment Agency Standing Advice on flood risk.

CIRIA advice sheets: Improving the flood resistance of your home (d)

CIRIA has produced a series of advice sheets on improving the resilience of homes to the damaging effects of flooding. These include advice on assessing risk of flooding to a property. For householders whose property is at risk from flooding, the advice notes provide information on practical steps to prevent, or reduce the impact of, flooding in the future. The sheets are designed for residents who are skilled at DIY or a builder, and are also intended to be useful to a householder working with builders and surveyors if they are unable to carry out the work themselves. The advice sheets include guidance on:

- Using one-way valves in drainage pipes to prevent back-up of water into buildings,
- Using removable flood barriers and other removable flood protection products,
- Using flood-resilient materials,
- Locating electrical services and boilers above likely maximum flood level,
- Raising damp-proof courses.

(a) www.abi.org.uk > publications > flooding

(b) www.communities.gov.uk > building regulations > building regulations approved documents and associated guidance

(c) Damage Limitation – How to make your home flood resistant. www.environment-agency.gov.uk/subjects > flood > floodline >

(d) www.ciria.org/flooding > reducing the impact online flood library > flood factsheets > preparing for a flood

5. Managing water resources

5.1 Why act now?

The summer of 2006 demonstrated that action is needed to improve management of water resources. Due to climate change, summers are becoming hotter and drier and winters are getting wetter. Precipitation patterns are also altering, producing more intense, heavy rainfall events. This means the way in which water is captured is affected, as higher temperatures and lower rainfall reduce soil moisture and the chance to replenish groundwater supplies. Climate change is leading to more frequent droughts, with consequent reduced water availability.

The extensive media coverage of this issue in summer 2006 clearly shows the implications of inaction. Reduced water availability in the summer of 2006 led to a hosepipe ban across London. As reported in *The Evening Standard* on 29th September 2006, London suffered its worst drought in 70 years, after lower than average rainfall almost every month since October 2004. This affected not only individuals but also businesses. On 22nd May 2006, *The Independent* reported that the Horticultural Trades Association, which represents the garden industry, estimated that the hosepipe ban will cost its members £300m in lost sales. The prolonged drought in the summer of 2006 also led to a spate of fires in the South East with thirty acres of grassland lost in East London. The fires also caused traffic chaos as flames encroached on to roads and smoke was blown across major routes. On the 19th July 2006, *The Evening Standard* reported that the London Fire Brigade had to attend an increasing number of 'bush fires'.

5.2 What does it mean?

The UKCP09 climate projections indicate that under a high greenhouse gas emissions scenario for the 2050s, summers in London are likely to become drier by between 11% and 28%. In the extreme, they could be up to 40% drier. This could have far-reaching consequences, as there could be restrictions on water use for industrial, commercial and public use. Impacts also include a higher risk of fire on scrub and heathland. Lower rainfall, combined with rising temperatures, mean that river flows are likely to be lower in summer, which will raise water temperatures and affect water quality.

There is already pressure on water resources across the South East. As shown in Figure 12, the majority of Greater London has no additional water available, meaning that summer surface water is already fully committed. The supply-demand balance for water in London currently stands in deficit. The increasing impacts of climate change, as well as the expected increase in population in the London area will compound these problems unless actions are taken to manage water resources more wisely.

'Better weather for the ducks as worst of the drought is over'
The Daily Telegraph, August 18th, 2006

At the beginning of April 2006, hosepipe bans were imposed on 13 million people across the South East of England. Some water companies banned watering of sports grounds, washing cars and filling pools.

The heatwave triggered the hottest July on record and the driest July in seven years, causing the hosepipe bans to be put in place as water resources were low.

After 20 months of below-average rainfall in the South East, supplies were at 70% of average for the time of year. Reservoirs were at 77% capacity and groundwater levels were 27% lower than average.

Water UK ^(a) said that twice the normal rainfall was needed during the winter of 2006 to replenish groundwater levels fully.

Sales of water butts soared and aerial photographs of the South East showed that many gardeners did not attempt to keep their lawns green.

^(a) Water UK is the industry association that represents UK water suppliers.

'Help call over climate-change fires'

London Lite August 11th, 2006

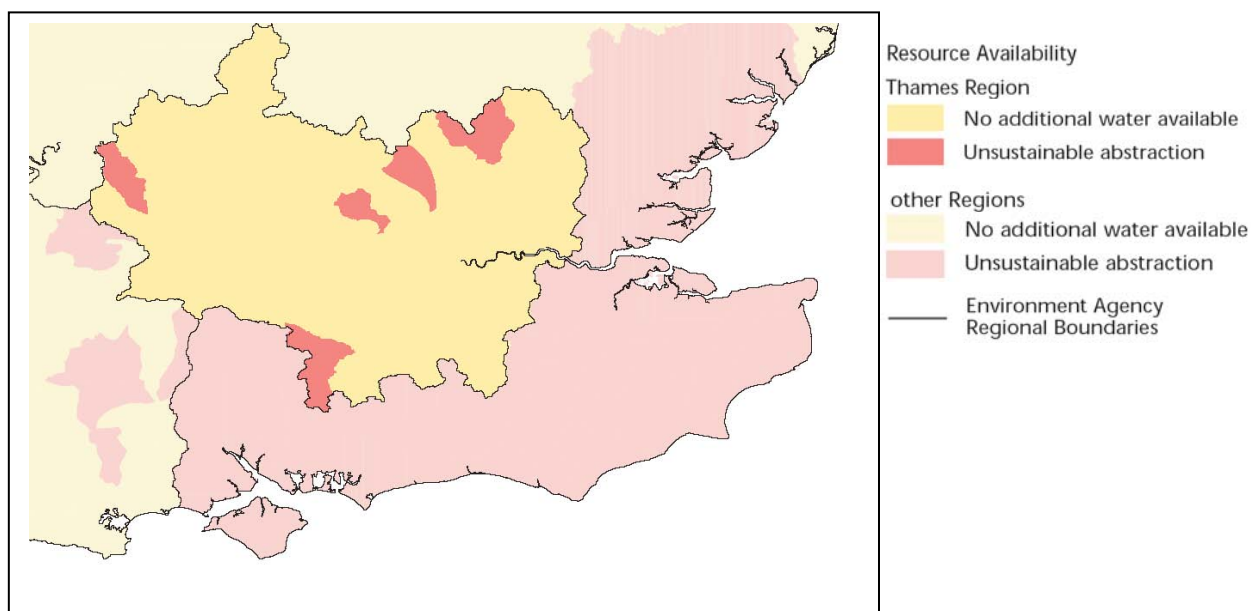
Climate change is increasing pressure on the fire and rescue services. Rescue services are facing additional pressures and substantial costs from the increase in the number of major fires due to dry conditions this summer. Resources were further stretched as the dry period was then followed by torrential rain causing flash flooding. The Union called for an immediate end to cuts in personnel and for an immediate cash injection of £60 million.

The Environment Agency has estimated that without further action to manage water demand, new strategic water resources may be required for London, under some scenarios, by 2020¹⁹.

Water comes from a variety of sources including directly from rivers, water captured and stored in reservoirs, and water pumped up from aquifers beneath the ground. Climate change is causing a reduction in river flows, and groundwater recharge of aquifers is occurring later in the season. Less water is being captured, as rainfall is occurring in more intense, heavy precipitation events. This runs rapidly off dry ground, rather than infiltrating and replenishing groundwater resources. This may lead to a change in how water is captured and stored.

Further details on water resource risks to the City due to climate change can be found in Appendix 1.

Figure 12: Summer water resource availability²⁰



5.3 What actions are already underway?

Action is underway at all levels from national to local authority level to manage water resources more efficiently.

National action

Under the Water Act 2003, all water companies have to prepare Water Resources Management Plans that detail current supply-demand balance and include water efficiency measures. The Environment Agency has published several advice notes on water efficiency measures and must be consulted on these plans. The Agency also has responsibility for ensuring the proper and efficient use of water resources.

The Government's Water Saving Group, which looked at improving the understanding and delivery of metering, came to a close in autumn 2008 after successfully improving the framework for water efficiency in England. Waterwise, one of the NGOs sitting on the Government's Water Saving Group, is currently developing 'Phase 2 of the evidence base'

¹⁹ Water Resources for the Future. A summary of the strategy for Thames Region. Environment Agency. March 2001.

²⁰ Water Resources for the Future. *Ibid.*

as a follow-up to its work for the Water Saving Group, which aims to provide better guidance and information for water companies on water efficiency rollout. All new houses in England are metered, and about one in every five households in London currently has a water meter.

In addition, the Climate Change Act includes provisions that give the Government the power to require public authorities and statutory undertakers (including water utilities companies) to report on how they have assessed the risks of climate change to their work, and what they are doing to address these risks.

London-wide action

The Mayor of London has addressed the need to manage water resources as part of both the London draft climate change adaptation strategy and the draft London Water Strategy. Both strategies propose a water management hierarchy for managing supply and demand in London. This includes addressing the pressure on water resources and managing water use through measures such as water metering in homes and flats, reducing the loss of water through better leakage management, and improving the efficiency of water use in residential and commercial properties. Greywater recycling and rainwater harvesting are also advocated. Detailed advice is given in the Mayor’s Supplementary Planning Guidance²¹ (SPG) on Sustainable Design and Construction.

Thames Water has released a draft Water Resources Management Plan that sets out water resource planning from 2010 to 2035, according to which demand management alone is not sufficient to balance supply and demand in the future. They have estimated that climate change will reduce water available for London by over 100 Ml/day by 2025, which will necessitate adaptation actions, some of which are outlined in Figure 13. Developing new water resources for London to address this need is an integral consideration of the London draft climate change adaptation strategy and draft London Water Strategy. The UK Government has given Thames Water consent to build a desalinisation plant in London. However, the Upper Thames Reservoir, initially proposed as Thames Water’s preferred option for increasing water resources, has been delayed by five years and may be reduced in size from 150 million cubic metres to 100 million cubic metres. In addition to these proposals, other resources are also being investigated to secure London’s water supply, including wastewater effluent reuse.

Figure 13: Thames Water actions to manage water resources in the face of climate change²²

Our response		
<p>In the medium term (2010-2015), we will:</p> <ul style="list-style-type: none"> • Assess and document the impacts of climate change (including extreme scenarios and weather events) on all activities and operational sites. • Continue to develop approaches to modelling that are consistent with those developed by our stakeholders and build the latest climate change scenarios from the UK Climate Impacts Programme (UKCIP) into our planning processes. • Implement our Water Resources Management Plan to safeguard water supplies from the impacts of climate change, with particular focus on leakage control, metering and water efficiency, and new water resources. 	<ul style="list-style-type: none"> • Enhance our sewerage design standards to increase capacity for projected additional flows. • Develop an enhanced sewerage network model to allow us to assess the impact of climate change on our network and to target capital expenditure more effectively. • Review and improve the resilience of our sites to flood events. • Continue to work in partnership with our stakeholders to promote understanding of climate change issues, options and solutions. 	<p>In the long term (2015-2035), we will:</p> <ul style="list-style-type: none"> • Continue to monitor the impacts of climate change on our activities and revise our adaptation responses as necessary. • Undertake full consideration of all environmental impacts, including energy use, in proposals for adaptive responses in order to minimise associated increases in carbon emissions. • Upgrade water treatment works to deal with poorer quality abstracted water as necessary. • Upgrade sewage treatment works to deal with reduced capacity of rivers for effluent dilution as necessary. • Continue to design our sites, and plan our operations, to adapt to increased flood risk.

²¹ <http://www.london.gov.uk/mayor/strategies/sds/spg.jsp>

²² Thames Water Strategic Direction Statement, 2009

Thames Water is also actively promoting water saving and efficiency with its customers, for instance through an educational website²³ that allows users to evaluate their water use and explore ways to decrease water use in their homes, businesses, or schools.

City of London action

The City of London Corporation has already implemented a number of actions to manage water resources more effectively:

- Water efficiency in new dwellings and flats will be controlled under the Building Regulations Requirement G2 which comes into force in April 2010. This requires that water consumption be limited to 125 litres per person per day using the 'Water Efficiency Calculator for New Dwellings' and a notice to that effect must be given to the Building Control Body. The calculator encourages the use of efficient fittings and appliances and 'non-wholesome' water such as harvested rainwater or reclaimed greywater for toilet flushing etc. This new Part G does not make provision for water efficiency in other types of building.
- Planning: The draft LDF core strategy policies on Utilities Infrastructure and Sustainable Development and Climate Change and Flood Risk include the requirement for buildings to incorporate measures to conserve water resources (and reduce impact on the drainage system). This document will be subject to external consultation and examination in public prior to expected adoption in 2011.
- City Surveyor's Department (energy team) are tracking water use within the Corporation and provide an Annual Report (only for the larger and medium operational buildings). This report identifies water use through Corporation's water bill and water meters.
- The City Property Advisory Team have a regular dialogue with Thames Water on the future needs for water supply in the City.
- The Contingency Planning team works to the National Drought Plan that is triggered by the government in times of drought.
- The 'Mind your own business' campaign was launched in 2009 to assist London's small businesses in developing business continuity plans.
http://www.cityoflondon.gov.uk/Corporation/media_centre/files2009/Small+Businesses+urged+to+Mind+Your+Own+Business.htm
- The LDF draft core strategy policy on Open Spaces and Trees includes the requirement that the design and management of open spaces is environmentally sustainable and take account of the effects of climate change. This document will be subject to external consultation and examination in public prior to expected adoption in 2011.
- All new City of London gardens are fitted with water-efficient irrigation systems. For example, in the City the use of container planting is minimised in order to allow natural drainage and to minimise the artificial watering required. However, old systems are not efficient and the Open Spaces department is seeking a more sustainable irrigation system.

²³ <http://www.thameswater.co.uk/cps/rde/xchg/corp/hs.xsl/3784.htm> accessed on 26.11.09

- The Open Spaces Department is beginning to favour drought-tolerant species already present 'on site' so that they have stock to replace less drought tolerant trees if they go into decline as a result of decreasing precipitation. This applies to maiden trees as well as new pollards.
- West Ham Park nursery grows over 250,000 bedding plants in a planting medium that has reduced need for watering by 50%. The nursery also provides its clients with drought-tolerant plants. All hanging baskets on buildings in the Park are automatically irrigated during the coolest parts of the day (early mornings and late evenings). All watering in the Park also takes place during the morning and again where required in the evening. The Park is currently investigating automatic irrigation for its formal gardens. (Open Spaces)
- The Open Spaces Department is currently working on a report on 'Climate change in Burnham Beeches', which will provide more information on how to manage existing environments in the face of climate change. The outcomes of this report will influence the next generation of site management plans.
- Sophisticated management and monitoring of water bodies is in place, for example at the Barbican Lakes and on Hampstead Heath, building up expertise in various technical solutions.
- Barley straw and 'bio-bombs' (bio-remediation treatment packs) are already in use within the City of London's open spaces. They are found to be most effective when combined with 'Aqua Blue Dye' which helps filter certain wavelengths of sunlight thus further enhancing its effects. Barley straw has been used as a means of reducing algae growth in several of the water bodies on Epping Forest. Approximately 500 bales of straw have been used over the last two years. At Hampstead Heath, Open Spaces have trialled the use of barley straw on blue-green algae scums on the worst affected ponds, a scheme developed following the advice of researchers at the Centre for Aquatic Plant Management, who suggest that the Heath scheme is the biggest in the country. In 2006 and 2007 the Men's Bathing Pond did not need to be closed due to toxic blue-green algae scums for the first time in 6 years. Hampstead's experience will help to inform other open spaces, should they also experience problems with blue-green algae.



Info Point D: Techniques for improving efficient use of water resources

Rainwater harvesting systems^(a)

Rainwater harvesting captures and diverts rainwater. The captured water can be used for irrigation purposes, car washing or toilet flushing, and is beneficial for two reasons:

- It reduces water demand and eases pressure on the mains water supply, reducing upstream energy and environmental costs,
- It helps to reduce the risk of flooding during storms by storing rainwater and buffering run-off before it reaches the drainage system.

Typically, rainwater is collected from rooftops and is diverted into barrels or large storage tanks. The amount of rainwater collected from a rooftop can be significant. A 93 m² (1,000 square feet) roof can catch 568 litres of water from rainfall of just 6 mm. A soakaway is sometimes used in conjunction with rainwater harvesting, rather than a storage tank. This is a low-lying area filled with stones, shingle or gravel, to allow water to drain away.

A rainwater harvesting system has been installed at a community resource centre 'The Hub' in London. The rainwater is collected from the roof and is stored in an underground tank for future use. It can then be redistributed for toilet flushing and plant irrigation, and is expected to contribute to a saving in mains water of around 50% per year^(b).

Greywater recycling^(c)

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 easing pressure on the mains water supply, reducing upstream energy and environmental costs. These systems require maintenance to ensure that they function correctly.

Reducing water use^(c)

The following measures reduce water use:

- 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 the amount of piping between boiler/hot water tank and tap, to reduce the need to 'run' the water,
- Install leak detection systems for major supplies.

(a) London Climate Change Partnership. Adapting to climate change: Lessons for London. GLA, London 2006.

(b) <http://www.arup.com/DOWNLOADBANK/download401.pdf>, accessed 06.11.06

(c) South East England Climate Change Partnership, Sustainable Development Round Table for the East of England and London Climate Change Partnership. Adapting to climate change: a checklist for development. GLA, London 2005.

5.4 What further actions are recommended?

Key adaptation actions to manage water resources included in the City of London Corporation's Adaptation Action Plans are summarised below.



'No-regrets' measures deliver benefits that exceed their costs, whatever the extent of climate change.



'Low-regrets' measures are low cost, and have potentially large benefits under climate change.



'Win-win' measures contribute to climate adaptation and also deliver other benefits.

Policy



The City of London LDF draft core strategy policies on Utilities Infrastructure and Sustainable Development and Climate Change and Flood Risk include the requirement for buildings to incorporate measures such as those shown in **Info Point D** to conserve water resources (and reduce impact on the drainage system). The City of London Corporation should investigate the feasibility and cost of incorporating rainwater harvesting systems in its operational properties, gardens and large open spaces where appropriate.



The City of London LDF should require rainwater harvesting and greywater recycling, where appropriate, in all new developments.

Practical actions - the City of London Corporation:



Should develop a coordinated and sustained awareness-raising campaign aimed at City businesses, property developers and residents regarding water use and water efficiency.



Should work with Thames Water Utilities to discuss contingency planning for vital City functions in times of extreme drought.



Should investigate the feasibility of installing rainwater harvesting systems in its market buildings, gardens and large open spaces.



Developers should, where feasible, design and install drought-resistant landscaping schemes and 'low water gardens' in open spaces that require minimal irrigation. The Open Spaces Department should investigate opportunities to improve water efficiency and ensure that drought-tolerant species are planted in appropriate places.



The City of London Corporation should consider the use of 'bio-bombs' or barley straw in water courses when needed to absorb nutrients and prevent algal blooms.

6. Managing heat risks and air pollution

6.1 Why act now?

Climate change is leading to increasing temperatures – higher average temperatures are being experienced and also many more extremely hot days. Summer heatwaves are becoming more frequent and more intense, and despite the unusually severe winter of 2010, the trend is for less severely cold winter weather. Research by the Met Office has demonstrated that the extreme temperatures experienced in the summer 2003 heatwave will be normal by the 2040s and will be considered ‘cool’ by the 2060s²⁴. Air quality is also a concern as increasing temperatures and prolonged hot periods are associated with summer ozone episodes²⁵. The effects of prolonged high temperatures were seen across the capital during the summer of 2006 and demonstrate the need to take action to manage heat risks.

On July 20th 2006, the Guardian reported that temperatures on board London buses had exceeded 50°C. Scores of schools closed early, including ten in central London, and hundreds of schools cancelled sports day amid fears for children's health. Transport disruption was also reported on July 20th 2006 in The Times, when trains were delayed as speed restrictions were imposed and a bridge would not close, after its metal parts expanded. On July 18th 2006, the Evening Standard recorded temperatures of 52°C on buses and 47°C on the underground system. In the same month, high temperatures affected health services in older hospitals that were not equipped with cooling systems. According to the London LCLIP, this may have affected patient comfort.

Business is also greatly affected - UK employers lost an estimated £154m a day in productivity during one week of the July 2006 heatwave, due to travel disruption and staff arriving late, according to the Centre for Economics and Business Research. It is estimated that work levels dropped by almost a third when temperatures soared to more than 30°C. Occupational health provider Active Health Partners (AHP) estimated that UK businesses lost £119m through absenteeism when temperatures topped 35°C on 19 July 2006.

The most significant effects of the 2003 heatwave in London were the number of deaths, especially amongst the elderly. Overall, there were approximately 600 all-age extra deaths in London²⁶ (see Figure 14 below).

‘The city that couldn't sleep’
The Evening Standard, July 19th,
2006

The heatwave caused roads to melt and gritting lorries had to be dispatched to spread crushed rock on recently laid roads to stop tarmac sticking to cars.

The London Fire Brigade said it had to attend an increasing number of ‘bush fires’.

Speed restrictions caused disruption on the Metropolitan and District lines. These were put in place to reduce the risk of tracks buckling in the heat.

The Department for Environment, Food and Rural Affairs issued a smog warning as smog levels had reached dangerously high levels.

The Department of Health said all hospitals had put their hot weather plans into action and GPs should have identified people most at risk from the heat and should have made arrangements for them to be checked regularly.

²⁴ Climate change and the greenhouse effect. A briefing from the Hadley Centre. The Met Office Hadley Centre. December 2005.

²⁵ Health effects of climate change on the UK. Department of Health. 2001.

²⁶ London Urban Heat Island: A summary for decision makers. Greater London Authority. October 2006.

There is still some uncertainty regarding the link between climate change and air quality but reports from the summer of 2006 have certainly shown that asthma sufferers were particularly badly affected during the heatwave.

On 10th August 2006, the Evening Standard reported that 434,000 of the capital's population are now being treated for asthma. The article reported that asthmatics suffered badly during the heatwave of summer 2006, as asthma attacks were triggered by increased pollution and thunderstorms. Doctors advised some workers in London who suffer from asthma that they should move out of the city. The cost to the NHS of treating asthma sufferers is £889m a year.

6.2 What does it mean?

Temperatures are increasing due to climate change, which means there are greater health risks, risks of damage to assets and infrastructure, transport disruption and business costs. Temperatures in the centre of London are several degrees higher than at the edge of the city due to the Urban Heat Island (UHI) effect, as Figure 15 shows. This makes London particularly vulnerable to increasing temperatures, since during heatwaves the UHI prevents the city from cooling down. As a result, night time temperatures are maintained at a level that affects human health and comfort. This is a huge factor in heat mortality and morbidity, especially for 'at risk' groups such as the young, the elderly and those with certain health conditions.

Increasing temperatures have wider implications for the business community. They can lead to passenger discomfort on public transport together with health and safety concerns for passengers. Transport can be disrupted as hotter summers cause damage to assets and infrastructure, such as buckled railway lines and melting roads. The knock-on impact of this to business can be significant as commuters are disrupted. More frequent heatwaves increase risks of heat stress, dehydration, heat-related mortality, skin cancer and eye cataracts for outdoor workers. For indoor workers, building thermal comfort and consequent heat risks to occupants is becoming more of an issue. Increased temperatures will reduce comfort of occupants in commercial and public buildings, leading to lower productivity, potential business disruption and heat stress. Additional business impacts may arise from effects on IT infrastructure, which can overheat and fail in extreme temperatures.

There will be an increase in demand for essential services such as social, health and emergency services to cope with these impacts. The Environmental Services Department at the City of London Corporation will likely have to cope with increases in vermin and risks of food poisoning due to increasing temperatures. Energy demands for cooling will increase in hotter weather, potentially causing overload of the electricity grid and power black-outs.

'Heatwave puts IT leaders in hot seat as systems wilt'
Computer Weekly, August 1st, 2006

The prolonged heatwave during July 2006 affected IT departments and data centres as power supply interruptions caused loss of vital cooling systems.

The London site of Globix, a data-centre operator, was protected by back-up generators, but others were not so lucky.

A local authority was forced to turn off non-essential servers and a leading media firm suffered a server room air conditioning failure. These organisations experienced minimal impacts because business continuity plans were in place.

Power cuts hit UK businesses
IT Week, July 31st, 2006

Major internet services and IT companies were hit by power cuts and blackouts in the UK during the hot weather in July 2006.

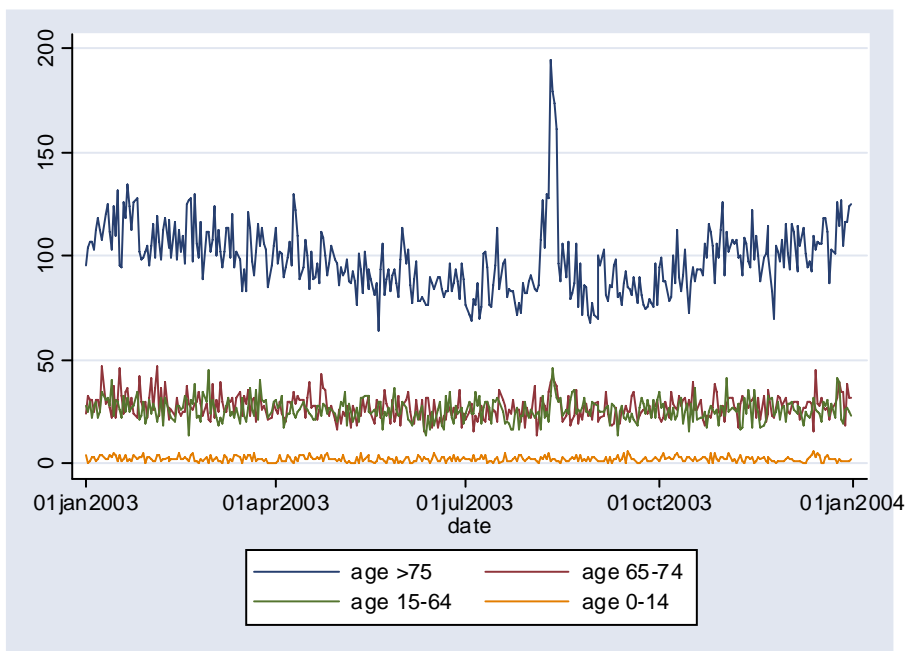
Yahoo UK suffered service disruptions and Level 3's London data centre was temporarily without power, affecting several other companies.

Heatwaves lead to various consequences on the City. Travel can be disrupted as roads melt and train lines buckle. While this has not yet halted travel like a snow event, it has slowed the commute to work as speed restrictions are put in place on some underground lines. High temperatures have also led to concerns over City infrastructure such as the waste gantry located at Walbrook Wharf, which started to buckle in the heat of summer 2006.

Heatwaves can also create the conditions for high air pollution levels which are exacerbated in the city as the heat and pollution gets trapped. Exposure to ozone and smog can irritate and cause inflammation of airways and can also increase a person's susceptibility to respiratory conditions.²⁷

Further details on heat and air pollution risks to the City due to climate change can be found in Appendix 1.

Figure 14: Daily mortality in Greater London in 2003²⁸



'Climate change blamed for Legionnaires' disease surge'

The Independent, October 18th, 2006

Record levels of Legionnaires' disease have been reported by the Health Protection Agency in the summer of 2006.

The Health Protection Agency believes this is the first example of an increase in infectious disease in Britain driven by climate change.

Ideal breeding conditions for the Legionella bacteria were thought to have been provided by a hot July followed by a wetter than normal August.

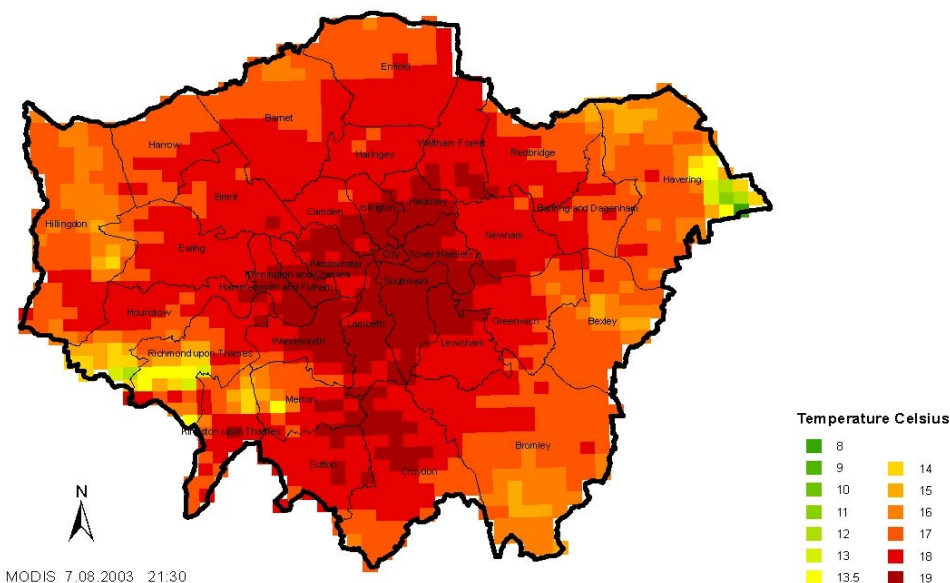
There were 128 cases of Legionnaires' in August 2006. This is the highest since records began in 1980, and more than double the total number of cases in August 2005.

²⁷ London's Urban Heat Island. A summary for decision makers. Greater London Authority. October 2006.

²⁸ Sari Kovats, Centre on Global Change and Health, London Schools of Hygiene and Tropical Medicine. GLA Urban Heat Island Project presentation. March 2006.

Figure 15: London's Urban Heat Island: Distribution of surface temperature across London at 21:30 during the heatwave on August 7th, 2003^(a).

Temperature distribution in London, August 2003



(a) London's Urban Heat Island: A summary for decision makers. Greater London Authority. October 2006.

6.3 What actions are already underway?

Action is underway at all levels from national to local authority level to manage heat risks and air pollution.

National action

In 2005, the UK's National Heatwave Plan was introduced by the Department of Health. The UK Met Office provides weather forecasting for the Heatwave Plan. Strategic health authorities, primary care trusts and local authorities then develop plans for their local setting.

The National Air Quality Strategy was published in 2000 and describes the plans drawn up by the government to improve and protect air quality in the UK in the medium-term. Local authorities under local air quality management (LAQM) need to work towards achieving the objectives within the strategy by reducing levels of seven key air pollutants.

London-wide action

The Greater London Authority (GLA) has published research on how to manage the intensification of London's Urban Heat Island²⁹. The research supports the need for more green roofs and street trees. Green roofs provide multiple benefits including reducing the Urban Heat Island effect and keeping buildings cool (see **Info Point E** below). The GLA has published a paper on green roofs and there is encouragement for them in new buildings in the Further Alterations to the London Plan, the Supplementary Planning Guidance on Sustainable Design and Construction and the Checklist for Development published with the South East and East of England regions. The GLA has identified and mapped 'areas of

²⁹ London's Urban Heat Island. A summary for decision makers. Greater London Authority. October 2006.

deficiency', where the public does not have access to good quality green space, and has provided guidance on how to improve access to nature in these areas³⁰.

The Mayor's Air Quality Strategy sets out policies and proposals to reduce air pollution. The Mayor's aim is to improve London's air quality to the point where pollution no longer poses a significant risk to human health. The GLA's air quality and cleaner transport initiatives should reduce emissions from transport and improve general air quality, and consequently reduce environmental stress on Londoners.

The London Air Quality Network (LAQN) was formed in 1993 to coordinate and improve air pollution monitoring in London. The network covers thirty-three London local authorities and provides bulletins on air pollution levels³¹.

Action by the City of London Corporation

The City of London Corporation is implementing a number of actions which can help to manage overheating risks and air pollution;

- The City Surveyor's Department (Energy Team) is in the process of implementing a 'set rule temperature policy' in the Guildhall complex, where a maximum temperature is set for air conditioned spaces and a maximum temperature is set for inside heating. The maximum legal heating limit is 19°C in offices.
- Commercial buildings currently apply a system of 'consequential improvements', which comes from Regulation 17D of the Building Regulations³², whereby the owner of a building must spend 10% of the cost of principal works to carry out improvements to thermal elements such as upgrading heating controls, replacing windows or installing energy efficient lighting, which give a payback time of 15 years. This system does not currently apply to dwellings, but Part L of the Building Regulations has been subject to a review this year and consequential improvements may cover dwellings when the new document comes into force in 2010.
- CPAT has been in ongoing contact with occupiers, developers and EDF Energy to ensure appropriate capacity and resilience is built into the power networks. CPAT has informed EDF of future growth scenarios and advised where development activity will occur. CPAT provided a co-ordinated response from City businesses and the property industry to the Distribution Price Control Review document that EDF issued in 2008, as this review forms the basis for the tariff review by the industry regulator, Ofgem.
- 2006 was the first year that summer energy demand outstripped winter energy demand. The majority of this is due to cooling systems. CPAT continue to meet with EDF on a regular basis to review issues with distribution of electricity supply and customer connections and to understand more about capital works and network improvement programmes. CPAT will also co-host regular stakeholder seminars with EDF, which will be attended by developers and occupiers throughout the Square Mile. CPAT is looking at the resilience of substations and the need for new substations.

³⁰ GLA: Improving Londoners' Access to Nature. See <http://www.london.gov.uk/mayor/planning/docs/access-to-nature.pdf> accessed on 10.11.09

³¹ <http://www.londonair.org.uk/london> accessed on 06.11.06

³² This is triggered when a building this size either has an extension, has an initial provision of any fixed building services, or has an increase to the installed capacity of any fixed building services installation.

- The Department of Children and Community Services, Social Care, holds a list of vulnerable people. This list is also supplied to the Primary Care Trust. During heatwaves, Social Care ensures that all these clients are visited daily to ensure their welfare. They are also supplied with a leaflet giving advice on 'Looking after yourself in hot weather'.
- Sir John Cass School has its own plan in place for managing heatwave conditions and guidance notes have been provided for nurseries.
- The City of London's Drinking Fountain Initiative involves the repair of historic drinking fountains and installing new fountains in the City. Planning is working with Thames Water and the Drinking Water Association. Approval has recently been given to a new drinking fountain to be installed in Carter Lane Gardens
- The City of London Corporation has encouraged TfL to install displays outside tube stations, showing underground temperatures.
- In light of the fact that Stoke Common will be increasingly at risk from fire if the predicted climate changes occur in the Southeast of England, Open Spaces are already working very closely with the Fire Brigade and Police to ensure that they have a workable fire plan that ensures speedy and effective response to minimise harm to the site and its visitors. Open Spaces have also worked with the Fire Brigade to provide electronic maps of Epping Forest with all access points referenced and all barrier gates marked to ensure efficient response to fires. Forest Keepers have limited fire fighting facilities but have a good liaison with all local Fire Brigade and all relevant risk assessments include heat wave factors.
- The City of London Corporation adheres to the National Heatwave Plan for England, which is triggered by government notification when temperatures cross a certain threshold. It was triggered for 3 days at Level 2 in summer 2009 and worked very well.
- The Department of Environmental Services (DES) has completed a computer modelling exercise to establish the potential impact of a change in climate on the air quality in the City. Overall, pollution levels are predicted to increase, but not by a significant margin. According to this research, pollution incidents (days of high pollution that are linked to the weather) are likely to decline during winter months but are likely to increase during the summer.
- DES currently operates a free pollution alert system known as *AirText*. Vulnerable people, those with asthma or heart related health problems, are invited to register for the service. They are notified by text message, voice message or email if the pollution levels are predicted to be high the following day. As a result, service users have the information to manage any potential symptoms that may be caused by poor air quality. The service is currently funded by the European Space Agency but the funding is due to expire soon.
- DES have a business continuity plan and contingency plan for waste collection.



Info Point E: Adaptation measures to manage heat risks and air pollution

Adaptation measures should be considered for individual buildings and also at the wider urban scale.

Building design^(a)

Building design can assist in reducing temperatures. Shading windows by installing shutters or blinds reduces solar gain and so internal heat build-up is reduced. Extending roofs can also provide shading to a building. Heavier weight building materials like concrete and stone have a tendency to keep buildings cooler in the day, by virtue of their thermal mass. Chilled ceilings and chilled beams can also be used.

Green roofs

Green roofs provide multiple benefits, including reducing the urban heat island effect and helping to keep buildings cool. (See Info Source B above for further details on green roofs.)

Cool roofs

A cool roof or 'white roof' can reduce the temperature of a building's roof dramatically, and hence also reduce the Urban Heat Island effect. Cool roofs have a coating of light-coloured water sealant, which can last 10 to 20 years, depending on the quality of the coating and the thickness applied. These white surfaces reflect and radiate a lot more heat than dark roof surfaces, and in the US they have been demonstrated to stay up to 40°C cooler^(b). By limiting the amount of absorbed solar energy, damage from ultraviolet radiation and daily temperature fluctuations – which cause repeated contraction and expansion – can be reduced. Both flat and sloping roofs can be made into cool roofs.

Cool roofs do not offer all the advantages of green roofs related to stormwater runoff, air quality and nature conservation, but they demand less investment. Furthermore, cool roofs are most effective on buildings with high roof-to-volume ratios, such as one or two storey buildings.

Cool pavements^(c)

Many of London's roofs, streets and pavements are typified by dark surfaces. 'Cool pavements' are comprised of light coloured material with high solar reflectivity and good water permeability. This is potentially a very effective way of reducing high urban temperatures as the amount of solar energy absorbed is decreased. 'Cool pavements' also encourage water storage and thus allow evaporative cooling.

Planting trees and vegetation

Trees can provide significant benefits in urban areas as they not only provide shade but can also reduce air pollution and the Urban Heat Island effect. Trees and vegetation are natural cooling systems as they convert water contained in their foliage into water vapour, which is released into the atmosphere by evapotranspiration. It has been estimated that, in certain locations, evaporatranspiration can result in the reduction of peak summer temperatures by 1 – 5°C^(c).

However, trees will need to be selected very carefully in the face of climate change, for example drought-resistant trees should be planted. Sufficient rooting space and an adequate water supply also need to be considered, as trees can aggravate or cause subsidence in certain soils^(d).

(a) Beating the heat: keeping UK buildings cool in a warming climate. Hacker, J., Belcher, S., and Connell, R. UKCIP Briefing Report. 2005.

(b) www.epa.gov/heatisland/strategies/coolroofs.html accessed on 06.11.06

(c) London's Urban Heat Island. A summary for decision makers. Greater London Authority. October 2006.

(d) BRE. Subsidence damage to domestic buildings. 2000.



Info Point E: Adaptation measures to manage heat risks *continued*

Heat Health Warning Systems (HHWS)^(e)

Heat Health Warning Systems predict the risk of dangerous heatwaves using meteorological information. Health departments and other agencies then implement intervention activities with the public. Philadelphia in the USA has introduced a HHWS which alerts the city's population when weather conditions pose risks to health. Measures that are put in place include a buddy system where media announcements encourage friends, relatives and other volunteers to make daily visits to vulnerable people during the hot weather. Television and other communication media networks publicise the weather conditions, along with information on how to avoid heat-related illnesses. A 'Heatline' was also created to provide information and counselling to the general public on avoidance of heat stress. Other adaptation measures included creating 'cool' centres in air conditioned public buildings for vulnerable people.

(e) London Climate Change Partnership. Adapting to climate change: Lessons for London. Greater London Authority, London. 2006.

6.4 What further actions are recommended?

Key adaptation actions to manage heat risks and air pollution included in the City of London Corporation's Adaptation Action Plans are summarised below.



'No-regrets' measures deliver benefits that exceed their costs, whatever the extent of climate change.



'Low-regrets' measures are low cost, and have potentially large benefits under climate change.



'Win-win' measures contribute to climate adaptation and also deliver other benefits.

Research and monitoring



The City of London Corporation should investigate risks of heat stress to residents of City of London Corporation-owned housing. The City of London Corporation should identify residents who are most vulnerable to heat stress (elderly, young and those with existing health problems) and ensure that they are regularly visited during heatwaves.



The City of London Corporation's Open Spaces Department should work with the Emergency Services to undertake an analysis of the relationship between weather conditions and fire risk in open spaces and parks and investigate the prevalence of these conditions now and in the future with climate change.

Policy



The LDF draft Core Strategy policy on Sustainable Development and Climate Change requires the highest viable standards of sustainability to be integrated into the design of each proposed development. As part of sustainable design, buildings should be designed to provide a comfortable internal environment with the least use of energy over their lifetimes, taking account of rising temperatures due to climate change. Cooling systems should maximise use of natural ventilation and low-carbon cooling techniques.

Practical actions



The LDF draft core strategy policies on Open Spaces and Biodiversity include requirements to enhance biodiversity. The City of London Corporation should ensure that where possible these enhancements to biodiversity include increased planting for shade in open spaces.



The City of London Corporation should liaise with electricity providers to the City to ensure security of supply for City buildings and infrastructure, taking account of climate impacts on seasonal demands.



The City of London Corporation should encourage Transport for London and tube companies to do everything possible to manage high temperatures on the underground and make the underground environment more comfortable.



The City of London Corporation, in partnership with other organisations, should examine the provision of 'cool' centres (cooled public buildings) during heatwaves, with extended opening hours for vulnerable people, and should include them in emergency plans.



The City of London Corporation should work with strategic health authorities and primary care trusts to implement the local heatwave plan in the City and to include actions to manage air pollution health risks in these plans, as high air pollution levels often coincide with heatwaves.



The City of London Corporation should build awareness among workers and residents over the wider impacts of high temperatures, such as increased risk of bacterial contamination of fresh food and the greater potential for noise due to increased use of outdoor space in warm temperatures.

7. Managing ground conditions

7.1 Why act now?

Subsidence and heave are already problems in parts of London and the risks are increasing due to climate change. The major cause of subsidence is clay shrinkage, which happens as the ground dries, as summers get hotter and drier. It can be exacerbated by tree roots sucking moisture out of the soil. Heave occurs when soils absorb water and swell, causing ground movements, and is likely to be worsened in wetter winters due to climate change. The number of incidents of subsidence and heave is rising dramatically in the UK, particularly in the South East. Alternate wetting of clays in winter and drying of clays in summer may cause increased ground movement, resulting in increased potential for damage. This not only damages buildings but can also affect roads, underground pipes and cables.

In 2003, when the UK experienced a prolonged heatwave, insurers were left with close to £400 million in subsidence claims. The Halifax's subsidence team reported that during the summer of 2003, subsidence claims rose by about a quarter.

Over the past 30 years, subsidence claims following summer droughts have been increasing steadily, accounting for £3.3 billion of insurance claims over the 1990s³³. Figures from the Association of British Insurers show that it anticipates household insurance costs to rise by between £3 billion and £12 billion by the 2080s as claims increase due to climate change.

7.2 What does it mean?

Subsidence is being aggravated by the hot, dry summers brought by climate change. Subsidence and heave of clay-based soils leads to damage to assets and infrastructure above and below ground. There is a risk that there may be an increase in the mobility of contaminants in the ground caused by changes in soil behaviour due to drying out and/or changing groundwater levels. Other specific risks such as rising insurance premiums or rising insurance policy excesses in insurance schedules also need to be considered in high risk areas.

As noted above, trees can enhance subsidence risks. As a result, it is important to know how to plant the 'right tree in the right place', considering issues such as subsidence, root penetration, water use, longevity and growth under a changing climate³⁴. These issues need to be balanced against the benefits of trees in providing cooling, shade and reduction of air pollution.

As climate change intensifies, adaptation measures to manage subsidence and heave will be required and some new buildings may require deeper foundations. However, this does not necessarily mean more expensive buildings in the long-term. According to research, climate-proofing new buildings in southern England against subsidence may only cost £32 million, compared to a possible annual cost of £200 - 400 million from damage claims if no action is taken³⁵.

Subsidence and heave does not appear to be a problem in the Square Mile, but property owned by the City of London Corporation elsewhere in London is potentially at risk. Further

³³ UKCIP Climate change and local communities: How prepared are you? An adaptation guide for local authorities. UKCIP. 2003.

³⁴ London Climate Change Partnership. Adapting to climate change: Lessons for London. GLA, London. 2006.

³⁵ Adapting to climate change: a checklist for development. South East Climate Change Partnership, London Climate Change Partnership and Sustainable Development Roundtable for the East of England. November 2005.

details on risks to ground conditions for the City of London Corporation due to climate change can be found in Appendix 1.

7.3 What actions are already underway?

Action is underway nationally and across London to manage ground conditions.

National action

The government upgraded Building Regulation Structure A in 2004 to take account of climate change. It now requires new buildings on clay soils to have foundations to a depth of 0.75m, revised from 0.5m previously.

Research³⁶ suggests that if the foundation depth was 1m then this would be sufficient to eliminate subsidence risk in the face of climate change until 2100.

London-wide action

Thames Water Utilities is working across London on its Victorian Mains replacement scheme, through which underground metal Victorian water pipes are being replaced with flexible plastic piping. This will reduce leakage and burst associated with old metal pipes.³⁷

The Mayor's Supplementary Planning Guide (SPG) on Sustainable Design and Construction addresses subsidence risk by stating that consideration needs to be given to the design of foundations and to the positioning and choice of trees³⁸.

7.4 What further actions are recommended?

Key adaptation actions to manage risks to ground conditions included in the City of London Corporation's Adaptation Action Plans are summarised below.



'No-regrets' measures deliver benefits that exceed their costs, whatever the extent of climate change.



'Low-regrets' measures are low cost, and have potentially large benefits under climate change.



'Win-win' measures contribute to climate adaptation and also deliver other benefits.

Practical actions



When designing landscaping, the City of London Corporation and developers should choose the types and locations of trees carefully, considering how subsidence and root penetration will be affected by climate change.



The City of London Corporation should keep a watching brief on the incidence of subsidence in City of London-owned property outside the City, to ascertain whether the problem increases as the climate changes. When underpinning existing buildings already affected by subsidence, building owners should ensure the underpinning is sufficient to cope with climate change.

³⁶ Driscoll and Crilly. Subsidence damage to domestic buildings: Lessons learned and questions remaining. BRE and FBE. 2000.

³⁷ http://www.thameswater.co.uk/en_gb/Downloads/PDFs/Network_Upgrade_-_Replacing_London_Victorian_Mains_FINAL_July05.pdf accessed on 02.11.06

³⁸ <http://www.london.gov.uk/mayor/strategies/sds/docs/spg-sustainable-design.pdf> accessed on 02.11.06

8. Cross-cutting issues

8.1 Why act now?

Climate change has impacts for all sectors and the impacts often have far-reaching consequences. Public sector decision-makers have a responsibility to ensure that a holistic approach is taken to address these risks, to ensure that adaptation measures in one area do not have unintended consequences elsewhere.

8.2 What actions are already underway?

Action is underway at all levels to address the cross-cutting nature of climate risks.

National action

The UK Climate Change Act was passed in 2008³⁹, making the UK the first country in the world to have a legally binding long-term framework to cut carbon emissions. It also creates a strategic framework for enhancing the UK's ability to adapt to climate change impacts. This will be done through:

- carrying out a UK wide climate change risk assessment every five years,
- putting into place a national adaptation programme that must be reviewed every five years to address the most pressing climate change risks,
- giving the UK Government the power to require public authorities and statutory undertakers (companies like water and energy utilities) to report on how they have assessed the risks of climate change to their work, and what they are doing to address these risks,
- requiring the UK Government to publish a strategy outlining how they will use this power and identifying priority organisations covered by it,
- providing, through the UK Government, statutory guidance on how to undertake a climate risk assessment and draw up an adaptation action plan,
- creating an Adaptation Sub-Committee of the independent Committee on Climate Change, to oversee progress on the Adapting to Climate Change Programme and advise on the risk assessment.

Consultation on the Adaptation Reporting Power of the UK Climate Change Act 2008 finished in November 2009, and according to the Climate Change Act timetable, first reports from authorities will be published by the end of 2011. The GLA has been identified as a priority reporting authority for this first round of reporting⁴⁰.

The Government's Adapting to Climate Change Programme is a cross-Government programme, coordinated by Defra. It brings together the work already being led by Government and the wider public sector on adapting to climate change, and aims to coordinate and drive forward the development of the Government's work on adaptation in the future. As part of the programme, government departments will produce Adaptation Plans by spring 2010, setting out how they are assessing and managing the risks from climate change. The programme is divided into two phases. Phase 1, from 2008-2011, aims to:

³⁹ The Climate Change Act, Defra. See <http://www.defra.gov.uk/environment/climate/legislation/index.htm> accessed 26.12.09

⁴⁰ See <http://www.defra.gov.uk/environment/climate/documents/rp-list.pdf> accessed on 10.12.09

- Provide evidence about the impacts of climate change,
- Raise awareness and help others take action,
- Ensure and measure progress,
- Embed adaptation into Government policy and process.

Phase 2, from 2012 onwards, will produce the National Adaptation Programme, as required by the Climate Change Act.

The Department for Communities and Local Government (DCLG) published a new planning policy statement, 'Planning and Climate Change'⁴¹ in December 2007 as a supplement to Planning Policy Statement 1. This policy statement covers both climate adaptation and mitigation. DCLG has also published a Code for Sustainable Homes which outlines better management of surface water, sets minimum standards for water efficiency, and also covers energy efficiency.

London-wide action

The Greater London Authority is preparing a London Climate Change Adaptation Strategy, which identifies the key risks to London and Londoners and prioritises the actions necessary to manage those risks. The strategy focuses on providing strong policy directions on how to address flood risk, water resources, overheating, health impacts, London's economy and infrastructure, and is one of the first comprehensive climate change adaptation strategies produced by any major city worldwide. It also identifies economic opportunities for London to capitalise on its leading position as a global centre of skills and knowledge required to prepare for predicted impacts.

The Mayor has also published Supplementary Planning Guidance on Sustainable Design and Construction, which includes detailed advice on addressing climate adaptation⁴², as well as a Best Planning Guidance on Health Issues in Planning in June 2007 that includes a section on how climate change will increase the following health risks: flooding, overheating, water shortages, subsidence and heave, windstorms⁴³. The GLA has also developed a Climate Change Adaptation Strategy.

The London Climate Change Partnership has been set up to help ensure that London is prepared for its changing climate. It comprises key stakeholders across different sectors of London government and business, including the City of London Corporation.

Action by the City of London Corporation

The City of London Corporation is implementing a number of actions which can help to manage cross-cutting issues;

- The Sustainability Appraisal of the LDF tests policy options against the objective "to anticipate, prepare for and adapt to the impacts of climate change"
- The Open Spaces Department and the Department of Environmental Services have educated their staff in sun-safety. There are sun cream stations in some of the mess rooms for staff to use and the department has also issued sun glasses and

⁴¹ See <http://www.communities.gov.uk/documents/planningandbuilding/pdf/ppclimatechange.pdf> accessed on 3.12.09

⁴² <http://www.london.gov.uk/mayor/strategies/sds/docs/spg-sustainable-design.pdf> accessed on 26.11.09

⁴³ <http://www.london.gov.uk/mayor/strategies/sds/docs/bpg-health.pdf> accessed on 26.11.09

hats. Notices go up on the notice boards when it is hot, to advise the public about drinking water and protecting themselves.

- The City of London Corporation hosted a London Climate Change Partnership event discussing adaptation issues related to biodiversity.

8.3 What further actions are recommended?

Key cross-cutting adaptation actions included in the City of London Corporation's Adaptation Action Plans are summarised below.



'No-regrets' measures deliver benefits that exceed their costs, whatever the extent of climate change.



'Low-regrets' measures are low cost, and have potentially large benefits under climate change.



'Flexible' measures are useful for dealing with uncertainties in the extent of longer-term climate change.

Policy



The City of London Corporation should thoroughly address climate adaptation in the Sustainability Appraisal of the LDF.



The City of London Corporation should review design standards and codes of practice for assets, infrastructure and services, to identify those that include climatic factors. Based on the outcome of the review, the City of London Corporation should consider upgrading design standards and codes of practice where required to take account of projected climate changes.



The City of London Corporation should encourage emergency planners, emergency services, and other stakeholders to assess and prioritise extreme events risks (e.g. flood, heatwave) taking account of climate change, and develop and implement related contingency plans.



The City of London Corporation should develop Supplementary Planning Guidance for the LDF that focuses specifically on climate change adaptation, in the event that the GLA's guidance does not adequately cover issues relevant to the City of London.



The City of London Corporation should integrate adaptation considerations into purchasing and tendering decisions.



The City of London Corporation should review existing measures in place for managing health and safety risks to people when they are outside, to see whether they provide sufficient protection against changing climate risks, such as educating outside staff on sun safety and ensuring that clothing has a sufficient sun protection factor (SPF), or providing shade in school playgrounds.



The City of London Corporation should monitor climate change impacts on biodiversity and link in to research on the issue.



The City of London Corporation should ensure that resourcing and delivery of waste management services is appropriate to cope with the added threats from climate change.

9. Opportunities

Climate change presents opportunities to develop new markets, products and services in response to changing customer expectations and needs.

Those organisations that are first to act on these opportunities can gain an 'early mover' advantage on their competitors. If opportunities are not realised then there could be loss of market share. Evidence of climate-resilience enhances an organisation's reputation with its stakeholders, provides security for investment and opportunities for reduced insurance premiums.

Some of the opportunities are highlighted below and additional examples are provided in Appendix 1.

- In terms of health benefits, increasing winter temperatures will mean a reduction in winter cold-related morbidity and mortality,
- There is a potential for an increase in visitors and tourists to London, as other destinations in southern Europe become less attractive in the height of summer due to climate change,
- The construction industry could benefit from an increased number of available construction days, as summer rainfall reduces and frosts in winter become rarer,
- The insurance sector has started to consider that consumer preferences and needs for insurance products will be different as climate change intensifies. A report commissioned by CERES⁴⁴ explores the opportunities for new products and services⁴⁵.

'Starbucks blames setback on frappuccinos queues'

The Guardian, August 4th, 2006

Starbucks struggled to cope with long queues of customers who wanted iced frappuccinos in the record hot weather.

Starbucks announced in July 2006 its like-for-like sales rose 4% which was below the usual trend of 6%. This reduction resulted in Starbuck shares falling by 11% on the Nasdaq.

'A sweltering day that outshone the glory of July 1911'

The Times, July 20th, 2006

Thousands flocked to the beaches. Bournemouth was one of the busiest, with about 15,000 bathers.

HSS, Britain's largest equipment hire chain, issued 7,581 air-conditioning units that week which was up 38 per cent from the same time last year.

Comet sold one fan every two seconds yesterday, its fastest rate ever.

⁴⁴ Ceres is a national network of investment funds, environmental organisations and other public interest groups working to advance environmental stewardship on the part of businesses.

⁴⁵ Availability and affordability of insurance under climate change: a growing challenge for the US. CERES. August 2006.

10. Next steps in implementing this climate adaptation strategy

This adaptation strategy identifies the highest priority measures to manage climate risks that face the City of London Corporation and its stakeholders.

Drawing on the measures outlined in this adaptation strategy, a series of five thematic adaptation action plans have been developed in 2009. These provide the mechanism for management, implementation, monitoring and reporting on progress against the actions recommended in this strategy, in partnership with City of London Corporation stakeholders.

The action plans are laid out according to the following key themes:

1. The Business City, Physical Infrastructure and Property,
2. People, Community and Culture,
3. Green Spaces and Biodiversity,
4. Environmental and Public Health,
5. Contingency Planning.

The actions in the plans will be taken forward by the individual City of London Corporation departments responsible for their delivery. Progress on implementation will be monitored at six-monthly intervals by a cross departmental officers working group. Annual reports will be submitted to the Sustainability Chief Officers Group (SusCOG) and to the Members' Sustainability Working Party.

Appendices

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Appendix 1: Climate risks to the City of London

Reference no.	Table A1.1 Asset and infrastructure risks	Risks will impact on:											Risk rating		
		CoL department										External stakeholders		Likelihood	Impact
		City Surveyor's	Planning and Transportation	Economic Development Office	Environmental Services	Community & Children's Services	Open Spaces	Town Clerk's	Markets	Residents	Business	Supporting services			
Very high															
A1	Flash flooding as drainage systems are overwhelmed by heavy downpours, affecting assets and infrastructure	X	X	X	X	X	X	X	X	X	X	X	X	4	5
A2	Changes in rainfall patterns with wetter winters and drier summers increasing risks of subsidence and heave, affecting the built environment including; buildings, underground cables, electricity pylons, underground utilities, escalators	X	X	X	X	X	X	X	X	X	X	X	X	4	4
A3	Increase in demand for electricity for air conditioning in summer leading to overburden of grid and power cuts, with consequent impacts on business.	X	X	X	X	X	X	X	X	X	X	X	X	4	4
A4	Increased temperatures on the London Underground, exacerbated by the urban heat island effect, is already leading to increased passenger discomfort and health and safety concerns for passengers	X	X	X	X	X	X	X	X	X	X	X	X	5	4
High															
A5	Subsidence and heave of clay based soils leading to damage to underground Victorian water pipes (which are currently being replaced with flexible plastic piping)											X		3	3

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A6	Increasing water demand when resources are already under stress due to changing precipitation patterns and increasing temperatures could lead to operation of Drought Management Plans, with restrictions on water use for public, commercial and industrial use	X	X	X	X	X	X	X	X	X	X	X	4	3
A7	Contaminated land: Increase in the mobility of contaminants in the ground caused by the changes in soil behaviour due to drying out and/or changing groundwater levels	X	X		X		X				X		3	3
A8	Hotter summers may damage elements of transport infrastructure with attendant disruption and repair costs e.g. buckled rails, rutted roads, cracking of bridge expansion joints										X	X	4	3
A9	Lower river flows in summer will raise water temperatures and aggravate water quality problems in the Thames and its tributaries, especially following heavy summer storms, which can cause combined sewer overflows to discharge pollutants into rivers				X		X					X	5	3
A10	Increased electricity demand for cooling will affect the City's ability to meet energy/emission reduction targets	X	X	X	X	X	X	X	X	X	X	X	5	3
A11	Tidal / river flooding would cause significant damage to assets and infrastructure in the City		X									X	1	5
A12	Higher summer temperatures leading to lower productivity of workers	X	X	X	X	X	X	X	X	X	X	X	4	2
Medium														
A13	Higher levels in the Thames mean more frequent barrier closures and therefore freight restrictions. The shutting of the Thames barrier is a problem as it means other gates have to be closed. This could disrupt waste transport using the river. As the EA adapts and increases the height of the flood defence then access to the river from the banks will need to adapt to this.		X		X				X		X	X	4	2
A14	Inundation of docks from both riverine flooding and sea level rise		X		X				X		X	X	3	2
A15	Higher levels in the Thames mean that the barges lie higher and offloading is a problem												3	2
A16	Impact of storminess on electricity and communications infrastructure - increased stresses and fatiguing of power lines, pylons, radio masts and mobile phone masts										X	X	3	2
A17	Strong winds causing roof and structural damage to housing stock					X					X	X	3	2
A18	Strong winds causing damage to commercial and industrial property	X									X	X	3	2
A19	Low river flows in summer, affecting passenger and freight movements on the Thames		X		X				X		X	X	2	3

Reference no.	Table A1.2 Business risks	Risks will impact on:											Risk rating		
		CoL department									External stakeholders		Likelihood	Impact	
		City Surveyor's	Planning and Transportation	Economic Development Office	Environmental Services	Community & Children's Services	Open Spaces	Town Clerk's	Markets	Residents	Business	Supporting services			
	Very high														
B1	Equity markets could fall, e.g. due to property and infrastructure damage due to climate risks			X							X		3	5	
B2	London's insurance industry could be exposed to an increased volume of worldwide claims from wind storms, subsidence and heave, and flood events worldwide			X							X		3	5	
	High														
B3	Transport disruption due to extreme events (e.g. flash flooding, heatwaves), leading to disruption to commuters and business interruption		X								X	X	3	3	
B4	Increase in transport disruption for goods/freight due to heatwaves, floods, especially for 'just in time' deliveries		X								X	X	3	3	
B5	Damage to reputation of developers if houses / offices are not 'climate-proofed', with consequent effects on share prices / profits	X	X	X						X	X		2	4	
B6	Resource availability (e.g. water and wastewater provision and utilities) may not be sufficient to support an increase in tourism in summer			X								X	3	3	

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B7	Insurance premiums or excesses could rise within higher risk areas with possible impacts on availability of mortgages thus leading to loss of customers					X				X	X		3	3
B8	Some insurance companies may withdraw from the market in some areas										X		5	3
B9	Impact of climate risks elsewhere in the world could affect London business especially those 'offshoring' to vulnerable locations	X	X	X	X	X	X	X	X		X	X	4	3
B10	Building suitability and consequent heat risks to occupants: Increased temperatures will reduce comfort of occupants in commercial and public buildings, leading to discomfort, lower productivity, potential business disruption and potential heat stress	X	X	X	X	X	X	X	X		X	X	4	3
B11	Assets in basements at increased risk of damage/loss from flooding		X					X			X		4	3
B12	Health and safety of outdoor workers – increased incidence of heat stress, skin cancer in sunnier summers, leading to losses through sickness and potential claims	X	X	X	X	X	X	X	X		X	X	4	3
B13	Tidal / river flooding could mean business disruption lasting for days and occurring in different areas than flash floods			X							X	X	1	5
Medium														
B14	Downturn of global economy – recession. Impacts on GDP and increase in interest rates (economic impacts on portfolios)			X							X		1	5
B15	Excessive summer heat may delay construction activities e.g. health and safety restrictions can vary seasonally and curing of concrete in high temperatures affects its strength	X	X								X		2	3
B16	Floods on and off site may delay construction activities	X	X								X		2	3
B17	Decrease in businesses moving into the area as buildings are viewed as 'not fit for purpose/climate'.			X							X		2	3
B18	Risks to outdoor workers from flood and possible increased storminess	X	X	X	X	X	X	X	X		X	X	3	2
B19	Increase in summer energy costs for cooling	X	X	X	X	X	X	X	X	X	X	X	4	2
B20	Leisure and recreational facilities and tourist attractions fail to provide a pleasant environment for visitors e.g. overheating			X							X		3	2
B21	Possible higher winds may cause difficulties for construction equipment e.g. cranes and scaffolding	X									X		2	3
B22	High temperatures could lead to residents leaving London in search of a more comfortable environment on holidays or breaks			X						X	X		3	2

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Low														
B23	Potential shifts in consumer demand may affect the way planners encourage the local economy and how they approach retail policy, e.g. Decrease in clothing and footwear market as experienced in summer of 1995; Increase in fruit and vegetable markets due to changes in eating habits as experienced in summer of 1995		X							X			4	1
B24	Shift of working times to earlier /late in the day, to avoid peak temperatures, leading to a change in asset usage patterns	X	X	X	X	X	X	X	X	X	X	X	2	2
B25	Increasing heat will impact on the cooling of IT systems (City trading systems etc)										X	X	3	1
B26	Construction industry will have reduced water available for site management e.g. dust suppression										X		3	1
B27	Price increases in some foodstuffs, as agriculture worldwide is affected by climate change			X					X				3	1
Opportunities														
B28	Increase in visitors and tourists as other destinations become less attractive under climate change		X	X							X	X	N/A	N/A
B29	Opportunities for increase in pavement cafes / restaurants attracting more visitors to the city			X							X		N/A	N/A
B30	Reduced energy costs in winter due to need for less heating	X	X	X	X	X	X	X	X	X	X	X	N/A	N/A
B31	Opportunity to develop new products e.g. insurance catastrophe bonds and weather derivatives or physical products e.g. floorboards, warning systems, cooling systems.										X		N/A	N/A
B32	Construction industry could benefit from an increased number of available construction days, as summer rainfall reduces and frosts in winter become more rare	X									X		N/A	N/A

Reference no.	Table A1.3 People risks	Risks will impact on:											Risk rating		
		CoL department									External stakeholders				
		City Surveyor's	Planning and Transportation	Economic Development Office	Environmental Services	Community & Children's Services	Open Spaces	Town Clerk's	Markets	Residents	Business	Supporting services	Likelihood	Impact	
Very high															
P1	Increased incidence of heat stress, dehydration, heat-related mortality, skin cancer and eye cataracts in hotter, sunnier summers for outdoor workers and other members of society, especially the elderly, sick and young. Health risks to vulnerable population groups in housing that overheats significantly. Risk of death in heatwaves.					X				X	X	X	4	4	
P2	Greater impact on asthma sufferers and potential for acute asthma epidemics due to: dust mites surviving longer in drier air; more dust raised in dry areas; poorer air quality and more frequent air pollution episodes				X	X				X	X	X	4	4	
P3	Flash flooding leading to increased risk of injury, disease, mental health problems and potentially death	X	X	X	X	X	X	X	X	X	X	X	3	4	
High															
P4	Severe water restrictions which could be put in place under a worst case scenario (e.g. standpipes) could pose access difficulties for vulnerable populations					X				X		X	2	4	
P5	Increase in outdoor lifestyles will increase levels of exposure to air pollution				X	X	X			X		X	3	3	

P6	Transmission of diseases may alter as there is a potential for increased risk of mosquitoes and other disease bearing insects, vermin and pest. Those in overcrowded accommodation are more susceptible to the spread of infectious diseases						X	X			X		X	3	3
P7	Increase in demand for social services supporting community care for vulnerable clients in heatwaves						X				X		X	4	3
P8	Waste storage may become more of a problem in higher temperatures, which may bring about a potential increase in vermin with associated local health risks.				X	X	X		X	X	X	X	4	3	
P9	Increased risk of overheating in school classrooms - extreme temperatures affect children's ability to concentrate	X				X							3	3	
P10	Increased heat stress risk and sun exposure to children in school playgrounds	X				X							3	3	
P11	Increase in instances of food poisoning as increased temperatures facilitate bacterial growth				X				X	X	X	X	4	3	
P12	Greater demands on emergency services, who may have insufficient resources to deal with more floods, fires, heat waves								X			X	4	3	
P13	Increased risk of tidal / river flooding leading to increased risk of injury, disease, mental health problems and death	X	X	X	X	X	X	X	X	X	X	X	1	4	
Medium															
P14	Less water available could mean more water restrictions e.g. hosepipe bans	X	X	X	X	X	X	X	X	X	X	X	2	3	
P15	Overcrowding of open spaces e.g. picnic raze may become a problem						X			X			3	2	
P16	Increased incidence of traffic accidents (including bicycle related accidents) in hotter weather		X										4	2	
P17	Increased disruption to waste collection and street cleaning services due to greater risk of flooding and extreme events				X					X	X		3	2	
P18	Climate impacts on frontline cleansing services will affect: rotas (e.g. changes to working hours if too hot during the day); equipment (e.g. overheating may necessitate change); suitable clothing (e.g. for coping with temperature increases); maintenance requirements etc				X								4	2	
P19	Increase in use of outdoor spaces will lead to an increase in street litter				X								4	2	
P20	Food health risks with wholesale markets and need to provide additional cooling to cope with increased temperatures				X				X				2	3	
P21	Different and more vermin and pests, leading to the need to use more pesticides / fly killers etc				X								3	2	

P22	School playgrounds tend to have a greater risk of flooding, particularly because of blocked drains					X							2	3
P23	Lower income households may find it more difficult to access adequate insurance cover in the face of increased flood risk			X		X				X			4	2
Low														
P24	Changing waste profile as a result of changes in eating habits due to climate change, which needs to be considered in the context of the push for greater recycling		X		X								2	1
P25	Increased public demonstrations and riots in hot weather					X							3	1
P26	Stress to flood victims					X					X		4	1
P27	Street cleaning: Reduced summer rainfall means less dilution for road run-off, resulting in higher concentrations of pollutants				X								3	1
P28	Changing patterns of leaf fall affecting street cleaning operations				X								3	1
P29	Increased illness / possible epidemics transmitted through increased use of indoor ventilation systems					X			X	X	X		3	1
P30	Increased noise problems as people are outside more, especially at night, and residents open windows to stay cool					X			X				3	1
P31	Planning consideration for better noise control required as conflicts exist already between residents and business community e.g. avoid mixing incompatible uses such as flats over pubs		X						X	X			3	1
P33	Recreational fishing may suffer, due to low river flows in summer				X								3	1
P34	Emotional impacts of extreme events affect public mental health and especially children's educational performance					X			X		X		4	1
Opportunities														
P35	Reduced winter cold-related morbidity and mortality					X						X	N/A	N/A
P36	Outdoor living may be more favoured, although some members of society may be less able to take advantage of this due to lack of facilities locally, fear of crime or other forms of social exclusion		X			X			X				N/A	N/A

Reference no.	Table A1.4 Open spaces and heritage risks	Risks will impact on:											Risk rating			
		CoL department									External stakeholders		Likelihood	Impact		
		City Surveyor's	Planning and Transportation	Economic Development Office	Environmental Services	Community & Children's Services	Open Spaces	Town Clerk's	Markets	Residents	Business	Supporting services				
	Very high															
	None identified															
	High															
S1	Overcrowding in City open spaces at lunchtimes leading to increased damage during summer months						X			X	X		4	3		
S2	Increased likelihood of algal blooms on watercourses, with implications for nature conservation, aesthetics and human health				X		X						3	2		
S3	Increase in flash flood risk in open spaces						X						3	3		
S4	Higher risk of fires on scrub and heath land						X				X		4	3		
S5	Loss or damage to freshwater, riparian, foreshore and wetlands habitats				X		X			X	X		3	3		
	Medium															
S6	Increased winter rainfall may raise water tables enough to kill roots, thereby reducing effective rooting depth and making trees more vulnerable to increasing temperatures, summer drought and windthrow						X						4	2		
S7	Water shortages could lead to restrictions on water use for open spaces management - when demand for water for irrigation is higher						X						4	2		

S8	Greater odour problems associated with standing water bodies				X		X					3	2
S9	Green and open spaces will be used more intensively requiring increased maintenance and management						X			X		4	2
S10	Pest species won't die in winter as temperatures rise, so may need more pesticide control				X							4	2
S11	Warmer weather would favour conditions for increased competition from exotic species as well as the spread of disease and pests, affecting both fauna and flora						X					5	2
S12	Earlier springs, longer frost-free seasons and reduced snowfall could affect dates of bird egg-laying, as well as the emergence, first flowering and health of leafing or flowering plants						X					5	2
S13	Historic buildings and archaeological remains more exposed to risk of water damage and flooding – some sites may need to be abandoned	X	X		X							2	3
S14	Destruction of historic remains uncovered during re-development if affected by extreme events e.g. floods	X	X		X							2	3
S15	Damage to historic buildings, libraries and archives and their fabric caused by: Increasing temperatures; Increase in pest species such as cockroaches and termites; Drainage systems in heritage buildings could be overwhelmed, leading to flooding; Increase in winter rainfall and more intense rainfall, leading to rain penetration and damp problems, and could increase biological attack or other forms of decay such as salt mobilisation; Greater risk of subsidence and heave on clay-based soils; Increase in photochemical smog.	X	X		X							4	2
Low													
S16	Increased tourism and leisure pressure at conservation sites			X			X				X	3	1
S17	Increased soil erosion associated with more intense winter rainfall				X		X					3	1
S18	Expectation of higher visitor numbers to outdoor environments - associated increase in dog visitors affects biodiversity						X			X		2	1
S19	Higher temperatures make historic buildings more unsuitable for occupation	X	X	X							X	2	1

Appendix 2: Adaptation options to manage climate risks

Identifying and appraising climate adaptation measures

Adaptation measures to manage the 'Very high' and 'High' priority climate risks have been identified through:

- Reviews of best practice emerging elsewhere in the UK and internationally,
- Workshops hosted by the City of London Corporation (see Appendix 4),
- Acclimatise's knowledge and expertise.

There are two main approaches to climate adaptation that the City of London Corporation and others can adopt, as recommended by the UK Climate Impacts Programme⁴⁶:

- Building adaptive capacity,
- Delivering adaptation actions.

The adaptation measures for the City of London Corporation have been split up into these categories.

Building adaptive capacity

'Building adaptive capacity' involves creating the conditions (regulatory, institutional etc) that are needed before adaptation actions can be undertaken. It includes the measures listed in Table A2.1 below.

As is clear from the table below, 'building adaptive capacity' includes organisational change management processes, which have been shown to be vital in bringing about adaptation⁴⁷. Work at Hampshire County Council demonstrates that awareness-raising alone is not sufficient to stimulate change – it needs to happen with three other factors:

- **Agency:** Change depends on developing a sense that there are meaningful responses that people can make to an issue as big as climate change.
- **Association:** Efforts are more effective and last longer, if people work together.
- **Action and reflection:** Action is needed, but it is important also to reflect on outcomes so that efforts can be refocused. Change involves 'unlearning' habits and reflection is key to doing this successfully.

⁴⁶ West, C.C. and Gawith, M.J. (Eds.) Measuring progress: Preparing for climate change through the UK Climate Impacts Programme. UKCIP Technical Report. UKCIP, Oxford. 2005.

⁴⁷ Alexander, Ballard & Associates and Rosslyn Research Ltd. How can local authorities stimulate & support behavioural change in response to climate change? A report for Hampshire County Council undertaken as part of the ESPACE project. July 2005.

Table A2.1: Measures for building adaptive capacity

BAC1	Research, data collection and monitoring to better understand climate risks and vulnerabilities, and to evaluate the most appropriate adaptation measures.
BAC2	Changing or developing policies, plans, standards, codes of practice, regulations and legislation to take account of changing climate risks. This should be informed by research, data collection and monitoring (BAC1).
BAC3	Awareness-raising and organisational learning, both within the organisation and with external stakeholders.
BAC4	Working in partnership to identify and coordinate climate adaptation activities.

Delivering adaptation actions

‘Delivering adaptation actions’ involves taking actions that will help to avoid or reduce climate risks, or to exploit opportunities. It includes the risk management measures in Table A2.2 below.

Table A2.2: Measures for delivering adaptation actions

DAA1	Avoiding risks – such as avoiding development in high risk locations and implementing contingency plans.
DAA2	Reducing risks – for instance by making technical or structural changes to infrastructure.
DAA3	Reducing vulnerability by: <ul style="list-style-type: none"> • Diversifying – for instance, developing business areas that are not sensitive to climate risks, • Identifying others willing to share the risk – such as through insurance.
DAA4	Bearing some losses, where they can not be avoided.
DAA5	Exploiting opportunities.

Who can deliver the adaptation measures?

The City of London Corporation believes it must take a leadership role with regards to adaptation, and in the light of this revised strategy it has developed five detailed action plans, each focussing on a single theme, which provide the basis for action within the Corporation’s departments. These action plans will be used for monitoring progress towards the implementation of this strategy.

However, we also recognise that the City of London Corporation does not manage all the services and infrastructure the City relies on, and there are also adaptation measures that need to be delivered by others including:

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- Other public sector bodies,
- Other utility and service providers in the city providing water resources, transport, energy, waste management, telecommunications, emergency services, health care and education,
- City businesses – including developers and owners of City property,
- City residents.

The City of London Corporation will continue to work with all our stakeholders to ensure that the risks posed by climate change are understood, and appropriate adaptive action is taken.

Appendix 3: Checklist for 'climate-proofing' City of London Corporation policies and projects

This checklist summarises the main 'climate-proofing' principles that should be considered by City of London Corporation Departments when developing policies and projects.

<p>Could climate risks affect your policy or project, directly or indirectly?</p> <p>⇒ Refer to the risk tables in the climate adaptation strategy for information on the range of climate impacts that could occur.</p> <p>⇒ Can you identify vulnerable receptors or populations at higher risk?</p>	<p style="color: green;">✓</p> <input type="checkbox"/> <input type="checkbox"/>
<p>Is the policy or project expected to provide benefits in the long-term (>10 years) or have other long-term consequences?</p> <p>⇒ Decisions with long-term consequences are likely to be more sensitive to climate change.</p>	<input type="checkbox"/>
<p>Could the policy or project possibly constrain other stakeholders' ability to manage climate risks?</p> <p>⇒ If so, have they been involved in the decision-making process?</p>	<input type="checkbox"/> <input type="checkbox"/>
<p>Has climate change already been accounted for at a strategic level?</p> <p>⇒ If so, was consideration of climate change adequate?</p>	<input type="checkbox"/> <input type="checkbox"/>
<p>Could your policy or project contribute to increasing climate risks?</p> <p>⇒ For instance, does it contribute to the urban heat island effect, increase risks of flooding, subsidence or heave, or does it increase water consumption?</p> <p>⇒ Refer to the risk tables in the climate adaptation strategy for a fuller list of climate risks.</p>	<input type="checkbox"/> <input type="checkbox"/>
<p>Could your policy or project be designed to contribute to reducing climate risks?</p> <p>⇒ Refer to the adaptation tables in the climate adaptation strategy for information on risk management measures.</p>	<input type="checkbox"/>
<p>Have opportunities arising from climate change been considered as part of the policy or project development process?</p> <p>⇒ Refer to the risk tables in the climate adaptation strategy for information on opportunities.</p>	<input type="checkbox"/>
<p>If climate risks are important to the policy or project, can options be identified that manage these risks to acceptable levels?</p> <p>⇒ Can 'no regret', 'low regret' and 'win-win' options be identified?</p> <p>⇒ Can options be defined in a flexible manner to take account of changes in climate over time?</p> <p>⇒ Would it be feasible or advisable to delay making a decision until further information about climate risks is available?</p> <p>⇒ Refer to the adaptation tables in the climate adaptation strategy for information on risk management measures.</p>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>

Checklist for ‘climate-proofing’ developments and infrastructure

This checklist summarises the main ‘climate-proofing’ principles that should be considered by developers and infrastructure managers⁴⁸.

<ul style="list-style-type: none"> • Have you addressed climate change risks and risk management measures as part of the Environmental Impact Assessment (EIA) for your development? 	<input type="checkbox"/>
<p style="text-align: right;">✓</p>	
<p>Managing flood risks</p>	
<ul style="list-style-type: none"> • Have drainage systems been designed with sufficient capacity to cope with heavier rainfall events expected over their lifetimes, taking account of climate change? 	<input type="checkbox"/>
<ul style="list-style-type: none"> • Have you considered sustainable drainage systems (SuDS) and floodwater storage areas to manage flash flood risks more sustainably? 	<input type="checkbox"/>
<ul style="list-style-type: none"> • Have you designed your development for flood resilience, ensuring that flood-sensitive assets and equipment are located away from high-risk areas, such as basements? 	<input type="checkbox"/>
<p>Managing water resources</p>	
<ul style="list-style-type: none"> • Does your development provide best practice in water efficiency? 	<input type="checkbox"/>
<ul style="list-style-type: none"> • Have you considered installing rainwater harvesting and greywater recycling facilities? 	<input type="checkbox"/>
<ul style="list-style-type: none"> • Have you ensured that your landscaping schemes are drought-resistant and require minimal irrigation? 	<input type="checkbox"/>
<p>Managing heat risks</p>	
<ul style="list-style-type: none"> • Have your buildings been designed to provide a comfortable internal environment with the least use of energy over their lifetimes, taking account of rising temperatures due to climate change? 	<input type="checkbox"/>
<ul style="list-style-type: none"> • Has your development been designed to incorporate green spaces to provide cooling and shade in the face of rising temperatures? 	<input type="checkbox"/>
<p>Managing ground conditions</p>	
<ul style="list-style-type: none"> • Does the design of your development and its foundations take account of climate change impacts on subsidence and heave over its lifetime? 	<input type="checkbox"/>
<ul style="list-style-type: none"> • In landscaping schemes, have you considered how subsidence and root penetration will be affected by climate change, when choosing and siting trees? 	<input type="checkbox"/>

⁴⁸ A more detailed checklist is provided in “Adapting to climate change: a checklist for development. Guidance on designing developments in a changing climate.” Greater London Authority. November 2005.

Appendix 4: Methodology for developing the City of London climate change adaptation strategy

A risk management approach

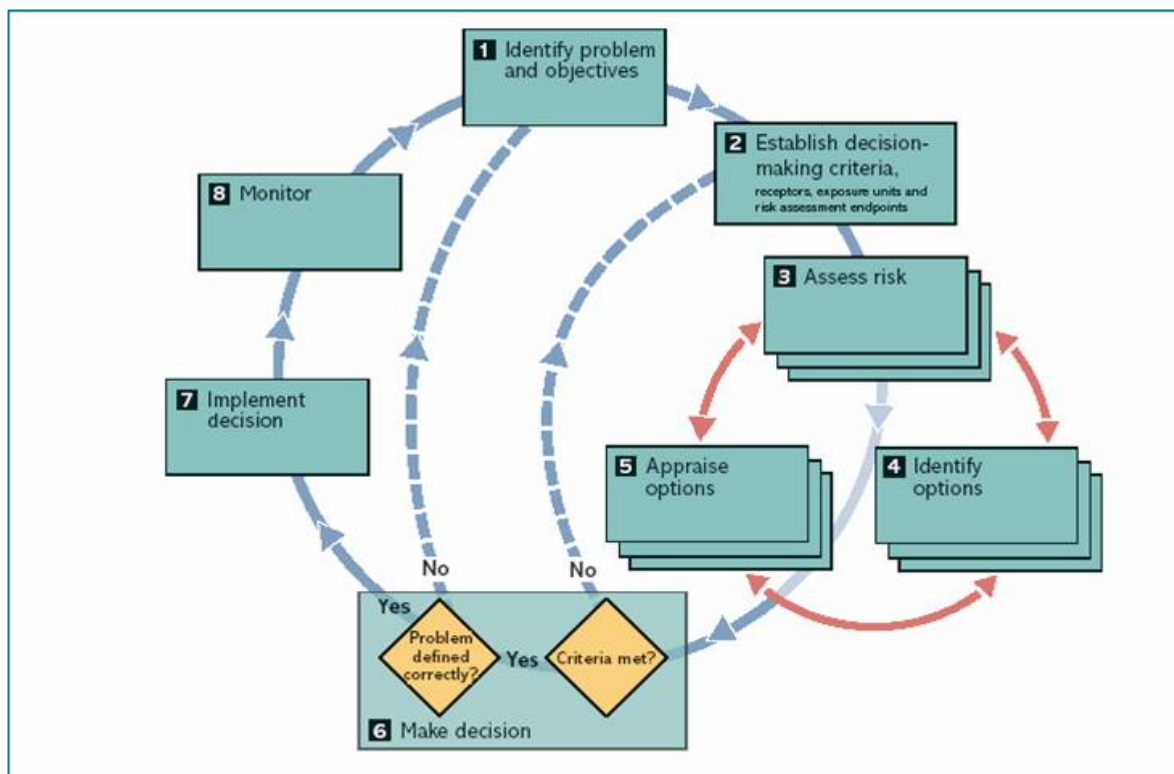
In line with best practice in policy-making and decision-making more generally, this adaptation strategy has been developed using a risk management approach. Its development has drawn on the UKCIP risk-based climate adaptation decision-making framework⁴⁹ (see figure overleaf), following stages 1 to 5 as follows:

- **Stage 1: Identify objectives:** This stage involves establishing the reasons for the development of the adaptation strategy, what it aims to achieve and who needs to be involved in its development.
- **Stage 2: Establish decision-making criteria:** Criteria for evaluating the range of possible adaptation options are determined at this stage.
- **Stage 3: Assess risks:** Climate risks are assessed. The development of this adaptation strategy drew existing information about climate risks to London, including the London Climate Change Partnership report, 'London's warming'⁵⁰. Additional risks were identified through a stakeholder workshop (see below).
- **Stage 4: Identify risk management options:** Options to manage the risks from Stage 3 are identified. Options were identified through reviews of existing literature and through a series of working meetings (see below).
- **Stage 5: Appraise options:** The adaptation options are appraised qualitatively against the decision-making criteria established at Stage 2. Where it is not possible to evaluate the suitability of an adaptation option, further research or investigation will be required.

⁴⁹ UKCIP. Climate adaptation: Risk, uncertainty and decision-making. UKCIP Technical Report. UKCIP, Oxford. 2003.

⁵⁰ London Climate Change Partnership. London's warming: The impacts of climate change on London. Technical Report. 2002.

The UKCIP risk-based climate adaptation decision-making framework



Stages 1 – 3: Decision-making criteria, risk assessment and prioritisation

Decision-making criteria for evaluating adaptation options

In discussion with City of London Corporation staff, the following criteria were identified as being important to evaluating adaptation options:

- Whether they are no-regrets, low-regrets or win-win measures,
- Acceptability to different stakeholder groups,
- How successful the measures are at reducing the climate risk,
- Value for money,
- Ease of implementation,
- Sustainability,
- Whether the measures are reliable and 'tried and tested',
- Adaptability of the measures in the face of changing climatic conditions.

Risk assessment and prioritisation

Climate risks and opportunities were identified from existing literature and through engagement with City of London Corporation staff and external stakeholders. Tables presenting the range of risk and opportunities identified for the City of London (see Appendix 1) were developed for the four main affected groups – the 'receptors':

- Assets and Infrastructure,
- Business,
- People,
- Open spaces and heritage.

For each climate risk, the tables detail the City of London Corporation departments likely to be most affected by the risk, and external stakeholders who are also affected.

There are some cases where detrimental risks will lessen as our climate changes – for instance the numbers of winter cold deaths are expected to decrease as temperatures rise. These have been identified as ‘opportunities’ in the risk tables, along with business opportunities arising from climate change, such as new financial products.

The risks identified have also been assigned a ‘risk rating’ so that they are prioritised according to their potential significance as ‘Very High’, ‘High’, ‘Medium’ or ‘Low’. This rating process has been undertaken using the method outlined in the Community Risk Register⁵¹ developed by the Central London Local Resilience Forum for contingency planning, since the Register is used by Contingency Planners in the City of London.

The risk rating method involves considering the two components of risk:

- Likelihood of hazard,
- Magnitude of consequence (impact).

The likelihood assessment relates to the probability of the hazard occurring over the lifetime of the particular asset or service in question. The magnitude is based on a qualitative assessment of the consequence of the hazard, by considering four categories of consequence:

- health,
- social,
- economic,
- environment.

The risk rating matrix from the Community Risk Register (see figure below), is then used to prioritise the risk as ‘Very High’, ‘High’, ‘Medium’ or ‘Low’.

Usability of risk rating approach in the context of a changing climate

Adoption of the risk rating approach has been undertaken as far as reasonably possible. However, there are limitations, particularly concerning the fact that the likelihood of hazards is changing, as climate changes. This has been addressed by considering two factors:

- First, considering any hazard ratings for climate-related hazards given in the Community Risk Register (e.g. storms and gales, flood risks),
- Secondly, considering whether the probability of the climate hazard is expected to change, as the climate changes:
 - If the probability is expected to increase due to climate change, then the hazard rating is increased. In judging whether to make any increases to the hazard rating, consideration has been given to the relative confidence levels attached to the changes, as detailed in Appendix 5.

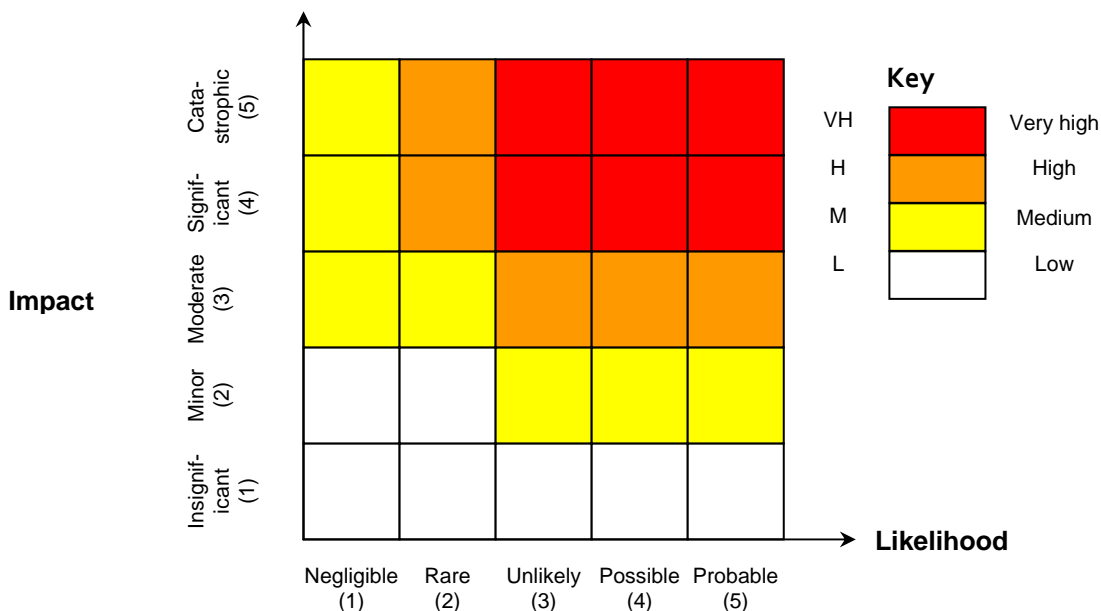
Therefore a risk is rated higher if:

- It is already a problem in the City of London, and/or
- The risk will become more significant over the lifetime of the asset or service in question.

⁵¹ Central London Resilience Forum. Community Risk Register Version 1.1. July 2006.

Specific examples of how risk ratings have been developed using this approach are outlined below, for tidal/river flooding and for winds and storms.

Risk rating matrix⁵²



Tidal/ river flooding

The risk of tidal/ river (fluvial) flooding has been rated 'High', as it has been assumed that:

- The very high standard of protection against flooding offered by the Thames Barrier – currently 1 in 2,000 years – will continue to be provided over the longer term; this standard sits on the boundary between 'negligible' and 'rare' likelihood according to the Community Risk Register,
- If the Barrier were overtopped, the consequences would be catastrophic.

Wind and storms

The Community Risk Register assigns wind and storm risks a 'Medium' rating. The climate change models do not indicate a significant change in average wind speeds, and there is a low confidence that the number of winter storms will increase somewhat by 2080s, as shown in Appendix 5. Therefore evidence for changes in storm hazards due to climate change, is poor, and hence the rating attached to winds and storms is considered to remain as 'Medium'.

Stage 4 and 5: Identifying and appraising climate adaptation measures

The risks were ranked into five categories, ranging from 'Very high' to 'Low', and also covering 'beneficial' risks, i.e. opportunities.

Adaptation measures to manage the 'Very high' and 'High' priority climate risks have been identified through:

- Reviews of good practice emerging elsewhere in the UK and internationally,
- Workshops hosted by the City of London Corporation, in 2006 and 2009
- Acclimatise's knowledge and expertise.

⁵² Central London Resilience Forum. Community Risk Register Version 1.1. July 2006.

The adaptation measures identified can be found in Appendix 2.

City of London Corporation departments covered in this adaptation strategy

While climate change will affect the City of London in many ways, the strategy has focused on those parts of the City of London Corporation that are expected to be most affected. These include:

- City Surveyor's Department,
- Planning and Transportation Department,
- Economic Development Office,
- Barbican Centre
- Environmental Services Department,
- Department of Community and Children's Services,
- Open Spaces Department,
- Town Clerk's Department,
- Markets.

Stakeholder engagement

There has been an emphasis on developing the adaptation strategy in consultation with stakeholders – including staff from within the City of London Corporation departments listed above as well as external stakeholders from City businesses and other infrastructure providers. This engagement, which involved both internal and external stakeholders (including businesses, utilities suppliers, regulators and neighbouring boroughs) has included the following:

Initial Report

- A large workshop to identify and discuss climate risks to the City of London, held in July 2006,
- Four smaller working meetings to identify and appraise adaptation actions to address the climate risks, held in August 2006.
- Consultation with TCT partnership on first draft of adaptation strategy

This Report

- Multi-stakeholder UKCP09 Workshop September 2009
- Five themed workshops to assess progress and identify new actions

Appendix 5: Summary of expected climate changes in London for the UKCP09 low and high emissions scenarios

Table A5.1: Projected changes in temperature and precipitation for the City of London, under low and high emissions scenarios for the 2020s and 2050s. The bold value is the central estimate (50th percentile value) of the projections. The wider range gives the 10th and 90th percentile of projections – future climate is very unlikely to fall outside this range.

Changes in climate hazards	2020s		2050s	
	Low emissions	High emissions	Low emissions	High emissions
Rise in winter mean temperature	1.3°C (0.5°C- 2.1°C)	1.4°C (0.6°C- 2.2°C)	2°C (0.9°C- 3.1°C)	2.5°C (1.4°C- 3.8°C)
Rise in summer mean temperature	1.6°C (0.7°C- 2.8°C)	1.5°C (0.5°C - 2.7°C)	2.5°C (1.1°C - 4.3°C)	3.1°C (1.4°C - 5.2°C)
Rise in summer mean daily maximum temperature	2.2°C (0.7 °C- 3.8°C)	2°C (0.5°C - 3.7°C)	3.5°C (1.2°C - 6.1°C)	4.3°C (1.7°C - 7.4°C)
Rise in summer mean daily minimum temperature	1.7°C (0.7°C- 2.9°C)	1.7°C (0.7°C - 2.9°C)	2.7°C (1.2°C - 4.6°C)	3.3°C (1.6°C - 5.7°C)
Increase in winter mean precipitation	+6% (-4% /+18%)	+7% (-3%/+18%)	+12% (0%/+27%)	+16% (+2%/+35%)
Decrease in summer mean precipitation	-7% (-24%/+13%)	-4% (-23%/+18%)	-14% (-37%/+16%)	-19% (-43%/+9%)

Enquiries and further information

Simon Mills, City of London Corporation

PO Box 270
Guildhall
London
EC2P 2EJ

T: +44 (0) 207 3323598
F: +44 (0) 207 7962621
E: simon.mills@cityoflondon.gov.uk
W: www.cityoflondon.gov.uk

Dr Richenda Connell, Acclimatise

Hexgreave Hall
Farnsfield
Newark
Nottinghamshire
NG22 8LS

T: +44 (0) 1623 884347
E: r.connell@acclimatise.uk.com
W: www.acclimatise.uk.com



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- o To provide modern, efficient and high quality local services and policing within the Square Mile for workers, residents and visitors whilst delivering sustainable outcomes.
- o To provide valued services to London and the nation.

Further information on the City of London and Climate Change Adaptation:

Sustainability Unit
City of London
PO Box 270
Guildhall
London
EC2P 2EJ

Tel 020 7606 3030
sustainability@cityoflondon.gov.uk
www.cityoflondon.gov.uk/sustainability