8. Summary and Policy Processes

8.1 Introduction

This section provides a summary of the potential impacts of climate change in London along with adaptation options. It also discusses the main policy processes that are or will need to consider the potential impacts in order to plan for them. Finally, ideas for where more research is needed and the opportunities that climate change may present are put forward along with overall conclusions for the study.

8.2 Summary of Potential Climate Change Impacts and Adaptation Options

8.2.1 Potential Climate Change Impacts

The following table summarises the potential impacts of climate change impacts for London.

Issue	Main Points
Increased Temperatures	Increased intensity of the urban heat island effect. This phenomena is caused by the density of buildings in London disrupting cooling air flows and the heat emitted from buildings through air conditioning outlets (i.e. warm air). This increase in temperature will be in addition to the level of warming estimated from climate change. Installation of more air conditioning (AC) could further exacerbate this problem, as more heat is emitted from buildings, especially for those who can't afford AC.
	Higher temperatures may affect the ability of children to concentrate at school.
Flooding	Increased risk of flooding of combined sewer systems during heavy rainfall events, if they have insufficient capacity.
	The Thames Barrier was closed 24 times over the Winter 2000/01. This was because of the exceptionally high river flows combined with the normal high Spring tides. The average number of closures for the Barrier for comparable periods is three.
	There is anecdotal evidence that flooding could be highly stressful to children, some of whom see any subsequent rainfall event as threatening.
	Increased flooding could have financial implications for individuals as well as the insurance sector. The widespread flooding in Autumn 2000 in various UK locations led insurers to review their insurance flood cover in high risk areas.
	There is substantial housing and commercial development planned for the Thames Gateway in the coming decades. Some of this area is low lying, downstream of the Thames Barrier and could be subject to increased flood risk.
	The most significant threat to London arises from tidal surges. The Thames Barrier provides protection from a 1 in 2000 year event, declining to 1 in 1000 by 2030. By 2050 a 34cm sea level rise at Sheerness changes the 1 in 1000 year level to a 1 in 200 year event. By 2100 it is estimated that the Thames Barrier would have to close 200 times a year to protect London from tidal flooding.

Issue	Main Points
	Climate change could reduce the standard of river flood protection through rising sea levels, rising groundwater and/or increased storm magnitudes. Beyond 2050 extreme precipitation events of 30 and 60 day duration could increase in magnitude. By the 2080s the 60 day precipitation event that occurs on average 1 in 10 years increases in magnitude by 10%, whereas the 1 in 20 year event increases in magnitude by 16%. This could bring with it increased risk of disruption and damage to underground infrastructure e.g. London Underground and power and telecommunication lines from flooding. Any increased flooding such as flash flooding due to heavy rainfall events would also affect above ground transport systems. For instance, it has been estimated that disruption to rail services caused by a flooded rail line affecting a London bound train in December 2000 cost more than £1 million.
Water Resources	Increased water demand. Domestic water use could increase as a result of more hot Summers leading to increased garden watering and personal washing. The Environment Agency estimates that outdoor water use will increase public water supply demand in the Thames Region by approximately 50 million litres a day due to climate change. Reduction in annual rainfall due to climate change could affect the availability of water for London. It has been estimated that there could be a decrease in average soil moisture both annually and in the Summer in the South East. Drier soils imply more clay shrinkage, induced subsidence and mains leakage. Drier soils will require more precipitation to induce groundwater recharge and surface runoff. Therefore the length of recharge season could decline by 8 days in the 2050s and 14 days by the 2080s. The scale of the intensification planned for London (700,000 population growth in the next 15 years) could exacerbate this problem in the short term. Increased winter rainfall may result in the swelling of clays Water resources could also be affected by a reduction in water quality due to wash-off being carried down to combined sewer overflows (CSOs) and low summer flows reducing the volume of water for dilution of treated effluent in receiving water courses. Changes in rainfall patterns might result in abstraction licences being granted on a shorter timescale to allow flexibility in planning for the availability of water resources.
Health	Increased extreme temperatures could lead to an increased mortality related to heat stress. It has been estimated that the summer heat waves in 1976 and 1995 were associated with a 15% increase in mortality in Greater London. Reduction in winter cold spell related mortality e.g. hypothermia. A recent Department of Health Report has estimated that, by the 2050s, up to 20,000 fewer deaths might occur in the UK as a whole as a consequence of climate change. Increased pollution episodes. It has been estimated that a 1°C rise in Summer air temperatures is associated with a 14% increase in surface ozone concentrations in London. There could be an average increase in the frequency of pollution episodes of over 4 days a Summer by the 2080s due to increased temperature inversions. This could have impacts on the health of susceptible people. Increased temperatures could increase opportunities for crime as windows and doors are left open longer. Higher temperatures could increase the number of road accidents due to driver drowsiness and increased numbers of people cycling and walking. Higher temperatures could mean that rubbish put out for collection may decay quicker, producing unpleasant odours.

Issue	Main Points
Biodiversity	Increased temperatures (coupled with any lack of availability of water) could result in increased pressure on London's green spaces. Stress on green spaces could also have adverse effects on biodiversity. Increased temperatures and its effect on water resources, water temperatures and river flows could have adverse effects on biodiversity including: • Increased evaporation from waterbodies leading to habitat loss; • Loss of important habitats e.g. saltmarsh and further decline in some indicator species e.g. Water Vole; • Earlier blooming of some species over recent years (records at Kew confirm this). Warmer temperatures in Spring are associated with earlier dates of oak leafing by about 6 days for each 1°C increase; • Populations of certain birds e.g. Wren are strongly related to average Winter temperatures and first egg laying dates are related to Spring temperatures; and • Changes in migratory patterns due to temperature changes have also been observed e.g. a 1°C increase in Spring temperature is associated with a 2-3 day earlier appearance of the Swallow in the UK. London's wetlands are already under threat from altered flood regimes, drainage, groundwater abstraction and development and this could be exacerbated by changes in precipitation and its implications for water availability. Moisture availability is critical to other habitats and studies have indicated that there could be a drying of heathland and adverse effects on beech trees. Other impacts could include: • Increased level of inundation and storm flooding; • Accelerated coastal erosion; • Sea water intrusion into fresh waters; • Excessive nutrients and sewage inputs; • Changes in tidal processes e.g. tidal range, sediment supply; and • Changes in air temperature and rainfall could affect growth of salt marsh plants with secondary effects on sedimentation. Severe storms can have devastating effects on trees. Richmond Park lost 10% of its trees in the storms of 1987 and 1990. Small stocks of veteran trees in the Park are especially vulnerable.
Built Environment	Increased temperatures could reduce comfort of occupants in domestic, commercial and public buildings that could lead to business disruption. Building simulations of a small commercial property in London for possible climate conditions in 2050 found that working conditions would be outside of established comfort levels for 415 hours or 11 working weeks. Failure to address this could result in a longer term problem in attracting employees to London. This could affect particular sectors disproportionately because of their importance to London e.g. financial and business services sector. More resources may be required to maintain the integrity of London's historic buildings and artefacts e.g. internal temperature control to protect fabrics and furnishings. The change in flow patterns in the Thames has already uncovered more extensive archaeological remnants. Whilst this is to be welcomed, as it provides sites of interest, this puts the artefacts at risk. More resources may be required to protect them. Higher wind speeds and more frequent storms may lead to business disruption due to damage to overhead power and telecommunication lines. As buildings in London have been designed for relatively benign conditions, any increased storminess may make them more vulnerable to damage. Again this has implications for the insurance sector (see above). More stormy weather could increase damage to older, historical buildings and may require higher expenditure on repairs and maintenance.

Issue	Main Points
Transport	Increased temperatures on the London underground could lead to disruptions to the network and reduced passenger comfort. This could result in a decline in use of the underground contributing to congestion elsewhere and also leading to business disruptions. Increased temperatures could lead to adverse effects on transport infrastructure e.g. rail buckling, melting of tarmac on roads, runways etc. This can cause disruption to the transport network. More frequent closure of the Thames Barrier and the construction of new barriers may cut off some areas for docking, affecting shipping businesses. Flooding of docks might increase under some conditions, depending on the flood management strategy adopted. Low flows on the River Thames during more frequent dry summers could also affect its navigability with implications for water based freight transport. Reduced snow fall should result in less disruption to transport e.g. road, rail and reduced maintenance costs e.g. reduced need for salting/gritting.
Insurance Industry and Finance	Higher temperatures and drier soils could lead to shrinkage of the clay layer beneath London. This could lead to increased subsidence of buildings and infrastructure (e.g. transport networks). According to the Association of British Insurers, their members already incur costs of nearly £1M a day on average due to subsidence claims. Underground infrastructure e.g. water pipes and telecommunication and power lines could also be damaged, resulting in business and service disruption. Climate induced changes in consumer behaviour are those generally related to temperature change. During the hot summer of 1995, there was a net cost to the retail sector in the UK of over £100 million in total. There was a loss to the clothing and footwear market of over £400 million due to people buying fewer clothes and a small gain for the market for fruit and vegetables due to changes in eating habits. Opportunities for designers to provide literally ‘cool’ goods and brands - implications for design and styling of clothing, fashion, buildings, cars and other consumer items. Some manufacturing sectors in London that use significant amounts of water e.g. brewing and the automotive sector could be affected by changes in water resource availability and any subsequent price adjustment. Current practice is for insurers to offset underwriting losses from climate change type events on property against their investment income. An increase in severity/frequency of these events will result in falling investment returns and higher insurance premiums. A severe event could trigger selling of assets in order to pay the insurance claims made, having knock on effects on the macro-economy. This process also involves the business and financial sectors and so they too could experience adverse impacts from this process. A growth in greenhouse gas emissions trading schemes presents opportunities for London as a financial centre to provide trading services. A system for greenhouse gas emissions trading is beginning to emerge in the UK. Another sector that may benefit from climate change impacts is the environmental goods and services sector. This includes a range of products and services including renewable energy (solar photo-voltaics, water heating, wind energy generation etc), environmental monitoring, waste management, flood defence and protection, both at the public and private level, including provision of sustainable urban drainage systems (SUDS). Relative price changes between virgin raw materials from overseas sources that could be subject to adverse climate change impacts and more locally sourced recycled material, could increase the demand for recycled materials by manufacturers. Unless appropriate responses are made, adverse climate change impacts in London could affect its attractiveness as a destination for investment in both economic development and individual organisations and companies. However, the scale of this must be measured against the level and effectiveness of action being taken in its competitor cities in response to potential climate change impacts.

Issue	Main Points
Tourism	Increased temperatures could attract more visitors to London, benefiting the tourist sector. However, measures would need to be taken to ensure that the experience of London was favourable in order to ensure that the opportunities are maximised e.g. high quality green spaces, comfortable facilities and transport systems. However, high temperatures could lead to residents leaving London in search of a more comfortable environment on holidays or breaks.
Leisure	There could be a move to a more outdoor lifestyle e.g. open air concerts, cafes and other recreational activities. This could have important benefits such as improved health due to more people taking exercise and increased community interaction. This could be particularly important for children given the current trend to obesity and a sedentary lifestyle.
Emergency Planning	Drier weather could bring an increased risk of fire. However, such events are, in many cases, started deliberately. More rapid fire detection may be necessary as well as educational campaigns aimed at dissuading people from starting fires. Increased flooding (as well as other climate changes such as increased temperature etc) may require additional responses from the emergency services. There is a London Flood Warning Plan that is updated regularly and is considering the potential impacts of climate change. The Government is also considering the legislation and funding for local authority emergency planning at present.
Energy	Less need for winter heating. Financial advantage for bill payers and so could reduce incidences of fuel poverty. More need for cooling and possible increase in use of mechanical air conditioning. Increase in summer fuel bills for bill payers. This could outweigh the decrease in winter fuel bills depending on energy source (e.g. gas or electricity for Winter heating compared to electricity for air conditioning in Summer). Increased temperatures and any associated increase in direct sunshine could make the use of renewable energy system more commercially attractive e.g. solar photo-voltaic panels as facades on high value buildings. Increased wind speeds could benefit the generation of energy from wind turbines.

8.2.2 Climate Change Potential Adaptation Options

The following table summarises the climate change adaptation options for London.

Climate Impact	Adaptation Options
Flooding	Accelerated investment in existing flood defence programmes. Improved flood risk identification, forecasting and awareness. Avoidance of developments in at risk areas or making sure that adequate protection is in place. Use of green/open spaces for temporary water storage to alleviate flooding. These latter two points are incorporated in specific policies in the draft London Plan (see below). Other options to address increased flood risk include: • Improved flood warning systems; • Ensure that adequate resources and systems are available for responses to climate related emergency events e.g. flooding; • Long term planning for managed re-alignment in the Thames Estuary; • Establishment of green corridors on the north and south banks of the Thames and London's other rivers as a flooding buffer zone and creation of areas for habitats and species; • Adjustment of timespan for planning permissions allowing flexibility over future development options in the light of climate change. This would have implications for the users of the development; • Promotion of flood proofing on buildings at increased risk from flooding; • Use/re-creation of natural eco-system buffers; • Use of sustainable urban drainage systems (SUDS); • Guidance on building design and developments that will be able to adapt to climate change should be included in the GLA's planned supplementary planning guidance on sustainable buildings; and • Increased collaboration between government bodies, developers and insurance companies could provide an economic impetus for appropriate, sustainable developments in areas at increased flood risk that need economic regeneration.
Water Resources	Reductions in leakage. Extension of metering. Promotion of water efficient appliances. Development of innovative water resource options. 'Use Water Wisely' campaigns. Restrictions on non-essential use.

Climate Impact	Adaptation Options
Living and Working Conditions	Reducing building densities.
	Changing building height, spacing and street orientation to increase shade.
	Improving building and cooling system design including enhancing natural ventilation.
	Use of trees and vegetation for shading.
	Use of reflective materials.
	Incorporation of large areas of vegetation and water features within urban landscape to encourage cooling airflows.
	Promote measures on the underground to deal with extreme heat situations.
	Use of pumped groundwater as a cooling medium for the London Underground.
	Increased use of water transport.
	Higher insulation levels to protect buildings from increased temperatures and reduce energy use in Winter.
	Provision within developments of spaces for outdoor activities e.g. shared areas for barbecues and entertainment.
	Use of groundwater for cooling. The new GLA building uses a borehole groundwater cooling system.
	Make buildings with AC available to the public during hot spells as a refuge from high temperatures.
	Use of remote sensing techniques to detect movement due to subsidence.
	Changes to the frequency of waste collection as higher temperatures may produce more rapid decay and associated odours
	Some of these measures could be incorporated in the GLA's planned SPG on sustainable buildings.
Air Quality	New fiscal and voluntary initiatives to control emissions (Low emission zones).
	Traffic restrictions.
	Improved public transport.
	Incentives to promote car sharing.
	Pollution warning services.
	Inventories of pollution sources.
	Monitoring of key pollutants and relevant weather variables.
Biodiversity	Development and protection of 'green corridors' e.g. river corridors, to facilitate migration of climate sensitive species
	Protection of green and open spaces
	Recognition of biodiversity hotspots with associated protection designation
	Introduction of new facilities to treat polluted water from CSOs during heavy rainfall.
	Use of softer engineering solutions to flood defence.
Education	Climate change can be an interesting and informative topic for the curriculum. It covers a range of topics and can be approached quantitatively and qualitatively.

8.3 Tolerance and Equity

8.3.1 Tolerance

With 27% of the population of London being Black and Ethnic Minority, tolerance, positive acceptance of difference and a notion of equity is a highly important 'glue' which keeps London working as a multi-cultural city. In the year ending April 2000, race crime levels in London were as high as the rest of the UK put together (at 63 incidents per day) (Livingstone 2000) noting that London is home to about half the Black and Minority Ethnic polulation in the UK. We cannot, however, identify any direct impacts of climate change upon equity and tolerance. A possible indirect impact would occur if climate change led to a change in migration into or out of of the capital. This effect might be experienced through less tolerance of inward migrants from the UK or elsewhere, due to over-crowding. Such intolerance can also be influenced by the political response. Political pressure may increase to address the issue of increased numbers of inward migrants.

8.3.2 Equity

Climate change impacts will, to some extent, affect different communities in different ways. Clearly those who live in a flood plain are potentially more vulnerable to flooding, but the actual risk depends crucially upon the standard of protection that is provided. It also depends on the ability of the community to adapt to and recover from the flood. A highly detailed analysis would be required in order to determine the actual flood risk in specific parts of London and hence it is not possible in this study to claim that *particular* areas or communities are more vulnerable to increased flood risk from climate change than others.

There is little, if any, evidence to suggest that the *direct* impacts of climate change will be greater for some communities than for others. It is not clear why climate change impacts would differentially affect individuals or communities on the basis on their gender, ethnic origin or socio-economic group. Clearly, there are physiological differences between human beings, such that some will be more affected by high temperature extremes than others. However, such differences occur more at the level of individual physiology than at the community-level. Older and less healthy people are generally more vulnerable to high temperature extremes than younger and more healthy people for example. As we have noted elsewhere, however, the more important effect of climate change upon individual health is the significant *benefits* for the elderly which arise from fewer very cold spells. Given that it is the less well off who suffer most from fuel poverty, climate change will reduce those inequalities which arise from the inability to heat homes properly in the winter.

What is much more important in terms of equity considerations than the direct effects are the *indirect* effects of climate change upon communities. Indirect effects arise because of the knock-on repercussions of climate change and invariably involve some response or adaptation to the perceived impacts of climate change. The notion of 'adaptive capacity' has been developed to describe and understand the ability of different social agents to respond to impacts (Adger 2001). Those agents with a high adaptive capacity will be able to respond more effectively, i.e. with fewer social, economic and environmental costs. Adaptive capacity cannot be defined in a single way, but possession of a sufficient stock of resources is an underlying theme of the concept. Those resources may be financial and material, but they may also be social, intellectual and political. Hence, those with more resources will tend to be less adversly affected by climate change, *contra* those with fewer resources, who have less adaptive capacity

and will bear the brunt of adverse impacts. Generally, the poorer will be harder hit by climate change impacts, not because of the direct impacts *per se*, but because they are less able to respond and adapt to those impacts.

'Poorer' here means not just those with less income or material resources, but also those who are have less 'social capital'. Individuals in more fragmented communities with few social linkages between individuals typically have less social capital than closely knit communities. Where strong communities exist, there is much more likely to be better information flow and support structures which allow a rapid and inclusive response to events such as floods or heat waves, including early warnings and ameliorative actions, than in more fragmented social networks. Put simply, neighbours who know each other are much more likely to warn one another about impending risks and to help one another respond. They are also likely to be more aware of individuals and families who are most vulnerable, e.g. the elderly or single parents or those whose first language is not English, and can prioritise assistance to them (or at least alert the emergency services).

We have alluded at many points in this section to the inequalities which may emerge due to the differential ability to adapt on the part of different communities and sections of society. How exactly individuals might respond in the 2050s depends upon the wider context of socio-economic conditions, regulations and cultural expectations; hence we have embedded the responses within the socio-economic scenarios. For example, under the Global Markets (GM) scenario, the more affluent will be able to install air conditioning in response to warmer conditions within buildings, which will then increase the problem for those who cannot afford to purchase AC units.

8.3.3 Case-Study: Flooding and Associated Insurance Costs

Climate change impacts could increase the costs of property insurance in London by raising premiums in flood and land subsidence risk areas to cover a higher premium.

Alternatively, if no differentiation of risk areas is undertaken, then general premiums might be raised to cover increased risks in specific localities. A typical UK premium in low flood risk areas is £300 (though crime loadings in London will usually result in higher figures in the capital). In high flood risk areas, the premiums could be several orders of magnitude higher. The ABI comment that:

> *"the impact of such [premium] increases would be to reduce the level of protection afforded to low income households either because they can no longer afford insurance or because they must find the first £2,500 - £5,000 of each subsequent flood claim" (ABI 2002).*

Even without any change in premiums there are significant costs associated with flooding, due to the fact that 25% of households choose not to insure their contents, this number rising to 50% for low income groups (ABI 2002). One of the key factors which limits uptake of insurance amongst low-income groups is the price (ibid). Furthermore, the ABI considers that many households and businesses are currently underinsured (an informal survey in Lewes, East Sussex, (which was seriously flooded in November 2000) suggested that 15% of residents were underinsured by between £5,000 and £20,000) (ABI 2002). Considering that flood claims are typically of the order of £15,000 to £30,000 on a household policy (ABI 2002), it is evident that the costs of *not* being properly insured are significant and will increase social inequality (because the less affluent are less well insured). There are a large number of basement flats in

London, as a consequence of the high value of property, and these conversions are particularly vulnerable to flooding especially since many such flats are rented-out and hence flood protection measures are less likely to have been installed by the owner. (Basements in some older properties have traditionally been designed to cope with flooding and groundwater intrusion). Occupiers of rented basement flats are likely to be amongst the less affluent, will have less insurance cover and hence the incidence of floods could increase the existing pattern of inequalities.

Already insurance companies are removing automatic flood risk protection from properties in vulnerable areas of the flood plain. The ABI has entered into a two-year agreement with the government to maintain cover for existing domestic properties and small business policy holders, but at the time of writing this is due to run out at the end December 2002 (ABI 2002). In June 2002, the first British insurer stated in public that it would no longer insure those living in areas at high risk of flooding. The company E-Sure estimate that the effect of covering flood-risk areas adds 5 to 10% onto the costs of all policies, such that excluding cover of such risks would save an average of £30 per dwelling per year across the board. Properties in flood risk areas in London could be affected quite soon if insurance cover is withdrawn. Such a policy change would have repercussions on property values and insurance premiums and/or could lead to certain risk being reclassified as uninsurable with subsequent withdrawal of coverage. Conversely while properties in flood risk areas may suffer in this way, many households not at risk of flooding might benefit financially from any move in the insurance industry toward exceptional provision of flood risk cover.

Higher flood risk insurance costs would reduce the availability of insurance for spreading risk, potentially increase the percentage of households without cover and increase the demand for government-funded compensation following natural disasters. In the event of such changes, the relative roles of public and private bodies in providing insurance and risk management resources can be expected to be re-examined.

8.3.4 Scenario Differences

In the GM world, private insurance cover would be the norm, but with much greater differentiation of the potential risk, i.e. less spreading of flood risk across all household premiums. Hence, those with property in high flood risk areas would find that their premiums would be much higher than for the average property and this would cause price reductions in areas where flooding occurred relatively frequently. High climate change combined with high premiums would accentuate property blight. More private provision of flood defences would limit payment of premiums to those households lucky enough to be situated behind adequate defences. Households in less well protected areas, and without sufficient resources to pay insurance cover, would suffer, both from the increased risk of, and vulnerability to, flooding and the lack of insurance protection should flooding take place.

Under GM, the better-off could simply pay increased insurance cover. The ‘insurance deficit’ between rich and poor would increase and flooding would come to affect a larger proportion of the less well-off than presently. There would be more paid-for investigation of the flood and subsidence risks associated with potential property purchases, though also more legal challenges to uncertain information about flood risks in GM. Such legal challenges might act to reduce the public provision of flood risk information where uncertainties remain. The differential responses to climate change due to differences in adaptive capacity would accentuate the existing inequalities within society.

In an RS world, the principle of sharing out the risk across a large number of households would be maintained. The government would step in to assist households which are flooded and do not have insurance cover, though the economy could not support large hand-outs. Information on flood and subsidence risk would be included as part of the local search associated with any new house purchase. Public policy would aim to limit any increase in inequality arising from enhanced flood risk. There would also be stronger communities and denser social networks in the RS world than currently, hence generally more social capital available; this would tend to address inequalities more effectively than in the GM world.

The table below summarises the key impacts upon equity which we identified in earlier sections.

Table 8.1 Summary of Possible Effects upon Equity Arising from the Indirect and Direct Impacts of Climate Change

Impact Area	Possible Increase or decrease in equality	Description of Impact
Individuals: Winter heating	Increase	Less need for heating in winter will benefit the health and incomes of those in fuel poverty (= the less well off)
Domestic buildings: Summer Cooling	Decrease	Wealthier will be able to pay for air conditioning or other cooling techniques, increasing waste heat in local environments
Commercial buildings: Summer Cooling	Decrease	Wealthier firms will install AC or other forms of cooling, increasing waste heat in local environments of other buildings who cannot afford cooling or wish not to. Those in overly hot offices and factories could suffer adverse health impacts.
Households: Insurance	Decrease	The less affluent are less well protected by insurance and will be more adversely affected by increasing insurance costs and subsequent flood or subsidence episodes. The less affluent are possibly less likely to pay for information relating to the flood or subsidence vulnerability of a property prior to purchase. More basement dwellers (more exposed to flood risk) are likely to be less affluent. Expensive private development could be accompanied by high quality flood protection, in contrast to less expensive development.
Households: Outdoor spaces	Decrease	The less affluent are less likely to have their own outdoors space for use in hot weather. They will be more dependent upon public open spaces. Also opening windows and doors for cooling purposes brings with it a higher risk in more crime-prone areas.
Households: Water prices	Decrease	If water shortages occur, the less affluent could be more exposed to increased water pricing to households.
Households: Over-crowding	Decrease	Those who suffer from over-crowding in their homes will be most vulnerable to extreme heat episodes and to any increase in the incidence of infectious diseases.
Individuals and communities: adverse health impacts	Decrease	The adverse impacts of climate change upon health will be felt most acutely and with greatest consequence by the underprivileged

Impact Area	Possible Increase or decrease in equality	Description of Impact
Individuals and communities: heat stress	Decrease	An increase in heat related deaths and illness episodes would particularly affect the elderly, sick and those without access to air conditioning or other forms of cooling.
Individuals and communities: crime	Decrease	At times of disruption (such as flooding) opportunistic crime can increase. This is likely to be greater in areas that are already more prone to crime.
Individuals and communities: lifestyle changes	Increase	More active, outdoors lifestyles and healthier diets consisting of fresh fruit and vegetables could both be more feasible across the social spectrum. The least well-off would probably benefit the most from such changes.

8.4 Climate Change and Policy Making for London

There are a number of policy processes that are ongoing in London that will need to consider the potential impacts of climate change. Many of these have been explored in the preceding sections. This section summarises the main policy processes and the nature of the climate change issues related to them. It makes recommendations on how climate change should inform further policy and strategy development.

The main strategy, policy and planning processes related to climate change in London include:

- The draft London Plan - the spatial development plan for London;
- The London Development Agency's economic development strategy;
- The Environment Agency's strategic processes including those for water resources, flood defence and water quality;
- Water companies' planning processes; and
- Others including local authorities, the Thames Gateway London Partnership, the Thames Estuary Partnership and the London Biodiversity Partnership.

These are examined in more detail below.

8.4.1 The Draft London Plan

The Greater London Authority's spatial development strategy 'The draft London Plan' puts forward policies that set the framework for land use and related issues in London for the next 15-20 years. The Plan is at the draft stage and the public consultation phase closed on 30th September 2002. Once published, boroughs' unitary development plans must be in 'general conformity' with the Plan. The Plan estimates that the following could characterise London by 2016:

- Population is projected to reach 8.1 million, 700,000 more than today. The make up of London's population is projected to change with more young people, many more people from black and minority ethnic communities and more young

newcomers from across Europe. The risk of climate change related impacts affecting the present level of population is increasing. With the steep rise in the population this could mean that even more people could potentially be affected in the future;

- A minimum target for new housing of 459,000 dwellings. This could represent a further intensification of development leading to exacerbation of the heat island effect and difficult choices about the location of development. For instance 30% of the housing allocation is for East London, some areas of which are at increasing risk from flooding; and

- Economic growth could provide up to 636,000 additional jobs. However, disparity between rich and poor has increased. Nearly 40% of this growth is expected to be in East London, including the City and the Isle of Dogs. This is the highest proportion of the projected growth. Certain economic sectors could be particularly vulnerable to climate change impacts as they are expected to provide a high proportion of economic growth in the future and have a requirement for significant associated development e.g. the growth in the financial and business services and its demand for more office space.

The main spatial priorities that are relevant to a consideration of climate change impacts are:

- Development in Central London will intensify and accommodate substantial growth, especially in economic activity; and,

- Major development to the east of London along the Thames Gateway with an expansion of some central London functions into the city fringe, Isle of Dogs and Stratford.

Climate change is only one of a number of changes that London will be facing over the coming decades. The potential impacts of climate change will need to be considered throughout the draft London Plan process. The draft Plan has a number of policies that refer to or that are directly relevant to climate change, its impacts and potential adaptation measures. These include polices on:

- Climate Change (Policy 4A.13). The policy states that "The Mayor will and boroughs should assess and develop policies for the likely impacts of climate change on London in light of the outcome of the work by the London Climate Change Partnership…". The remainder of the policy relates to flood risk and the supporting text for the policy highlights that a significant proportion of future development will be in East London, which could be increasingly at risk from tidal flooding.

- Sustainable design and construction (Policy 4B.6). The Mayor will work with partners to produce Supplementary Planning Guidance (SPG) on sustainable design and construction. This policy has the ability to address many aspects of the quality of the built environment under conditions of climate change including vulnerability to storm and flood damage, subsidence, user comfort under elevated temperatures and energy use. Ensuring that climate change related issues are addressed in the SPG would be one mechanism for improving the performance of the built environment under potential climate change.

- Biodiversity and nature conservation (Policy 3D.12). The Mayor will work with partners to protect, manage and enhance biodiversity in support of the Mayor's Biodiversity Strategy. The potential climate change impacts on biodiversity are examined in preceding sections. It is recommended that potential climate change impacts and appropriate adaptations are a significant feature of the development of the Mayor's Biodiversity Strategy.

- Realising the value of open space (Policy 3D.8). The Mayor will work with boroughs and other partners to protect and promote London's network of open space. Open spaces will become even more important to London under anticipated climate change. They will be put under even greater demands from elevated temperatures, reduced availability of water and fire risk during long dry spells. However, if developed properly, they could act as a refuge from elevated temperatures and poor air quality, providing a cooling breeze, some tree cover and opportunities for a more outdoor focused lifestyle. Community focused activity such as festivals and concerts could be come even more common, if suitable provision were made for increased public open spaces. In some circumstances, open spaces could act as temporary flood storage, although this would need to be managed to ensure that public safety was not compromised. Appropriately managed and maintained open and green spaces could provide valuable habitats for London's species. These aspects of open and green spaces have been explored in the preceding sections. Climate change impacts and adaptation options should be incorporated in polices and programmes for open spaces.

The Blue Ribbon Network consists of London's systems of rivers, canals and water bodies. The Mayor has produced a strategy for the Blue Ribbon Network. This replaces RPG3b/9b (Strategic Planning for the River Thames). A number of policies that could be affected by climate change come under the Blue Ribbon Network Strategy including:

- Flood plains (Policy BR5). Boroughs should identify areas at risk from flooding (flood zones). In particular, boroughs should avoid permitting built development in functional flood plains. In other areas of flood risk a flood risk assessment should be carried out. This will influence the location and design of proposed development. This is a key policy from a climate change perspective. Given the anticipated demand for new housing and growth in business premises needed for the anticipated economic growth in the next 15 years, this policy will need to be successfully implemented in order to ensure that inappropriate development i.e. that at major risk from flooding or with a lack of appropriate flood protection or not adapted to flooding, does not occur. The draft London Plan has a specific policy on encouraging sustainable urban drainage systems (SUDS) on developments (see below). Their success will depend on the physical characteristics of the site as well as specific development proposals. There is no doubt that SUDS could play a role in managing flood risk in London, along with other flood management techniques (see below).

- Flood defences (Policy BR6). For locations adjacent to flood defences, permanent, built development should be set back from those defences to allow for the replacement/repair of the defences and any future raising to be done in a sustainable and cost effective way. The supporting text for the above flood related

policies also states that as built development is to be avoided on floodplains, there may be scope for renewable energy developments such as wind turbines.

- Sustainable drainage (Policy BR7). The use of sustainable urban drainage systems should be the norm unless there are practical reasons for not doing so.

- Rising groundwater (Policy BR8). In considering major planning applications in areas where rising groundwater is an existing or potential problem, the Mayor will and boroughs should, expect reasonable steps to be taken to abstract and use that groundwater. The water may be used for cooling or watering purposes or may be suitable for use within the development or by a water supply company. The supporting text for the policy refers to the General Aquifer Research, Development and Investigation Team (GARDIT) project that is examining ways of abstracting and using groundwater again. A strategy has been put in place to ensure that groundwater is maintained at levels which do not threaten the stability of, or flooding to, vital infrastructure.

- Water supplies (Policy BR9). The Mayor will work in partnership with appropriate agencies to protect and conserve water supplies in order to secure London's long term needs. The supporting text for this policy states that the pressure on water supplies is likely to increase due to climate change. This could occur because of changes to rainfall patterns and the availability of water resources at particular times of the year. Elevated temperatures could also result in changing demand for water for domestic and commercial uses.

- Water quality (Policy BR10). The Mayor will and boroughs should seek to protect and improve water quality to ensure that the Blue Ribbon Network is healthy, attractive and offers a valuable series of habitats. This policy is helpful in supporting measures to improve water quality. Specific actions taken by the EA and water companies as well as the impacts of climate change on water quality are described in separate sections below.

- Water and sewerage infrastructure (Policy BR11). The Mayor expects developers and local planning authorities to work together with water supply and sewerage companies to enable the inspection, repair or replacement of water supply and sewerage infrastructure, if required, during the construction of development. The Mayor will work with Thames Water, the Environment Agency and other relevant organisations to ensure that London's drainage and sewerage infrastructure is sustainable. See below for a discussion of the relevant policy framework for the EA and water companies.

Overall the policies for the Blue Ribbon Network are helpful in relation to climate change and should allow appropriate action to be taken including adaptation.

The draft Plan also refers to the present study, the work of the London Climate Change Partnership and a forthcoming study on climate change adaptation stating that the policies of the Mayor and other planning authorities should adapt to the finding of the study. This is encouraging but much work remains to be done on the potential impacts and adaptation options for specific developments. A number of actions should be considered in relation to the draft London Plan and climate change:

- A review of the polices to ensure that they have incorporated potential climate change impacts and responses. The present study will inform that process. This may lead to the need for additional polices or modifications of existing ones; and,
- An effective review process to ensure that climate change related policies are implemented and monitored for their effectiveness.

The draft Plan underwent a sustainability appraisal. This was an opportunity to highlight climate related issues, amongst a wide range of objectives, and helped to feed climate change issues through to the development of many of the above policies. The Plan will operate up to 2016 but it is acknowledged that a longer term perspective needs to be adopted as many of the development decisions taken now will have implications far beyond the Plan period e.g. transport infrastructure takes many years to design and build. In examining the longer term perspective through the use of alternative scenarios the Plan states:

> *"…The imperative of sustainable development will grow even stronger as problems such as climate change become inescapable…"*

The recognition of the long term nature of climate change issues in the draft Plan is encouraging. This needs to continue and feed into supporting effective long term planning and appropriate responses. The forthcoming study on climate change adaptation options for London will be an important first step in considering appropriate responses. As the remainder of this section shows, there is already much work that is being done that can support a robust approach to long term planning. The London Climate Change Partnership should play a key role in this area.

There are a number of other strategies that the Mayor has or is producing including:

- Transport;
- Economic Development;
- Biodiversity;
- Air Quality;
- Municipal Waste Management;
- Ambient Noise;
- Culture;
- Energy;
- Children.

Some of these could be affected by climate change impacts e.g. air quality, economic development and biodiversity. Others have a role to play in reducing the greenhouse gas emissions that contribute to climate change e.g. energy and transport. The majority of these have been used to inform the sections on social, economic and environmental impacts in this report. Various agencies are responsible for producing and implementing these strategies e.g. London Development Agency for economic development and Transport for London for transport infrastructure. A discussion of their role forms part of the preceding sections. The analysis below looks at their main policy roles.

8.4.2 London Development Agency

The London Development Agency is a functional body of the Greater London Authority and is responsible for:

- Furthering the economic development and regeneration of London;
- Promoting business efficiency, investment and competitiveness;
- Enhancing and developing the skills of local people; and
- Contributing to sustainable development.

London's economy seems set to experience some significant changes in the coming decades. As was discussed above, it is estimated that London's economic growth could result in up to 636,000 additional jobs by 2016. Nearly 40% of this growth is expected to be in East London, including the City and the Isle of Dogs - an area at risk from increased flooding. Continued growth is expected in financial and business services with around 440,000 further jobs (the most significant contribution to economic growth - over 50% of the total new jobs), along with distribution, hotels and catering, retailing, health and education and other service sectors. The public administration, primary/utilities and manufacturing sectors are expected to decline. It is thought that because of these dynamics, the financial and business services sector could be vulnerable to certain constraints such as undersupply of office accommodation, lack of suitably skilled employees, inadequate transport and other infrastructure e.g. ICT and poor environment. As has been discussed in previous sections these could be exacerbated by climate change. It has been estimated that London could require 7-9.2 million square metres of new office space by 2016. The current stock is 26.7 million square metres. This is between a 26 and 34% increased in office space - a further intensification that could contribute to increases in the climate related phenomena such as the urban heat island effect. It is clear that climate change could have significant impacts on key economic sectors including:

- Business interruptions due to infrastructure disruption e.g. flooding and elevated temperatures affecting roads and rail and subsidence and soil shrinkage disrupting power lines, ICT linkages.
- Deteriorating working conditions due to elevated temperatures and reduced air quality exacerbated by increases in the urban heat island effect. This could lead to reduced productivity and a reduction in the ability to attract and retain suitable employees who might prefer to work in a more attractive environment.
- Reducing attractiveness of London as a business location leading to a reduction in investment in London in preference to other cities that are either less vulnerable to climate change or have invested in the necessary adaptations.
- Changing flooding patterns could affect or restrict the location of developments or increase their costs because of the need for flood management provision. A large proportion of the estimated development is expected to occur in East London, an area that could be vulnerable to increased risk from flooding.
- Specific sectors may need to make significant investments in climate change related infrastructure e.g. water companies, local authorities and the EA.

- Business costs could rise substantially due to rising costs of insurance for developments at risk from flooding and storm damage. One response could be to ensure that developments were designed and constructed to withstand potential climate change impacts.

All the above points to a need to consider the potential impacts of climate change on the present and future economy of London. As London represents a significant proportion of the UK's economic activity and hence has wide reaching influences, it is doubly important that serious consideration is given to potential climate change impacts and that these form part of the London economic development strategy. As has already been discussed there could be significant opportunities for economic development in emerging sectors such as the environmental industries sector and other more established sectors of the London economy such as tourism. Studies are already being undertaken to asses the potential of environmental industries in London and the South East and what support would be required to nurture their growth. The Environment Agency

The Environment Agency (EA) is responsible for environmental regulation and related issues. The following comments are based on discussions with Agency staff. The issues of particular relevance to consideration of climate change impacts include:

Water Resources

- The EA has produced a Water Resources Strategy for the Thames Region that includes London. It states that a high proportion (55%) of the effective annual rainfall is already used for water supply. 86% of this is for public water supply.

- The supply-demand balance in London is in deficit at present by approximately 180Ml/d. Using the rising groundwater in London as a resource could supply 30-50Ml/d but other schemes could help bridge the gap. Water resource management measures are essential to deal with both demand increase and some of the potential impacts of climate change. Sustainable management of water on London includes such measures as urban drainage, rainwater re-use, metering, tariff development, leakage control, water conservation in private households (low flush/dual flush toilets, water butts, grey-water use), water re-cycling in industry, re-use of water in climate control systems and pressure and flow management of taps in commercial premises.

- Without further action to manage demand and reduce leakage, new strategic water resources may be required under certain scenarios by 2020 for London. Metering and new, innovative tariffs will be essential to manage the pressures and costs of water and protecting the environment if, and when, climate change impacts start to take effect.

- The Thames Region Water Resources strategy used a range of scenarios that included potential climate change, to inform the development of the strategy. However, more work needs to be done to consider the impacts at the catchment level. The EA is developing Catchment Abstraction Management Strategies to assess the total amount of water available in a catchment and develop a strategic plan for supply and demand. Another process - the "Restoring Sustainable Abstraction" programme is assessing other ways of obtaining water for supplying needs in particular areas. Both of these processes should be informed by the

present study as well as seeking further ways of assessing the potential impacts of climate change on water resources for London. Statistical downscaling techniques could deliver the local, catchment scale scenarios needed to undertake these investigations.

Water Quality

- As discussed in the environmental impacts section, a key issue for the impacts of climate change on water quality in London is the capacity of its combined sewer systems. These were designed and constructed for certain conditions and climate change may result in significant changes in the quantity of water they have to carry e.g. under heavy rainfall events that may lead to flooding. The EA, Thames Water and others are carrying out an assessment of current capacity and the various proposals for increasing this. This will assess the various solutions being put forward to the problem of capacity. It is intended that it will be completed for the next round of water company investments - Asset Management Plan 4 (AMP4 - 2004). It is a £5M project, over 5 years and has been running for about a year so far. It is unclear at present how OFWAT propose to assess the impact of climate change on water company investment needs in AMP4. Also it is important to ensure that any solution to combined sewer system capacity does not result in increased energy use e.g. for pumping, to the extent that long term environmental objectives elsewhere are impeded. It would be useful to assess this as part of the project, if possible. An example of this approach is the UKWIR project that is examining waste water treatment technologies, their ability to meet more stringent water quality standards and the implications for energy use and greenhouse gas emissions. There are a range of treatment technologies with various greenhouse gas emissions profiles. Use of renewable energy for any increased energy demand could help to reduce emissions. This could be beneficial for a number of areas. Renewable energy is not subject to the climate change levy and it could create more demand for the development of renewable energy.

- With regard to other aspects of water quality, EA river water quality objectives (RQOs) are already heavily influenced by discharges from sewage treatment works. The EA are already planning for low flows and hence low dilution that could occur under conditions of climate change. This is discussed in the previous section on the potential impacts of climate change on the environment.

Flood Risk Management

- The EA, working with a range of partners, is developing a strategy for flood risk management in the Thames Estuary for the next 100 years. "Planning for Flood Risk Management in the Thames Estuary" covers the tidal Thames and its natural floodplain from Teddington in west London to Sheerness/Shoeburyness in the outer estuary.

The Project aims to:

- Assess and understand the tidal defences in the context of the wider Thames Estuary setting. This includes assessment of the residual useful life of the defences together with an understanding of the 'drivers' including climate change, urban development, social pressures and the environment.

- Inform and gain the support of political and funding partners and stakeholders; and
- Prepare and manage a programme of studies linked with consultation, leading to a strategy for flood risk management in the Thames Estuary for the next 100 years.

The project will take five years to complete and involve research to build up a detailed understanding of the physical processes affecting the Thames Estuary. Again, statistical downscaling techniques could be used to develop scenarios of tidal surges that compliment existing work with physical models of the estuary.

Development and Flood Risk

As part of its role in the permitting and regulation of flood management and related issues the EA has been assessing its approach to development and flood risk. PPG25 suggests allowance should be made for climate change. Recent research has led to the incorporation of an allowance of 20% extra fluvial flow over a 50 year period, based on Thames and Severn (Environment Agency). By contrast allowance for sea level rise has been a consideration for the past few decades. PPG25 currently quotes 6mm per year although during the design in the 1970s of the current tidal defences for the Estuary, a figure of 8mm per year sea level rise was used. The EA is considering two main issues at present:

- A project to assess whether 20% is an appropriate figure for all watercourses, or should this be adjusted up or down based on such factors as urbanisation, catchment size and geology; and
- Can more refined guidance be developed based on the smaller grid size of the UKCIP 2002 scenarios compared to UKCIP 1998, e.g. a regional London & South East figure rather than an England figure?

Both of these issues concern accuracy and reliability of current information. Other issues being considered include:

- Will flood defence standards decline with time (i.e. 100 year standard becomes 50 in the future etc).
- Should defences be upgraded to maintain the current standard or accept a lower standard in future? The latter option would increase the flood risk at a site, which may alter the PPG25 risk category, and hence restrict future options for development.
- Adding 20% to flows enlarges the floodplain, though not necessarily by 20%, the figure will vary with topography. In areas not at risk now, but at risk in 50 years, there could be a series of options: (a) do nothing, (b) object now or (c) ensure a design that allows for changing risk, e.g. raise floor levels to cope with future flood levels. Should the same option be chosen everywhere, or should it be varied depending on location/development type or lifespan?
- Planning policies which reflect the changing risk associated with climate change need to be developed with Local Authorities, GLA etc.
- Flood risk assessments for PPG25 need to include climate change, including work for strategic sites such as the Thames Gateway.

- Could developers contribute toward flood mitigation costs on sites that are well protected now but perhaps not in future? The defences may need replacing or upgrading e.g. Lee Valley. EA NE Area Thames is currently undertaking a modelling exercise on the River Lee Flood Defence Channel (RLFDC) to ensure it can cope with the expected 20% increase in flow during storm conditions. Findings are expected during 2002 and decisions on whether the capacity needs to be upgraded will be taken after this time.
- Can surface water systems cope with increased storminess and how can this be incorporated in design, maintenance and upgrading? SUDS, which may be appropriate in some circumstances, offers scope for easier upgrading than fixed pipe sizes, unless they are oversized now and hence will be able to cope with increased flows in the future.
- Can SUDS be retrofitted to locations to assist in strategic surface water management?
- The EA grants consent for culverts etc. Should these consider the 20% extra flow expected to be carried? This should be a policy decision.
- What is the best way to communicate all these issues especially where they may affect sensitive issues such as house purchases?
- What is the best way to begin to raise awareness of potential flood risk and any mitigation needed? A 1 in a 1000 year (0.1%) event is a high standard but it could fail or be overtopped, especially under climate change conditions. Do we start warning existing development which is at high flood risk, because of a high flood impact (risk = probability x impact) or which has high damage impact potential e.g. due to computers in basements, or residential accommodation below high water level?

The EA has or is commissioning two projects to address the last two issues. One is examining methods for communicating flood risk and the other is examining the socio-economic impacts of flooding.

Consideration needs to be given to the widespread application of construction methods that can deal with flood risk, where development in flood plains is considered to be acceptable. This could include elevated floor levels, access routes, construction materials and flood protection devices.

The EA NE Area and SE Area (Thames), who are both involved in managing the tributaries to the Thames such as the Wandle, Brent and Crane, Colne etc., are developing Catchment Flood Management Strategies for the river catchments that feed the Thames. These will be ready by the end of 2003/04 and implementation will follow.

The above processes operate mainly at the national and regional level. There are some more local process e.g. Local Contributions (these supersede the Local Environment Agency Plans) that identify local environmental priorities and actions. It is at this local level that the impacts of climate change need to be understood in more detail in order to formulate appropriate actions. As well as the strategic processes identified above, the EA is contributing to a number of climate change related projects including:

- A project with partners in the South East and Europe called European Spatial Planning Adapting to Climate Events (ESPACE). Part of this will be the development of a Decision Testing Tool to see how decision making will stand up to the impacts of climate change.
- The Thames Regional Climate Change Impacts study (WS Atkins, July 2001) that identified a number of priority actions for the EA:
- Thames Estuary – develop baseline scenario and understand impacts of climate and social and economic change on the estuary including impacts of combined sewer overflows (CSOs) on the estuary under climate change;
- Review effect of climate change on current level of flood defence;
- Assess costs and benefits of maintaining target standards in the face of climate change;
- Develop appropriate wildlife corridors;
- Manage habitat change rather than preserve designations; and
- Further development of regional water resources modelling.

As can be seen from the above many of these actions are being taken forward or have strategic processes associated with them that have the ability to integrate climate change into policy development. However, the approach is not yet comprehensive and all these initiatives need to feed into strategies and plans in order to identify and secure the necessary actions and resources. There is also a need for maintenance of high quality monitoring systems and long term, homogenous observational records to measure and help in the assessment of climate change. The EA is identifying climate change R&D needs to support its strategic and planning processes including:

- The likely impact of either low flows during drought periods or violent storms on the geomorphology and hydrology of London's rivers. The sedimentation patterns of rivers are dependent upon flow, deposition will occur in slow moving water and high flows are likely to deepen the channel. It would be useful to add investigation of erosion and accretion in the estuary to these studies; and
- The impact of climate change on water quality due to changes in dilution, dispersal and degradation of chemicals and pollutants in the water. This could in turn affect discharge consents to the water environment.

Both the above have significant implications on the ecology of the river, smothering plants and animals or preventing colonisation by plants and recruitment of invertebrates and fish and preventing the ability of the rivers to sustain life.

This R&D will support the EA's strategy and policy development.

8.4.3 Water Companies

Water companies have a statutory duty to provide a safe and reliable supply of potable water and to maintain the water mains system and to reduce leakage. They also have a duty to

consider recreation and conservation. Thames Water is additionally responsible for collecting and treating waste water, for collecting trade effluent and maintenance of the sewer system.

The potential effects of climate change on water companies' business can include the following: reduction in quantities of both groundwater and surface water available for abstraction; lower flows in rivers leading to reduced effluent dilution; additional stresses on mains and sewage networks due to increased ground movement; increased amounts of sewage effluent during storm events; and increased and higher peak demands during hot weather.

Water companies take account of climate change in the planning process as part of their overall approach to business risk. Companies put contingency plans in place to ensure the maintenance of services given the expected climate change impacts. This is because the time scales necessary to undertake major capital construction schemes involve taking decisions now, which may not lead to completion of the scheme for another 20 years, when climate change impacts may be more fully realised.

The potential impacts of climate change on the requirement for new developments e.g. water resources, wastewater treatment and the management of existing assets, is informed by water industry research and regulatory requirements. The UK water industry research group (UKWIR - funded by water companies) is carrying out a number of climate change related projects including:

- Phase III of a study examining the impacts of climate change on water quality. This phase will develop modelling tools; and
- A study on the hydraulic capacity of sewers.

The outcome of these studies will be used to inform water company asset development plans. However, in relation to water resource requirements, more research needs to be carried out on the relative significance of catchment land use and climate change.

Other research projects funded by water companies are addressing amelioration of climate change impacts. One example is Thames Water's Thames Tideway Strategic Study which is currently assessing the environmental impact of storm sewage discharges to the tideway and is also considering what improvements (and associated costs) may be desirable with a view to developing technical solutions. This study recognises that climate change predictions for more frequent storms could aggravate water quality problems.

8.4.4 Local Authorities

London's Local Authorities have a key role as community leaders and service providers. Many have, as part of their Unitary Development Plans and Local Agenda 21 strategies, addressed some of the issues raised by potential climate change effects. Local authorities work with key stakeholders, public sector agencies and business and have a key statutory role in a number of areas which may be affected by climate change including transport, the environment and housing.

Local authorities provide a range of services that could be affected by climate change including:

- Social services including those for people with disabilities and the elderly;
- Land use planning and development control. The strategic planning aspects of this role and the implications of climate change are explored above for the GLA;

- Waste management including collection, disposal and recycling;
- Fire and rescue;
- Emergency planning - co-ordinating responses from the emergency services to disasters such as flooding;
- Roads, highways and transportation including the provision, management and maintenance of roads;
- Ensuring local housing needs are met; and
- Environmental health including food safety and pollution control.

London's local authorities have a key role as community leaders and service providers. Many have already started to address climate change issues in their Unitary Development Plans as well as in their community and Local Agenda 21 strategies. They have a key statutory role in implementing strategies in a number of areas affected by climate change such as housing, transport and the environment.

8.4.5 Thames Gateway London Partnership

Thames Gateway London Partnership is a sub-regional alliance of thirteen local authorities, five universities, the Learning and Skills Council London East and the London Development Agency working together with the private sector, local communities and strategic agencies to deliver the economic, physical and social regeneration of the Thames Gateway in London. It is Europe's largest and most ambitious regeneration initiative and extends from Tower Bridge eastwards to Thurrock and Dartford. They are involved in a number of developments relevant to climate change including partnerships with the EA, GLA and Thames Estuary Partnership including contributing to the 'Planning for Flood Risk Management in the Thames Estuary' project.

8.4.6 Thames Estuary Partnership

Thames Estuary Partnership (TEP) was formed to integrate the wide range of uses and interests on the Thames Estuary. It has a mainly environmental focus and has produced the Management Guidance for the Estuary which fulfils the role of the EA's Local Environment Action Plan (LEAP). It covers the Thames from Tower Bridge to Shoeburyness on the north side and Isle of Grain on the south side. The Thames Estuary Research Forum is part of the TEP and seeks to address the research priorities for the estuary such as biodiversity, fisheries, flood defence and physical dynamics, recreation and access and water quality. The Thames Estuary Partnership is working with the Environment Agency who have initiated the "Planning for Flood Risk Management in the Thames Estuary" project. This is a partnership project involving a range of organisations, developing a strategy for flood risk management in the Thames Estuary for the next 100 years. The project covers the covers the tidal Thames and its natural floodplain from Teddington in west London to Sheerness/Shoeburyness in the outer estuary.

8.4.7 London Biodiversity Partnership

The London Biodiversity Partnership has produced a series of habitat audits and species and habitats action plans. The ones of most relevance to a consideration of climate change impacts are covered in the section on potential environmental impacts.

8.4.8 DTI Foresight

The Foresight initiative is developing a project on flood and coastal defence. Its aim is "to produce a long-term vision for the future of flood and coastal defence which takes account of the many uncertainties, but which is nevertheless robust, and which can be used as a basis to inform policy, and its delivery. In common with other Foresight projects, the vision produced should be challenging and independent." The outcomes of this study may be helpful in informing the strategy and planning processes relevant to climate change in London.

8.4.9 Concluding Remarks

Many of the key strategic and policy processes have begun to consider the potential impacts of climate change. Awareness of climate change issues amongst stakeholders involved in this study was high and is accelerating. However, most of the strategy and policy responses are of a scoping nature and more work needs to be done to begin to quantify the potential climate change impacts and adaptation options at the local level including impact on water resources, employment, flooding, water quality, settlement patterns, working conditions, open spaces, infrastructure, biodiversity, economic sectors, health and the built environment.

8.5 Further Research Requirements

A number of recommendations for further research have been identified throughout this report. This section summaries those research needs.

8.5.1 Monitoring Indicators of Climate Change

It is recommended that current monitoring programmes should be reviewed holistically in light of their ability to elucidate to what extent climate change continues to happen within London. For example, actions to improve air quality in London cannot be considered in isolation from those designed to reduce greenhouse gas emissions. However, more attention needs to be paid to diffuse sources – in particular, those linked to the transport infrastructure. This could take the form of: new fiscal and voluntary initiatives to control emissions; traffic restrictions; improved public transport systems; incentives to promote carpooling; and pollution warning services (e.g. London Air Quality Network). Such endeavours should be underpinned by regional inventories of pollution sources, as well as by systems for continuous monitoring of key pollutants and relevant weather variables.

Rising ambient air temperatures in central London and concomitant increases in temperatures across the London Underground network have been raised as a key area of stakeholder concern. Although some data and model results are available for the new terminal at King's Cross, there are no long-term temperature records for the wider network. Until such monitoring systems are in place, claims of rising underground temperatures and possible links to climate change will remain largely anecdotal.

8.5.2 Modelling

The Thames Region Water Resources strategy used a range of scenarios that included potential climate change, to inform the development of the strategy. However, more work needs to be done to consider the impacts at the catchment level. The extent of probable impacts of climate change on the Thames water resource strategy can only really be answered through an integrated regional water resource modelling exercise, that incorporates more climate change detail within the Environment Agency's four socio-economic scenarios. Alternatively, research could be targeted at critical elements in the strategy, such as modelling the reliable yield of a new reservoir, or levels of leakage, under the full set of UKCIP02 scenarios.

The EA is developing Catchment Abstraction Management Strategies to assess the total amount of water available in a catchment and develop a strategic plan for supply and demand. Another process - the 'Restoring Sustainable Abstraction' programme is assessing other ways of obtaining water for supplying needs in particular areas. Both of these processes should be informed by the present study as well as seeking further ways of assessing the potential impacts of climate change on water resources for London. Statistical downscaling techniques could deliver the local, catchment scale scenarios needed to undertake these investigations.

The EA, working with a range of partners, is developing a strategy for flood risk management in the Thames Estuary for the next 100 years. The project is co-ordinated by the Thames Estuary Partnership. Its aim is to assess and understand the tidal defences in the context of the wider Thames Estuary setting. This includes assessment of the residual useful life of the defences together with an understanding of the 'drivers' including climate change, urban development, social pressures and the environment. The project will take five years to complete and involve research to build up a detailed understanding of the physical processes affecting the Thames Estuary. Again, statistical downscaling techniques could be used to develop scenarios of tidal surges that compliment existing work with physical models of the estuary. This project should also examine the potential for the use of open and green spaces for temporary flood storage. Research is also currently being carried out on the adaptation of urban drainage systems (see water companies section above).More research needs to be carried out on the relative significance of catchment land use and climate change.

8.5.3 Comparison with other Global Cities

The draft London Plan argues that it is most appropriate to compare London to other global cities such as New York, Tokyo, Paris, Berlin and so on. The very preliminary comparison of climate change impacts in Tokyo and New York carried out in this study, suggests that the adverse effects would be slightly greater than in London, at least in the current socio-economic conditions. Impacts upon other comparative European cities have not been evaluated. Our guess is that they would be broadly similar, though possibly with a smaller negative effect. The most robust conclusion to draw is that a preliminary comparison between competitor cities indicates that London does not face any significantly greater adverse or beneficial impacts than other cities. A more robust comparison between impacts on global cities is an important future research task.

8.5.4 Dams

The condition of dams in London should continue to be assessed (the Reservoir Act 1975). This should, and does, include consideration of the potential impacts of climate change on their performance.

8.5.5 Health and Climate Change in London

Further consideration and formulation of appropriate responses to:

- The potential contribution of climate change to increased incidences of poor air quality and its impact on the health of susceptible people;
- Impact of increased temperatures on levels of heat stress;
- The potential of the move to a more outdoor lifestyle to improve people's health;
- Ways of improving road safety in conditions of climate change for potential increased numbers of pedestrians and cyclists;
- Health education initiatives to warn of the dangers of more exposure to sunlight and appropriate preventative actions;
- Impact on vulnerable groups of climate change and their service needs; and
- Hotter weather can lead to an improvement in eating habits e.g. more preference for salads, fruit and vegetables etc. However, not everyone has access to these foods either because there aren't the right kind of shops near to them or because they can't afford them. Increased demand for such foods under climate change conditions should be one of the factors in examining ways of ensuring access to fresh and healthy food across London.

8.5.6 Biodiversity and Climate Change in London

Further consideration of the potential impacts of climate change on habitats, species and green and open spaces in London along with appropriate response strategies.

8.5.7 Emergency Planning

Development of systems and processes to respond to climate related emergencies e.g. flooding, damage to buildings and the natural environment, heat stress and outbreaks of food poisoning.

Climate change impact may occur concurrently, such as exceptionally high tides in conjunction with severe river flooding events, or may occur with other extreme socio-economic events such as a stock market crash and a flu epidemic at the same time. Emergency Planning Authorities need to consider the combined effect of such events.

8.5.8 Historic Environment

Further work should be carried out on the potential impacts of climate change on archaeology and historic assets. As they are a key factor in attracting visitors and the quality of life in London, efforts should be focussed on ensuring they are protected from any damage that may result as a consequence of climate change

8.5.9 Strategic Processes

Apart from the present study, the policy processes set out in section 8.3 need to be informed by the forthcoming study on climate change adaptation options and the other strategic processes highlighted in this section.

There is a need to develop appropriate strategies and action plans to respond to the opportunities that climate change may present including:

- Move to a more outdoor lifestyle - more social interaction, entertainment opportunities, pavement cafes and sporting events e.g. outdoor athletics, cycling races and triathlon.
- Promotion of the environmental goods and services sector e.g. renewable energy (solar and wind), flood protection and flood proofing, sustainable urban drainage systems (SUDS) through appropriate developments and support for appropriate businesses.
- Examination of the potential for more water based transport. The Thames runs past many commercial, tourist and retail areas and so London could be well placed to provide more water based transport. This could be a pleasant i.e. cooler alternative to the current transport options. It may also assist in integrating development options in the East with the central areas.
- Examine the potential for London to act as a centre for greenhouse gas emissions trading building on its strengths as a financial services sector.
- Use climate change as a topic in the national curriculum. Its multidisciplinary nature could prove interesting to pupils.
- Examine the potential to enhance and extend biodiversity habitats that will benefit from some climate change conditions. The development of the redundant reservoir at Barn Elms into the London Wetland Centre is a good example of an innovative solution that could act as a model for other biodiversity developments.
- Examination of the potential to develop and provide consumer goods and services that are adaptable to climate change e.g. more extensive use of fabrics that are both breathable and waterproof, solar powered appliances, water efficient appliances and plants tolerant of higher temperatures.

The London Climate Change Partnership has taken the first step in commissioning this study so we can begin to understand the many ways in which climate change may affect London . The next important step is to ensure that the effects of climate change, both good and bad, are built into the decision making process for London, allowing the city to prepare for these impacts and take advantage of any opportunities.

8.5.10 Engaging the Public

The general public are already beginning to make the link between severe weather events and climate change such as the heavy rainfall and flooding in the winter of 2000. It is impossible to say whether individual events like these are caused as a direct result of human induced climate change but they are consistent with results from climate models. A well planned approach to communication is needed to present the public with well-founded, appropriate and accessible information. They need to know what the issues are and what to do.

It is particularly important that the public understands what they can do in emergencies that may be related to climate change such as extensive flooding, poor air quality episodes and intense hot spells that could directly affect their health and safety. The needs of vulnerable groups such as the elderly, those whose first language is not English and people with disabilities should also be identified and addressed.

Education (both formal and informal) should be used to engage the public. Climate change can be an interesting topic for learning in schools and other less formal methods due to its multi-disciplinary nature. Many schools are already using climate change as a teaching and learning topic.

The LCCP will need to consider how it wishes to engage other social groups and stakeholders in London. This may require developing a broader Partnership.

8.5.11 Local Authorities

A survey should be conducted of London local authorities to assess whether and if so how much they have considered climate change and its potential impacts on their services. Asking them to sign up to the Nottingham Charter for Climate Change may help to focus their attention on the need to plan for climate change.

8.5.12 Buildings

Further work needs to be done on how both new and existing buildings can be designed or adapted to improve the living and working conditions under climate change. Issues that need to be considered include:

- Cooling and heating systems e.g. use of groundwater cooling, role of natural ventilation;
- Layout and landscaping of development to provide shading and necessary air flow;
- Appropriate materials e.g. appropriate levels of glazing and insulation;
- Flexibility - ability to adapt to future climate conditions;
- Flood defence/proofing and adaptation;
- Water efficiency measures; and
- Weather proofing.

The GLA are planning to develop supplementary planning guidance (SPG) on sustainable buildings. The SPG should put forward measures that will allow buildings to adapt to climate change.

8.5.13 Specific Developments

Further work should be carried out to examine, as far as possible, the specific potential impacts of climate change on strategic developments e.g. the Thames Gateway, along with the formulation of appropriate responses strategies, where necessary. Suggestions for adaptation options that may be appropriate are contained in the tables above.

8.5.14 Further Quantification of Economic Impacts

As a result of the link between the insurance and financial markets, the financial service sector may also be impacted indirectly by climate change related extreme weather events. The size of this impact will be determined by the extent that the insurance sector has been able to pass on risk to other financial institutions. It is believed that the policy of portfolio diversification which large financial institutions have will ensure that this risk will be reduced and the impact mitigated. This conclusion is not well established and needs to be supported by further research.

The economic costs of disruption to London transport systems was the economic impact most widely identified by stakeholders in the consultation process. Detailed modelling of transport flows to, and within, the city, in combination with climate change model scenarios, are required to accurately assess the likely extent of such costs.

Further work is required to clarify the net balance of change in energy demand as a consequence of climate change in London. The supply infrastructure network is vulnerable to windstorms and clay shrinkage. The economic impacts of disruption to the power supply for extended periods has not been estimated in quantitative terms but is believed to be significant.

Further work is required to clarify the uncertainty surrounding the net economic impact of climate change on tourism and leisure. Revenues may increase as London - and the UK - becomes a more attractive destination in summer relative to those in Southern Europe and elsewhere that are likely to suffer from adverse climate change impacts. However, more trips may be taken from London to escape, for example from uncomfortable temperatures.

9. Conclusions

9.1 Initial Study Findings

The climate in London, as measured by key environmental indicators such as air temperature, rainfall, snowfall, evaporation and relative humidity, river flow, groundwater levels, tidal levels, river water quality, air quality and biodiversity has changed during the 20th century.

The climate in London is expected to continue to change in the 21st century due, at least in part, to greenhouse gas emissions from human activities.

London has a number of unique and key features that could be vulnerable to the impacts of climate change: businesses like insurance and utilities will be likely to feel the strain as climate induced stress on infrastructure and built environment increases; the workforce will be affected by changes in transport, health and the nature of the working environment; culture, leisure and tourism sectors will face increased visitor and site management challenges; flood defences will probably have to be strengthened and water resource management reviewed; rare habitats and species may be threatened as the environment changes around them; the seasonality of energy demands will be likely to evolve with reduced demand for heating in winter and increased demand for cooling in summer.

As well as some of the threats of climate change identified above, during an initial stakeholder workshop held at the start of the project, a number of climate change related opportunities were identified. These included: an increase in outdoor lifestyles such as increased use of open spaces for "open air festivals" and an increase in cycling and walking which would reduce pressures on transport systems; the opportunity to develop sustainable houses and neighbourhoods; climate change as a driver for greater environmental awareness and action; increased demand for "green products and services" including renewable energy; increase in London's tourism and leisure markets; and new opportunities for carbon trading services.

9.2 Key Climate Change Impacts on London

- London may be particularly sensitive to increases in temperature in the future because of the urban heat island effect. Models show progressive increases in both summer heat island intensity and frequency with climate change. This will have detrimental effects on air quality, summer electricity demand (although there will be a reduction in demand for winter heating), and comfort in the city's buildings and transport network. By the 2080s, London's summer extreme temperatures could be comparable with those of present day New York.

- London is exposed to far greater potential damage from flooding than any other urban area in the UK - due to the value of its assets and the fact that a significant proportion of London lies within the floodplain of the River Thames and its tributaries. Whilst flood protection levels are presently good, in the longer term, unless current action to increase investments in flood management measures is continued, the increased risk of flooding from climate change could lead to damage

to buildings and property and disruption of London's transport network. New developments to address the growing demand for housing will need adequate flood protection from all flood sources.

- The indirect costs of a perceived increased flood risk arise from relocation of business and commercial activities to other (global) cities and/or a relocation of highly skilled parts of the labour force, have not been quantified but are thought by stakeholders to be significant.
- Adaptation strategies for flood prevention are being developed. There is evidence of broad stakeholder involvement in this process though the process is at an early stage.
- London is one of the driest capital cities in the world, with available water resources per head of population similar to that of Israel. Climate change could reduce the amount of water available and increase demand in summer. Lower river flows in summer will raise water temperatures and aggravate water quality problems in the Thames and its tributaries, especially following summer storms.
- Poorer air quality that may result from climate change could pose serious problems for asthmatics as well as causing damage to London's plants and buildings. Increased extreme temperatures could lead to higher levels of mortality related to heat stress. It has been estimated that the heat waves in 1976 and 1995 were associated with a 15% increase in mortality in greater London. However, higher winter temperatures would be likely to lead to a reduction in winter cold spell related mortality.
- Climate change could affect biodiversity in several ways. 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. Rising sea levels could threaten rare saltmarsh habitats and increased summer drought could cause stress to wetlands and beech woodland. 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.
- Flood risk threats to buildings and infrastructure along with changing atmospheric conditions associated with a warmer climate present immediate challenges in building and urban design. These climate change issues do not relate only to London. There therefore appears to be a significant opportunity for London's established creative industries, particularly design and architecture, to capitalise on existing Sustainable City initiatives.
- The built environment may also be subject to subsidence that will worsen as clay soils dry out in summer and autumn. Alternate wetting of clays in winter and drying of clays in summer may cause increased ground movement resulting in increased potential for damage to underground pipes and cables. However, the building industry could benefit from an increased number of available construction days.
- London's transport system and ancillary services are vulnerable to disruption from flooding and other extreme weather events that are expected to increase in

frequency and intensity. Increased temperatures on the London Underground, exacerbated by the urban heat island effect, will lead to passenger discomfort. Hotter summers may damage elements of transport infrastructure, causing buckled rails and rutted roads, with their attendant disruption and repair costs. However, higher temperatures will lead to a reduction in cold weather-related disruption.

- The economic costs of weather-related disruption to London transport systems was the economic impact most widely identified by stakeholders in the consultation process. Detailed modelling of transport flows to, and within, the city, in combination with climate change model scenarios, is required to accurately assess the likely extent of such costs. Historical analogues of a single weather-related disruption on only one stretch of the rail network suggest costs of broadly £2 million.

- The London insurance industry, as one of the three largest global insurance centres, is particularly exposed to an increased volume of claims from business and domestic customers that are likely to occur in the event of higher and more extreme wind storms and flood events. Since UK insurers offer greater insurance protection for weather-related damage than their competitors elsewhere, they are, consequentially, more exposed to climate change effects. As well as claims that may be made by those who have suffered damages to assets in London, there is a significant threat from claims that may be made by those in other parts of the world who are vulnerable to extreme climate change events (e.g. typhoons in South Asia).

- Catastrophic storms such as the 1987 windstorm can force insurance companies to sell some of their equity holdings including stocks and shares and property. This could lead to a fall in value of this equity, with a consequent deflationary effect on the economy. The inter-linking of international insurance and capital markets means that the wider financial service sector is likely to be impacted by both domestic and global extreme climate change events.

- Many households do not have adequate insurance cover, and this is more acute for those on lower incomes. This means the effects of flooding fall disproportionately upon these households, which increases inequality still further.

- However, there are significant business opportunities to the financial services sector arising from climate change for example, in the development of markets for catastrophe bonds and weather-related trading in the international financial markets. There are also opportunities from mitigation of greenhouse gas emissions, for example, in carbon emissions trading, energy auditing and verification consultancy.

- Manufacturing could be subject to disruption of raw materials (e.g. food stuffs) that are supplied from parts of the world adversely impacted by climate change. Consumer prices may then be expected to rise. The same mechanism may result in opportunities for recycling businesses, where the price of virgin raw materials (e.g. rubber, wood pulp) increases and makes recycled substitute products more competitive.

- Flood risks, transport disruption, and heat island effects are climate change impacts that might result in relocation of members of the workforce, or changes in

commuting patterns. These effects might impact on the supply of labour to London's public administration, and other economic sectors.

- Increased temperatures could attract more visitors to London, benefiting the tourist sector. Leisure and recreational facilities and tourist attractions will need to be able to cope with climate change by providing a pleasant environment for visitors. However, high temperatures could lead to residents leaving London in search of a more comfortable environment on holidays or breaks.
- Climate change may cause changes in lifestyles. 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. Green and open spaces will be used more intensively.

9.3 Policy Processes

There are a number of policy processes that are ongoing in London that will need to consider the potential impacts of climate change. The main strategy and policy processes related to climate change in London include:

- The draft London Plan - the spatial development plan for London;
- The London Development Agency's economic development strategy;
- The Environment Agency's strategic processes including those for water resources, flood defence (including flood warning) and water quality;
- Water companies' planning processes; and
- Emergency planning

Many of the key strategic and policy processes have begun to consider the potential impacts of climate change. Awareness of climate change issues amongst stakeholders involved in this study was high and is accelerating. However, most of the strategy and policy responses are of a scoping nature and more work needs to be done to begin to quantify the potential climate change impacts and adaptation options at the local level including impact on water resources, flooding, water quality, settlement patterns, employment, working conditions, open spaces, infrastructure, economic sectors, biodiversity, economic sectors, health and the built environment.

9.4 Concluding Remarks

This scoping study is the first step in the process of understanding the impacts of climate change on London and has:

- Identified the main climate change impacts and issues for London.
- Made recommendations as to how climate change should inform further policy and strategy development.
- Identified research gaps and needs.

- Engaged a wide range stakeholder views and raised further awareness of climate change impacts and issues amongst these stakeholders.

This scoping study provides a platform for LCCP to further engage stakeholders in the development of robust strategies and action plans to address the impacts of climate change on London.

Appendix A
The London Climate Change Partnership

1 Page

The following organisations have taken part in meetings of the Partnership during 2001:

Ashurst Morris Crisp Solicitors

Association of British Insurers

Association of London Government

British Waterways

Confederation of British Industry

Corporation of London

Cory Environmental

DEFRA

Environment Agency

Forum for the Future

Government Office for London

Greater London Authority

Hadley Centre, et Office

Housing Corporation (London Region)

J Laing plc

KPMG

London Development Agency

London Electricity plc

London Fire and Emergency Planning Authority

London First

London School of Hygiene and Tropical Medicine

London Tourist Board

London Waste

Thames Gateway London Partnership

Thames Water Utilities Ltd

UKCIP

Appendix B
Stakeholder Workshop Outputs

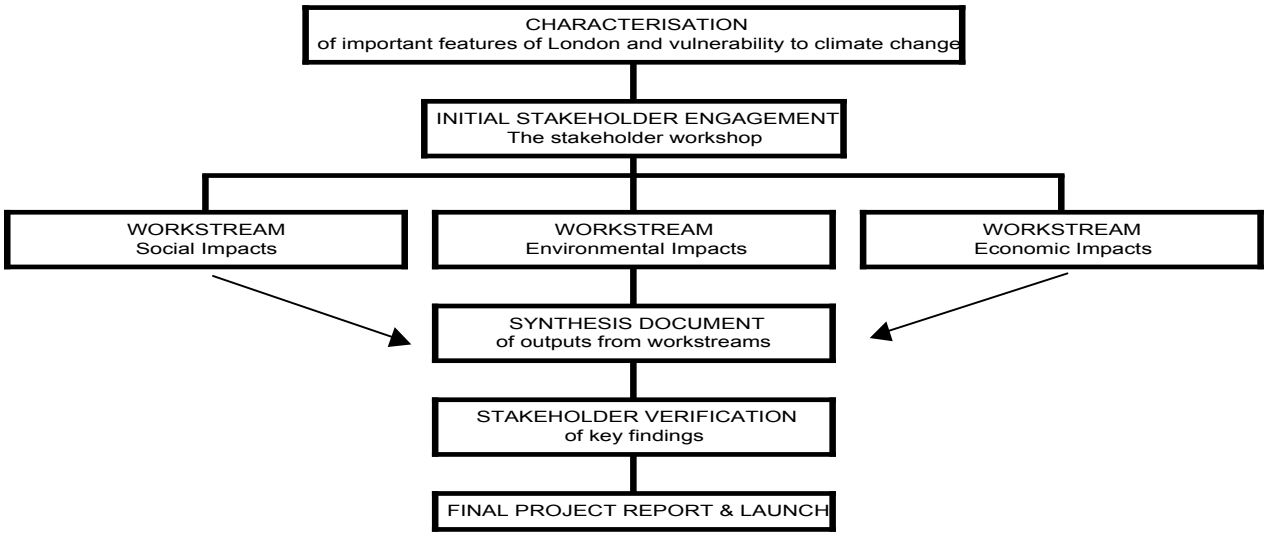
Stakeholder Engagement

Introduction

'Stakeholder engagement', a key objective of this study, is a broad term used to encompass (*inter alia*) the processes of: raising awareness amongst stakeholders; involving stakeholders; stakeholder consultation, and; consensus building amongst stakeholders. Stakeholder engagement has been addressed in several ways by this project but primarily through a workshop setting.

This section summaries the methodology used to engage stakeholders within workshops at two functional levels. These are represented in Figure 1 below which provides a summary of the overall project methodology. At the first functional level, an initial stakeholder workshop was held involving stakeholders selected from a broad range of organisations and interest areas. Subsequently separate smaller workshops and discussions were held on each of three themes or *workstreams* covering environmental, social and economic impacts of climate change. This section summaries the outputs from these workshops.

Figure 1 Summary of overall project methodology



Initial Stakeholder Workshop

Aim of the Workshop

The aim of the main stakeholder workshop was to highlight a broad range of issues around the impacts of climate change in London, from a variety of stakeholder perspectives. The information gained at this event was used to inform the project workstreams through prioritisation of key impacts for more detailed discussion and analysis and also to create stakeholder contacts for involvement in these workstreams.

The Stakeholders

The LCCP provided comprehensive lists of potential stakeholders for the workshop. These were combined with Entec's existing contacts and from potential participants recommended by the GLA. Over 150 stakeholder organisations were invited by e-mail to attend the workshop. Stakeholders invited were from businesses and organisations representing the following areas:

- Central Government;
- Local Government (planning and economic development);
- Environment and Sustainable Development;
- Transport;
- Health;
- Local partnerships;
- Housing;
- Utilities;
- Development and investors;
- Landowners;
- Construction;
- Insurance;
- Business and commerce (trade associations).

It was considered important to engage a range of stakeholders to provide a cross-section of views from across London. There was a great deal of interest in the project resulting in around 70 stakeholders attending the workshop.

Approach

Briefing material was provided to the stakeholders prior to the workshop, this included the following:

- Agenda;
- Characterisation of London (a document summarising the key characteristics of London and their vulnerability to climate change impacts); and
- Summary of UKCIP02 climate change scenarios.

A series of presentations at the workshop provided some background for the participants on climate change scenarios and their potential impact on London. This set the scene for the breakout discussion groups (a total of six discussion groups two groups for each workstream) that followed. During the breakout discussions, stakeholders were invited to:

- Identify the key social/environmental/economic characteristics of London;
- Identify potential impacts of climate change on London related to these characteristics;
- Prioritise impacts on London that they considered required further research;
- Expand and debate the priority impacts on social/environmental/economic aspects of London;
- Identify threats and opportunities for London presented by climate change impacts.

Key Impacts Identified by Stakeholders

The discussions that resulted provided a considerable amount of information and demonstrated a broad range of views. The key impacts discussed in detail are shown in Table 1.

Table 1 Key impacts identified by stakeholders

Social impacts	Environmental impacts	Economic impacts
Housing	Air Quality	Transport
Air Quality (Health)	Biodiversity	Business profiles
Built Environment	Flooding	Workforce
Migration	Water Resources	Wealth Generation

The impacts identified in Table 1 (and their inter-relationships) are discussed in detail elsewhere in this report.

Opportunities and Threats

Following the group discussion, individuals were given an additional opportunity to express personnel opinions on the impacts of climate change. This was achieved through a 'post-it note exercise' in which each delegate recorded their own views on the opportunities and threats which climate change would create and recorded them under social, environmental and economic headings. Key results are outlined in Table 2. These results were used as a primary input into each workstream workshop and are considered in detail in Sections 5, 6 &7.

Table 2 Summary of opportunities and threats identified by individual stakeholders

	Opportunities	Threats
Social impacts	More active outdoor lifestyles improve quality of life. Increase in cycling and walking will reduce strain on transport systems. New migrants will bring new skills and cultural richness particularly with regard to living in a warmer climate. Opportunity to develop sustainable houses and neighbourhoods.	Adverse health effects related to increased exposure to heat and UV-radiation. Potential for increased social disorder due to rise in temperature and associated stress. Environmental refugees, increasing the burden on the social/welfare state.
Environmental impacts	Climate change as a driver for greater environmental awareness and action: Sustainable Urban Drainage. Renewable energy. Positive review of environmental policy. Improved green space management.	Habitat loss with little opportunity for species migration due to fragmented habitat zones. Water stress - reduced summer availability for domestic, commercial, industrial and wildlife requirements (particularly wetlands). Increased incidents of flooding including sewer flooding.
Economic impacts	Increased demand for 'green products and services' including renewable energy. Increase in London's tourism and leisure markets. New opportunities for carbon trading.	Large impact on insurance industry - large pay outs, reduced cover, dented investor confidence. Mitigation funding and planning procedures are not in place. Will funding climate change (impact) mitigation adversely impact business or vulnerable areas of society.

Evaluation of Initial Workshop

Forty one of the participants completed an evaluation form after the workshop. The feedback, on the whole, was positive with the majority of people enjoying the workshop. Thirty seven of the participants completing an evaluation were interested in making a further contribution to the study through the workstreams. The evaluation results and comments are also provided in the Appendix.

Environmental Workstream

The Environmental Workstream Workshop held on the 10th May was attended by a broad range of delegates representing key organisations - including the GLA, Thames Gateway, London Development Agency, Thames Water, the EA and UKCIP. The workshop was designed to allow the stakeholders to consider the practical consequences of the UKCIP02 scenarios and to expand on areas of particular concern, highlighted at the main stakeholder event, within the context of environmental/water issues of London.

The workshop identified numerous groups that are already acting to monitor and mitigate the effects of environmental change in London and the South East. Notes from the workshop were circulated for approval and further comment, and the information consolidated in Section 5.

Social Workstream

The Social Workstream Workshop held on the 20th May was attended by a broad range of delegates representing key organisations - including the GLA, Thames Estuary Partnership, Transport for London, Forum for the future, the Directorate of Health and Social Care, and the Corporation of London. The workshop was designed to allow the stakeholders to expand on areas of particular concern, highlighted at the main stakeholder event, specifically social, political and cultural aspects of London life.

The workshop was based on a definition of 'social': "overall health and well-being, social and economic equity, public safety, public health and infrastructure, civil cultural and political society (including political institutions), and who bears the cost and reaps the benefits in future London." From this base the group examined three key areas in detail: flooding, higher temperatures; and impacts of climate change upon demography.

Notes from the workshop were circulated for approval and further comment and have been drawn together in Section 6.

Economic Workstream

The Economic Workstream output was based on a series of one to one interviews (meetings, telephone interviews and e-mail correspondence) conducted between the 10th-21st June. The sectoral stakeholders involved included representatives from Insurance companies (CGNU & D. Crichton), the National Grid, Thames Water, Business Services (Frost, KPMG), Environmental business, the London Tourist Office and Manufacturing industry. Notes from the interviews were circulated for approval and further comment and the results combined with information produced from an extensive literature review to produce Section 7.

STAKEHOLDER WORKSHOP

Seventy stakeholders attended a workshop on the impacts of climate change in London on May 1st 2002, held at the GLA offices in London. A series of presentations were made followed by small group discussions on the social, economic and environmental aspects of the impacts of climate change on London.

REVIEW OF IMPACTS OF CLIMATE CHANGE

For the discussion sessions the stakeholders were split into six groups. Two groups focused on social impacts of climate change, two groups looked at environmental impacts of climate change and two groups looked at economic impacts of climate change.

Each group was asked to:

1. Identify gaps in the characterisation of London presented by Entec UK Ltd
2. Identify impacts of climate change around the key characteristics of London
3. Prioritise two impacts they wished to discuss in greater detail (shown below as number of *votes*)
4. Discuss their chosen impacts in detail by responding to a series of questions

The notes made by group facilitators have been pulled together into the record of workshop outputs below. This will be used to inform the environmental, social and economic workstreams and the project report.

Group 1 - Social

Social Characteristics and related impacts

Population

- Will domestic energy use increase?
- Ageing - NHS (Heat wave warning systems) (1 vote)-
  - Social Care
  - Heat Stress *(1 vote)*
  - Institutional Care *(1 vote)*

Housing

- Density - Urban Heat Island *(2 votes)*
- Sustainable Build Regulations - old housing stock - Energy Efficiency - Air Conditioning *(4 votes)*
- Flood Risk - Great uncertainty

- Link to other studies - Thames Gateway - Thames Strategy East *(5 votes)*
  - Sustainable Urban Drainage Systems (SUDS) - Heavy rain -> Damp, subsidence
  - Services - Waste, water, power, education *(2 votes)*

Social Deprivation

- Fuel poverty *(1 vote)*
- Health - Respiration etc. *(4 votes)*
- Distribution of equitable impacts - variability of population *(3 votes)*

Ethnic Diversity

- Migration driven by Climate Change - political uncertainty
- London as gateway

Household Size

- Migrant households

Migration (additional key heading)

- Dispersal/migration of population resulting from climate change in other areas - 'Refugees' *(3 votes)*

- Health needs *(3 votes)*
- Economic mobility

Impact 1 - Migration

Discuss the consequences of this impact for London.

- Migration
  - Within London
  - Into London
  - Into UK via London
- Housing
- Economy/Employment/Skills - new people leads to new needs
- Services
  - Education
  - Health including new health needs
  - Infrastructure
- Social Exclusion
- Equity
- Out migration/Displacement
- Transport
- Skill pool

What information do we need to understand/measure/monitor this impact? - How might this be collected?

- Examine changes elsewhere - politically sensitive impacts of Climate Change on other countries
- 'Competitor Cities' - Economic migration, - Climate migration - To and From
- Past migration Patterns - Examine drivers
  - Push
  - Pull
  - Ask current migrants

What mechanisms and structures already exist to assess the issues?

- Greater London Authority (GLA)

- Past population census have been used to distribute resources
- NHS -> Migrant Health
- IPCC

Where or who is existing information coming from?

- GLA - growth predictions
- DTLR

In addition to climate change, what other factors can contribute to or influence this impact?

Policies

- Economic -> Predictions validity?
- Development planning
- Infrastructure
- Availability of services -> Water -> Power -> Health etc

Frameworks

- GLA

Other drivers of change or potential causes

- Migration within UK
- North/South divide
- Regional competitive report - DTI or DTLR

What tensions arise when you consider the other aspects of sustainable development related to this impact?

- Increased Development/Demand

Impact 2 - Built Environment 'Commercial'

Discuss the consequences of this impact for London.

- Housing
  - Flood
  - Heat stress
  - Commercial
- Productivity
  - Heat stress
  - Long lunches!

  - Acceptable working conditions are variable with the external temp
- Occupational Illness
  - Heat stress
  - Long lunches!
  - Acceptable working conditions
  - Variable with external temp
  - Workforce obligations
- 'Physical Shock' - Move from regulated to unregulated temperature zones
- Residential
- Subsidence
  - Flooding -> People impact -> Depression -> Trauma etc.
  - Migration -> Choice where to live
- Land Values
- Preparation for extreme events
- Building Regulations
- Sewage Flooding

What information do we need to understand/measure/monitor this impact?

How might this information be collected?

- Look at other 'Hot Countries'
- Flood studies - where will houses be built after a 1 in 1000 event?

What mechanisms and structures already exist to assess the issues?

- EA

In addition to climate change, what other factors can contribute to or influence this impact?

Policies

- Working condition policies
- Building Regulations
- SUDS
- Flood plain building
- Frameworks

- Local Government implementation

Other drivers of change or potential causes

- Big floods
- Extreme heat waves
- Will developer pay for change

Group 2 - Social

Social Characteristics of London

Population

Housing

- Multi occupancy 500,000 new houses - will be flats!
- Characteristics of housing
- How housing is accommodated
- Smaller households - single occupier - small units
- What are the design elements needed to account for climate change?
- Cost implications from design needs
- Economics and market choice for size of house
- If moving toward multi-occupancy/communal space there are safety issues
- Construction raises safety issues
- Need proper management for social housing - build management issues into design
- Vulnerable to storm damage due to the way we live. This may promote a shift to increase densities of green spaces

Social Deprivation

Ethnic Diversity

- Cultural backgrounds changing service demands and needs

Recreation and amenity (additional key heading)

Education and skills and training (additional key heading)

Household Size

Health Inequality (additional key heading)

Impacts of Climate Change on London

- Transport infrastructure *(2 votes)*
- Water use for cooling underground - New technology
- Flooding (3 votes)
  - Flash floods
  - Drainage
  - Sewage

- Water table
- Air conditioning - cooling
- Energy demands *(1 vote)*
- Location of housing *(3 votes)*
- Design of housing *(7 votes)*
  - Flood plains
  - Street layout
  - Construction design
- Flooding properties
  - Bed-sits/Basement property
  - Vulnerable groups
- Subsidence
- Deprived groups/sector of community forced into poorer higher risk properties
- Fuel poverty
- Water metering - water poverty
- Poorer air quality *(5 votes)*
- Green space and parks *(3 votes)*
  - Recreation management
- More outdoor lifestyle improving health
- Damp property and drainage
- The impact on health of temperature changes *(6 votes)*
  - Respiratory problems
  - Hayfever
- Migration *(3 votes)*

Impact 1 - Air Quality

Discuss the consequences of this impact for London.

- Less attractive as a world city
- Impact on travel to work and working from home - Other local impacts
- Good or bad impact?

- Pollution concentrations
  - If Met. is increasing, high pollution episodes need a response, with traffic etc.
  - The loop related to energy use in air conditioning and emissions implications
- Potential out migration may have economic impacts on inward investment
- Concentrations of pollution in relation to population
  - Noise
  - Housing
  - Recreation
  - Exposure levels - Internal and external
- Knowledge gap exists, need more detailed resolution i.e. pollution in specific areas and specific streets
- Vulnerable groups, e.g. - Schools playtime, old people's homes

What information do we need to understand/measure/monitor this impact? How might this be collected?

- Identify existing controls - integrated planning
- Tie resolution models with emission inventory
- Need monitoring of outdoor air pollution
- Influence on planning decisions- demographics and hotspots

What mechanisms and structures already exist to assess the issues?

- Reporting of high pollution incidents
- Needs to be greater awareness - better publicised
- Comprehensive air quality network information exists
  - Healthy schools initiatives
  - Information is made available and used by asthmatic/respiratory sufferers

Where or who is existing information coming from?

- Imperial College - DAPPLE - air quality/modes
- University of Birmingham - in airport
- Internal
- LA have to produce Air Quality Plans and there will be a requirement to produce traffic plans

- London Health Observatory
- Department of Health and World Health Organisation

In addition to climate change, what other factors can contribute to or influence this impact?

- How much impact does traffic management actually have on air quality?
- Low emission zones
- International implication of particulate regulations, Kyoto and other international targets
- Shifting distribution in economic sector - e.g. manufacturing or farming! May increase in London what would the impacts be of this shift?
- Global cities - competition
    - Quality of life based, e.g. Edinburgh and Leeds are competitors, if they offer a better quality of life people will move there

Impact 2 - Housing

What information do we need to understand/measure/monitor this impact?

How might this information be collected?

- What happens to existing stock/level clearance/grants available
- Design for conditions in 100 years rather than now - building regulations, e.g. flood proofing

What mechanisms and structures already exist to assess the issues?

- Housing Association are able to 'design in' environmental and safety aspects whereas private housing doesn't as it is profit driven.
    - Economic
    - Choice
    - Markets
- Public sector should lead way on best practice

Where or who is existing information coming from?

- Construction industry are beginning to recognise Climate Change
- TCPA are doing some thinking around Climate Change
- EPSRC - impacts of Climate Change on the built environment
- BRE/CIFIA/Tyndall Centre
- Housing Health and Safety rating system - hazard issues

In addition to climate change, what other factors can contribute to or influence this impact?

- Ethnically diverse population and changing socio demographics mean new and changing expectations
- Community involvement and social regeneration
- Location of jobs in London and the south east
  - Commuting and migrating populations
- Business location and transport to/from/between work and home
  - Changing business practices
  - Work from home
  - Decentralised/multicentric business
- Global recession/war
- Government intervention
- Technology improvements - affordability of technology

What tensions arise when you consider the other aspects of sustainable development related to this impact?

- Capital cost - revenue cost
  - Cost to construction industry, running cost for home owner is rising
- Long-term changes in economic practice. What is considered as good practice now may be different in the future
- Sustainable development and environmental accountability
- Skills shortages - employers become more aware of importance of environmental and social needs
- Realisation from consumers, who want a good quality of life, that they as 'drivers' of markets will have to pay
- Inequality - social deprivation

Group 3 - Environmental

Environmental Characteristics

<u>Water Quality</u>

- Temperature of the Thames - fish, cooling
- Increased silt
- Less dilution capacity - low flows

- Differences due to seasons - resource implications

Flooding

- Public/corporate 'education'
- Loss of fresh water habitats *(1 vote)*
- Impact on emergency services *(1 vote)*
- Long-term evaluation of flood defenses *(2 votes)*
- Impact on nearby landfill

Water Resources

- Supply/demand balance *(5 votes)*
- Water levels on fresh water wetlands
- Decrease of burst pipes

Air Quality

- More cooling needed - building and transport *(1 vote)*
- Impact on building fabric
- Benefits to pest reduction

- Affect of wind to improve air quality - people moving to outskirts

Biodiversity

- Dangerous species may increase e.g. Malaria
- Impact on reservoirs
- Distribution of species
- More people in outdoor areas

Waste Management

- IPPC
- Greater volume

Riverside Development

- Demand to live by the river
- Changes in physical Environment

Transport

- Exodus in the summer

Environmental Impacts of Climate Change in London

- Difficult to maintain quality *(1 vote)*
- Location of sewage works *(1 vote)*
- Impact of sea-level rise and flows to rivers
- Flood storm over-flows *(1 vote)*
- Algal blooms
- Flooding/protection of buildings *(6 votes)*
- Better design
- Insurance blight
- Protect flood plains
- Plans could improve environment
- Increased demand *(1 vote)*
- More in winter/less in summer
- Rising ground water *(1 vote)*
- Borehole cooling;
- Need to water green spaces - outdoor use
- More fires on scrub and health leading to decrease in air quality *(1 vote)*
- Smog/ozone have health impacts increasing pressure on Doctors and Hospitals *(2 votes)*
- Health less cold/fuel poverty *(1 vote)*
- Impact on habitats?
- Exposure - more outdoors
- Greater use of air conditioning
- Scrub/heath fires *(1 vote)*
- Requirement to protect SSSIs
- Loss of habitats *(3 votes)*
- Changes to habitats
- Changes to species
- Preservation Vs Conservation

- Landfill location by river
- Speedier rotting - Quicker collection
- Change in waste composition *(1 vote)*
- Increase re-cycling/composting
- Locations for disposal *(1 vote)*
- Available sites - but flooding? *(1 vote)*
- Properties set back from flood plain
- Properly already on flood plain
- Riverside defenses - more *(1 vote)*
- De-zoning of green belt to provide alternative sites?
- Need to cool
- London Underground - flooding?
- More walking/cycling? (unless increased rain)
- Facilities in the work place
- More need - waste/deliveries

Impact 1 - Flooding

Discuss the consequences of this impact for London.

- Flooding/protection of buildings - Graded Mapping of Flood Risk
- Causes:- a) Tidal flooding
  b) Watercourse Flooding
  c) Sewage flooding
  d) Localised shallow groundwater flooding
- Managed realignment
- Protection of buildings
- Design of buildings
- Long-term Flood Design Strategy
- Warning/Emergency Planning
- Insurance issues

What information do we need to understand/measure/monitor this impact? How might this be collected?

- Planning for flood risk project
- Thames Strategy East
- Strategic Environmental Assessment
- PPG25 Assessments (with EA)
- Sewer capacity

What mechanisms and structures already exist to assess the issues?

- Development Plans
- PPG 25
- Building Regulations (SUDS)
- SDP

Where or who is existing information coming from?

- Borough Appraisals
- EA for Flood Risk 1 or 2
- Water Company for flood risk 1 or 2
- Transport for London
- Developers, Association of British Industry

In addition to climate change, what other factors can contribute to or influence this impact?

- Migration - Common sense on habitats (sustainability)
- Developers/public awareness
- Greater flooding
- Condition of current assets
- Leakage issues
- Reliance on water-based sewer system
- Manage water resources better through increased enforcement e.g. -> SUDS - in building regulations?
- Fiscal Policy
- Culture - use too much water

- Water company Asset Management Planning (AMP) process

What tensions arise when you consider the other aspects of sustainable development related to this impact?

- Tensions are limits to growth
- Development areas have to be in Flood Risk Areas
- Historic/sacrosanct issues
- Impacts/flexibility of infrastructure
- Current unsustainable lifestyle
- Nation of gardeners (farmers)
- Culture/legislation
- Conflict between London and South East competition for resources
- Housing demand/targets

Impact 2 - Water Resources (supply and demand)

Discuss the consequences of this impact for London.

- Health & hygiene issues (less usage/sanitation)
- Extremes in water availability _ Price rises, water bills
- Less water for putting out fires
- Competition for space for storage
- Greater need for SUDS and water demand/efficiency management (metering)
- Utilise: Increasing G.W. as a resource
- Habitat changes
- London requirement for storage reservoir
- Effluent re-use - Reservoir, de-salination
- Food production/agriculture

What information do we need to understand/measure/monitor this impact? How might this information be collected?

- Current use/extrapolate
- Drier springs and wetter winters (understand the differences between the CC scenarios)
- Potential for SUDS - what 'types' most effectively applied to London
- Subsidies (cross-subsidisation?)

What mechanisms and structures already exist to assess the issues?

- Used to addressing these issues therefore structures should be in place - (certainty better adopted than for floods)
- Catchment Abstraction Management Strategies (CAMS) (EA) process

Where or who is existing information coming from?

- Water companies _ Strategic for use etc.
- EA (CAMS)

Group 4 - Environmental

Environmental Characteristics and Impacts of Climate Change in London

Air Quality *(4 votes)*

- Noise 'aesthetics' (identified as an additional characteristic)
- Not all transport sources
- Local/point sources (stacks)
- Diffuse-traffic, constriction
- Indoor and underground air quality
- Open window - more vulnerable to traffic noise etc.
- Nitrogen deposition
- Thermal inversions
- London impacts on surrounding areas e.g. more air travel
- Odours - smog - ozone rises as Temp rises
- More building - dust - VOC's
- Dry ground - dust more fires - effects air quality

Biodiversity *(5 Votes)*

- Wetlands
- Water bodies
- Thames Estuary
- Gardens & garden escapes
- Pest control
- Fires - bracken?
- PPL's expectations of parks etc. Ponds, water ?
- Rising climate space for species habitat fragmentation

- Impacts on national, international designated species
- Species rising - completion, dynamics
- Increased tourism pressure
- Brownfield - impact on biodiversity/habitats
- Soil erosion + tree damage

Water Quality *(4 Votes)*

- Drinking water quality
- River SLR/saline
- Ground proposing more deep levels
- Shellfish & human health
- Worsens more treatment needed but no room
- Hence - Intensive treatment
- Hence - Energy intensive
- Sedimentation - from upstream & in London

Flooding *(6 votes)*

- London Underground already being pumped
- Assets STW 'standard'
- Convective storms in London
- Urban 'flashy'
- Thames Gateway
- Coastal squeezes (also biodiversity)
- Flood defenses raised
- Access + visual affected
- How to manage - hard/soft higher defenses when they are breached catastrophe

Water Resources *(4 votes)*

- London depends on external sources (incl. reservoirs)
- Conflicts over use e.g. for drinking Vs nature conservation
- Rising groundwater - could tap into this - local treatment needed
- Winter storage?

- Resource = finite/reducing
- Demand increase with Climate Change - grey water storage/rainwater harvesting

Sewage

- Foul flooding cut across all sectors
- Urban area any building very disruptive + difficult

Waste Management

- All goes outside London
- Increased emphases on recycling more incinerators (air quality), re-use, landfills are full
- Increasing offices - paper and electronic equipment (computers)
- Contaminated land & ground water
- Contaminated in landfill sites

Riverside Development

- Air quality
- Odours/rats health
- Flooding
- Biodiversity loss
- Access

Transport *(2 votes)*

- Construction of schemes environmental impacts
- Storm damage
- Insurance
- Air quality
- Noise

Impact 1 - Air Quality

Discuss the consequences of this impact for London

- Cycling of carbon - 'human/animals (short time scale) % fossil fuel etc. - long time scale
- Sulphates - declining
- N-growing problem

- How will atmosphere chemistry change because of CC? (Imperial College)
- Athens - smog! Taste of things to come?
- Study air quality but not including CC?
- Sources - sulphates - Nitrates - smog - O_3
- Skin/Health impacts 'Point'
- Sun + Air Pollution
- Diffuse transport
  - Alternative modes - i.e. cycling
  - Work on feasibility of low emission vehicles/for areas in London
- Nitrogen - how will wet/dry deposition be impacted. Nitrogen enrichment on land, water and lighting
- Drier atmosphere increase dust with impacts on health
- If more construction dust will increase
- Hotter- open windows and spend more time outside - indoor air quality will be poor - dust mites survive easier. Air conditioning will increase

What information do we need to Understand/measure/monitor this impact?

How might this information be collected?

- EA & LA's do air quality monitoring - but need more!
- Need to understand air quality and climate change - modelling
- Network of automatic stations - need more of these including monitoring metrology
- Are we monitoring the right pollutants in the right places?

What mechanisms and structures already exist to assess this issue?

- Need to monitor & understand urban microclimate & e.g., street canyons
- Modelling needed - CC + air quality
- Will we have more exceeds of air quality standards?
- Integrate with air quality - managing strategies

Where or who is existing information coming from?

- Also monitor traffic - flow/condition/vehicle types
- Also monitor construction sites

- EA/LA's keep monitoring data for industrial processes

In addition to climate change - what other factors can contribute to/or influence this impact?

- Policies - air quality - IPPC, AGMS, NAQS
- Targets for traffic emissions Sulphur and Nitrogen protocols
- SOC economic changes in pollutant sources - e.g. traffic, waste strategies, energy policy, transport policy will affect extent if impact.
- Local community 'pressure' e.g. if odours from waste worsens more rubbish collection will be demanded
- Tourism changes may lead to traffic changes

What tensions arise when you consider the other aspects of sustainable development related to this impact?

- Always winners & losers. Must aim for net grain.

Impact 2 - Biodiversity

Discuss the consequences of this impact for London.

- Changes to species (flora/fauna composition habitats)
- Have to explain/educate people that change will occur - need to gain acceptance.
- Designated sites have more value and can be used to manage change
- Current debate in nature conservation world on managing change
- Parks (increased pressure on them) - Green spaces - physical climate
- Parks vital biodiversity resource in London - under pressure from tourism
- Use roofs as green space or for water storage etc
- Hamstead Heath - recreational uses different from Hamstead Common which is more nature conservation focused!
- Availability of green space in cities to allow species to move to new climate space.
- Do we restrict access to parks, to protect species threatened by climate change?
- Impacts of sea level rise on estuarine habitats and changing species composition - water bird numbers

What information do we need to understand/measure/monitor this impact?

How might this information be collected?

- Historical data - phonology - UK phonology network
- Engage public to do this - e.g. 'biodiversity network' being set up by Corporation of London

- Learn from climate change modelling studies - e.g. MONARCH
- Can't 'learn lesson' from other countries with similar climates - e.g. day length in UK doesn't change with Climate Change

What measures and structures already exist to assess the issues?

- Biodiversity Action Plans (BAP) consult on what populous value/should be protected through engaging the public (e.g. 'wildlife trusts') educate populous about climate change
- BAP process at all levels policies on the ground need to take account of climate change
- Habitats directive/birds directive/Ramsar don't currently take account of dynamic change should do! The water framework directive doesn't acknowledge dynamic system - no change!

Where or who is existing information coming from?

- English nature, Monarch funders and researchers
- Water sector contribute e.g. BAPs, LEAPS (EA + Water companies)

In addition to climate change what other factors can contribute to or influence this impact?

- CBD, FCCC, LA21
- Community Strategies (soon)
- Water quality
- Air quality
- Flooding
- Planning
- Transport
- Leisure
- Tourism
- Agriculture etc

What tensions arise when you consider the other aspects of sustainable development related to this impact?

- Planning/LU/USP's
- Need to know where goal posts are for nature conservation
- Do we accept climate change impacts or try to resist them?

Group 5 - Economic

Economic Characteristics and Impacts of Climate Change in London

Profiles

- Spatial characteristics
- Dynamic/changes *(3 votes)*
- More Home working!
- Impacts on Thames gateway + costs of protection
- London's position may improve in comparison to other cities
- Impacts on developing countries may have effects on London (e.g. migration)

Transport

- Commuting (9 votes)
- Increase demand for public transport
- Air Conditioning for modes of transport
- Increase in leisure travel
- Flooding disruption
- Greater measure for technological improvement - cycles and cars

Workforce

- Unemployment *(3 votes)*
- Employment opportunities in new technologies e.g. renewables - solar
- Consultancy opportunities
- Hotter climate may discourage manufacturing
- Seasonal and tourism employment

Tourism and Leisure *(4 votes)*

- May be more seasonal employment
- Floods may discourage tourism and leisure
- Overall trend is positive
- More outdoor activities garden/parks

Construction

- Heat island effects intensified with increased housing/development density

- Design and materials will change
- Flood plain issues
- Flood defense - SUDS

Government

- Effects how decisions are taken
- Big issue in London - (big for UK - London Centre)

Cultural Heritage

- Indoor tourism related to heritage becomes less attractive
- Could impact on design of buildings
- Historic buildings maybe more difficult to use/adapt
- More costly to maintain

Knowledge Economy *(1 vote)*

- Climate change studies will benefit academies
- Financial services study on issues - climate change

Wealth Generation *(8 votes)*

- Financial Services - insurance
- Investment changes
- Carbon trading skills
- London insurance capital of world - high risk to industry!
- Floods/hazards will have potential detrimental impact

Consumption

- Consumption of water may increase *(2 votes)*
- Increased energy consumption (and demand for) air conditioning, fridge's etc
- Depends on where goods come from material may change

Impact 1 - Transport

What information do we need to understand/measure/monitor this impact?

How might this information be collected?

- Draft London Plan, transport strategy and other strategies
- Environmental monitoring, risk analysis of impacts on transport

What mechanisms and structures already exist to assess the issues?

- Flood doors on tubes - functional?
- Bridge over viaducts - flood plains functional
- Maintenance systems checked reviewed for extreme events

Where or who is existing information coming from?

- Local authorities
- Transport plans
- Air quality monitoring
- Surveys e.g. British airports authorities

In addition to climate change, what other factors can contribute to/or influence the impact?

- Population increases
- Clustering tendencies for businesses
- Housing density
- Work patterns - technology dependant
- Infrastructure development - by rail, transport for London/highways agency
- Port authorities
- Airport development

Considering economic, social and environmental impacts, what are the opportunities and threats that may rise from the impacts of climate change?

- Push to travel less distance - work/home
- Mode shift - walk/cycle - sustainability
- Investment in cleaner transport - energy efficiency
- Social diversion in access to recreation

Impact 2 - Wealth Generation

What information do we need to understand/measure/monitor this impact?

How might this information be collected?

- Information on alternative investments + associated risks
- Evidence of climate change

What mechanisms and strengths already exist to assess the issues?

- Reliance on current EC reporting for Households - media

Where or who is existing information coming from?

- IPCC
- LA/EA on flood risk

In addition to climate change, what other factors can contribute to or influence this impact?

- Globalisation - Clustering effects
- Employment trends

Group 6 - Economic

Economic Characteristics and impacts of climate change in London

Workforce *(5 votes)*

- Working conditions and getting to work
- Population projections
- Migration as a source of new values social + economic
- More house working
- Discourage people from working late
- Does it exasperate inequality *(1 vote)*
- Depends on drain on welfare/special services

Tourism & Leisure

- Few hotels with air con at moment
- Change in type of tourism
- Water storage
- Could become more seasonal?
- Provision of more outdoor facilities
- Winters warmer but wetter - cloudier - could be positive

Economic Characteristics *(2 votes)*

- Level of capital assets at risk from climate change! Only from flooding
- Data could exist
- power supply
- Business interruptions e.g. underground
- Power supply telecom

Profiles *(4 votes)*

- Business costs - ventilation (3 votes)
- Discuss the consequences of this impact for London
- New GLA building borehole cooled
- Energy costs more - renewable increased opportunity
- Natural poor indoor air quality
- Corridors - new high buildings
- Building design outdoor e.g. Lloyds, register of shipping HSBC

Transport *(5 votes)*

- Heat stress more workers
- Public transport
- Impacts
- V hot tube
- 3 heat emergencies in Toronto. AC offices open to public
- Road gravel etc heat! Effects etc.
- Railtrack more leaves on track

Cultural Heritage

- Competitor cities

Knowledge Economy

- Water shortage *(1 vote)*
- Property prices *(2 votes)*
- Impact of floods risk on house prices
- Flooding + property prices
- Business impacts e.g. - manufacturing, watering?
- Does it help tall buildings

Wealth Generation *(1 vote)*

- Economic development issues
- London Plan
- Interruptions

- Business - transport + infrastructure
- Costs - Water - energy-land property
- Workforce

Impact 1 - Transport

Discuss the consequences of this impact for London

- Better weather more walking + cycling
- Showers at work - raise water use
- Shift from home to work
- Depends of proximity
- House prices
- Larger commuting
- Business locating in mixed use areas - live near to work
- Focus on East
- Open areas - access in London to outside
- Congestion changing to help with shift/outdoor lifestyle
- Actual interconnection between living locations + job locations
- Quality of walking/cycling experience Limit number of cars
- Working at house e.g. Sutton Meadway
- Changing in working patterns
- Other cultures - more renting/more flexibility
- Cycling pedestrians lower emissions problem + A & Q + bus lanes help
- River transport
- Speed/quality
- Interchanges

Opportunities

- Green chains walks
- Better use through better access
- What about using the issue as reason to make London transport (underground + air conditioning)

OPPORTUNITIES AND THREATS

Using post it notes, stakeholders gave their individual views on the threats and opportunities of Climate Change in London. The results of this are shown below.

ECONOMIC THREATS

- Insurance - Currently under writing losses are offset against investment income. Impact of climate change on investment returns - implications for premiums
- Reduced capitalisation/insolvency of insurance/mortgage lenders due to increased natural hazards.
- Threat to global reinsurance pool from global climate event claims (by 2050 > world GDP).
- Insurance industry leads to growing impact of extreme weather on insurance claims of some areas/activities becoming uninsurable.
- Major shift of economic and social enterprise away from London.
- Dented investor confidence if flooding message is not handled sensitively.
- Restrictions in emissions may lead to limits on economy growths.
- Damage to commercial and cultural buildings.
- Who will pay for additional infrastructure e.g. reservoirs? Will people pay today for the population of the future?
- The poor could pay proportionately more of the costs of climate change impacts.
- Inability of the planning process to respond to issues about developing of land at risk from flooding in the near future. Time lags.
- Fires and flooding will place an increased resource demand on emergency services.
- Possibility that public transport improvements do not keep track with climate change (e.g. air-conditioning) forcing people to use private cars more often.
- That London becomes fairly unbearable especially during long hot summers. Transport systems in particular will become unpleasant to use.
- Extremes of temperature may effect current transport systems in terms of location and frequency of use.
- Location of brownfield land and impact on supply - Greenwich: most brownfield land along river front. If that can't be developed for climate change reasons, supply will go down significantly.
- Increased energy demand and high energy prices leading to fuel poverty.
- Increased punitive legislation e.g. ROC, CCL.
- The £30bn flood event and knock-on effects.

ECONOMIC OPPORTUNITIES

- Sustainability - what happens to it? This is the over-arching and uniting factor that will help tie together arguments/actions from economic, social and environmental perspectives.
- Evening economy
- Products made from sustainable materials.
- Investment in more sustainable industries/activities.
- Need to distinguish between sectors that need to act in the short and long term e.g. restaurant owners - short, property developers - long.
- Increase in eco-economy jobs. New services such as climate change strategy, climate change consulting, green house gas auditing and verification. New need for environmental green collar market e.g. water recycling and solar energy.
- Increased maintenance requirements on housing may lead to new products offering servicing.
- Insurance opportunities - greater hazards lead to greater consumer demand. Longer life leads to increase in pensions/savings product demand.
- Opportunity to include environmental and social externalities in economic reasoning.
- People may become more resource efficient.
- Opportunity to develop real price for carbon related to environmental cost.
- Cut down on importing carbon fuels from abroad which equals better balance of payments
- Investment in renewable energy companies/technology due to high P/E ratio predicted.
- Shift towards less fossil fuel dependent transport.
- New markets: carbon trading weather derivatives.
- Development of alternative energies e.g. wind power.
- Employment in energy efficiency industry (development and manufacture).
- Increase amount of vegetated structures (through planning policy ad guidance) in built development to provide benefits for energy/noise limitation, air quality and therefore economic benefits (see Chicago and Canadian studies for cost savings on green roofs).
- Increase density and create new open space.
- Reduction in need to travel if new ways of doing business can be found.

- Improving transport e.g. tram links. Encouraging cycling and walking through development plans, community plans and by improvements to the urban environment. Improvements to the tube including East London line extension.
- New crops e.g. vineyards, olives and tomatoes.
- Opportunity for London to benefit economically from increased/new tourism opportunities
- That London becomes a relatively more attractive climate than other European cities e.g. Paris, Madrid, Rome i.e. it doesn't get as bad as they do.
- Potential reduction in long distance tourism.
- Tourism will benefit from hotter summers and milder winters, cleaner transport and green living.

SOCIAL THREATS

- Impact on economy of increased levels of occupational sickness or absenteeism as a result of temperature changes.
- Impact of temperature change implications on local health care provision.
- Health impacts of higher temperatures combined with air pollution etc e.g. asthma (air quality) skin cancers (sunlight).
- Increased health problems e.g. respiratory diseases from poor air quality - economic a social issue.
- Increased stress leads to increase in crime. Heat stress leads to instability, which leads to social unrest.
- Hot weather leads to open windows which leads to greater opportunistic burglary.
- Greater social disorder due to rise in temperatures leading to increased stress and arguments/conflict.
- Global trend leads to increased environmental refugee, which leads to increase in burden or social welfare/state.
- Fire - drier weather leads to greater vulnerability. Water shortage leads to problems pumping at incidents.
- Segregation of different social groups: ability to pay.
- Effects of fuel poverty.
- Effects of 'cooling' poverty leads to inequalities.
- Blight on homes/property in flooding areas.
- Health and safety impacts of flooding events (tidal, watercourse, sewer overflow). Effects of water shortages on aspects such as hygiene, gardening.

- Increased risk of flooding and associated disruption - impacts on development.
- Water metering and re-evaluation of our 'free and unlimited' view of water is essential.

SOCIAL OPPORTUNITIES

- Make society more aware of impacts of its actions and hopefully act to reduce consumption.
- Need to link to neighbourhood renewal strategies i.e. raise local awareness.
- New migrants can bring new culture.
- Greater demand for street café culture? (but inability of councils to deal with this).
- International immigration - Leads to new knowledge and skills including how to live in a hot climate.
- More outdoor activities/lifestyle and appreciation, picnics, sport, alfresco dining. e.g. better/warmer summers/springs/autumns
- Better national sporting performances due to warm weather training and greater opportunities to train.
- Longer motorcycling season.
- More outdoor leisure activities - better quality of life, better health.
- Increased cycling due to public transport avoidance (hot, cramped) (and private cars).
- Our social activities may change so we become healthier i.e. more outside activities, increased walking, cycling.
- Seriously revolutionise urban street networks to encourage cycling for recreation and community impacts on health air quality, safety, noise, well being.
- Wider variety of gardens, roof gardens etc.
- Restriction of development on flood plains will increase potential public open space.
- Improved attractiveness/equality for Londoners and immigrants by improved quality of life through imaginative investigations of climate change effects.
- Make more use of riverside developments along Thames corridor.
- Sustainable urban drainage/natural solutions often have beneficial effects on landscape and urban environment.
- Encourage jobs in developing and installing new technologies e.g. energy generation and use in buildings.
- Promote/link to need for co-operation on emergency planning issues.

ENVIRONMENTAL THREATS

- Environmental preservation needs to take precedence over short-term economic arguments.
- Fragmented habitats within London adaptation for species difficult without migration.
- (Planning policies could lead to) loss of habitat/species diversity, e.g. Loss of inter tidal habitats through 'coastal squeeze' and loss of designated habitats currently protected by sustainable defences.
- Over intense development causes increased noise/nuisance, poor access to open space, reduced diversity of habitats and species.
- Lack of water resource to maintain and re-create wetland habitats.
- Inflexibility of current conservation legislation (e.g. Habitats regulations) to adopt to changes.
- Habitat loss and therefore increase flood risk.
- Loss of habitat and erosion of environmental legislation (EU habitats directive).
- Loss of trees driven by an insurance industry which sees trees as economically damaging.
- Air pollution.
- Dust due to dryer climate in summer plus increased construction to accommodate new housing.
- Increased use of energy for cooling.
- Climate change could be overcome by social acceptance of improved/safer Nuclear Energy Generation possibly on a localised and modularised basis.
- Water contamination from sewers and flooding of landfill.
- Can water resources, rivers, flow, biodiversity be maintained/managed?
- Lack of water for say normal use WC's, basin, baths, taps. More importantly for fire fighting. Need to collect/save rainwater run off in the area it falls?
- Storm/flood damage occurrence.
- Increase in sewer flooding.
- Damage to historic and natural resources e.g. historic parks and palaces.
- Threat to existing character of area by higher densities/over development.
- Increased pollution as a result of increased road use - if public transport disruption.
- Threat on agricultural production - type of food types etc.

- In Central London positive feedback loop from air conditioning plant increasing air temperatures outside in the heat island.
- More Grass, heath and scrub fires in summer.

ENVIRONMENTAL OPPORTUNITIES

- Climate change as a driver to greater environmental awareness.
- Need to study the role of trees to demonstrate their benefits to the population.
- Role of tree planting to create shade, filtering of pollution etc.
- Reduced development on green field sites. Stem tide of decline in green spaces.
- Planning policies could help create new habitats leading to increased biodiversity.
- New habitat creation.
- Opportunity to 'internationalise' nature conservation agenda - shared objectives to accommodate shifting species (for e.g.).
- Encourage pedestrianisation of certain areas where transport links are good.
- More cycling and walking - hopefully less road congestion and raise health, less Public Transport congestion.
- Consideration of microclimates in design of development.
- Promoting use of water saving devices at the home especially hippos for toilets.
- SUDS (grey water retention/filtering) and better urban landscape.
- More use of rainwater storage for housing (make use of winter rain).
- Green roofs for: heat island mitigation (local cooling etc).
- Encouraging natural lighting and ventilation. Encourage sustainable building design through development plans. Encourage use of groundwater resources and recycling of 'grey water'. Encourage renewable energies and efficient use of resources.
- Managed realignment - Combined with imaginative design and construction of associated buildings - lifetime gains for developments, quality of life gains for occupants. Flood mitigation.
- Imperative for quality environment as housing density increases.
- SPG on sustainable construction and design (part of Mayor's draft London Plan).
- Sustainable building can also lead to an increase in quality building.
- Local protection/retreat of flood defences/imaginative construction and design.
- More sustainable design and integration of this information into planning mechanisms.

- Climate change could be overcome by social acceptance of improved/safer nuclear generation possibly on a localised and modularised basis.
- Integrating solar energy with mechanical ventilation and cooling to reduce peak energy demand and increase renewable energy.
- Increased opportunity for use of renewable energy sources e.g. solar power wind/wave energy.
- Hydrogen Fuel Cells - (hydrogen generated from natural gas in short term, renewable in longer). Delivering zero carbon. Efficient power, clean water securities of supply.
- Greatly improve air and environmental quality by using zero carbon fuels in transport and buildings e.g. Hydro power, photo-voltic.
- Change fuel usage from fossil to renewable in a major way in London e.g. wind and rooftop photo voltaics.
- More water resources to capture winter rain (reservoirs) - manage as wetlands and leisure facilities as well as storage.
- Could the research please take note of the importance of developing strategic environmental appraisal (SEA) techniques so that all plans covering London (especially the SDP) are properly evaluated in terms of their likely impact on climate change and response to it!
- Reduce fuel poverty in winter.
- To be more aware (data) of the quality of life in and out of work.
- Activities that reduce CO_2 emissions benefit health and environment raise air quality, decrease traffic and accidents, raise cycling and physical activities.
- More use of parks and all year round. More sport better for health.
- Promoting outdoor lifestyles - link to increase in physical activity - need to link to open/green space issues - biodiversity and impact of rise in pollution on health.
- Imminent change has got people together to address issues therefore better understanding of contributing.
- Restoration of multi-functioning river flood plains, providing flood water storage and environmental benefits.
- Create a Thames Park to allow flood protection in the Thames Gateway.
- Extend the Thames Path beyond the barrier to allow river terraces to be built.

WORKSHOP EVALUATION

Participants evaluated the workshop at the end of the session. The results are shown below.

Question	Response	Total respondents
To what extent do you feel this workshop has contributed to your knowledge and understanding of climate change impacts in London?	Not at all	
	Not very much	**3**
	Contributed little	**18**
	Improved considerably	**23**
How useful did you find the presentations?	Not at all useful	
	Not very useful	**2**
	Quite useful	**25**
	Very useful	**17**
How useful did you find the group work?	Not at all useful	**1**
	Not very useful	**4**
	Quite useful	**28**
	Very useful	**11**
How easy did you find it to contribute your ideas?	Not at all useful	
	Not very useful	**2**
	Quite useful	**25**
	Very useful	**17**
How enjoyable did you find the workshop?	Not at all enjoyable	
	Not very enjoyable	**2**
	Quite enjoyable	**28**
	Very enjoyable	**14**
Are you interested in making further contributions to study through the workstream research?	Yes	**37**
	No	**4**

Additional comments on the workshop made by participants are recorded below:

- I work on these issues so found the initial presentations facile - but understand that you have a mixed audience.
- Facilitation of group work wasn't too good and made worse by overcrowded noisy room and the questions that were posed, there were too many questions to answer not all of which really got at the key matters. The post it session at the end was useful to capture free ranging ideas.
- Acoustics poor for plenary sessions.
- Difficult to desegregate impact of climate change on London's economy of impact of responses to Climate Change on London's economy. Still unclear as to extent to when the two can be separated.
- The workshop had too many issues to cover. Sometimes the workshop leaders didn't seem as open to ideas as perhaps should (i.e. views were already formed). May have benefited from a smaller group size and separate room?
- Six break-out sessions in one room makes life very difficult unless interests developed very early. One major point that needs to be made is that the impact of

climate change is likely to be incremental in terms of its effects in problems that already exist rather than posing new problems i.e. London is essentially not sustainable.

- Geoff Jenkins presentation very helpful, others less so. Breakout sessions too long, too noisy.
- In the morning presentations, which were generally very good, there seemed to be an assumption that the audience was familiar with some of the technical issues and jargon.
- Facilitation could be better. Opportunity for ideas was stifled!
- The work of this group (Acchiles) is crucial. It will benefit from being 'joined-up' by attendance from most stakeholders.
- I found the venue rather difficult - difficult to hear/see initial presentations. Rather noisy in the workshops. Hope this could be addressed in future sessions? Otherwise a very useful and wide ranging morning - Thanks.
- I know that due to over subscription of people to groups you wished to allocate people. However, I think that maybe workshops should be allocated by a first come first serve basis so people have the opportunity to talk about areas that they are most interested in. This may generate more of a debate.
- Workshop very well organised (Emily did a great job in our group!) I look forward to receiving a report of the outcomes from the day.
- The space in which such a large group was required to undertake open discussion made it a little difficult to hear comments by other group members.
- Vast subject to cover in short period of time. Many other aspects to do with development of London and sustainable development touched on due to wide reaching effects of climate change and interests of stakeholders present.
- Very encouraging start to this project. Very good mix of people, all of whom were keen to participate.
- It was good to see representatives from a wide spectrum of organisations together in the same workshop. The people present not only represent a source of ideas but potentially a lot of information/data which could feed into the study.
- Workshop was well organised and run. A great deal of knowledge was displayed by participants and researchers. Increased my knowledge of (localised) climate change and possible implications quite considerably.
- Initial presentation by Entec a little basic - need deeper study.
- Background work should consider individual mayoral strategies and not just the (draft or consultation draft) London Plan - which does not contain the detail. For biodiversity, don't rely on English Nature's and RSPB's rural focus for telling us what we need to know about urban bio impacts. I am especially interested in

further study to examine multiple benefits offered by green roofs, energy, noise, water, air quality, cost, biodiversity, waste … all are relevant!

- Would welcome future workshops to examine the opportunities and potential (part or full) solutions to the impacts of climate change.
- In terms of the workshops, I would recommend tighter facilitation to ensure more efficient discussion and therefore raise quality outputs.
- Well done! Difficult to manage such a large group you made it very pleasant and informative.
- The presentations by Geoff Jenkins and Jim Kersey were excellent. (Are copies of the overheads to be made available?) A well planned/organised event. Thanks for the opportunity. The Climate Change Impacts Study should be part of a general Future Impacts Study. Climate change effects cannot be considered effectively in isolation.

WORKSHOP PARTICIPANTS

Amy Bahia	International Underwriting Association of London
Sarah Beuden	Southwark Council
Peter Brittain	Government Office for London
Dave Brook	DTLR
Alan Byrne	English Heritage
Jane Carlsen	GLA - draft London Plan
Tom Carpen	Greenwich Borough Council
Justin Carr	London Borough of Croydon
Simon Cartwright	Thames Gateway
Dr Sebastian Catovsky	DEFRA
Roger Chapman	Association of London Government
Matthew Chell	GLA
Richenda Connell	UK Climate Impacts Programme
Linda Collins	London Development Agency
Keith Colquhoun	Thames Water
Richard Coppin	London Borough of Redbridge, Energy Manager
Cameron Dash	London Borough of Lambeth
Dave Farebrother	Land Securities
James Farrell	GLA
David Fell	London First
Aleyne Friesner	GLA
Tom Frost	KPMG
Lucy Golding	Cross River Partnership
Andrew Griffiths	Chartered Institute of Environmental Health
Lesley Harding	London Development Agency
Mike Harley	English Nature
Vicky Hobart	NHS - London Region
Ralph Hodge	Ralph Hodge Associates
Richard Jackson	Confederation of British Industry

Geoff Jenkins	Hadley Centre, Met Office
Kirsty Johnson	London Borough of Hammersmith and Fulham
Catherine Jones	Transport for London
Petra Klemm	London Borough of Barnet
Sari Kovats	London School of Hygiene and Tropical Medicine
Chris Lee	Association of London Government
Mike LeRoy	Westminster City Council
Jon Lilley	Thames Estuary Partnership
Mark Lowers	London Borough of Havering, Energy Management
Shanti Majithia	National Grid
Jane Milne	Association of British Insurers
Simon Mills	Corporation of London
Olivia Morris	London First
George Moss	Chartered Institute of Loss Adjusters
Alex Nickson	Thames Gateway
Dirk Paterson	London Chambers of Commerce
Tina Perfrement	London Remade
Kevin Reid	GLA
Tim Reeder	Environment Agency
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Julia Ricketts	Department of Health
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Bob Roper	London Borough of Havering
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C Steenberg	London Borough of Richmond
Trevor Sumner	London Fire
Al Sule	Housing Corporation
Carrie Temple	RSPB
Joshua Thumin	GLA
William Trevethan	Corporation of London Planning Dept

Tim Walker	CGNU
Tony Winlow	Greenwich Borough Council, Energy Manager
Patrick Witter	London Borough of Sutton
Simon Young	London Fire

Appendix C
Representing Soil Moisture Variations Using the Hydrological Model CATCHMOD

In CATCHMOD a 'direct percolation' mechanism, allows fixed proportions (D_p) of incoming precipitation, that exceed the potential evaporation rate, to bypass the soil store (even during periods of soil moisture deficit). This process represents the observed behaviour of fractured soils and macropores during summer rainfall and is only relevant to soils overlying permeable strata. The soil moisture sub-model is based on Penman's (1949) drying curve such that when the supply of moisture is limited, evaporation occurs at a constant proportion, k, of the potential rate. The value of the soil moisture deficit above which evaporation occurs at the reduced rate, D_c, (termed the potential drying constant) is derived via parameter optimisation. The 'upper' soil horizon, therefore, has a finite capacity equal to this constant. The 'lower' horizon is depleted by the reduced rate only when the upper horizon is empty, and can accumulate large deficits (as witnessed during the severe 1976 UK drought). During recharge, wetting by precipitation fills the upper reservoir before any replenishment of the lower. When a basin zone becomes saturated excess moisture from the soil store contributes to total percolation. Where a soil is underlain by permeable geological formations, excess water from the overlying soil zone percolates through the unsaturated zone to the aquifer below.

GLOSSARY

Terms in *italics* are found elsewhere in this Glossary.

Aerosols Airborne solid or liquid particles, with a typical size between 0.01 and 10 m that reside in the atmosphere for at least several hours. Aerosols influence the *climate* directly through scattering and absorbing radiation, and indirectly through the formation and optical properties of clouds.

ALG Association of London Government

Anthropogenic Resulting from, or produced by, human beings.

Aquifer Layer of permeable rock, sand or gravel which allows water to pass through it and which if underlain by impermeable material, holds water to form a saturated layer or water table.

Atmosphere The gaseous envelope surrounding the Earth, comprising almost entirely of nitrogen (78.1%) and oxygen (20.9%), together with several trace gases, such as argon (0.93%) and *greenhouse gases* such as carbon dioxide.

Black box Describes a system or model for which the inputs and outputs are known, but intermediate processes are either unknown or unprescribed. See *regression*.

Climate The 'average weather' described in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organisation (WMO).

Climate change Statistically significant variation in either the mean state of the *climate*, or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or to *external forcings*, or to persistent *anthropogenic* changes in the composition of the atmosphere or in land use.

Climate model A numerical representation of the climate system based on the physical, chemical and biological properties of its components, their interactions and feedback processes, and accounting for all or some its known properties.

Climate prediction An attempt to produce a most likely description or estimate of the actual evolution of the climate in the future, e.g. at seasonal, inter–annual or long–term time scales.

Climate projection A projection of the response of the climate system to emission or concentration scenarios of *greenhouse gases* and *aerosols*, or *radiative forcing* scenarios, often based on simulations by *climate models*. As such climate projections are based on assumptions concerning future socio–economic and technological developments.

Climate scenario A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships, that has been constructed for explicit use in investigating the potential consequences of anthropogenic *climate change*.

Climate variability Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events.

CSO Combined Sewer Outfall: - Structure which discharges effluent to watercourses when the sewage system becomes overloaded during periods of heavy rainfall.

Culvert A pipe or other covered passage under a road or railway, which carries a stream or drainage ditch. In the centre of some cities, small rivers that were important in the early development of the city are frequently enclosed in culverts and built over.

Deterministic A process, physical law or model that returns the same predictable outcome from repeat experiments when presented with the same initial and boundary conditions, in contrast to *stochastic* processes.

Domain A fixed region of the Earth's surface and over-lying atmosphere represented by a *Regional Climate Model*. Also, denotes the grid box(es) used for statistical *downscaling*. In both cases, the downscaling is accomplished using pressure, wind, temperature or vapour information supplied by a host GCM.

Divergence	If a constant volume of fluid has its horizontal dimensions increased it experiences divergence and, by conservation of mass, its vertical dimension must decrease.
Downscaling	The development of climate data for a point or small area from regional climate information. The regional climate data may originate either from a *climate model* or from observations. Downscaling models may relate processes operating across different time and/or space scales.
Emission scenario	A plausible representation of the future development of emissions of substances that are potentially radiatively active (e.g. *greenhouse gases*, *aerosols*), based on a coherent and internally consistent set of assumptions about driving forces and their key relationships.
External forcing	A set of factors that influence the evolution of the climate system in time (and excluding natural internal dynamics of the system). Examples of external forcing include volcanic eruptions, solar variations and human–induced forcings such as changing the composition of the atmosphere and land use change.
Extreme weather event	An event that is rare within its statistical reference distribution at a particular place. Definitions of 'rare' vary from place to place (and from time to time), but an extreme event would normally be as rare or rarer than the 10th or 90th percentile.
Fluvial	Riverine, pertaining to rivers.
General Circulation Model (GCM)	A three–dimensional representation of the Earth's atmosphere using four primary equations describing the flow of energy (first law of thermodynamics) and momentum (Newton's second law of motion), along with the conservation of mass (continuity equation) and water vapour (ideal gas law). Each equation is solved at discrete points on the Earth's surface at fixed time intervals (typically 10–30 minutes), for several layers in the atmosphere defined by a regular *grid* (of about 200 km resolution). Couple ocean–atmosphere general circulation models (O/AGCMs) also include ocean, land–surface and sea–ice components. See *climate model*.
GLA	Greater London Authority

GQA	General Quality Assessment
Greenhouse gas	Gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere and clouds. The primary greenhouse gases are water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3).
Grid	The co–ordinate system employed by *GCM* or *RCM* to compute three–dimensional fields of atmospheric mass, energy flux, momentum and water vapour. The grid spacing determines the smallest features that can be realistically resolved by the model. Typical resolutions for GCMs are 200 km, and for RCMs 20–50 km.
GOL	Government Office for London
LCCP	London Climate Change Partnership
NCEP	The acronym for the National Centre for Environmental Prediction. The source of re–analysis (climate model assimilated) data widely used for dynamical and statistical *downscaling* of the current climate.
Normalisation	A statistical procedure involving the standardisation of a data set (by subtraction of the mean and division by the standard deviation) with respect to a predefined control period. The technique is widely used in statistical *downscaling* to reduce systematic biases in the mean and variance of climate model output.
OFWAT	The Office of Water Services, responsible for making sure that the water sewerage companies in England and Wales give a good quality, efficient service at a fair price. They are a government department led by the Director General of Water Services.
Parameter	A numerical value representing a process or attribute in a model. Some parameters are readily measurable climate properties; others are known to vary but are not specifically related to measurable features. Parameters are also used in climate models to represent processes that are poorly understood or resolved.
PPG25	Planning Guidance Note 25: - Local Planning Authorities are to ensure that flood risk is properly taken into account in the planning of developments to reduce the risk of flooding .
Predictand	A variable that may be inferred through knowledge of the behaviour of one or more *predictor* variables.

Predictor	A variable that is assumed to have predictive skill for another variable of interest, the *predictand*. For example, day–to–day variations in atmospheric pressure may be a useful predictor of daily rainfall occurrence.
Radiative forcing	The change in net vertical irradiance (expressed as Watts per square metre) at the *tropopause* due to an internal change or a change in the *external forcing* of the climate system, such as, for example, a change in the concentration of carbon dioxide, or the output of the Sun.
Random	See *stochastic*.
Regional Climate Model (RCM)	A three–dimensional, mathematical model that simulates regional scale climate features (of 20–50 km resolution) given time–varying, atmospheric properties modelled by a General Circulation Model. The RCM *domain* is typically 'nested' within the three–dimensional *grid* used by a GCM to simulate large–scale fields (e.g. surface pressure, wind, temperature and vapour).
Regression	A statistical technique for constructing empirical relationships between a dependent (*predictand*) and set of independent (*predictor*) variables. See also *black box, transfer function*.
Relative humidity	A relative measure of the amount of moisture in the air to the amount needed to saturate the air at the same temperature expressed as a percentage.
Resolution	The *grid* separation of a climate model determining the smallest physical feature that can be realistically simulated.
Scenario	A plausible and often simplified description of how the future may develop based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios may be derived from projections, but are often based on additional information from other sources, sometimes combined with a 'narrative story–line'.
SDP	Strategic Development Plan.
Specific humidity	The ratio of the mass of water vapour (in grams) to the mass of moist air (in kilograms) in a given volume of air.
Station	The individual site at which meteorological measurements are systematically observed and recorded.

Stochastic A process or model that returns different outcomes from repeat experiments even when presented with the same initial and boundary conditions, in contrast to *deterministic* processes. See *weather generator*.

Transfer function A mathematical equation that relates a *predictor*, or set of predictor variables, to a target variable, the *predictand*. The predictor(s) and predictand represent processes operating at different temporal and/or spatial scales. In this case, the transfer function provides a means of *downscaling* information from coarse to finer resolutions.

Tropopause The boundary between the lowest part of the atmosphere, known as the troposphere, and the highly stratified region of the atmosphere, known as the stratosphere. The tropopause is typically located 10 km above the Earth's surface.

Uncertainty An expression of the degree to which a value (e.g. the future state of the climate system) is unknown. Uncertainty can result from a lack of information or from disagreement about what is known or knowable. It can also arise from poorly resolved climate model parameters or boundary conditions.

Weather generator A model whose stochastic (random) behaviour statistically resembles daily weather data at a location. Unlike *deterministic* weather forecasting models, weather generators are not expected to duplicate a particular weather sequence at a given time in either the past or the future. Most weather generators assume a link between the precipitation process and secondary weather variables such as temperature, solar radiation and humidity.

Weather pattern An objectively or subjectively classified distribution of surface (and/or upper atmosphere) meteorological variables, typically daily mean sea level pressure. Each atmospheric circulation pattern should have distinctive meteorological properties (e.g. chance of rainfall, sunshine hours, wind direction, air quality, etc). Examples of subjective circulation typing schemes include the European Grosswetterlagen, and the British Isles Lamb Weather Types.

Index

Note that where there is more than one page reference and one or two are considered more significant than the others, they are highlighted in **bold** typeface.

Partners

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This study was commissioned by the London Climate Change Partnership.

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This is one of a number of studies conducted under the umbrella of the UK Climate Impacts Programme (UKCIP). Based at the University of Oxford, UKCIP was set up by the Government in 1997, to provide a framework for an integrated assessment of climate impacts and to help organisations assess how they might be affected by climate change, so they can prepare.

This report and the more detailed technical report of the study can be found at **www.ukcip.org.uk/london/london.html**

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More information on climate change can be found at:
www.defra.gov.uk/environment/climatechange/
www.metoffice.gov.uk/research/hadleycentre/
www.ipcc.ch/

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October 2002

designed by Atkinson Duckett