LONDON climate change PARTNERSHIP

Wild weather warning

a London climate impacts profile

October 2009

UK Climate Impacts Programme

LONDON COUNCILS

LONDON climate change PARTNERSHIP

Wild weather warning

a London climate impacts profile

This report was prepared by AEA under contract to the London Climate Change Partnership, Greater London Authority and London Councils.

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Executive summary

This London-wide Climate Impacts Profile Report reviews the ways in which weather has impacted service provision in London over the last 10 years, in order to raise awareness so that future responses to such events can be more effective.

The Local Climate Impacts Profile (LCLIP) approach was developed by the UK Climate Impacts Programme (UKCIP) as a tool to help assess vulnerability to extreme, local weather impacts in the UK. This tool sits between a 'top-down' national approach to climate change impact assessment and a 'bottom up' vulnerability based approach, which tends to be largely reactive rather than proactive. The LCLIP tool intends to highlight to its users where the greatest vulnerabilities to service provision lie. Do weather impacts mostly affect transport provision, or health service providers? Do the Emergency Services need to be most concerned with responding to heavy rainfall events or to snowfall?

Because it is based upon events and impacts reported by news media sources, the climate impacts profile is inevitably biased towards those events and issues likely to be of most interest to the target audience of each source. Weather events are not reported consistently in newspapers, and may be ignored if more significant news stories arise. For these reasons, the climate impacts profile should not be viewed as an exhaustive scientific inventory of all weather events. Rather, it is a tool for raising awareness of the kinds of impacts that weather can have.

This report presents findings on how sectors and organisations across London have been affected by the weather in the last ten years. We first discuss the findings from a survey of newspaper reports to show which sectors and services appear to be most affected, and the nature of the key weather impacts. We then discuss related findings from interviews with organisations in London. Perhaps unsurprisingly, more than half of the weather impacts reported are related to the transport sector. Other sectors affected by the weather during 1998–2008 included health, safety and humanitarian services, recreation and environment, emergency services, and local government sectors.

In the last ten years, London has experienced many extreme weather events. These include unseasonally high or low temperatures, heavy rain, periods of dry weather (drought), high winds, and snowfall.

At the beginning of July 2007, for example, heavy rainfall disturbed scheduled, popular sporting events and severely disrupted London's transport network. More than 150 Wimbledon matches were affected, and there was localised flooding on the underground network, resulting in thousands of disappointed tennis fans and disgruntled users of London's public transport network. Surface water build up led to traffic jams blocking roads, and extra resources were required to clear railway tracks of debris. Accessibility of bus routes, underpasses, subways and major road networks was seriously affected across London.

High temperatures during the heat wave of August 2003 demonstrated how very different weather can also affect sectors and organisations in London. Temperatures exceeded 30°C for over 10 days in a row, and between the 6th and 10th August they exceeded 35°C. It is estimated that this resulted in around 600 more deaths than would normally be expected during the period. The impacts on transport, tourism and

health were catastrophic as the media published headlines like ‘Wrong kind of sunshine cuts services and slows trains’ and ‘Heat wave: two teenagers dead and child in intensive care’ (The Guardian, 7th August 2003). As London became ‘hotter than Barbados,’ the high temperatures had a range of serious impacts including threats to human health and the functioning of health services, disruptions to airports and underground, rail, bus and road networks as well as pressures on plants and animals in London’s parks, zoos and homes.

Snowfall affected London in January 2003, resulting in tens of thousands of commuters being delayed for hours during rush hour on the 7th and 8th January (Evening Standard, 2003). The impacts on transport had a knock-on effect on the delivery of services by key London-wide organisations as well as on the general public. The Ambulance Trust called upon the Red Cross for support in responding to emergency calls during the snow; many responses required the use of four-wheel drive vehicles as the snow resulted in limited access to some areas.

Evidence exists that the climate is changing and some types of weather will become more frequent and more extreme. The debate is now moving beyond whether climate change is real, towards how societies can prepare to cope with these changes. Organisations need to consider how they might be affected by such extreme weather in the future, and what they can do now to reduce the risks. The LCLIP approach focuses on identifying locally experienced weather-related impacts, placing emphasis on increasing the resilience and reducing the vulnerability of a given locality, rather than waiting until it is too late.

We offer the following recommendations for further work:

- The GLA, London Councils and the London Climate Change Partnership could make use of the events described in this report to raise awareness about weather and climate risks.
- London Boroughs could use the information provided in this report, and in the accompanying spreadsheet (Appendix 2), to help prioritise which areas within their own remits are likely to require attention to climate risks. The kinds of impacts, and the individual events listed within the spreadsheet, should provide a starting point for London Boroughs to embark upon developing their own LCLIPs.
- Other organisations responsible for providing services across London, and particularly those more susceptible to weather impacts such as the transport sector, could review their own vulnerability to weather impacts and consider whether their existing risk management systems are adequate to deal with climate risks.
- The GLA may wish to bear in mind the impacts of extreme weather, and how impacts are recorded and reported, in the development of the Mayor’s Climate Change Adaptation Strategy.
- The current study could be extended by
    - more detailed analysis of the weather observations related to particular events reported in the media
    - examination of thresholds for certain weather variables that appear to lead to the highest impact weather events, for example the cumulative

rainfall over preceding days that results in the most severe flash floods in London

- analysis alongside the UK Climate Projections in order to estimate changes in frequency or severity of particular kinds of weather events (and their impacts) under future climate scenarios
- more detailed examination of newspaper archives alongside the full weather record for the period, which could provide further insight on what kinds of weather events and impacts make it into media reports, and why.

Subsequent stages of LCLIP work

For subsequent stages of the London-wide LCLIP project, the LCLIP methodology could be further revised and improved to suit the needs of London Boroughs. Learning from the challenges faced in this study, we recommend that London Boroughs focus on:

- Careful consideration of time-scales chosen to conduct the research
- Early engagement of participating organisations/departments through clearly highlighting the benefits of participation
- A focus on approaching service areas where records are known to exist
- A two-ended approach to the research whereby weather events are identified in the media and followed up with interviewees and vice versa, that is, that weather impacts are identified by interviewees and followed up with data from the media trawl and weather observations.

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1 Introduction

The London Climate Change Partnership (the Partnership) and London Councils are undertaking a project to report on weather-related impacts across London and to encourage and assist London Boroughs to develop Local Climate Impacts Profiles (LCLIPs). The Partnership's LCLIP project consists of four stages, managed jointly by the Partnership, London Councils and the Greater London Authority (GLA). AEA was commissioned to complete Stage 1 of this project.

This report delivers a Climate Impacts Profile for London. It provides a record of recent weather-related impacts on London over a ten-year period based on newspaper reports, corresponding weather station observations, and interviews with several London-wide organisations to verify the impacts on a cross section of London's stakeholders. The primary audience for this report is decision-makers with London-wide remits, but we anticipate that officers in London Boroughs will also benefit as they prepare to carry out LCLIPs in the near future.

1.1 The London Local Climate Impacts Profiles Project

The LCLIP approach was developed by the UK Climate Impacts Programme (UKCIP) to bridge the gap between a 'top-down' scenarios approach to climate change impacts and a bottom up 'vulnerability' based approach, which focuses on locally experienced weather-related impacts. The LCLIP acts as an information resource to aid Local Authorities in forming a better understanding of how their area has already been affected by weather and may in future be affected by changes in climate.

The London-wide LCLIP project consists of 4 stages, as outlined in Table 1.1. This report completes Stage 1.

Table 1.1 The 4 stages of the London-wide LCLIP Project

Stage	Timing	Lead
1 London climate impacts report	Feb – Apr 2009	Partnership
2 Guidance for boroughs	May 2009	UKCIP/Partnership
3 Borough LCLIPs	Jun – Dec 2009	London Councils
4 Integrated report	Early 2010	Partnership

This Stage 1 of the LCLIP project aims to produce Climate Impacts Profile at the London-wide level to offer a quick start for London boroughs looking to produce their own LCLIPs.

Stage 2 will involve developing a standard methodology for completing individual borough LCLIPs. This will provide comprehensive guidance and case studies, a training workshop for borough officers and general support to boroughs throughout the project.

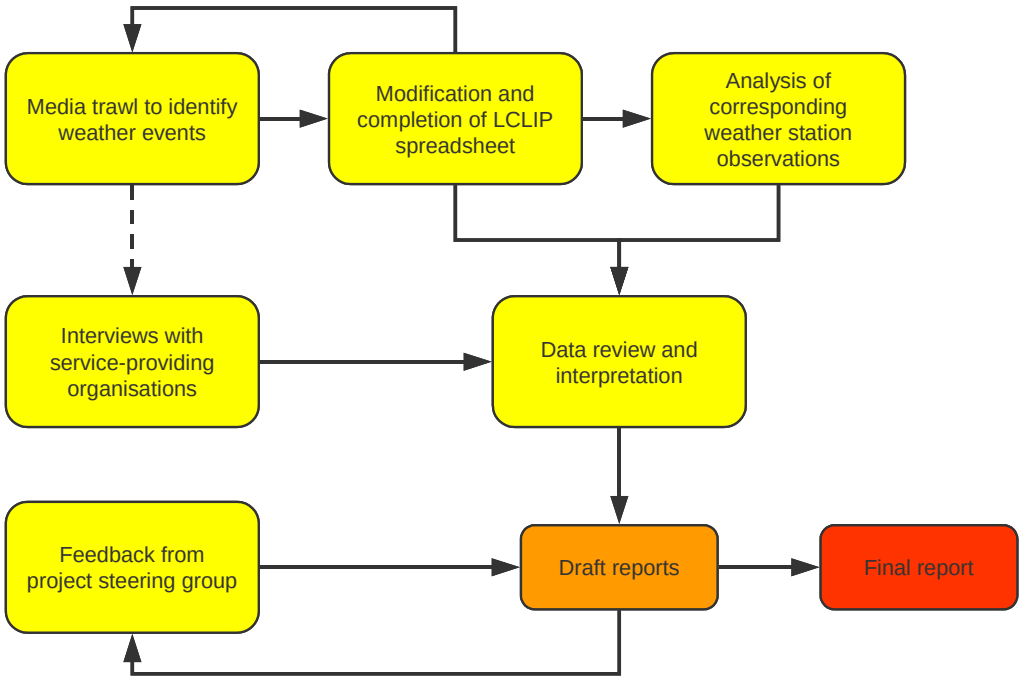
Stage 3 will involve the production of individual London borough LCLIPs and aims to run from June to October 2009.

Stage 4 will develop an integrated report based on the results from all LCLIPs undertaken in London, and will run from November to December 2009. This report will confirm or provide further detail on the Stage 1 report, particularly around adaptation costs across the region.

1.2 Approach to Stage 1

Our approach to this study has been based on the application of the UKCIP LCLIP methodology. The main elements of our approach are shown in Figure 1.1. The media trawl researched issues of “The Times”, “The Guardian” and “London Evening Standard” from 1998–2008. Weather station observations from official London weather stations were purchased from the Met Office and interviews were conducted with a selection of London organisations to provide more detail on the way in which weather has affected services over recent years. At all stages, the project team has been in close contact with the customer steering group (comprising the GLA, London Councils and UKCIP). More detail on the methodology is provided in Appendix 1.

Figure 1.1 The approach taken in this study



This report is accompanied by a spreadsheet (Appendix 2) that details how weather was reported to affect London organisations and sectors over the last ten years. The spreadsheet contains information about the weather events, including impacts and consequences on sectors and organisations, and affected locations as reported in news articles. The level of detail provided reflects what was reported in newspapers at the time. The methodology conforms to UKCIP good practice and weather-related impacts are described in 9 categories:

1. Total number of media stories recorded
2. Dates of the media stories
3. Dates of incidents
4. Locations reported (London regions, boroughs or specific locations)
5. Weather type (heavy rain, high winds, high temperatures, low temperatures, snowfall, severe dry weather)
6. Weather impacts (pluvial and fluvial flooding, subsidence, landslides, damage, disruption, health and safety)
7. Detail of impacts (costs in £s, staff time lost, resources lost & used to respond to incidents)
8. The sector affected
9. The organisation affected

2 Recent weather impacts on London

2.1 Introduction

This chapter presents the main findings from the media research on weather events in London between 1998 and 2008, cross-referenced with weather observations from London weather stations, provided by the Met Office. The discussion has been supplemented by comments or anecdotes provided in stakeholder interviews. The media analysis identified 145 weather stories during the period in the 3 papers reviewed. These reports featured impacts across London, rather than at only one or two localities.

The media research does not provide an exhaustive evidence base but provides information (as reported by the three newspapers considered) on weather events that had a London-wide impact during 1998-2008. The balance of reporting can be skewed by the choice of media source. For example, the Evening Standard is a London newspaper aimed at commuters and has a particular interest in transport.

Figure 2.1 Overview of media research

The way in which articles were selected from newspaper archives is explained in Appendix 1. The total number of weather impacts identified from these articles was 300: single weather events can result in several different impacts. For the purpose of this London-wide LCLIP, weather events are those occurrences of weather identified by the media to be unusual or particularly extreme for a given season. Impacts arise directly from the weather event, causing inconvenience or behaviour change among city residents, workers and visitors.

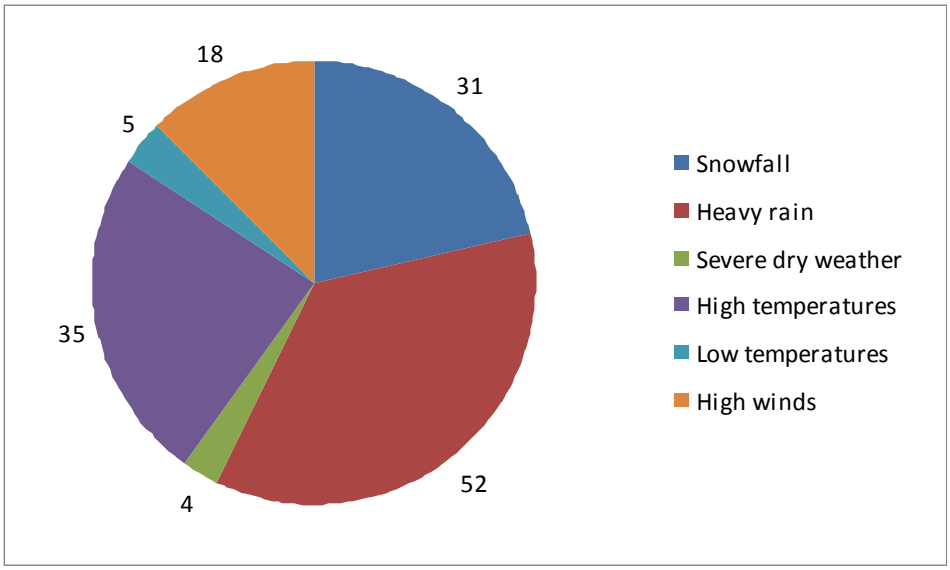
Throughout this report, we categorise what was reported in the media into 6 types of weather. This list of weather types was selected based on a review of the London's Warming report[1] and the Mayor's draft Climate Change Adaptation Strategy[2], which provide evidence of how London is vulnerable to the changing climate (see Appendix 1 for further information). The weather types considered in the report are:

- Heavy rain
- High winds
- High temperatures
- Low temperatures
- Snowfall
- Severe dry weather

[1] London's Warming (2002) http://www.ukcip.org.uk/images/stories/Pub_pdfs/London_tech.pdf
[2] Mayor's draft Climate Change Adaptation Strategy (2008) http://www.london.gov.uk/mayor/publications/2008/08/climate-change-adapt-strat.jsp

Figure 2.2 shows the breakdown of the 145 media stories by weather type. Heavy rain was the most frequently occurring weather type, related to 52 of the incidents logged in the spreadsheet. The second most frequent weather type was high temperature, responsible for 35 out of 145 weather events. Snowfall was reported in 31 of the media stories, followed by high winds (18), low temperatures (5), and severe dry weather (4).

Figure 2.2 Weather types reported in media research



Case studies of several weather events have been prepared with three events described in more detail and accompanied by maps of impacts. We present the findings from the media research for 'high impact' weather events reported, and link information collected during the interviews to the corresponding weather events. Findings are organised in the remainder of this chapter under the 6 weather types.

Weather verification tables have been included this chapter to allow the reader to compare the descriptions of weather conditions and impacts reported in news articles with the actual weather recorded at Met Office weather stations.

Table 2.1 illustrates the format of these tables. Particular features to note include:

- The table caption includes the date that the newspaper reported the weather event (in this example, 11th July);
- Weather data from more than one weather station are provided, where appropriate;
- Data covering a period from at least the day before to the day following the date of the news article are provided;
- Additional data have been included in the tables if the weather recorded on other days surrounding the date of the reported weather event seemed to be particularly extreme.

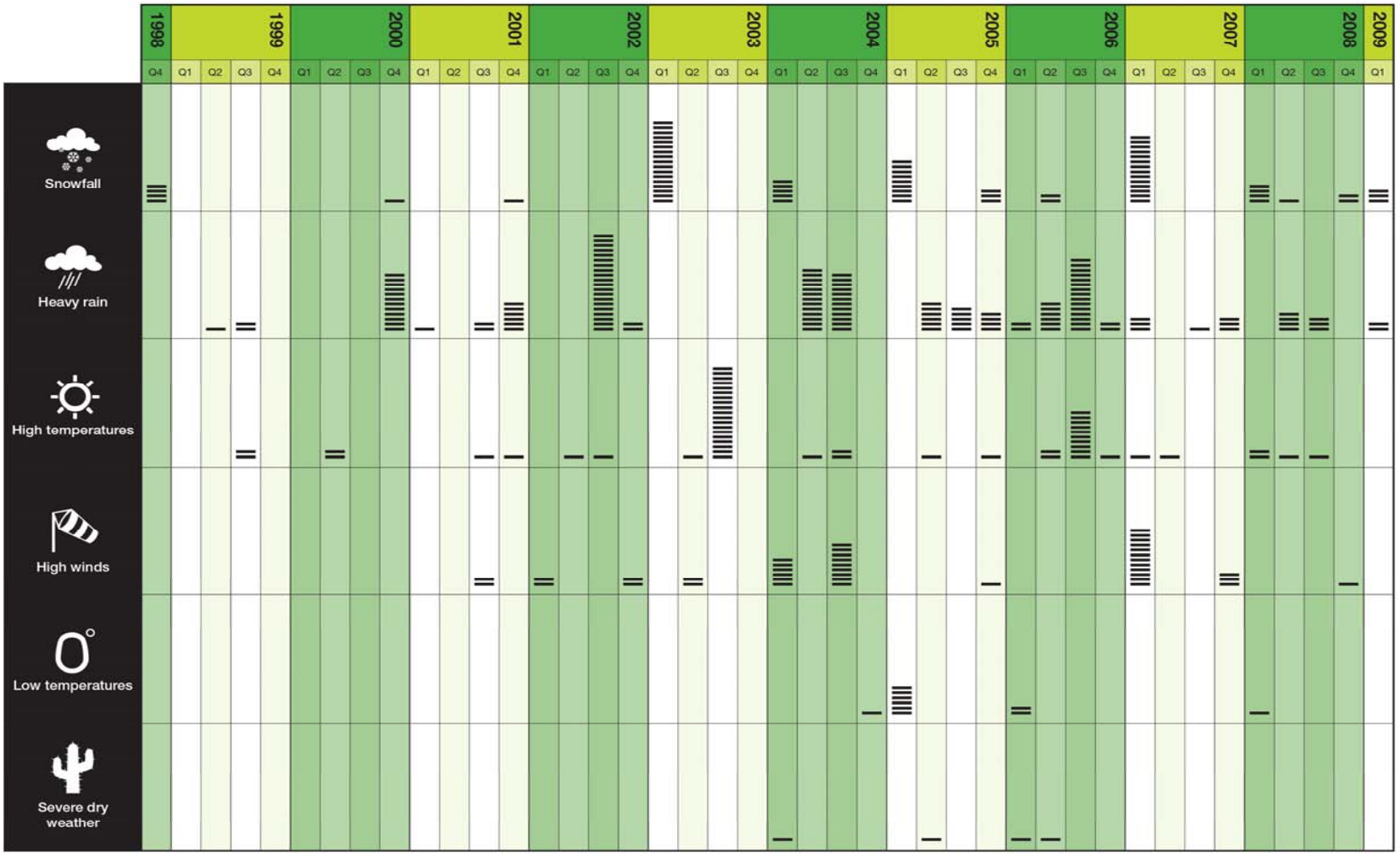
Table 2.1 Example to explain format of Met Office verification tables (temperatures reach 35.0°C on 11th July)

Location of weather station	Date	Temperature (°C)
London Weather Centre	10th July	32.6
	11th July	36.0
	12th July	35.1
St James's Park	10th July	32.9
	11th July	35.9
	12th July	34.5
Northolt	10th July	33.0
	11th July	36.1
	12th July	35.2

Usually, the date of the news article reporting on a weather event is the day after the extreme weather occurred, although in the case of the Evening Standard, the report is often on the day of the weather event itself. For extended periods of extreme weather, reports can appear over a number of days. In some instances, inconsistencies between what was reported and what actually happened are apparent.

The timeline in Figure 2.3 (following page) shows when impacts have occurred during the last 10 years, as reported in the newspapers studied, and categorised by the 6 weather types. The timeline suggests that weather affecting London was reported most frequently during 2003–2007.The summer heat waves of 2003 and 2006 are clearly visible as are the disruptive snowfall events which occurred during the winter of 2003 and 2006.

Figure 2.3 Weather event timeline



2.2 Heavy rainfall events and impacts

This section discusses the following events:

- Flooding event - 8th August 2002
- Flooding event - 3rd August 2004
- Flooding event - 10th August 2004
- Flooding event - June and July 2007

Heavy rain events were the subject of 52 out of the 145 media stories analysed. Within this, pluvial (flash) flooding accounted for a greater proportion than river flooding, although both were significant. Flooding has implications for all service providers across London, from health services and emergency response units to environmental protection and utility providers. The events described below all occurred in July or August, when average monthly precipitation (for 1971–2000) is 38.3 mm and 47.3 mm respectively.

Figure 2.4 Rain clouds loom over Big Ben

2.2.1 Flooding event – 8th August 2002

On the 8th August 2002 the media reported that 29.9mm of heavy rainfall caused disruption across London. A number of underground stations were affected from Green Park, Kilburn and Chalk Farm to Finchley Road, Aldgate and Wembley Park. The heavy rain also brought flooding to many other parts of the country and caused travel chaos across London and the South East, in particular at Liverpool Street Station and Euston Station (The Guardian, 8th August 2002).

London Fire Brigade reported one of its busiest evenings ever with over 900 calls in four hours. Meanwhile it was reported that streets had been quickly turned into rivers and commuters had to wade through water which built up in minutes (The Guardian, 8th August 2002). The flooding also caused damage to residential buildings, parks, streets and water pipes across the city. Some of the buildings affected by localised flooding included those belonging to Primary Care Trusts and some wards had to be shut down (Strategic Health Authority, 2009).

Most of the rain causing this flooding fell the day before, on 7th August, with 32.6mm recorded at the London Weather Centre, 31.4mm at St James's Park and 17.8mm at Northolt (Table 2.2). So some parts of London experienced over just two days more than 80% of the rainfall usually expected during the whole of August.

Table 2.2 Verification of heavy rainfall event on 8th August 2002

Location of weather station	Date	Rainfall (mm)
London Weather Centre	7th August	32.6
	8th August	8.4
	9th August	2.2
St James's Park	7th August	31.4
	8th August	8.6
	9th August	0.4
Northolt	7th August	17.8
	8th August	6.2
	9th August	8.4

2.2.2 Flooding event – 3rd August 2004

The media trawl identified that heavy rainfall had severe impacts across London in August 2004. On the 3rd August, one month's rain reportedly fell in one hour leading to flash flooding. The flooding flushed more than 600,000 tonnes of raw sewage into the Thames at Brentford, Kew and Isleworth (The Times, 5th August 2004). Tens of thousands of fish were killed and the services of the Environment Agency were called upon quickly.

Canoeists were also hospitalised following contact with sewage in the Thames as a result of the flooding (Evening Standard, 4th August 2004).

Table 2.3 shows that high rainfall was recorded at Heathrow and Northolt on 3rd August, though very little rain occurred at the London Weather Centre. However, the records at these locations do not support the description of "one month's rain in one hour", since the monthly average for August is 47.3mm. The event seems to have been characterized by extremely localized weather, and so it is possible that downpours were much more intense in some locations than in others.

Table 2.3 Verification of heavy rainfall event on 3rd August 2004

Location of weather station	Date	Rainfall (mm)
Heathrow	2nd August	trace
	3rd August	16.8
	4th August	trace
Northolt	2nd August	0.2
	3rd August	14.6
	4th August	1.0
London Weather Centre	2nd August	0.8
	3rd August	1.0
	4th August	0.0

2.2.3 Flooding event – 10th August 2004

The media reported that on 10th August 2004, 10mm of heavy rain fell within 2 hours. The rain threatened to burst riverbanks across the country and sewage was discharged into the Thames near Isleworth and Battersea Park (The Times, 11th August 2004).

However, Met Office data in Table 2.4 show that on 10th August, there was only 3.0mm, 0.4mm and 0.2mm of rainfall at St James's Park, Northolt and Heathrow respectively. More rain fell the day before on 9th August with 12.0mm, 8.4mm and 7.4mm at each weather station. Whilst the rain fell on 9th August, there is a time-lag before the Thames in London experiences flood conditions, and a delay before flood-related impacts occurred.

Note that while the rainfall data for 9th–11th August in London do not appear as extreme as for other events, two aspects of this event could have lead to more dramatic impacts: first, the fact that this followed closely after a previous episode of high rainfall earlier in the month (see section 2.2.2) and so groundwater levels and river levels were already high ; second, when rain falls in particularly intense downpours it can overwhelm the capacity of urban drainage systems and lead to overland flow (flash floods), even if the total volume of rain is not especially large.

Table 2.4 Verification of heavy rainfall event on 10th August 2004

Location of weather station	Date	Rainfall (mm)
St James's Park	9th August	12.0
	10th August	3.0
	11th August	0.2
Northolt	9th August	8.4
	10th August	0.4
	11th August	1.0
Heathrow	9th August	7.4
	10th August	0.2
	11th August	1.2

2.2.4 Case study: June and July floods 2007

The following case study explores the implications of a particularly disruptive series of flood events, which occurred across London, and identifies common themes arising from the media trawl.

Weather impacts occurred throughout the months of June and July 2007 but our media trawl did not highlight all of these. The media trawl identified weather events during the first week of July, but no impacts were found later in the month. This suggests that following the first major impacts on 4th and 7th July, media coverage reduced as the story became familiar to the public.

Figure 2.5 Snapshot of impacts across London during June and July floods 2007

(Blocks of colour show widespread disruption in regions and boroughs, red dots show specific incidents as mentioned by interviewees, reported in the media or through the Met Office).

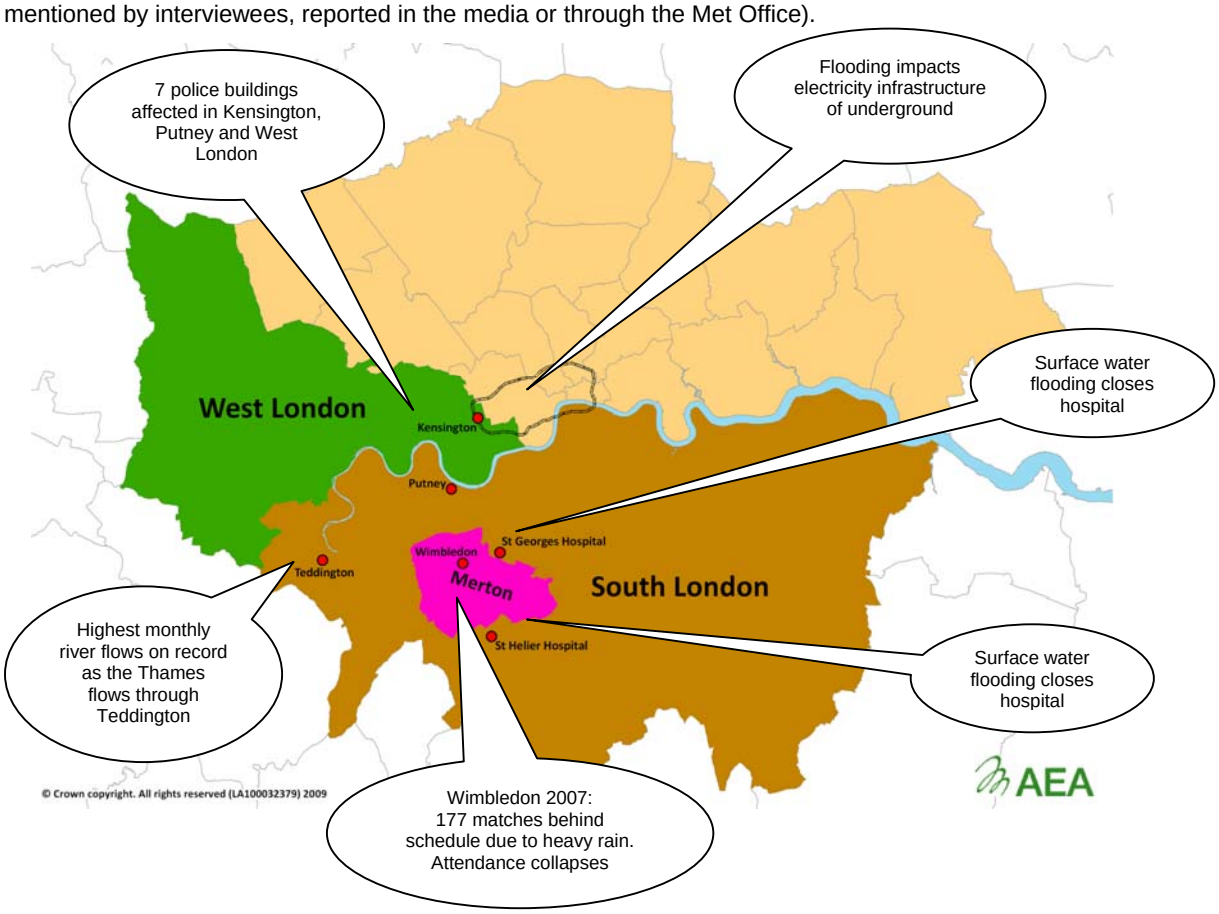


Table 2.5 Verification of heavy rainfall event on 4th July 2007

Location of weather station	Date (2007)	Rainfall (mm)
St James's Park	2nd July	7.8
	3rd July	5.8
	4th July	4.0
	5th July	0.6
Northolt	2nd July	10.2
	3rd July	5.4
	4th July	2.8
	5th July	1.2
Heathrow	2nd July	12.0
	3rd July	5.0
	4th July	3.6
	5th July	0.6

Table 2.5 shows that more rain fell on 2nd July, with 12.0mm at Heathrow. By 4th July, the day that extensive impacts were reported in The Guardian, rainfall reduced to between 2.8mm and 4.0mm. Intense downpours on 3rd or 4th July could have exacerbated impacts. Figure 2.6 describes the range of impacts that occurred in London during this period of rain.

Figure 2.6 Summer floods 2007

In June and July 2007 there were major floods in parts of London when exceptionally large amounts of rain fell in very short periods.

On 4th July 2007, The Guardian reported 'Wimbledon 2007: Attendances collapse as repeated rain scares away a flood of fans' and 'Miserable days of persistent and occasional torrential rain in South West London has left the 2007 tournament 177 matches behind schedule'.

On 7th July 2007, The Guardian reported 'Hailstones the size of 20p pieces smacked into the streets of South London and officials at Wimbledon considered extending play into a third week because of miserable weather'. Impacts were felt across many services in London and the Flash warnings from the Met Office were issued to key organisations across London on the 20th July.

The River Thames and its tributaries in Wiltshire, Oxfordshire, Berkshire and Surrey flooded. The Thames Catchment received 121mm of rainfall in July 2007, equivalent to 247% of the long-term average. In London, most of this fell on 20 July 2007 as short torrential downpours. Low soil moisture deficits, which affects the amount of water that soil can hold, and the hard surfaces of the urban environment increased the run-off into rivers and drains. This combination caused surface water flooding and rapid rises in river flows at many locations. By the end of July 2007 average monthly river flows at many sites, including Teddington, were the highest on record.

Many London Boroughs were affected by the flooding including over 500 properties, 80 schools and parts of several hospitals (Drain London, 2009) including St George's Hospital in Tooting and St Helier Hospital in Carshalton which were temporarily closed due to flooding (Environment Agency, 2007). While there was only around two hours of rainfall over London, parts of the city experienced serious surface water flooding as drainage systems were overwhelmed by the extreme rainfall (Environment Agency, 2007).

Transport disruptions were felt across London. The electricity infrastructure of the underground is extremely vulnerable to flooding and this had implications for transport services. The closure of tube lines affected the ability for Royal Parks staff to travel to work (Royal Parks, 2009)

Road networks were disrupted due to floods causing traffic jams and a knock on effect on the wider transport network. Surface water flooding from the 2007 floods was extremely localised and impacts on underpasses, subways and roadways caused disruption to services and blockages of routes. Where surface water runoff was inhibited train tracks were affected and resources were required to ensure the tracks were free of debris (TfL 2009).

The floods caused serious disruption to social and health care infrastructure (Department of Health 2008). The 2007 July storms over the South East of the UK and western Europe caused disruption at Heathrow; some departures were delayed and many aircraft were diverted away. Many airlines had to rearrange their flight schedules. The Metropolitan Police were affected during the 2007 floods particularly around West London. The heavy rainfall and surface run off caused flooding of seven of their properties and the diplomatic protection department lost their base in Kensington for 24 hours. Their building in Putney was flooded by a combination of high tides and heavy rainfall causing a back flow of foul water.

Figure 2.7 Flooding of the River Thames, Summer 2007

2.2.5 Other impacts

The media research and interviews revealed a number of other impacts that occurred from heavy rainfall over the last ten years. For example:

- In 2001, newspapers reported that 'Heavy rainfall today spelled misery for thousands of Londoners caught in isolated floods' (Evening Standard, 8th November 2001). This long period of rainfall and flooding caused road closures and travel disruptions (Environment Agency, 2009). The Fire Brigade attended over 50 flooding incidents (Evening Standard, 8th November 2001).
- The Fire Brigade logged hundreds of flood-related calls in April 2004 when heavy rain led newspapers to print headlines like 'Monsoon London'. During this event, hundreds of homes were flooded across London, as half the average monthly rainfall reportedly fell in 2 hours (The Evening Standard, 28th April 2004; The Guardian, 28th April 2004). Closed tube stations and delays on railways during the evening rush hour affected services provided by Transport for London and National Rail (The Evening Standard, 28th April 2004).
- Lightning also accompanied the storms of April 2004: house fires were caused by lightning strikes during this year, and again in 2006 when fire destroyed the homes of 6 families (The Guardian, 28th April 2004; The Evening Standard, 5th July 2006).
- Heavy rain and high winds resulted in power failures as a tree collapsed damaging power lines in August 2004 (The Guardian, 8th July 2004).

- On 12th September 2005, the Evening Standard reported ‘Heavy rainfall and storms in West London - Thames Water and Borough Councils blamed’. The flooding which occurred was blamed on Borough Councils neglecting the maintenance of drains.
- Heavy rainfall in 2005 led to pluvial flooding at airports, resulting in flight delays at Heathrow.
- The Guardian reported on 14th June 2006 ‘After a heat-wave, torrential rains caused chaos for commuters, homes and businesses.’ As a result, City Hall was evacuated when water leaked into offices.
- In June 2006, 1.4 inches of rain reportedly fell in 1 hour; this is a tenth of what is considered heavy for June. Newspapers reported that there were over 650 calls to London Fire Brigade from people stranded in buildings caught in flash floods. As a result 50 fire engines and 250 fire-fighters were mobilized to respond to calls (The Evening Standard, 14th June 2006).
- Landslides have sometimes been triggered by heavy rain events in London. In July 2006 at Boston Manor station near Heathrow, 600 people were evacuated from an underground train when 4 tonnes of earth tumbled onto the track (The Evening Standard, 28th July, 2006).
- A noticeable failure of electrical supplies occurred when lightening hit a water pump in 2006 (Evening Standard, 28th July 2006).
- Erratic weather was also identified as affecting the numbers of blue tits, house sparrows and starlings by the RSPB in March 2007(The Evening Standard, 26th March 2007).
- In May 2008, the BUPA 10K run was affected by heavy rain and drew heavily on the services of emergency crews (The Evening Standard, 27th May 2008).
- In August 2008, London was ‘deluged by one of the most intense rainstorms’ that year as newspapers reported a fifth of the rainfall expected for the whole of August falling in just one hour. Roads were particularly dangerous due to flooding (The Evening Standard, 12th August 2008).

Figure 2.8 Heavy rainfall at a London Airport

2.3 High temperature and heat wave events and impacts

This section discusses the following events:

- High temperatures – 29th July 2002
- Heat wave – August 2003
- Heat wave – July 2006
- High temperatures – July 2008

High temperatures, including incidences of heat waves, were reported in 35 out of the 145 media stories examined in the study. Key impacts arising from high temperatures and heat waves included:

- Overheating on trains and tube carriages
- Heat and sun-related illnesses including fainting from over-exposure and dehydration
- Traffic jams on roads and motorways around London as people leave the city for the coast
- Railway tracks buckling and road tarmac melting.

2.3.1 High temperature event – 29th July 2002

On 29th July 2002, very high temperatures, up to 32.7°C, were reported in London. The London Ambulance Service estimates that they received 4,000 calls that day as a result of increasing occurrences of fainting and people having difficulty breathing due to the high temperatures (The Times, 30th July 2002), and people used the fountains of Somerset House to keep cool.

Table 2.6 shows that the highest temperatures recorded by Met Office weather stations during this event were 32.2, 32.6 and 32.5°C at London Weather Centre, Northolt and Heathrow respectively. Humidity levels were moderate, reaching 68.8% on 30th July at London Weather Centre.

Table 2.6 Verification of heat wave on 29th July 2002

Location of weather station	Date	Maximum temperature (^{O}C)	Humidity % (London Weather Centre only)
London Weather Centre	28th July	30.9	44.0
	29th July	32.2	49.7
	30th July	26.4	68.8
Northolt	28th July	30.0	
	29th July	32.6	
	30th July	25.3	
Heathrow	28th July	29.7	
	29th July	32.5	
	30th July	25.4	

Figure 2.9 Crowds enjoy the sun in Regent's Park during the summer heat wave 2006

2.3.2 Heat wave – August 2003

On 7th August 2003, The Guardian reported 'Meltdown as London record is broken'.

In London, maximum temperatures exceeded 30°C for over 10 days in a row, and between the 6th and 10th August temperatures exceeded 35°C (Met Office, 2009). This heat wave of August 2003 compelled the UK and the European community to recognise the risk of high temperatures on human health especially among the elderly. Excess mortality during the heat wave has since been analysed for the UK and it is estimated that over 2000 excess deaths in England and Wales, and 100% increase in mortality in 'retirement homes' were attributable to the heat wave (Kovats et al., 2006)[3]. It is estimated that in London there were 600 deaths more than normal during the August heatwave, possibly due to the higher night temperatures caused by the urban heat island effect (Evening Standard, 11th October 2006).

There were severe impacts on transport, tourism and health, and the media published headlines like 'Wrong kind of sunshine cuts services and slows trains' and 'Heat wave: two teenagers dead and child in intensive care' (The Guardian, 7th August 2003). London became 'hotter than Barbados' as hospitals were forced to accommodate a 16% increase in admissions in those aged 75 and over in London (Kovats et al., 2006)[3].

The high temperatures disrupted the transport network in London and across the country: Virgin train services connecting London to Birmingham were halved as speed restrictions caused delays (The Guardian, 5th August 2003).

[3] Kovats, S et al., (2006). Mortality in Southern England during the 2003 heat wave by place of death. http://www.statistics.gov.uk/articles/hsq/1419.pdf

Conditions on the underground were reported to be dangerous due to the high temperatures; in an article with the headline 'How they see us', The Times reported that the hot temperatures being experienced on the tube at the time was higher than the limit allowed for the transport of animals (The Times, 22nd July 2003). However, there is very little evidence that travelling on the tube during the heatwave had direct effects on human health related incidents (Transport for London, 2009).

Travel on the roads was affected. The AA reported an increase by a third in the number of calls received in connection with cars overheating (Evening Standard, 11th August 2003). Hot temperatures brought changes to traffic patterns as people travelled away from London to escape the heat. On 10th August, motorways became jammed with day-trippers to nearby beaches as people left London. It was estimated by the RAC that 15 million cars, a fifth above average, were using the roads that weekend. The heat also damaged the roads themselves, as 'many roads in the south of England reduced to a syrupy mess as tarmac baked in the sunshine' (The Guardian, 11th August 2003). A spokesman from the AA warned that minor roads could be slippery due to loose stones rising to the surface in the heat (The Guardian, 7th August 2003).

During the same period, staff at a London airport were on a Wildcat Strike, resulting in more than seven thousand passengers stranded as flights were suspended. Stranded passengers suffered effects from the heatwave, and the ambulance service was inundated with calls related to fainting and dehydration as the high temperatures affected people's health. The Red Cross were called upon to provide water, food, translations to non English speaking passengers and medication to the ill (The Red Cross, 2009).

On 11th August 2003, Charing Cross Hospital and University College Hospital treated numerous patients for dehydration and St Mary's Hospital, Paddington, treated twice the normal number of asthmatics (Evening Standard, 11th August 2003).

The heat wave scorched the grounds of the Royal Parks as trees and vegetation also suffered from the high temperatures. While most of the trees in Hyde Park survived, they were affected, and Royal Parks have increased replanting schemes since then as a result (Royal Parks, 2009).

Keeping animals cool at London Zoo involved feeding monkeys and sloth bears 'fruity ice lollies made in buckets, while penguins pecked at fish-flavoured ices' (The Guardian, 11th August 2003).

For Britain's bookmakers, the 10th August was 'one of the worst meteorological payouts (they had) ever seen' as people placed bets that the temperature would reach 100F: it did at 2.50pm when Heathrow recorded 100.6F (37.9°C). A spokesman of Ladbrokes suggested that the industry would have lost over £400,000 on the day (The Guardian, 11th August 2003).

The temperatures recorded by the Met Office at weather stations across London were in keeping with what was reported in the media at the time (Table 2.7). The highest recorded temperature in London during the heat wave event was at Heathrow on the 10th August 2003 (37.9°C).

Table 2.7 Verification of heat wave August 2003

Location of weather station	Date	Maximum temperature (^{o}C)	Humidity % (London Weather Centre only)
London Weather Centre	3rd August	30.4	65.1
	4th August	30.8	71.6
	5th August	30.3	61.9
	6th August	35.7	57.3
	7th August	29.7	60.8
	8th August	30.3	63.1
	9th August	36.0	71.9
	10th August	37.6	44.9
	11th August	34.6	67.3
Northolt	3rd August	29.4	
	4th August	31.7	
	5th August	31.3	
	6th August	35.1	
	7th August	29.4	
	8th August	29.7	
	9th August	35.2	
	10th August	37.7	
	11th August	34.3	
Heathrow	3rd August	29.5	
	4th August	31.8	
	5th August	32.2	
	6th August	35.2	
	7th August	29.7	
	8th August	30.7	
	9th August	35.0	
	10th August	37.9	
	11th August	33.7	
St James Park	3rd August	29.7	
	4th August	30.5	
	5th August	30.5	
	6th August	35.6	
	7th August	30.1	
	8th August	30.7	
	9th August	35.2	
	10th August	37.6	
	11th August	33.7	

2.3.3 High temperature event– July 2008

In July 2008 high temperatures affected London again, with the media reporting temperatures up to 27.8°C (The Guardian, 2nd July 2008). At Wimbledon, 50 spectators at the tennis championships were treated by the St John Ambulance service after fainting, on a day reported to have been the hottest of the year.

Table 2.8 shows that the highest temperatures occurred on 1st July, when they reached 28.2, 26.8 and 27.3°C at London Weather Centre, Northolt and Heathrow respectively.

Table 2.8 Verification of heat wave in July 2008

Location of weather station	Date	Maximum temperature (^{o}C)	Humidity % (London Weather Centre only)
London Weather Centre	1st July	28.2	32.7
	2nd July	21.5	53.9
	3rd July	22.0	41.9
Northolt	1st July	26.8	
	2nd July	19.3	
	3rd July	21.5	
Heathrow	1st July	27.3	
	2nd July	19.5	
	3rd July	21.3	

2.3.4 Case Study – Heat wave of July 2006

Figure 2.10 Summer heat wave 2006

Temperatures for much of the UK were significantly above average during summer 2006. It was the warmest June for thirty years and July continued the warm trend. The Met Office issued a level 3 heat wave warning for England and Wales on 17th July that continued until Friday 21st July.

Impacts were immense across London in many sectors. Firefighters battled a blaze near Clapham Junction where undergrowth caught fire near a railway line spreading to a house on Strathblaine Road (Evening Standard 2006). London Fire Brigade reported increasing bush, heath and forest fires in soaring temperatures that were resource intensive for the Brigade to deal with. Farmland was also a cause for concern where certain land uses and long grasses made land vulnerable to fires during prolonged hot and dry spells.

Kings Cross Station's entrance to the underground was 41°C as reported by the Guardian on the 13th July 2006. The national media stated that temperatures were high enough to affect the health of passengers on public transport (The Times 2006). TfL responded with health campaigns to encourage passengers to carry water and avoid peak travel times and are now looking at addressing temperature control on the underground.

Tarmac on the highways started to melt in the increasingly uncomfortable conditions. Services were called out to grit the roads to prevent further damage of the road and car tyres (Evening standard 2006).

Many people traveled out of London to escape the heat. Police handed out thousands of bottles of water on the roads where passengers were stranded on the A1(M) Southbound where there was a six mile tail back (Evening Standard 2006). Financial costs were associated with replacing rail sections where they had buckled due to heat, and with resurfacing roads where there had been heat damage.

High temperatures inside buildings across London affected the services they provide to people. Many older hospitals are not equipped with cooling systems and this may have impacted on patient comfort during the heat wave. The Metropolitan police had impacts on their IT infrastructure, as they needed to keep control rooms cool to continue services. Critical services were maintained but the problem was highlighted as an issue for the future and plans were made to ensure further resilience of IT infrastructure.

A long period of low rainfall during the heat wave resulted in the Environment Agency imposing a hosepipe ban and the South East was described as being in a drought. Emergency services and utilities as well as the Environment Agency worked hard to educate the public on water efficiency. Water consumption was reduced by around 8% for Thames Water in relation to the public campaigns. High-rise flats were identified as vulnerable in terms of getting water to residents in need during the high temperatures.

The heat wave affected the grounds of the Royal Parks (Royal Parks, 2009). As thousands of people flocked to green spaces across London, the importance of quality green space and shading was further highlighted.

The map in **Figure 2.11** shows key locations within London affected by the 2006 summer heat wave, based on findings from the media trawl and interviews with service providers.

Figure 2.11 Snapshot of impacts across London during summer heat wave 2006

(Blocks of colour show widespread disruption in regions and boroughs, red dots show specific incidents as mentioned by interviewees, reported in the media or through the Met Office).

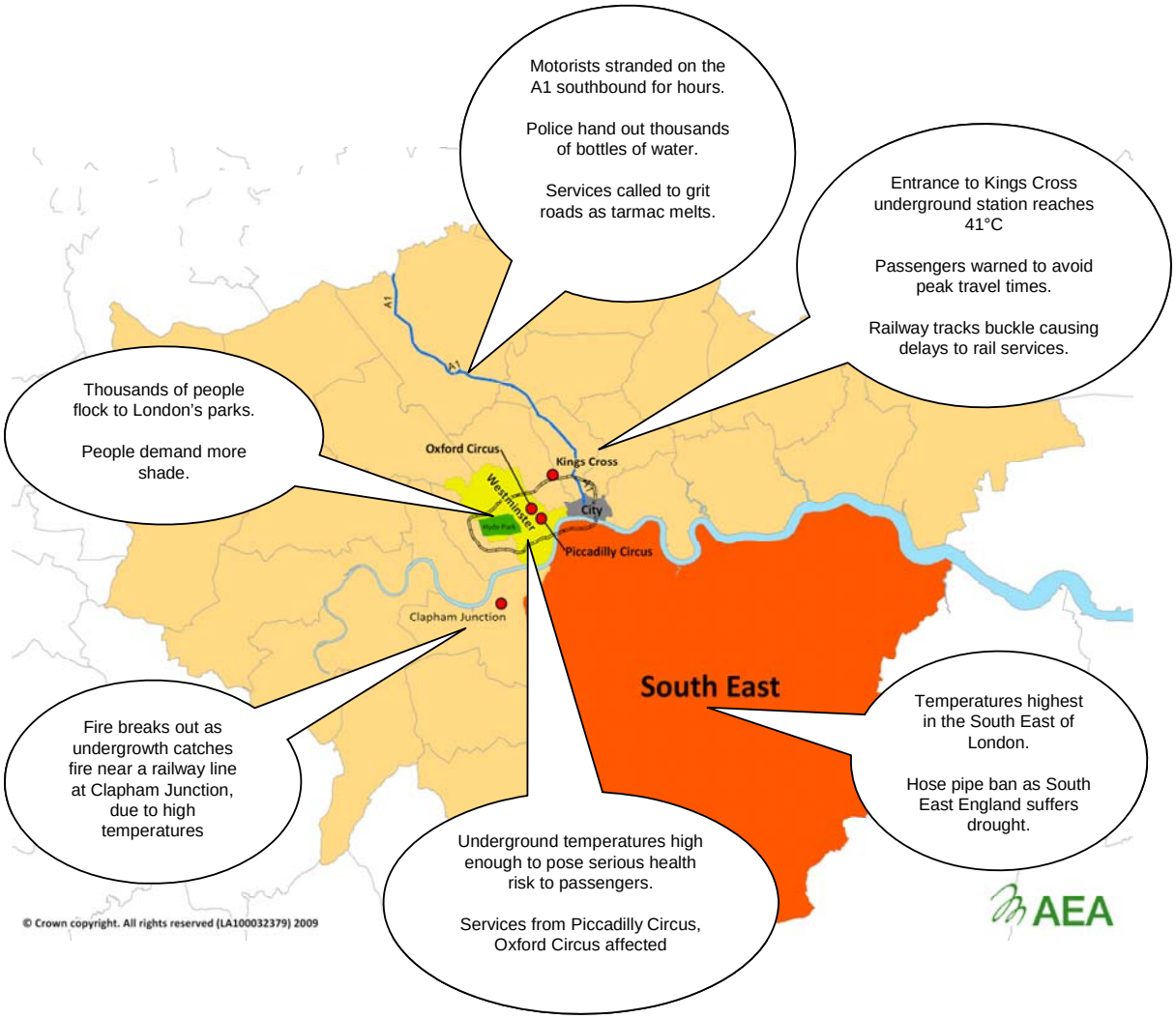


Table 2.9 Verification of heat wave in July 2006

Location of weather station	Date	Maximum temperature (^{o}C)	Relative humidity (London Weather Centre only)
London Weather Centre	12th July	28.6	29.5
	13th July	22.9	56.7
	14th July	22.6	37.1
St James's Park	12th July	27.5	
	13th July	23.3	
	14th July	23.1	
Heathrow	12th July	27.6	
	13th July	23.6	
	14th July	24.0	

Media coverage of the event was most widespread on 13th July, following the peak temperatures which occurred on 12th July, when they reached 28.6, 27.5 and 27.6°C at London Weather Centre, St James's Park and Heathrow respectively (Table 2.9). London's temperatures were particularly high on 12th July as a result of the urban heat island effect preventing sufficient cool-down during the night. It is important to note that temperatures recorded outside by the Met Office cannot easily be compared with internal temperatures reported, for example at Underground stations.

2.3.5 Other impacts

The media research and interviews revealed a number of other impacts from high temperatures over the last ten years. For example:

- In 2004, hot temperatures resulted in severe weather warnings as hot temperatures combined with an absence of pollution and clouds exposed people to harmful ultra-violet rays. Hotter weather also had effects on domestic pets as fears rose about dogs in cars suffering dehydration, and there was an increased demand on RSPCA services.
- October 2006 was set to bring the highest October temperatures on record with headlines about the 'freak heat', and reports about the popularity of London's parks: 'London's parks still host visitors in skimpy summer clothing' (Evening Standard, 11th October 2006).
- In April 2007, large numbers of people used recreational facilities in Hyde Park as temperatures were hotter in London than in Majorca.

2.4 Snowfall events and impacts

This section discusses the following events:

- Snow – January 2007
- Snow – January 2003

Snowfall was the subject of 31 of the media stories reviewed. Key impacts arising from snowfall identified in media reports or through stakeholder interviews include:

- Travel delays on road, rail and air caused by slow moving traffic or road closures
- Knock on effects of people being unable to get to work on time or at all
- Increased pressure on health and emergency response services

Figure 2.12 Heavy snowfall outside London shops and offices

2.4.1 Snowfall event – January 2007

On 24th January 2007, reports such as 'light snow paralyses rail networks and causes travel chaos' and 'snow brings travel chaos' dominated the headlines as snowfall affected London. South London and Coulsdon were particularly affected (The Times, 24th January 2007).

Tube journey times were severely affected, and resulted in criticism of Metronet for failure to prepare for and respond accordingly to snowfall (Evening Standard, 19th January 2007).

Weather station records (Table 2.10) show that only 3 cm of snow fell on 24th January at Heathrow, indicating that London's transport services in particular are vulnerable to even relatively small amounts of snowfall.

Table 2.10 Verification of snowfall January 2007

Location	Date	Minimum temperature (^{O}C)	Snowfall (cm) *(Heathrow only)*
Heathrow	23rd January	0.6	0.0
	24th January	-1.9	3.0
	25th January	0.1	0.0
London Weather Centre	23rd January	1.2	
	24th January	-0.4	
	25th January	0.7	
St James's Park	23rd January	1.3	
	24th January	-1.2	
	25th January	0.7	

2.4.2 Case study – Snow in January 2003

Figure 2.13 Snowfall 2003

When the extreme southeast recorded 2 to 5 cm of snow early on the 7th of January 2003, there was travel chaos during the rush hour that day with tens of thousands of commuters delayed by 2 to 3 hours (Evening Standard 2003).

In central London, the snow was the heaviest since February 1991 (Met Office). Between 4 and 8 cm fell in most places across London, and Essex received up to 12 cm. More snow on the 8th January affected Greater London in the south to the M25, NW Kent, Essex and parts of Surrey.

Long sections of the M25 outer London orbital motorway and the London to Cambridge motorway, the M11, were jammed solid, and some motorists and lorry drivers were stranded over night (Guardian 2003). Snow and black ice brought roads to a standstill over high ground and around Hampstead Hill (Evening Standard 2003). The AA said it was the worst traffic they had ever seen (Evening Standard 2003).

On the underground, the Victoria and Waterloo and City line were the only tubes running (Guardian 2003). Fast high winds during the snow meant that Paddington Station had to be closed (Times 2003).

The Ambulance Trust called upon the Red Cross to support them in responding to emergency calls during the snow. Four-wheel drive vehicles were needed for mobilising staff where it was difficult to get access due to weather conditions (Red Cross 2009).

Further cases of cold related health problems impacted on the vulnerable and added to pressures within the health service. Many service agencies have contingency plans for events such as this: the Red Cross have a contract with EDF energy for responding to calls during cold spells where energy may be an issue for vulnerable households (Red Cross 2009). The London Fire Brigade also has contingencies in place to allow for issues with staff being impeded from getting to work due to snow (London Fire Brigade 2009).

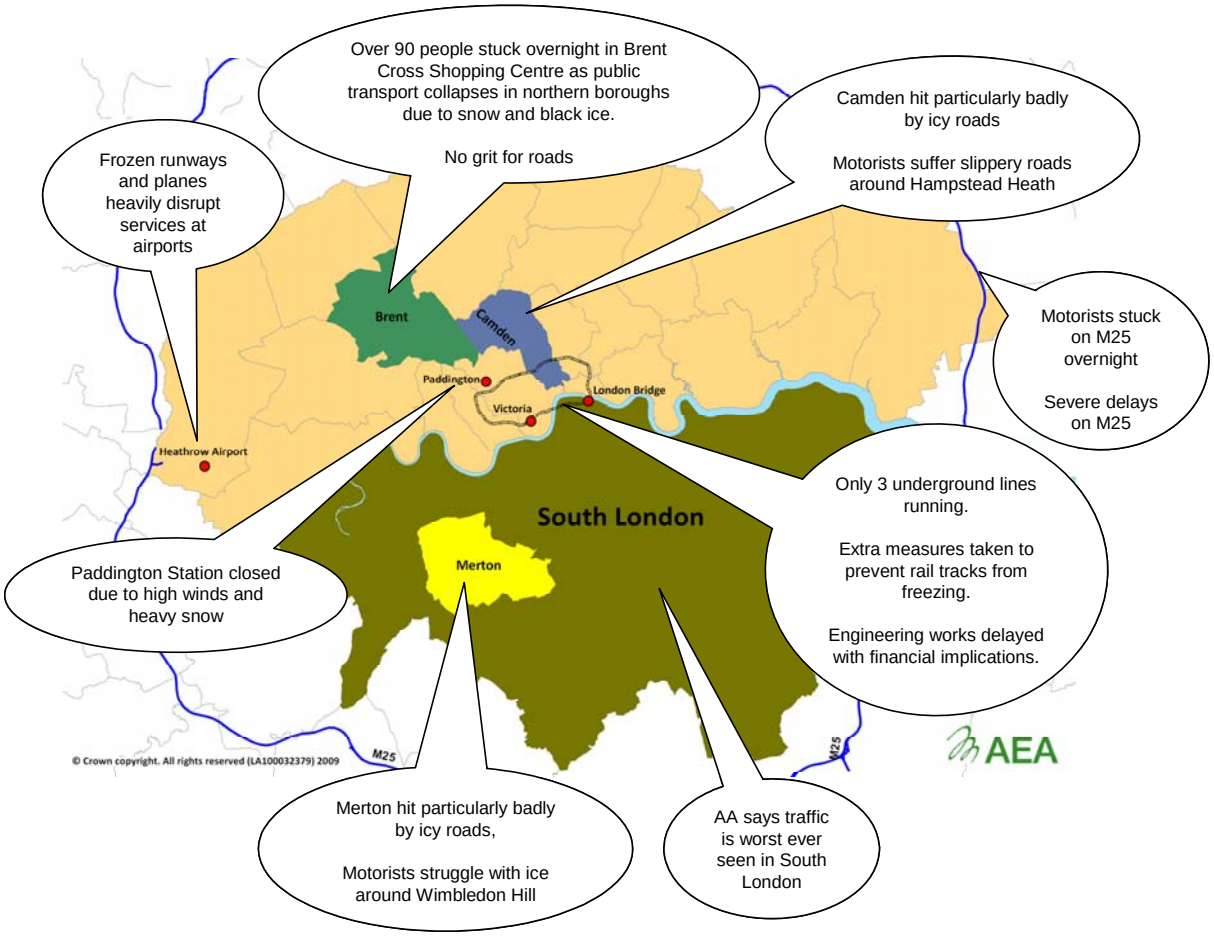
Airports were affected during snow and ice conditions where more planning was required to de-ice runways and planes. This caused a build up of air traffic and delays followed. High costs were incurred by rail companies as they worked to prevent rail tracks freezing and engineering works taking place during the period had to be rescheduled.

Table 2.11 Verification of snowfall January 2003

Location	Date	Minimum temperature (^{O}C)	Snowfall (cm) *(Heathrow only)*
Heathrow	6th January	-1.6	0.0
	7th January	-1.7	1.0
	8th January	-3.8	0.0
London Weather Centre	6th January	0.3	
	7th January	0.2	
	8th January	-1.8	
St James's Park	6th January	-0.1	
	7th January	-0.3	
	8th January	-2.2	

Figure 2.14 Snapshot of impacts across London during 2003 snowfall

(Blocks of colour show widespread disruption in regions and boroughs, red dots show specific incidents as mentioned by interviewees, reported in the media or through the Met Office).



2.4.3 Other impacts

The media research and interviews revealed a range of impacts that had occurred from snowfall over the last ten years. For example:

- In 2000, snowfall affected road and rail journeys, and many roads froze before they could be gritted.
- Dozens of people became stuck overnight in Brent Cross Shopping Centre as heavy snowfall in 2003 disabled the public transport system.
- Snow led to one football match being 'abandoned' in 2006 as well as cancellations of matches in 2008.
- On 8th February 2007, the Evening Standard reported 'the worst snowfall in 7 seven years'. As a result, school closures took place.
- Snowfall and a lack of gritting in preparation resulted in traffic delays in 2008, while predictions of such events led to efforts by local councils to utilize resources and stockpile salt for gritting.
- In February 2009 heavy snowfall affected airports: London City and Gatwick airports closed runways.
- In the snow of February 2009, many employees were unable to get to work due to travel problems. Staffing problems affected some Emergency Service units.

Figure 2.15 London dusted by snow

2.5 High wind events and impacts

This section discusses the following events:

- Strong winds – 20th October 2000
- Strong winds – 22nd March 2004

High wind events were responsible for impacts reported in 18 out of the 145 media reports studied. Some of the most disruptive impacts have been in the transport sector and include windstorms blowing trees onto railway tracks causing accidents, severe delays to services, and flying debris causing damage to buildings and infrastructure.

2.5.1 Strong wind event – 30th October 2000

On 30th October 2000, storms with winds gusting up to 100mph, and torrential rains, occurred across London and the Southeast. A widespread problem was trees being blown onto railway tracks: there were three separate train crashes as trains collided with trees (Evening Standard, 30th October 2000). On the London Piccadilly line, a train smashed into a fallen tree at Hounslow. The media reported that while no passengers were on board, the train 'hit the tree, dragging it along…then hit a bridge and rebounded onto the driver's cab'. The driver had serious injuries and had to be cut from the wrecked cab (Evening Standard, 30th October 2000).

It was estimated that this single weather event cost in the region of £2 billion in losses (Evening Standard, 30th October 2000).

The weather caused havoc for engineers who worked overnight to clear debris that had blown onto railway lines. It was reported that 'as fast as they cleared the lines, the leaves, trees and huge broken branches were blown back on' and this caused severe disruption during rush hours as 'commuters suffered the most serious travel chaos ever' (Evening Standard, 30th October 2000).

Most trains were affected as they came into London, stacking up as they approached the city due to speed limits and overcrowding of the few trains that were running. Over 100 people who were trying to get to London in the extreme winds 'had to be walked along the tracks to safety,' when a Great Malvern to Paddington service hit a tree at Campden (Evening Standard, 30th October 2000).

Table 2.12 shows the mean wind speed and maximum gusts on 30th October 2000. The maximum mean wind speed was recorded at Kenley Airfield which is some distance southeast of London. Maximum gusts were recorded at Northolt and Kenley Airfield, at 78.2mph respectively. The Evening Standard reported that gusts reached 100mph.

Table 2.12 Verification of strong winds on 30th October 2000

Location of weather station	Date	Mean wind speed	Wind – maximum gust
Heathrow	30th October	17.8kn – 20.5mph	57kn – 65.5mph
Northolt	30th October	19.3kn – 22.2mph	68kn – 78.2mph
Kenley Airfield	30th October	21.3kn – 24.5mph	68kn – 78.2mph

2.5.2 Strong wind event – 22nd March 2004

On 22nd March 2004, The Guardian reported 'Gales bring death and destruction' along Thames side, between Hammersmith and Putney, and the Millennium Bridge. It was reported that people had to be rescued from the Thames. Table 2.13 shows that the maximum gusts observed were 50.6mph and these were recorded at Northolt.

Table 2.13 Verification of strong winds on 22nd March 2000

Location of weather station	Date	Mean wind speed	Wind – maximum gust
Heathrow	22nd March	19.5kn – 22.4mph	41kn – 47.1mph
Northolt	22nd March	17.3kn – 19.9mph	44kn – 50.6mph
Kenley Airfield	22nd March	16.5kn – 18.9mph	38kn – 43.7mph

2.5.3 Other impacts

The media research and interviews revealed various other impacts from high winds over the last ten years. For example:

- On 28th October 2002, high winds of up to 75mph caused damage and destruction London-wide. London Fire Brigade took 5000 emergency calls in one evening (8 times more than normal) (Evening Standard, 28th October 2002).
- In 2002, high winds causing damage to trees resulted in two fatalities as a tree fell onto a car (Evening Standard, 10th December 2002).
- Emergency Services were called to rescue oarsmen in the 2004 Varsity boat race, as boats capsized due to high winds (The Guardian, 22nd March 2004).
- A tornado in 2006 resulted in serious concerns for Local Government, which had to deal with the sudden homelessness of a number of families in north-west London.
- In 2007 high winds and storms led to hundreds of staff working overnight to clear up to 1,000 major obstacles to ensure transport for commuters would be viable by morning.
- Several instances of strong gales and storms caused tree damage and falls in 2007.

- A woman was knocked unconscious and hospitalized by an advertising hoarding blown down in the high winds during March 2008 as she waited for a train (Evening Standard, 12th March 2008).
- Strong winds in March and April 2008 caused disruptions to flights at London airports.
- Serious chest injuries were sustained by a Londoner taking part in extreme sports (kite-boarding) during high winds in 2008 (Evening Standard, 6th October 2008).

2.6 Low temperature events and impacts

This section discusses the following event:

- Low temperatures – 4th March 2005

Low temperatures were the focus of 5 out of the 145 media stories reviewed, although some low temperature events were classed as snow.

2.6.1 Low temperatures – 4th March 2005

The Evening Standard reported on 4th March 2005 that freezing temperatures led to travel disruption to London's road, rail, tube and air transport networks. Whilst temperatures fell to -2 °C, the wind chill factor made it feel like -9°C. The Evening Standard reported that Stansted and Luton Airports were closed as a result of the extreme temperatures (4th March, 2005).

Data in Table 2.14 confirm that temperatures were at their lowest on 4th March, reaching –4.8°C and –5.5°C at Heathrow and Northolt respectively. Temperatures were low for a number of days before and after the 4th March. Mean wind speeds were relatively light, but near-gale and gale force gusts of 29 knots and 34 knots were experienced at Heathrow and Northolt respectively. Only 1cm of snow was recorded at Heathrow on 4th March.

Table 2.14 Verification of freezing temperatures on 4th March 2005

Location of weather station	Date	Minimum temperature (^{o}C)	Wind *(Heathrow and Northolt only)*
Heathrow	3rd March	-1.0	
	4th March	-4.8	Mean speed – 6.9 knots or 7.9mph (light); Max. gust – 29 knots or 33.3mph (near gale)
	5th March	-0.6	
London Weather Centre	3rd March	-0.5	
	4th March	-0.7	
	5th March	0.3	
Northolt	3rd March	-1.4	
	4th March	-5.5	Mean speed – 5.7 knots or 6.5 mph (light); Max. gust – 34 knots or 39.1mph (gale)
	5th March	-0.8	

2.6.2 Other impacts

Several other impacts from low temperatures were reported over the last ten years. For example:

- A low temperature induced burst water main resulted in severe road traffic delays in 2004.
- Falling temperatures affected a range of service providers. British Gas had to put an emergency plan into place to deal with increased demand during prolonged cold spells, while “antique” draining systems used by utilities companies were blamed for flooding (Evening Standard, 12th September 2005).
- London’s green spaces were affected by low temperatures in 2006, with poor daffodil growth observed in Kew Gardens by March of that year (Evening Standard, 20th March 2006).
- In 2007, low temperatures resulted in 30 flights being cancelled from Heathrow and 40 from Gatwick because airlines could not de-ice planes in time for take-offs (The Guardian, 2nd February, 2009).
- 2007 also saw reports on impacts on wildlife, particularly birds, as breeding patterns were fluctuating as a result of changing temperature and weather patterns.

2.7 Severe dry weather events and impacts

This section discusses:

- The prolonged period of drought during 2004 – 2007.

London experienced a drought from November 2004 through to January 2007. Unlike other types of weather that have been reported in the media, drought is something that emerges over a long period of time. Newspapers reported the impacts of the drought at different times during the period.

On 8th March 2005, it was reported: ‘London facing hosepipe ban after driest winter in years’. The threat of a hosepipe ban was due to a very dry winter, which resulted in ground water levels dropping by up to 50% (Evening Standard, 8th March 2005). It was later reported that the rainfall from November to March 2005 had been only 65% of the average for the time of year (The Times, 23rd April 2005).

In January 2006, newspapers reported 2005 to be the driest year since 1921. This led Southern Water to apply for a drought permit to increase the amount of water abstracted from the River Medway.

In April 2006, newspapers reported that Thames Water imposed a water usage ban in response to the drought after rapidly falling groundwater levels hindered supplies. This was the first hosepipe and sprinkler ban in London since 1991 and affected 13 million people across southern England. The 9-month ban was lifted in January 2007 after London received 50% more rain than usual during autumn 2006 and winter 2006/07 (The Evening Standard, 2007).

2.7.1 Other impacts

Other reported impacts from dry weather over the last ten years included:

- The long period of low rainfall led to the Environment Agency imposing a hosepipe ban and the South East was described as being in a drought. Emergency services and utilities as well as the Environment Agency educated the public on water efficiency. Water consumption was reduced by around 8% for Thames Water in relation to the public campaigns (Environment Agency, 2009). Residents of high-rise flats were identified as potentially vulnerable to restricted water supplies.
- The lack of water during this drought period also affected the Royal Parks. Impacts of the drought were more frequently reported during the 2003 and 2006 heat waves. The drought highlighted the high risk of future rainfall shortages in London’s parks which can put pressure on trees and vegetation.

Figure 2.16 Hyde Park in London after a long dry summer.

2.8 Consequences for London's service providers

The weather events and impacts discussed so far have provided examples of how damaging and disruptive weather can be to London's infrastructure and systems. The media research and interviews have shown how different types of weather can affect London in different ways. Here, we present findings on which organisations appear to be most affected by certain types of weather and provide short summaries of the types of weather and impacts by sector. A greater insight into how weather can affect specific organisations is provided by two case studies on Transport for London and the British Red Cross.

2.8.1 Summary of weather and impacts by sector

To identify which sectors and organisations in London have been most affected by the weather over the last ten years, the impacts related to each weather event were categorised, and the sectors affected by each impact were identified.

The impacts categories were selected following a review of the London's Warming report[1] and London's draft Adaptation Strategy[2]. Appendix 1 provides justification for the following selection of categories:

- Pluvial (flash) and Fluvial (river) flooding
- Subsidence
- Landslides
- Damage (transport & related infrastructure)
- Damage (buildings)
- Damage (other)
- Drought
- Disruption (travel)
- Disruption (other)
- Health and safety

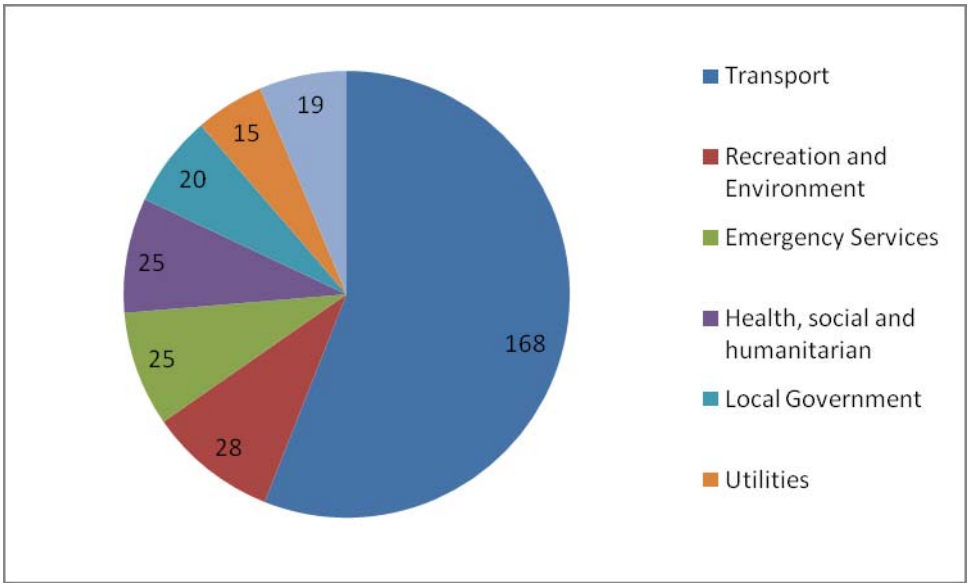
We selected 6 sector categories to capture all the London organisations mentioned in the media reports we surveyed. These are:

- Transport
- Emergency services
- Health, social and humanitarian services
- Recreation and environment services
- Government
- Utilities

Of the 300 weather impacts linked to the weather events identified in the media review, over half were reported to affect the transport sector (168 weather impacts). The second largest sector to be affected was recreation and environment (28 impacts), followed by health, social and humanitarian and emergency services (25

weather impacts each). Local Government was affected by 20 impacts, and utilities providers were affected by 15 out of 300 weather impacts (see Figure 2.17)

Figure 2.17 Number of reported weather impacts by sector



2.8.2 Transport

Transport was the sector most frequently reported to be affected by weather events. Figure 2.18 shows the types of weather events affecting transport providers in London. Of the 168 impacts on transport in London, heavy rain and snowfall were the main weather types causing disruption. From the reports identified in the media research, it appears that high and low temperatures and high winds were less problematic to the sector than heavy rain and snowfall.

Figure 2.18 Types of weather events affecting transport providers in London

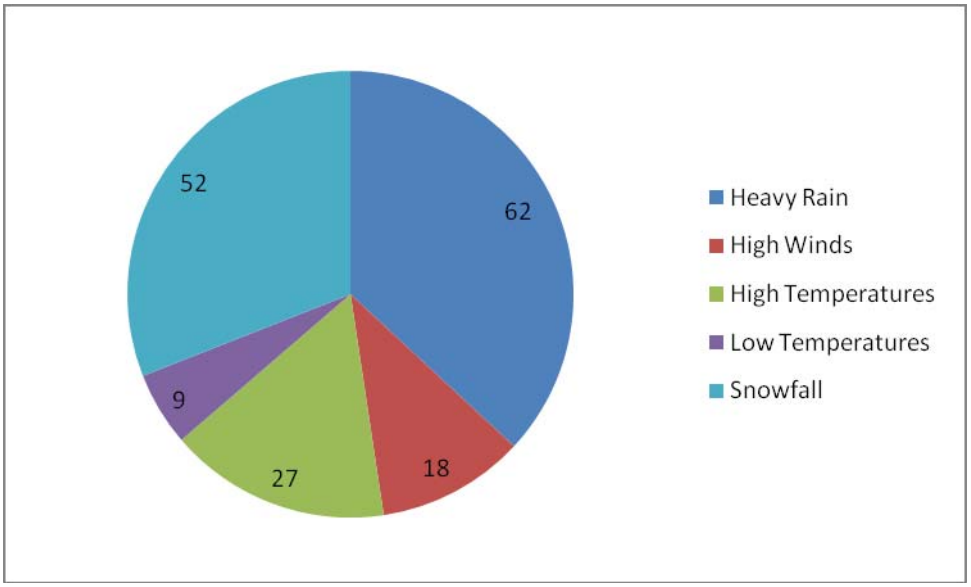


Figure 2.19 shows reported impacts by transport organisation. Of the 168 impacts on transport provision in London, Transport for London (TfL) was the most frequently reported organisation to be affected. The majority of occasions were related to the London Underground and overground rail networks. 34 impacts were found to have

affected other rail service providers, including Virgin Rail, Connex South Eastern, National Rail, South West Trains and the Eurostar. These weather impacts tend to have been geographically more widespread, as reported in the media, with effects extending beyond London.

Some media stories did not identify specific organisations but it was clear from the information reported, that impacts related to a certain sector. This is reflected in a 'Non-Assigned (N/A) category in the break down of all reported impacts by transport sector organisations in Figure 2.19

Figure 2.19 Number of weather impacts reported to affect London transport organisations

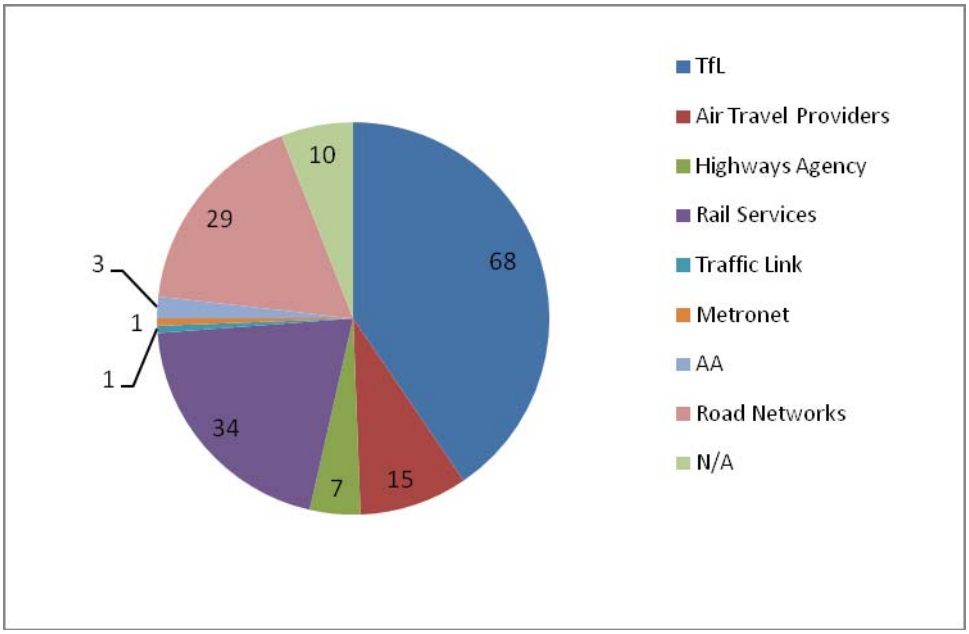


Figure 2.20 Case Study on Transport for London

Transport for London (TfL) is the integrated body responsible for the Capital's transport system. Its role is to implement the Mayor's transport strategy for London and manage transport services across the Capital, for which the Mayor has responsibility. TfL manages London's buses, London Underground (LU), Docklands Light Railway (DLR), London Overground and London Trams. It also runs London River Services (LRS), Victoria Coach Station (VCS) and London Transport Museum.

As well as running London's Congestion Charging scheme, TfL manages a 580km network of main roads, all of London's 6,000 traffic lights and regulates taxis and the private hire trade.

TfL also play an important role in shaping and influencing transport policy across London including low emission zones and play a part in policing and working closely with the transport police.

Weather has affected London's infrastructure, including transport for many years. Three main types of weather have historically impacted upon services: snow, heavy rainfall and heat.

Snow events cause transport problems on the road network. The London Underground can be impacted, mainly due to snow affecting the signals. This can bring about delays or periods where the line is closed. On the underground Victoria and Waterloo and City line were the only tubes running during the heavy snowfall of 2003 (Guardian 2003). This impacts upon passengers and also staff and the organisation as a whole where there are financial implications.

There is a cost impact to TfL's engineering activities, for example in processes to prepare tracks in advance for extremes of temperatures or from cancelled engineering works. A cost/benefit analysis is completed when it is decided that works will needed to be cancelled.

There is a system called winter weather precautions that involves an established routine with warnings coming from the Met Office. The Met Office can provide data on how the weather will affect rail conditions; for example predicting ice on the tracks.

Across London's service sector, during severe snow events such as February 2009 it can be difficult in snow conditions for staff to actually get to work to start operations and services in the first place.

Heavy prolonged rainfall can affect services that TfL provides. The electricity infrastructure of the underground is vulnerable to flooding which can cause signalling problems resulting in delays. Surface water flooding from the 2007 floods was localised and impacts on underpasses, subways and roadways caused disruption to services and blockages of roads and over ground routes. Where surface water run off was inhibited train tracks were affected and resources were required to ensure the tracks were free of debris. (TfL 2009).

Whilst the London Underground is largely buffered from high temperatures above ground, longer heat wave circumstances can cause uncomfortable conditions for passengers on public transport. The national media stated that temperatures during the 2006 heatwave were high enough to affect the health of passengers on public transport (Times 2006) although TfL's incident records do not show any increase in health-related incidents. In periods of hot weather, TfL puts in place its campaigns to encourage passengers to carry water and avoid peak travel times. There are contingency measures for shipping in supplies of bottled water where necessary.

The new subsurface line trains will have air conditioning and there is a programme of research addressing temperature control elsewhere on the network, which is otherwise limited by older design constraints.

TfL log all incidents and records are kept in order to improve service delivery and planning in severe weather events. Future planning around resilience and being prepared for future conditions is underway.

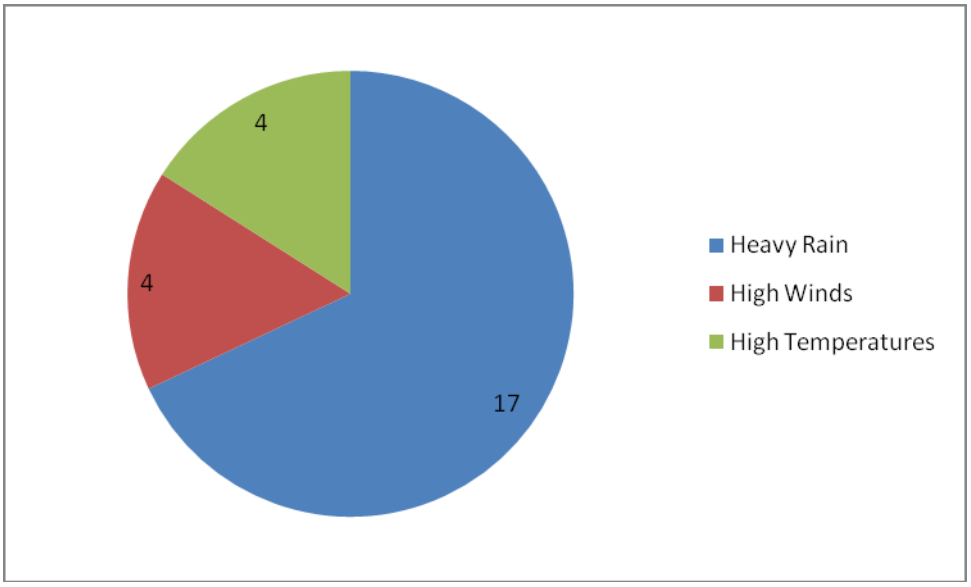
Where possible, when services are cancelled, alternative methods of transport are offered to passengers such as replacement bus services.

2.8.3 Emergency services

Emergency services are among those most frequently asked to help during weather-related events. Heavy rain is the main weather type reported to affect the Emergency Services. Flooding as a result of heavy rain has led to significant peaks in demand for Fire Brigade services. In particular, increased resources are required during periods of transport chaos due to flooding: frequently this involves helping stranded passengers.

Wind and high temperatures account for around one fifth of all impacts. While the analysis of media reports has not identified any cases of impacts from snowfall and low temperatures focused on the Emergency Services, these types of weather do also affect this sector, often as a knock-on via other sectors (for example, primary impacts might be on transport or travel, with a secondary impact on emergency services).

Figure 2.21 Types of weather events affecting Emergency Service providers in London



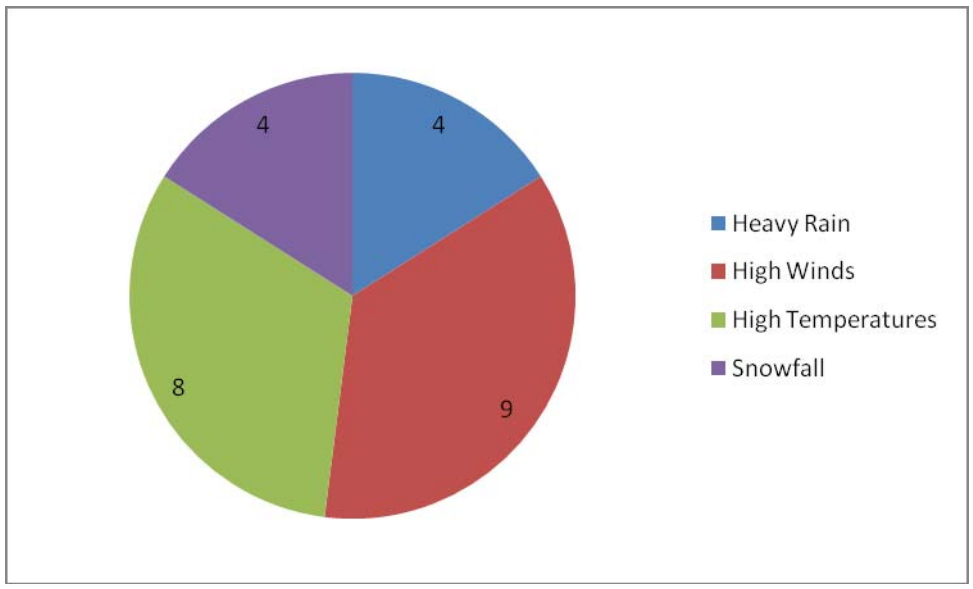
2.8.4 Health, social and humanitarian services

Health, social and humanitarian service providers were affected by 25 out of 300 weather impacts. High winds and high temperatures were the most frequent weather types reported to cause disruption to this sector (Figure 2.22). This does not mean that health, social and humanitarian services are not affected by other weather types: these are the results of analysis of reports from three newspapers only.

The health and safety impacts of hot weather were reported frequently in the media. Most of these involved stress to members of the public including dehydration, the dangers of travelling on the Tube in hot temperatures, and increased suffering of those with asthma and heart conditions.

The NHS was the organisation in this sector most frequently mentioned in newspaper reports, identified in more than half of the weather impacts reported. Articles contained very few references to other specific organisations in this sector. ‘NHS’ is often used in the media as a blanket term for public health services, and there may be a bias in newspaper reports towards ‘bad news’ stories about the NHS.

Figure 2.22 Types of weather events affecting health, social and humanitarian services



The case study in Figure 2.23 provides an overview of how the emergency response, health and social care, and humanitarian services provided by the Red Cross can be affected by weather.

Figure 2.23 Case Study on the Red Cross

The Red Cross provides services in three broad areas in London: emergency response, health and social care, and humanitarian action.

The organisation's response to situations arising from severe weather events across London is often in partnership with many of the first response emergency services, such as the police and ambulance service. The Red Cross is regularly involved if severe weather impacts upon public health. Red Cross staff responded to a flooding incident at Lee valley during 2002 where they assisted in evacuations and set up risk centres. This was in partnership with Thames Water.

The Red Cross responded to a situation that arose during the 2003 heat wave. Heathrow staff were on a Wildcat Strike which resulted in passengers being stranded at the airport as flights were suspended. The ambulance service was inundated with calls related to fainting and dehydration as over 7,000 people were stranded during the heat wave. The Red Cross came on site for 4 days during the problems to provide water, food, translations to non English speaking passengers and medication to the ill. Temporary shelters were provided.

The aftermath of the 2004 Thailand Tsunami also called upon the Red Cross in London. Red Cross staff worked at Heathrow for 2 weeks after this event and at Gatwick for 2 months, treating passengers with health problems related to the event as they returned from areas affected by the Tsunami. Many passengers needed to be treated for injuries and psychological trauma. Tsunamis are not weather phenomena, nor are they related to climate change. However, the episode demonstrated that there can be large impacts in London from extreme events occurring elsewhere in the world.

As an emergency response organisation The Red Cross have a department that monitors Met Office data, horizon scanning for potential problems that the organisation may need to respond to swiftly and efficiently. Resources can be mobilised from other parts of the UK; for example assets were deployed to Gloucester during the 2007 floods.

2.8.5 Recreation and Environment Services

Impacts on the recreation and environment sector in London were most frequently linked to rain and flooding in media reports. High winds accounted for around one quarter of impacts on this sector, followed by heat, snow and low temperatures.

Fish kills from flooding events were commented upon in the newspapers, particularly after the 2004 floods that resulted in the release of sewerage into rivers.

Of the 28 weather impacts reported to have affected recreation and environment organisations, Royal Parks have been most frequently mentioned in reports, followed by sporting events such as Wimbledon, boat races and marathons. Other organisations mentioned in news stories included the Environment Agency and the Met Office.

2.8.6 Government

Local Government was affected by only 20 out of the 300 weather impacts identified in the media reports. Impacts on local government were most commonly linked to heavy rain and flooding, but snowfall, high temperatures and high winds also resulted in impacts on this sector.

Most of the related weather impacts involved criticisms of the management of council property (for example lack of maintenance of drainage systems resulting in flooding, lack of gritting in preparation for low temperatures). Other impacts involved damage to council buildings and schools as well as traffic congestion, often due to flash flooding. Several impacts cross-cut local government service provision such as when people were stranded overnight in Brent Cross Shopping Centre.

2.8.7 Utilities

Impacts on utilities providers in London were most commonly connected to heavy rain and flooding, followed by drought, which led to impacts such as water shortages and hosepipe bans. There were fewer reports of impacts from wind affecting utilities providers.

Sewerage treatment was a particular issue, notably during the 2004 floods, when 600,000 tonnes of raw sewage flowed into the River Thames (The Guardian, 5th August 2004).

Dry weather and hot weather reportedly led to adjustments in operations, and impacts on utilities providers were more frequent when a wetter period rapidly followed a dry period.

Direct impacts from weather on this sector have a range of secondary or knock-on effects onto other sectors and the population at large.

Media stories referred to in Chapter 2

Evening Standard, 30th October 2000. ‘The fatal storm: more travel misery, storms and safety checks combine to bring chaos’.

The Guardian, 22nd November 2000. ‘Queen has cancelled a journey today from London to Cambridge by train and will go by car instead, since the usual 45mins journey is taking up to two hours’.

The Times, 10th September 2002. ‘Storms Cause Chaos across the country’.

Evening Standard, 28th October 2002. ‘Seven die as winds reach almost 100MPH’.

The Times, 30th July 2002. ‘How to keep cool in a heat wave’.

Evening Standard, 4th August 2004. ‘August Monsoon sweeps London’.

The Guardian, 8th August 2002. ‘Flood chaos on rail and roads’

Evening Standard, 10th December 2002. ‘The big chill as first snow of winter arrives’.

Evening Standard, 8th January 2003. ‘More snow brings second day of chaos for commuters.’

The Times, 22nd July 2003. ‘How they see us’.

The Guardian, 5th August 2003. ‘Wrong kind of sunshine cuts services and slows trains: Summer in the City: London Hotter than Barbados.’

The Guardian, 7th August 2003: ‘Meltdown as London record is broken’

The Guardian, 11th August 2003. ‘Bookies lose shirts as record tumbles. 100F. Phew! What a scorcher.’

Evening Standard, 11th August 2003. ‘AA received a third more calls than normal, many to deal with overheated cars stuck in traffic jams.’

Evening Standard, 11th August 2003. ‘We’re the capital of cool again as temperature falls.’

The Guardian, 22nd March 2004. ‘Gales bring death and destruction’.

The Evening Standard, 28th April 2004. ‘Monsoon London’.

The Guardian, 28th April 2004. ‘Freak thunderstorms swamp the south east.’

The Guardian, 8th July 2004. ‘Gales, storms…is it really July?: Widespread disruption as high winds hit Southern England ‘

The Times, 5th August 2004. ‘Thousands of fish die as storms flush raw sewage into Thames’.

The Guardian, 5th August 2004. ‘Storms kill 10,000 fish in Thames.’

The Times, 11th August 2004. ‘Rain brings flood fears as sewage flows into Thames’.

Evening Standard, 4th March 2005. ‘Freezing Friday sees an early escape home: Waterloo Winterland.’

Evening Standard, 8th March 2005. ‘London facing hose pipe ban after driest winter in years’.

The Times, 23rd April 2005. ‘Sprinkler ban’.

Evening Standard, 12th September 2005. ‘Heavy rainfall and storms in West London - Thames Water and Borough Councils blamed’.

Evening Standard, 12th September 2005. ‘Stormy weather’.

Evening Standard, 3rd January 2006. ‘Driest year since 1921’.

Evening Standard, 20th March 2006. ‘Spring has sprung but it still feels like winter’.

Evening Standard, 5th July 2006. ‘Storms strand 40,000’.

The Evening Standard, 14th June 2006. ‘Swamped in Monsoon London’.

The Guardian, 14th June 2006. ‘After a heat-wave, torrential rains caused chaos for commuters, homes and businesses’.

The Guardian, 13th July 2006. ‘As Britain staggers through another long hot summer, consumption of mineral water is set to break all records’.

Evening Standard, 28th July 2006. ‘Landslides and flash floods hit tubes, planes and roads’.

Evening Standard, 11th October 2006. ‘We’re on course for the warmest October yet’.

Evening Standard, 19th January 2007. ‘Huge storm leaves massive trail of devastation - worst winds to hit Britain in 17 years. Killed 14 people in UK’.

Evening Standard, 8th February 2007. ‘The worst snowfall in 7 seven years’.

The Evening Standard, 17th January 2007. ‘Hosepipe ban in London is lifted after weeks of rain’.

The Times, 24th January 2007. ‘Snow brings travel chaos’.

Evening Standard, 26th March 2007. ‘Birds under threat from unusual weather’.

The Guardian, 4th July 2007. ‘Wimbledon 2007: Attendances collapse as repeated rain scares away a flood of fans.’

The Guardian, 7th July 2007. ‘Reports of the death of summer as hailstones the size of 20p pieces smacked into the streets of South London’.

Evening Standard, 20th November 2007. ‘Heavy rain plunges homes into darkness’.

Evening Standard, 12th March 2008. Britain braced for new storm front as forecasters warn 'the worst is yet to come'.

Evening Standard, 27th May 2008. ‘One month’s rain in two days and more to come’.

The Guardian, 2nd July 2008. ‘Summer hits stride as temperatures top 27C’.

Evening Standard, 6th October 2008. ‘Kite boarder seriously hurt after plunging head first onto heath’.

The Guardian, 3rd February 2007. ‘Snow business means no business for many firms but fun for pupils: Hundreds of school close as warnings to prevent transport chaos’.

Evening Standard, 6th October 2008. ‘Kite boarder seriously hurt after plunging head first onto heath’.

The Guardian, 2nd February 2009. ‘Transport hit as UK wakes to heaviest snow in decades: People warned to avoid unnecessary journeys: Airport runways, rail and roads all face disruption’.

3 Project context

3.1 Policy context

Recognition of the need for climate change adaptation is now widespread as a result of high profile reports such as the IPCC 4th Assessment Report, the Stern Review on the Economics of Climate Change and the EU White Paper on Adaptation, all of which identified the need for urgent action on adaptation. Adaptation strategies are being developed and implemented in response to scientific evidence for increasing climate variability and future climate change. The projected increase in frequency and severity of extreme weather events is of particular concern for human and natural systems at the national and regional level in the UK, and internationally.

In December 2007, United Nations delegates gathered in Bali to develop new strategies for advancing responses to climate change by the end of 2009. The key document emerging from the Conference was the Bali Road Map, which comprises, amongst other documents, the Bali Action Plan[4]. The Action Plan highlights the importance of designing and implementing Adaptation Strategies, which involves producing vulnerability assessments and action prioritisation reports at local, national and regional scales.

3.1.1 The UK Climate Change Act, 2008

Since the launch of the Bali Roadmap, the UK has become one of the first countries in the world to introduce a long-term legally binding framework to tackle the threats of climate change. The Climate Change Act[5] was introduced in November 2008 and will now shape the Government's approach to managing and responding to climate change.

In relation to adaptation, the Government is now required to report on an assessment of the risks for the UK of the current and predicted impact of climate change (referred to as the national climate change risk assessment, CCRA). The first CCRA must go to Parliament no later than November 2011, and subsequent reports no later than five years after each previous report.

The Act also introduces a power for the Secretary of State to direct a reporting authority (public body, such as a local authority, or statutory undertaker, like a utility company) to prepare reports that will explain how the organisation is assessing and acting on the risks and opportunities from a changing climate. Statutory Guidance will help authorities prepare their reports, and a strategy on how the reporting power will be used is out for public consultation during 2009.

The requirement for local authorities to adapt may also be encouraged by the Civil Contingencies Act (2004)[6] which requires statutory bodies to 'assess, plan and advise' on the associated risks of emergencies which include extreme weather events. The Civil Contingencies Act and its associated forums focus on short-term risk mitigation and response rather than proactive long-term planned adaptation. However, many of the risk registers produced under this Act, including both the UK's

[4] UNFCCC (2008b) The Bali Action Plan. [Online at http://unfccc.int/files/meetings/cop_13/application/pdf/cp_bali_action.pdf on 10th December 2008].
[5] Climate Change Act , 2008 [Online at http://www.official-documents.gov.uk/document/cm70/7040/7040.pdf on 10th December 2008].
[6] Civil Contingencies Act (2004) [Online at http://www.opsi.gov.uk/Acts/acts2004/ukpga_20040036_en_1 on 10th December 2008].

National Risk Register and local registers in London[7], feature extreme weather events among the risks that they consider.

3.1.2 Adaptation in London

Alongside work on impacts and adaptation at national level, there has also been considerable progress in understanding the impacts of climate change for England's regions, and how appropriate organisations should respond. For London, a groundbreaking report, published in 2002, evaluated the potential impacts of climate change across the city[1], and some adaptation strategies at local level in London have already been produced, such as by the City of London Corporation[2].

The Mayor's draft Climate Change Adaptation Strategy[2], which was published in August 2008, identifies the key climate change risks for London and Londoners. A revised draft is expected in 2009. The draft Strategy outlines the urgent need for London to begin to make changes in every day life in order to prepare for the threats and benefits that the changing climate may bring. The Strategy acknowledges the need for London to address two main challenges:

- Reduce greenhouse gas emissions to minimise dangerous climate change
- Adapt to the climate change impacts that are already inevitable

London's draft Climate Change Adaptation Strategy introduces moves to address the second of these challenges and provides a framework that:

- "Identifies the main climate impacts likely to affect London
- Establishes the current risk baseline to understand who and what is at risk today
- Analyses how climate change will change the risk of flooding, drought and heat waves through the century
- Uses this analysis to inform a risk-based prioritisation of actions to manage the impacts and to capitalise on any benefits"

The London Climate Change Partnership (the 'Partnership') is a stakeholder group set up and coordinated by the GLA and is comprised of working groups from 30 London organisations. The aim of the Partnership is to assist London in preparing for the impacts of climate change. Set up in 2001, the Partnership works by developing and disseminating information and research and encouraging organisations to work together to embed adaptation to climate change in their decision making.

3.1.3 Local Government National Indicator 188

As part of the new Local Government Performance Framework[8] introduced in March 2008, the Government included a national indicator on preparing to adapt to climate change (NI188). The aim of this indicator is to embed the management of climate

[7] See for example, http://www.london-fire.gov.uk/LocalResilienceForums.asp
[8] The performance framework and full set of indicators is introduced on the Communities and Local Government website at Hhttp://www.communities.gov.uk/localgovernment/performanceframeworkpartnerships/nationalindicators/H, while NI188 is supported by guidance available from the Defra website at Hhttp://www.defra.gov.uk/environment/climatechange/adapt/action/local-authorities.htmH

risks and opportunities across all levels of services, plans and estates. NI188 is outlined in Figure 3.1.

Figure 3.1 National Indicator 188

The Local Government White Paper (October 2006) set out a new performance framework for local government. A single set of 198 national indicators was announced as part of the Comprehensive Spending Review 2007, and these have been reported by all areas from April 2008.

"NI188 – Planning to Adapt to Climate Change" is a process-based indicator that measures progress in assessing the risks and opportunities from climate change.

The aim of the indicator is to ensure local authority preparedness to manage risks to service delivery, the public, local communities, local infrastructure, businesses and the natural environment from a changing climate, and to make the most of new opportunities.

Local authorities report the level of preparedness they have reached against 5 levels of performance:

Level 0 Baseline (Authority has begun the process of assessing)

Level 1 Public commitment and prioritised risk-based assessment

Level 2 Comprehensive risk-based assessment and prioritised action in some areas

Level 3 Comprehensive risk-based assessment and prioritised action in all priority areas

Level 4 Implementation, monitoring and continuous review

The indicator is designed to measure progress in preparedness for climate change, assessing and addressing the risks and opportunities of a changing climate, and incorporating appropriate action into local authority and partners' strategic planning.

Guidance on NI188, provided by Defra, indicates that local authorities will need to assemble their own evidence bases on how they are affected by climate risks, carry out risk assessments and develop prioritised action plans. While there are many different methods and approaches which can help authorities to achieve these ends, one tool that can help to provide evidence of the impacts of weather events in a local area and to raise awareness is the Local Climate Impacts Profile (LCLIP) developed by UKCIP.

3.2 The Value of LCLIP

As tackling climate change has become more of a priority for local authorities over recent years, it has become increasingly important for LAs to identify a suitable response to climate impacts and risks. However it can be difficult for climate change scenario data to be related to the local level. Impacts studies based on the outputs of climate models provide useful information for longer term planning but are able to tell decision-makers little about what the shorter-term consequences at a local scale might be. A Local Climate Impacts Profile (LCLIP) acts as an information resource to aid Local Authorities in forming a better understanding of how their area has been affected by weather over recent years, and therefore how it may be affected by

changes in climate in the future. The merits of the LCLIP process are that it gives responsibility to those who will need to deal with the impacts of climate change; it is flexible, and it can be produced with limited effort. It is based on the principle that climate impacts will primarily be experienced at a local level and hence any suitable response must also be local in character.

The output of the LCLIP provides a platform for local authorities to:

- Identify where the authority is currently vulnerable to weather-related impacts as a means of identifying future vulnerabilities
- Monitor current vulnerabilities to the local weather
- Share the evidence across the authority in an accessible format and so build understanding
- Understand weaknesses in the present responses of the authority
- Identify critical thresholds as a basis for interrogating future climate scenarios

Step-by-step guidance has been produced by UKCIP[9]. The key stages in the development of an LCLIP are:

1. Research journalistic sources
2. Make immediate responses to journalistic information
3. Assemble information about relevant future weather and climate
4. Make historical comparisons (optional)

In addition, the LCLIP guidance suggests that individual councils may prepare their LCLIP in a way that maximizes its use for their local needs. For this study, we modified the LCLIP methodology to apply at the London-wide level: to our knowledge this is the first time that the LCLIP has been produced at a regional scale.

[9] Full details of each stage of an LCLIP are outlined in the booklet available on the UKCIP website, at www.ukcip.org.uk

3.3 Stakeholder organisations in London

London operates under a two-tier system of regional (Greater London Authority, GLA) and local (32 boroughs and the City of London) government. The GLA, with an elected Mayor, is a unique strategic citywide government for London, setting out an overall vision on a range of issues including air quality, development, transport and waste[10]. The Government Office for London represents central government across the capital working closely with the GLA and local boroughs, delivering policies and programmes for eleven central government departments[11].

Figure 3.2 The London Boroughs (Source: London Councils, 2008)

London Councils is a cross-party organisation that represents and works on behalf of all the London authorities, the Metropolitan Police Authority, and the London Fire Brigade. The 33 London authorities deliver day-to-day services for their individual localities and communities. The London Resilience Forum is the first strategic coalition of key agencies, which joined forces in May 2002 to co-ordinate and prepare for potential emergencies across London.

Due to the size of the city, there are many organisations that are pivotal in the functioning of everyday life in London, and their ability to deliver services can be negatively affected by weather events. During the course of this project, the team approached about 20 organisations with responsibility for service delivery across London in order to find out about the impact that weather has had on them (see Appendix 1). The organisations that agreed to participate were Transport for London, Metropolitan police, Red Cross, BAA, London Royal Parks, the Environment Agency, the Strategic Health Authority and London Fire Brigade (see Figure 3.3).

[10] http://www.londoncouncils.gov.uk/londonlocalgovernment/default.htm
[11] http://www.gos.gov.uk/gol/

Figure 3.3 The London-wide organisations interviewed during this project

Transport for London (TfL) is the integrated body responsible planning and delivering the Capital's transport system. Its role is to implement the Mayor's transport strategy for London[12] as part of the Greater London Authority Group.

Metropolitan Police Authority: The Metropolitan Police is the largest police service to operate in greater London and covers an area of 620 square miles and a population of 7.2 million. The organisation employs over 45000 individuals including officers, police staff, traffic wardens, Policy Community Support Officers Provides policing services to the Borough planning officers[13]. The organisation is a member of the London Resilience Forum and multi agency responses for chemical, biological and radiological incidents London-wide.

Red Cross: The Red Cross provides services to 3 broad areas within London: 1) Emergency responses to support 1st and 2nd response services, 2) Community based health sevices such as providing first aid training and enabling communities to be more resilient and 3) Support to refugees and migrants in London.

British Airports Authority (BAA): BAA is a large, complex company and its work touches almost every area of airport life – from day-to-day security and retail to strategy and investment. BAA runs three London airports; Heathrow is the only one that lies within the GLA boundary.

London Royal Parks: Royal Parks is an executive agency of the Department for Culture, Media and Sport and manages the eight Royal Parks in London.

Environment Agency (EA): Public body responsible for protecting and improving the environment in England and Wales. Protecting people from floods - last year the EA increased flood protection to around 30,000 properties by building or improving flood defences. Works with industry to protect the environment and human health - since 1990 have reduced the amount of sulphur dioxide released into the air by 75%

Strategic Health Authority (SHA): In charge of regional buildings and infrastructure for Health Services across London. Implement high-level management of estates for the NHS. The SHA develop and assess capital estates grants and complete assessment and provide approval. They are the "gatekeepers" for the Department of Health for policy and information so we disseminate information out to PCT and NHS.

London Fire and Emergency Planning Authority: The fire service delivers prevention and education to the public for fire incidents and other emergency situations. Protection measures are also provided for the built environment to help ensure that buildings are safe in the event of fire. Emergencies are responded to and resources and people mobilised to emergency events.

[12] http://www.tfl.gov.uk/assets/downloads/corporate/TfL_Factsheet_May_2008.pdf
[13] http://www.met.police.uk/about/

Appendices

Appendix 1:	Methodology and Recommendations for the ongoing project
Appendix 2:	A spreadsheet containing an analysis of the media articles over the period including 145 weather events and their impacts, in tabular form, is also available. Contact the London Climate Change Partnership www.london.gov.uk/lccp.
Appendix 3:	Climate Change Context

Appendix 1 Methodology and Recommendations

Contents

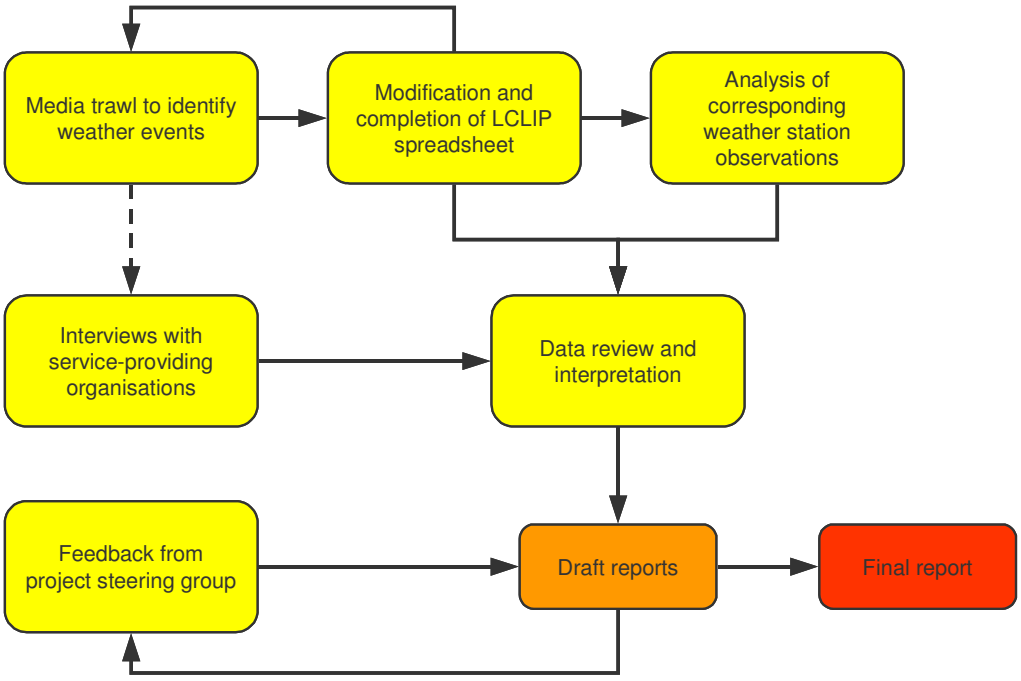
- Approach
- Media Research
- Stakeholder Interviews
- Weather Data
- Recommendations for the ongoing project

Approach

Our approach to this study has focused on the application of the UKCIP LCLIP methodology, revised to reflect the regional nature of this project. The main elements of the approach are indicated in the diagram below. The media trawl researched issues of "The Times", "The Guardian" and "London Evening Standard" during 1998–2008: this research was carried out at the British Library using their electronic newspaper archives.

Weather station observations from official London weather stations were purchased from the Met Office on request, for the dates of weather events reported in the newspaper sources. Interviews with 11 of London's service-providing organisations were carried out, to provide more detail on the way in which weather has affected services over recent years. At all stages, the project team has been in close contact with the customer steering group (comprising the GLA, London Councils and UKCIP). Here we explain the various stages of our approach, including the media research, stakeholder interviews and weather data and outline some lessons learnt and recommendations for the ongoing project.

The approach taken in this study



Media Research

In order to obtain information on observed extreme events from over the last 10 years, 1998 to 2008, the project team utilised the "Newsbank" database available in the British Library, London. The "Newsbank" database allows a search of keywords from a wide range of newspapers within the UK, at national and local level.

Newspaper and Keywords covered

In order to cover a wide range of events within the journal sources, a selection of broad and specific search terms were chosen after a brainstorming session by the project team. A combination of specific and broad terms was used in an effort to capture the maximum amount of relevant stories about the impacts of recent weather events on London.

Table 1 Keywords used for the research of journalistic sources

Keywords used for the research	
Term chosen	Type of word
Heavy Rain	Broad
High Wind	Broad
High Temperature	Broad
Low Temperature	Broad
Snowfall	Broad
Rainfall	Specific
Downpour	Specific
Gale	Specific
Storm	Specific
Lightning	Specific
Heat-wave	Specific

Due to the high number of articles found per key word, this was considered to be a valid number of search terms to consider for this project. The chosen key words covered the wide range of climate impacts, which could have a potential affect on London and offered different degrees of detail when searching for articles.

Pilot study

In order to assess whether the chosen key words would provide appropriate results, a short pilot study was conducted using the Newsbank database to find out whether the types of keywords, number of keywords and search criteria were suitable and how they could be changed to maximise the number of suitable results.

The first step was to find out how many articles would be produced when searching the database and how this search could be amended to provide a suitable data sample. The initial search of our keywords from "The Evening Standard" and "The Guardian" showed that the keywords, when searched through the whole text of the article, returned 669 and 623 results respectively, of which many were articles were not project appropriate. Articles that were considered as 'not relevant' were articles that brought up "London" and a "keyword" but the content of the article did not address an impact due to a weather event. For example "Derby **Storm** dented London Leopard's hopes of retaining their Budweiser League title with an 88-81 victory at the London Arena last night." The research teams did not use these types of articles, as they did not contribute to the aim and purpose of the project.

Changing newspapers

The Sun was initially used as a third newspaper during the search, however, during the pilot study it was identified that this newspaper provided very few relevant articles and it would be

more appropriate to research an alternative source of media articles. After searching 6 keywords in The Sun, only one article was found to be relevant to the project. After consulting with the client, The Times newspaper was decided upon as an alternative to The Sun, providing a greater number of articles about impacts from weather events across London. The change to a different newspaper meant that more information about the impact of weather events on London was picked up during the media trawl and therefore a greater depth of analysis was conducted.

Searching within the first paragraph

When searching the database for the keywords within all the articles, a large number of results were produced. Many of these results were not relevant to the project and so were not used.

In an effort to produce more specific results and narrow down the potential number of articles, a test was conducted to find out where in the articles the keywords appeared and whether there was a relationship between this and the articles relevance.

There were 10 articles (one for each year between 1998 to 2008) analysed, which identified that, when the keyword was found much later in the article, the article tended to not directly address weather impacts and therefore was not relevant to the study. However, for articles that reported the impact of weather events in London, the keyword tended to be found in the first paragraph. An example of the difference in the % of relevant articles and irrelevant articles when searching with these two methods is presented in the Figure 1 below.

Figure 1 - Percentage of relevant climate impact articles found in the Evening Standard when searching for keywords in the whole article and the first paragraph.

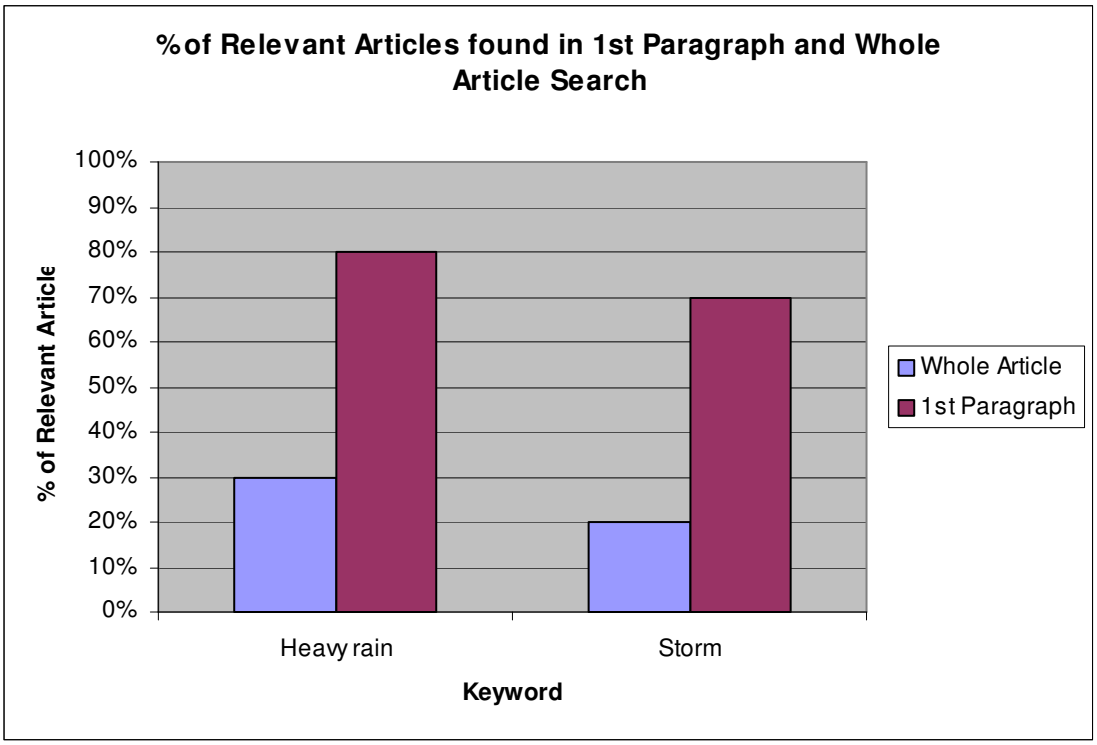


Figure One is an example of how searching keywords within the entire article and the first paragraph was done to determine which method would produce the best results considering the relevance of results and time limits of the project.

Logging the results

In order to manage the results from the media trawl, a spreadsheet was used to log information from each article detailing the significant weather impact events. The core

template for this spreadsheet was obtained from UKCIP and was revised to meet the specific requirements of this project (for example columns were added to add extra detail on location due to the expanse of area covered for the London-wide context of the project). The spreadsheet allowed for details about each article and event to be entered and given a unique code to ensure information was logged and could therefore be analysed as clearly as possible.

All impacts reported in the three newspapers were logged in the spreadsheet, even if there was more than one article written about a certain weather event. Repeated searches for each weather event were undertaken to ensure that all impacts reported in the media were documented. This process was quite time consuming but the process was helped as the database provided search results in chronological order.

Each impact was assigned to the weather event that it related to and so impacts documented in the spreadsheet for a certain weather event could be from a range of different newspaper articles. In hindsight it would have been useful to separate impacts by newspaper article as well as weather event in order to analyse the frequency of reporting for each weather event and weather type.

It was most efficient to search through one newspaper at a time and this has led to the list of weather events and impacts being presented by the newspaper in which they were mentioned. Subsequently, if the same weather event was reported in more than one of the newspapers reviewed, the event and related impacts will be listed more than once in the spreadsheet.

The spreadsheet used in the media research has been revised to enable users to search and sort the information collated from newspaper reports. The user-friendly spreadsheet accompanies this report and details the climate impacts that have affected the delivery of London-wide services over the last ten years. The spreadsheet is divided into 3 parts (A,B and C). Part A displays basic information about the weather incidences reported in the media stories and Part B displays detailed information about the incidences, including impacts and consequences on sectors and individual organisations. Part C displays names of London boroughs that were reported by the media story to have been affected by the impacts. The media stories did not go into sufficient detail when reporting on the location of the impacts so anything that was mentioned related to location is displayed in Part B. The methodology conforms to UKCIP good practice and enables recent climate and weather-related impacts to be sorted by 9 categories including:

1. Total number of media stories recorded
2. Dates of the media stories
3. Dates of incidents
4. Locations reported (London regions, boroughs or specific locations)
5. Weather type (heavy rain, high winds, high temperatures, low temperatures, snowfall, severe dry weather)
6. Weather impacts (pluvial and fluvial flooding, subsidence, landslides, damage, disruption, health and safety)
7. Detail of impacts (costs in £s, staff time lost, resources lost & used to respond to incidents)
8. The sector affected
9. The organisation affected

Systematic numbering has been used to reference detailed information reported in stories. The data contained within the spreadsheet has been protected to allow users to query the master data spreadsheet without accidentally corrupting the data within, an error commonly made when searching and sorting larger spreadsheets.

The UKCIP spreadsheet was reviewed and revised to suit the London-wide context of the project in the best way possible. It was decided that this London-wide LCLIP spreadsheet required additional columns for location, weather impact and responsible unit. Here we explain our choices:

Location

Recognising that the UKCIP LCLIP spreadsheet is intended for use at the local authority level, the project team identified the need to insert a second column for location. This is because at local authority level the contents of cells in the location column are selected from a pre-defined list to identify which parts of a local authority's administrative area were affected by a specific event. In the case of this London-wide project, categorising location by typical regions such as North, South, East and West would be too broad for the overarching aim of the project and so a second list for textual entries on specific locations was added. This also helped mitigate a challenge experienced in the media trawl, when locations of relevant weather events were described in very diverse ways (rarely did one paper quote post-codes or even names of boroughs in every story, for example).

Once the initial media trawl had been completed, time was spent conducting follow-up Internet research on each of the events listed. In light of the wider objectives of the greater London-wide climate impacts project being coordinated by the GLA, London Councils and the Partnership, the team realised the need for London boroughs to be able to search the spreadsheet by borough name. This would give London boroughs a head start in the production of their own LCLIPs through being able to view the weather incidents of relevance to their locality. Wherever possible, the 145 weather incidents recorded have been linked to names of boroughs so that the auto-filter tool on Microsoft Excel can be easily used to bring up all the weather incidents that were reported in the 3 papers over the 10 year period for each London borough.

The second column for location was used to enter as much location-specific information as possible beside each weather incident. At the London-wide scale this has enabled maps to be produced for specific weather incidents to show which regions were affected (e.g. South London), which borough's were affected (e.g. Merton) and also to identify visually the locations of certain infrastructures (e.g. Piccadilly train station) that were specifically mentioned in the media as being disrupted.

Weather types

The London's Warming report, which was published in 2002 to assess the impacts of climate change on London, brought together evidence that London is vulnerable to its changing climate. The weather types chosen for the pre-selected 'weather type' list in the project spreadsheet were based on a review of the London's Warming report and the Mayor's draft Climate Change Adaptation Strategy. A short description of these categories is provided here.

Heavy rain: As a significant proportion of London's built up area is situated on the floodplain of the River Thames and its tributaries, heavy rain can lead to flash-floods from tributaries and the drainage system. Intensive rainfall events in the past (for example the 7th August 2002 when over an inch of rain fell on London in half-an-hour) have seriously disrupted the transport network in London.

High winds: Storms and periods of high winds have cost London millions of pounds. High winds or flying debris can cause damage to a range of infrastructure types such as homes and railway stations, and make travel hazardous. Some households do not have inadequate insurance to cover damage, while the cost to insurers can be in the £ millions.

High temperatures: Heat waves are becoming more frequent in London and the hottest temperatures are experienced according to typical urban heat island temperature profiles, in the centre of the city. High temperatures can result in health problems and are particularly hazardous for people travelling on the underground network.

Low temperatures: Low temperatures can result in hazardous, icy conditions across London requiring constant maintenance, especially for the transport network.

Snowfall: Heavy snow has the power to disrupt and disable services across London. Refuse collections and postal services can be delayed if access is unavailable. The transport network is seriously disrupted during heavy snow.

Severe dry weather: London's aquifers are already over-abstracting. Severe dry weather can lead to water shortages in a city that is already relatively water short.

Sector and organisation

The UKCIP methodology requires the LCLIP team to use a pre-selected list for the columns relating to responsible unit. For this project, we added another column, in order to provide as much detail as possible on the real impacts of weather across London. The organisations chosen for this pre-selected list matched those that were viewed to be of greatest importance to the delivery of important London-wide services and therefore these were also the organisations chosen to approach for participants. At borough-level, the pre-selected list here is likely to consist of the different departments within the authority, and these also are likely to be approached for interview.

London organisations identified in media reports

Sector	Organisations
Transport	Transport for London
	Metronet Rail
	Train operating companies (TOCs) specifically Connex and Virgin Rail, Network Rail
	The AA
	Road maintenance organisations (including Highways Agency)
	Port of London Authority
	Traffic Link
Emergency services	Metropolitan Police
	Marine Support Unit
	London Ambulance Service
	Fire Brigade
	St John's Ambulance
Utilities	Thames Water
	British Gas
	Sutton and East Surrey Water
Recreation and environment	Royal Parks
	Environment Agency
	RSPB
	RSPCA
	Met Office

	Lifeguards
	London Tourism
	London Zoo
Health, social and humanitarian	NHS
	Help the Aged
Government	Local Authorities (including schools)

Weather impacts

To identify which sectors and organisations in London have been most frequently affected by the weather during the time period, categories of impacts were allocated beside each media story and categories of sectors were allocated to each impact.

The impacts categories chosen were decided on based on a review of the London's Warming report and London's draft Adaptation Strategy. Here we provide justification on why each of the following categories was selected:

Categories of impacts used in this study

Pluvial (flash) and Fluvial (river) flooding: As a significant proportion of London's built up area is situated on the floodplain of the River Thames and it's tributaries, and because of the high value of London's assets, the capital is exposed to a greater risk of damage from flooding than any other urban area in the UK.

Subsidence: In summer and autumn soils can dry out with high temperatures causing damage to buildings and construction sites. Increased ground movement resulting from alternative wetting of clays in winter and drying in summer has the potential to damage underground pipes and cables.

Landslides: Following intense rainfall events, flooding can lead to landslides, the impact of which can be catastrophic depending on infrastructure affected.

Damage (transport & related infrastructure): London's underground network is already a health risk in high temperatures. Transport operators also hold responsibility for ensuring roads are gritted in icy conditions and safe and accessible during other extreme weather events such as floods.

Damage (buildings): Buildings can be damaged by flying debris during high winds and storms, flood water, low and high temperatures as well as subsidence problems affecting water and gas pipes, telecommunications cables etc.

Damage (other): The above weather types can cause damage to a range of London's assets, not only buildings, in many different ways. It is important to enable all types of damage to be documented.

Drought: Londoners use (per capita) approximately 5 litres more water per day than what is the average per capita use for England. Available water resources per head in London are far lower than in many other capital cities and projected climate impacts are likely to disrupt water quality and quantity in London in the future.

Disruption (travel): The ability to travel around London is essential for the functioning of London and business continuity. A large proportion of Londoners rely on public transport to get to work. If employees do not turn up at work, it can lead to a range of knock on effects (e.g. school closures, shortage of staff in hospitals and transport centres).

Disruption (other): The above weather types can cause disruption to a range of London's residents and service delivery organisations in many different ways. It is important to enable all types of disruption to be documented.

Health and safety: Heat stress due to high temperatures can lead to morbidity and mortality. Extreme low temperatures can also cause health problems particularly in the elderly and vulnerable groups. Transport safety is of high importance for Londoners due to large population densities and high reliance on public transport. The closure of schools as a result of unsafe conditions for children (e.g. slippery playgrounds or cold class-rooms) can have a vast London-wide impact, as employees cannot attend work due to child-care commitments.

Stakeholder interviews

Organisations approached

Contact details were obtained from the customer via an introductory email from the customer to the participant. Information was sent to the participant giving an overview of the project and then key dates of weather events uncovered during the first stage of the project, the media trawl, were sorted and sent according to the organisation the participant was representing. Individuals from TFL, Metropolitan police, Red Cross, BAA, London Royal Parks, Environment Agency, Strategic Health Authority and London Fire Brigade took part in a mixture of face to face and telephone structured interviews in which they were asked 11

questions to gather information on how severe weather events had impacted their organisation. We would like to thank all the people that gave their time to the interviews.

Not all the key organisations identified by the project team as being important to the delivery of London-wide services were available to participate in the project. Here are listed the organisations that agreed to participate in the project.

Transport for London (TfL) is the integrated body responsible planning and delivering the Capital's transport system. Its role is to implement the Mayor's transport strategy for London[1] as part of the Greater London Authority Group.

Metropolitan Police Authority: The Metropolitan Police Services is the largest police service to operate in greater London and covers an area of 620 square miles and a population of 7.2million. The organisation employs over 45000 individuals including officers, police staff, traffic wardens, Policy Community Support Officers Provides policing services to the Borough planning officers[2]. The organisation is a member of the London Resilience Forum and multi agency responses for chemical, biological and radiological incidents London-wide.

Red Cross: The Red Cross provides services to 3 broad areas within London: 1) Emergency responses to support 1st and 2nd response services, 2) Community based health sevices such as providing first aid training and enabling communities to be more resilient and 3) Support to refugees and migrants in London.

British Airports Authority (BAA): BAA is a large, complex company and its work touches almost every area of airport life – from day-to-day security and retail to strategy and investment. BAA runs three London airports; Heathrow is the only one that lies within the GLA boundary.

London Royal Parks: Royal Parks is an executive agency of the Department for Culture, Media and Sport and manages the eight Royal Parks in London.

Environment Agency (EA): Public body responsible for protecting and improving the environment in England and Wales. Protecting people from floods - last year the EA increased flood protection to around 30,000 properties by building or improving flood defences. Works with industry to protect the environment and human health - since 1990 have reduced the amount of sulphur dioxide released into the air by 75%

Strategic Health Authority (SHA): In charge of regional buildings and infrastructure for Health Services across London. Implement high-level management of estates for the NHS. The SHA develop and assess capital estates grants and complete assessment and provide approval. They are the "gatekeepers" for the Department of Health for policy and information so we disseminate information out to PCT and NHS.

London Fire and Emergency Planning Authority: The fire service delivers prevention and education to the public for fire incidents and other emergency situations. Protection measures are also provided for the built environment to help ensure that buildings are safe in the event of fire. Emergencies are responded to and resources and people mobilised to emergency events.

Interview questions

Each set of interview questions were amended to suit the context of each interview. The standard set of questions that were used for the interviews is displayed here.

	Questions for Interviewees
01	Please can you outline what services you provide and background to your organisation?

[1] http://www.tfl.gov.uk/assets/downloads/corporate/TfL_Factsheet_May_2008.pdf
[2] http://www.met.police.uk/about/

02	In the last 10 years can you cast your mind back to any weather events that affected your work? What was the event? Can you remember when the event occurred and any details eg dates? Type of weather event?
03	How did this affect your work? Did you have plans in place to cope with the event?
04	How were the services you deliver affected due to the event?
05	Did it affect your workforce?
06	Did it affect the finances in your organisation for example number of days lost due to staff absence? If so can you place a value (to the nearest £k) on this financial impact?
07	Were any of the consequences reputation damaging to you organisation?
08	Can you categorise any impacts felt due to issues with; Transport? Health? Water supply? Planning? Tourism?
09	Do you feel that you are well prepared for future extreme weather events? What do you have in place to be prepared?
10	What do you not have in place which you feel you need?
11	What would aid you in being prepared for an extreme weather event in the future?

Weather data

Weather data obtained from the Met Office has been used to cross-check the findings of the media trawl. Analysis of the weather data has flagged up possible inconsistencies in what was reported and what actually happened.

The scope of weather data used in this report was limited to what was available from the Met Office: For each of the five weather stations across London – London Weather Centre, Heathrow, Northolt, St James's Park and Kenley Airfield (south of London), daily maximum and minimum temperatures and precipitation (mm) data has been obtained for the period 1998 to 2009. There were some limitations on the availability of weather data:

- Relative humidity levels (%) are available only for the London Weather Centre and for the period 1999 to 2008.
- Wind data (knots) is available only for Northolt, Kenley Airfield and Heathrow for the period 1999 to 2008.
- Snowfall is recorded only at Heathrow. It is likely that the lack of data for snowfall could affect analysis of weather events and their impacts. For this reason, conclusions can only be drawn where snowfall events near Heathrow are identified –

in all other cases, it is possible only to make informed assertions about the extent to which the weather impacts have been exaggerated by the media.

Lessons learnt in applying LCLIP method

The table below displays the main challenges experienced during the London-wide LCLIP project, a description of measures taken to overcome the challenges and a rating of success of the measure taken.

Challenges experienced	**Measures taken**	**Success of measure taken (H,M,L)**
Inaccuracy of data collected from the media trawl	Data is collected to support the information recorded from the media trawl Results from the media trawl were verified not only through conducting interviews, but also through cross-referencing the results from the media with daily weather data recorded at weather stations across London by the Met Office	M
Choice of newspaper	Search exercise piloted, newspaper choice revised.	H
Data collection from interviewees	Highlighting dates of interest to interviewees prior to interview Sending back interview transcripts with highlighted dates of interest for more detail Attempts to ask interviewees to use maps to indicate where impacts were felt - this was a move which came after most of the interviews had been conducted and as a result of the short time-scale available interviewees were not well placed to contribute to this exercise. Regular communication, email contact from senior figures Emphasising importance of engagement and wider benefits of participation	M M L H H
Short time-scale and timing of this project	Constant chasing of participants to engage	M

Recommendations for the ongoing project

This report and data collected could be used in later stages of the overall project. Not only does it provide information as a stand-alone report on weather events in London and their impacts on a selection of sectors and organisations, but it provides an example and information source for London boroughs in compiling their own LCLIPs, as is necessary for Stage 3 of the overall project.

The case studies and depth of factual information presented in the report will aid the management of the overall LCLIP project in efforts to raise awareness about weather and climate risks. The headline messages from this project could be used to highlight to London

Boroughs and other stakeholders, the benefits of participation in the subsequent stages of the London LCLIP project.

Also, the information provided on how weather affects the delivery of services for selected organisations may help authorities to understand how organisations that operate within their locality are vulnerable to the weather. Until now, these vulnerabilities may not have been immediately apparent to London boroughs.

London Boroughs may wish to use the information provided in this report, and in the accompanying spreadsheet to help prioritise which areas within their localities are likely to require attention.

The methodology employed in this study is not directly replicable for individual London Boroughs, who should follow, first and foremost, the official guidance provided by UKCIP for producing LCLIPs. However, we would encourage London Boroughs as a first stop to consider the weather events identified in the spreadsheet that accompanies this report and check whether they were affected. Those events and the impacts covered in this report may provide them with an initial feel for the kinds of issues they may be dealing with, though of course this report does not mention all of the weather events that may be locally relevant to each London Borough. In particular and in future stages of the London-wide LCLIP project, London Boroughs could produce similar maps to those contained in this report (case studies) in order to show how key weather events have affected parts of, and features within, boroughs.

The project team responsible for producing this London-wide climate impacts profile expected the need to overcome certain hurdles, as this is the first time that the UKCIP LCLIP methodology has been used at the regional level. In discussions with local authority contacts however, it would seem that the difficulties experienced at the London-wide scale are also quite typical of those experienced at the local scale; UKCIP published a summary report of ongoing case studies in 2008 within which local authorities reported challenges relating to timescale (Aylesbury Vale District Council), delays contacting relevant personnel (Worcestershire County Council, Aylesbury Vale District Council), patchy records of past weather events and their impacts (Oxfordshire County Council, Aylesbury Vale District Council)[3]. When London boroughs come to produce LCLIPs for their locality they may want to expect similar challenges, particularly with regards to data collection and follow the most recent guidance provided by UKCIP to address these.

In the longer term, it is recommended that macros are used in the spreadsheet to create a user-friendlier query interface. The master data worksheet would be hidden, and the user would see a query sheet with several embedded drop-down box, text box, and list box controls (e.g. Weather Type, Date Range, Borough, Impact and custom boxes to allow simple filters to be applied to selected columns). This would give an immediate indication of the filter values applied, and one place to set/ reset them. One change of any filter setting would result in the relevant 'passing' rows being copied from the hidden master sheet to the Query sheet. The user could then sort as desired without corrupting the master data set.

An overview of the main recommendations for London boroughs that are preparing to complete their own LCLIP following the completion of this London-wide LCLIP is provided here. Importantly, London boroughs must focus on:

- Careful consideration of time-scales chosen to conduct the research
- Early engagement of participating organisations/ departments through clearly highlighting the benefits of participation
- A two-ended approach to the research whereby weather events are identified in the media and followed up with participants and weather impacts are identified by participants and followed up with data from the media search and weather data
- A focus on approaching service areas where records are known to exist

Time-scales

[3] UKCIP (2008). A local climate impacts profile: Summary report of ongoing case studies. www.ukcip.org.uk

Future stages of the London LCLIP project will be facilitated if the Parternship, London Councils and the GLA check that the planned time-scale of the London borough stage of the project is of ample length and takes place during quieter periods. The research carried out for the London-wide climate impacts profile stage of the project was scheduled to take place during the last two months of the financial year (February and March 2009). As a result of ambitious targets during this time of year, the project team experienced severe difficulties in collecting data, as participants simply did not have the time to source the data.

A period of several months may be required for London boroughs to collect the data in sufficient detail required for production of an LCLIP. Several participants in this London-wide project suggested that they would require up to five months to collect the requested data. Over-estimating the amount of time required to collect the data and selecting an appropriate time-scale to conduct the research will also enable participants to provide the maximum level of detail when conducting the interviews and in the follow-up collection of data.

Early engagement of participating organisations/ departments and ensuring benefits of participation are clearly communicated to participants

Making it clear how the participating departments or organisations will benefit from the findings of the project at an early stage is essential in order to achieve adequate engagement in the project. This is important as participants will be required to invest time into the project to find out if and where relevant data is held, and to follow organisational procedures in order to obtain this data from the relevant contacts. This can be a long and drawn-out process, especially when this type of data can be commercially sensitive. Asking participating departments to start collecting available data that has been recorded in the past, which monitors the delivery of services of the organisation, immediately after the initiation of the project is also likely to help secure relevant information. If relevant data is not usually recorded, departments can begin taking notes of any current weather incidents that are affecting the delivery of every day services – more data is always better than not enough!

A two-ended approach

The spreadsheet recommended to be used for London boroughs to complete their LCLIPs is available on the UKCIP website www.ukcip.org.uk. This spreadsheet provides columns for researchers to identify which organisation or department is responsible for dealing with the impacts associated with each weather event recorded.

It is recommended that, at the earliest opportunity, the researchers sort the initial results of the media trawl into weather events that impacted each responsible organisation or department. These key events should be sent to the relevant departments at an early stage in order for participants to have a sufficient amount of time to look into the incidents specifically affecting them ahead of the interview.

While the time-scale of this London-wide climate impacts profile restricted the ability for participants to provide information through drawing the impacts of identified weather events on a map, there is a possibility that this could work to identify locations of impacts when London boroughs come to produce their own LCLIPs. Not only could this allow for participants to provide more detail on where impacts reported in the media occurred, but it could also enable participants to visualise their locality and suggest weather events that may have disrupted the delivery of services for which they are responsible. This can highlight weather impacts that were not necessarily reported in the media at the time. Furthermore, maps can easily be digitalised at a later date and collated to produce a London-wide picture of current climate impacts. It is not known whether using maps in this way would work, but this methodology could certainly be tested in the future.

New record keeping

The production of this London-wide climate impacts profile has identified how weather in the past has affected London-wide organisations and brought to light the fact that record-keeping on major impacts of weather on service delivery is not currently a substantial characteristic of

London-wide organisations. This project emphasises the importance to start new record keeping so that the impacts of major weather events can be assessed accurately and plans to mitigate risks can be developed. As records are increasingly kept up to date, future efforts to assess and plan for the risks associated with climate change across London will be facilitated. There is little harm for those in the process of producing local level LCLIPs to consider reviewing procedures that are currently in place to monitor more general issues affecting the delivery of services while records are brought up to date because any impacts relating to weather are likely to have been recorded here.

Appendix 2

A spreadsheet contining an analysis of the media articles over the period including 145 weather events and their impacts, in tabular form, is also available. Contact the London Climate Change Partnership
www.london.gov.uk/lcc

Appendix 3 Climate change context

Contents

- London's current climate
- Expected climate impacts

London's current climate

Weather data for several variables has been obtained from the Met Office to check that the reporting of weather disruptions to services by organisations and the media is accurate. For reference, this section provides an overview of London's current climate, while Appendix 2 displays more detail on current weather patterns and trends for London.

London has a temperate marine climate. The mean annual temperature is about 11°C and London normally receives less than 650 mm of rain annually. This places London in one of the driest parts of the UK (with the driest being parts of Eastern England with annual rainfall totals of 500 mm and the wettest being the western Scottish Highland with over 4000 mm annually).

Monthly and annual weather averages for London are displayed in the table below[5]. Here, data on maximum temperature (°C), minimum temperature (°C), days of air frost, hours of sunshine and rainfall (mm) show how weather changes throughout the year.

Climate averages for London[1]

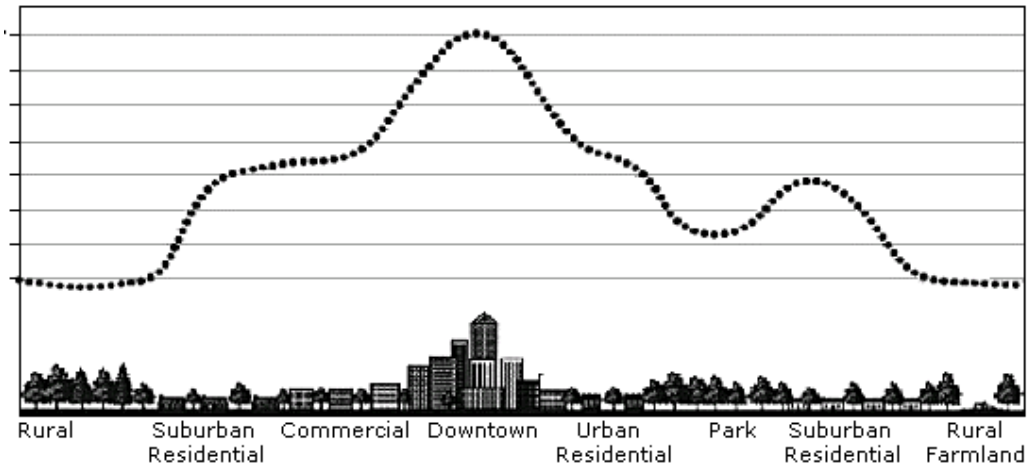
Seasonal averages for Greenwich, London (based on 1971–2000 averages)						
	Max Temp (°C)	Min temp (°C)	Days of Air Frost (days)	Sunshine (hours)	Rainfall (mm)	Days of Rainfall >=1mm (days)
Annual	**14.8**	**7.2**	**29.1**	**1461.0**	**583.6**	**106.5**
January	7.9	2.4	7.4	45.9	51.9	10.9
February	8.2	2.2	7.4	66.1	34.0	8.1
March	10.9	3.8	2.9	103.2	42.0	9.8
April	13.3	5.2	1.1	147.0	45.2	9.3
May	17.2	8.0	0.1	185.4	47.2	8.5
June	20.2	11.1	0.0	180.6	53.0	8.4
July	22.8	13.6	0.0	190.3	38.3	7.0
August	22.6	13.3	0.0	194.4	47.3	7.2
September	19.3	10.9	0.0	139.2	56.9	8.7
October	15.2	8.0	0.3	109.7	61.5	9.3
November	10.9	4.8	3.0	60.6	52.3	9.3
December	8.8	3.3	6.9	37.8	54.0	10.1

London experiences the urban heat island effect and as a result snowfall in the city is less common than the rest of Britain due to the higher temperatures that occur. In winter months, London is also

[1] Obtained from the Met Office

usually up to 5°C warmer than the rest of Britain, with central London experiencing higher temperatures than the rest of London as illustrated by the temperature profile below.

A temperature profile typical of an urban heat island (GLA, 2006)[2]



Extreme weather events have disrupted London and the southeast in the past. The Met Office has produced case studies of the following three extreme weather events:

- Severe fog and smog disabled London for several days during the Great Fog in 1952[3]
- In 1953 the greatest storm surge on record for the North Sea resulted in the collapse of 100 metres of sea wall in London's East End leading to the flooding of over 1,000 homes due to 640,000 cubic metres of water from the river Thames flowing into the streets of West Ham. The local economy was also seriously affected as industry was brought to a standstill when the surge travelled to London's docklands, electricity generating stations, oil refineries, factories and cement works[3].
- Summer heat wave of 2003. The summer heat wave of 2003 was 3.4 deg. C above average summer temperatures[4]. Record temperatures were recorded at several London weather stations. Central London experienced the highest levels of heat related discomfort, due to the affect of the urban heat island. NASA has produced a temperature profile of London during the heat wave, which clearly shows the temperature variations experienced from central London to the outskirts (more detail is available in the London draft Climate Change Adaptation Strategy).

[2] GLA (2006). London's urban heat island: A summary for decision makers. http://www.london.gov.uk/mayor/environment/climate-change/docs/UHI_summary_report.pdf
[3] Met Office. The UK east coast floods of 1953 http://www.metoffice.gov.uk/corporate/pressoffice/anniversary/floods1953.html
[4] GLA (2008). London draft Climate Change Adaptation Strategy

Expected climate impacts

The climate of London is already changing. Climate scenarios developed by UKCIP suggest that by the 2050s the type of temperatures experienced during the summer 2003 heat wave are likely to be typical of the average summer. Furthermore, the impact of London's urban heat island effect is likely to intensify due to climate change (and also by increasing population density, anthropogenic contributions and drier summers). These recent UKCIP climate scenarios show levels of likely climate change and the London's Warming report demonstrates the likely impacts of climate change. As demonstrated by the Climate Change Adaptation Strategy, such impacts pose different levels of risk and adaptive capacity for areas and groups across London.

It is expected that changes to annual and seasonal temperature and rainfall averages will be accompanied by an increase in the frequency and intensity of extreme weather events such as heat waves, tidal surges, windstorms and heavy rainfall events. As demonstrated by the comparison drawn between the 2003 heat wave and UKCIP projections, changes to the average climate will mean that in the long term what is considered 'extreme' weather today may become the 'average' weather of tomorrow, with a new and greater intensity defining 'extreme' weather[2]. The table here provides an overview of the projected changes to London's climate in the future[6].

An overview of projected changes to London's weather (Met Office

Expected changes to London's climate as time progresses		
Climate variable	Summers	Winters
Temperature	• Warmer - 1.5 to 3.5ºC hotter by the 2050s and as much as 5ºC hotter by the 2080s • Daily maximum temperatures of 33ºC, which currently occur about one day per summer in the south-east, could occur 10 days per summer by the 2080s	• Warmer - 1 to 2ºC warmer by the 2050s and by up to 3.5ºC by the 2080s.
Rainfall	• Drier - by 20 to 40% in the 2050s and may be 50% drier by the 2080s	• Wetter - by between 10 to 20% by the 2050s and up to 30% by the 2080s • Heavy winter rainfall could occur twice as frequently by the 2080s
Extreme weather	• Increased frequency of 'very hot' days • Summer soil moisture may reduce	• The number of storms each winter crossing the UK could increase from five (the 1961-90 average) to eight by the 2080s.

	by 50% or more by the 2080s	• Snowfall amounts will decrease by between 50 to 100%.
Urban heat island effect	• Currently adds up to 5 to 6ºC to summer night temperatures, will intensify in the future.	
Wind & Cloud cover	• Summer cloud cover may decrease by as much as 18% by the 2080s	• Mean winter wind speeds may increase by as much as 10% by the 2080s.
Sea levels	• Relative sea level in the Thames Estuary will continue to rise by between 26 and 86cm by the 2080s and will rise further in the future. • Current extreme sea levels will be experienced more frequently.	

The London draft Climate Change Adaptation Strategy finds that the main three impacts for London likely to result from projected climate changes are increasing risk of heat waves, floods and droughts. The table below gives further details of how these climate impacts are likely to change in the future.

The three main climate changes likely to affect London, according to London's draft Climate Change Adaptation Strategy[5]

Climate impact	Expected change in the future
Heat waves	**Increasing risk:** As summer temperatures become hotter, the intensity of heat waves increase and London's urban heat island influences nighttime temperatures, the risk of heat waves is likely to increase. Increased temperatures reduce the comfort of occupants in domestic, commercial and public buildings and the productivity of business can be significantly affected as a result. Increased temperatures could increase the risk of fires and water scarcities could put pressure on London's infrastructure. Subsidence could worsen as clay soils dry out in summer and autumn.
Floods	**Increasing risk:** Increases in average winter rainfall and extreme rainfall events during more frequent and severe winter storms as well as the threat of sea level rise, could lead to more intense and frequent floods across London. The threat of flooding in London comes from five sources: the sea (tidal flooding); the Thames and its tributaries (fluvial flooding); from heavy rainfall overcoming the drainage system (surface water flooding); from the sewers and from rising groundwater. It is estimated that nearly 15 per cent of London lies at risk from tidal and fluvial flooding[4]. The areas surrounding the Thames are particularly vulnerable. See Appendix 2 to see the extent of the area of London that would be flooded by an extreme flood if there were no flood defences[4].
Droughts	**Increasing risk:** Summer rainfall is likely to decrease and higher temperatures are likely to increase the rate of evaporation leading to increased public water demand. Over-abstraction is already happening at the London aquifer and catchments.

[5] GLA (2008). London draft Climate Change Adaptation Strategy

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Supporting organisations

www.ukcip.org.uk/

www.londoncouncils.gov.uk