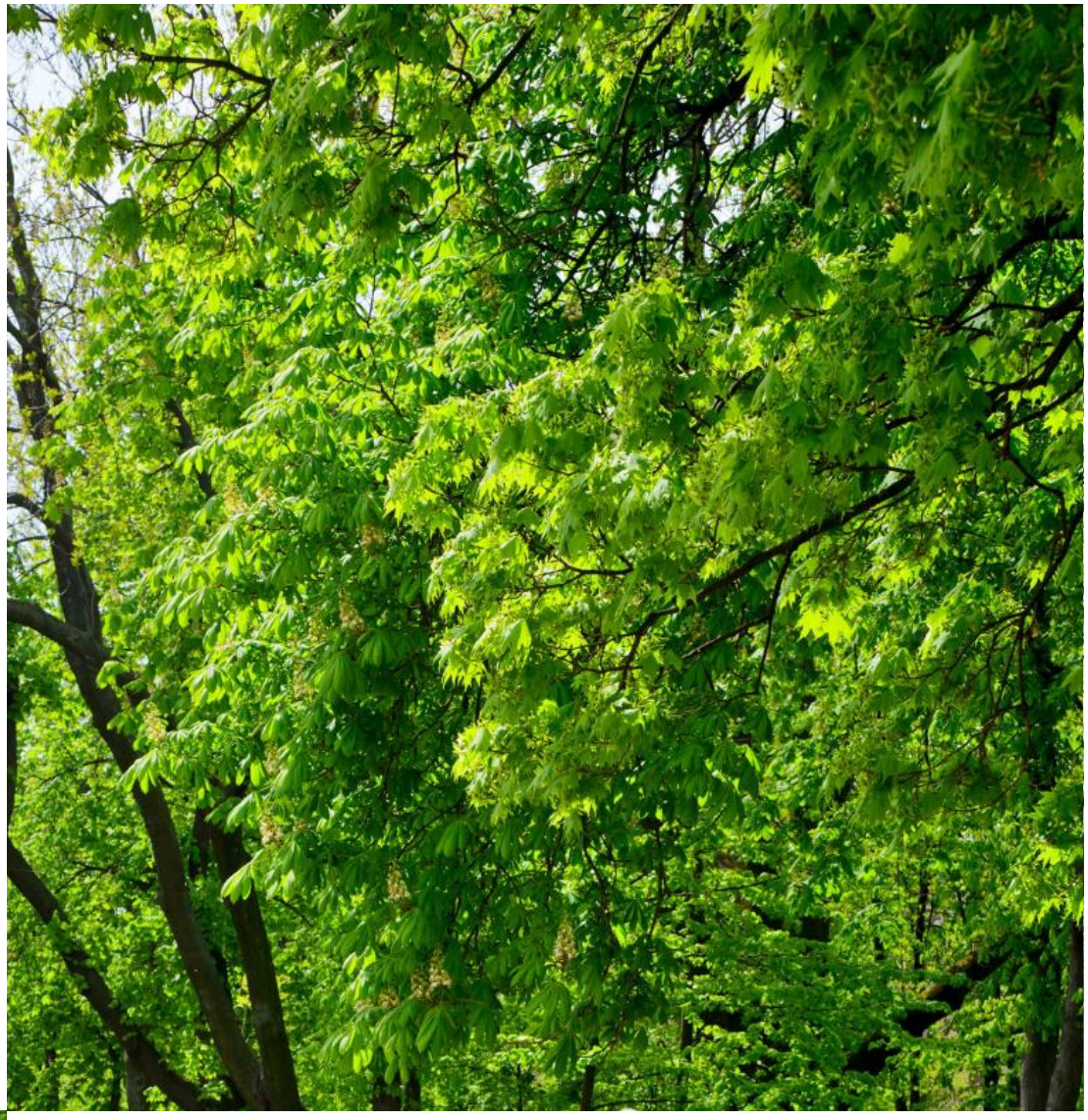
MOTT MACDONALD



Reading Climate Change Adaptation Plan

19 December 2019

Mott MacDonald
One Valpy
20 Valpy Street
Reading RG1 1AR
United Kingdom

T +44 (0)118 902 7800
mottmac.com

Reading Climate Change Partnership
https://readingcan.org.uk

Reading Climate Change Adaptation Plan

19 December 2019

Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
Final report	19/12/19	L Horrocks, N Kent, F Bruni Roccia	J Allen	S Price	Issue 1

Document reference: 408644 | 1 | A

Information class: Standard

Contents

Foreword

It is a more than interesting time to be writing this foreword to our first Reading Climate Change Adaptation Plan. Climate change has been a regular news item over the last couple of years. This week the World Meteorological Organisation reports that greenhouse gases have hit a new record high, with carbon dioxide at levels higher than we have experienced in the whole of human history[1]. This is serious. It is a genie that is not going back into the bottle. Global temperatures are rising, and they are rising for us here in Reading. Driven by this increase in energy in the atmosphere, we are seeing an increase in the frequency and magnitude of extreme weather events - events that have the potential to affect our lives and our livelihoods.

I have had the honour of Chairing the Reading Climate Change Partnership (RCCP) since April 2018. Creating an Adaptation Plan for Reading was the top priority that I set into my vision for the Partnership. I know that making sure we get ready to face the impacts of Climate Change is vital. And we need to be ambitious here. As I have said in talks many times: we must make sure that this town is not just a safe place - in the face of these coming decades of climate change - but it needs to be a good place! It needs to be a good place to live, to work and to raise a family. And I feel that even more acutely as a recent father, as I look out with concerned eyes for my son's future.

I would like to express my deep gratitude to Lisa Horrocks and Nikki Kent, from Mott MacDonald, for writing this plan for us. I am particularly grateful for their patience and openness as I have been quite pressing with some of my demands. We had a limited budget, but this does feel like the right scale of work for our first Adaptation Plan, and I am really pleased with the result.

I wanted a plan that is focused on Reading, rather than just something with generic adaptation messages. I also wanted something accessible and understandable so people can learn about what some of the biggest risks we face are and how we can respond to them. This is an introduction and a start to an adaptation planning journey for Reading. For those readers who have knowledge and expertise in adaptation, this may seem simplistic but please note the importance of 'bringing everyone into the room' on this. We need all people (voters), businesses, planners and decision makers to understand the importance of considering climate change and extreme weather in their thinking.

This Plan is a first plan. There are useful 'low-regrets' and 'win-win' actions which we can all pick up on. There are also important considerations about how we should manage adaptation planning in Reading. We will certainly need a second, then a third plan as we move forward into an evolving process of understanding what changes we need to make, and by when. Through this we can help shape the Vision for Reading in 2050, which will be an important adaptation milestone.

There is a deeper consideration behind this as well: understanding the challenges of adaption, you will realise that the scale (and cost) of changes that we need to make are very dependent on the how much the climate is due to heat up…this of course is very much down to the choices we make on how quickly we reduce our demand for burning coal, oil and gas. As I write this, I am very proud to note the Zero Carbon 2030 Climate Emergency that Reading has declared.

[1] Equivalent CO2 levels were last this high 3-5 million years ago, long before the evolution of modern humans. https://public.wmo.int/en/media/press-release/greenhouse-gas-concentrations-atmosphere-reach-yet-another-high and https://www.un.org/en/sections/issues-depth/climate-change/index.html

Meeting that 10-year, zero-carbon target is challenging. But this is small compared to the costs and the risks of allowing greater levels of climate change so I hope we will all see the urgency in bringing our emissions quickly under control.

Our environment has shaped the development of the town. Reading is in one of the warmest and most water-stressed parts of the country. As a hydrologist and a climate specialist I have always been impressed by our ability to supply water freely, and the infrastructure it takes to make this happen. We can build on this. Climate change and growth will put extra pressure on the fabric of the town but these are challenges that we can certainly rise to. Some of the solutions will demand changes to our behaviour. Other solutions will alter the appearance of the town.

There is a positive vision to create here though. The thought of Reading with more trees and green space to help cool our children is inspiring; as is the thought of less traffic and less air pollution, as we move towards a more sustainable model for transport. We are going to need to protect ourselves from more intense storms and bigger river floods. We also need to be ready to make positive choices about the retrofitting of our homes and reducing our demands on the finite resources that we have available. Embracing this vision, we will create a healthier town for all of us.

Finally, I would like to offer my thanks to my partners on the RCCP for supporting me and for agreeing to fund this work. I would also like to thank the Environment Agency Kings Meadow House management team for adding a valuable financial contribution to help us get this started. And I want to thank you for reading this. The climate is demanding we change: we can make this a positive thing, and together we can make sure we get Reading ready to face the future.

Wishing us all the very best,

Chris Beales

RCCP Chair

29 November 2019

Executive Summary

The climate in Reading is changing. The five warmest summers recorded in Reading all occurred since 1976, while the five coldest summers occurred before 1955. Weather events such as heavy rain and flooding, storms, heatwaves and drought, already have a significant impact on people, businesses and the environment in and around Reading.

The latest projections of climate change in the UK show that Reading is likely to experience milder, wetter winters and hotter, drier summers along with an increase in the frequency and intensity of extremes, during the 21st century. Hot summers are expected to become more common, and variability in rainfall is increasing. Reading will need to be resilient to a wider range of conditions than it has been in the past, and the projected changes will lead to different impacts on sectors and places in the town.

Impacts

Many people will experience climate change through its effects on water. Water resources across the Thames Valley are already stressed, and the population is increasing. The impacts of climate change may exacerbate this situation. Climate change will increase the risk of flash flooding in urban areas, in response to increasing rainfall intensity.

Rising temperatures (during both day and night time), and increased solar gain, may cause overheating in buildings, particularly during heat wave events, impacting energy performance and internal comfort. Climate change will have an impact on the design, construction, management and use of our buildings and surroundings. The health and social care sector is particularly susceptible to the impacts of flooding and heatwaves. The health burden of hot weather is likely to be amplified by the ageing population.

Extreme events can cause severe damage to transport networks: as well as being costly to recover, the loss of transport services can affect people's health and wellbeing, and local economic activity. Flooding, extreme weather, and heatwaves affect business and commercial activities, production and consumption, through a wide range of impacts on different business functions. Through international supply chains, distribution networks and global markets, local businesses can be exposed to the risks of extreme weather around the world. Climate-related disruption to business operations will depend, in part, on the resilience of local infrastructure

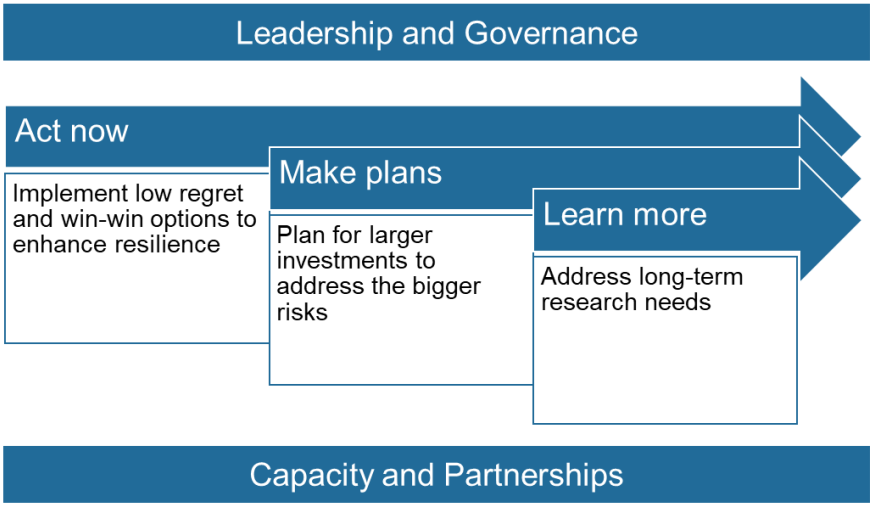
Rising average temperatures, and changes in seasonality, including the earlier onset of spring, can affect the timing of life-cycle events in the natural environment. Increased variability in precipitation, with increased intensity and prolonged dry periods will impact on the availability (and management), quality and quantity of water for biodiversity.

Adaptation

Many Reading-based organisations are already preparing for the impacts of climate change. Case studies with The Oracle, Berkshire Healthcare NHS Foundation Trust, and the University of Reading, show that these organisations already have a good understanding of climate change, and that some adaptation is already underway. The focus in adaptation so far has been on building awareness and undertaking short-term actions which offer additional benefits.

Reading's approach to adaptation is summarised in the figure. A combination of low-cost early action to generate immediate benefits with longer-term planning and research to support larger

investments are underpinned by working in partnership and growing awareness and understanding of climate risks across the town.



This first Reading Adaptation Plan is not a detailed action plan. It indicates headline climate impacts for Reading by the end of the century, describing the big picture risks alongside the opportunities for the town to adapt. It sets out key steps for consideration in each category of adaptation and recommends the following areas of work to advance the development of Reading's Adaptation Plan:

- To establish clear governance and implementation arrangements for the plan, including responsibility and ownership for actions, and monitoring of progress. It may be possible to learn from the structures and arrangements, including the high-level sponsorship, that other towns have set up.
- To identify the most relevant communication tools and channels to support the partnership and capacity-building aspects of the plan, and to foster interest and wider buy-in. Artistic impressions, video presentations and the engagement channels used by related initiatives (such as Reading 2050) may be relevant.
- To identify the higher risk spots in the town. Digital mapping of vulnerability data representing individuals, communities, critical systems and future plans would enable targeted effort, and a baseline against which to compare climate information.
- To produce accessible forms of Reading-specific climate change scenario information, based on the UK Climate Projections (UKCP18). This should enable scenario-based analysis by businesses and public sector and provide a common understanding of the range of climate futures that Reading might encounter.
- To coordinate deep-dive case studies for organisations or sites within the town, exploring both climate risks and short- and long-term adaptation actions, and to facilitate sharing of insights and collaborative working on overlapping challenges and solutions.

1 Introduction

The Reading Climate Change Partnership (RCCP) is leading the development of a coordinated plan to adapt to the impacts of climate change. This report is the first adaptation plan for Reading, bringing into one place information to help organisations in the town work together to address climate risks.

1.1 Reading's first climate change adaptation plan

Reading's climate change strategy, "Reading Means Business on Climate Change" was reviewed in 2018 and the 3rd Reading Climate Change Strategy (2020-2025) was launched for consultation in June 2019. To date, Reading has focused mainly on mitigation, with adaptation covered in only a limited way in the climate change strategy (Appendix A), and so this report has been compiled to underline the case for adaptation. This report sits alongside the climate change strategy, and adaptation has also featured as a cross-cutting theme for consideration by the sector groups responsible for developing the climate change strategy.

This first adaptation plan is for the town of Reading. It identifies impacts and opportunities that may be relevant to many businesses or organisations operating here. It does not lay out a detailed action plan for any single organisation. The target audience is RCCP partners and other organisations, including Reading Borough Council, which need to adapt assets and services to the changing climate. The expectation is that future iterations of Reading's adaptation plan will add greater detail and specificity around roles, responsibilities and actions.

Reading Climate Change Partnership

The Reading Climate Change Partnership (RCCP) was formed in 2009 as a sub-group of Reading 2020, the Local Strategic Partnership. The RCCP Board has representatives from the business, public, community and voluntary sectors. This currently includes Environment Agency, University of Reading, Greater Reading Environmental Network (GREN), Connect Reading, Bottomline Technologies, The Oracle, Berkshire Healthcare NHS Foundation Trust and Reading Borough Council.

https://readingcan.org.uk/reading-climate-action-network/about-rccp

1.2 Why adapt?

There are many reasons why it makes sense for Reading to take bold action to adapt to climate change.

Adaptation to climate change

Adaptation is the process of adjustment to the actual or expected climate and climate hazards, seeking to reduce the negative impacts or exploit beneficial opportunities. Adaptation covers all the ongoing activities and initiatives that are helping Reading to prepare for the unavoidable impacts of climate change.

Reading is already dealing with extreme weather events and the physical impacts of climate change that has occurred over the last century. Section 2 includes examples of experiences of some recent weather events in Reading.

As climate change progresses, some adaptation is needed so that the town not only remains liveable, functional and prosperous in the future, but can thrive and grow in a changing climate. Adaptation presents new opportunities for the town and its businesses and citizens, including enhancing Reading's reputation as a leader in this emerging topic.

Adapting to climate change provides opportunities to enhance quality of life in our town. Many solutions can incorporate green space, healthier buildings, reduced energy use, and water efficiency, among other things. The benefits from improved management of extreme weather will make a difference to us today, as well as in the future.

As Reading continues to grow in size, in population and in prosperity, the need for resilience grows too. With greater assets at risk, maintaining business integrity and the protection people and the environment is ever more important, to enable Reading's continued economic growth and evolution as a smart and sustainable city.

The financial effects of climate change can be just as devastating as the physical ones. Unexpected expenditures from storms, flooding, snow removal and drought can lead to major disruptions in business operations and town budgets. Adapting to climate change at the local level – through avoidance or reduction of risks – makes economic sense.

Because the impacts of climate change are experienced uniquely at local levels, adaptation needs to happen in response to, and in keeping with, the geographical, socio-demographic or economic characteristics of any given place. This presents both the opportunity and the need for local collaboration and community level solutions to address the impacts. Working together to tackle climate change is what the RCCP is all about.

National policy recommendations and planning requirements also highlight the importance of urban areas and new development adapting to the impacts of climate change. Much of the wider policy context for adaptation confirms and reinforces the approach of the RCCP to increase action in adaptation across Reading.

Wider policy context for adaptation in Reading

The UK Government's National Adaptation Programme (NAP, 2018) sets out government's response to the second UK Climate Change Risk Assessment (CCRA, 2017), as required by the Climate Change Act 2008. It sets out objectives to, among other things,

- bring the public, private and third sectors together to work with communities and individuals to reduce the risk of harm, particularly in areas vulnerable to flooding risk
- deliver more, better quality Green Infrastructure, particularly in response to the risks to health and well-being from high temperatures in urban environments
- work to restore natural processes within river systems to enhance water storage capacity, to help address risks of water shortages

The CCRA highlighted key risks to the UK in six priority areas, many relevant to Reading:

- flooding and coastal change risks to communities, business and infrastructure
- risks to health, productivity and well-being from high temperatures
- risks of shortages in the public water supply and for agriculture, energy generation and industry
- risks to natural capital, including terrestrial, coastal, marine and freshwater ecosystems, soils and biodiversity
- risks to domestic and international food production and trade

- new and emerging pests and diseases, and invasive non-native species, affecting people, plants and animals

The third CCRA is under development and will be published in 2021.

In June 2019, the Committee on Climate Change released its latest assessment[2] of how well the UK is preparing for climate change. Some of the conclusions and highlights were:

- The Government had failed to increase adaptation policy ambition and implementation through its latest NAP, despite the urgency of addressing the risks from climate change
- Vulnerability and exposure to climate change continue to increase in many areas: urban greenspace, which has benefits for reducing flood and heat risks, continues to decline, from 63% of urban area in 2001 to 55% in 2018. The proportion of impermeable surfacing in towns and cities, which increases flood risk, has risen by 22% since 2001. The number of people with chronic respiratory conditions that make them more vulnerable to poor air quality continues to increase
- The priority given to adaptation, including through the institutional and support framework in England, has been eroded over the past ten years; leaving adaptation responses to local communities and individual organisations without a strategic plan will not properly manage the risks from climate change.

Alongside its objective to achieve sustainable development, the National Planning Policy Framework[3] emphasises the role that local planning should play in supporting climate change adaptation. Specifically,

- “Plans should take a proactive approach to mitigating and adapting to climate change, taking into account the long-term implications for flood risk, coastal change, water supply, biodiversity and landscapes, and the risk of overheating from rising temperatures.”
- There is a legal duty under section 19(1A) of the Planning and Compulsory Purchase Act 2004 to ensure that climate change mitigation and adaptation are core objectives integrated across all local planning policy.

1.3 This is Reading

The population of the Borough of Reading was 156,000 at the 2011 census, the largest component of the Reading-Wokingham urban area (total population of 318,000 in 2011). It is the largest town (by population) in the UK not to have city status.

Reading straddles the Thames and Kennet flood plains. Highest land in the town is in Caversham and Tilehurst (around 105 m above sea level), to the north-west and west of the town centre, with the lowest-lying areas next to the waterways (around 40 m above sea level). The M4 motorway lies to the south, the Oxfordshire hills to the north, and the River Loddon to the west. The town has a moderate to high-density suburban fabric, but it also has 23 Local Wildlife Sites, 4 of which are designated as local wildlife reserves, and 2 Biodiversity Opportunity Areas.

Reading’s economy, which is highly connected nationally and internationally and is one of the strongest in the UK, is based on high tech industry, innovation and inward investment. Reading’s success is based on its physical and virtual connectivity networks in an increasingly

[2] https://www.theccc.org.uk/publication/progress-in-preparing-for-climate-change-2019-progress-report-to-parliament/
[3] https://www.gov.uk/guidance/climate-change

globalised world. Reading is a key hub in a wider polycentric network of towns in the Thames Valley.

Reading 2050 Vision

Reading's Vision 2050 work identified three scenarios. These scenarios are not mutually exclusive and draw upon the strengths and opportunities unique to Reading.

- A City of Rivers & Parks recognises how water has shaped much of Reading
- A Green Tech City builds upon the established technology focus of our city.
- A City of Culture and Diversity would build on the success of the iconic Reading Festival.

All three themes are crucial to Reading's long-term success a smart and sustainable city. In each case, it will be essential to plan how to deliver this vision for 2050 in a future climate that is different from what we experience today.

https://livingreading.co.uk/reading-2050

2 Reading's changing climate

The latest climate projections for the UK show increased chance of warmer, wetter winters and hotter, drier summers along with an increase in the frequency and intensity of extreme events. Reading benefits from an excellent record of local weather observations dating from 1902, gathered by the University. Even over the period of this record, it is possible to see some indications of changes in climate.

2.1 Weather events and impacts in Reading

Located in the Thames Valley, one of the warmest parts of Britain, Reading has a mild climate and sees relatively few extremes of weather. This is one of the driest parts of the country, but it can experience prolonged rainfall in autumn and winter or intense thundery downpours in summer. When extreme weather events, including storms, floods and heatwaves, have occurred in Reading over recent years, there have been impacts[4] on businesses and residents.

Rain and flooding during winter 2013/14

The very wet winter of 2013/14, with heavy and persistent rains, led to widespread flooding along Reading's waterways and floodplains (Thames, Loddon and Kennet). Sonning Bridge was closed on two occasions in January and for part of February, while Loddon Bridge Park & Ride was closed for much of January. In some areas, flooding due to rising groundwater levels was a problem. There was widespread Christmas travel disruption, exacerbated by windy conditions. January 2014 was the wettest January on record in Reading, with 151 mm of rail (251% the normal January rainfall). February 2014 was the wettest February on record in Reading, with 117 mm of rain (287 % of normal).

Flash flooding in July 2007

While unusual, flooding has occurred during the summer in Reading in the past. In July 2007, 69 mm of rain fell in only 15 hours (the monthly mean rainfall for July in Reading is 46 mm) during prolonged heavy thunderstorms, leading to flooding on many local rivers, including through The Oracle.

Storms and wind

The Great Storm of 1987 – 16 October 1987 – caused immense damage and disruption across much of southern England. Hundreds or possibly thousands of trees were felled or badly damaged around Reading, some of these falling onto houses or blocking roads. There were few injuries because the worst part of the storm was during the early hours of the morning. The strongest wind gust recorded at the University during this storm was 77 mph.

A storm on 25 January 1990 caused considerable damage with many trees felled. More than 200 casualties were treated at the Royal Berkshire Hospital for cuts or broken bones due to flying debris. Pupils were evacuated from a primary school when its roof blew off.

Heatwaves and drought in 1976

June 1976 was easily the warmest June on record in Reading, with a mean temperature of 18.1 °C (2.8 °C above the June average for 1981-2010). The very hot weather continued into July. After a dry start to the year, the hot dry conditions led to widespread forest and woodland

[4] "One hundred years of Reading weather" by Brugge and Burt, published by the University of Reading in 2015, provides insight to past weather events in the town.

fires in Berkshire (and many other places in south and south-east England). Maximum temperatures reached 30 °C or above every day for 14 days from end of June into July 1976, peaking at 34.0 °C on 26 June.

Summer 1976 saw the culmination of a prolonged drought which had started in April 1975. July/August 1976 saw barely any rain for 37 days, making it the longest period without measurable rainfall.

High temperatures in 2019

Following a very hot summer in 2018, Reading also experienced some record-breaking temperatures during 2019, along with the rest of the UK (Table 2.1).

Table 2.1: 2019 temperature records in Reading

UK Weather record	Date	Temperature in Reading
Hottest day in February on record *the first time temperatures in February reached over 20 °C*	26 February 2019	19.5 °C
Hottest Easter Sunday on record	21 April 2019	23.7 °C
Hottest Easter Monday on record	22 April 2019	24.4 °C
Hottest day on record *highest temperature in England recorded at 38.7 °C in Cambridge*	25 July 2019	36.0 °C
Hottest Summer Bank Holiday on record	25 and 26 August 2019	32.1 °C and 31.0 °C

Source: Baseline from the University of Reading's CLIMAT meteorological record[5]

Since 1908, only five days have reached 35 °C or higher in Reading. The hottest day recorded in Reading was 36.4 °C on 10 August 2003.

2.2 Past Climate Change in Reading

Reading benefits from an excellent record of local weather observations dating from 1902, gathered by the University. Just from this record, it is possible to see indications of changes in climate. For example[6], the six warmest summers recorded in Reading all occurred between since 1976 (with 2018 the warmest), while the five coldest summers all occurred before 1955. Since 1961, mean temperature in Reading has been rising at a rate of 0.26 °C per decade (J. Lowe, pers. com, 2019).

University of Reading weather observations

Meteorological observations have been made almost continuously at the University of Reading since 1901. Although records for some of the earlier years have been lost, an almost complete daily record of many elements can be assembled from January 1908 to date.

The weather station has occupied two major sites – from 1901 to 1967 on the London Road campus and then at the Whiteknights campus since January 1968 (and at the current site since 1 January 1970)[7]. The University's Atmospheric Observatory on the Whiteknights campus has been a centre for atmospheric measurements, micrometeorological research and meteorological observations since 1968: the records are widely used for teaching and

[5] https://metdata.reading.ac.uk/cgi-bin/climate_extract.cgi

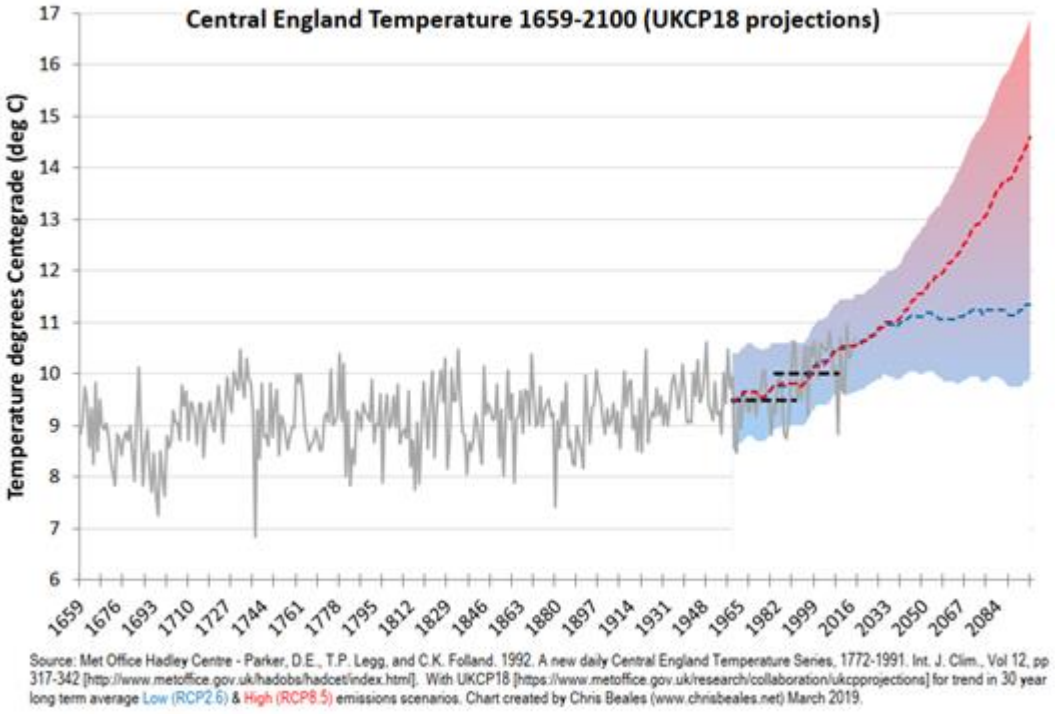
[6] https://research.reading.ac.uk/meteorology/atmospheric-observatory/weather-updates/

[7] https://research.reading.ac.uk/meteorology/atmospheric-observatory/

research purposes, as well as continuing Reading's long climatological record as a node within the Met Office UK climate network[8].

A longer record of temperature observations provides compelling evidence of climate changes experienced in England as a whole. The Central England Temperature (CET) dataset[9] is the longest instrumental record of temperature in the world. Figure 2.1 was created to show the climate change experienced and expected in England. The grey line is the CET record: this shows that, despite year-to-year variations in annual temperature, it has been relatively stable around 9 °C for the last 360 years. The latest 30 years are notably warmer. The most recent decade (2009-2018) was around 1 °C warmer than the pre-industrial period (1850-1900). This temperature rise in the UK is consistent with warming that has been observed at a global scale, of around 1 °C since pre-industrial. The 21st century so far, has been warmer than the previous three centuries[10].

Figure 2.1: Mean Central England Temperature Record



Source: C. Beales (pers. Comm., 2019)

The plume of rising temperatures, shaded from blue to red in Figure 2.1, shows the range of model results from the UK Climate Projections[11]. The blue dashed line is an average, assuming greenhouse gas emissions are limited to meet the 2 °C Paris Climate Agreement target. The

[8] https://research.reading.ac.uk/meteorology/wp-content/uploads/sites/8/Atmospheric-Observatory-A4-DL-brochure.pdf

[9] Parker, D.E., T.P. Legg, and C.K. Folland. 1992. A new daily Central England Temperature Series, *1772-1991. Int. J. Clim., Vol 12, pp 317-342* available at https://www.metoffice.gov.uk/hadobs/hadcet/Parker_etalIJOC1992_dailyCET.pdf ; http://www.metoffice.gov.uk/hadobs/hadcet/index.html

[10] UK Climate Projections: Headline Findings September 2019, Version 2 https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp-headline-findings-v2.pdf

[11] For more details on how this is derived please refer to https://chrisbeales.net/environment/CET-plus-climate-change.html

red dashed line is a high emissions future, assuming a reasonable worst-case of high global economic growth, powered by intensive fossil fuel emissions. Both futures are considerably warmer than in the whole of the CET record.

2.3 Future Climate Change for Reading

The latest UK climate projections[12], UKCP18, are the most reliable source of information to show how Reading's climate may change in the future (Figure 2.2). Higher resolution future climate projections at a local 2.2 km^2 scale have been published in September 2019 and these provide better information on, and improved representation of, hourly rainfall and extreme events (as well as the influence of mountains, coastlines and cities) such as localised heavy summer rainfall, which can result in flash floods and surface water floods[13]. For further details about the UK Climate Projections 2018 see Appendix B.

Climate change projections over land for the UK for the 21st century show we are likely to have **milder, wetter winters and hotter, drier summers** along with an **increase in the frequency and intensity of extremes**.

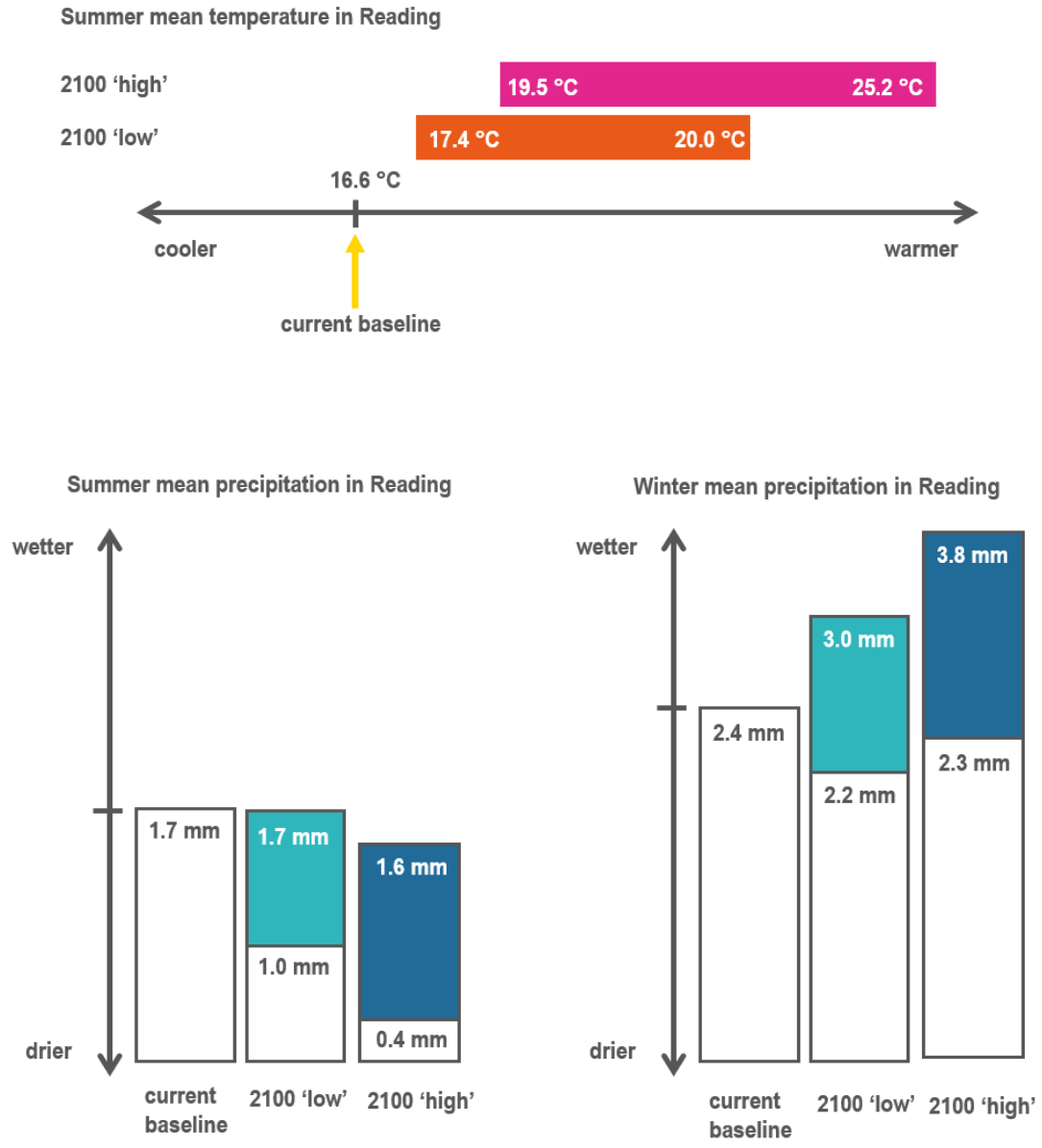
- **Hot summers are expected to become more common**. In the recent past (1981-2000) the chance of a summer as hot as 2018 (one of the hottest on record) was less than 10%. The chance has already increased due to climate change and is now between 10% and 25%. With future warming, the chance of a summer as hot as 2018 is around 50% by mid-century.
- In Reading, **the 2018 heatwave saw temperatures reach a high of 32.9 °C**, with **seven hot days** where the temperature reached 30 ºC or over (and no rain fell for 30 consecutive days).
- Variability in rainfall is increasing. **Wet winters will get wetter,** but we can still expect some dry winters. **Summer rainfall is expected to decrease significantly**, but when it rains in summer there may be more intense storms.

Reading will need to be resilient to a wider range of conditions than in the past.

[12] Available at https://www.metoffice.gov.uk/research/collaboration/ukcp

[13] For further details on the UKCP18 Local data see: https://www.metoffice.gov.uk/pub/data/weather/uk/ukcp18/science-reports/ukcp-infographic-new-and-exciting.pdf

Figure 2.2: Projected changes in temperature and rainfall for Reading to 2100



Notes:

- Mean temperature or mean precipitation is the projected mean across the relevant season averaged for a 20-year period.
- 2100 'high' = High emissions scenario (RCP 8.5), 2100 'low' = Low emissions scenario (RCP 2.6).
- RCP = Representative Concentration Pathways that describe different 21st century pathways of GHG emissions and atmospheric concentrations, air pollutant emissions and land use.
- RCP2.6 is representative of very stringent emissions reduction aiming to keep global warming likely below 2°C above pre-industrial temperatures, which is the equivalent to meeting the Paris agreement. RCP8.5 is representative of very high GHG emissions.
- The current baseline is for 1981-2000. General climate trends from UKCP18 Headline Findings: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18-headline-findings.pdf
- Data sources: Baseline from the University of Reading's CLIMAT met record https://metdata.reading.ac.uk/cgi-bin/climate_extract.cgi and all future projections are from the UK Climate Projections 2018 (UKCP18) for the 10th-90th percentile range for the 2080-2099 period relative to 1981-2000 https://www.metoffice.gov.uk/research/collaboration/ukcp/key-results

3 Impacts by Sector

This section provides headline information about the potential impacts of climate change aligned to the sector themes in Reading's Climate Change Strategy.

3.1 Water Resources and Flood Risk

Many people will experience climate change through its effects on water, and especially through floods and droughts. We expect more floods and larger floods, particularly during winter. Summer flash flooding may become more common. Increased variability in precipitation, with increased intensity and prolonged dry periods will directly affect the water sector.

- Water resources across the Thames Valley are already stressed, and the population is increasing. The impacts of climate change may exacerbate this situation.
- As our climate warms and rainfall patterns change, there may be increased competition for water between households, agriculture, industry and the needs of the natural environment.
- Summer droughts may become more frequent and more severe causing problems for water quality and supply.
- Demand for public water supply may increase with temperature. Water demand for agriculture is also expected to increase with temperature.
- Changes in rainfall patterns will affect both rainfed and irrigated agriculture.
- Flooding can already have a devastating effect on those affected. With climate change likely to alter rainfall patterns and bring more heavy downpours, we expect flood risk to increase in the future.
- Climate change will increase the risk of flash flooding in urban areas, in response to increasing rainfall intensity. This could impact on properties and infrastructure – with serious consequences for people, businesses and communities.

3.2 Low Carbon development and energy

Rising temperatures (during both day and night time), and increased solar gain, may cause overheating in buildings, particularly during heat wave events, impacting energy performance and internal comfort. Increases in the frequency, severity and extent of flooding will increase the exposure of development (or re-development) to flooding. More intense rainfall events and storms will test building weather resistance and drainage.

- Whether retrofitting existing or building new, climate change may present issues with overheating, water management (in flood and drought), and weather resistance.
- Climate change will have an impact on the design, construction, management and use of our buildings and surroundings.
- Around 20 % of homes in England overheat even in the current climate, while 1.8 million people live in areas which are at significant risk of flooding.
- Dwelling types that have been found to be more prone to overheating include 1960s–1970s and post-1990s mid- and top-floor purpose-built flats that lack sufficient ventilation and protection from heating by the sun.
- In London during a heatwave in the 2030s it is estimated that around two-thirds of flats and up to half of detached properties would overheat.

- Vulnerable populations in social housing are likely to be affected the most by weather impacts.
- There is some evidence that the risks of overheating in hospitals, care homes, schools and offices will increase in the future.
- The proportion of urban greenspace in England has dropped since 2001 from 63% to 55%, adding to the problem of increased temperatures in cities.
- Climate change can impact power distribution, with impacts ranging from damage caused by extreme weather events, to reduced transmission efficiency occurring because of temperature fluctuations.

Figure 3.1: Terraced houses in Reading backing onto River Kennet

Source: L Horrocks August 2019

Overheating in residential buildings

There is no accepted or agreed definition of "overheating" for residential buildings. However, for temperate zones, the WHO guidance[14] on thermal comfort indicates that temperatures above 24°C cause discomfort and, in the more fragile and susceptible members of the population, can cause harm. The England and Wales Heat-Health Watch Service[15] identifies external temperatures that could have a significant effect on health if reached on at least two consecutive days and the intervening night. For south east England these threshold values are daytime maximum of 31 °C and night time minimum of 16 °C.

Overheating risk affects many new or refurbished homes as well as existing homes. The health and wellbeing impacts of overheating can be significant for residents, resulting in stress, anxiety, sleep deprivation and even early deaths in heat waves, especially for vulnerable occupants.

The Committee on Climate Change[16] estimated that mortality rates arising from overheating could rise from 2000 per year in 2015 to 7000 per year by the 2050s.

It is not possible to identify clearly an external temperature that would result in buildings in Reading to be too hot for healthy living: the potential overheating inside a building depends not only on the temperature outside, but also on other factors, including building fabric, dwelling characteristics and occupant behaviours:

- Solar gains through building fabric and windows
- Internal heat gains (almost all the electricity used in a home is converted into heat)
- The Urban Heat Island effect
- Location within the urban area or within the building
- Orientation (with elevations from south to west receiving greater solar gain)
- Design and construction, including level of insulation, and air-tightness, thermal mass of building materials
- Means of ventilation and behaviours

Some conclusions about overheating in residential buildings are:

- Not all types of dwelling overheat, but it varies. Some types of buildings do seem to perform better in hot weather than others.
- There are some simple options for managing heat in existing residential buildings, including shading, reflection and protection, effective ventilation, and behavioural changes
- Climate trends towards more very hot days (and nights) mean that heat management in homes is a growing challenge
- Both BRE[17] Centre for Resilience and CIBSE have issued new guidance relatively recently on understanding and assessing overheating risk in homes, which means that new homes should cope better.

[14] Ormandy and Ezratty, 2012, Health and thermal comfort: From WHO guidance to housing strategies. Energy Policy Vol 49, 116-121. Available at https://doi.org/10.1016/j.enpol.2011.09.003

[15] https://www.metoffice.gov.uk/public/weather/heat-health/

[16] ASC, 2017, Progress in preparing for climate change

[17] BRE's Centre for Resilience published Guidance Document "Overheating in dwellings" in 2016, available from http://www.bre.co.uk

3.3 Health and Well-being

The health and social care sector is particularly susceptible to the impacts of flooding and heatwaves. The frequency and intensity of extreme heatwaves are both expected to increase during this century.

- A warming climate may bring benefits to health and wellbeing, providing more opportunity to be outdoors and enjoy a healthy and active lifestyle, while reducing mortality in winter.
- The impacts of hotter drier summers and a greater number of heatwave events are numerous and principally negative. Direct impacts include a greater number of deaths from heart and lung-related diseases, while heat-related illnesses (heat cramps, heat exhaustion and heat stroke) increase during heatwaves. Higher temperatures increase perspiration and evaporation, which can increase the risk of dehydration.
- The elderly, very young and people with pre-existing heart and respiratory diseases are most at risk from heat-related impacts. In otherwise healthy people, overheating can cause discomfort leading to lack of sleep, productivity and alertness. The health burden of hot weather is likely to be amplified by the UK's ageing population.
- Extreme weather events may disrupt the lives of individuals and communities, pose risks to health and social care delivery, limiting access to vital services and impacting on people's physical and mental health.
- Surface water flooding can lead to damage to health and care facilities, restricted access for staff and contractors, failure of key services such as heating, cooling or water supplies, water contamination and supply-chain interruption.
- As well as risks to life and property, flooding causes long-term damage to health, wellbeing, livelihoods and social cohesion.
- The changing climate may exacerbate risks to health from changes in air quality.

There is a wide range of other possible impacts from climate change on the 'wider determinants of health', including education, employment, income, housing, social networks, environmental factors such as air quality, access to affordable, nutritious food and quality green spaces, and access to public services, including health and social care.

3.4 Transport

We expect more floods and larger floods, particularly during winter. Summer flash flooding may become more common especially in urban areas. High temperatures and heatwaves affect the infrastructure itself, people travelling and public services. Storminess, including high winds and heavy rain during extreme storm events, affects transport systems (and their supporting infrastructure) directly. Fog, lightning and humidity also affect transport, but future projections of these remain uncertain.

- Extreme events can cause severe damage to transport networks – as well as being costly to recover, the loss of transport services can affect people's health and wellbeing, and local economic activity.
- Increasing frequency and severity of flooding represents the most significant climate change risk to UK infrastructure – the number of assets exposed to significant levels of flood risk could double by the 2080s.
- On the roads, heavy rain and high winds lead to accidents, treefall, road closures, and delays.
- Increases in intense rainfall may increase the risk of slope and embankment failure along transport corridors.

- Changes in river flows and bank erosion rates may put bridges at risk from increased scour.
- Increased temperatures and severe heatwaves increase the risk of disruption and may reduce efficiency or safety associated with almost all infrastructure services.
- High temperatures increase the risk of rail buckling, electricity cable sagging and road surface softening and rutting, while signalling and communications equipment can overheat and fail.
- While warmer weather may encourage more people to walk or cycle, (with health and greenhouse gas reduction benefits), high temperatures can present health and wellbeing risks to people on public transport.

Our infrastructure is closely inter-linked – climate-related risks to individual assets can pose risks to wider networks, with knock-on disruptions to services.

Figure 3.2: Mainline railway at Reading

Source: Shutterstock

3.5 Natural environment and green spaces

Rising average temperatures, and changes in seasonality, including the earlier onset of spring, can affect the timing of life-cycle events in the natural environment. Evidence of long-term shifts in the distribution and abundance of some species due to higher temperatures is already discernible. Increased variability in precipitation, with increased intensity and prolonged dry periods will impact on the availability (and management), quality and quantity of water for biodiversity.

- Climate change presents a substantial risk to the UK's native wildlife and also to the vital goods and services provided by the natural environment to people. Some species and habitats may be unable to respond to changing climatic conditions, while others may find new opportunities for colonisation.

- The natural environment is already stressed by other non-climate pressures including pollution, habitat loss and fragmentation, recreational pressure, and spread of non-native and invasive species. This constrains the natural resilience of species and ecosystems to adjust and adapt to change.
- Future climate change is likely to accelerate current rates of decline and loss of biodiversity and ecosystem function. Across the country, some distinctive species may struggle and could be lost, invasive non-native species may thrive, while a degraded environment may not be able to sustain productive land or water supply.
- The natural environment depends on water in many ways. Lower summer river flows may lead to poor water quality. Warmer rivers and lakes may suit some species, but others will not thrive. Flooding and erosion can damage important habitats. Both water scarcity and flood pose risks to wildlife.
- Land management practices may exacerbate flood risk (which includes upstream land management practices impacting flood risk in urban areas downstream).
- Increase in the frequency and duration of prolonged drought periods will reduce tree growth. There are likely to be effects on street trees due to higher urban temperatures and reduced effective water availability.
- The proportion of urban greenspace in England has dropped from 63% in 2001 to 55% in 2018 adding to the problem of increased temperatures in cities (the Urban Heat Island effect).

Green infrastructure interventions are widely recognised as playing an important role in reducing the risk of flooding by absorbing, storing or dispersing floodwater, and filtering pollutants.

Figure 3.3: River Thames in Reading

Source: L. Horrocks August 2019

3.6 Production, consumption and waste

Flooding, extreme weather, and heatwaves affect business and commercial activities, production and consumption, through a wide range of impacts on business functions (site locations, capital, labour, supply chains and distribution networks, products and services).

- For businesses, the main climate risks arise from flooding and extreme weather events, affecting their assets and people directly, and also disrupting transport, energy and communications on which they rely.
- Increased temperatures reduce the comfort of occupants in domestic, commercial and public buildings and productivity can be affected, though there is uncertainty about the magnitude of impacts.
- Projections of larger routine deficits in the availability of water for abstraction constitutes a risk to water-intensive industries.
- Through international supply chains, distribution networks and global markets, UK businesses are exposed to the risks of extreme weather around the world, with trade networks in south and south-east Asia and sub-Saharan Africa indicated as more vulnerable.
- Climate impacts will be imported to the UK through the price and safety of food and other commodities, changes in the patterns of trade, disruption to global supply chains, insurance costs, and risks to overseas investments
- The manufacture and supply of food, clothes and electronic equipment are understood to be particularly exposed to international climate change impacts.
- There is recognised growth in an “adaptation economy” in the UK and worldwide, as new products and services come to market in response to adaptation-related opportunities.
- Climate-related disruption to business operations will depend, in part, on the resilience of local infrastructure.

4 Impacts by place

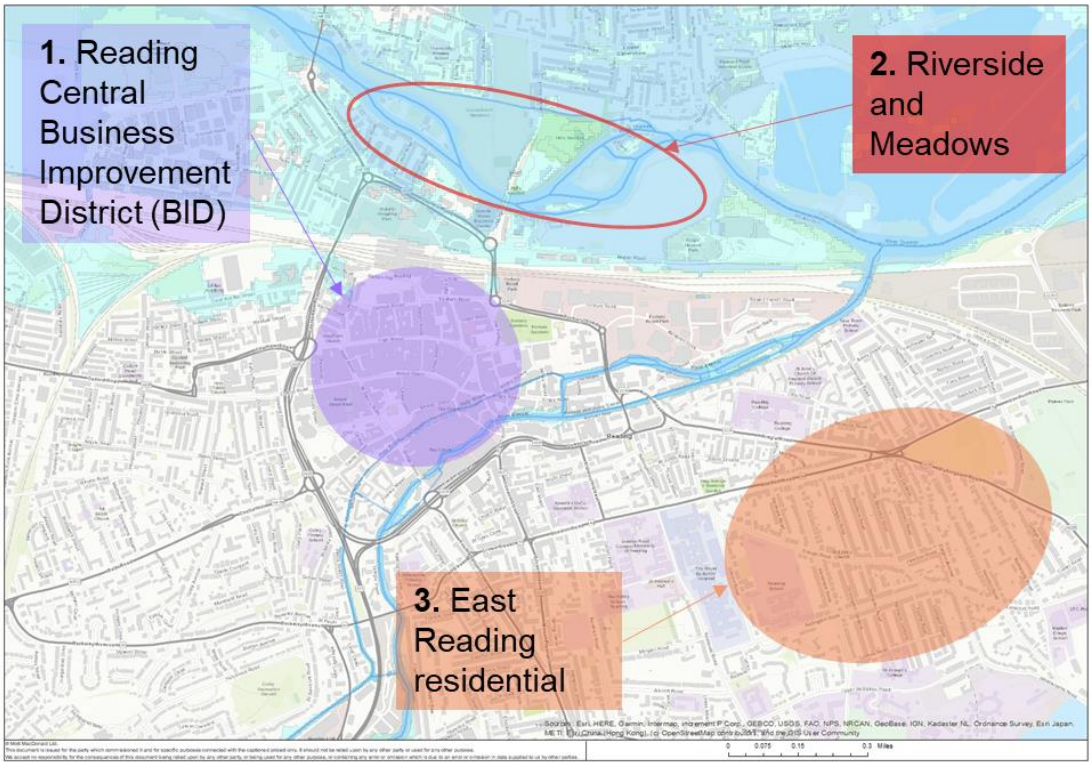
This section provides information about the potential impacts of climate change on three places in Reading.

This place-based view allows for consideration of the coincidence of sectoral impacts and risks in these places. Three central locations, linked with the themes for Reading Vision 2050, were selected by RCCP for this initial study:

1. Reading Central Business Improvement District (BID).
2. Riverside and Meadows.
3. East Reading residential.

Subsequent iterations of the adaptation plan can extend this approach to other places in the wider Reading area.

Figure 4.1: Locations for the impacts by place



Source: Basemap Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community. Main rivers and Flood zones: © Environment Agency copyright and/or database right. © Crown copyright and database rights 2018 Ordnance Survey 100024198

4.1 Reading Central Business Improvement District (BID)

What are the main climate impacts?

- Rising temperatures causing **overheating** (especially during heatwaves) and solar gain impacting energy performance and internal comfort.
- Rising temperatures and heatwaves combined with UHI effect causing outdoor discomfort.
- More intense rainfall events and storms leading to **surface water flooding**, drainage and building weather resistance issues.

Urban Heat Island effect in Reading

The Urban Heat Island (UHI) effect arises where an urban area or metropolitan area is significantly warmer than its surrounding rural areas due to human activities. The temperature difference is usually more pronounced at night than during the day. The main cause of the UHI effect is from the modification of land surfaces and the different thermal properties of urban fabrics compared to surrounding countryside. A secondary factor is the larger production of waste heat from energy usage in urban areas.

Reading's UHI ranges from around 0.4 °C in winter to 0.8 °C in summer, based on comparative temperature records from the University's weather stations at the London Road site and Whiteknights campus (Brugge and Burt, 2015. One hundred years of Reading weather).

Sectors affected: Business and commercial, transport, low-carbon and energy (including buildings), health and well-being

Climate change challenges

- Direct physical impacts affecting business assets and people.
- Interdependencies: knock-on impacts to power, telecoms, internet, water, sewerage, drainage
- Transport: disruptions to people and supply chains.

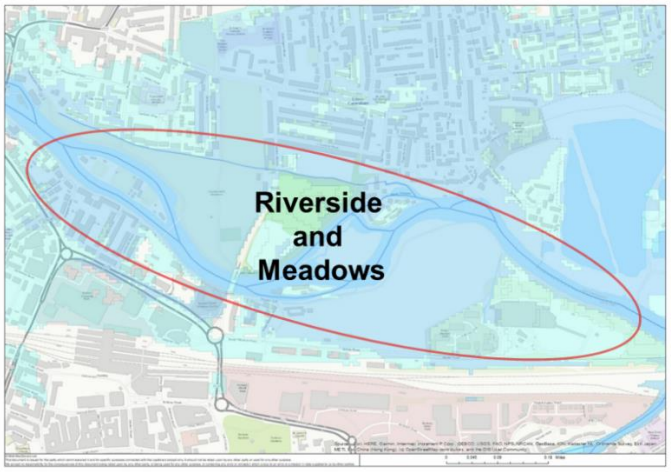
Opportunities for adaptation and co-benefits

- Increasing the viability of a prospering central business and commerce district under a changing climate.
- Adaptation as good business – enhancing the Reading Central Business Improvement District business and renewal plan.

Proxy indicators: *Seasonal footfall and periods of closure during extreme weather events*

Further work to collect indicator data would require set up and sharing of recorded data for climate change impacts across the Business Improvement District following integration of the metric as part of the business and renewal plans moving forward.

4.2 Riverside and Meadows



River Thames at Reading

Source: Shutterstock

What are the main climate impacts?

- Rising temperatures changing seasonality/earlier spring, shifts in species.
- Increased intensity and **prolonged wet and dry periods**
- **River flooding** causing damage and temporary closure of parts or all of the Meadows.

Sectors affected: Natural environment and green space, water resources and flood risk, transport, health and well-being, recreation.

Climate change challenges	Opportunities for adaptation and co-benefits
• Maintaining water availability and quality for biodiversity and recreation • Increased use and pollution during prolonged warmer and drier periods • Changing maintenance and waste removal regimes • Flooding of Lower Caversham and at Reading Bridge.	• Providing and enhancing access to quality green space for citizens, also as an adaptation response during hot weather • Maintaining (and enhancing) urban biodiversity and providing additional shading and cool spaces • Flooding of landscaped areas to create storm and flood water • Public awareness.

Proxy indicators: *Number of days of no or restricted access to the Riverside and Meadows*

Days with no or restricted access to the: River Thames, meadows green space, surrounding roads, houses and businesses (and the number affected). Changing water availability, water quality and maintenance needed during events. Further work to collate indicator data and monitor closure or restricted access, water quality and changing maintenance regimes would be required.

North Reading and Lower Caversham Flood Alleviation Scheme

North Reading and Lower Caversham are vulnerable to flooding from the River Thames. In 2012 and 2014, homes and businesses in low lying areas of Caversham flooded. In 2003, many houses were surrounded by floodwater and roads were closed for as long as 5 days. Some routes towards Caversham Bridge (A4155) and Reading Bridge (B3345) are also at risk of flooding. These two bridges form the primary river crossings for road vehicles, and hold strategic importance for the wider area including access to the M4, Reading railway station and the Royal Berkshire Hospital.

With the risk of flooding expected to increase for everyone in the future, the Environment Agency is working on a plan to reduce flood risk from the River Thames in north Reading and Lower Caversham.

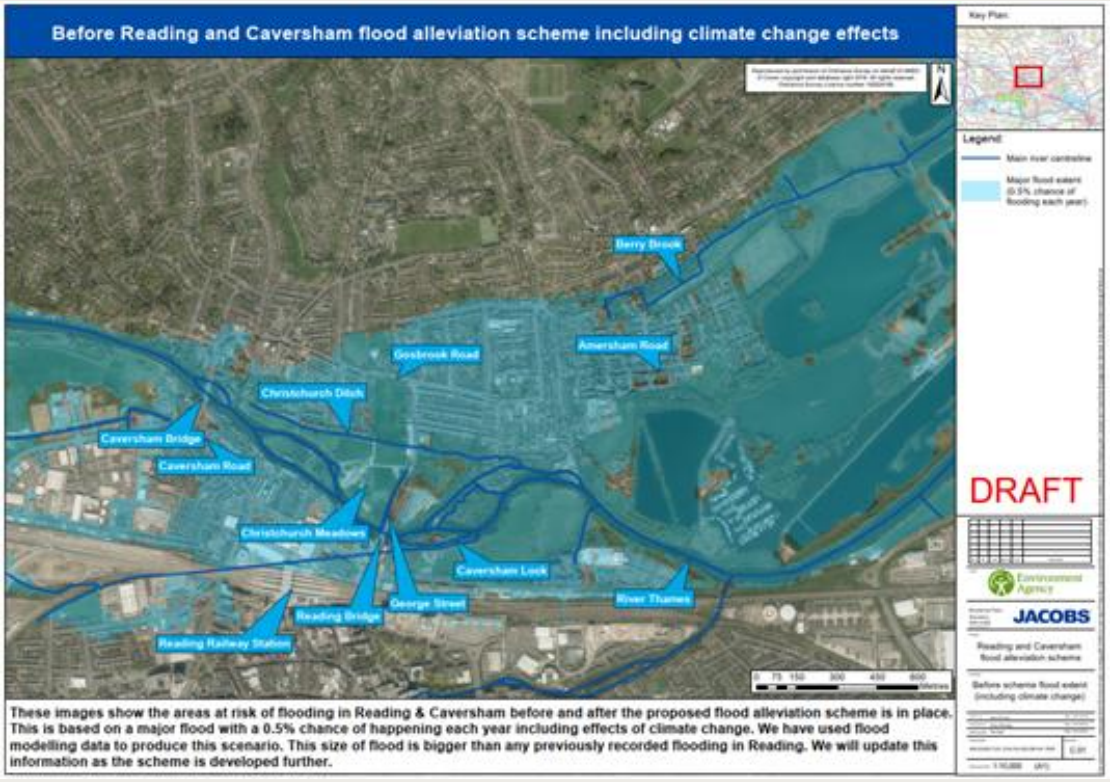
The plans[18] would reduce flood risk to many properties during a larger flood than has been experienced in recent years. Measures could include a combination of flood walls, temporary barriers and embankments and would run from Promenade Road to just past the Berry Brook on the north side of the River Thames and from Caversham Bridge to Reading Bridge on the south of the River Thames. The scheme would also include a conveyance channel through a small section of Christchurch Meadows and the south part of Hill's Meadow car park, re-entering the River Thames close to Caversham weir.

The Environment Agency cannot reduce flood risk alone. The scheme also depends on what the town wants for the area. The proposals are not finalised and the Environment Agency is seeking the views of people who live in and use the area, to influence the scheme design.

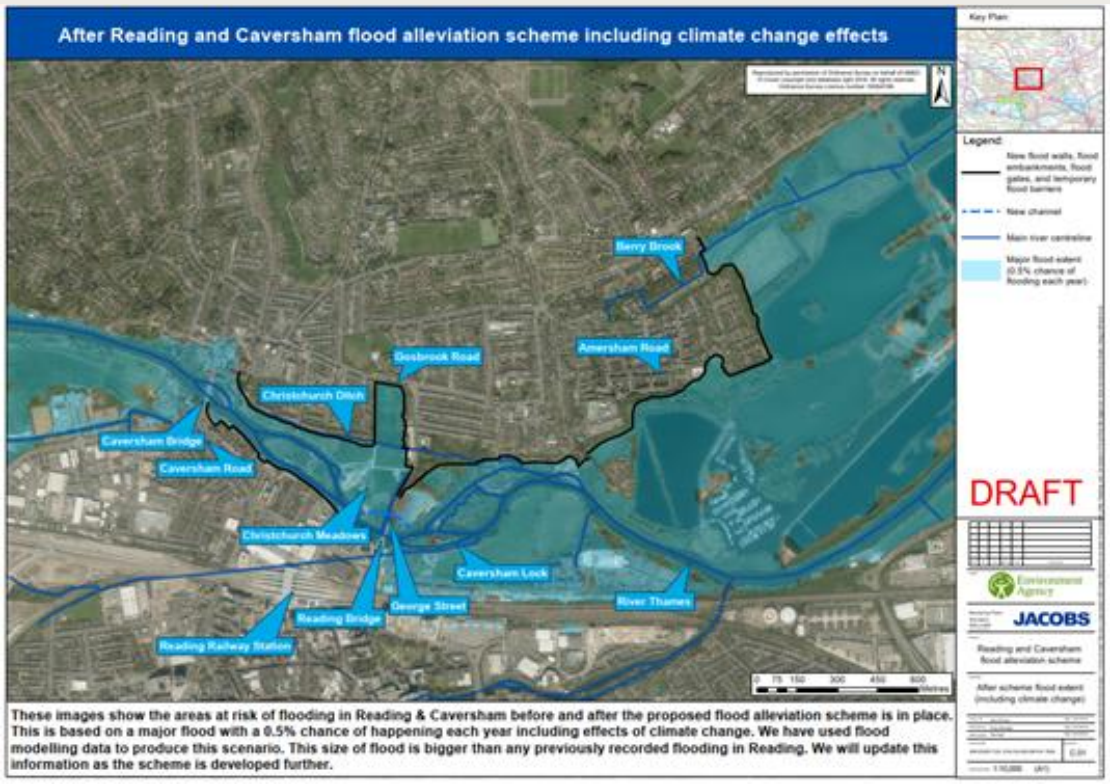
The project is not fully funded and does not have approval or planning permission at this stage. It is currently estimated that the scheme would cost between £25 and £30 million but this may change as the project progresses. The project already has an allocation of £11 million from Central Government and partnership funding. The Environment Agency will work with partners, government departments, business and industry to seek further funding to take the proposals forward to reduce flooding in Reading in the future.

The first image below shows the present-day risk of flooding from a major flood (including climate change effects) in the north Reading and lower Caversham area without a scheme in place. The second image shows the present-day risk of flooding from the same major flood if the proposed scheme was in place.

[18] More information on the Reading and Caversham Scheme can be viewed on the scheme website at https://www.gov.uk/government/publications/north-reading-and-lower-caversham-flood-alleviation-scheme/north-reading-and-lower-caversham-flood-alleviation-scheme

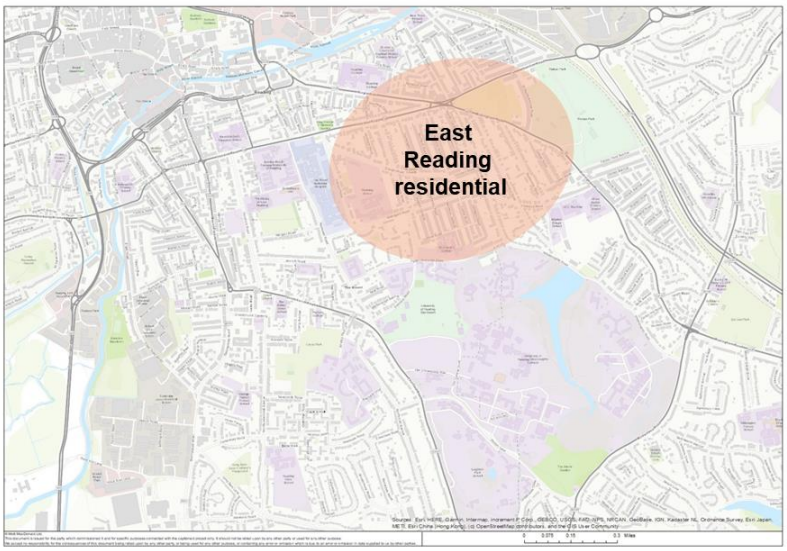


These images show the areas at risk of flooding in Reading & Caversham before and after the proposed flood alleviation scheme is in place. This is based on a major flood with a 0.5% chance of happening each year including effects of climate change. We have used flood modelling data to produce this scenario. This size of flood is bigger than any previously recorded flooding in Reading. We will update this information as the scheme is developed further.



These images show the areas at risk of flooding in Reading & Caversham before and after the proposed flood alleviation scheme is in place. This is based on a major flood with a 0.5% chance of happening each year including effects of climate change. We have used flood modelling data to produce this scenario. This size of flood is bigger than any previously recorded flooding in Reading. We will update this information as the scheme is developed further.

4.3 East Reading Residential



What are the main climate impacts?

- Issues with **day and night time overheating**
- Water management (in flood and drought)
- Building weather resistance in existing older terraced housing.
- Combined impacts from traffic congestion and seasonal weather extremes

Sectors affected: Health and well-being, Housing, Transport

Climate change challenges

- Residential housing lacking sufficient protection from overheating.
- Lack of access to green space for heat and flood alleviation.
- Vulnerable populations in social housing are likely to be affected the most by weather impacts
- Traffic congestion at Cemetery Junction and local streets during hot weather.
- Integrated management of climate and transport planning issues together

Opportunities for adaptation and co-benefits

- Improving local community resilience to climate change and city liveability
- Reducing petrol- and diesel-powered vehicles in the area can reduce heat-related health impacts
- Co-benefits of providing green corridors
- Access to funding for improving streets and properties.
- Integrated planning can increase adaptive capacity.

Simple adaptation to help address overheating in homes

Simple measures to prevent overheating in existing dwellings include the following:

- Insulation – the provision of additional thermal insulation to the walls and loft (roof) will help prevent solar gain through the structure.
- Shading, reflection and protection – various options exist to provide shading to limit solar gain through windows facings south through to west, including internal shutters, curtains. External protection is preferable and can include a brise-soleil or an awning, external blinds and external shutters.
- Providing a light-coloured finish to flat roofs can reflect sunlight, and green roofs also provide protection from solar heat gain. It's likely that some protection can be provided by roof-mounted solar panels.

- Ventilation – ideally this should be passive (not requiring additional energy), but to be effective, it needs to be able to achieve a high air change rate, without negative impact on residents (e.g. noise, security). Natural ventilation (opening windows) is only useful when the outdoor temperature is lower than the indoor. Ventilation at night to replace warm indoor air with cooler air from outside is important.
- Occupier behaviour – limiting heat gain needs active participation of occupiers, to use available means of shading and understanding appropriate day/night ventilation. One cool room in a building can provide relief
- Cooling systems – if other measures to minimise overheating have been taken, a comfort cooling system could be installed. Any mechanical system has running costs and may have knock-on impacts as heat rejected from one household can increase the temperature in the local micro-environment, adding to overheating problems nearby.

BRE Guidance Document “Overheating in dwellings” (2016) available from www.bre.co.uk

5 Local Adaptation Case Studies

Many Reading-based organisations are already preparing for the impacts of climate change. In this section we provide snapshots of adaptation activity underway in the town. The case studies highlight some experiences to inspire or challenge others.

5.1 The Oracle – Corporate policy driving local action on risks and opportunities

The Oracle is Berkshire's premier shopping and dining destination. Owned and managed by Hammerson, and with an annual footfall of 12.7 million shoppers, this retail destination straddles the River Kennet in the commercial heart of the town. Hammerson create vibrant, continually evolving spaces, in and around thriving European cities, with a focus on flagship retail destinations and Premium Outlets.

Figure 5.1: Bridge over the Kennet at The Oracle, Reading

Source: Hammerson

5.1.1 Motivation

The Oracle's action on climate change is underpinned by Hammerson's sustainability strategy, Positive Places, Hammerson's sustainability vision is "to create destinations that deliver net positive impacts economically, socially and environmentally". In its 2018 sustainability report, Hammerson reinforced that climate change remains its primary sustainability concern. Investors now expect that businesses understand the potential risks that climate change presents for their operations between now and 2050.

5.1.2 Progress

During 2018, Hammerson undertook a portfolio-wide climate change assessment that focused on the potential physical risks that climate change poses to its assets, including The Oracle. Hammerson's physical climate risk analysis considered the UKCP09 and UKCP18 climate projections along with similar data sets for France and Ireland to build a picture of potential climate stress points for its assets in the 2030s and 2050s.

The key stress points identified were the expected increase in summer peak temperatures and extreme rainfall. Summer peaks temperatures in the region are expected to increase by 4.3 °C from current levels by 2050 and the likelihood of extreme rainfall events is predicted to increase 5 % by 2050. Both outcomes would have implications for the smooth operation of The Oracle, including higher operating costs, disruption to retail deliveries and trading, and increased pressure on tenants. This suggests that by 2050 The Oracle will need to be able to keep visitors and colleagues comfortable in a climate that was not foreseen when the building and its mechanical systems were designed.

Figure 5.2: Green wall at the Riverside entrance to The Oracle

Source: L Horrocks, August 2019

Because of The Oracle's location on the River Kennet, the original development incorporated strong flood defences, which significantly reduces the exposure of the asset to fluvial flood risk. Regardless, extreme rainfall events still present challenges for the asset, including service yard flooding.

By carrying out this analysis now, Hammerson is in an excellent position to develop and implement any necessary changes to The Oracle and its other assets to maintain their integrity and smooth running for all its stakeholders.

The centre already has green walls and roofs, which can help mitigate flood risk and manage temperatures. Further interventions will be identified that will support the asset's response to these climate challenges and can be implemented through normal business planning time scales because the work has been done early.

5.1.3 Outcomes

Adaptation to climate change makes sense for The Oracle because it addresses both a business need to enhance the destination's desirability and a focus on Hammerson's Net Positive commitment.

The Oracle increasingly recognises that local partnership efforts to address climate risks are both needed and desirable. Examples include the importance of working with local drainage authorities to address flood risks, and with the University to explore innovative approaches to

adaptation combined with other water, energy or environmental benefits. In 2018, an MSc student from the University of Reading worked with the Technical Services team to undertake a feasibility study for introducing a rainwater harvesting system. Co-benefits for water and energy efficiency have been an important aspect of The Oracle's climate adaptation options.

However, some potential adaptation options can also be in tension with other important business, environmental or social targets, e.g. increasing tree cover can affect security if it obstructs CCTV, and introduction of air conditioning would increase energy use and carbon emissions.

Having established a solid understanding of the climate risks and opportunities locally, The Oracle's Environment and Community Manager is now keen to learn from other cities around the world about how other flagship consumer destinations and public spaces can adapt to the impacts of climate change.

5.2 Berkshire Healthcare NHS Foundation Trust – Implementing room temperature monitoring and green space enhancement for cool area provision

Berkshire Healthcare NHS Foundation Trust is a community and mental health trust, providing a wide range of services to people of all ages living in Berkshire. To do this, they employ approximately 4,500 staff who operate from many sites as well as out in people's homes and in various community settings. The Cremyll Road site in central Reading (Figure 5.3) is a busy hub for Berkshire Healthcare and is a base for a wide range of community and mental health services as well as administration staff. The Trust has a relatively small estate but requires a large number of staff across many smaller specialist sites.

Figure 5.3: Berkshire Healthcare NHS Foundation Trust Cremyll Road community Hub and offices

Source: P Harrison, September 2019

5.2.1 Motivation

Alongside the main legislative drivers (Climate Change Act 2008 and Civil Contingencies Act 2004) the following policy drivers for Berkshire Healthcare are motivating adaptation to climate change:

- Heatwave Plan for England[19] - recommends a series of steps to reduce the risks and includes making the provision for cool rooms or cool areas.
- Adaptation to Climate Change for Health and Social Care organisations[20] - Adaptation guidance produced in response to the Climate Change Act 2008 (and supported directly by Berkshire Healthcare)
- Sustainable Development Management Plan – subsequent adaptation actions will feed into this plan.

In 2011 a need was identified by the Sustainability Manager to compile the evidence base for Berkshire following several extreme heat and flooding events (and documented in their 2013 Climate Change Adaptation Strategy Scoping study). Particular vulnerabilities are recognised around:

- Getting staff to and from sites during flood event (e.g. Cremyll Road site), including estate staff (would cover multiple sites).
- Medicine not working as effectively or its ability to be stored correctly under higher temperatures.
- How to maintain health services and site management (including waste collection) during extreme events.

For Reading, the scoping study identified the areas potentially more at risk from climate change, where there are also sections of the community that are less likely to have the financial means to be able to adapt to a changing climate. This in turn could increase the demands on health service provision in these areas. The local Environment Agency Flood Risk Assessment at the time showed that the Cremyll Road site was the only one that Berkshire Healthcare occupy that could be at risk from a 1 in a 100-year flood event.

5.2.2 Progress

The initial scoping study identified a vast number of issues, concerns and impacts that could affect health service delivery across Berkshire. They can be broadly grouped into impacts from increased temperatures (exacerbating any health issues and so impact upon health service delivery and potentially the environment within health service buildings) and flooding (which can affect the delivery of health service in many ways including direct injuries, long-term mental health issues, access to health buildings and disruption to health service provision).

The scoping study provided the evidence to identify and determine multiple key areas that should be addressed to ensure the Trust is preparing for climate change, including: setting up the internal processes to ensure the NHS Heatwave Plan is implemented and complied with and; identifying the budgetary and financial implications that climate change adaptation could have on the Trust.

Monitoring of room temperatures across the Trust's estate is now actively taking place (and is fully embedded into risk management services) in order to be able to understand, provide and monitor the requirement for cool spaces (of 26 °C or below) in the Heatwave Plan for England.

[19] Heatwave Plan for England (2019) https://www.gov.uk/government/publications/heatwave-plan-for-england

[20] NHS Sustainable Development Unit (2012) Adaptation to Climate Change for Health and Social Care organisations "Co-ordinated, Resilient, Prepared" https://www.sduhealth.org.uk/documents/publications/Adaptation_Guidance_Final.pdf

The (draft) NHS Berkshire Climate Change Adaptation Strategy[21] sets these key areas identified and the associated actions in an action plan. The Trust has the opportunity to revisit the adaptation scoping study and draft strategy following the next five-yearly review of the Sustainable Development Management Plan in 2020 which it links to.

5.2.3 Outcomes

Due to the Heatwave Plan for England requirement for the provision of areas that can be maintained at 26 °C or below, more attention is being paid to measuring, monitoring and reporting on room temperature and the provision of cool areas and integrating this into the wider risk reporting and staff awareness.

Some of the barriers to doing more on adaptation include: engagement and the level of knowledge across the organisation (a need to increase understanding, explaining what adaptation is and Berkshire Healthcare's role in the process); the need to work with multiple organisations and to rely on major transport links between east and west (which can all be affected by extreme events, hampering county-wide continuity of Berkshire Healthcare's health service provision).

Some of the realised benefits of climate change itself are cost and carbon reduction in gas and electricity consumption, through milder winters (but could be offset if the provision of strictly controlled air-conditioning in healthcare increases). There can be wider health benefits when adaptation is combined with other factors, such as opportunities to utilise therapy gardens, tree planting and green space enhancement benefiting patients, staff, visitors and the general public.

Recommendations to other organisations in Reading include: offering staff flexibility with working arrangements during extreme weather; looking at supply logistics provided on a "just in time" model and asking for evidence from contractors for increased capacity to deliver during extreme weather; proactively seeking to expand or enhance green spaces and tree planting.

Figure 5.4: Therapy garden at West Berkshire Community Hospital

Source: Copyright Berkshire Healthcare NHS Foundation Trust

[21] Draft NHS Berkshire Climate Change Adaptation Strategy and action plan (available upon request from Paul Harrison, Sustainability Manager, Berkshire Healthcare NHS Foundation Trust Paul.Harrison@berkshire.nhs.uk)

5.3 University of Reading – integrating climate risks into organisation-wide strategy and plans

The University of Reading has local campuses in the centre of town on London Road, to the south at Whiteknights and at Greenlands to the east of Henley-on-Thames. The Whiteknights campus includes lakes, conservation meadows and woodlands as well as being home to most of the University's academic departments and several halls of residence. There are approximately 18,500 staff and students associated with the University in Reading, and it is an integral part of the town, making a valuable contribution to the local area, offering public space, events and activities to non-students.

Transform 2026 is the University's £200 million capital investments and campus improvement programme, which includes upgrading existing facilities and creating brand new ones. While the projects address the need for more study space and better technical resources, other key factors address sustainability, such as improving energy efficiency and reducing carbon emissions.

Figure 5.5: Health and Life Sciences Building, expected completion late 2019

Source: http://www.reading.ac.uk/about/2026-transform/current-projects-capital-investments.aspx

5.3.1 Motivation

The main climate hazards faced by the University's local estate come from extreme weather, including overheating concerns for some of the older buildings. The University is also vulnerable to some impacts shared by many organisations in Reading, such as the knock-on effects of extreme weather on staff and local transport.

However, the challenge of climate change goes much wider, affecting not only the management of the University's local physical assets, but also its markets (such as the direction of research and innovation) and its customers (such as global impacts on the international student body).

The University anticipates that the issue will only grow in importance, as awareness and expectations of students, and the wider public, rise.

"The changing climate poses direct risks to campus and community infrastructure, historically and culturally significant buildings and artefacts, and the wellbeing and safety of students, academics and support staff. By acting early and building resilience, universities and colleges can anticipate both direct and indirect climate risks, and so minimise future disruption. FHE institutions will also have to contend with disruption to teaching, research, capital projects and income, and will have to cope with the subsequent repairs. Planning for this now will save money in the long run. Adapting for climate change also opens up a massive field of research, and the most proactive FHE organisations can capitalise on new sources of funding and partnerships in the public, non-profit and private sectors."

From Foreword to report "Adapting universities and colleges to a changing climate" published by EAUC and the Higher Education Business Continuity Network (HEBCoN), 2019.

5.3.2 Progress

A few years ago, the University put together an initial overview of the potential climate risks it faces, considering risks to people, markets, assets and finance. The University has continued to take a risk management approach, integrating climate risks into its overall risk management approach, and incorporating climate adaptation and mitigation within a mature environmental management system (EMS) aligned with ISO 14001.

The development of new buildings presents the opportunity to integrate adaptation features in a cost-effective way. For example, in response to the University's commitment to building to BREEAM Very Good standards, its 2017 Berry Brook and Bourne buildings at Greenlands have incorporated a greywater water re-use system that collects and filters shower water for use in WCs. Outdoors across the University's estate, planting schemes and grounds maintenance already incorporate an awareness of suitability for hotter, drier summer seasons.

Figure 5.6: The 2017 Berry Brook and Bourne buildings at the University's Greenlands campus incorporated a greywater water re-use system

Source: University of Reading

Recognising the need for local collaboration to address climate risks, the University is a member of Reading Climate Change Partnership, and actively engages with key local stakeholders, such as Reading Borough Council and the Environment Agency, for climate-sensitive management of joint assets, such as the reservoir.

Through world-leading environment and development research and innovation, the University is also supporting adaptation to the impacts of climate change around the world, particularly through the School of the Built Environment[22], the Department of Meteorology[23], the Department of Geography and Environmental Science[24] and the Walker Institute[25].

5.3.3 Outcomes

The Vice Chancellor is personally concerned to promote environment and sustainability, and for the University to be recognised as a leader in relevant league tables, such as the People & Planet's University League[26]. Consequently, the language of sustainability and resilience in its widest sense runs through the University's latest Strategy. This establishes high-level support not only for a growing reputation in related areas of research, but also for action in climate change adaptation in practical ways across the University as an organisation.

[22] http://www.reading.ac.uk/built-environment/built-environment.aspx

[23] http://www.reading.ac.uk/met/

[24] http://www.reading.ac.uk/ges/

[25] http://www.walker.ac.uk/

[26] People & Planet's University League is the only comprehensive and independent league table of UK universities ranked by environmental and ethical performance. University of Reading is ranked 29th in the 2019 assessment. https://peopleandplanet.org/university-league

5.4 Thames Water – making the business more climate resilient

Thames Water has produced different case studies, partnerships, reports, policies and statements, outlining how they are responding to the impacts and causes of climate change. Thames Water's environmental, sustainability and climate change policies all include dedicated adaptation responsibilities and provide case studies of work to tackle specific themes in relation to climate change, ranging from biodiversity, to supply chain, to flood resilience and preparing for wet weather.

The 2016 Planning for Climate Change progress report[27] (under the Adaptation Reporting Power set out as part of the UK's Climate Change Act 2008) shows the good progress Thames Water has made in integrating climate change into their business planning process. Thames Water has:

- Reviewed and improved flooding resilience at 17 significant water and wastewater sites
- Commissioned a desalination plant which can produce up to 150 million litres per day of potable water to improve the resilience of water availability at times of drought
- Delivered a range of demand-side measures to reduce water consumption
- Met the leakage target for the last nine years
- Established clear goals to improve our resilience to flooding and water availability and reduced dependence on energy from the grid
- Developed new methods to understand the sensitivity of their business activities to the impacts of climate change.

The report also sets out how Thames Water will embed measures to address climate change in their plans for the next five years and the longer term.

See Appendix C.2 for further details.

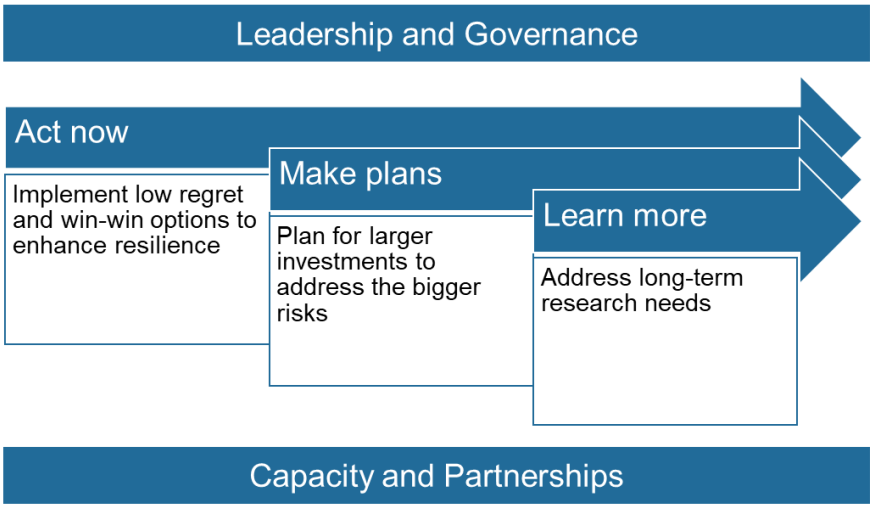
[27] https://www.thameswater.co.uk/-/media/Site-Content/Corporate-Responsibility/CRS-201617/Addressing-climate-change/PDFs/Other-PDFs/Thames-Waters-progress-in-planning-for-climate-change.pdf

6 Reading's Next Steps in Adaptation

In this final section, the next steps for adaptation in Reading are explained. A combination of low-cost early action to generate immediate benefits with longer-term planning and research to support larger investments are underpinned by working in partnership and growing awareness and understanding of climate risks across the town.

Reading's approach to adaptation is illustrated in Figure 6.1.

Figure 6.1: Step-wise approach to adaptation



6.1 Leadership and governance

Although adaptation in Reading is something that all organisations need to address for themselves, the implementation of a coherent plan needs management, leadership and some form of oversight or governance. This helps to avoid duplication or gaps in adaptation planning, and to find efficiencies where adaptation actions can be coordinated. Both within and across organisations, "political" backing for adaptation contributes to success. If high-level support is evident from the start, at executive level or through elected officials, then adaptations are more likely to move forward. The Reading Climate Change Partnership is an established focal point for mitigation and increasingly adaptation action in the town.

Key steps in this category include:

- Identify and build the case for action in Reading to provide a consistent platform
- Communicate the potential impacts from climate change on delivery of critical services and functions in the town
- Communicate the potential opportunities that climate change may have for businesses or organisations that can respond proactively
- Own the plan, establishing a focal point or central hub for all organisations involved in delivering action on adaptation in Reading
- Monitor the plan, maintaining a process for tracking, reporting and communicating progress
- Lead the development of the next iteration of the Reading Climate Adaptation Plan

A view from Reading Borough Council

Reading Borough Council has been building climate change mitigation and adaptation into its policies for over a decade, since the first climate change strategy 2008 to 2013 was launched.

The latest Local Plan includes a specific policy on adaptation, which covers design of new buildings, trees and planting and sustainable urban drainage.

The Council has biodiversity and tree strategies which are currently being revised. These revised strategies will consider the latest evidence and link to the climate change strategy and adaptation plan.

Reading Borough Council is the Local Lead Flooding Authority and has published a local flood risk management strategy which outlines the responsibility for managing flood risk in its local area through collaboration, sustainable urban drainage, emergency response and other measures.

The Council is the local highway authority and owns Council housing stock. The local transport plan and housing strategy are both in the process of being revised and will link to the climate change strategy in terms of both mitigation and adaptation to climate change.

6.2 Capacity-building and partnerships

Adaptation to climate change brings direct benefits to those who invest in it, through reduced damage costs or enhanced quality of life. However many, or most, adaptation actions require some form of collaborative or partnership working, because of the complex systems in which Reading's businesses and organisations operate. Successful adaptation for the town will depend largely on the way in which key stakeholders and beneficiaries can work together, sharing resources and insights, and coordinating their activities, but efficient use of stakeholders' time is crucial for ongoing engagement.

Reading's organisations span a wide spectrum of awareness and knowledge of climate impacts and adaptation, and the available knowledge-base through research and experience is expanding all the time. These key themes of partnership-working and capacity-building will be continuous throughout the process of delivering the adaptation plan. Importantly, partnership projects still need to be framed in tangible, practical ways with clear and relevant business cases, in order to achieve buy-in.

Key steps in this category include:

- Dedicate resources to assess and understand the risks and opportunities, including impacts from past weather events, and access to relevant local or regional climate projection data
- Work in partnership to find funding, to share resources, to develop understanding of climate change risks, to work collaboratively on joint solutions.
- Identify the most effective partnerships to tackle specific issues in places in the town.
- Share experience of adapting in Reading, and learning from the experience of other towns, drawing down on expertise from national or parent organisations.
- Arrange appropriate forums (meetings, seminars, training, etc) to enhance understanding of the local issues and explore the context for difficult decisions.

An example in Reading: All the case studies in this report undertook some form of climate change risk assessment exercise to build their own capacity to start to address adaptation.

An example in Reading: The Oracle drew down from the corporate knowledge, central resources and wider experience of the parent company, Hammerson, to help them get going in adaptation.

6.3 Act now: implementing low regret options

Organisations can take some immediate actions to start adapting. There are many small-scale or low-cost options that may provide resilience or other benefits now, regardless of how the climate changes in future. These low regret options can also help raise awareness and build enthusiasm for taking bolder steps to prepare for longer term changes in climate, where appropriate. Adaptation actions which also deliver benefits in areas like health, regeneration, and sustainability, should clearly identify these.

Key steps in this category include:

- Change behaviours to enhance effectiveness of managing extreme weather, such as protocols for opening/closing windows during heatwaves
- Raise general standards of building and asset maintenance to improve weather resistance
- Provide flexibility in working arrangements, where possible, to reduce impacts of weather-related transport disruption, for example, to enhance business continuity planning
- Explore retrofitting options that can improve energy efficiency and reduce costs in buildings and enhance resilience to extreme weather
- Explore options that can enhance water efficiency or enable water re-use and support local or regional drought-planning
- Explore options that can add or improve green space, boosting ecological networks and providing natural drainage and cooling
- Make use of planned maintenance, upgrades or improvements to incorporate additional climate resilience cost-effectively
- Use sustainability, environment, quality of life or business continuity standards and ratings as a vehicle to bring in climate resilience enhancements.

An example in Reading: Berkshire Healthcare NHS Foundation Trust has implemented room temperature monitoring across its estate to help it provide cool spaces during heatwaves.

An example in Reading: The strategic benefit of achieving strong scores in the People & Planet's University League is an additional motivation for the University of Reading to take action in environment and sustainability.

Cambridge: Integrating adaptation to strengthen local policies

The Cambridge Climate Adaptation Plan was published in 2018 by the City Council. It was developed as one of the actions in the Council's Climate Change Strategy. The Strategy sets out five key objectives for how the Council will address the causes and consequences of climate change. The Adaptation Plan reflects Objective 5 and Action 5.10:

- Objective 5: "Supporting Council services, residents and businesses to adapt to the impacts of climate change".
- Action 5.10 calls for the development of an "Evidence base on climate change adaptation to have better understanding of the climate risks facing the city and the adaptation actions that will have the greatest benefit across the city".

Adaptation is also integrated into Cambridge's other local plans, policies and partnerships; ensuring cohesive planning but also strengthening its other policies:

- Local Plan: include policies which will support residents to adapt to the impact of climate change; design building easier to keep cool and do not overheat in hotter weather; and advice on flood risk mitigation.
- Cambridge Sustainable Housing Design Guide - Any proposed new City Council developments will also contain Sustainable Drainage systems (SuDS).
- Cambridge Sustainable Drainage Design and Adoption Guide - To promote the use of SuDS within Cambridge, the council has taken the decision to adopt SuDS that are located within public open space and produced the Cambridge Sustainable Drainage Design and Adoption Guide.
- Cambridgeshire Flood and Water SPD - The Council continues to work with the Cambridgeshire Flood Risk management partnership to manage climate change-related flood risks. Key actions have included the production of the Cambridgeshire Flood and Water Supplementary Planning Document (SPD).
- Greater Cambridge Partnership - It will be important to ensure that consideration to all forms of flood risk are given to projects delivered via partnership working on projects such as the transport infrastructure projects being delivered by the Greater Cambridge Partnership.

For further information see Appendix C.

6.4 Make plans: planning for larger investments

With the pace of growth and expansion in Reading, longer-term planning needs to prepare for potentially larger changes in climate. New roads and buildings being constructed now have asset lifetimes lasting many decades and could be in use for longer than that. The inclusion of climate resilience into new development requires effort, but large investments may also be needed to enhance existing critical infrastructure to make it fit for the future. Realistic timescales are needed because large scale projects have significant lead-in times, and innovations can take longer.

A pathways approach to long term adaptation planning can offer flexibility and phasing of investment that is responsive to the landscape of evidence for, and experience of, climate impacts that unfolds over time. Even low-cost options are best understood within the context of a wider portfolio and plan of adaptation options from individual up to city-scale (Figure 6.2).

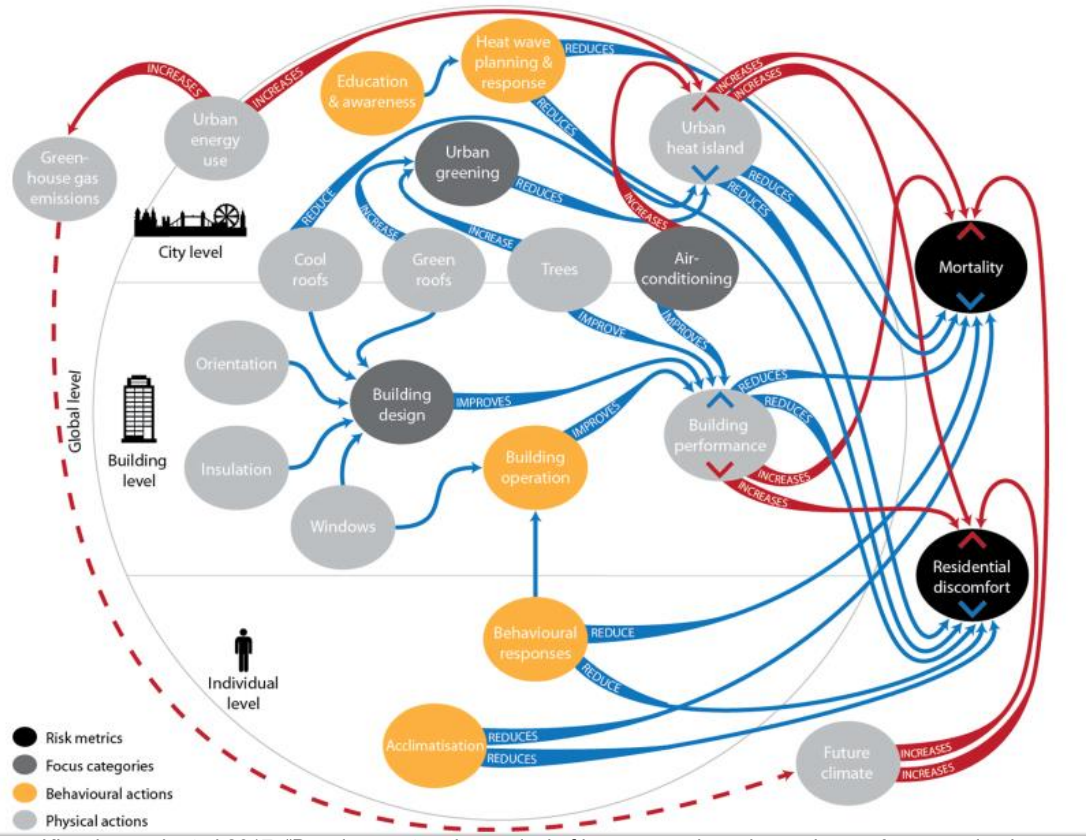
Key steps in this category include:

- Allocate resources to climate risk management or adaptation in forward business planning – all organisations could ensure that climate change is featured within enterprise risk management so that potential risks to long term business strategies are considered
- Include long term climate adaptation explicitly within the scenarios and action-planning for Reading Vision 2050
- Continue to assess long-term requirements for flood risk management, and establish co-ordinated funded plans for enhanced defences along rivers, sustainable flood water storage, and building-level drainage and flood resistance measures in flood-prone areas
- Improve understanding of and establish options for improvement of underground drainage in the town centre

- Integrate climate scenarios into long-term transport planning in and around Reading, and connecting Reading with the rest of the UK and beyond, so that road and rail upgrades and improvements incorporate adaptation cost-effectively.
- Identify external or co-funding to support innovative or collaborative investments that could provide step change in the town's resilience to extreme weather and future climate risks.
- Develop a set of practical indicators, at organisation level or town-wide, to enable monitoring of climate impacts and to identify trigger points for further adaptation action.

An example in Reading: The University of Reading integrates adaptation features into the campus improvement programme and includes resilience in its latest strategy.

Figure 6.2: Urban adaptation actions and their impact on heat risk



Source: Kingsborough et al 2017, "Development and appraisal of long-term adaptation pathways for managing heat-risk in London", Climate Risk Management 16 (2017) 73–92. http://dx.doi.org/10.1016/j.crm.2017.01.001

Planning for the long term with adaptation pathways

An adaptation pathways approach helps organisations to identify what decisions need to be made immediately and what decisions can be made in the future. It offers a process that is flexible, strategic and well organised across a given timeline, and is particularly helpful where there is deep uncertainty, due to factors such as population, demographic, land-use and technological change. Pathways help decision-makers to understand the best time to revisit the outcome of an action taken to continue the process of adaptation into the future.

The Environment Agency pioneered an adaptation pathways approach in the Thames Estuary 2100 project[28] to plan for flood risk management over this century including the potential for a new Thames Barrier.

Kingsborough et al (2017) applied adaptation pathway methodology to urban heat risk management and found that strategies focusing solely on urban greening or building level adaptations based on current best practice might not cope with rising temperatures over the long-term. Air-conditioning may play a growing role in managing heat-risk, although this will exacerbate the urban heat island.

6.5 Learn more: addressing longer term research needs

There are many gaps in the knowledge base needed to support larger investments and good decisions in adaptation. While individual organisations will put their own limited resources towards finding answers to the most pressing and urgent resilience issues they face, collaborative efforts may provide scope to research the longer-term uncertainties around adaptation in Reading. The town is extremely well-placed to build on the existing reputation of its University as a leading centre of expertise in climate change and the built environment, and together with major businesses and utility companies in the area, there is potential to establish fruitful research partnerships.

Key topics in which Reading may wish to learn more include:

- Detailed vulnerability mapping under different socio-economic scenarios (complement the Vision 2050 work)
- Understand co-benefits (or possible conflicts) between adaptation and related challenges
- Water resource management under different scenarios of extreme drought or rainfall
- Enhancing knowledge of negative and positive implications of changing climate on delivery of critical services and functions
- Information about adaptation solutions (technical measures), in theory and practice
- The nature and scale of climate-related business and innovation opportunities for Reading (jobs and skills)
- International impacts on supply chains critical to business and livelihoods in Reading, and/or enhancing resilience

6.6 Next steps for the development of the adaptation plan

While all stakeholders in Reading will have some role to play in defining and delivering the adaptation plan for the town, those roles will be extremely varied, depending on the resources and responsibilities of each organisation. Table 6.1 is a guide to the possible areas of involvement of different stakeholder categories in the town.

[28] https://www.gov.uk/government/publications/thames-estuary-2100-te2100

Table 6.1: Developing an adaptation plan for Reading

	Leadership and governance	Capacity-building and partnerships	Implementing low-regret actions	Planning for larger investments	Addressing longer term research needs
RCCP	■	■			■
Local government	■	■	■	■	■
Businesses		■	■	■	
Utilities or services		■	■	■	■
Residents		■	■		

The following areas of work are recommended to advance the development of Reading's adaptation plan:

- To establish clear governance and implementation arrangements for the plan, including responsibility and ownership for actions, and monitoring of progress. It may be possible to learn from the structures and arrangements, including the high-level sponsorship, that other towns have set up.
- To identify the most relevant communication tools and channels to support the partnership and capacity-building aspects of the plan, and to foster interest and wider buy-in. Artistic impressions, video presentations and the engagement channels used by related initiatives (such as Reading 2050) may be relevant.
- To identify the higher risk spots in the town. Digital mapping of vulnerability data representing individuals, communities, critical systems and future plans would enable targeted effort, and a baseline against which to compare climate information.
- To produce accessible forms of Reading-specific climate change scenario information, based on the UK Climate Projections (UKCP18). This should enable scenario-based analysis by businesses and public sector and provide a common understanding of the range of climate futures that Reading might encounter.
- To coordinate deep-dive case studies for organisations or sites within the town, exploring both climate risks and short- and long-term adaptation actions, and to facilitate sharing of insights and collaborative working on overlapping challenges and solutions.

7 References and further reading

This section provides a list of references used in this report and signposts to further reading.

Climate change impacts and adaptation – general

- Brugge, R. and Burt S. (2015) One hundred years of Reading weather, published by the University of Reading https://research.reading.ac.uk/meteorology/atmospheric-observatory/weather-updates/
- UK Climate Projections https://ukclimateprojections.metoffice.gov.uk
- UK Government National Adaptation Programme (2018) https://www.gov.uk/government/publications/climate-change-second-national-adaptation-programme-2018-to-2023
- The UK's 2nd Climate Change Risk Assessment (2017) https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-2017
- The UK Committee on Climate Change https://www.theccc.org.uk/tackling-climate-change/preparing-for-climate-change/
- AECOM (2018) Adaptation actions in cities: what works? https://www.theccc.org.uk/publication/adaptation-actions-in-the-natural-environment-and-cities-what-works/
- Living With Environmental Change (LWEC) Climate change impacts report card for Infrastructure (2016) https://nerc.ukri.org/research/partnerships/ride/lwec/report-cards/infrastructure/
- National planning policy framework guidance on climate change https://www.gov.uk/guidance/climate-change
- Central England Temperature Record: Parker, D.E., T.P. Legg, and C.K. Folland (1992) A new daily Central England Temperature Series, 1772-1991*. Int. J. Clim., Vol 12, pp 317-342* https://www.metoffice.gov.uk/hadobs/hadcet/Parker_etalIJOC1992_dailyCET.pdf ; http://www.metoffice.gov.uk/hadobs/hadcet/index.html
- Kingsborough et al (2017) Development and appraisal of long-term adaptation pathways for managing heat-risk in London, *Climate Risk Management 16 (2017) 73–92*. http://dx.doi.org/10.1016/j.crm.2017.01.001

Water resources and flood risk

- Living With Environmental Change (LWEC) Water climate change impacts report card (2016) https://nerc.ukri.org/research/partnerships/ride/lwec/report-cards/water/
- Thames Water https://corporate.thameswater.co.uk/About-us/Protecting-our-environment/Climate-change
- Thames Water (2016) Planning for Climate Change progress report https://www.thameswater.co.uk/-/media/Site-Content/Corporate-Responsibility/CRS-201617/Addressing-climate-change/PDFs/Other-PDFs/Thames-Waters-progress-in-planning-for-climate-change.pdf
- Environment Agency https://www.gov.uk/government/collections/environment-agency-and-climate-change-adaptation
- Environment Agency 2018 impacts and adaptation summary https://www.gov.uk/government/publications/climate-change-impacts-and-adaptation

- Environment Agency Thames Estuary 2100 project https://www.gov.uk/government/publications/thames-estuary-2100-te2100

Low carbon development and energy

- The UK Committee on Climate Change "UK housing: Fit for the future?" https://www.theccc.org.uk/publication/uk-housing-fit-for-the-future/
- The UK's 2nd Climate Change Risk Assessment 2017 https://www.gov.uk/government/publications/uk-climate-change-risk-assessment-2017
- BRE Centre for Resilience (2016) Overheating in dwellings http://www.bre.co.uk
- UK Green Building Council https://www.ukgbc.org/uncategorised/climate-resilience-awareness-raising-resources/
- NBS https://www.thenbs.com/knowledge/climate-change-adaptation-in-buildings
- Adaptation and Resilience in the Context of Change https://www.arcc-network.org.uk/adaptive-places/
- EAUC and the Higher Education Business Continuity Network (HEBCoN) (2019) Adapting universities and colleges to a changing climate

Transport

- Network Rail https://www.networkrail.co.uk/communities/environment/climate-change-weather-resilience/
- Living With Environmental Change (LWEC) Climate change impacts report card for Infrastructure (2016) https://nerc.ukri.org/research/partnerships/ride/lwec/report-cards/infrastructure/
- Adaptation and Resilience in the Context of Change https://www.arcc-network.org.uk/infrastructure/

Health and wellbeing

- NHS Sustainable Development Unit https://www.sduhealth.org.uk/areas-of-focus/community-resilience.aspx
- NHS Sustainable Development Unit (2012) Adaptation to Climate Change for Health and Social Care organisations "Co-ordinated, Resilient, Prepared" https://www.sduhealth.org.uk/documents/publications/Adaptation_Guidance_Final.pdf
- Living With Environmental Change (LWEC) Climate change impacts report card for Health (2015): https://nerc.ukri.org/research/partnerships/ride/lwec/report-cards/health/
- Joseph Rowntree Foundation https://www.jrf.org.uk/report/public-health-changing-climate
- Adaptation and Resilience in the Context of Change https://www.arcc-network.org.uk/health-wellbeing/
- Heatwave plan for England https://www.gov.uk/government/publications/heatwave-plan-for-england
- England and Wales Heat-Health Watch Service https://www.metoffice.gov.uk/public/weather/heat-health/
- WHO guidance on thermal comfort: Ormandy and Ezratty (2012) Health and thermal comfort: From WHO guidance to housing strategies. Energy Policy Vol 49, 116-121. https://doi.org/10.1016/j.enpol.2011.09.003

Natural Environment and Green Spaces

- Living With Environmental Change (LWEC) Climate change impacts report card for Biodiversity (2015): https://nerc.ukri.org/research/partnerships/ride/lwec/report-cards/biodiversity/
- Town and Country Planning Association https://www.tcpa.org.uk/
- The Green City https://uk.thegreencity.eu/
- Environment Agency 2018 impacts and adaptation summary https://www.gov.uk/government/publications/climate-change-impacts-and-adaptation

Appendices

A. Adaptation priorities in Reading's 2nd climate change strategy

Adaptation was covered in a limited way in Reading's 2nd climate change strategy 2013-2020 and the strategic priorities which touched on adaptation are summarised in the table.

Table A.1: Adaptation strategic priorities in Reading's 2nd climate change strategy

	Action
Low carbon development	
T2SP1	Continue to develop planning policies that support the reduction of greenhouse gas emissions directly and indirectly from the borough and allow for adapting to the impacts of climate change
T2SP3	Develop and implement adaptation measures to reduce the impact of high and low temperatures
Natural environment	
T3SP1	Improve the quality and connectivity of natural habitats
Water supply and flooding	
T4SP1	Manage demand for and supply of water to reduce the expected impact of water shortages on consumers and on wildlife
T4SP2	Reduce the risk of damage due to flooding
T4SP3	Develop an adaptation plan for Reading so we can plan for extreme events associated with the changing climate
Education, Communication and Influencing Behaviour	
T7SP1	Integrate learning and practice of skills for climate change throughout schools and colleges, homes, businesses and workplaces
T7SP2	Raise awareness (with the stakeholders mentioned above), of the range of opportunities, initiatives, successes and challenges relating to climate action across Reading
Community	
T8SP2	Build community resilience to climate change: collective and individual

Source: Reading means business on climate change (August 2018 update)

B. Overview of the UK Climate Projections 2018 (UKCP18)

B.1 Introduction to the UK Climate Projections

The UK Climate Projections provides the most up-to-date assessment of how the climate of the UK may change over the 21st century and is designed to provide information to help with climate change risk assessments and adaptation plans. The UK Climate Projections 2018 (UKCP18) is the fourth generation of national climate projections for the United Kingdom (replacing UKCP09) and aims to provide users with the most recent scientific evidence on projected climate changes with which to plan for the future.

Like UKCP09, UKCP18 includes estimates of the range of probable outcomes of future climate. UKCP18 uses newer climate models, additional observations and more recent views of how emissions may change in the future. These improvements increase our confidence in the ranges of future climate over the UK.

B.2 Headline differences between UKCP09 and UKCP18

The headline results in the latest set of climate projections are broadly consistent with UKCP09, although there are some differences (e.g. temperature and rainfall) that may be important for climate risk assessments, especially in the tail end of the projections.

Risk assessments and adaptation decisions should use these new projections but will also need to be regularly reviewed to ensure they take account of the latest scientific understanding, longstanding and emerging vulnerabilities, as well as changing socio-economics.

UKCP18 adds tools and capabilities, providing new insight compared to the previous projections, thus enhancing capacity for analysing climate risks.

In September 2019, additional projections are now provided at 2.2km resolution, comparable to those used for weather forecasting. This high-resolution data provides information on events such as localised heavy summer rainfall, which can result in flash floods and surface water floods (UKCP18 headline findings[29]).

B.3 Data differences between UKCP09 and UKCP18

The main data differences between UKCP09 and UKCP18 set out in UKCP18 Guidance: UKCP18 for UKCP09 users[30]. It is important to note that:

- For UKCP18 not all emissions scenarios, geographical domains nor all individual climate variables are available across all of the suite of different climate projections datasets. For further information see UKCP18 Guidance: Data availability, access and formats[31]. There are two main ways to download the data: the UKCP18 User Interface

[29] Available at https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp-headline-findings-v2.pdf

[30] Available at https://www.metoffice.gov.uk/binaries/content/assets/mohippo/pdf/ukcp18/ukcp18-guidance-ukcp18-for-ukcp09-users.pdf

[31] Available at https://www.metoffice.gov.uk/binaries/content/assets/mohippo/pdf/ukcp18/data-availability-access-and-formats-.pdf

(currently on UK not global data is available) and the CEDA Data Catalogue (designed for those who are familiar with coding and handling large climate datasets).

For UKPCP09 the user interface is no longer available. However, the UKCP09 datasets are available for the UKCP09 land and marine regions and observed data[32] via the CEDA catalogue[33] (but only as non-customisable entire model outputs and is designed for those who are familiar with coding and handling large climate datasets).

[32] UKCP09: Land and marine past climate and future scenario projections data for the UK available at https://catalogue.ceda.ac.uk/uuid/094d9c9b9dda42c0aa1a1848af9fb56b

[33] The Natural Environment Research Council's Data Repository for Atmospheric Science and Earth Observation - Centre for Environmental Data Analysis (CEDA).

C. City examples – Cambridge and Copenhagen

C.1 Cambridge

C.1.1 Cambridge Climate Adaptation Plan: how it integrates adaptation with other existing policies

The Cambridge Climate Adaptation Plan was published in 2018 by the Cambridge City Council. It was developed around the following existing national and local policies:

- **Cambridge City Council**

  The Council has a vision of "One Cambridge – Fair for all"[34] in which economic dynamism and prosperity are combined with social justice and equality. This vision is particularly important from a climate risks perspective as climate change will disproportionally affect disadvantaged communities.

- **Climate Change Strategy 2016-2021**[35]

  The Cambridge Climate Adaptation Plan has been developed as part of one of the actions identified in the Council's Climate Change Strategy. The Strategy sets out five key objectives for how the Council will address the causes and consequences of climate change. The Adaptation Plan reflects Objective 5 and Action 5.10:

  – Objective 5: "Supporting Council services, residents and businesses to adapt to the impacts of climate change".

  – Action 5.10 calls for the development of an "Evidence base on climate change adaptation to have better understanding of the climate risks facing the city and the adaptation actions that will have the greatest benefit across the city".

- **Climate Local**

  In 2015, the Environment Agency Climate Ready team, in partnership with Climate UK and the Local Government Association produced the publication "*Climate Ready Councils: The Business case for managing the impacts of severe weather and a changing climate*"[36] which sets out a council business case for managing the cross-cutting impacts of severe weather and a changing climate.

  – Climate Local: initiative launched in June 2012 to support councils both to reduce carbon emissions and to increase resilience to a changing climate. Only one of its kind in England. It supports local authorities in the following ways:

    ○ Provides a platform owned and led by councils, to promote activity on climate change and demonstrate leadership locally and nationally.

    ○ Supports local authorities to share good practice and identify other authorities undertaking similar initiatives, to support joint working and the sharing of experience and ideas.

[34] Cambridge City Council, Climate Change Adaptation Plan, 2018, https://www.cambridge.gov.uk/media/5996/climate-change-adaptation-plan.pdf

[35] Climate Change Strategy 2016-2020, 2015, https://www.cambridge.gov.uk/media/3230/climate_change_strategy_2016-21.pdf

[36] Climate Ready Councils, The business case for managing the impacts of severe weather and a changing climate, 2015, https://www.sustainabilitywestmidlands.org.uk/wp-content/uploads/FINAL-CR-Business-Case-for-Adaption-Report.pdf

- Provides practical tools and advice to councils on climate change issues.

Raises the profile of carbon reduction and adaptation nationally.

- **Cambridge Sustainable Housing Design Guide**[37]

  Any proposed new City Council developments will also contain Sustainable Drainage systems (SuDS), in line with planning policy and guidance contained in the Cambridge Sustainable Housing Design Guide.
- **Cambridge Sustainable Drainage Design and Adoption Guide**[38]

  To promote the use of SuDS within Cambridge, the council has taken the decision to adopt SuDS that are located within public open space and produced the Cambridge Sustainable Drainage Design and Adoption Guide.
- **Cambridgeshire Flood and Water SPD**[39]

  The Council continues to work with the Cambridgeshire Flood Risk management partnership to manage climate change-related flood risks. Key actions have included the production of the Cambridgeshire Flood and Water Supplementary Planning Document (SPD).
- **Greater Cambridge Partnership**[40]

  It will be important to ensure that consideration to all forms of flood risk are given to projects delivered via partnership working on projects such as the transport infrastructure projects being delivered by the Greater Cambridge Partnership.
- **Partnership with other institutions**[41]
  - Environment Agency
  - Cambridgeshire County Council
  - The Greater Cambridge Partnership
  - Cambridgeshire and Peterborough Combined Authority
  - Cambridge Water
  - University of Cambridge
  - Centre for Climate Repair (Launched May 2019)
  - Global Sustainability Institute at Anglia Ruskin University

C.1.2 Current Adaptation Actions

Cambridge City Council is currently undertaking several actions in order to adapt to climate change, among which:

- Local Plan: include policies which will support residents to adapt to the impact of climate change; design building easier to keep cool and do not overheat in hotter weather; and advice on flood risk mitigation.[42]

[37] The Cambridge Sustainable Housing Design Guide, 2017, https://www.cambridge.gov.uk/media/1503/cambridgeshire-sustainable-housing-design-guide.pdf

[38] Cambridge Design and Adoption Guide, 2016, https://www.cambridge.gov.uk/media/5457/suds-design-and-adoption-guide.pdf

[39] Cambridgeshire Flood and Water Supplementary Planning Document, 2016, https://www.cambridge.gov.uk/media/7107/cambridgeshire-flood-and-water-spd.pdf

[40] Greater Cambridge Partnership https://www.greatercambridge.org.uk/ , Cambridge City Council, Climate Change Adaptation Plan, 2018, p.11, https://www.cambridge.gov.uk/media/5996/climate-change-adaptation-plan.pdf

[41] Cambridge City Council, Climate Change Adaptation Plan, 2018, p.16, https://www.cambridge.gov.uk/media/5996/climate-change-adaptation-plan.pdf

[42] Cambridge City Council, Climate Change Adaptation Plan, 2018, p.13, https://www.cambridge.gov.uk/media/5996/climate-change-adaptation-plan.pdf

- Sustainable Drainage Systems (SuDS): exploring opportunities to install SuDS on Council property and open spaces. The Council is working with developers to secure installation of sustainable drainage systems to mitigate the impacts of new developments and is retrofitting property level flood protection at some properties.[43]
- Partnership: working with Cambridgeshire County Council and other partners in the Cambridgeshire Flood Risk Management Partnership to manage climate change-related flood risks. The Council is working closely with Anglian Water and Cambridge Water to identify infrastructure requirements needed to support the growth agenda in Greater Cambridge and to better align the Council's strategic planning with the Water Companies Business Plan and Water Resource Management Plans.[44]
- Health Risk Advise: providing advice for residents on how to reduce health risks during heat waves and minimise risks of surface water flooding, including via the Council's website and the Cambridge Matters residents' magazine. Promotion of advice to be linked to specific climate events (e.g. heat wave guidance to be published in spring ahead of possible heat-wave events).[45]
- Water Meters: running a series of pilot projects to switch residents onto water meters.[46]
- Water Efficiency Standards: Requiring new domestic properties to meet high water efficiency standards (no more than 110 litres of water to be consumed per day) along with standards for non-domestic properties.[47]
- Water courses Management: enhancing watercourses' flow and storage capacity and deliver wider biodiversity benefits (e.g. a project to control an invasive weed; restoration project to bring back a watercourse into use and enhance the biodiversity and habitats for plant and animal life).[48]
- Tree Planting: the new tree strategy sets out the Council's policies for managing and increasing the city's tree stock. It ensures that planting in open spaces owned or managed by the City Council is drought resistant and requires less watering.[49]

Evidence Base Reports: developing an evidence base for climate change adaptation to enable the Council to have a better understanding of the climate risks facing the city and the adaptation actions that will have the greatest benefit across the city (number of plans, strategies and assessments have been produced).[50]

[43] Cambridge City Council, Climate Change Adaptation Plan, 2018, p.13, https://www.cambridge.gov.uk/media/5996/climate-change-adaptation-plan.pdf

[44] Cambridge City Council, Climate Change Adaptation Plan, 2018, p.15, https://www.cambridge.gov.uk/media/5996/climate-change-adaptation-plan.pdf

[45] Cambridge City Council, Climate Change Adaptation Plan, 2018, p.17, https://www.cambridge.gov.uk/media/5996/climate-change-adaptation-plan.pdf

[46] Cambridge City Council, Climate Change Adaptation Plan, 2018, p.15, https://www.cambridge.gov.uk/media/5996/climate-change-adaptation-plan.pdf

[47] Cambridge City Council, Climate Change Adaptation Plan, 2018, p.13, https://www.cambridge.gov.uk/media/5996/climate-change-adaptation-plan.pdf

[48] Cambridge City Council, Climate Change Adaptation Plan, 2018, p.16, https://www.cambridge.gov.uk/media/5996/climate-change-adaptation-plan.pdf

[49] Cambridge City Council, Climate Change Adaptation Plan, 2018, p.15, https://www.cambridge.gov.uk/media/5996/climate-change-adaptation-plan.pdf

[50] Cambridge City Council, Climate Change Adaptation Plan, 2018, p.16, https://www.cambridge.gov.uk/media/5996/climate-change-adaptation-plan.pdf

C.1.3 Future Adaptation Actions

- Car Park Refurbishments: ensure that measures to help adapt to climate change are included, where possible, in car park refurbishment.[51]
- Outdoor Events: consideration given to the impacts of extreme weather in the management of outdoor events (e.g. training programme for community event organisers, delivered through the Festivals and Events Liaison Group).[52]
- Potable Water: rainwater harvesting equipment installed and utilised for watering planting and other functions, reducing the use of potable water.[53]
- Hosepipe Ban: Promotion of the use of council pools, paddling pools and splash pads in the event of hosepipe bans in conjunction with the local water company, to encourage residents to utilise council facilities instead of using water to fill up garden paddling pools etc. Use of council communication and paddling pools at times of low rainfall and hosepipe bans.[54]

C.2 Copenhagen

- The Climate Adaptation Plan proposes implementation of the following projects[55]:
  - Reduction in the hydraulic load on watercourses;
  - Passing on knowledge to the public and businesses on options for climate-proofing;
  - Planning and implementation of Plan B measures in City of Copenhagen (control of water on surfaces/ roads during extreme rain events);
  - Opening of watercourses in pipes;
  - Disconnection of stormwater from sewer;
  - Quantification of the effect of different SUDS measures;
  - Coordinated wastewater planning in the whole catchment area of Lynettefaellesskabet sewage treatment plan
- The Climate Adaptation Plan recommends the following:
  - Separation of wastewater using SUDS is incorporated into the wastewater plan. Specific work should be done to look at where wastewater can be disconnected from the sewer.
  - Establishment of pumps in runoffs as consequence of rises in sea level is incorporated into the wastewater plan.
  - Integrate SUDS into future urban planning.
  - A climate-adapted dimensional design base for new sewers is incorporated into municipal plans.
  - Work is done on the introduction of differential billing for stormwater and wastewater at the Lynettefaellesskabet sewage treatment plant as an incentive for disconnecting stormwater in the catchment municipalities.

(Plan B is a term used for various methods used to direct stormwater on the surface. The aim of the methods is to convey the stormwater to where it causes least -or no- damage.)

[51] Cambridge City Council, Climate Change Adaptation Plan, 2018, p.17, https://www.cambridge.gov.uk/media/5996/climate-change-adaptation-plan.pdf

[52] Cambridge City Council, Climate Change Adaptation Plan, 2018, p.17, https://www.cambridge.gov.uk/media/5996/climate-change-adaptation-plan.pdf

[53] Cambridge City Council, Climate Change Adaptation Plan, 2018, p.17, https://www.cambridge.gov.uk/media/5996/climate-change-adaptation-plan.pdf

[54] Cambridge City Council, Climate Change Adaptation Plan, 2018, p.18, https://www.cambridge.gov.uk/media/5996/climate-change-adaptation-plan.pdf

[55] Copenhagen Carbon Neutral by 2025, Copenhagen Climate Adaptation Plan, 2010, https://en.klimatilpasning.dk/media/568851/copenhagen_adaption_plan.pdf

- Measure against groundwater changes:
  - Sealing of basements and foundations:
    - New Buildings: buildings to be constructed in such way that foundations and basements are sealed in relation to the existing groundwater level.
    - Existing Buildings: can be sealed in relation to increased groundwater pressure (more costly than new buildings).
  - Groundwater pumps: Establish permanent pumping-away of groundwater. This solution entails some sustainability problems, both in relation to energy consumption and based on a view of groundwater as a resource. Permanent pumping-away of groundwater is therefore not permitted in CPH in new building projects.
- Recommendations on the indirect consequences of Climate Changes. Projects recommended to be implemented:
  - Registration of the municipality's own properties: registration of current condition and safety of buildings and roads in relation to climate change and preparation of an action plan, including analysis of needs for investment.
  - Information to citizens: information material and information campaigns on options for climate-proofing.
  - Upgrading of qualifications/ training: preparation of guidelines and syllabus/ material for municipal employees with relevant contact with the public, with a view to ensuring fundamental knowledge on the significance of climate change and options for action by the public.

Cloudburst plan[56]

The Cloudburst Management Plan is an offshoot of the Copenhagen Climate Adaptation Plan. It outlines the methods, priorities, and measures recommended for the area of climate adaptation including extreme rainfall.

Originally, the Climate Adaptation Plan recommended that rainwater from extreme rainfall should be evacuated by draining it to places where the flooding would cause a minimum of disruption (parks, sports grounds, open spaces). The idea was to store the rainwater in these buffer areas until the drainage system had recovered its capacity. The extreme rainfall event in 2011 and subsequent calculations have now proved that this method is inadequate in preventing pluvial flooding. Estimates show that plan B in the Climate Adaptation Plan would only be able to cover a minor part of the need for draining off rainwater.

The major part of the precipitation resulting from intense downpours must be drained out to sea/harbours while a minor part must be channelled to freshwater basins.

[56] The City of Copenhagen Cloudburst Management Plan 2012, 2012, https://en.klimatilpasning.dk/media/665626/cph_-_cloudburst_management_plan.pdf

D. Policy review – Environment Agency and Thames Water

D.1 Environment Agency

Following are climate change adaptation policies, plans, responsibilities and tools that the Environment Agency has put in place:

Climate Impact Tool[57]

EA developed the Climate Impacts Tool to help them understand the potential risks and impacts from climate change. It is used at a high level to start discussions at the early planning stage of a new or revised strategy plan. It is not appropriate for short-term planning or for plans and projects at a detailed, local or site-specific level. Once the climate risks and impacts are identified, a more in-depth assessment is then required. The climate tool provides changes for England consistent with a 4°C rise in global mean temperature by the end of the century. The guidance does not replace other published EA guidance in relation to climate change.

Climate Adaptation reporting (Second Round)[58]

The report explains the EA's strategy for adapting to a changing climate. It is the second report under the Climate Change Act (2008) and was produced in response to an invitation from government ministers. The first part of the report discusses how the EA responds to sever weather today, how climate change will affect its work and how they will manage that risk. The second part of the report provides the technical information requested by the government.

EA's adaptation strategy is divided into 6 main actions:

1. Work with EA's customers and partners to adapt their activities and manage climate risk.
2. Invest in climate resilient projects (e.g. flood, coastal and catchment management schemes).
3. Adapting and improving regulatory mechanisms and approaches to take climate change into account.
4. Improving the understanding of climate change.
5. Work at a catchment scale works with natural systems to provide multiple benefits for people and the environment.
6. Provide EA staff with the right tools, training and information on climate change and adaptation.

[57] Climate Impact Tool, 2019, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/798032/Climate_impacts_tool.pdf

[58] Adapting to a changing climate – The Environment Agency's second adaptation report under the Climate Change Act, 2016, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/526000/climate-adrep-environment-agency.pdf

Climate Change impacts and adaptation[59]

This is an evidence-based report summarising climate change in England. It includes examples of current and future impacts and the adaptations that are needed. It outlines what has happened and what is expected to happen to the UK climate.

Furthermore, it outlines the main adaptation actions that are being taken, or that are being planned, to prepare for the impacts of climate change.

Flood risk assessments: climate change allowances[60]

It is a guidance explaining how local planning authorities can use future flood allowances in flood risk assessments. Climate change allowances are predictions of anticipated change for:

- Peak river flow by river basin district
- Peak rainfall intensity
- Sea level rise
- Offshore wind speed and extreme wave height

They are based on climate change projections and different scenarios of carbon dioxide (CO2) emissions to the atmosphere. The EA uses these allowances as benchmarks when providing advice on flood risk assessments and strategic flood risk assessments.

Adapting to climate change: guidance for risk management authorities[61]

Risk management authorities must apply this guidance to projects or strategies seeking government flood and coastal erosion risk management grant in aid funding. The purpose of this advice is to ensure that an economically credible appraisal can be made to support Government investment decisions. This is necessary to ensure that a fair comparison can be made between investment in projects in different locations that compete for central government grant, as well as ensuring that the most appropriate means of reducing risk is investigated in any one place.

Climate change approaches in water resources planning[62]

Explores how climate change impacts are incorporated into the water resources planning process in England and Wales, offering both flexibility and guidance on different climate change approaches.

Thames Estuary TE2100[63]

The EA worked with its partners to develop the Thames Estuary 2100 plan. The EA has a lead role in managing the Plan. The purpose of the Plan is to help manage tidal flood risk in the Thames estuary to the end of the century (from Teddington in the West to Sheerness and Shoeburyness in the East). The plan has 3 phases (phase 1 2019-2035; phase 2 2035-2050; phase 3 2050-2100). The Plan was developed using the latest climate change guidance available in 2009, as well as independent research However today the EA monitors 10

[59] Climate change impacts and adaptation, 2018, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/758983/Climate_change_impacts_and_adaptation.pdf

[60] Flood risk assessments: climate change allowances, 2016, https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

[61] Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities, 2011, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/571572/LIT_5707.pdf

[62] Climate change approaches in water resources planning, 2013, https://www.gov.uk/government/publications/climate-change-approaches-in-water-resources-planning-new-methods

[63] Thames Estuary 2100, 2011, https://www.gov.uk/government/publications/thames-estuary-2100-te2100

indicators of change and uses this monitoring to carry out a 5-yearly review of the plan. It is recognised as a leading example of climate change adaptation.

D.2 Thames Water

Thames Water has delivered different case studies, reports, policies and statements, outlining how they are responding to the impacts and causes of climate change.

Reducing Our Greenhouses Gas Emissions

Thames Water is currently undertaking several actions to significantly reduce both their operational carbon footprint and their energy consumption. The actions are outlined in the following two reports:

- How we manage carbon emissions and sludge[64]
  - From October 2016 TW started to purchase 100% Renewable Energy Guarantees of Origin (REGO) accredited renewable grid electricity.
  - TW can now focus on emission from other non-grid related sources, and better understanding the carbon related and wider environmental benefits of the way they manage their sludge.
  - TW has treated sludge to high standards using anaerobic digestion, producing biogas that can be used as a fuel in their combined head and power engines.
- Becoming a more energy aware business[65]
  - Regularly engage with TW people (digital engagement – articles email bulletins, social media, yammer; energy savings tips; employee engagement emails).
  - Analyse data from more than 900 sub-meters across 25 of TW largest sites.
  - Host workshops across the business to ensure their sites are as energy efficient as possible.

Produce reports to inform the operational teams how, when and where they use energy and to identify where they could reduce consumption and cost.

Partnerships[66]

Thames Water has carried work with a range of other organisations to tackle climate change issues, including:

- The Aldersgate Group
- The Prince of Wales Corporate Leaders Group on Climate Change
- Business in the Community
- The Thames Water Customer Challenge Group
- DEFRA
- London Climate Change Partnership
- The Climate Change Committee's adaptation sub-committee
- Action for the River Kennet (ARK)
- WaterUK

[64] How we manage carbon emissions and sludge, 2017, https://sustainability.thameswater.co.uk/-/media/Site-Content/Corporate-Responsibility/CRS-2017-18/ACC/Case-studies/How-we-manage-carbon-emissions-and-sludge.pdf

[65] Becoming a more energy aware business, 2017, https://sustainability.thameswater.co.uk/-/media/Site-Content/Corporate-Responsibility/CRS-2017-18/ACC/Case-studies/Becoming-a-more-energy-aware-business.pdf

[66] https://sustainability.thameswater.co.uk/Addressing-climate-change/Working-with-others

- UKWIR
- BEIS
- Haven Power
- Academic Institutions (University of Oxford and Imperial College London)

Our climate change policy[67]

The policy briefly lists the actions Thames Water intends to implement in order to respond to the challenges of climate change.

Our sustainability policy[68]

The policy outlines 9 sustainability themes that Thames Water is committed to implement:

- Water a precious resource
- Providing sustainable drainage
- Mitigating climate change
- Climate change adaptation
- Ensuring responsible operations
- Enhancing customer inclusion
- Delivering efficient operations
- Sustainable and safe workforce
- Long-term sustainable investment

Our environment policy[69]

The policy summarises how Thames Water will fulfil their environmental responsibilities.

Case Studies

Thames Water has published case studies undertaken to understand how to tackle specific themes in relation to climate change.

- Biodiversity, Assets and Climate Change[70]

The study, commissioned by Thames Water, assessed the potential impacts of climate change upon sites of biodiversity interest owned and/or managed by Thames Water. The study found that the impacts of climate change could challenge TW's ability to maintain existing habitats at some of the sites. The findings have been used to help inform Thames Water's long-term planning and prioritisation.

[67] Our climate change policy, 2018, https://sustainability.thameswater.co.uk/-/media/Site-Content/Corporate-Responsibility/CRS-2017-18/Policies-and-other-pdfs/Climate-Change-Policy-2018.pdf

[68] Our sustainability policy, 2018, https://sustainability.thameswater.co.uk/-/media/Site-Content/Corporate-Responsibility/CRS-2017-18/Policies-and-other-pdfs/Sustainability-Policy-2018.pdf

[69] Our environment policy, 2018, https://sustainability.thameswater.co.uk/-/media/Site-Content/Corporate-Responsibility/CRS-2017-18/Policies-and-other-pdfs/Environment-Policy-2018.pdf

[70] Case Study – Biodiversity, Assets and Climate Change, 2015, https://corporate.thameswater.co.uk/-/media/Site-Content/Thames-Water/Corporate/AboutUs/Protecting-our-environment/Climate-change/BAC.pdf

- Planning for Flood Resilience[71]

The study explains the approach developed by Thames Water to better identify flood risk and investment whilst avoiding unnecessary costs. The approach is 3-phased:

1. Initial screening and priority sites and initial solutions and initial costs identified;
2. Further screening of priority sites and solutions refinement
3. Climate change sensitivity analysis

- Supply Chain[72]

Thames Water has produced guidance for suppliers on the importance of their contributions in helping the company both to mitigate its contributions to climate change and to adapt to its likely impacts.

- Thresholds and Monitoring[73]

Thames Water has been involved in interdisciplinary groups which have developed industry best practice methodologies for a risk-based adaptation approach that identifies vulnerable networks, processes, assets and receiving waters.

- Water Resource Planning[74]

Thames Water evaluates the resilience of a range of options in response to projected future extreme weather events against a range of criteria including:

  - Environmental and social
  - Cost
  - Acceptability
  - Deliverability
  - Resilience
  - Sustainability
  - Climate Change

- Preparing for Wet Weather[75]

Thames Water has invested heavily in equipment with more than £700,000 spent on having the right protective kit available to our teams so they can react much faster to any flooding incidents across the region.

[71] Case Study- Planning for Flood Resilience, 2016, https://sustainability.thameswater.co.uk/-/media/site-content/corporate-responsibility/pdfs/climate-change/0100tw-arp2-6-case-study--planning-for-flood-resiliance.pdf

[72] Case study- Supply chain, 2016, https://corporate.thameswater.co.uk/-/media/Site-Content/Thames-Water/Corporate/AboutUs/Protecting-our-environment/Climate-change/Supplychain.pdf

[73] Case study- Thresholds and Monitoring, 2016, https://corporate.thameswater.co.uk/-/media/Site-Content/Thames-Water/Corporate/AboutUs/Protecting-our-environment/Climate-change/ThresholdsandMonitoring.pdf

[74] Case study- Water resource planning, 2016, https://corporate.thameswater.co.uk/-/media/Site-Content/Thames-Water/Corporate/AboutUs/Protecting-our-environment/Climate-change/WaterResourcePlanning.pdf

[75] Case study- Preparing for wet weather, 2015, https://corporate.thameswater.co.uk/-/media/Site-Content/Thames-Water/Corporate/AboutUs/Protecting-our-environment/Climate-change/WaterResourcePlanning.pdf

Thames Water's progress in Planning for Climate Change[76]

The report updates on the progress Thames Water made, in order to make their business more resilient to the impacts of climate change. Thames Water climate change policy sets out the following principles:

- Incorporate the latest climate change assessments and understanding into our business planning processes
- Continue to assess how climate change affects our operations and operational sites and develop appropriate responses
- Work with eight2O, our business partners, contractors and supply chain to increase resilience to the impacts of climate change
- Implement our statutory Water Resource Management Plan to safeguard water supplies from the impact of climate change, with particular focus on leakage control, metering and water efficiency and the development of new water resources
- Engage with and seek support from our customers for our resilience/adaptation and mitigation responses
- Review and improve the resilience of our sites to flooding

[76] Thames Water's progress in planning for climate change, 2016, https://www.thameswater.co.uk/-/media/Site-Content/Corporate-Responsibility/CRS-201617/Addressing-climate-change/PDFs/Other-PDFs/Thames-Waters-progress-in-planning-for-climate-change.pdf